State of Alaska
Department of Natural Resources
Division of Geological and Geophysical Surveys
ENERGY RESOURCES SECTION
3001 Porcupine Drive
Anchorage, Alaska 99501

Alaska Open File Report # 75

An Evaluation of Energy Alternatives, Alaska and the Western United States and Review of EIS 74-90, Section F (Energy Alternatives)

By R. M. Klein and K. M. O'Connor

February 1975

TABLE OF CONTENTS

TABLES

ILLUSTRATIONS

INTRODUCTION

An evaluation of energy alternatives of the Western United States and Alaska was undertaken by the Energy Resources Section of the DGGS at the request of the Attorney General's office. This evaluation became necessary after a review by the DGGS found the energy alternative section of the draft EIS, "Proposed Increase in Acreage to be Offered for Oil and Gas Leasing on the Outer Continental Shelves" to be little more than a description of types of energy alternatives existing in the United States at this time.

The report, on page 349, suggests that more details are available in a companion publication by the BLM entitled "Energy Alternatives and Their Environmental Impacts". This may be true, but it is our opinion that by definition, environmental impact means that a detailed analysis of alternative courses of action is mandatory and should be included in the statement itself so that at the very least, rational preliminary judgments can be made.

This report will discuss Section F of the EIS and then present our own views of the problem. The urgency for solutions to our national and state energy crisis required that this study be undertaken over a very short time period and on the basis of our in-hand data. A more comprehensive evaluation of all Alaskan energy resources is underway by the Energy Resources Section and will be completed in the near future.

DISCUSSION

COMMENTS OF DRAFT EIS SECTION F

A very major criticism of Section F is that it does not address itself to the pertinent question: Are there energy alternatives which could be utilized in the near future, and what effect would these alternatives have on the immediate needs of the nation to develop the petroleum resources of the Outer Continental Shelves? Most of the section merely contains descriptions of alternative energy systems without investigating what it all means in terms of being able to reduce the nations almost total dependency on oil and gas for energy.

There is no discussion of economics, very little discussion of real potential of alternate energy, only present development trends, etc., etc. For example, the AEC has issued growth forecasts for nuclear power which are all neatly shown in the statement, but how does this relate to O.C.S. leasing? Presumably a higher growth of nuclear power would alleviate stresses on O.C.S. leasing, but how much and how many more environmental problems would be caused by increased nuclear power capacity compared to diminished O.C.S. leasing? Would the trade off be worth it? It seems that these types of questions are fairly pertinent to any environmental analysis of energy alternatives.

The following sections contain a quick analysis of each energy alternative as contained in DES 74-90; they include:

1. A review of material presented in DES 74-90.

2. Alaska's potential for contributing to the alternate energy potential. (Unfortunately Alaska could rely 100% on alternative energy sources, export all of its oil and gas and still not affect the nations situation to any degree. Alaskan energy consumption in 1971 was only 31 million BOE per year, compared to 2,012 million BOE per year for the 12 western states (Wilkinson, 1974).

3. Due to the small effect Alaska will have on the nation (with regard to alternative energy only), whenever possible the effect of using and developing alternate energy sources within the Western United States was also considered.

4. Table I is an attempt to collect and organize pertinent data concerning alternate energy sources available in the western United States so that the various possibilities and combinations can be seen. The table is very simplistic and only looks at the more obvious factors involved and doesn't look at these in the detail needed (for example, increasing the coal supply as an alternative involves a detailed analysis of everything from capital availability, to iron ore mining, to the capacity of steel mills, to the transportation network in the U.S. None of these less obvious factors have been considered). A much more detailed analysis is definitely needed. This detailed analysis is in our opinion what should be contained in DES 74-90, but in our limited time frame and considering the availability of information to us, only

the factors in Table I were used to consider energy alternatives. At least an attempt was made, however, lacking in detail and complexity, to objectively evaluate various factors as they relate to each energy alternative. Table I considers only what contribution the western United States can make by 1985 with regard to each alternative energy choice.

The following should be noted with regard to interpreting Table I:

1. All energy figures have been converted to Barrels of Oil Equivalent (BOE). BOE is a unit of energy equivalent to the energy contained in a barrel of crude oil. (One of the major problems in interpreting DES 74-90 is that energy is represented in every conceivable form from watt-hours to cubic feet of gas. It is impossible to compare alternatives unless a common unit of energy is used.)

2. Column 8 in Table I discusses maximum possible available energy for the western United States by 1985. If conversion is made to delivered energy, other factors should enter into the computation. For example, conversion of fossil fuel energy (coal, oil, gas) to electricity involves a 66% efficiency loss, and conversion of geothermal energy to electricity involves an 86% energy efficiency loss.

3. The estimated demand for total energy use only in the 12 western states[1] in 1985 is 3200 million BOE per year or 8.7 million BOE per day. The estimated electrical demand in 1985 is 1400 million BOE per year or 3.8 BOE per day (Wilkinson, 1974).

CONCLUSIONS

Our conclusion is that there are definitely energy alternatives which can be utilized in the near term to alleviate the pressures of an all out massive campaign to develop, produce and deplete domestic oil and gas resources on the O.C.S. without regard to long term conservation concepts. A few of these alternatives are available now or will be in the near future and will probably cause comparatively few environmental problems. A number of other alternatives are readily available, but there is a question whether environmental problems created would be more pronounced or less pronounced than developing the O.C.S. Some alternatives have serious technologic, economic or environmental problems which will have to be overcome before they can be considered as viable alternatives. These various energy alternatives are shown and listed in order of preference[2] in Table I. The intent was not to condemn or advocate any one type of energy alternative. The

---

[1]These states are Alaska, California, Montana, New Mexico, Oregon, Colorado, Arizona, Utah, Wyoming, Washington, Idaho, and Nevada.

[2]This preference is a subjective judgment by the authors based on an objective evaluation of the factors listed in Table I.

attempt was to evaluate various alternatives and make realistic estimates of the value of each to the western United States within the next 10 years. It is our opinion that in the western United States, the combination of energy conservation, greater onshore exploration, rational utilization of hydroelectric energy and development of geothermal energy could not only provide more energy in the near term than O.C.S. leasing on the west coast and Alaska but may be able to do so at less environmental, technological, and economic costs.[1] However, it should be noted that further detailed studies should be undertaken by the Federal Government immediately to evaluate these alternatives and that this analysis only concerns the western states. The need for increasing domestic oil and gas reserves is real and this in no way should be construed to mean that leasing of the O.C.S. should be discontinued, only that there are alternatives, which, if followed, might allow O.C.S. to be developed in an orderly manner and with regard to long term conservation practices. The frontier O.C.S. areas are the nations last great storehouse of easily obtainable fossil fuels which can be extracted without huge environmental sacrifices. They should be treated as such. If possible, the development of our Outer Continental Shelves should be undertaken within the framework of a long range plan and not on a crash basis to satisfy the needs of short term crisis.

---

[1]For an analysis of possible energy flow in the Western U.S. in 1985, see Appendix I of this report. This shows the value to the nation of energy conservation, and development of alternate energy sources such as geothermal.

ENERGY ALTERNATIVES:

AN ANALYSIS OF EACH SOURCE

INCREASED ENERGY CONSERVATION

I. Review of DES 74-90 Section F

This was a well written general overall perusual of the possible energy saving methods available to everyone. The only fault I can find is that it didn't emphasize enough the large amount of energy which can be saved using this alternative. For example, if a 20% savings in total energy consumption could be effected for the next 10 years in the U.S. the total savings by 1985 would be 35 billion BOE, a figure which is over 30% of the total estimated recoverable oil and gas resources of the entire Alaskan O.C.S.[1], and almost double the total estimated recoverable resource base for the Gulf of Alaska O.C.S.[1].

II. Alaska's Potential

Potential for conservation in Alaska is probably less than in many other areas because of low population and due to the climate, better insulated buildings. However, a 20% reduction of energy consumption in Alaska by 1985 would probably conserve more than 9 million BOE per year[2].

III. Western U.S. Potential

Projected energy use for the 13 western states in 1985 is 8.7 million BOE per day[2]. A 20% reduction would result in a daily saving of 1.75 million BOE.

IV. Summary and Conclusions

Energy conservation is far and away one of the best short and long term answers to the energy problems of this country. A 20% reduction of energy use would entail much less personal sacrifice than most people realize (most of it could be accounted for in better insulation, smaller, lighter cars, lowered speed limits, more efficient appliances, etc.). If energy consumption was cut by 20% over the next 10 years an amount would be saved equal to 30% of the total estimated Alaska OCS recoverable oil and gas resources and double the Gulf of Alaska OCS resources. In Table I energy conservation is ranked first out of 14 possible alternatives.

---

[1]Alaska Division of Geological and Geophysical Surveys, 1974, Energy Resources of Alaska: Oil and Gas; Open File Report #50.

[2]Wilkinson, Lawrence, 1974, "Energy Resoruce Development for the West", Western Interstate Nuclear Board, Lakewood, Colorado.

INCREASED HYDROELECTRIC POWER

I. Review of DES 74-90 Section F

This section of DES 74-90 fails to fully and clearly explain the impact of hydroelectric power on the energy problem. A great number of percentages are cited but only tend to be confusing. No comparison between the amount of energy that could be contributed by hydroelectric sources and that expected from the development of the Outer Continental Shelf is made. The discussion of environmental impacts is good.

