ENERGY AND THE U.S. ECONOMY

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The United States is known as an energy glutton. It consumes significantly more energy per person than most other countries. We consume almost twice the energy per person of many developed countries in western Europe, and about 60 times the energy per person of India. In addition to energy waste, there are specific differences between the U.S. economy and other developed economies which explain a significant portion of the differences in per capita energy consumption.

If we compare the energy consumption per person per unit of industrial output, we find that the U.S. per capita energy consumption in industry is not very different from that in many other countries. Even for a country like India which consumes so much less energy in total, the industrial energy consumption is similar. If we compare the energy consumption in the household and commercial sector in the United States with that in other countries, we find that although we do consume more generally, the differences are not nearly so large as the differences in total energy consumption per person.

So the significant difference in energy consumption between the United States and other world countries is in the transportation sector. We consume many times more energy per person in transportation than any developed European country and hundreds of times more than the developing economies.

The energy which we use in transportation is primarily liquid energy. In the United States, we don't have an energy problem per se; rather we have a shortage of energy liquids and the national security problems that are associated with a heavy dependence on foreign sources.

Currently, about one half of our energy consumption is from oil, about one fourth from natural gas, about 18 percent from coal, and the remaining 7 percent from nuclear, hydropower, and other sources. In contrast, about 90 percent of our proven energy reserves are coal and only 8 percent is oil and natural gas. So oil and natural gas constitute three-fourths of our energy consumption and only about 8 percent of our energy reserves. Clearly there is a serious imbalance between our reserves of fluid energy resources and our current consumption pattern. It is this imbalance between reserves and consumption and the national security problems caused by the high level of oil imports which is the cause for concern in our current energy situation.

Approaches to Solving Our Energy Problem

Given our energy problem, what alternative approaches do we have to solving that problem? We can divide the possible approaches into five different categories: (1) energy conservation, (2) increase the domestic oil supply, (3) change consumption from liquids to solids, (4) convert other sources to liquids, and (5) move to renewable energy sources.

Energy conservation.

Energy conservation has been called our cheapest energy source. Up to a point this is correct. The cost of better insulation and more efficient energy management techniques is generally far less than the cost of the energy that would have been consumed. Significant amounts of energy can be saved with improved architectural design in buildings. Large amounts of energy can and will be saved with more fuel efficient automotive fleets. In general, better energy management can lead to significant savings of energy both in industry and in the home. In fact, over the past few years significant savings in energy have been achieved in the industrial sector. Many industries have reduced energy consumption by 30 percent or more during the last four years.

One problem with implementing greater energy conservation is that at least up to this point we have been unwilling to price energy at its replacement cost which is higher than current market prices. The greatest incentive for conservation is higher price, yet politically we find it difficult to raise energy prices and thereby encourage conservation. So much of the incentive for conservation has come from public relations gimmicks such as television commercials encouraging us to save energy.

If Congress really wanted us to conserve energy, they could send us a message which would lead to greater conservation. That message would be that through higher prices we would each find it in our own interest to conserve.

Increase the oil supply.

The second approach to solving the energy problem is to try to increase the oil supply. Increases in domestic oil production could come about from two different sources: increased exploration of new oil deposits and enhanced recovery of existing deposits.

With current technology, we are able to produce only about one third of the actual oil in place. The remaining two thirds of the oil in place is trapped in the geological formation and requires additional expense to be recovered. New techniques are being developed to inject steam, water, and chemicals into the formation and drive a portion of the remaining oil towards a producing well. To the extent that these techniques are successful, significant amounts of oil from existing reserves could be recovered. Our domestic oil supply could be increased by a combination of both increased exploration and enhanced oil recovery.

Change consumption from liquids to solids.

The third approach to our energy problem is to change consumption from liquids to solids. The most direct means of accomplishing this is to switch from using fuel oil for electricity generation or industrial process heat to using coal to generate that heat. Significant amounts of utility and industrial process heat using fuel oil could be converted to coal thereby saving significant amounts of liquid energy.

Another means of changing consumption from liquids to solids which is longer term in nature is to convert our existing vehicle fleet from its current status of liquid consumption to an electric vehicle fleet. The electricity could be generated from coal or nuclear power thereby accomplishing the change from consuming liquids for transportation to using solids via the electric vehicle. Clearly this is a longer term option but it does offer potential for changing consumption from liquids to solids.

