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THE ENERGY OUTLOOK FOR THE 1980's

A STUDY

PREPARED FOR THE USE OF THE

SUBCOMMITTEE ON ECONOMIC PROGRESS

OF THE

JOINT ECONOMIC COMMITTEE
CONGRESS OF THE UNITED STATES

BY

DR. W. N. PEACH

DECEMBER 17, 1973

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LETTERS OF TRANSMITTAL

DECEMBER 14, 1973.

To Members of the Joint Economic Committee:

Transmitted herewith is a study entitled "The Energy Outlook for the 1980's" which was prepared for the Subcommittee on Economic Progress under my chairmanship. Because of the great importance of adequate energy sources to our economic growth and well-being, the Subcommittee has been concerned with the subject for some time.

This volume was prepared as part of the continuing review of energy and related issues that the Subcommittee has been pursuing. It will be followed by a second study, to be issued early in 1974, indicating the developments that would make it possible for the United States to achieve energy self-sufficiency in the 1980's. While the study was initiated in August before the current shortage became manifest, it has become even more timely by reason of the current situation.

The paper was prepared by Dr. W. N. Peach of the University of Oklahoma. The views expressed in the paper are those of the author and do not necessarily represent the views of the Joint Economic Committee, individual members thereof, or the Committee staff.

WRIGHT PATMAN,
Chairman, Joint Economic Committee.

DECEMBER 12, 1973.

Hon. WRIGHT PATMAN,
Chairman, Joint Economic Committee,
U.S. Congress, Washington, D.C.

DEAR MR. CHAIRMAN: Transmitted herewith is a study entitled "The Energy Outlook for the 1980's" which was prepared as part of the continuing review of energy and related issues by the Subcommittee on Economic Progress, under your chairmanship.

The study looks beyond the present crisis to the prospects for developing the energy resources of the United States. It provides an overview of the ways in which the Nation can increase substantially its output of energy in the years ahead. The resources that can contribute to such expansion are: Coal; offshore production of oil and gas; Alaskan oil and gas; oil shale deposits, nuclear energy; geothermal energy; and Canadian tar sands. It also discusses possible improvements such as improved transportation, more intensive extraction of oil, and better conservation. Hopefully, this study and a more detailed volume soon to be published will help to provide policymakers and the public with much needed perspectives on our long-term energy outlook.

The study was prepared by Dr. W. N. Peach of the University of Oklahoma. The views expressed in the paper are those of the author and do not necessarily represent the views of the Joint Economic Committee, individual members thereof, or the Committee staff.

JOHN R. STARK,
Executive Director, Joint Economic Committee.

CONTENTS

INTRODUCTION

The United States consumes more energy than any other country in the world. We also consume more energy per capita than any other country. We consume about three times as much per capita as the countries of Western Europe. Yet, people everywhere in the nation are terrified at the prospective shortages of natural gas and heating fuels during the winter of 1973–1974. Chronic gasoline shortages and higher prices are sources of constant irritation and inconvenience.

As a host of witnesses before various Congressional committees during the past two years have testified (including geologists, engineers, spokesmen for the National Petroleum Council, and the Independent Petroleum Association of America) there is no physical shortage of energy resources in America. Our resources are more than adequate to meet our needs for the foreseeable future. Until recently, many but by no means all of these resources have been uneconomic to produce with the current technology available. But, with recent price increases and the prospect of still further increases, these resources have become economic to produce.

Surely, a nation that can put men on the moon in the 60's can solve its energy problems in the 70's. But we can't solve them with a "business as usual" approach.

We are being bombarded around the clock with false or misleading scare stories. We are being told that we are running out of cheap petroleum and natural gas. We are being told that the end of the fossil fuel era is close at hand. We are being told that we will have to import petroleum and natural gas from North Africa and the Middle East, and that these countries are not a dependable source of supply, that imports will involve huge deficits in our balance of payments and that imports involve serious national security problems. We have witnessed on TV a former football coach riding over crowded streets in a helicopter telling us that the real villain is the consumer and his insatiable appetite for more and more energy. We are also being told that the real villain is the environmental movement and government regulation.

The price system can be relied on to allocate energy resources in normal times, but these are not normal times. Mandatory allocation of heating oils, LP gas and natural gas can assure priority users of adequate supplies for the next two or three years. Coal is our most abundant energy resource and supplies are adequate to last hundreds, even thousands of years. Coal can be liquefied and gasified with prevailing technology, with technological assistance from England, Germany, Japan, Russia, and other countries. Offshore production of petroleum and natural gas can be vastly expanded. To date only about 1 percent of the offshore area of the United States has been tested. The discovery of oil and gas in Alaska and the Cook Inlet is a boon to the United States. Congress can consider now the need for three or

four additional pipelines to bring Alaskan oil, as well as oil produced from Canadian tar sands, to the lower 48 States.

The immense oil shale deposits in the Green River area of Colorado, Utah and Wyoming can be exploited without delay at less than the present price of crude and within environmentally acceptable standards. The disparity between the interstate and intrastate price of natural gas can be abolished. Nuclear energy plants, operable and planned, can provide a significant portion of our electric needs, if the plants can be made safe. Geothermal energy can provide another significant portion of our needs for electricity. This is the lowest cost of any known method of producing electricity. It does not pollute the environment or involve international complications. Secondary and tertiary recovery of oil from existing wells holds the hope of doubling the volume of oil. The recent growth in the size of tankers has called for the building of superports, 20 to 40 miles offshore.

Congress might give consideration to the establishment of a number of TVA-type corporations to help out with the energy crisis. These corporations might be established, for example, in the gasifying and liquefying of coal, in offshore production, in oil shale production, in the production of geothermal energy and in production of oil and natural gas in Alaska and the Cook Inlet. Such corporations might have a beneficial effect in giving preference to priority customers, in salvaging the independent refiner and marketer, and in infusing a greater degree of competition into the whole energy field. This is not a suggestion for nationalizing the energy industry, but for having the federal government make some input into the industry.

Thus, while the energy problem is acute for some users and will remain acute for the next few years, now is the time to abandon the scare stories and to begin to implement some of the solutions which are relatively easy to accomplish.[1]

[1] This was written before the Arab boycott which further exacerbated the current supply situation.

THE ENERGY CRISIS

Although brown-outs and blackouts had occurred in various major cities of the nation during the past five or six years, the energy shortage became obvious to all Americans in the winter of 1972 and throughout 1973. School systems were having difficulty in getting fuel to heat their plants. Cities that use natural gas were discovering that pipelines and distributing companies were not able to live up to their contracts, and in many cases there was rationing. Farmers were unable to get fuel for harvesting crops, such as wheat and corn. Tobacco growers were unable to get fuel for curing their crops. Shortages of gasoline at the filling station became almost nationwide. There was rationing of gasoline on turnpikes and in other areas. In Denver the situation became critical. People were lined at service stations for miles trying to get gasoline for their cars. Many people were forced to stay in town overnight because they couldn't get gas. Thousands of filling stations had been forced to close for lack of gas. Many of them are either going out of business or staying open shorter hours. There has been a rise in the price of gasoline, and a reduction in the octane count. Stations frequently run out of regular gas and offer only high test (that is higher priced gasoline), which customers did not need. The American Automobile Association began making nationwide gas surveys on a weekly basis.

There have been hearings before numerous committees and subcommittees of both the Senate and the House. There have been reports of shortages in the newspapers, on radio, and TV. There have been scare stories to the effect that we are running out of this or that source of energy and even indications that we will have to go back to candles and the horse of another era. The President of the United States has issued two energy messages during 1973, and many TV specials and shows have been devoted to the energy shortage. We have been told that we are running out of domestic fuel and will be forced to import a third or a half of our energy from abroad and that this will mean paying Middle East and North African countries $30 billion or more a year for oil and gas imports. There is uncertainty everywhere. There is widespread confusion over our ability to meet short term and long term energy needs, which are rising rapidly. There are reports that the purchase of small cars is soaring as a result of the energy shortage.

Americans are deeply interested in the current energy crisis because it affects virtually all of our population and our living standards. Man has come to rely on the fossil fuels only in recent years. For example, in 1850 fossil fuels supplied 5 per cent of the world's energy. Men and animals 94 per cent. By 1950 the percentages were 93 per cent from coal, oil, and natural gas; 1 per cent from water power and 6 per cent from the labor of man and animals. By 1970 the energy required to give the United States a gross national product of over $1 trillion was 95.9 per cent from fossil fuels, 3.8 per cent from water power, and 0.3 per cent from nuclear power.[1]

[1] Hearings before the Committee on Insular Affairs, House of Representatives, 92d Cong., 2d Sess., on *Fuel and Energy Resources, 1972*, Part 2, Washington, U.S. Government Printing Office, Serial 92-42, p. 629, Statement of Admiral H. G. Rickover, U.S. Navy.

In the United States in 1900, 89 per cent of our energy came from coal. Crude petroleum and natural gas provided less than 8 per cent and water power 3.2 per cent. As late as 1945 coal still provided more than half our total energy requirement, with crude petroleum and natural gas providing most of the remainder. (See table 1.) By 1971 coal had declined radically to 17.6 per cent, while crude petroleum and natural gas had risen to more than 75 per cent. Water power, although important in producing electrical energy, still accounted for only about 4.1 per cent. Nuclear power was a fraction of 1 per cent.

TABLE 1.—PRODUCTION OF MINERAL ENERGY FUELS AND ENERGY FROM WATER POWER IN THE UNITED STATES, SELECTED YEARS, 1900–71

[In percent]

	1900	1945	1971
Coal	88.9	51.1	17.6
Crude petroleum	4.7	30.7	44.5
Natural gas	3.2	13.7	33.2
Water power	3.2	4.5	4.1
Nuclear power			0.6
Total	100.0	100.0	100.0

Source: U.S. Bureau of Mines, Department of the Interior, "Minerals Yearbook," 1961, vol. II, pp. 4 and 5, table 1, for 1900 and 1945; data for 1971 from Ibid., 1971, vol. 1, table 7, p. 22.

If one compares per capita energy consumption in a large number of countries around the world and their per capita income, it can be seen that, generally speaking, those countries with high energy consumption are also the countries with high per capita income. In those countries where men and the brute animal do the work, per capita income is low. This is done in table 2 for 120 countries. Energy consumption is in terms of kilograms (about 2.2 pounds) of coal equivalent where coal is the equivalent of 1.0. A metric ton of crude petroleum is given a value of 1.3. A metric ton of liquified petroleum gas is counted as the equivalent of 1.67 tons of coal. Lignite briquettes are counted as 0.67 tons of coal. Similar procedures are followed for the other sources of energy. There are difficulties with the per capita income figures. For example, population estimates for many countries are at best crude, and income estimates are even worse. There are also difficulties in converting other currencies into dollars.

Nevertheless, granting these and other shortcomings, the broad pattern is clear. With minor exceptions, the countries with high per capita consumption of inanimate energy are the countries with high per capita incomes, and, generally speaking, the countries with low energy consumption are the countries with low incomes. This is what one might expect because energy is the capacity to do work.

One of the striking facts brought out in the table is that the United States uses more than 11 tons of coal equivalent per person and per capita income was the highest in the world at $4,270. In general, the other countries with high per capita energy consumption were found in Western Europe, Canada, Japan, Australia and New Zealand; their per capita incomes were correspondingly high. At the other end of the scale were the countries in Asia, Latin America, and Africa, where energy consumption and per capita incomes were low. Kuwait, Trinidad, and Libya are exceptional cases. In these countries, there is a small population. Also, in two of them, petroleum production is high, and petroleum related activities in all of them rank high.