II. Alaskan Potential

If the development rate increases, Alaska may be able to supply 172 billion kilowatt hours per year in the long term and 131.8 billion per year in the near future.[1] The short term potential amounts to .613 million BOE per day.

III. Western U.S. Potential

Only 30% of the nation's hydroelectric potential is being used at this time.[2] Most of the undeveloped resources are in the Western states. Western hydroelectric power development may supply as much as 191.2 billion kilowatt hours per year by 1985.[3] This is equivalent to .89 million BOE per day.

IV. Summary and Conclusions

Adding the potential energy contributions that may be expected by 1985 from Alaska and the Western States, we obtain a figure of 1.5 million BOE per day. The demand for electricity in the Western States is expected to reach 3.8 million BOE per day by 1985.[4] If the hydroelectric resources are developed as expected the Western States (including Alaska) may be able to supply about 39% of the anticipated electricity demand.

Unfortunately, it is difficult to transport electricity over great distances. Unless Alaska is "plugged" into the nation's power grid, the electricity generated from her waters will have to remain in the state (16% of projected western demand). The Western States could supply 23% of their projected electricity demand by 1985. This alternative was ranked 2nd of a possible 14 in Table I.

---

[1]DES 74-90, page 384.

[2]"Energy from Falling Water", Energy Perspectives, No. 14, Sept. 1974.

[3]Energy Resource Development for the West, page 20.

[4]Ibid, page 4.

GEOTHERMAL

I. Review of DES 74-90 Section F

The conclusion of this section on page 415 of DES 74-90 that within 20 years geothermal energy may account for only 1 or 2 percent of total U.S. energy needs is inconsistent with many other projections. This is discussed further in the following sections.

II. Alaskan Potential

Alaska has a large potential for utilization of geothermal energy. It has been estimated that the State's geothermal resources may contain the energy equivalent of 500 billion barrels of oil assuming hot dry rock systems to be technically exploitable.[1] However, since utilization of this energy in Alaska would make only a very small overall energy saving to the U.S. as a whole (Alaska consumed only 31 million BOE[2] of energy in 1971 (Wilkinson, 1974), the problem becomes one of transporting this energy to the lower 48 and overcoming the technical problems concerned with hot dry rock exploitation. The only way to transport Alaska's geothermal energy is to convert it to electricity and connect it to the U.S. power grid through overhead transmission lines or some other method. For the short term (Gulf of Alaska oil could be on stream between 1980-85) it appears that the technologic and environmental problems associated with utilizing and transporting Alaskan geothermal resources would probably have little appreciable effect on the energy problems of the U.S. However, for the long term and for the State of Alaska's ability to supply its citizens with the energy they need (no matter how much oil and gas this State has it will be required to participate in any shortages suffered by the rest of the U.S.), an immediate program of research and development must be initiated within the State to guarantee the people a long term supply of energy at reasonable costs. This program should be funded by non-renewable energy revenues now so that when our non-renewable resource base is exhausted we have a viable alternative.

III. Western U.S. Potential

It has been estimated that in 1985 energy consumption of the 12 western states will be 8.7 million BOE per day (Wilkinson, 1974). In a statement to the Senate Committee on Interior and Insular Affairs (Serial No. 93-3 part 2, page 709), John Nassikas, Chairman of the Federal Power Commission estimated that with proper incentives the potential of geothermal energy could be almost 4.25 million BOE by 1985. (By contrast it would probably take the immediate discovery of Prudhoe Bay type reserves in the Gulf of Alaska to be producing one-half million barrels of oil per day by 1985.) 4.25 million BOE per day would be almost 50%

---

[1]Personal communication: Alaska Geological and Geophysical Surveys.

[2]BOE is Barrels of Oil Equivalent; a unit of energy equivalent to the energy in a barrel of crude oil or 5,800,000 BTU's (Western Interstate Nuclear Board def.)

of the total energy consumption of the 12 western states in 1985, and would definitely constitute more than 1 or 2 percent of total U.S. energy demands as stated in DES 74-90. Also, the indiginous energy (geothermal) would supply the western states (most of the geothermal potential of the U.S. lies in the west) and free other forms of energy to be exported east. It should be emphasized that the above figures are based on assumed potential, not present development trends. Thus, realization of the above potential would depend on a large influx of capital both from government and industry, a highly motivated and well funded research and development program by the Federal government, a much more enlightened leasing program for geothermal resources on public land and probable incentives such as a depletion allowance to allow new technologies and advance theories to be tested by industry for practical development.

IV. Summary and Conclusions

Production and conversion of geothermal heat to electricity represents by far the least detrimental method in regard to adverse environmental impact if one considers the total fuel cycle, and also energy production. For example, when the effects of a nuclear power station are considered, one has to also consider the environmental impact of strip mining the uranium ore, refining the ore, enriching the ore, and transporting the final product to the station (all of which, incidentally, consume large amounts of energy in themselves. For every 1000 BTU's of delivered energy from a nuclear fission (LWR) plant 664 BTU's are used to manufacture that energy. For every 1000 BTU's of delivered energy from dry steam geothermal sources only 99 BTU's are used to manufacture that energy.)[1]

Therefore, from an environmental, energy saving, and economic (for a discussion of the economics of geothermal energy utilization see Tsai Meidav, 1974) point of view, the immediate development of the U.S. geothermal resource base could have a significant impact on the massive campaign to develop U.S. oil and gas resources at a rate which in the final long term analysis may prove to be of more harm than good. Substituting a depletable domestic resource for a depletable foreign resource merely substitutes one source of instability for another, unless those resources are used for a transition to a permanently sustainable domestic resource base. The only way to accomplish this is to use each resource conservatively for what it is best suited for. In the long term using oil and gas to produce electricity is not only wasteful but it may prove disastrous to those segments of the economy which can use only oil and gas. Geothermal energy is uniquely suited to electrical energy production (among other things) and should be utilized as soon as possible. Geothermal energy was ranked 3rd of 14 alternatives in Table I.

---

[1]Testimony by the Oregon Office of Energy Research and Planning, September 18, 1974.

INCREASED ONSHORE PRODUCTION

I. Review of DES 74-90 Section F

Gas: The statement indicates that "Conventional gas supplies are expected to decline despite U.S. estimated gas potential" (page 356). This is a curious statement. Why, with good potential will supplies decline? The answer lies in the regulated price of gas. (Converting to BOE and assuming 42¢ per mcf for gas and $10.00 per barrel of oil: One BOE of oil is now $10.00. One BOE of gas is now $2.27. Even if $7.00 per barrel is a more realistic price, the price of gas is a tremendous bargain and this has led to its popularity with users and its unpopularity with resource suppliers. The net result is that by de-regulating the price of gas, exploration and therefore supplies should increase by a large but undetermined amount by 1985 and should be closer to Case IV on page 355 of DES 74-90 than any of the others.

Petroleum Liquids: The forecast of onshore petroleum supplies on page 356 is completely inadequate. First of all, the estimates were probably made in 1972 before the large price increase in oil and, secondly, it includes expected offshore production which doesn't make sense since one is presumably comparing offshore production with onshore. For Alaska alone the table doesn't take into account future discoveries near Prudhoe Bay, NPR-4 development, Native development and State Tidelands development. The increased price of oil has stepped up exploration in the lower 48 to the limit of available drilling rigs and shows no signs of stopping. All these factors will combine to increase domestic onshore reserves, probably far in excess of what was predicted in 1972.

II. Alaskan Potential

The combination of further development of Prudhoe Bay, Beaufort Tidelands (most of which can be drilled from shore or islands), NPR-4, exploration on Native lands, and further development of State and Federal lands make onshore Alaska a prime area for discovering onshore reserves. The State of Alaska Geological and Geophysical Surveys have estimated the potential resources of onshore Alaska as 26 billion barrels of oil and 95 trillion cubic feet of gas.

III. Western U.S. Potential

The potential for increasing onshore production in the Western U.S. is largely unknown. The price increases in oil have stimulated exploration to the limit of available rigs and will make previously uneconomic secondary and tertiary recovery systems economic. Also, low producing stripper wells previously uneconomic may be rejuvinated or will continue to produce. California is probably in a mature state of exploration, but the Rockies are in a youthful stage. The chances of finding any giant oil fields are considered small, but still possible. Thus, production will surely increase, but this may not be enough to offset declining production in known areas.

IV. Summary and Conclusions

Increased onshore oil and gas production may be a very viable energy alternative. The situation is better than shown in DES 74-90 and if gas prices are deregulated the situation will be very good. More time has to be spent on determining just how much this increase is going to amount to over the next 10 years in the entire country, in order to make meaningful comparisons. This alternative has been rated 4th out of 14 options on Table I.

INCREASED USE OF COAL

I. Review of DES 74-90 Section F

The statement fails to indicate the possible near-future contribution of coal. It merely states the reserves of low-sulfur coal in the United States and the expected production by 1980 given current economic and technological conditions. A more complete approach would be to assume that coal could be developed to its full potential by improving coal economics. This is a possibility if the U.S. could refuse to develop its domestic oil and gas resources and put a stop on all foreign imports for energy generation.

II. Alaskan Potential

According to a recent (and as of this time unpublished) report by the DGGS, Alaska may contain as much as 133 billion tons of low-sulfur coal reserves.[1] The 70 billion tons quoted in DES 74-90 seems to be somewhat pessimistic. The amount of coal in Alaska is equivalent to about 458.6 billion BOE. This is 27.6 times the amount of energy thought to be in the Gulf of Alaska Outer Continental Shelf.