Convert other sources to energy liquids.

The fourth approach is to convert other sources of energy to liquids. This is the so called syn-fuel option. Liquid fuels can be made from coal, oil shale, or tar sands. The United States has very large reserves of coal and oil shale. About 10 years ago it was believed that oil could be produced from oil shale for around $8 per barrel. Since that time the price of oil shale crude has always remained a step ahead of the price of crude oil. Today estimates of producing crude from oil shale range from the high twenties to nearly $50 per barrel. The cost of producing oil from coal also lies somewhere in this range. Despite the fact that these prices are very high, syn-crude could become economic with either government subsidies or government taxes on petroleum.

Renewable energy sources.

The fifth approach to handling our energy problem is to move in the direction of using more renewable energy sources. The ultimate source of renewable energy is the sun, but other closely related energy sources are included. Biomass, wind power, ocean thermal, hydropower, and other energy sources which are directly or indirectly related to solar energy are usually included. The recent book, *Energy Future* published by Harvard Business School, advocated moving quickly towards dependence on renewable energy sources. The potential for producing energy from agriculture falls within this category also.

Energy from agriculture.

Before moving on into some of the policies and inflation issues, I would like to spend just a moment talking about the results of a recent study we completed at Purdue on the potential of producing energy from agriculture. Biomass energy encompasses a wide range of energy sources including forestry, crops, crop residues, agricultural wastes, aquaculture, mariculture, and municipal solid waste.

I will restrict my discussion to the potential of producing energy from crops and crop residues alone. In estimating the total potential energy production from crop residues, the starting point was a calculation of the total residue production in agriculture each year. The estimate for total crop residue each year in the United States is about 400 million tons, most of which is from corn and small grains. To estimate the usable crop residue we made several adjustments to this gross residue availability number. To allow for soil conservation, we estimated the amount of residue that needed to be left on the soil for each soil type in each land resource region in the country. We also estimated losses in harvesting, transportation, and storage. After deducting the residue needed for soil conservation and the losses in the harvesting transportation and storage systems, we arrived at a total usable residue number of about 78 million tons per year.

Therefore, only about 20 percent of the gross residue production could actually be used safely each year. We also estimated the amount of additional crop production which could become available if the demand for crops for energy were sufficiently high. The total amount of alcohol which could be produced each year from agriculture crop residues, additional crop acreage, forage crops, and production of grains on set-aside acreage alone—ranges from 12 to 19 billion gallons. Our current gasoline consumption is about 115 billion gallons per year. Therefore, 10% of our gasoline consumption could be produced from agricultural sources. However, it is unlikely in the near term that much of resources would be withdrawn from agriculture and used for energy. But even if that much production could be achieved, how much energy does it represent in a relative sense?

Gasoline makes up about one half of our total oil consumption, and oil represents about one half of our total energy consumption.

If we can produce 10% of our gasoline from agriculture by producing alcohol, we can only produce about 2.5 percent of our total energy needs from agriculture. Two and one-half percent of our total energy may sound like a very small amount, and in a relative sense it is. However, 2.5 percent of our energy is significant. It is more than the total commercial energy consumption in India each year. It is about the same as the peak of our imports from Iran. It is almost two quadrillion BTUs. In our next energy transition we are going to depend on a wide variety of sources to replace imported oil. Achievement of 2.5 percent from any one source will be an important contribution.

Alternative Energy Policies

Given the five approaches to handling our energy problem, what policy measures could be used to implement any or all of them? I would like to discuss six policy alternatives. The first is to impose a tax on oil high enough to make synthetics economic. In my view, such a tax to be effective, would need to be $10 or $15 per barrel. However, the tax could be phased in at the rate of about $2 per year. Since it takes about five years to get a syn-fuel plant operational, the tax would be high enough to make syn-fuels economic by the time the plants are producing. This option also would encourage energy conservation through the price mechanism. The main difficulty with this option is political—Congress seems unwilling to use taxes and the price mechanism to solve our energy problem.

