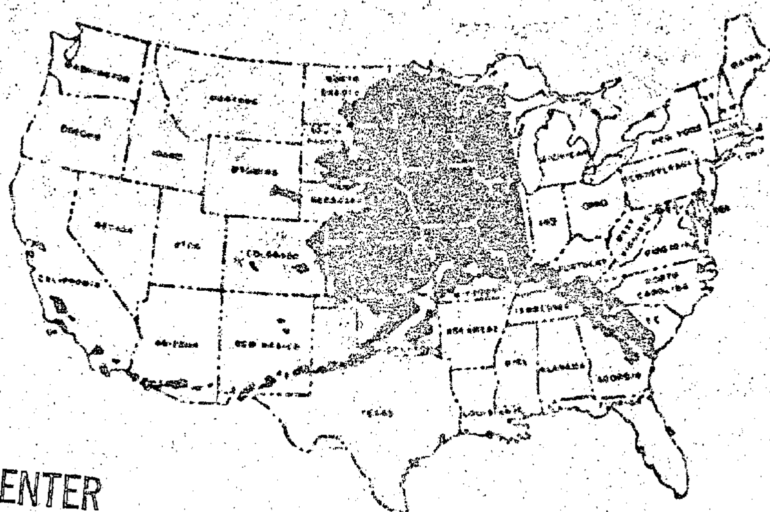
ALASKA REGIONAL ENERGY RESOURCES

PLANNING PROJECT—PHASE 1

VOLUME I

"ALASKA'S ENERGY RESOURCES, FINDINGS AND ANALYSIS

FINAL REPORT



OCTOBER 1977

Prepared by:

Alaska Division of Energy and
Power Development, Department of
Commerce and Economic Development
338 Denali Street
Anchorage, AK 99051

Prepared for:

Division of Regional Assessments
Office of Technology Impacts
Office of the Assistant Secretary for the Environment
U.S. Department of Energy
Mail Stop E201
Washington, D.C. 20545
Under Contract No. EY-76-C-06-2435