TABLE 2.—RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND INCOME IN 120 COUNTRIES, 1970

Country	Energy consumption per capita (kilograms of coal equivalent)	Per capita income (U.S. dollars)
United States	11,128	$4,274
Canada	8,997	3,214
Kuwait	8,661	[1] 3,353
Sweden	6,304	3,695
Belgium-Luxembourg	5,955	[2] 2,406
Denmark	5,862	2,875
Australia	5,374	2,629
United Kingdom	5,358	1,993
Germany, Federal Republic of	5,151	2,698
Netherlands	5,080	2,156
Norway	4,813	2,550
Trinidad	4,415	[3] 683
Finland	4,177	1,952
Iceland	4,167	2,026
France	3,799	2,606
Austria	3,430	1,741
Switzerland	3,390	2,859
Puerto Rico	3,239	1,671
Japan	3,215	1,658
Ireland	2,994	1,246
New Zealand	2,850	2,004
South Africa	2,769	728
Brunei	2,769	973
Italy	2,685	1,587
Venezuela	2,573	836
Surinam	2,267	[4] 438
Israel	2,138	1,636
Argentina	1,686	978
Panama	1,661	629
Spain	1,478	889
Cyprus	1,452	802
Chile	1,278	613
Greece	1,259	998
Jamaica	1,250	545
Mexico	1,203	632
Barbados	1,124	[4] 421
Guyana	1,014	308
Malta	961	711
Uruguay	920	773
Gabon	887	688
Iran	887	334
Saudi Arabia	827	[3] 344
Singapore	818	930
Korea, Republic of	785	241
Lebanon	719	521
Portugal	687	610
Libya, Arab Republic	647	[1] 1,417
Peru	630	363
Iraq	617	[1] 278
Colombia	602	366
Democratic Yemen	589	[5] 153
Martinique	544	[5] 573
Southern Rhodesia	542	252
Zambia	515	[1] 375
Ryuku Islands	487	[5] 285
Turkey	479	348
British Honduras	476	[5] 346
Brazil	468	341
West Malaysia	468	[1] 309
Algeria	460	[1] 170
Syrian Arab Republic	457	254
Costa Rica	407	$501
Liberia	385	[1] 194
Nicaraugua	378	380
Reunion	311	[5] 546
Vietnam, Republic of	302	[3] 163
Jordan	295	[1] 282
Ecuador	293	247
Philippines	291	327
Egypt	262	[1] 203
Tunisia	259	224
Thailand	245	[1] 169
Guatemala	239	338
Dominican Republic	237	298
Ivory Coast	227	309
Honduras	222	259
Bolivia	217	190
Congo	208	[1] 263
Morocco	194	212
India	189	[1] 86
Mauritius	183	223
Ghana	164	[1] 238
Senegal	157	[1] 190
Angola	156	[3] 251
Kenya	153	131
Mozambique	151	[5] 145
Paraguay	146	230
Sudan	114	[1] 103
Indonesia	111	89
El Salvador	106	271
Sierra Leone	105	[1] 150
Guinea	97	[1] 73
Pakistan	95	[1] 132
Mauritania	94	[3] 160
Cameroon	91	[3] 158
Zaire	77	87
Uganda	72	105
Madagascar	67	126
Togo	64	118
Laos	62	[5] 61
Central African Republic	62	[5] 98
Burma	59	[3] 75
Gambia	54	[1] 118
Khmer Republic (formerly Cambodia)	48	[5] 117
Oman	46	[5] 83
Malawi	46	67
Nigeria	45	[1] 83
Somalia	38	[1] 62
Dahomey	32	[4] 78
Ethiopia	32	[1] 62
Haiti	27	[1] 87
Afghanistan	27	[4] 80
Chad	23	[5] 58
Mali	21	[5] 71
Niger	19	[1] 92
Nepal	14	80
Upper Volta	13	[3] 58
Yemen	13	[5] 53
Portuguese Timor	10	[5] 88
Burundi	9	[1] 50

[1] Data are for 1969.
[2] Data refer to Belgium. Per capita income in Luxembourg was slightly higher.
[3] Data are for 1968.
[4] Data are for 1967.
[5] Data are for 1963.

Source: Data on energy consumption from United Nations, Statistical Papers, Series J. No. 15, World Energy Supplies, 1961–70, New York, United Nations, 1972, table 2, pp. 10–63: data on per capita income from United Nations, Yearbook of National Accounts Statistics, 1971, vol. III, international tables, New York, United Nations, 1973, table 1B, pp. 8–12.

Much of the testimony given before various committees and subcommittees of the House and Senate during the past two years—to the general effect that we are running out of resources, that our reserves are dwindling and will soon disappear—is going to make humorous reading by the turn of the century. The same holds true of much of the radio and TV network material, and materials in the daily newspapers and periodicals. Man has been using his resources for perhaps 50,000 years. In the past century he has probably used more resources than in all preceding history, yet never have resources been so plentiful and never has the outlook for the future looked brighter.

For example, petroleum was not a resource to the American Indian, because he had no use for it. It could not satisfy any of his needs. Oil was discovered in the United States in 1859 in Titusville, Pennsylvania, in a well that was some 35 feet deep. A preacher in the town condemned the project as being immoral because, he said, the oil was needed down there to feed the fires of hell and to withdraw it was to protect the wicked from the punishment they so justly deserved.[2]

The first uses of petroleum were for medicinal purposes. Later it was used to light our streets and then our factories. When it was possible to drill wells only a hundred feet or a few hundred feet deep, the petroleum in the ground more than a thousand feet deep was not a resource because man could not get to it. We are now drilling wells 30,000 feet deep and the result has been that we are now drilling oil at the rate of billions of barrels per year instead of 2 or 3 million barrels in the earlier period. Who knows that in a decade or two we will not be able to drill wells 60,000 feet and we may find 10 or 20 times as much oil as we now know about?

This preoccupation with single tangible phenomenon in nature creates the false impression of resources as things static and fixed, whereas actually they are as dynamic as civilization itself. Resources are not things or substances but refer to functions that things or substances can perform or to an operation in which they may take part. Man's resources to an overwhelming extent are not natural resources, although it is true that nature provides the opportunity for man to display his skill and apply his ever expanding knowledge. But, nature offers free only an infinitesimal fraction of her treasure and withholds the rest and seems to place innumerable obstacles in the way of resource seeking and resource creating man.

The bulk of man's resources are the result of human ingenuity, aided by acquired knowledge and experience. For example, petroleum is found in nature, but petroleum readily accessible and available is rare. Without the aid of the geologist, the geophysicist, the petroleum engineer, expensive drilling rigs, power driven machinery, human inventions of many kinds, and man-made contraptions in great variety, man would long ago have run out of petroleum. Petroleum occurs in nature, but not gasoline, fuel oils, fuel for airplanes, and petrochemicals. All the elements are found in nature, but this is of no value to a man who is not even aware of their existence and even less capable of isolating and using them. If there are a hundred or a hundred and fifty elements, there are billions of compounds which can be built up by combinations and permutations out of the hundred or so elements, and only a fraction of them occur in nature.

[2] The physical location of Hell had not been so precisely pinpointed geographically since Dante's Inferno.

Thus, nature provides the neutral stuff, but man, through his knowledge, creates the resources. To be sure, knowledge cannot create matter or energy out of nothing nor can any science ever restore to human use the energy once locked up in coal or oil or gas, but now spent. Most of man's resources, therefore, are the result of man's knowledge applied to the neutral stuff. Perhaps the most significant characteristic of knowledge is that it does not wear out through use, but continues to expand by usually small increments. Thus the prospect is for more resources, not fewer resources. No responsible person advocates the reckless squandering of resources, but a growing number of experts are coming to the view that true conservation means, not hoarding, but efficient and intelligent use of resources. The pessimistic assumption about the future availability of resources runs into a powerful array of opponents and factual data. As Eugene Holman (then Chairman of the Board of Standard Oil of New Jersey) said in his classic article twenty years ago:

> For many years, I believe, people have tended to think of natural resources as so many stacks of raw material piled up in a storehouse. A person with this sort of picture in his mind logically assumes that the more you use of any natural resource, the sooner you get to the bottom of the pile. Now I think we are beginning to discover that the idea of a storehouse—or, at least, a single-room storehouse—does not correspond with reality. Instead, the fact seems to be that the first storehouse in which man found himself was only one of a series. As he used up what was piled in that first room, he found he could fashion a key to open a door into a much larger room. And as he used the contents of this larger room, he discovered there was another room beyond, larger still. The room in which we stand at the middle of the twentieth century is so vast that its walls are beyond sight. Yet it is probably still quite near the beginning of the whole series of storehouses. It is not inconceivable that the entire globe—the earth, ocean, and air—represents raw material for mankind to utilize with more and more ingenuity and skill.[3]

A host of witnesses before congressional committees, scholarly groups, geologists, engineers, economists have testified that there is no physical shortage of energy resources. As a spokesman for the Independent Petroleum Association of America testified, potential supplies of energy fuels, both natural and synthetic (crude oil, natural gas, oil shale, coal, synthetic gas and coal, nuclear energy, etc.) are more than adequate to meet U.S. requirements for the foreseeable future.[4] And the National Petroleum Council has stated "fortunately we have an adequate energy resource base." [5]

No one seriously doubts the ability of the United States to continue to produce energy at current levels for the indefinite future and no one seriously doubts our ability to make moderate or even substantial

[3] "Our Inexhaustible Resources," An *Atlantic Monthly* article by Eugene Holman. Copyright 1952 by The Atlantic Monthly Company, reprinted by permission Standard Oil Company (New Jersey) Room 1626, 30 Rockefeller Plaza, New York, N.Y.

[4] Hearings before the Committee on Insular Affairs, House of Representatives, 92d Cong., 2d Sess., on *Fuel and Energy Resources*, 1972, Part 2, Washington, U.S. Government Printing Office, Serial 92-42, p. 605, Statement of Bob Birch on behalf of the Independent Petroleum Producers Association of America.

[5] *Guide to National Petroleum Council Report on U.S. Energy Outlook*, National Petroleum Council, 1972.

increases over the next few years. The so-called crisis is based on projecting current demands for oil, natural gas, etc. over the next 10 or 15 or 20 years at recent rates of increase. If we were forced to get along on current levels of production, we would still have more energy than any other country in the world, and several times as much as most countries. Whether we will be able comfortably to double or nearly double our output of energy by 1980 is questioned by many people. And it is for that reason that our reliance mainly on North African countries and the Middle East shows up as a deficit in the balance of payments of $10 or $20 or $30 billion dollars a year. These dire predictions are based on the assumption that no new technology will be introduced in the next seven or eight years and that prices will remain the same. But there has already been a revolutionary increase in the prices of some energy sources, particularly in the price of crude oil and natural gas, and the prices of these two sources may be expected to increase still further. These developments make it economically feasible to develop new sources of energy which have only been produced in minor, almost insignificant, amounts in the past. This is in reference especially to oil shale, tar sands, and geothermal energy. All responsible estimates indicate that any one, or any combination of these three, can help us solve our needs for the indefinite future. The problem is to get on with the job of producing from these known sources. Furthermore, offshore drilling, which is a big prospect, may be expected to increase substantially during the remainder of 1973 and 1974.

Even though the prospects of increasing the production of energy in the near future are bright, this is not to deny that the energy crisis of 1972–1973 is a reality. The crisis is very severe when it come to farmers who are unable to get enough oil to harvest their crops and to cure them once they are harvested. It is very real when school systems must close down for lack of fuel. It is very real when cities cannot get the energy they need to operate their heating, lighting, and cooling systems. It is very real when police departments run short of energy. The cure for these shortages which are real and which result in much inconvenience and hardship is, in the short run, a system of compulsory allocation to make sure that high priority needs are satisfied. We can ill afford to conduct business as usual, with the threat of widespread shortages hanging over us. Surely, a nation that can put a man on the moon in the sixties can solve its energy problems in the seventies.

With 6½ percent of the world's population, the United States consumes 35 percent of the world's energy. This makes us the largest energy consumer among the nations of the world and also the largest consumer per capita. On a per capita basis, we consume 5 to 6 times as much as the world average and twice as much as the developed countries of the world. We consume more than 30 times as much as the developing countries of the world. We consume about three times as much per capita as the countries of Western Europe.

Our preeminent position as the number one economic, political and military nation is based mainly on our high energy consumption, although there are many other factors. For the foreseeable future, the

position of the United States seems to be assured, if reasonably wise policies are pursued.

Because energy is so crucial in the United States economy, there have been a number of suggestions that the United States Government establish one or more TVA-type corporations to supplement the energy supplies provided by private companies. This merits serious consideration for a number of reasons. Such incursions by the Government have ample precedent both at home and abroad. In Canada, England, Italy, the Middle East, in Brazil and other countries, the central government plays an important, frequently dominant, role in oil exploration, development and distribution. Second, most of the offshore areas of the United States, most of the oil shale, and most of the geothermal energy is on government owned lands. Third, government, federal, state, and local, is a large consumer of energy. The military is also a large consumer of energy. Fourth, government energy corporations would inject an element of competition into the whole field.

Coal

A century and a quarter ago, the world was worried about running out of trees. Coal production at the time was relatively small, but quickly became the major source of inanimate energy for most of the world until about the middle of the twentieth century. During that period, the economic, political, and military power of the world was dependent on coal and iron. At the beginning of the twentieth century coal—that is, anthracite, bituminous, and lignite—accounted for 90 percent of the energy used in the United States. The remainder came from water power and petroleum. During this century there has been a continued expansion of energy use. But there has been a revolution in the relative importance of the various sources. In recent decades, coal has lost some of its most important markets. For example, in 1930 railroads were the largest consumers of coal in the United States; but, with the introduction of the diesel engine, railroads are no longer coal consumers. Coal for heating homes was another big use of coal, but in recent decades most homes have shifted to natural gas and fuel oil, because they are easier to handle and cleaner. Somewhat earlier, ships converted from coal to oil. Coal is now used mainly in manufacturing electricity and in making steel and other manufactured goods.

Coal today is our most abundant fossil fuel. It is the backbone of our fuel inventory, accounting for 73 percent of total recoverable fossil fuels in the nation. By contrast, oil and natural gas account for 9 percent and oil shale about 17 percent.

One difficulty with coal is that it is heavy, relative to the number of BTU's it produces. It cannot be used in autos and airplanes. Furthermore, much coal, particularly in the eastern states, is too high in sulfur content. In many states of the United States coal with a high sulfur content is prohibited by environmental restrictions. Furthermore, much coal is produced by strip mining and this also runs into environmental problems.

Nevertheless, efforts are now underway to produce gas from coal and to liquefy coal, in view of the impending shortages of natural gas.[6] The reserves of coal are sufficient to last hundreds of years and perhaps thousands. The Russians have offered to share their technology for producing natural gas from coal [7] and a British gas corporation has offered to share with us their technology for manufacturing a substitute natural gas to help fight the current fuel shortage.[8] The British process can easily be modified to make the gas interchangeable with natural gas. The plants are quick to build and low in capital cost. The plant components are of simple design. The British process is considered ideal from an environmental standpoint. We might not only cooperate with Russia and the British, but also the Germans and other Western European nations who have had long experience in deriving gas from coal.