III. Western U.S. Potential

According to DES 74-90, reserves of low-sulfur coal in the Western States amount to 70 billion tons. This quantity of coal is equivalent to 241.4 billion BOE. Compared with the Gulf of Alaska oil and gas resources of 16.6 billion BOE of available energy, we find that the energy contained in western coal reserves is 14.5 times that contained in Gulf of Alaska petroleum resources.

By 1982, coal-fired electricity generation may require 100 million tons of coal per year for plants which are planned for the near future or are already under construction.[2] If plant construction and coal production were increased to attempt to meet growing energy needs, we may anticipate a need of up to 200 million tons of low-sulfur coal per year. At that consumption rate, the 70 billion tons of western coal would last for 350 years producing 1.89 million BOE's of available energy per day. By 1985, with maximum development, the Gulf of Alaska may produce 109.5 million BOE per year, .3 million BOE per day. (See Table I for further clarification and comparison with other energy alternatives.)

---

[1]Open File Report #51, Mineral Resources of Alaska and the Impact of Federal Land Policies on Their Availability - Coal, by D. L. McGee and K. M. O'Connor. In press.

[2]The Independent Coal Miner, Vol. 17, No. 1, Sept. 1973.

IV. Summary and Conclusions

Coal reserves in the Western States are enormous and could serve as an important source of energy in the future if environmental difficulties are overcome and production could be drastically increased. This is much easier said than done. To increase coal production would require huge capital investments to produce the additional necessary equipment and open new mines. Several techniques for cleaning coal of pollutants are currently being investigated, but a crash program of research would have to be started if we are to expect coal to become more important as a near term source of energy. If coal could be used in greater amount for electricity generation, oil and gas that is currently being used in that capacity could be released for other uses for which there are no substitutes, such as production of synthetics, etc. This alternative was ranked 5th of a possible 14 in Table I.

INCREASED NUCLEAR CAPACITY

I. Review of DES 74-90 Section F

There is very little to review in this section since there was no analysis of the consequences of increased nuclear power capacity. How much could the capacity be increased? Would this make a significant dent in energy needs? Are there raw materials available to build the plants? What would this do to uranium reserves? Would we have to import uranium? Would enrichment facilities be able to handle increased loads? Would increased environmental problems be worth the effort? These are but a few of the questions which need to be answered, not only about nuclear power but about all energy alternatives.

II. Alaskan Potential

The potential for nuclear power to make any significant contribution to Alaskan power needs is probably small for the near and far terms. Hydroelectric and hopefully geothermal power alone can probably supply Alaska's needs into the forseeable future with much less adverse environmental impact. However, Alaska does contain potential for containing significant amounts of uranium,[1] and if nuclear power development continues at the pace projected, possible exploitation of this valuable resource in the state may be of paramount importance insofar as development in Alaska itself is concerned.

III. Western U.S. Potential

The Western U.S. contains close to 25% of the world uranium reserves and its electrical demand is such that increased nuclear power production is already planned. Therefore, an increase in power plant construction would have significant effects to the west in terms of increased mining pressures and depletion of uranium reserves. Doubling of planned reactor capacity could add .420 million BOE per day by 1985. This still constitutes only 11% of projected electric demand for the western states by 1985.

IV. Summary and Conclusions

The DES 74-90 contains forecasts for nuclear power growth, but what does this mean with regard to increased oil leasing, particularly leasing in Alaska? Increased nuclear power development would lessen the immediate need for development on the OCS. However, this would increase exploitation of uranium (which could significantly affect Alaska if uranium reserves are discovered) and would increase the environmental and technical problems from which the nuclear power industry is suffering from today. In summary, this resource could be expanded to help alleviate extraction from the OCS, the question is, is the environmental and technological tradeoff worth it? This energy source is ranked 7th out of 14 possible alternatives.

---

[1] Division of Geological and Geophysical Surveys, personal communication.

INCREASED PIPELINE IMPORTS OF NATURAL GAS

I. Review of DES 74-90 Section F

This particular alternative has been reasonably well presented in this section. The analysis fails to point out two very critical problems which would have to be dealt with if Canadian imports were to be greatly expanded:

1. It would incur a large drain on the U.S. Treasury. For the expanded case, it would cost the United States (after subtracting the estimated throughput of Prudhoe Bay gas[1]) an estimated 700 million dollars per year. (This is at U.S. regulated prices of $.42 per MCF, at $1.00 per MCF it would cost 1.7 billion dollars per year.)

2. The reluctance of Canada to export her gas to the United States. Canada has recently told the northwestern states to expect large cutbacks of Canadian gas in the near future.

II. Alaskan Potential

Alaska's natural gas potential recoverable resource base is very large. It is estimated to be anywhere from 188 TCF[2] (trillion cubic feet) to 400 TCF[3] of which only about 30 TCF[3] has been discovered. Alaska will be a significant supplier of natural gas in the future when the price becomes deregulated, but the resource is depletable and this gas should be conserved and used for only those purposes for which it is uniquely suited.

III. Western U.S. Potential

About 75% of Canadian imports have been used in the west, but recent policy changes in the Canadian government have increased prices and in some cases cancelled long term contracts to the United States. Therefore, the potential for increasing this supply is very limited, unless large amounts can be found and imported from Mexico.

IV. Summary and Conclusions

Over the short term and long term, depending on increasing imports is not the answer to the United States energy problems. Although it does conserve domestic resources and is environmentally a reasonable alternative, its instability and large economic sacrifices combine to make it an unviable alternative. When compared with other energy alternatives discussed in DES 74-90 (Table I), it ranked 9th out of a possible 14 alternatives.

---

[1]El Paso Natural Gas, personal communication.

[2]Energy Resources of the United States, 1972, U.S. Geol. Survey Circ. 659.

[3]Alaska Division of Geological and Geophysical Surveys, 1974, Energy Resources of Alaska - Oil and Gas, Open File Report #50.

INCREASED LNG IMPORTS

I. Review of DES 74-90 Section F

This section did not discuss the relative advantages or disadvantages of LNG imports. It would cost the U.S. in balance of payments almost 5 billion dollars per year (at an estimated $1.25 per MCF) in 1985 according to estimates of potential LNG imports given in DES 74-90.

Also, much of the LNG would be coming from unstable political areas of the world and would therefore be unreliable.

II. Alaskan Potential

Alaska will be a major supplier of natural gas to the U.S. Much of this gas will be in LNG form even if the now proposed pipeline is built through Canada. The details of Alaska's natural gas potential are given under the preceding section on pipeline imports.

III. Western U.S. Potential

Most of the imported LNG will come to the east coast. However, a significant exception is the large reserves in Siberia which would probably be imported to the west coast. One 42 inch pipeline simillar to the El Paso proposal for the trans-Alaska gas pipeline could supply the west coast with 3.5 billion cubic feet of gas per day, or about .648 million BOE. The 12 western states are estimated to consume 8.7 million BOE per day in 1985.[1]

IV. Summary and Conclusions

The major benefits and drawbacks to increasing this alternative are the same as pipeline imported gas, that is, it would increase domestic conservation and is environmentally acceptable, but the economics and instability factors make this a less viable alternative than some others. Table I discusses a number of factors involved in comparing this alternative with others. Considering these factors LNG imports ranked 10th out of 14 alternatives.

---

[1]Wilkinson, Lawrence, 1974, Energy Resource Development for the West: Western Interstate Nuclear Board, Lakewood, Colorado.

INCREASED OIL IMPORTS

I. Review of DES 74-90, Section F

This section discussed quite well the potential problems associated with increased oil imports; balance of payments, instabilities and construction of supertanker ports. However, there are some benefits, the greatest being conservation of domestic resources.

II. Alaskan Potential

Alaska will be a net exporter of petroleum, and should not be subject to imported energy problems for a long time. However, oil and gas are depletable resources. The United States uses about 20 million barrels of oil per day and Alaska may contain a resource base of 86 billion barrels.[1] If Alaska supplied all the lower 48 needs its estimated resource base would last 12 years. This is obviously impossible, but it makes the point that Alaska's resources are depletable. The state should begin programs to implement alternate energy sources immediately and use revenue from depletable resources to develop these alternative energy sources.

III. Western U.S. Potential

Most of the oil imports will come to the east coast. West coast sources would be Canada and Siberia. If oil imports were increased these could be significant suppliers subject to stipulations indicated under Section I.

IV. Summary and Conclusions

This is an unviable alternative for the same reasons as discussed under importing natural gas. The environmental problems are greater than in importing gas, but it would conserve domestic petroleum resources, at a tremendous cost to the nation. This alternative was ranked 11th out of 14 alternatives in Table I.

---

[1]Division of Geological and Geophysical Surveys, Alaska Open File Report #50.

SOLAR ENERGY

I. Review of DES 74-90 Section F

The DES 74-90 discussion of solar energy is greatly lacking in detailed information. There is no mention of actual costs of any of the various conversion methods mentioned in the text and the uses are not discussed in enough detail. How much land would have to be covered by solar cells to produce a certain amount of electricity? How much energy could be saved by a house heated and cooled by solar energy? The statement failed to discuss at least three indirect methods of harnessing solar power -- wind, ocean currents and biological photosynthesis.[1] Each different form should have been discussed and evaluated as to cost, environmental impact, technology and eventual contribution to the energy crisis.