The second alternative is to deregulate domestic oil prices to encourage exploration and enhanced oil recovery. The President has done this. However, deregulation—no matter how desirable it may be—is not a panacea for our energy problem. Domestic controlled new oil prices are already high enough to stimulate production of most types of domestic oil. Only special categories of oil would benefit from higher prices such as some offshore oil, Alaskan oil, heavy oils, oil from stripper wells, and enhanced oil recovery. However, stripper oil, heavy oils, and enhanced oil recovery already receive the world price. The prime constraint offshore and in Alaska is the rate of federal leasing, not the price.

For deregulation to have much of a production impact, the supply must be elastic, and all the available evidence indicates that supply elasticity of domestic oil between the new oil regulated price and world oil price is very low. Hence, the main impact of deregulation will be higher income for the owners of existing domestic oil reserves. Certainly, deregulation will not raise oil prices high enough in the near term to make syn-fuels economic.

The third policy alternative is to require companies to use synthetic fuels for a fraction of their total sales. This policy would be analogous to the fleet mileage requirements for automobiles.

Under that policy the averaged total sales of each manufacturer must meet a mileage standard. The standard rises each year and reaches 27.5 miles per gallon in 1985. Each manufacturer is left to decide how best to meet the standard. The syn-fuels policy would work much the same way. Each producer of fuel would be required to have synthetic fuels as a fraction of his total sales.

The fraction would start out at 1 or 2 percent and rise through time. The synthetic fuels could come from any domestic non-petroleum energy source including coal, oil shale, or biomass. The oil companies would be left to decide what mix of resources and technologies to use to meet the goals. The higher cost of the synthetics would be averaged in with the petroleum based fuels thereby providing some incentive for conservation.

The fourth policy alternative would be to subsidize synthetic fuels. This is the option currently favored in Washington. Under this option, Congress would provide guaranteed loans, tax credits, purchase guarantees, or some combination of these to the private sector for development of synthetic fuels. Each synthetic fuel could have a different level of subsidy. The choice of resources and technology would be jointly decided by the private sector and the federal government with the federal government having the final decision. Also, the subsidy option would not encourage conservation because it would lower the syn-fuels price.

The fifth policy is for the federal government to reduce the risk in synthetic fuels development without attempting to subsidize it. Many believe that world crude oil prices will rise in real terms significantly over the next five to ten years. If that occurs, syn-fuel plants could be built economically without a subsidy. But there is a real risk that oil prices won't rise fast enough to make syn-fuels competitive. Under this option the federal government would provide a price guarantee beginning say in 1985.

If world oil prices rise as expected, the federal government would be out nothing, but if world oil prices rise slower than expected or fall, the federal government would make up the difference between the world oil price and the price guarantee. This option leaves the resource and technology decisions largely in private hands although the federal government would have the right to deny a price guarantee if the resource or technology were deemed unsuitable.

The sixth and final option I want to discuss is government development of synthetic fuels. With this option, the government, probably through a public sector corporation, would select technologies and resources, build plants, and produce synthetic fuels. You can decide the merits and demerits of this approach for yourself.

The actual policy followed by our government will be some combination of these six options and perhaps others. My own judgment is that we would be better off with the first or third options—either increase the price of oil through taxes to make syn-fuels economic or require syn-fuels as a fraction of each supplier's sales.

Energy, Inflation, and Economic Growth

We now turn to the impact of energy prices and supply on the U.S. economy. Some have advanced the notion that historically there is a strong coupling of the rate of growth of GNP to the growth in energy consumption. However, that link is not so rigid as we might think. From the mid 1920s to the late 1960s GNP increased at an average rate of 3.1 percent per year. During that same period, energy consumption grew at 2.5 percent per year. The energy—GNP ratio declined 0.6 percent per year.

This decline in the energy—GNP ratio is particularly important because it occurred during a period of steadily declining real energy prices. We would expect the opposite result with declining real energy prices. Several factors accounted for the declining energy —GNP ratio over this period: (1) the changing composition of national output, (2) trends in energy intensity, and (3) the significance of changing energy forms.

By the 1920s much of the transition from an agrarian society to one with a heavy industrial base had been completed. During the last 50 years, much of the changing composition of national output has been towards increasing the services component which, generally, is less energy intensive.

Changes in energy intensity also have been important. In the 1960s it took less than half as much coal to generate a kilowatt of of electricity as it did in the 1920s. Changing energy forms also have been important. The development of electricity provided economies of operation which steam power could not provide. Electricity made possible the reorganization of production into more efficient sequences and patterns which weren't permitted with the previous systems of belts and shafts. In a similar sense, the internal combustion engine powered by liquid fuels permitted the mechanization of agriculture.