Industry spokesmen in this country have indicated that the cost of gas produced from coal will likely be in the 85 cents to $1.10 per thousand cubic feet range. Although this would be higher than most prices at the present time, it would still be cheaper than imported natural gas. The Congress might want to give consideration to speeding up the small experiments in gasifying coal and reducing the sulfur content of coal.

Petroleum

The petroleum industry is an American industry. From the discovery of the first oil well in 1859 through 1948, the United States dominated the world petroleum industry. It accounted for two-thirds of world output. It had developed most of the technology for drilling and refining oil. It was also a large exporter to other countries, especially to Western Europe.

Petroleum is produced in 29 states, but four of them account for the bulk of domestic production. They are Texas, California, Louisiana, and Oklahoma. These four states account for about three-fourths of U.S. production.

But 1948 was the turning point. Since that time we have become an increasingly large net importer. Until recently, most of our imports came from Venezuela and Canada, with only relatively small amounts from the Middle East. The Middle East and North African countries are becoming more important sources of petroleum and natural gas for the United States. Many people believe they will become the dominant source of petroleum in a few years.

The price of crude oil ranged from about $3.00 to about $3.50 in the 1960's. Since then the price has risen. Currently (that is, August, 1973) it is selling in the neighborhood of $4.30 per barrel. (See table 3.) This is still cheaper than the cost of petroleum in Libya. For example, in late August, 1973, American companies were buying crude oil from Libya at $4.90 a barrel.

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[6] For discussion of the environmental impact of coal gasification see: Calvin Kentfield, "New Showdown in the West," *New York Times Magazine*, Jan. 28, 1973, pp. 12-13 and 30-33; David F. Salisbury, "Coal into Gas—Bright Light of the Future?", *Christian Science Monitor*, March 17, 1973, p. 11; Sally Jacobsen, "The Great Montana Coal Rush," *Bulletin of the Atomic Scientists*, April, 1973, pp. 37-42; William Greenburg "Cheap Coal and Hollow Promises," *Sierra Club Bulletin*, March, 1973, pp. 10-14; Peter Barnes, "Stripping the Prairies; Mining Coal Because it is There," *New Republic*, March 24, 1973, pp. 19-21; and James Stein, "Coal is Cheap, Hated, Abundant, Filthy, Needed," *Smithsonian*, Feb., 1973, pp. 19-27.

[7] For the Russian offer to participate with the United States in coal gasification see *The Daily Oklahoman*, July 28, 1973, p. 25.

[8] For the British offer see *British Record*, No. 8, May 2, 1973, p. 4.

TABLE 3.—*Crude oil prices in the Oklahoma-Texas area, 1937–1970*

	Price
1937:	
Prior to Jan. 1	$1.10
Jan. 28	1.22
1938: Oct. 12	1.02
1939: No change	-----
1940: No change	-----
1941	1.17
1942: Feb. 3 prices frozen at Oct. 1, 1941 level	-----
1946:	
Apr. 1	1.27
July 25	1.52
Nov. 15	1.62
1947:	
Mar. 10	1.87
Oct. 15	2.07
Dec. 6	2.57
1948–52: No change	-----
1953: June 15	2.82
1954–56: No change	-----
1957: Jan. 3	3.07
1958: Oct. 3	3.00
1959: Feb. 20	2.97
1960–63: No change	-----
1964: Apr. 15	2.92
1965: No change	-----
1966: May–September	3.00
1967: Aug. 1	3.07
1968: June 13	3.12
1969: Mar. 1	3.17
1970: December	3.52

Source: Adapted from World Oil, Feb. 15, 1971, p. 61. Data refer to 36°–36.9° Gravity.

The Middle East and North African countries, which produce almost half the world's oil, consume less than 5 percent of it. Hence, these countries export most of their petroleum to Western Europe, Japan, and the United States. Most of the concessions to drill for and produce oil in the Middle East and North African countries have been owned by large American and British companies with a sprinkling of Dutch, French, and others. Recently the producing countries have joined the Oil Producers' Export Association (OPEC).[9] This presents the situation where representatives of large American and British petroleum companies as a unit are bargaining with the OPEC countries as a unit. Many of these countries are showing signs of using petroleum as a political weapon in the Arab continuing struggle with Israel. We do not know what the future holds in that area, but it is not a dependable source of supply and the price of oil may easily go as high as $10.00 a barrel, yet the cost of bringing a barrel of petroleum to the surface in the Middle East has been estimated recently at $0.20 a barrel, compared with $2.00 in the United States.[10]

The United States now uses about 18 million barrels of oil per day, and many projections are to the general effect that it will increase by about 50 percent by 1980. It is to be emphasized that the United States can maintain its present level of production for the indefinite future so that we are not going to run out of oil. The basic problem

[9] Although OPEC was formed much earlier, it did not have any real power until 1970–71.

[10] Thomas O'Poole, in *The Washington Post*, "Domestic Oil Gap Expected to Grow," Nov. 27, 1972, pp. A1 and A10.

facing the United States over the next decade or two is not only the rate of increase of energy demand, but, also, in what form. The answer to this complex problem largely depends on relative prices. Lately, this decision has been complicated by the activities of the environmentalists. In many cases, they have been able to place restrictions on oil companies.

Offshore Oil

The most promising area for the United States, at least in the short run, lies in the vast deposits of oil and gas in the area of the outer Continental shelf surrounding the United States. The first drilling for offshore oil took place around 1900 in California.[11] But offshore production in the modern sense really began after the Outer Continental Shelf Plans Act of 1953 was passed. The United States Geological Survey has estimated the potential resource base in the outer continental shelf to be between 1 trillion and 1.5 trillion barrels of oil in place, and from 3 quadrillion to more than 4 quadrillion cubic feet of natural gas. Of this the United States Geological Survey estimates that, with current technology, the oil industry should be able to recover from 160 billion to 190 billion barrels of oil (about twice as much as the industry has produced in its entire history), and from 800 trillion to 1.1 quadrillion cubic feet of gas.[12] Yet, of America's total continental shelf area of 1.8 million square miles, only about 1 per cent has been tested for oil and gas to date.

Through 1971 the petroleum industry had invested $13 billion in marine exploration and production. It has drilled more than 15,000 wells in the Gulf of Mexico, the Pacific Ocean and Alaska's Cook Inlet. Eight thousand of these have been producers. Since 1953 production from the continental shelf has grown from 85,000 to 1.5 million barrels of crude oil per day, and from less than 200 million cubic feet to 10 billion cubic feet of gas per day. Offshore production now accounts for 15 to 16 per cent of the nation's total. If our onshore wells were as productive as those offshore, we would need in the United States some 50,000 to 55,000 producing wells, instead of the 530,000 we have in 1973. This would mean a reduction in the number of wells of about 90 per cent.

It costs much more to drill wells offshore than onshore. Drilling platforms must be designed and built and if oil or gas is discovered, expensive pipelines must be built to carry the oil to an onshore storage plant. A typical Louisiana offshore drilling platform designed for 150 feet of water might cost $2 million. The cost increases to $6 million in 400 feet of water and to $32 million in 800 feet of water.[13]

The technology of offshore drilling has improved dramatically during the past twenty years. In the early period it was possible to drill only in depths of about 50 feet. Then, with the steady flow of improvements, it was possible to drill in 100 feet and 150 feet and gradually this has been extended. Drilling in water up to 20,000 feet deep with penetrations into the bottom of up to 3,300 feet has been achieved by the National Science Foundation in a deep sea drilling project.[14] It is confidently expected that by 1980 we will have the technology developed for drilling for oil and gas anywhere in the oceans. Not only

[11] *World Oil*, July, 1973, p. 82.
[12] *The Humble Way*, Third Quarter, 1972, pp. 12, 13.
[13] "One Answer to the Energy Crisis," *American Petroleum Institute*, p. 20. (No date.)
[14] *World Oil*, July, 1973, p. 92.

has the technology for drilling been improved but the oil industry has made considerable progress in meeting environmental problems. The industry has banded together in the case of oil spills and has developed numerous ways of reducing the damage done by oil spills. The drilling of an offshore oil well is not so dangerous nor is the likelihood of spills so great as it was a decade or a decade and a half ago. The industry has made considerable progress in diminishing the danger to fish and marine life.

Thus, drilling for oil and gas offshore has a bright future. In view of the substantial lead time required between leasing and the production of significant quantities of oil, the Congress might take steps to see that the leasing options for offshore drilling are made more readily available. The Congress might also want to consider a TVA type corporation to drill for some of this oil, inasmuch as virtually all of it is federally owned.

Alaskan Oil

The discovery of oil in Alaska and offshore in the Cook Inlet a few years ago was a big boon to the United States. Senator Henry Jackson, Democrat from the State of Washington, has referred to the colossal discovery of black gold in Alaska as a "junior Persian gulf." [15] Delivery of oil from Alaska was delayed for several years by environmental controversies. Happily, the issue was resolved in the summer of 1973 when the Congress passed a law permitting the oil companies to build a line from Prudhoe Bay to Valdez. From Valdez it will be shipped to the West Coast of the United States in large tankers. Oil is expected to flow through the pipeline in a period of three or four years, that is, 1976 or 1977. Current estimates are that the pipeline will add two million barrels of oil a day to our supplies. This will be a big boost, but it will not solve the impending shortage. The additional future demand for petroleum is supposed to be many times the supply that can be expected from Alaska. These projections assume current prices.

There are indications, however, that the Alaskan oil supply may be much bigger than had been thought even a year ago. It may be that three or four pipelines may be necessary in a few years. An estimate of the reserves range from 10 billion to as high as 50 billion barrels. Each well in the Prudhoe Bay area is expected to produce 10,000 barrels a day in contrast to the 18 barrels per day in the lower 48 states. Cost of producing a barrel of oil in Prudhoe Bay has been estimated at 40 cents.[16] Thus, even with higher transportation costs, Prudhoe Bay oil will be cheap.

The North Slope of the Prudhoe Bay area also contains huge amounts of natural gas. One estimate is that the area contains some 350 trillion cubic feet of natural gas. In addition to the Alaska area, the Arctic Isle has some 400 trillion cubic feet, for a Far North potential of 750 trillion cubic feet.[17] Already plans are underway for additional pipelines for natural gas from Alaska and the Canadian Arctic.

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[15] *The Washington Post*, July 30, 1973, p. A1.

[16] *Oil and Gas Import Issues*, Hearings before the Committee on Interior and Insular Affairs, United States Senate, Pursuant to S. Res. 45, 93rd Congress, 1st Session, January 10, 11, and 22, Serial Number 93-3 (92038), Part 3, statement of Richard B. Mancke, University of Michigan, p. 1181.

[17] *Relationship of Energy and Fuel Shortages to the Nation's Internal Development*, Hearings before the Subcommittee on Flood Control and Internal Development of the Committee on Public Works, House of Representatives, 92 Cong., 2nd Session, August 1-11, 1972, (92-46), statement of George H. Lawrence, Vice-President, American Gas Association, p. 388.

To put these large figures of potential gas supplies in perspective, the United States now consumes 22 to 23 trillion cubic feet of natural gas per year.

Oil Shale

Vast oil shale deposits exist in the Green River area of Colorado, Utah, and Wyoming. This area covers some 16,000 or 17,000 square miles of land and is estimated to contain some 2.6 trillion barrels of potentially recoverable oil. This is not an exotic source of oil. Oil shale research has been going on in this country and abroad for more than a century. A Scottish firm produced oil from oil shale as long ago as the 1860's. A century later in the 1960's a number of experiments were made. The technology exists to produce oil from shale and the environmental problems can be solved, if we so desire. Many people have testified to this effect and two, who are intimately involved in oil shale operations, may be cited. The first is Mr. Morton M. Winston, President of the Oil Shale Corporation, in a statement before a congressional committee: "But so far as oil shale is concerned, we are convinced that through privately financed and managed efforts the technology is already at hand to bring about commercial production."[18] And Russell J. Cameron, President, Cameron Engineers, Inc., Denver, Colorado, stated: "We have known for years the basic technology to make oil and gas from coal and oil shale. It is inconceivable that the conqueror of the atom and the nation that sent men to the moon and back could not develop its largest energy resources."[19] Oil shale is the second most abundant source of energy available in the United States, exceeded only by coal.

Coal accounts for 73 percent of our fossil fuels, enough to last us for hundreds or thousands of years. Oil shale accounts for 17 percent of our fossil fuels. Although not included in the published figures on "Proved reserves", the oil shale in the Green River area is much greater than the oil in the entire Middle East. It is lying idle, awaiting development, and it may be noted that its development involves no international complications.[20]

It has been estimated that an oil shale complex to produce 100,000 barrels per calendar day will require a capital investment of $426 million. A selling price of $3.74 per barrel of product will be necessary to maintain a discounted cash flow rate of 12 percent.[21] Other estimates of the cost range from $1.95 to $5.00 per barrel. With annual operating costs of $85.5 million, and assuming a sale price of $4.50 per barrel (approximately the prevailing price and lower than some), it will be possible to recover the cost of the plant in 5 to 6 years.