13867

FOREWORD

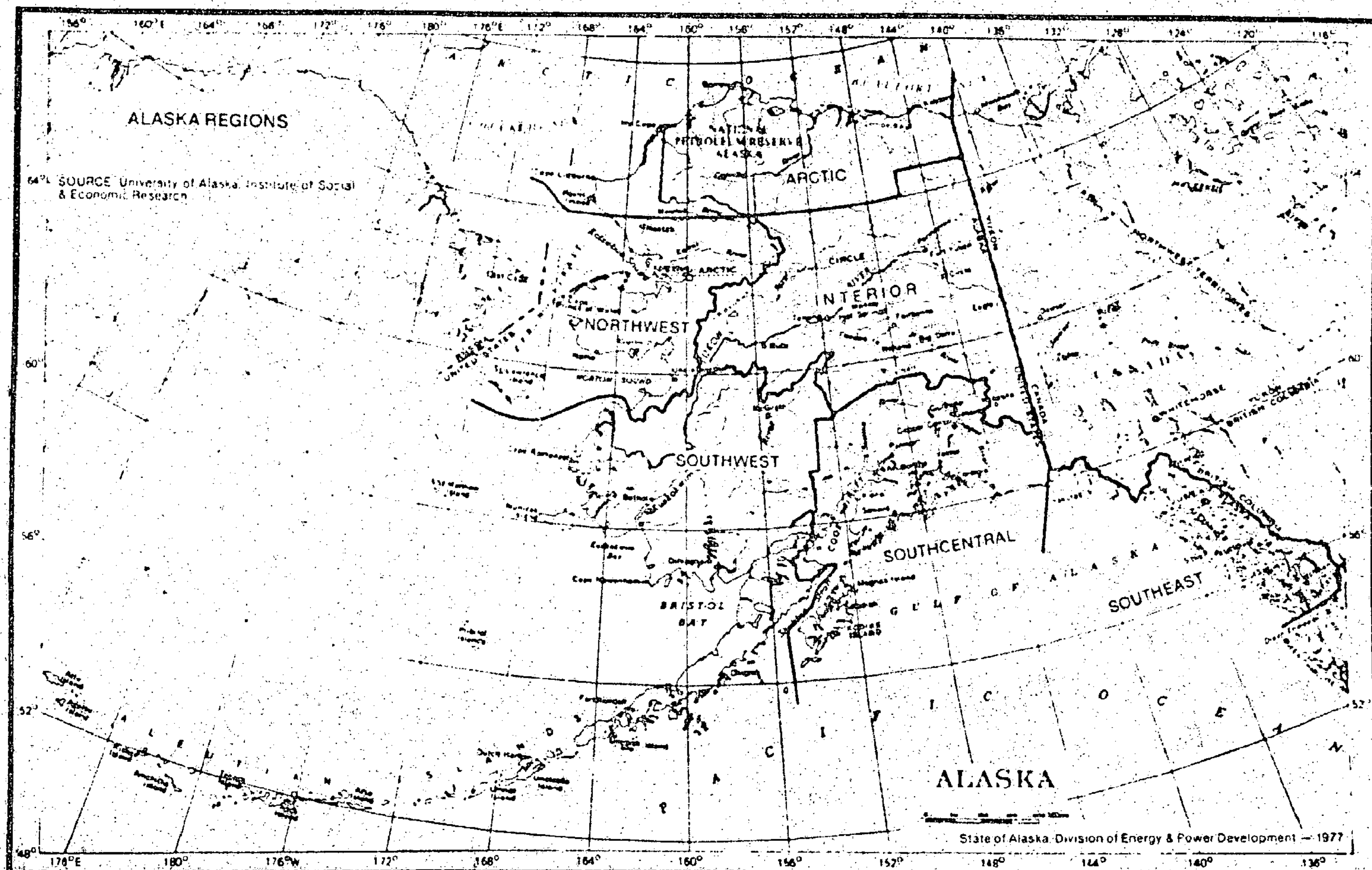
This two volume Alaska Regional Energy Resources Planning Project report represents the first statewide assessment of five of Alaska's energy resources. Volume 2 consists of energy resource inventories for oil and gas, coal, hydroelectric and uranium. Volume 1 presents the findings and analysis of the major elements affecting energy development in Alaska: the resource sites which may develop between now and the year 2000, land tenure problems affecting energy development, alternative technologies and environmental concerns resulting from development.

Since beginning Phase 2 of this effort, August 2, 1976, many significant events have occurred such as passage of the 1977 Clean Air Act Amendments, changes in offshore federal lease sale schedules, decisions on the route for the gas pipeline from Prudhoe Bay, and release of additional open file reports on Alaska's resources. Therefore, the reader must recognize that information and data about Alaska's resources, operations and issues are continually being supplemented and modified. Reports such as this become dated before they are published and distributed.

Since this report is based to a great extent upon scientific, geological, and engineering work done by others, the reader is urged to obtain the original documents for greater detail. The report does not attempt to establish state, federal or Native Corporation policy, but does provide information that may assist policy makers.

W. McConkey / D. Lane / C. Quinlan / M. Rahm / G. Rutledge

U.S. Dept. of Energy


ALASKA REGIONS
SOURCE University of Alaska Institute of Social & Economic Research
ARCTIC
NORTHWEST
INTERIOR
SOUTHWEST
SOUTHCENTRAL
SOUTHEAST
BRISTOL BAY
ALASKA
State of Alaska Division of Energy & Power Development — 1977

ACKNOWLEDGEMENT

This report has benefited from contributions and input supplied by staff members from several state and federal agencies, Native corporations, utilities, libraries, industrial corporations, national laboratories, and consultants. A number, but not all, of the energy experts who assisted us are listed by name in various chapters of the text. Without the help of the many people who contributed, this report would not have been possible. It is hoped that all who assisted will also find this report useful.