II. Alaskan Potential

Alaska does not possess a large potential for direct uses of solar energy. Over most of the state, there isn't enough direct sunlight for an adequate length of time to warrant the use of solar cells or thermal systems to produce electricity for either single residences or on a larger scale for whole cities. Residential solar heating and cooling systems have a low potential for use in the 49th State also. In the Aleutians there is a large potential for using wind energy to generate electricity for local communities, although methods need to be perfected to store the electricity over calm days. Any attempt to use ocean currents will necessitate construction of extremely strong undersea "windmills" to withstand severe storms.

III. Western U.S. Potential

States in the more southern section of the U.S. have a better chance of using solar energy to produce electricity directly or heat and cool their homes and businesses due to a more appropriate climate. Wind, ocean thermal gradients, ocean currents, and biological photosynthesis all have good potentials for use in the Western States if technologies could be developed to store the energy and reduce the sizes of the systems. Using solar energy to provide the heat for bioconversion of wastes is a particularly attractive proposition.

IV. Summary and Conclusions

The use of solar energy would require many changes but could contribute a significant amount to the energy shortage. At this time solar energy is more expensive than oil and gas, but it is quickly becoming more comparable in price. It appears now that the best uses of the sun may be in heating and cooling private homes and businesses.

---

[1]Alternate Energy Sources, Energy Perspectives, "Energy from the Sun - Part One", Issue No. 12, July 1974.

This alone could constitute a great savings of petroleum products. Converting waste to methane and oil would be advantageous in two ways: (1) It would help solve waste disposal problems; and (2) it would result in useful energy products. This process has been used successfully in Chicago and Los Angeles but technical problems remain to be solved before it can be used on a large scale. This alternative was ranked 12th of a possible 14 in Table I.

SYNTHETIC NATURAL GAS AND OIL PRODUCTION

I. Review of DES 74-90 Section F

This section of DES 74-90 discusses only above-ground processing of coal and petroleum and neglects in-situ conversion of coal. No comparison of available energy was made between that which could be supplied by coal and natural petroleum. The possibility of air pollution is reduced by coal conversion because sulfur and particulates are removed during the process.

II. Alaskan Potential

Alaska contains enormous coal resources, much of which might be converted to gas and oil.[1] A study is necessary to compare the economic and environmental aspects of mining the coal and processing it within the State versus exporting the raw coal to refineries in the continental U.S. In-situ processing would have the least environmental impact and is especially applicable to much of the coal in Alaska. The amount of energy in Alaskan coal was discussed in Part 4 - Increased Use of Coal.

III. Western U.S. Potential

The 70 billion tons of low-sulfur coal reserves and much of the other coal in the Western States could be used for conversion to gas and liquid hydrocarbons.

IV. Summary and Conclusions

Converting oil to gas seems to be a waste of energy. Oil can be used for other things besides the production of gas. Importing oil and natural gas for feedstocks defeats the whole purpose of Project Independence and should not be considered as a viable alternative. If enough incentive could be supplied, coal gasification and liquifaction could be important contributions to the energy supply. An increase in coal production would require large amounts of capital, an increase in the production of iron ore and other metals for the manufacture of equipment. Techniques for in-situ processing and land reclamation should be encouraged. A plant is in operation in the U.S.S.R. which is extracting low-BTU gas from burning coal in the ground and using the gas to generate electricity. The process has proved to be economically feasible. Techniques are in the pilot plant stage which allow the refinement of coal into petroleum products that could replace natural oil and gas. A combination of the Solvent Refined Coal and Bi-Gas processes has been proposed which would result in a synthetic natural gas, propane, fuel oil, and solvent refined coal (which can be burned to generate electricity). Sulfur and other pollutants are extracted during the process and become valuable by-products. This alternative was ranked 13th of a possible 14 in Table I.

---

[1] Open File Report #51, Mineral Resources of Alaska and the Impact of Federal Land Policies on Their Availability - Coal, by D. L. McGee and K. M. O'Connor. In press.

OIL SHALE PRODUCTION

I. Review of DES 74-90 Section F

Again, DES 74-90 fails to compare the amounts of energy that could potentially be supplied by oil shale with O.C.S. development. The statement also makes no mention of the quantity of resources or reserves, it merely mentions that "Oil shale occurs in large volumes throughout the U.S. and potentially could contribute significantly to U.S. energy supplies." (DES 74-90, page 399) This section also lacks any conclusions. The environment aspects are discussed adequately.

II. Alaskan Potential

Alaska's oil shale potential is thought to be quite large, but so far only minor studies have been made and the data are unavailable at this time.

III. Western U.S. Potential

The U.S. has an oil shale potential of over 2 trillion BOE and the western states contain most of that amount.[1] Project Independence calls for production of at least 500,000 BOE per day by 1980.[1] That would amount to 182.5 million BOE per year. At that rate, U.S. reserves could supply energy for approximately 11,000 years. Note that the Alaskan Gulf of Alaska O.C.S. will probably supply 109.5 million BOE per year with a total resource of 16.6 billion BOE.

IV. Summary and Conclusions

Although the oil shale potential is large, there are extreme environmental problems associated with its production that may well over-shadow its benefits. The most environmentally sound method with which to mine oil shale is in-situ, that is, actually extracting the oil from the shale while it is still in the ground. Some success has been achieved in combining underground mining and in-situ retorting. If more lucrative incentives were offered, perhaps this method would find more commercial use in the near future. Oil shale petroleum can only marginally compete economically with conventional petroleum at current prices. This alternative was ranked 14th of a possible 14 in Table I.

---

[1]Alternate Energy Sources, Energy Management, Federal Energy Administration, Commerce Clearing House, Chicago, Illinois.