It is estimated that 80 percent of the shale oil in the Green River area is on federal lands. On most of this land it is estimated that about 30 gallons of oil, called kerogen, can be produced from a ton of shale. The shale rock is very hard and it is necessary to crush the stone and then get the shale out in a retort. The oil that is obtained is low in sulfur content.

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[18] Statement of Morton M. Winston, President of the Oil Shale Corporation and Lewis Davis, Executive Vice-President, Atlantic Richfield Company, in Hearing before the Subcommittee on Minerals, Materials, and Fuels of the Committee on Interior and Insular Affairs, United States Senate, 92nd Congress, First Session on S. 2510, November 15, 1971, Serial No. 92-12, *Oil Shale*, p. 84.

[19] *Ibid.*, p. 90.

[20] See *infra*, pp. 17-19.

[21] Sidney Katell and Paul Wellman, *Mining and Conversion of Oil Shale in a Gas Combustion Retort*, U.S. Department of the Interior, Bureau of Mines Oil Shale Program, Technical Progress Report—44, October 1971, pp. 1, 10 and 51; see also *Oil Shale*, pp. 59-69.

A story in the *Wall Street Journal*,[22] states that Exxon has become the ninth company to join a proposed project to test the new process for extracting oil and gas from shale. Sohio (Standard Oil of Ohio) is organizer of the group, and each partner is to put up $500,000 for the project. Other companies in the venture are Cleveland-Cliffs Iron Company, Gulf Mineral Resources, a unit of Gulf Oil Corporation, Kerr-McGee Corporation, Arthur G. McKee Corporation, Shell Oil Company, Southern California Edison Company, and the Standard Oil Company of Indiana. Exxon will participate through a subsidiary—Carter Oil Company. The project is to be conducted at the federally owned Anvil Points oil shale facilities near Rifle, Colorado.

Problems connected with the production of oil from shale and the abundance of other cheap energy sources held back the research and development efforts until recently, but that is no longer the case. The oil produced from shale is now competitive, even after making generous allowances for restoring the land to something like its present condition. Strict environmental standards should be imposed on the oil shale and there is no good reason to permit the companies that produce oil from shale to lay waste the countryside as they have done in producing coal, copper, lead and zinc, and other minerals. The restoration cost properly belongs as part of the total cost of producing the oil shale. We can continue with minor experiments for another hundred years and not produce more than token amounts of oil from shale, or we can begin to produce it now with the technology we have. With existing technology and appropriate investment funds available, an output of 2 million barrels per day should be available within four or five years. As improved technology becomes available, it can be introduced into further operations. There are sound arguments for suggesting that if private industry is not willing to develop the shale oil immediately, government should take the initiative.

There are many sound reasons for the belief that the federal government should build and operate oil shale plants, especially in the near future. The federal government now owns most of the oil shale lands in the Green River area. This area hold the greatest promise of solving our "energy crisis". If the oil shale deposits are developed, it will free the United States from dependence on foreign oil. The federal government has already spent large amounts of money on experimental plants. The experience gained with the first plants will be valuable to private firms later on. Finally, the federal government can take the lead in restoring the land for future use.[23] The cost of such restoration will also be valuable to private industry. Public investment of something on the order of $5 billions could produce some 500,000 barrels of crude oil per day. While this will not solve the energy shortage, this amount will be an important contribution and can lead the way to further big increases in production.

Natural Gas

Throughout most of the history of the petroleum industry natural gas has been associated with drilling oil wells. Since man had no or little use for the gas, it was flared (or burned) at the well. For example,

[22] August 9, 1973, p. 6.

[23] See, *Draft, Environmental Impact Statement for the Prototype Oil Leasing Program*, Section 102(2) (C) of the National Environmental Policy Act of 1969, Prepared by the U.S. Department of the Interior, June, 1971; also *Program Statement of the Proposed Prototype Oil Shale Leasing Program*, U.S. Department of the Interior, June, 1971; and *Draft Environmental Statement for the Proposed Prototype Oil Shale Leasing Program*, DES–72089, Vols. I-III, U.S. Department of the Interior, September, 1972.

natural gas consumption in 1920 amounted to less than a trillion cubic feet, but a decade later it amounted to almost 2 trillion cubic feet. As late as 1948 only about a third of the natural gas was used across state lines. New England, the Pacific Northwest, and the South Atlantic states did not get natural gas until the 1950's. Since then consumption of natural gas has zoomed. It reached 22 trillion cubic feet in 1970 and is expected to rise to 32 trillion cubic feet in 1980.

Natural gas is now produced in 34 states, but two states—Texas and Louisiana—including the offshore areas of those states, account for 70 per cent of the total ultimately recoverable natural gas known in the United States. If to that we add Oklahoma, California, and Alaska, we account for more than 90 per cent of the ultimately recoverable natural gas in the United States.[24]

The largest industrial use of natural gas is for the generation of electricity. Oil and gas field use is the second largest category. Other industrial uses include oil refining and manufacturing, chemical processing, manufacturing of iron and steel, stone, clay, glass, food, paper, and other nonmetals. It is also used as a chemical raw material to manufacture fertilizer and other petro-chemicals. Some 40 million residential consumers use natural gas. As indicated earlier, during the past quarter century the use of natural gas has gone upward sharply. This is because natural gas was thought to exist in unlimited supplies and it was also due to aggressive marketing tactics. Gas now accounts for a third of all our energy. With the passage of the Environmental Protection Act, gas use skyrocketed because gas is the cleanest of all of the fossil fuels.

The Federal Power Commission has regulated the price of natural gas in interstate commerce since 1938, when very little gas was crossing state lines. In 1954 the Supreme Court handed down a decision, in connection with the Phillips Petroleum case, that the Federal Power Commission had the power to regulate the price of gas at the wellhead. Since that time a number of significant developments have occurred. Environmental factors have had a twofold effect. First, anti-pollution laws have increased the use of gas because it is clean burning. At the same time, environmental groups have opposed the search for new gas in the most promising regions—off the Gulf Coast and in Alaska.

The Federal Power Commission regulates the price of interstate gas, but does not regulate the price of intrastate gas. The result has been a sharp differential between the price producers can get for interstate and intrastate gas. Although the Federal Power Commission has made some recent changes, during most of the period from 1966 to 1972 the price charged for natural gas was generally in the 15 to 21 cents per thousand cubic feet. Producers could get two to three times as much by selling their natural gas intratstate. The result was that the new natural gas flowed mainly into the intrastate market, and the interstate market almost dried up. Clearly, the differential in the price of intrastate and interstate gas must be abolished. One way to do this would be to declare that, since much of the newly found gas is on

[24] *Reserves of Crude Oil, Natural Gas Liquids, and Natural Gas in the United States and Canada, and United States Productive Capacity, as of December 1971*, Volume 26, May 1972, published jointly by the American Gas Association, the American Petroleum Institute, and the Canadian Petroleum Association, Tables XV and XVI, pp. 168 and 169.

federal offshore lands, newly found gas will be interstate. Another, less satisfactory from the viewpoint of residential consumers, would be for the Federal Power Commission to permit the price of interstate gas to rise until it is about equal to the intrastate price. This would doubtless cause some increase in the price to consumers, especially in the big East Coast area of the United States, but it would still be much cheaper than importing natural gas from overseas.

It is to be noted that only about 10 per cent of the cost to residential consumers of natural gas in markets distant from producing areas is the price of natural gas at the wellhead. The remaining 90 per cent is pipeline cost of moving the gas and the distribution cost. Even if the price were to rise from 18 cents to 75 cents per thousand cubic feet, it would still be cheaper than the $1.15 or higher it will cost consumers to purchase gas from Algeria, Libya, and other countries overseas.

The bringing of natural gas to the United States from North Africa or the Middle East requires the construction of extensive facilities for liquefying the natural gas. The gas is frozen to as low as minus 259° F. and reduces the space required for transporting by 600 to 1. They now have under construction ships that will carry 300,000 barrels of liquefied natural gas (LNG), equivalent to 1 billion cubic feet of natural gas.

Electricity

Electricity is not a primary source of energy and it is not an addition to man's total energy supply, but it is energy in another form. Chiefly because of its great flexibility and divisibility, it has made important contributions and has contributed to the creation of whole new industries such as the telephone, the telegraph, radio, radar, refrigeration, air conditioning, electronics, television, heating and cooling of houses, factories on the farm, and in office buildings. The list could be expanded indefinitely.

Electricity can and is produced from all of the primary sources of energy including coal, oil, natural gas, hydro, geothermal, and nuclear. There is substitutability of one source of energy for another, depending on such factors as price, availability, etc.[25]

The electric industry is less than a hundred years old but during that time it has increased almost continuously. We now use more than three hundred times as much electricity as we did at the beginning of the century. There have been major technological advances in the production and distribution of electricity during that period. For example, at the turn of the century it required seven pounds of coal to produce 1 kilowatt hour of electricity. Now it requires less than 1 pound. Projections of past trends indicate a near doubling of electricity by 1980. Population growth will almost surely continue, but possibly at a reduced rate. The increased per capita use of electricity will continue, but on the other hand, there are factors tending toward a reduction in the rate of growth in the use of electricity. For one thing, conservation in houses and office buildings may tend to cut the

[25] For a discussion of the substitutability of one resource for another, see the article by Nathan Rosenberg, "Innovative Responses to Material Shortages," *American Economic Review*, Papers and Proceedings of the 85th Annual Meeting of the American Economic Association, Toronto, Ontario, December 28-30, 1972, vol. LXIII, May 1973, No. 2, pp. 111-118.

rate of growth. The better design of houses and appliances may contribute somewhat to a reduced rate of growth. Of more importance are the higher prices per kilowatt hour that are likely to prevail in the next few years and this may tend to cut down on the rate of growth. Environmental concerns may contribute to a rise in the price of electricity, because the higher costs of clean fuels and clean air will almost certainly be passed on to the consumer. Finally, a doubling of the current output may not be feasible by 1980 or a few years thereafter.

But assuming a substantial increase through 1980 what can be done about it? There will almost certainly be big shifts in the sources of energy used for producing electricity. There are differences of opinion about the role of coal, our most abundant source of energy. If gasification and liquefaction proceed, more coal may be used. If environmental constraints on the use of high sulfur coal are relaxed, more coal will be used and perhaps coal will account for a larger percentage. As noted elsewhere, we have ample amounts of coal for the next few centuries. It may be noted here that the use of gas to produce electricity to heat and cool homes is only half as efficient as using the gas directly for heating.

Hydroelectric power, which is important but has never accounted for as much as 5 per cent of our energy needs is, according to all projections, certain to account for a decreasing share in the next few years. Natural gas may become more or less important in the next few years, depending on its availability. Oil may provide a greater source than at present, although this is not certain. The big increase is expected to be in nuclear sources over the next few years, if safety and other problems can be solved. Current projections are that nuclear power will provide 20–30 percent of electricity by about 1980. Again, these projections assume current prices.

The time required for building an electricity faicility is four to five years, whereas the time for building a nuclear facility is eight to ten years or longer. About a third of the electricity used in the United States is for residential purposes, while the other two-thirds is used by the commercial and industrial sectors. (See table 4.)

For the next six or seven years the Congress has the choice of doing nothing about electricity or it can contribute to the increase in electricity output on a number of fronts. One way would be to contribute to the technology of coal gasification and liquefaction. This can be done also by cooperating with other countries, particularly Russia and Germany. It can take steps to increase the output of oil and natural gas. There is not much that can be done to increase the output of hydroelectricity. Geothermal energy offers a real possibility and the Congress can stimulate geothermal energy production particularly in the western states or it can set up immediately a TVA type corporation to produce some of the geothermal energy itself. The role of the Congress in nuclear energy is mainly in the field of providing funds for making nuclear plants safer.

TABLE 4.—DEMAND FOR ELECTRICITY IN THE UNITED STATES (ACTUAL, 1970, AND PROJECTIONS FOR 1980), BY REGION

[In millions of kilowatt hours]

Area	Electricity demand	
	1970	1980
Residential demand:		
New England	20,900.0	42,246.4
Mideast	69,146.0	129,657.1
Great Lakes	79,687.0	139,981.8
Plains	35,339.0	62,558.2
Southeast	129,124.0	272,694.1
Southwest	40,127.0	81,273.6
Rocky Mountains	9,652.0	15,795.9
Far West	63,820.0	98,599.3
United States	447,795.0	842,806.1
Commercial demand:		
New England	14,643.0	30,840.3
Mideast	57,696.0	103,129.0
Great Lakes	53,911.0	108,139.0
Plains	21,406.0	39,663.0
Southeast	63,556.0	132,157.8
Southwest	33,628.0	62,652.6
Rocky Mountains	10,356.0	18,474.5
Far West	57,554.0	102,300.1
United States	312,750.0	597,356.1
Industrial demand:		
New England	18,161.0	22,897.8
Mideast	94,108.0	123,566.9
Great Lakes	123,395.0	139,361.6
Plains	30,703.0	45,549.8
Southeast	160,003.0	229,185.7
Southwest	50,853.0	88,833.6
Rocky Mountains	16,642.0	20,065.0
Far West	78,657.0	106,143.1
United States	572,522.0	775,603.4
Total demand:		
New England	55,261.4	98,768.0
Mideast	233,765.1	377,021.4
Great Lakes	267,272.7	402,981.6
Plains	90,421.2	152,795.1
Southeast	365,732.3	657,496.9
Sojthwest	129,966.1	242,559.4
Rocky Mountains	38,262.6	56,726.1
Far West	210,632.6	323,315.8
United States	1,391,312.0	2,311,872.0

Source: Adapted from: Duane Chapman, Timothy Tryrell, and Timothy Mount, "Electricity Demand Growth and the Energy Crisis," Science, Nov. 17, 1972, vol. 178, No. 4062, p. 707.