All of these changes brought about productivity increases which far exceeded the increased energy use. We could go on with other examples, but the important point is that the energy—GNP ratio declined over this period even in the face of declining real energy prices. What might have happened with rising real energy prices? The historical evidence indicates there may be room for significant de-coupling of energy and GNP.

Now lets turn to the more recent energy history beginning with the oil embargo of 1973-74. A clear consensus has emerged that the quadrupling of oil prices in 1974 led to a permanent reduction in potential output of the U.S. economy. Most estimates put the reduction in potential GNP in the 3 to 5 percent range. The productivity of existing capital and labor was reduced, and conventional demand stimulus policies will be unable to retrieve the lost production potential. In other words, the U.S. economy is now on a lower growth path than would have existed in the absence of the oil price increase.

To better understand these effects of past oil price increases and to project the impacts of future changes, we need to understand some of the macroeconomic relationships involved. First, we must realize the initial impact of world oil price increases is *deflationary.* Since our demand for imported oil is quite inelastic, a price rise means a higher oil import bill which means a reduction in domestic aggregate demand.

What actually has happened, of course, is that the initial deflationary impact of higher oil prices has been more than compensated for by expansive monetary and fiscal policies. Through time then, the price increases get built into the economy and become a part of the inflationary cycle. In 1976, the estimated value of gross energy inputs into the U.S. economy was $89 billion or 5 percent of GNP. The value of final energy consumption was about $200 billion or 12 percent of the 1976 GNP, which is a significant share of national output. The share of energy in personal consumption expenditures in 1976 was about 9 percent. From these figures it is clear that while energy prices do not drive the economy or even the inflationary forces in the economy, they are an important factor.

Second, the econometric work generally supports the theory that energy and labor are substitutes and energy and capital are complements. This means that an increase in energy prices increases the demand for labor and decreases the demand for capital. This is exactly what happened in the recovery from the 1974-75 recession. The recovery in capital spending has been very weak.

The growth rate of business fixed investment exceeded that of GNP from 1970 to 1973—3.7 compared to 3.5 percent. Business investment from 1974 to 1978 has fallen short of the growth rate of GNP—1.7 compared to 2.3 percent per year. The growth of employment was slow during the recession but has picked up considerably in 1976-78. The previous econometric work and the recent evidence clearly support the energy-labor substitutability and energy-capital complementarity.

Now, let us attempt to relate this to the policy alternatives we discussed earlier. All of the alternatives are oriented towards some combination of increasing domestic energy supplies or consuming less energy. Either directly or indirectly, use of domestic energy supplies means higher priced energy because much of the domestic resources cannot be tapped at current world oil prices.

Higher priced energy means less energy consumed. Hudson and Jorgenson recently completed an analysis of the GNP impacts of reducing energy use between now and the year 2000. They concluded that the growth in energy use can be slowed but at some cost in the economic growth rate. However, the reduction in the rate of economic growth is less than the reduction in energy use. On average, each 1 percent reduction in energy use leads to a 0.2 percent reduction in real GNP. The relative cost of reducing energy use becomes higher the more reduction is achieved because of increasing economic costs at higher levels of reduction.

GNP losses occur because the substitution of other inputs for energy is less than perfect. Labor and other inputs can help to compensate for the reduced energy input but some reduction in output still occurs. Also, as more labor is substituted for energy, labor productivity is reduced. What all of this points to is that energy policy is going to be an important factor in determining the performance of our economy. The energy-inflation relationships are very complex and depend upon monetary and fiscal policy responses to changes in energy prices as well as the energy price changes themselves.

I haven't provided you with answers to the energy questions and issues that face us. In concluding I would like to present in capsule form what I consider to be the two most important issues we face:

(1) From an efficiency perspective we know that higher energy prices would provide an improvement in our economy and national security. However, from an equity perspective, we know that higher energy prices will hurt poor people the most. It is this dilemma which is stalemating the energy policy process in Washington.

(2) We can increase our national security by producing more energy domestically and by consuming less energy. However, this increase in national security can be achieved only by reducing the rate of growth of GNP. Policymakers must judge this economic cost against the increase in national security which would be achieved.