The authors wish to express special thanks to Margee Fitzpatrick and the other secretarial staff members of the division who assisted in the preparation of this report, namely, Lynette Abbott, Pat Aubrey, Carla Grubbs, Nancy Knowlton, and Donna Silva. Carole Bennett and Randall Montbriand did an excellent job on the difficult task of proofing and correcting the report.

Also, funding from the Department of Energy (formerly Energy Research and Development Administration) is acknowledged and appreciated. The assistance of Dr. Paul Gerhardt, Division of Regional Assessments, in the direction of the early stages of this project was especially helpful as well as his continued interest in the progress of the study.

CONTENTS

(Volume I)

BLANK PAGE

LIST OF FIGURES

LIST OF FIGURES (Cont.)

LIST OF TABLES

LIST OF TABLES (Cont.)

CHAPTER I

INTRODUCTION

This first-year report of the Alaska Regional Energy Resources Planning Project includes a compilation of available information on many of the renewable and the non-renewable energy resources in Alaska, including oil and gas, coal, hydroelectric power and uranium. Potential future energy sites have been screened and ranked according to likelihood for development between now and the year 2000. The various energy development operations such as exploration, recovery, storage, transportation, processing and use have also been addressed.*

The authors of this report do not consider the material it contains to be the "last word" on Alaska energy. Rather, the purpose is to present the readers with an overview of Alaska's energy resources (and related subjects) in the late 1970's and the best available evidence on the direction development of those resources may take prior to the turn of the century. To the best of our knowledge, no other such catalogue of Alaska's energy resources and related information exists in one document.

As one attempts to analyze the probable pattern of energy development and production in Alaska, it becomes necessary to give close attention not only to the State's abundant energy resources, but also to such interrelated issues as social, economic, technological, conservation, governmental, and environmental considerations.

All of these issues, complex enough in themselves, are further complicated by a number of land tenure problems in Alaska with respect to both surface and subsurface property rights. Native, State and Federal land claims are still several years from settlement, creating considerable uncertainty regarding the course of development in large areas of the state. In addition, important international offshore boundary negotiations with Canada and the Soviet Union have not been completed.

Environmental issues will continue to be of major concern in Alaska because of special climatic conditions, abundant and varied wildlife, and unparalleled scenery, some of which is easily disturbed and difficult to reclaim.

Advanced technology has played a significant role in energy recovery and transportation in Alaska. The world's largest privately-funded construction project, the trans-Alaska oil pipeline is in operation. Oil and gas platforms in Cook Inlet, frequently exposed to high winds, ice and strong currents (a combination of conditions not found elsewhere in the world), have a long history of successful production. Additional technological advances, such as solution mining and fluidized bed heat transfer mechanisms may enable future energy resource development not now possible.

The Alaska Energy Planning Project is a multi-year planning effort funded by the Energy Research and Development Administration (now part of the U.S. Department of Energy). This report, the first of five, represents a significant start toward identifying and planning for Alaska's energy needs and energy opportunities. It also illustrates the potential role Alaska can play in meeting the country's energy needs.

*Although some elements of the methodology used in this study are mentioned in the body of the report, Appendix F provides greater detail on several methodological issues encountered in the course of the study.

BLANK PAGE

Second-year efforts (Phase 2) will emphasize coal and hydroelectric development, conservation of non-renewable resources, and technological and environmental issues. Conversion and reclamation, energy alternatives and social and economic impact assessment methodologies will also be considered. The energy resources inventory will be expanded and updated. Phases 3, 4, and 5 will continue an evaluation of various combinations of energy planning elements.

A major goal of the project is to enable users of this type of information, both private and public, to complete their related tasks more efficiently. Rural community leaders will be able to better determine the energy options available for their areas. The information will assist local and state policy makers in developing appropriate responses to energy issues that continue to grow in number and complexity. Federal officials will be able to determine, in a more quantitative fashion, the role Alaska can play in the national energy program.