The cost of producing electricity varies considerably in the United States, both because of the necessary investment of dollars per kilowatt hour in plant and equipment, and because of the cost of the energy. Operating costs also vary widely. Cost comparisons for electricity from four sources are shown in Table 5. It will be noted that the investment in geothermal plants is only $110 per kwh, $150 for coal, $225 for nuclear power and $250 for hydro power. The energy costs per kilowatt hour were 3 mills for coal, 2 mills for nuclear power and 2.66 mills for geothermal power per kilowatt hour. Total costs, assuming a 90 per cent load factor, were 4.55 for hydro power, 4.86 mills for geothermal, 5.92 for coal, and 6.50 mills for nuclear. Thus, nuclear power is the highest and hydro electric power the lowest. The fuel costs for gas and fuel oil were 2.5 for gas and 6 mills per kilowatt hour for fuel oil. Both of these are expected to increase from now until 1980, whereas no change in price per kilowatt is indicated for coal and nuclear power.

TABLE 5.—COST COMPARISON OF 4 ELECTRICITY SOURCES IN THE UNITED STATES

	Geothermal	Nuclear	Hydropower	Coal
Plant investment (dollars per kilowatt)	$110.00	$225.00	$250.00	$150.00
Fixed charges (14 percent per year per kilowatt)	15.40	31.50	35.00	21.00
Fixed charges (millions of kilowatt-hours)	1.95	4.00	6.10	4.36
Operating costs (millions of kilowatt-hours)	.25	.50	.10	.25
Energy costs (millions of kilowatt-hours)	2.66	2.00		3.00
Total costs:				
Variable load factor (millions of kilowatt-hours)	4.86	6.50	6.20	7.61
90 percent load factor (millions of kilowatt-hours)	4.86	6.50	4.55	5.92

Source: Richard G. Bowen and Edward A. Groh, "Geothermal Earth's Prinoidial Energy," Technology Review, October–November 1971, p. 46, as reproduced by William W. Ritter "Exciting Prospects Ahead for Geothermal," Electrical World, May 15, 1973, p. 44.

Nuclear Energy

The atomic or nuclear energy industry is now more than three decades old. Its primary use has been for making bombs, but it also has applications in such diverse fields as medicine, agriculture, desalting sea water, oceanographic exploration, nuclear ship propulsion, development of nuclear explosives for massive earthmoving projects. It is being used in mining and recovery of natural gas. Although it was known for a long time that nuclear energy could be used for generating electricity, until recently this activity has received little notice. Nuclear energy production still accounts for only about 1 per cent of our energy demands.

The Atomic Energy Commission has wavered in its interest. At the present time, and in most recent years, the Atomic Energy Commission has been pushing for the generation of electricity from nuclear sources, and has been emphasizing, not always successfully, that nuclear plants are safe. There have been debates over how to dispose of radioactive wastes, the possibility of accidents in transporting nuclear fuel the likelihood that fissionable plutonium produced by reactors might be stolen or misused. More recently there has been debate over what will happen if a rupture should occur in a reactor's pressure vessel or in one of the pipes that carry the water which cools the reactor's core. There has been growing interest in the safety of nuclear plants. For example, the Rand Corporation in California has recommended the slowdown in nuclear power plant construction in that state. Ralph Nader and Senator Mike Gravel of Alaska have been calling for a nationwide moratorium. Environmentalists, scientists, journalists, and suburbanites have joined the fray.

In all of this there has developed a serious AEC creditability gap. It seems apparent that the AEC isn't nearly as certain about nuclear safety as it ought to be. It has suppressed unwelcome evidence of possible hazards that have been discovered by its own researchers. When the researchers have pressed their doubts on higher officials, the AEC suppressed their reports and terminated their experimental programs, and sometimes researchers have been fired.[26]

Nuclear capacity in the United States, operable, being built and planned, where the reactors have been ordered, will soon amount to 156 million kilowatt hours. (See figure 1.) It will be noted that most of the plants are in the eastern part of the United States, with a scattering in Texas, Colorado, Nebraska, California, Oregon, and Washington. At present, 34 plants are now operable with a capacity of 19

[26] See the *EXXON* article, "The Big Blowup over Nuclear Blowdowns," *Fortune*, May 1973, pp. 216–219 and 299–315; also see Richard Lewis, "Citizens v. Atomic Power," *New Scientist*, 23 Nov., 1972, pp. 450–452; also Thomas Ehrich, "Atomic Lemons," *Wall Street Journal*, May 3, 1973, pp. 1 and 23.

million kilowatts. There are 57 being built with a capacity of an additional 51 million kilowatts, and planned plants where the reactors have been ordered amount to another 86 million kilowatts, for a total of 156 million kilowatts. To put this in perspective this means that when all the plants now being built or planned are in operation, nuclear power will account for a third or more of the present electricity capacity in the United States.

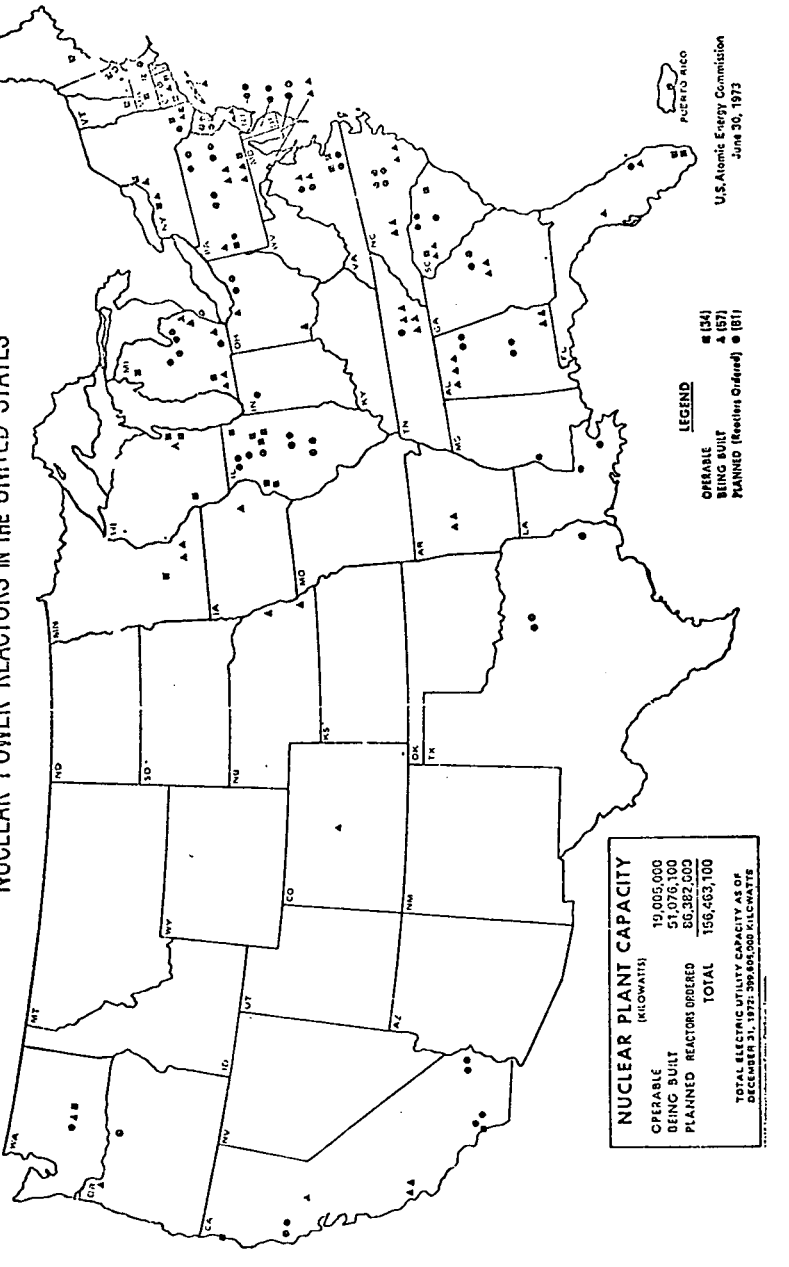


FIGURE 1

Electricity generated from nuclear power depends on uranium as a source. In the early years of the atomic program, the United States imported uranium mainly from Canada, the Congo, and South Africa, but then the United States government began to subsidize efforts to find domestic sources of uranium. The program proved highly successful. Most domestic uranium is produced in New Mexico, Arizona, Colorado, Utah, and Wyoming. The United States is now self-sufficient in uranium and is likely to remain so for the indefinite future. It is expected that uranium will be adequate for the next 20 to 30 years at $15 a pound, and one pound of uranium can make as much electricity as 26 million pounds of coal.

Geothermal Energy

The demand for electricity in the United States is gargantuan. It is doubling every eight to ten years. Private utilities are having difficulty in getting adequate supplies of natural gas and oil. Although electric supply from nuclear power is expected to increase sharply in the near future, the United States will have great difficulty in meeting its expected demand.

Geothermal energy, which is essentially heat from the earth's core, recoverable either as steam or hot water, promises to be important in the future. Estimates range from the ability to generate the total U.S. electrical supply for hundreds of years and recent developments at Los Alamos may make it possible to supply U.S. needs for thousands of years. Although in the United States there is only one plant in operation, there has been considerable activity in recent years. The Pacific Gas and Electric Company operates a relatively small generating plant at the Geysers in Somona, California, about 90 miles north of San Francisco. This plant has been in operation since 1958 and has been enlarged several times. Some 200 homes and greenhouses in Boise, Idaho have been heated by underground steam since 1890; five hundred homes, seven schools, and several factories are heated by geothermal steam in Klamath Falls, Oregon. Other small communities in California, Idaho, Nevada, and Oregon use underground steam for home heating. One Russian scientist claims the geothermal energy potential of the Soviet Union is greater than all of its other energy sources put together.[27] There is also considerable drilling activity in southern California in the Imperial Valley, and across the border a plant is now in operation in Mexico.

Although there has been limited activity to date in the field of geothermal energy in the United States, this is not so in other countries. In Italy it has been used for 70 years, with no sign of running short. It has also been used in Iceland and other countries. Geothermal exploration programs are being carried out in the following countries: Algeria, Columbia, Chile, Dominica, El Salvador, Ethiopia, Guadeloupe, in the French West Indies, Greece, India, Indonesia, Israel, Italy, Japan, Kenya, Mexico, Morocco, New Hebrides, New Zealand, Philippines, Rwanda, St. Lucia, Taiwan, Tanzania, Turkey, Uganda, and the U.S.S.R.[27a]

Production of electricity from geothermal sources involves none of the perils of nuclear energy. There is no significant threat to the environment, no international complications of oil. There are an esti-

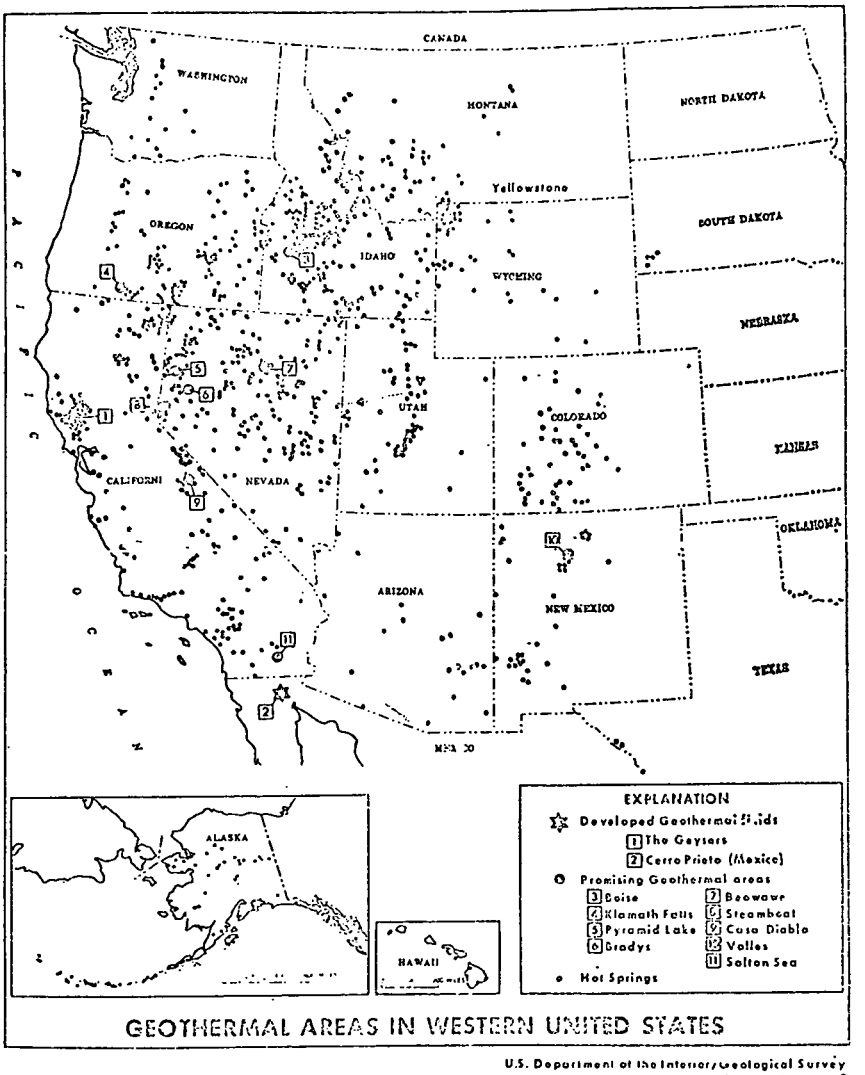
[27] From testimony of Senator Barry Goldwater in *Hearings before the Committee on Interior and Insular Affairs, United States Senate, Pursuant to S. Res. 45*, "A National Fuels and Energy Policy Study," 92d Congress, Second session, June 15 and 22, 1972, Washington, U.S. Government Printing Office, 1972. p. 5.