TABLE I COMPARISON OF SOME PERTINENT FACTORS OF ENERGY ALTERNATIVES DISCUSSED IN DES 74-90*

ENERGY ALTERNATIVE	AVAILABILITY	STATE OF TECHNOLOGY	ECONOMICS	ADVERSE ENVIRONMENTAL CONSEQUENCES	CONSERVATION	EXTERNAL ENERGY USED TO PRODUCE THE ENERGY BTU/1000 BTU'S OF DELIVERED ENERGY[1]	MAXIMUM POSSIBLE CONTRIBUTION BY 1985 AVAILABLE BOE/DAY (WESTERN U.S. ONLY)	BENEFICIAL ENVIRONMENTAL CONSEQUENCES
Increase energy conservation	Immediately	Presently available	May decrease industrial growth with consequent loss of jobs May increase recession potential	None	Excellent	0	Assuming a 20% reduction in projected energy demand 1.75 million[2]	1. Reduces all potential pollution and a portion of existing pollution
Western U.S. Increase Hydroelectric Alaska	Only subject to construction and development time Only subject to construction and development time	Present technology adequate	Economically competetive Requires large initial capital investment	1. Eliminates large areas for multiple land use 2. Large negative effect on indigenous and anadromous fisheries	Hydroelectric is essentially a renewable resource and it helps conserve other depletable resources	32±	Using projected figures for hydro-electric development in 1985: .893 million[3] If Anchorage and Fairbanks are 100% hydro by 1985 Alaska could export an additional .007 million	1. Reduces air pollution 2. Recreation areas
Geothermal	Only available in certain areas and is non transportable Subject to discovery of resource and consequent development Also subject to Federal leasing program	Present technology adequate for dry steam and flashed steam fields Inadequate for hot water and dry rock, but demonstration technology available shortly	Dry steam and flashed steam very economic With proper technology hot water and dry rock would be economic with nuclear and fossil fuels	Comparatively small 1. Noise 2. Possible noxious gases and disposal problems 3. Development factors	Only small amounts of dry steam are known and it is depletable. A much greater amount of hot water and dry rock exist. Utilization would conserve oil and gas resources	57± (Electric)	50% of the geothermal potential stated by the Chairman of the Federal Power Commission 2.12 million[2]	1. Only small area of land affected and it is not developed 2. Reduce air pollution 3. Excellent socioeconomic effects
Increase onshore oil and gas production	Needs to be discovered before production can commence Exploration stage Rockies - Young California - Mature Alaska - Infant	Present technology adequate except for future more efficient recovery techniques	Oil - excellent Gas - poor, due to regulated low prices	Comparatively small Oil spills, pipeline breaks, and development activity	All out exploitation will deplete domestic reserves faster and postpone development of non-depletable alternate energy	250± (Oil) 345± North Slope Oil 24± Natural gas	If discovered maximum, presently unable to estimate but probably less than .5 million[5]	1. Reduce offshore environmental damage
Increase coal production for conventional use	Only subject to development time	Present technology adequate for coal removal; inadequate for eliminating pollutants	Economically competitive	High adverse impact 1. Disrupt large areas of surface 2. Air pollution during mining and burning	Conserve oil and gas, but is depletable, creates large disrupted areas which can only be used if and when large scale reclamation takes place	566± (Electric only)	Assuming electric use only, and doubling planned development to 1982 1.89 million This is still only 49% of projected 1985 electric demand[6]	1. Possible creation of recreation areas
West Coast OCS leasing	Needs to be leased, discovered and developed	Present technology available	Economically feasible, direct market, most facilities for transport, refining, development, etc. are available (due in part to declining California production)	1. Oil spills 2. Increased development in area of high population density 3. Increased air pollution 4. Visual pollution	Depletable resource ideally oil and gas should be conserved for demands that only they can satisfy	250±	Maximum if discovered: presently unable to estimate but less than .3 million[7]	1. Exploitation near an already developed area under similiar conditions
Increase nuclear power	Only subject to availability of construction materials and enriched uranium and time to construct	Present technology adequate except for radioactive waste disposal	Presently competitive with other forms of electric generation Requires large capital investment in power station, uranium exploitation, and uranium enrichment	1. Strip mining 2. Radioactive waste 3. Development of mills and enrichment plants 4. Radiation hazards 5. Thermal pollution 6. Development of power plants and mining areas	Conserve domestic oil and gas resources all out effort could deplete domestic U_3O_8 resources before breeder is developed	451± (Electric only)	Doubling the now planned reactor capacity: .420 million[6] This is still only 11% of projected 1985 electrical demand in Western U.S.	1. Air pollution benefits
Alaska OCS leasing	Needs to be leased, discovered, and developed	Technology partially available, the remainder is more of an extension of known engineering principles than new concepts	Economically feasible but large transportation and development costs	1. Oil spills from wells and tankers 2. Massive in a totally undeveloped area 3. Air pollution	Depletable resource ideally oil and gas should be conserved for demands that only they can satisfy	300±	If discovered maximum: .3 million[7]	
Increased pipeline imports of natural gas	Needs to be discovered and pipelines built before production can begin, most would be from Canada and this is an unreliable source	Present technology adequate except for Arctic development technology	Subject to radical price increases, interuptions in supply, and balance of payments, leads to depressed domestic exploration and production	Comparatively small Development activity	Conserves domestic gas resources, but limits the incentive to develop domestic gas reserves and other domestic alternate energy sources	24±	Using 74% of the most optimistic case in DES 74-90 1 million[3]	Cleanest burning fuel available very little damage in extraction process transportation simple cheap and does little environmental damage
Increased LNG imports	Subject to construction of LNG tankers, plants, pipelines, etc. BUT UNRELIABLE	Present technology adequate	Presently poor due to artificial price controls, requires large front end capital investment balance of payments depress domestic market	Comparatively small Development activity and tanker problems	Conserves domestic gas resources but limits incentive to explore domestically thus lowering U.S. reserves	48±	Assuming 42" gas pipeline from Siberia delivered to West Coast .648 million[8]	Help eliminate air pollution problems, other environmental problems are minimal
Increase energy imports (Oil)	Immediate availability but unreliable	Present technology except for construction of more supertankers and ports	Subject to radical price increases, supply problems, balance of payments, etc., leads to depressed domestic exploration and production	Supertankers - 1. Major oil spills 2. Construction deep water ports 3. Major shoreline developments 4. Increased air pollution due to burning	Conserve domestic resources, but is a depletable resource	300±	Probably unrealistic because the west is self sufficient in energy, imports would mainly go to East Coast	1. Reduce oil spill potential from blowouts 2. Less domestic development
Solar energy	Immediately available depending on climate and construction and development time	Technology not available for large scale electric generation, however, residential solar heating and cooling is available now	Residential:	Individual units very little or none, large scale units would adversely effect the ecology of large areas and create some visual pollution	Non depletable energy resource and would conserve other domestic energy sources can only be used in certain areas	Unknown but small	Presently unable to estimate	Completely clean, unobtrusive and can be designed into each building
Synthetic gas and oil production	Production would be from coal, which is available, subject to development time	Small amount of demonstration technology, no commercial technology available	Requires large front end capital investment, hasn't been proven to be economic yet	1. Strip mining 2. Air pollution 3. Water problems 4. Development problems	Coal is depletable but conserves oil and gas and can directly substitute for gas	138± (Non electric) 519± (Electric)	Most favorable estimates by National Petr. Council in DES 74-90, estimate based on relative proportion of low sulfur coal reserves in east and west U.S. 1.3 million[3]	1. Air pollution diminished 2. Eases transportation problems
Oil shale production	Available subject to construction of refineries, leasing of land, and startup of mining activities	Demonstration technology exists but there has never been any commercial production	More favorable than in the past but rising costs, and due to the tremendous front end capital investment, it still may be marginal	1. Strip mining and development 2. Disposing of the spent oil shale 3. Large amounts of water are needed 4. Water and air pollution	A depletable resource, but would conserve domestic oil and gas and more importantly could directly substitute for these resources	483± (Non electric) 1576± (Electric)	Department of Interior estimates: 1 million3	

* References for the material contained in this table which is not cited is contained in the REFERENCES at the end of the report, or is a result of expertise in the Division of Geological and Geophysical Surveys.

REFERENCES FOR TABLE I

1. Testimony prepared by Oregon Office of Energy Research and Planning, September 18, 1974.

2. Wilkinson, Lawrence, 1974, "Energy Resource Development for the West", Western Interstate Nuclear Board, Lakewood, Colorado.

3. U.S. Department of Interior, Draft Environmental Statement, Proposed increase in acreage to be offered for oil and gas leasing on the Outer Continental Shelf, DES 74-90.

4. Alaska Power Survey. 1974, Resources and Electric Power Generation in Alaska.

5. The recent economic situation has created a much more favorable climate for increasing onshore reserves, but in the time available we were unable to make an estimate of just how much it will contribute.

6. It should be remembered that increasing to a great extent the production of anything involves much more than ordinarily comes to mind, such as availability of steel, labor, water, etc. As such, this prediction may simply be physically impossible to do even if all other factors are good.

7. This estimate is based on the realities of platform construction, etc. It assumes that significant discoveries will take place.

8. El Paso Natural Gas, personal communication.

RANKING OF ALTERNATE ENERGY RESOURCES

The following grid (Table II) corresponds to Table I. The effects of each factor on each energy alternative were rated on a scale of one to ten. A rating of one indicates the smallest adverse effect from the energy alternative, and ten indicates a large adverse impact.

Summation of these numbers allows the ranking of each energy alternative with regard to the factors considered. This is a subjective ranking based on the authors' opinions. The economic factor was weighted by three because it is the most influential factor. For example, in all other respects, importing energy is an excellent alternative, except that the economic problems associated with it make it prohibitive.

TABLE II RANKING OF ALTERNATE ENERGY RESOURCES

ENERGY ALTERNATIVE	AVAILABILITY	STATE OF TECHNOLOGY	ECONOMICS (WEIGHT FACTOR X 3)	ADVERSE ENVIRONMENTAL CONSEQUENCES	CONSERVATION	EXTERNAL ENERGY USED TO PRODUCE THE ENERGY BTU/1000 BTU'S OF DELIVERED ENERGY	MAXIMUM POSSIBLE CONTRIBUTION BY 1985 AVAILABLE BOE/DAY (WESTERN U.S. ONLY)	TOTAL
Increase energy conservation	1	1	1	1	1	1	2	10
Increase hydroelectric	3	1	1	3	2	1	6	19
Geothermal	9	3	4	3	4	2	1	34
Increase onshore oil and gas production	6	1	1	4	9	5	8	36
Increase coal production for conventional use	3	1	3	8	4	10	2	37
West Coast OCS leasing	6	1	2	5	9	5	8	40
Increase nuclear power	3	5	3	10	3	8	8	46
Alaska OCS leasing	6	3	3	6	9	6	8	47
Increased pipeline imports of natural gas	6	1	10	3	2	1	5	48
Increased LNG imports	5	2	10	4	2	1	7	51
Increase energy imports (Oil)	3	3	10	6	2	6	1	51
Solar energy (large scale)	6	7	8	4	2	1	8	52
Synthetic gas and oil production	5	7	8	8	4	3	4	55
Oil shale production	3	7	8	9	5	10	5	63

Each factor rated 1 - 10, 1 is best and 10 is worst.

APPENDIX I

ENERGY MODELS: WESTERN U.S.

CONCLUSIONS

FROM ANALYSIS OF ENERGY MODELS OF WESTERN U.S.

1. Figure 1 indicates projections of energy use for the western U.S. Note that this projection assumes that the west will use the same percentage of total U.S. energy in 1985 as in 1970. This may be a low estimate, because the west is growing at a faster rate than the rest of the country and thus by 1985 will probably be using more than 15% of the total U.S. demand. However present energy conservation measures will offset this so the curve is probably fairly realistic.

2. The increase of electricity in the energy mix (Fig. 2), will require large amounts of raw energy to produce it (particularly note the increase in planned coal use from Fig. 3 to Fig. 4). One wonders how much of the 1.2 million BOE per day of electricity for residential and industrial uses (Fig. 4) will be used for heating and cooking purposes. (Direct use of coal or oil for heating is 75% efficient; their use for electric generation is 32% efficient.)

3. Assuming that onshore production in the western U.S. of oil and gas will remain the same in 1985 as it was in 1971, (this is a very tenuous assumption since production is declining rapidly, however, price increases have increased exploration), and assuming Prudhoe Bay oil and gas come to the west coast, and assuming energy flow and amounts as shown on Fig. 4. Western U.S. will be just self-sufficient in gas and will have to import .61 million BOE per day of oil in 1985. With maximum exploratory success and no technologic problems it would barely be possible for the OCS areas off California and Alaska to make up this difference. Using these assumptions, but conserving 20% of total energy use and expanding coal and geothermal potential, Fig. 5 indicates that by 1985 the western U.S. could be exporting .43 BOE per day of gas, and 1.75 million BOE per day of oil.

   The real situation will probably lie somewhere between these two models. The key to both models with regard to OCS leasing is how much onshore oil and gas can the western U.S. supply. An analysis of this situation is needed, and may be done, but in the time frame allowed we were unable to get the information.