Others, whether private citizens, planners, utility managers or representatives of other fields affected by energy developments, also will find the information to be of value.

CHAPTER 2

SUMMARY: ALASKA'S ENERGY RESOURCES

One fact is certain: Alaska is the storehouse of the nation's energy resources. Estimates of the State's resources are very large. However, an analysis of these estimates reveals that neither the actual extent nor the location of the State's oil and gas, coal, hydropower or uranium is fully known.

Experts don't agree on the methods used to appraise the State's energy resources, the nomenclature of the State's petroleum provinces and coal fields, or their configurations. The number and locations of potentially developable hydropower sites remains uncertain and there is only slight agreement on where new discoveries of petroleum resources are most likely to be found.

Resource estimates vary widely (Table 2-1). Most of the disagreement stems from the frontier character of Alaska's energy resource exploration and development. There isn't as much information on Alaska's resources as there is on resources elsewhere in the United States. This is due, for the most part, to a lack of geologic field work needed to adequately investigate them in the State. Some energy resources, however, are better known than others.

Of the energy minerals, least known is Alaska's uranium potential--although this is in the process of changing. A federally funded uranium assessment is presently underway in an effort to discover additional deposits of this high value commodity. Probably best known is the distribution of Alaska's coal, although the quantity remains uncertain. Locations are known because of the visible occurrences of coal along streamcuts and bluffs. Least known is probably Alaska's oil and gas potential, especially offshore. To know whether petroleum is present, drilling must be done, and drilling has not been as extensive in Alaska as elsewhere in the U.S.'s petroleum provinces. Hydropower potential, especially the larger sites--2,500 kilowatts of continuous power and larger--has long been known in Alaska, although it is scarcely tapped. No inventory at all is available for the smaller sites.

Uranium

Resource estimates have been made by Klein for the State of Alaska, Division of Geological and Geophysical Surveys in 1975; and by ERDA in 1976. At this time Alaska has no known identified reserves of uranium. Undiscovered resource estimates vary widely from 1,000 tons to 206,000 tons of uranium.

There is presently no production of uranium in Alaska.

Oil & Gas

Estimates of crude oil and natural gas resources, prepared in 1975 for Alaska by the State of Alaska, Division of Geological and Geophysical Surveys (DGGS) as well as the U.S. Geological Survey (USGS)--the resource divisions of both the State and the Federal government—are widely divergent, both as to extent and location of future discoveries.

Table 2-1
SUMMARY OF ENERGY RESOURCE ESTIMATES:
CRUDE OIL, NATURAL GAS, COAL, HYDROPOWER, URANIUM

	Alaska Identified Resources	Potential Additional Resources	Total Resources
Recoverable Crude Oil [1] onshore & offshore (billions of barrels)	10.5 - 17.139	26.188 - 75.43	43.327 - 85.93
onshore (billions of barrels)	16.768	10.958 - 25.34	27.726 - 35.64
offshore (billions of barrels)	0.371	15.23 - 50.09	15.601 - 50.09
Recoverable Natural Gas [2] onshore & offshore (trillions of cubic feet)	29.7 - 49.274	71.25 - 380.5	120.524 - 410.2
onshore (trillions of cubic feet)	46.991	32.25 - 85.18	79.241 - 85.18
offshore (trillions of cubic feet)	2.283	39.000-295.32	41.283 - 295.32
Remaining Coal [3] onshore & offshore (trillions of short tons)	0.139 - 0.141	1.7 - 4.8	1.85 - 5
Potential Undeveloped Hydropower [4] (million kilowatt hours)	193,785	----	193,785
Recoverable Uranium [4] (excluding offshore) (thousands of short tons)	0	1 - 206	1 - 206

Recovery Factors --(State-of-the-art) and sources of resource estimates:

1 Crude oil estimates (above) are 30-32 percent of remaining in-the-ground oil. Estimates are from the State of Alaska, Division of Geological & Geophysical Surveys and the U.S. Geological Survey, Resource Appraisal Group.