[27a] Felice C. Jaffe, Bulletin Der Vereinigung Schweiz Petroleum-Geologen Und Ingenieure De L'Association Suisse Des Geologues et Ingenieurs Du Petrole, October 1971, *Geothermal Energy, A Review.*

mated 100,000 square miles of geothermal sources in the United States, mainly in the Western States. (See figure 2.) There is some corrosion and scaling of equipment, but companies think they now have that problem solved. When the steam comes out of the ground, it makes a noise somewhat akin to jets taking off at an airfield, but this can be solved with muffler like devices. Estimated costs of geothermal plants and operating costs vary, but all the estimates indicate that they are less than those from nuclear power, and coal, although slightly higher than from hydro power.[28] Production of electricity from geothermal energy is, therefore, the lowest cost of any known method of producing electricity.

[28] See Table 5, p. 41 *infra*.

FIGURE 2



GEOTHERMAL AREAS IN WESTERN UNITED STATES

U.S. Department of the Interior/Geological Survey
News Release, October 6, 1971, p. 3.

Los Alamos, New Mexico scientists have come up with a new method of using geothermal heat. This method consists of drilling two holes 15,000 feet deep. The first step is to pump cold water down one hole. This is heated by the hot rock and then brought up the other hole as hot steam. One overwhelming advantage of this new method is that it is not, like geothermal energy, limited to the western states.

Congress passed the *GEOTHERMAL STEAM ACT OF 1970* and the U.S. Department of the Interior is in charge of granting leases. Most of the companies interested in geothermal energy have been the major oil companies, because the technology of drilling for geothermal energy has been borrowed in large part from the petroleum industry. Electric utilities make up the other group that are interested in it.

The technology for producing this cheap, abundant electricity has been known for seventy years. Many people are enthusiastic about the prospects of producing electricity from geothermal sources. Although there are minor problems still to be solved, if we get on with the job, it is known that geothermal energy holds the promise of solving our electrical needs for the next century or the next thousand years. One of the reasons that utility companies neglected geothermal energy for so long is that there has always been a cheap and plentiful source of natural gas and oil. That reason is no longer valid.

There have been suggestions that a governmental agency be formed to develop all or part of this promising source of energy as a check on private energy interests. If this suggestion is deemed worthwhile, it must be considered soon by the Congress because the Department of the Interior is planning to issue bids on long term leases within the next few months.[29]

Oil and Gas Tankers and Superports

As oil and gas imports into the United States, Western Europe and Japan have increased, the size of tankers has grown dramatically. For example, in 1950 a tanker that could carry 30,000 tons was the prize of the fleet. By contrast, in 1971 a 370,000 dead weight ton tanker was launched, and two new 447,000 dead weight ton vessels are scheduled to go into service in 1973. If this trend continues, it is conceivable that vessels with a dead weight ton of 1 to 2 million may be built by 1980.[30] As ships have become larger, the cost of transporting oil has been cut by more than one-half.

But the larger ships have outgrown the traditional port facilities and in various parts of the world it has become necessary to build superports, 20 to 40 miles offshore. Then, the oil or natural gas is unloaded and usually piped ashore or it can be brought to shore in smaller ships. The United States will have to build a number of superports, if it is going to be able to import enough crude to meet domestic demands during the next decade. At the present time, plans are moving ahead for the construction of superports off the coast of Louisiana and Texas. They have apparently solved the problem of making the superports environmentally acceptable by taking representatives of environmental groups out to show them how the super-

[29] See, for example, the editorial in *The New Republic*, "Escaping Steam," by Peter Barnes, April 14. 1973, pp. 9 and 10.

[30] A dead weight ton refers to the long tons of cargo a ship is capable of carrying.

ports will be built. Another superport is being built in the Gulf of Mexico off the coast of Florida.

In August, 1973, it was announced that the governors of South Carolina, North Carolina, and Georgia have called for a $300,000 study of the economic and environmental impact of a superport to be located 20 to 40 miles off the coast. This would be the first deep water port on the east coast. Participating with the Governors were six oil companies including Cities Service, Exxon, Mobil, Tenneco, Standard Oil of Kentucky, and Shell.[31] And a superport has been announced off the coast of California near Monterrey to handle the giant tankers that will bring Alaskan oil to the West Coast. On Canada's east coast one superport is already operating, and the province of Nova Scotia is building a superport. The province of Quebec wants to build one on the St. Lawrence River.[32]

Secondary Recovery of Oil

With the knowledge prevailing and the price of crude oil, it is estimated by the industry that it has been able to produce about 30 per cent of the oil in place in recent years. The three principal factors that determine the efficiency of oil recovery are: the permeability of the rock, the viscosity of the oil, and the pressure of the reservoir. But experiments in secondary (and tertiary) recovery are continuing, and with the higher prices of crude oil now prevailing, many companies are finding that investment in "secondary recovery" has a higher payoff than the drilling of new wells. The secondary recovery consists mainly of the injection of gas and various fluids into wells, known as stimulating recovery. Speculation is that, with the higher crude oil prices, secondary recovery may reach as high as 60 per cent of the oil in place.

Canadian Tar Sands

There are big, rich deposits of tar sands in Canada, especially in the northern part of Canada. Some people look on these tar sands as the best chance of an alternative source of energy for the United States. A slight increase in price will make the oil that could be produced from the sands commercial. Some maintain that the recent increase in the price of crude has already made them commercial and anticipate a much larger production in the near future.[33]

Conservation in the Use of Energy

Up to the present time the United States has been on a binge of trying to increase the supply of energy to meet ever increasing demands. To a considerable extent, the increasing demand has been fostered by vigorous promotion efforts. On radio, TV, in fact, through all the media available, we have been told by natural gas distributing companies that gas is better than electricity. At the same time we have been told by the electric companies that the all-electric home is better

[31] See *The Daily Oklahoman*, August 30, 1970, p. 42.

[32] *Business Week*, May 26, 1973, pp. 68, 69; also, Frank M. Craggett, "A New Breed of Tankers," Washington, D.C., American Petroleum Institute, *Petroleum Today*, Fall 1971, pp. 16 and 17; also, Sandy Sivewright, "LNG—Cargo for the 1970's," *New Scientist*, June 15, 1972, pp. 610–612.

[33] See *The Economist*, (London) 7–13 July, 1973, p. 38.

than gas, even though electric heating of homes with electricity manufactured from gas is only half as efficient as using the gas directly in the home. Most of the testimony before Congressional Committees takes for granted the continued rapid expansion in the demand for energy. Oil companies have hired former football coaches to ride in helicopters over crowded streets to tell us that the real villain in the whole energy squeeze is the consumer and his insatiable demand for more and more energy.

There is a feeble, weak, but growing body of opinion that says, in the words of the illustrious song, "It Ain't Necessarily So." This body of opinion insists that significant savings in energy use can be achieved by adopting sensible, and simple conservation measures.[34] Only a few examples will be cited here, but the list could be extended indefinitely. Some utility and petroleum companies have lately begun to suggest ways of cutting down on energy consumption.

Fuel for autos, trucks, buses, trains and airplanes consumes one-fourth of our energy budget, mainly in the form of petroleum. Manufacturers of automobiles, plus the construction and maintenance of highways, consume even more. Yet, the internal combustion engine is so inefficient that three-fourths of the gasoline burned is wasted, mainly in the form of pollutants that foul the air in our cities. The average miles per gallon of gas has decreased almost steadily since World War II and is expected to decrease even more as more stringent emission standards go into effect. It is widely known that Detroit can make automobiles which are more efficient and will get more miles per gallon. It is time to take the wraps off some of these depressed inventions. In our cities, bus travel is more than twice as efficient, in terms of average energy expended per passenger mile, as automobile travel. Commuting by trains is more than twice as efficient as commuting by automobile. Yet, the number of revenue passengers on mass transit has been cut practically in half during the past three decades.

Shipping freight between urban areas by rail is four times as efficient, in terms of energy expended per ton mile, as shipping by truck. Yet, the percentage of total tonnage shipped by rail has fallen steadily since 1950, while that shipped by truck has steadily increased. Clearly, travel by autos and the movement of freight by truck can be substantially reduced, and the energy saved will be very substantial.

About 40 per cent of all the energy consumed yearly in this country is for heating, cooling, ventilation, lighting, and power systems in homes and commercial buildings. Much of this energy is wasted. Energy conservation, through improved design, can reduce the yearly consumption of new buildings by as much as 35 to 50 per cent and of

[34] Many of the facts on potential advantages of conservation are taken from the following: *Petroleum Product Shortages*, Hearings before the Committee on Banking, Housing and Urban Affairs, U.S. Senate, 93rd Cong., 1st Sess., on The Impact of Petroleum Product Shortages on the National Economy, May 7–11, 1973, pp. 347, 348. Exhibit B., "Action to Reduce the Demand for Petroleum Products;" James H. Krieger "Energy: The Squeeze Begins," *Chemical and Engineering News*, Nov. 13, 1972, pp. 20–22, 24–28, and 33–37; Glenn T. Seaborg, "Energy and Our Future," *Public Utilities* Fortnightly, Feb. 1, 1973, pp. 13–17; David B. Large, "Conserving Energy: Some Things that Can Be Done," *Not Man Apart*, March, 1973, pp. 10 and 11; Cynthia Riggs Stoertz, "Plugging the Energy Leaks," *Petroleum Today*, Volume 14, No. 1, 1973, pp. 21–25; "Energy Study Calls for Money and Care," *The Washington Post*, August 16, 1973, p. G10; Charles F. Meyer, and David K. Todd, "Conserving Energy with Heat Storage Wells," *Environmental Science and Technology*, June 1973, pp. 512–516; H. Harry Phipps, "Energy Conservation: A New Dimension for Engineering Responsibility," *Professional Engineer*, Nov., 1972, pp. 24–27; Eugene Kramer, "Energy Conservation and Waste Recycling," *Bulletin of the Atomic Scientists*, April, 1973, pp. 13–18; and Rothschild, "Illusions About Energy," *The New York Review*, August 9, 1973, pp. 29–32; Morris K. Udall, *Congressman's Report*, June 11, 1973, Vol. XII, No. 4; Alan L. Hammond, "Conservation of Energy: The Potential for More Efficient Use," *Science*, Volume 178, December 8, 1972, pp. 1079–1081; also the statement of Fred S. Dubin before the Committee on Energy of the House Science and Aeronautics Committee, June 12, 1973.

existing buildings by 15 to 20 per cent. More than half the savings in energy can be accomplished with no appreciable increase in costs. Twenty-four per cent of all electric energy goes for lighting, yet ordinary incandescent lights convert only 5 per cent of the electrical energy they consume into useful light. Fluorescent lights convert 20 per cent. Increased thermal installation in homes and buildings can reduce energy consumption by as much as 40 per cent and still save the owner money by reducing fuel and electricity consumption. In all-electric homes, air conditioning follows space and water heating as the major consumer of electricity. Eighteen per cent of the growth in residential electricity consumption between 1960 and 1970 was due to the growing popularity of air conditioning. Studies have shown that the least efficient model consumes 2.6 times as much electricity as the most efficient one, while accomplishing the same amount of cooling. This is especially true of room units. All-electric homes are inherently inefficient. From 75 to 90 per cent of the energy resource in the ground never makes it to the consumer of electricity. For example, the frost-free refrigerator uses 60 per cent more electricity than its conventional counterpart. The pilot light uses about half the gas a stove consumes. There are inexpensive and safe automatic lighters that do not use gas.

Industry consumes 40 per cent of the total energy in our nation. One-third of this is used to produce a few basic materials, primary metals, aluminum, and steel, chemicals and paper products. A study by the Office of Emergency Preparedness concludes that industry, given incentives, can reduce its energy consumption by 10 to 15 per cent by replacing old and inefficient equipment with newer models. The basic materials that use one-third of industry's energy in their manufacture—metals, chemicals, and paper—can be recycled, thus conserving resources and alleviating part of the problem of waste disposal.