4. These energy flow models are very informative and can be used extensively in planning for future needs with regard to oil and gas development and exploration, industrial development, population expansion, etc. It is suggested that a model for Alaska be set up immediately to better be able to predict the energy needs, and types of alternate energy for the state. For example, should we depend so heavily on natural gas to generate our electricity, or are we heading in the same direction as Los Angeles (Fig. 6)?

Figure 1

TOTAL ENERGY USE AND TOTAL ELECTRICAL DEMAND PROJECTED FOR WESTERN U.S.

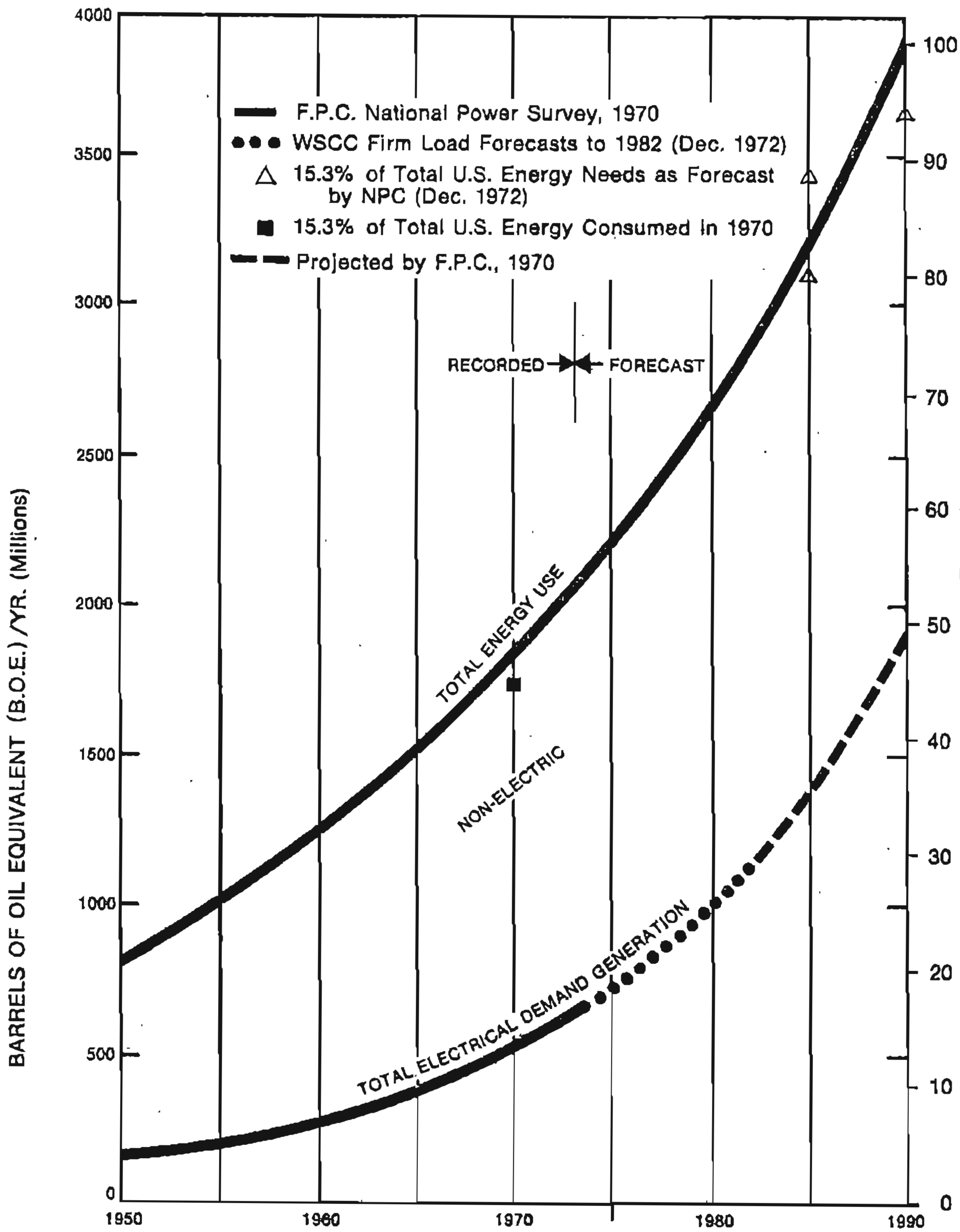
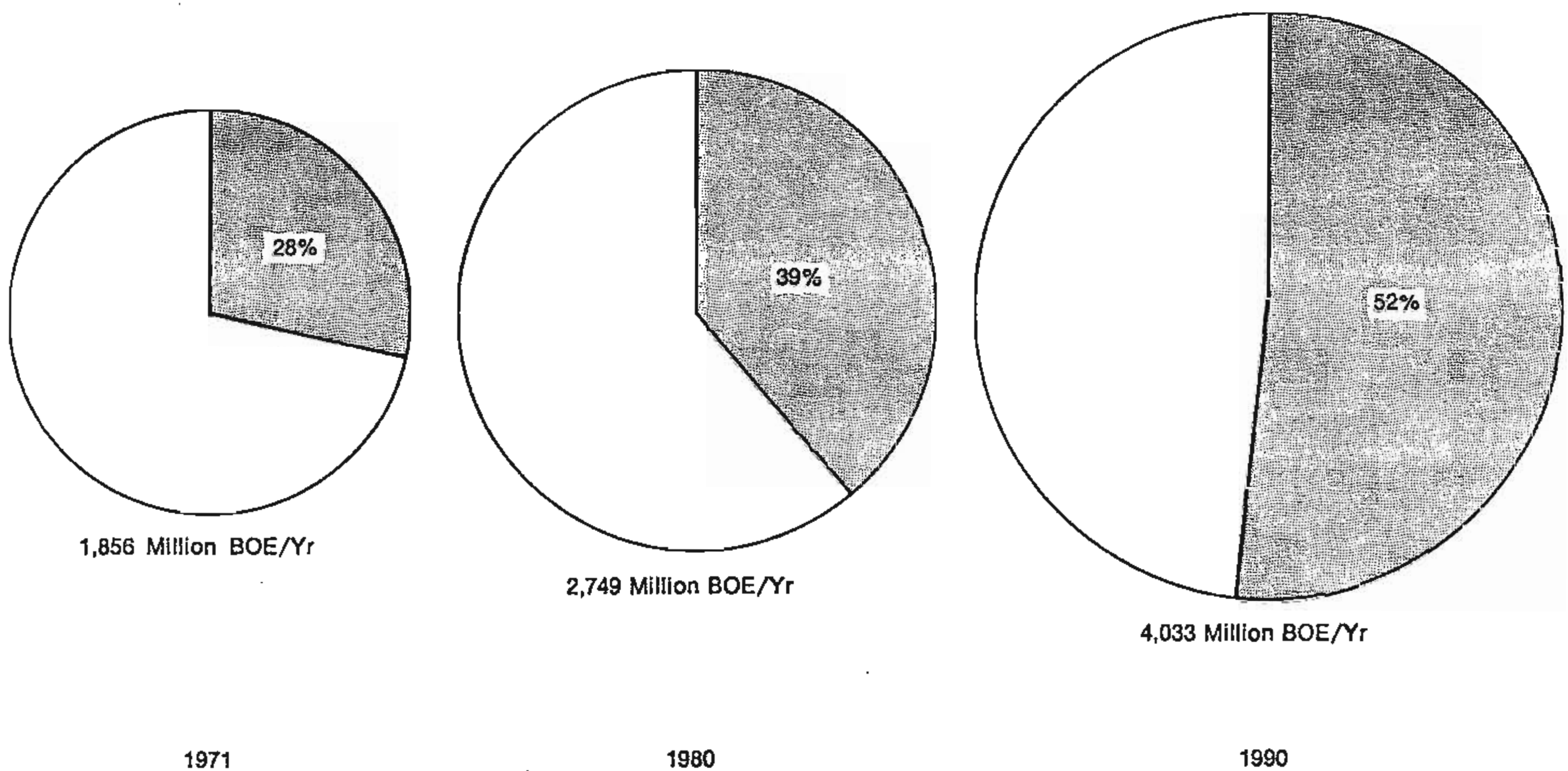


Figure 2

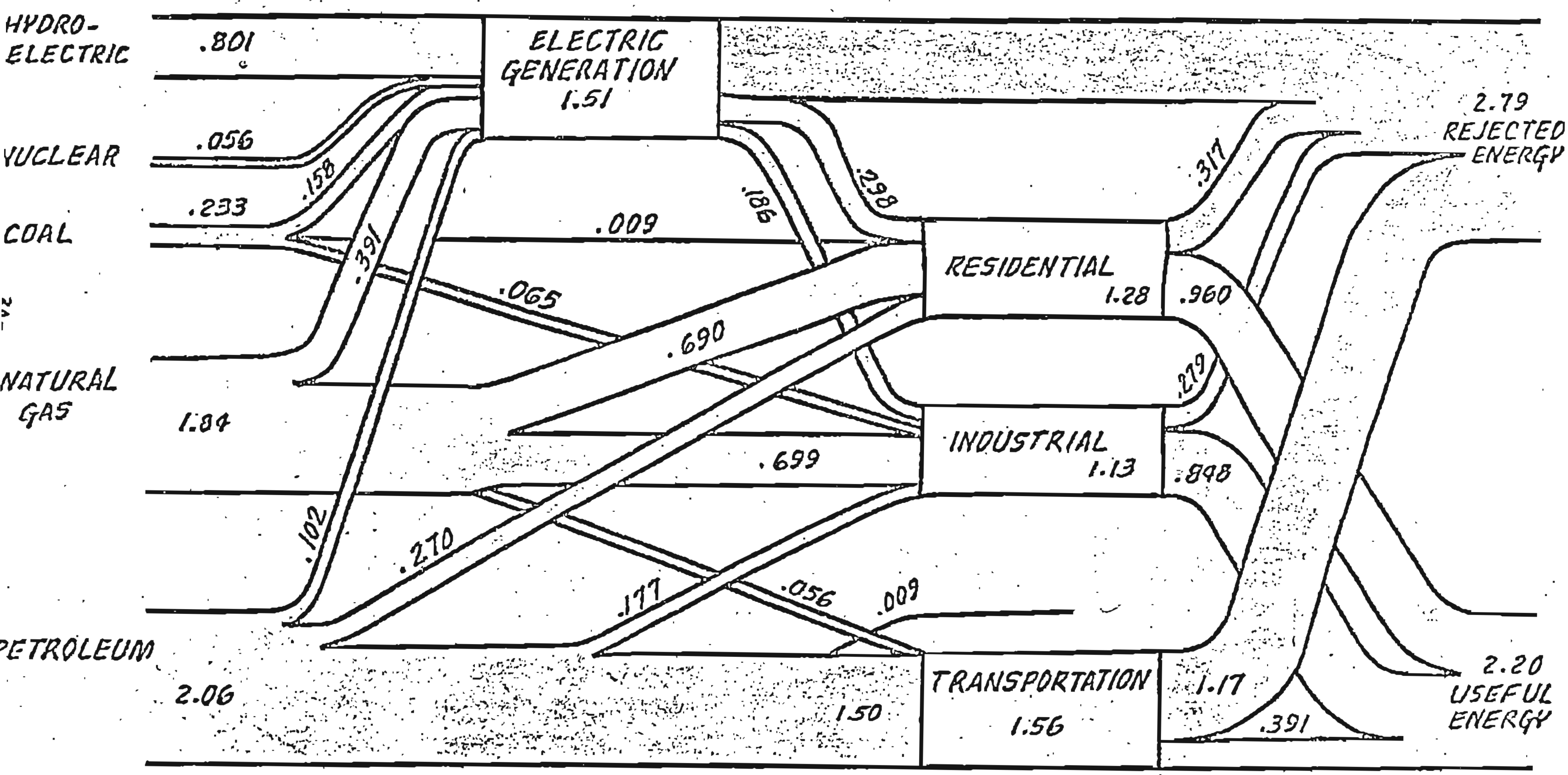
PROJECTED ELECTRICAL PORTION OF FUTURE ENERGY DEMANDS IN WINB MEMBER STATES



SOURCE: FPC 1970 National Power Survey

Fig.3

ENERGY UTILIZATION: WESTERN U.S.-1971 *
BARRELS OF OIL EQUIVALENT PER DAY IN MILLIONS

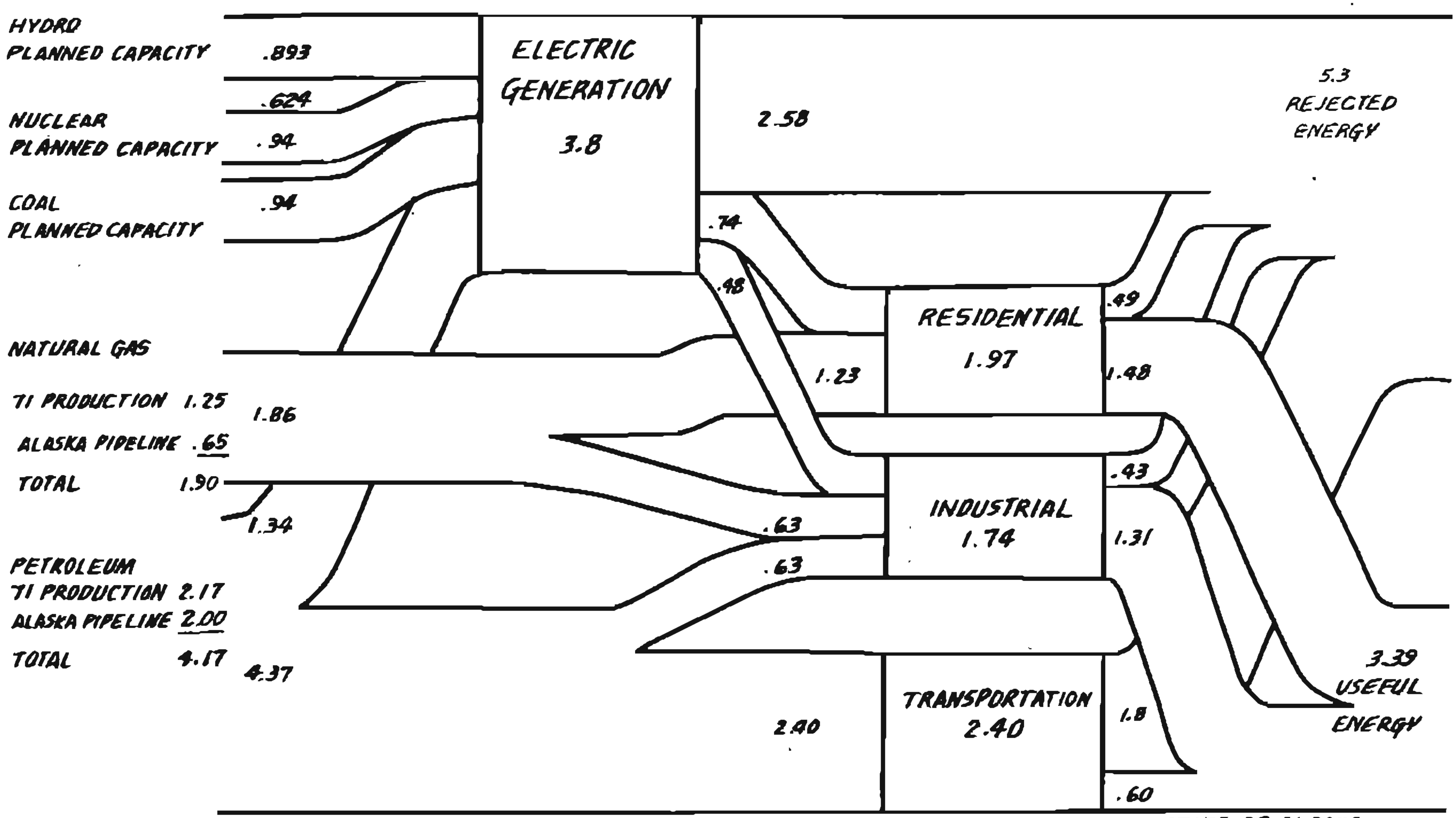


* MODIFIED FROM WILKINSON, (1974).