SOME NONCOMPETITIVE PRACTICES OF THE PETROLEUM INDUSTRY

The purpose of the following pages is to present sufficient evidence to indicate that there is a tendency toward non-competitive, monopolistic practices that have characterized the petroleum industry almost from its inception. When Middle East oil became significant, international cartels were formed, and the underlying principles of these cartels exist today. The international majors and international minors control most of the domestic and foreign petroleum industry from exploration through production, refining, transportation, and marketing. In addition to having control over petroleum and natural gas, which accounts for 75 percent of our total energy supply, these same companies control a significant part of the coal, uranium, geothermal, offshore wells, and oil shale in the United States. By no stretch of the imagination does the petroleum industry fit the economist's traditional model of a purely competitive industry. It goes almost without saying that the information does not constitute a legal indictment of the petroleum industry, although it is to be noted that the Federal Trade Commission and several states have suits pending against the industry.

Joint ventures are prevalent in the petroleum industry. Because of these, the petroleum industry does not fit the usual oligopolistic model of the economists either. There is no clear-cut market model in economics that describes the industry. There is room for a great deal of work by economists in this category and, at the same time, there is clearly a variety of ways to make the industry less complex as a market structure, for example, stricter government delineation of the role of the petroleum industry in the broader category of energy.

The original Standard Oil Trust was organized in 1879. The devices used were railroad rebates, control of pipelines, and control of refining. Formation of the trust followed the discovery of oil in Pennsylvania by only 20 years. (In January 1860 the price of crude oil was $20 a barrel, but fell to as low as 10 cents a barrel by the end of 1861.[1]) After a lengthy court debate, the Supreme Court decided in 1911 that the trust was engaged in a conspiracy to violate the antitrust laws of the United States and ordered the trust dissolved.[2] The history of this case has been widely documented. The Court did not spell out the method of dissolution, and there are many who insist that it did little to restore competition.

The formation of an international petroleum cartel dates from 1928 when Standard Oil of New Jersey, Royal Dutch Shell, and the Anglo-Persian (now British Petroleum) entered into two written agreements. The first, the so-called Achnacarry, or "As Is," agreement, related to marketing. The second, or "Red Line" agreement, concerned pro-

[1] Henry R. Seager and Charles A. Gulick, Jr., *Trust and Corporation Problems*, New York, Harper and Brothers, 1929, p. 96.
[2] *Ibid.*, Chapters VIII and IX.

duction in the Middle East. The underlying principles of these two agreements are largely in effect at the present time.[3]

The most important features of the Achnacarry Agreement were that each of the three would accept and maintain as its share of the industry its actual share as it was in 1928 (hence, the "as is" agreement) and that each firm would add new facilities only as actually needed to supply increased requirements of consumers, and that each would prevent any surplus production in a given geographical area from upsetting the price structure in any other areas. The three firms signing the agreement had virtually complete control of Middle East oil production, and at the time controlled most of the world's production outside the U.S. and the U.S.S.R.

In 1928 the same three companies entered into the "Red Line" agreement, which was an agreement to share the oil production of almost the entire Middle East. This was the most far-reaching of the joint ventures through which most of the Middle East oil output over the years has come to be shared by the Seven Sisters (Standard Oil of New Jersey, Royal Dutch Shell, British Petroleum, Socony-Mobil, Standard Oil of California, Gulf Oil Corporation, and Texaco). The other four companies were added to the original three when they became important in the Middle East. The "Seven Sisters" still control most of the production in the Middle East. Although there have been some changes recently, in 1966 the large American and British firms controlled 84 percent of Middle East oil production, with the remainder scattered among Dutch, French, and other companies.

Two recent, related studies have shown that the "Seven Sisters", that is, the international majors, through the device of joint ventures, control a large share of world petroleum. The joint ventures may be a contractual relationship between two or more companies to share in the costs or profits, or both, of a venture, or they may divide up the costs or profits, or both, through a joint subsidiary. In these joint ventures, the majors are not autonomous units, but are legally bound to act as one unit. Through the device of joint ownership the majors control 77 per cent of the oil production, 60 per cent of the pipeline mileage, and 60 per cent of the refining capacity outside the United States and the Communist-Bloc countries. On the periphery of the international majors are the international minors and government owned companies. These two groups are interlocked among themselves as well as with the international majors. Collectively, the international majors and the international minors have control over 96 per cent of the oil production, 92 per cent of the pipeline mileage, and nearly 100 per cent of the refining capacity in the areas in the world outside the United States and the Communist-Bloc countries. In the following three tables, data is presented on the interlocking ownership through joint ventures for the various phases of the petroleum industry outside the United States and the Communist Bloc countries. The data indicate that the "Seven Sisters" have 916 joint ventures with each other. If to this distinguished group we add the joint ventures with 18 other companies, we find that the number rises to 3,222. If to that we add joint ventures with local private

[3] *The International Petroleum Cartel*, Staff report to the U.S. Federal Trade Commission, submitted to the Subcommittee on Monopoly of the Select Committee on Small Business, U.S. Senate, August 22, 1952, 82nd Congress, 2nd Session, Committee Print No. 6, Washington, U.S. Government Printing Office, 1952.

capital, local government, nonhost government and others, the total number of joint ventures rises to 6,419. Joint ventures are a way of life in the petroleum industry.

Energy Companies

One of the dramatic developments in recent years has been the emergence of energy companies, that is, companies with substantial holdings and operations in all energy sources. Petroleum companies have, of course, had control of most of the petroleum and natural gas. But, oil companies also control an estimated 80 percent of the uranium reserves in the United States.[4] Oil companies also control an estimated 20 percent of domestic coal reserves, although this figure may be considerably lower than actual. The major oil companies are also the ones which are dominant in the oil shale field, possibly one of the big developments in the near future. Most of the exploratory work in the field of geothermal energy is also dominated by major oil companies. The oil companies, which are interested in the development of coal in Montana, Wyoming, North Dakota, and South Dakota, including some parts of Colorado, are Shell Oil, Atlantic Richfield, Mobil Oil, Exxon, Gulf, and Chevron.[5] Due to the widespread substitutability of one fuel for another, this gives the oil companies control over every major source of energy, except possibly hydroelectric power, which accounts for less than 4 percent of the total and is expected to account for even less in the future.[6]

[4] *Oil and Gas Journal*, March 1, 1971, pp. 19–20.
[5] *The Washington Post*, August 26, 1973, p. C4.
[6] For the oil companies that control coal production see: *Fuel and Energy Resources*, 1972, Part I, Hearings Before the Committee on Interior and Insular Affairs, House of Representatives, 92nd Congress, 2nd Session April 10–13, 1972, Serial No. 92–42, p. 59. See also: *Congressional Record*—House, Jan. 15, 1973 for a speech by Congressman Kastenmeier, p. H265 and 266.

TABLE 6

JOINT VENTURES OF MAJOR INTERNATIONAL OIL COMPANIES WITH EACH OTHER

Company / Company	Standard New Jersey	Dutch Shell	Texaco	Mobil	Gulf	Standard California	British Petroleum	Total
Standard Oil (New Jersey)								
Royal Dutch Shell Group	186							186
Texaco	32	45						77
Mobil Oil	59	46	31					136
Gulf Oil	21	22	23	14				80
Standard of California	19	98	100	31	15			263
British Petroleum	33	44	22	37	25	13		174
Total	350	255	176	82	40	13	0	916

Source: Based on unpublished studies of John Münkirs and Jim Sturgeon, University of Oklahoma.

TABLE 7

JOINT VENTURES OF MAJOR INTERNATIONAL OIL COMPANIES WITH INTERNATIONAL MINOR OIL COMPANIES

	Standard Oil, New Jersey	Royal Dutch Shell	Texaco	Mobil	Gulf	Standard Oil, California	British Petroleum	Standard Oil, Indiana	Atlantic Richfield	Continental	Tenneco	Phillips	Occidental	Union	Sun	Cities Service	Ashland	Standard Oil, Ohio	Amerada-Hess	Getty	Signal	Marathon	Cie Francaise des Petroles	Badische Anilin und Sodafabrik	Petrofina	Total
Standard Oil, New Jersey																										
Royal Dutch Shell	186																									186
Texaco	32	45																								77
Mobil	59	46	31																							136
Gulf	21	22	23	14																						80
Standard Oil, California	19	98	100	31	15																					263
British Petroleum	33	44	22	37	25	13																				174
Standard Oil, Indiana	10	10	8	3	7	6	1																			45
Atlantic Richfield	220	15	15	12	10	19	133	112																		536
Continental	12	13	12	7	26	11	7	4	10																	102
Tenneco	3	1	3	3	1	1	1	1	2	3																19
Phillips	5	4	5	98	5	10	10	6	14	8	4															169
Occidental	1	1	2	1	1	2	1	3	2	1	1	1														17
Union	4	5	9	5	4	9	18	30	28	5	5	3	1													126
Sun	4	5	8	4	3	4	2	106	147	6	2	15	0	9												315
Cities Service	5	5	2	2	1	1	2	2	6	16	1	1	1	3	13											61
Ashland	2	2	2	1	2	2	2	3	5	2	1	5	1	2	3	2										37
Standard Oil, Ohio	3	4	5	4	10	5	10	0	6	6	0	1	0	1	1	1	0									59
Amerada-Hess	1	2	0	0	0	0	0	70	1	4	1	0	0	0	0	0	4	0								83
Getty	11	8	10	8	12	9	9	8	16	12	2	6	2	5	3	2	3	11	16							153
Signal	7	6	6	7	6	8	5	6	13	3	4	1	6	5	1	17	1	4	1	10						120
Marathon	6	9	4	3	1	4	2	3	15	10	1	1	0	8	3	3	1	0	5	4	0					83
Cie Francaise des Petroles	27	36	14	23	5	7	25	0	7	8	2	23	0	3	1	0	1	4	2	6	2	14				210
Badische Anilin und Sodafabrik	10	12	9	3	0	2	4	2	0	0	0	0	0	0	1	0	1	0	0	0	3	4	3			54
Petrofina	3	1	2	1	1	1	11	3	4	4	0	65	0	1	2	0	1	0	0	2	0	1	14	0		117
Total	689	391	292	267	135	114	243	359	276	88	24	122	11	37	28	25	12	19	24	22	5	19	17	0	0	3222

Source: Based on unpublished studies of John Munkirs and Jim Sturgeon, University of Oklahoma.

TABLE 8

JOINT VENTURES OF INTERNATIONAL MAJOR OIL COMPANIES WITH INTERNATIONAL MINORS AND OTHER GROUPS

	Standard Oil, New Jersey	Royal Dutch Shell	Texaco	Mobil	Gulf	Standard of California	British Petroleum	Standard Oil of Indiana	Atlantic Richfield	Continental	Tenneco	Phillips	Occidental	Union	Sun	Cities Service	Ashland	Standard of Ohio	Amerada Hess	Getty	Signal	Marathon	Cie Francaise des Petroles	Badische Anilin und Sodafabrik	Petrofina	Local Private Capital	Local Governments	Non-host Government	Other	Total
Standard Oil, New Jersey																													
Dutch Shell	166																												180
Texaco	32	45																											77
Mobil	59	45	33																										130
Gulf	21	22	23	14																									80
Standard Oil, California	19	98	100	31	15																								263
British Petroleum	33	44	2	37	25	13																							174
Standard Oil, Indiana	10	10	8	3	7	6	1																						45
Atlantic Richfield	220	15	15	12	10	19	133	112																					536
Continental	12	13	12	7	26	11	7	4	10																				102
Tenneco	3	1	3	3	1	1	1	1	2	3																			19
Phillips	5	4	5	98	5	10	10	6	14	8	4																		169
Occidental	1	1	2	1	1	2	1	3	2	1	1	1																	17
Union	4	5	9	5	4	9	18	30	28	5	5	3	1																126
Sun	4	5	8	4	3	4	2	106	147	6	2	15	0	9															315
Cities Service	5	5	2	2	1	1	2	2	6	16	1	1	1	3	13														61
Ashland	2	2	2	1	2	2	2	3	5	2	1	5	1	2	3	2													37
Standard Oil, Ohio	5	4	5	4	10	5	10	0	6	6	0	1	0	1	1	.	0												59
Amerada-Hess	1	2	0	0	0	0	0	70	1	4	1	0	0	0	0	0	4	0											83
Getty	11	8	10	8	12	9	9	8	16	12	2	6	2	5	3	2	3	11	16										153
Signal	10	6	6	7	6	8	5	6	13	3	4	1	6	5	1	17	1	4	1	10									120
Marathon	6	9	4	3	1	4	2	3	15	10	1	1	0	8	3	3	1	0	5	4	0								83
Cie Francaise des Petroles	27	36	14	23	5	7	25	0	7	8	2	23	0	3	1	0	1	4	2	6	2	14							210
Badische Anilin und Sodafabrik	10	12	9	3	0	2	4	2	0	0	0	0	0	0	1	^	1	0	0	0	3	4	3						54
Petrofina	3	1	2	1	1	1	11	3	4	4	0	65	0	1	2	0	1	0	0	2	0	1	14	0					117
Local Private Capital	40	26	38	36	16	33	41	24	3	9	4	80	0	6	5	0	0	0	12	4	8	8	5	54	54				508
Local Governments	12	10	11	10	31	7	10	4	5	25	2	6	3	6	3	1	2	0	58	2	0	0	46	1	1	98			362
Non-host Government	29	13	17	14	3	11	19	4	6	4	4	104	1	7	3	14	0	1	1	1	0	2	152	4	71	121	123		729
Other	80	79	43	61	76	32	43	41	139	56	21	55	7	53	131	14	33	15	94	27	14	22	80	20	5	117	115	125	1596
Total	850	530	461	388	263	197	356	432	429	202	155	367	22	109	170	54	47	35	189	56	27	51	500	79	131	335	238	125	0	6119

Source: Based on unpublished studies of John Minkirs and Jim Sturgeon, University of Oklahoma.

In June 1973, Carl Bagge, President of the National Coal Association, proposed that diversified energy conglomerates be permitted. He insisted that if this were done, true, effective and vigorous competition would exist.[7]

In July 1973 the Federal Trade Commission released a preliminary staff report on its investigation of the petroleum industry. Its main conclusions were:[8]

> The survey data lead to certain tentative conclusions about the operation of the various markets of the petroleum industry:
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> 1. The eight largest majors have effectively controlled the output of many of the independent crude producers.
> 2. A high degree of control over crude is matched by relatively few crude exchanges with independents, an exclusionary practice which denies a high degree of flexibility to the independent sector while reserving it to the majors.
> 3. Independent refiners are largely dependent on the majors for their crude supply, but independents sell very little of their gasoline output back to major oil companies. Independent refiners sell the largest amount of their output to independent gasoline marketers and to their own stations. Thus, the welfare of the independent marketing sector is largely dependent on the well-being of the independent refiners.
> 4. The continued existence and viability of the independent refiner is necessary for the survival of the independent marketer. This is especially true since the eight largest majors rarely sell gasoline to the independent marketers.
> 5. The major oil companies in general and the eight largest majors in particular have engaged in conduct which exemplifies their market power and has served to squeeze independents at both the refining and marketing levels. Such conduct and associated market power has its origin in the structural peculiarities of the petroleum industry and has limited the independents' share of the market to approximately one-quarter of the total, especially in Districts 1 and 3, resulting in a threat to the continued viability of the independent sector in this market.

The FTC wants the major oil companies to divest themselves of refining and pipelines in order to encourage more competition, but this has run into vigorous opposition from the White House and the Treasury Department.[9]

In July, 1973 the Attorney General of Connecticut filed an antitrust suit intended to break up the oil industry and predicted that at least two dozen other states will file similar complaints. The suit

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[7] Springfield, Illinois, *Illinois State Journal*, June 18, 1973, p. 1.

[8] *Investigation of the Petroleum Industry*, Permanent Subcommittee on Investigations of the Committee on Government Operations, United States Senate, 93d Cong., 1st Sess., July 12, 1973, p. 43; see also *Energy Crisis and Small Business*, Permanent Select Committee on Small Business, House of Representatives, 93 Cong., 1st Sess., July, 1973.

[9] See *The Washington Post*, August 2, 1973, p. F2 and *Ibid.*, September 1, 1973, p. A1 and A6; also, *The Sunday Oklahoman*, September 8, 1973, Section A, p. 11.

accuses 22 major oil companies and three of their subsidiaries of having violated federal and state anti-trust laws. The suit asks for treble damages and for divestiture of all activities, except refining and marketing. A similar divestiture was asked by Florida, the first state to go to court seeking a breakup of the industry. The Florida suit was filed earlier in July, 1973. Other states that are planning suits against the oil companies include Maryland, Massachusetts, Michigan, New York, North Carolina, and Rhode Island. Attorney General Killian said that "big oil is bigger than the United States Government."

Killian said that the firms being sued control 85 per cent of all domestic crude oil, 97 per cent of domestic offshore crude. The firms dominate 75 per cent of the retail gasoline market, and almost 75 per cent of total domestic refining. They control at least 60 per cent of crude and refined petroleum pipelines.[10]

[10] *The Washington Post*, July 27, 1973, pp. A1 and A4.

CONCLUDING REMARKS

With 6½ per cent of the world's population the United States consumes 35 per cent of the world's energy. The United States is the largest consumer of energy among the nations of the world and also the largest consumer per capita. On a per capita basis, we consume 5 or 6 times as much as the world average and twice as much per capita as the developed countries of the world. We consume more than 30 times as much per capita as the developing countries of the world. We consume about three times as much per capita as the countries of Western Europe.

The energy industry, especially petroleum and natural gas, is the most pervasive in the world. It directly affects government, business, and the consumer in thousands of ways. Now we are being told through every available media that we are about to run out of petroleum and natural gas. We are told that we will have to depend on petroleum and natural gas imports from the Middle East and North Africa and that these imports will result in a deficit in the balance of payments ranging from $10 billion to $60 billion a year. We are told, furthermore, that the Middle East and North African countries are not a dependable source of petroleum and natural gas and that imports involve serious national security problems. Shortages of gasoline at the filling station, accompanied by higher prices when it is available, brown-outs in our cities, the shortage of natural gas and heating fuels in various parts of the nation have created a feeling of uncertainty and fear throughout the land. People everywhere are terrified at the prospects of disastrous shortages during the winter of 1973–74.

Now is the time to examine this barrage of self-serving propaganda, to take stock of our assets, and see what reasonable men can do to improve the situation. Surely a nation that can put men on the moon in the 60s can, with similar dedication, solve its energy problems in the 70s, but we cannot do it with a "business as usual" approach. Adjustments, sometimes inconvenient and painful, may be required.

If tomorrow we were suddenly cut off from all North African and Middle East oil (but assuming that imports from Canada and Venezuela continued at least at their current levels), we would still have more petroleum and natural gas available to the citizens of the United States than any industrialized nation in the world, and several times as much as most countries. As pointed out earlier, the United States is not about to run out of petroleum and natural gas, or other forms of energy. All responsible projections point in the opposite direction, if we will act.

No one seriously doubts the ability of the United States to continue to produce energy at current levels over the next decade or two, or to increase production moderately (Some would argue that it can increase production significantly). The basic decision facing the American people in the next few years is the *rate* of change in demand that will be permitted, the prices, and the sources of energy.

There is substantial evidence that energy prices will rise during the next five years, but only a reckless and irresponsible person would predict that this will continue through the next decade or two, or a longer period. Let it not be forgotten that petroleum was selling for $20 a barrel in 1860 and dropped to 10 cents a barrel in less than two years thereafter. It costs only 10 cents to 20 cents to bring a barrel of Middle East oil to the surface. Current estimates are that Alaskan oil can be brought to the surface for 40 cents a barrel, although the cost of transportation must be added. The cost of energy may rise in the future, but it also may remain stable or decline. Price will depend mainly on the extent of new discoveries.

Many sources of domestic energy are available to the American people, anyone of which, or, any combination of which, will augment our supplies. Although there is a time lag involved in bringing these sources into significant production, the time lag suggested by much of the testimony before various Congressional Committees can be substantially reduced. For example, we can continue to conduct experiments for the next century without any appreciable increase in output, or we can use the technology now available in the United States and other countries to begin immediately to increase our output. It is suggested that the Congress might give consideration to all available sources, in view of the current crisis and lend added support to those techniques which hold the greatest promise. Some sources of energy were available in large quantities but were not economically feasible to produce a year or two ago because of the prevailing prices. With the recent price increases, many of these sources have now become economically feasible.

For the immediate future (i.e., the winter of 1973–74) mandatory allocation of heating oils, LP gas, and natural gas seems inevitable. Schools, hospitals, cities, and other priority users must be assured of adequate supplies. Under normal circumstances the price system can be relied on to allocate resources, but, by common consent, these are not normal times.

What follows is a catalog, in summary form, of some of the ways the United States can substantially increase its output of energy over the next few years. More detail is provided in preceding sections of this report.

1. Coal is our most abundant energy source and there are adequate supplies to last for centuries, even thousands of years. The technology is available in the United States, with substantial help from England, Germany, Japan, Russia, and others to gasify and liquefy coal now. Delays for further experiments are unthinkable.

2. Offshore production of petroleum and natural gas now provides about 16 per cent of America's total. Yet, only about 1 per cent of the offshore area of the United States has been tested. Vast expansion of offshore production can and should be begun without delay.

3. Discovery of oil and gas in Alaska and the Cook Inlet a few years ago has been a boon to the United States. Now that the pipeline from Prudhoe Bay to Valdez has been approved by the Congress, we should be getting 2 million barrels of oil a day from that source in 1976 or 1977. This will be of considerable help in easing the shortage by "Proved Reserves," but, vast as they are, they are only a fraction of what will probably be produced in the area. Consideration should

be given now to the need for three or four additional pipelines to bring Alaskan and Canadian oil to the lower 48 States.

4. Oil shale deposits in the Green River area of Colorado, Utah, and Wyoming are the second most abundant source of energy in the United States, exceeded only by coal. Oil from shale is sometimes classified as an exotic fuel, implying that oil from shale will be economically feasible only in the distant future. The technology is currently available at competitive prices to produce high quality oil from these deposits. Oil can be produced from these deposits under environmentally acceptable conditions. As improved technology is developed, it can be introduced but further delays in getting started seem unwarranted.

5. The wide disparity between the price of interstate and intrastate gas must be somehow abolished. In the near future it may be necessary to import some natural gas from Algeria, Libya, and other countries, but it is to be borne in mind that imported natural gas is much more expensive than the highest prices projected for domestically produced natural gas.

6. To date, nuclear energy has provided only about 1 percent of our energy needs but nuclear capacity which is operable, being built, and planned where the reactors have been ordered, will soon provide 20 to 30 percent of our electrical needs, if the safety of the plants can be reasonably assured. But the Atomic Energy Commission has developed a serious credibility gap in recent years by suppressing unwelcome evidence of danger and by demoting or firing researchers who have pushed their findings too vigorously. In view of the huge investment in nuclear plants, the Congress might want to investigate the extent of danger in nuclear plants.

7. Geothermal energy, which is heat from the earth's core, recovered either as steam or hot water, holds great promise for the immediate future. Although in the United States there is only one plant currently in operation, it is being used in Idaho, Nevada, and Oregon. It has been used to produce electricity for 70 years in Italy. It is widely used in Iceland. It is also being used in New Zealand, Japan, and the United Nations is assisting in the search for geothermal energy in more than 30 countries around the world. One advantage of geothermal energy is that after the heat has been used to turn the turbines to generate electricity, the water can be pumped back into the same or nearby holes and reheated. Furthermore, geothermal energy does not pollute and it has none of the international complications of foreign oil. One Russian scientist maintains that the geothermal energy of the Soviet Union is greater than all other sources of energy, and her energy resources are tremendous. Geothermal energy has the lowest cost of any known method of producing electricity and is widely scattered through the Western States. One of the reasons utility companies have neglected geothermal energy for so long is that there has always been a cheap and abundant supply of natural gas and oil. That situation no longer exists.

8. In recent years the size of tankers for importing oil and gas has grown dramatically and the larger ships have outgrown the traditional port facilities in various parts of the world. The result has been it has become necessary to build superports, 20 to 40 miles offshore where the oil and gas is unloaded and either piped ashore or brought to shore

in smaller ships. At the present time private companies are planning to build superports off the Gulf Coast near Texas, Louisiana, and Florida. Preliminary studies are underway for a superport off the East Coast and another on the West Coast. Since these ports will be further out to sea than the traditional 3-mile limit or 12-mile limit, their location will involve delicate international negotiations. There is question whether these superports should be built by private companies or be built and operated by the Federal Government.

9. Typically, when an oil well is drilled in the United States with existing technology and prevailing prices, it has been possible to extract about 30 per cent of the "oil in place." With improved technology and the higher prices prevailing and in prospect, it has been possible to engage in secondary recovery and even tertiary of recovery of oil. The process consists essentially of injecting gas and various fluids into wells. This is known as stimulating recovery. There is speculation that with the higher crude oil prices, secondary recovery may make it possible to get out as much as 60 per cent of the oil in place.

10. Canadian tar sands offer the possibility of an alternative source of energy for the United States.

11. The people of the United States have been wasteful in uses of energy, mainly because the energy has been cheap and abundant. Recently, there has developed a whole body of opinion to the effect that we can save a substantial portion of energy by simple conservation techniques, such as our use of the automobile, houses, office buildings, factories, etc. Up to the present our efforts have all been to the effect of increasing the supply to meet an ever-increasing demand. As the price of energy rises, much of that demand may not be effective.

Possible Role of Congress

In view of the current prices and for other reasons, it has been suggested that the Federal Government enter directly into the production and distribution of energy in the United States. This is not meant to nationalize the existing petroleum industry. But it does mean that in this big industry, the United States Government might carve out for itself a slice of, say 20 to 30 per cent, and that the device might be a series of TVA-type corporations. The Federal Government now pays for most research and development. The Federal, state, and local governments are also large consumers of energy. Most of the offshore lands, most of the geothermal lands, most of the oil shale lands, and most of the oil-producing lands in Alaska are owned by the Federal Government.

Among the TVA-type corporations which the Congress might consider are: one for building and operating superports; one for offshore drilling; another for geothermal energy; another for oil shale; another for the production of Alaskan oil. It might want to consider the operation of several refineries. Such corporations would not take any existing operation from private companies, but would operate a fraction of the increase in petroleum production.

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