Fig. 4

SIMPLE ENERGY MODEL: WESTERN U.S. 1985

BARRELS OF OIL EQUIVALENT PER DAY IN MILLIONS

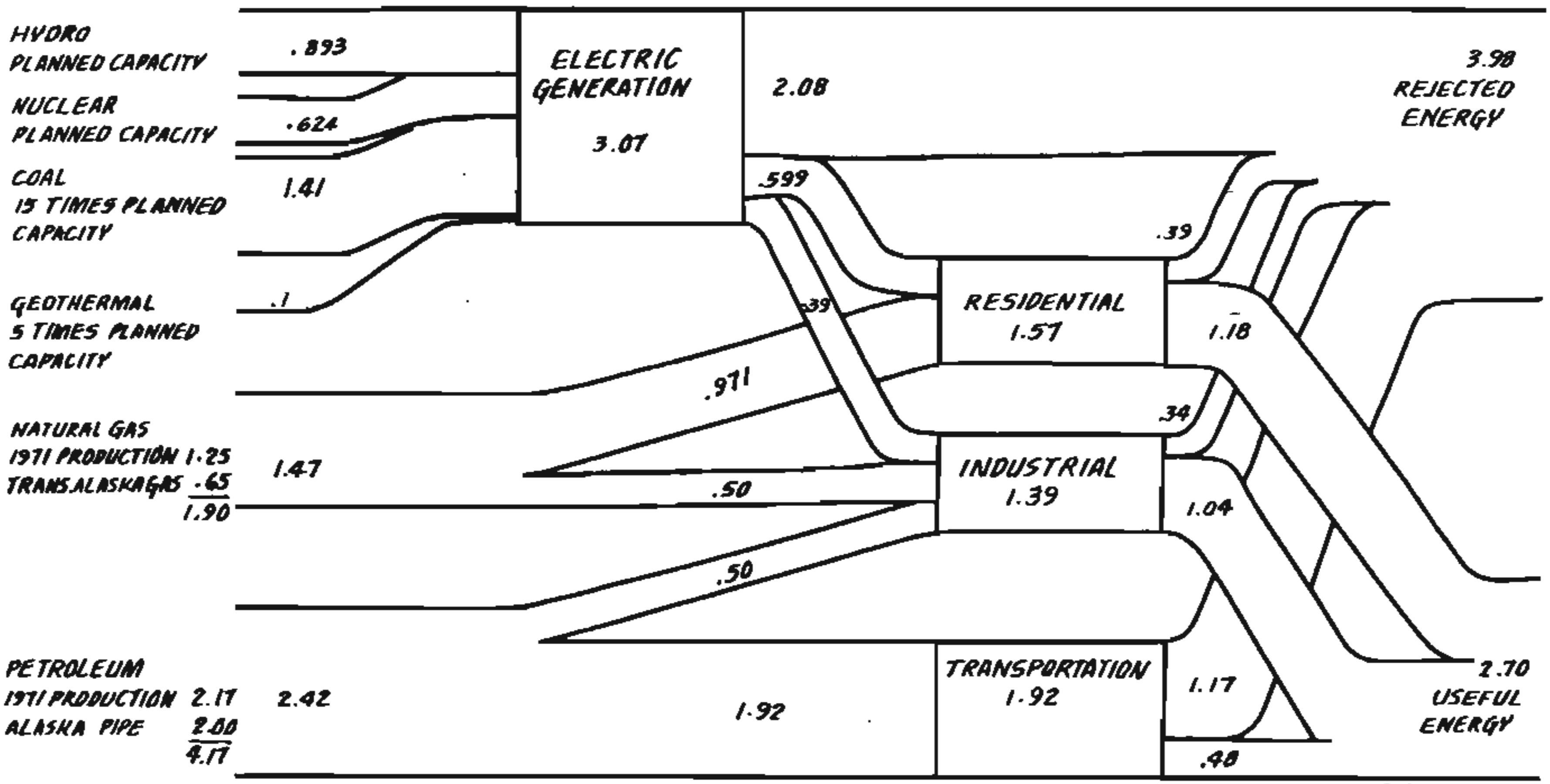


ASSUMPTIONS:
1. 100% OF PROJECTED ENERGY ENERGY DEMAND (WILKINSON, 1974)
2. NUCLEAR, COAL & HYDROELECTRIC AT PLANNED CAPACITY
3. ELECTRIC ENERGY EQUALS 45% OF TOTAL ENERGY MIX

STATE OF ALASKA
DGGS
R. M. KLEIN

Fig. 5

SIMPLE ENERGY MODEL: WESTERN U.S. 1985
BARRELS OF OIL EQUIVALENT PER DAY IN MILLIONS



ASSUMPTIONS:
1. 80% OF PROJECTED DEMAND
2. COAL EXPLOITED AT 1.5 TIMES PLANNED CAPACITY
3. GEOTHERMAL EXPLOITED 5 TIMES PLANNED CAPACITY
4. ELECTRICITY IS 45% OF ENERGY MIX

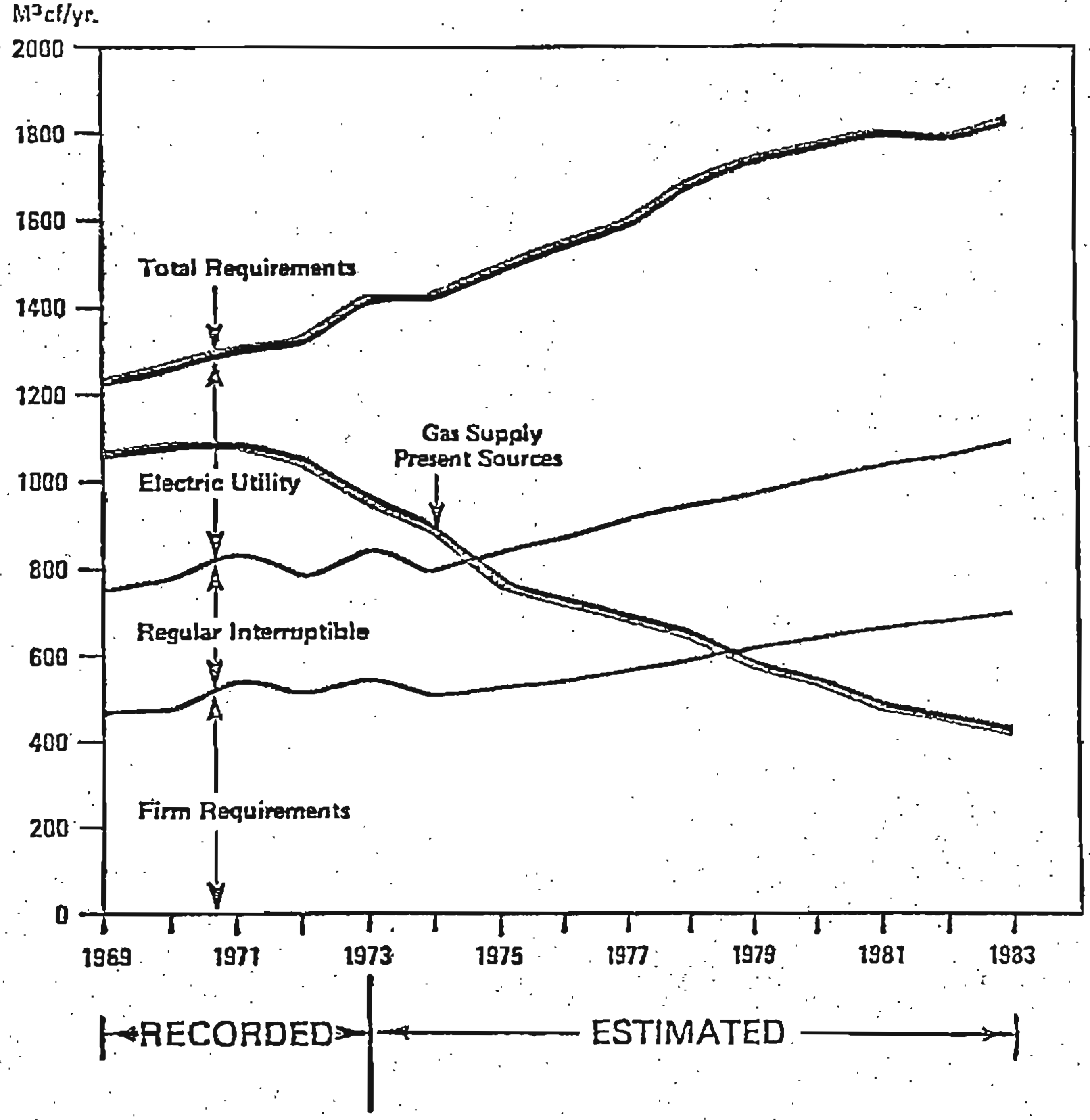
STATE OF ALASKA
DGGS
R.M. KLEIN

Fig. 6

Pacific Lighting Utilities

GAS SUPPLY-REQUIREMENTS COMPARISON

PRESENT GAS SUPPLY SOURCES



SOURCE: 1974 California Gas Report

REFERENCES

Alaska Power Survey, 1974, A report of the technical advisory committee; "Resources and Electric Power Generation".

Armstead, Christopher H., 1973, Geothermal Energy: The Unesco Press, Bulletin No. 12.

"Combustion of High-Sulfur Coal without Air Pollution is Definite", The Independent Coal Operator, Vol. 17, No. 1, September 1973.

Dieckamp, H., 1971, The Fast Breeder Reactor Transactions of the American Geophysical Union E.O.S.: Vol. 52, No. 11.

"Energy from the Ocean", Energy Perspectives, No. 13, August 1974, Battelle Memorial Institute, Columbus, Ohio.

"Energy from Falling Water", Energy Perspectives, No. 14, September 1974, Battelle Memorial Institute, Columbus, Ohio.

"Energy from the Sun", Energy Perspectives, No. 12, July 1974, Battelle Memorial Institute, Columbus, Ohio.

Federal Energy Administration, "Alternate Energy Sources", Energy Management: Clearing House, Inc., Chicago, Ill.

Finney, J. P., The Geysers Geothermal Power Plant: Chemical Engineering Progress, July 1972.

Klein, R. M., et al, 1974, Energy and Mineral Resources of Alaska and the Impact of Federal Land Policies on Their Availability - Oil and Gas: Alaska Div. of Geol. and Geoph. Surveys, Open File Report #50. (Also in press: Uranium and Geothermal)

Kovacik, J. M., "Which Energy Systems for Coal Gasification Plants?", Oil and Gas Journal, Dec. 16, 1974.

Kruger, P., and Otte, C. (Ed.), 1973, Geothermal Energy, Standard University Press, Stanford, California.

McGee, D. L. and O'Connor, K. M., Energy and Mineral Resources of Alaska - Coal: Alaska Div. of Geol. and Geoph. Surveys, Open File Report #51, (in press).

Meidav, Tsvi, 1974, "Geothermal opportunities bear closer look": Oil and Gas Journal, May 13, 1974.

Muffler, L. J. P., 1973, Geothermal Resources: U.S. Geol. Survey Prof. Paper 820.

Oregon Office of Energy Research and Planning, Testimony given September 18, 1974.

Salvon, Dennis E., 1973, Survey of Energy Resources in the Pacific Northwest: Seattle Chamber of Commerce.

"Synthetic Liquid Fuel from Coal", Energy Perspectives, No. 10, May 1974, Battelle Memorial Institute, Columbus, Ohio.

Theobald, P. K., et al, 1972, Energy Resources of the United States: U.S. Geol. Survey, Circular 650.

U.S.A.E.C. Statistical Data of the Uranium Industry, Jan. 1, 1974, Grand Junction Office.

U.S. Dept. of Interior, 1974, Draft Environmental Statement, Proposed Increase in acreage to be offered for oil and gas leasing on Outer Continental Shelf, DES 74-90.

Wilkinson, Lawrence, 1974, "Energy Resource Development for the West", Western Interstate Nuclear Board, Lakewood, Colorado.