2 Natural gas estimates (above) are 80-85 percent of remaining in-the-ground gas. Estimates are from the State of Alaska, Division of Geological & Geophysical Surveys and the U.S. Geological Survey, Resource Appraisal Group.

3 Coal estimates (above) are 100 percent of remaining in-the-ground coal. About 50 percent of coal is recovered in underground mining; and 80-90 percent is recovered in surface mining. Estimates are from the State of Alaska, Division of Geological & Geophysical Survey, and the U. S. Geological Survey.

4 Uranium estimates--recovery factor unknown. Preliminary estimates are from the State of Alaska, Division of Geological & Geophysical Surveys & U. S. Energy Research Development Administration.

Oil

The State DGGS's estimate of Alaska's total recoverable crude oil (onshore and offshore, identified and undiscovered) is 85.93 billion barrels, or nearly twice as much as the Geologic Surveys' estimates of 43.327 billion barrels of oil.

Identified oil reserves, onshore and offshore, are estimated at 10.5 billion barrels by the State DGGS. The United States' Geological Survey estimate of identified reserves is 17.139 billion barrels. Here the U.S. Geological Surveys estimate of the total identified oil reserves (measured, indicated and inferred) is nearly 1 and 2/3 times the State DGGS's estimate.

Total undiscovered oil resources are estimated at 75.43 billion barrels by the State DGGS. The United States Geological Survey estimates these at 26.188 billion barrels, thus the State DGGS estimate is nearly 3 times the United State Geological Survey's estimate for undiscovered, hypothetical and speculative oil resources for Alaska, onshore and offshore.

Oil production is presently taking place onshore and offshore in Upper Cook Inlet in the Southcentral Region; and near Barrow and at Prudhoe Bay in the Arctic Region. Two refineries are located at North Kenai, on the eastern shore of Upper Cook Inlet, which process some of the crude from nearby production. Tankers transport the bulk of the region's production to refineries outside of the State. Another refinery at North Pole in the Interior Region began processing a small amount of Prudhoe Bay's crude oil late in 1977, but most of the slope's production is being transported to refineries outside the State. The oil moves via the trans-Alaska pipeline from Prudhoe Bay 800 miles south to Valdez, which has an excellent deep-water, ice-free port in the Southcentral Region. Tankers transport the oil from Valdez (the southern pipeline terminus) to the west coast and the Gulf of Mexico for processing and marketing in the U.S.

Gas

Estimates made by the State Division of Geological and Geophysical Surveys and the United States Geological Survey are as divergent for natural gas as they are for oil.

Totalling the estimates of identified recoverable reserves and undiscovered recoverable resources, onshore and offshore, results in an estimate of total recoverable resources, onshore and offshore of Alaska. The State DGGS estimates the total recoverable gas resources to be 410.2 trillion cubic feet and the United States Geological Survey estimates them to be 120.524 trillion cubic feet. The State DGGS's estimate is over 3 1/3 times the United States Geological Survey's estimate. Widely divergent estimates such as these point out the frontier character of the State and the need for extensive exploration drilling.

The State D.G.G.S. estimates the identified recoverable natural gas resources, onshore and offshore, at 29.7 trillion cubic feet, while the United States Geological Survey estimates the identified resources to be 49.274 trillion cubic feet or 1 and 2/3 times the State D.G.G.S.'s estimates.

For undiscovered recoverable resources, the State D.G.G.S. estimates speculative natural gas resources, onshore and offshore, of Alaska at 380.5 trillion cubic feet. Estimates by the United States Geological Survey place these at 71.25 trillion cubic feet, making the State D.G.G.S. estimates over 5 1/3 times those of the United States Geological Surveys'.

Natural gas is being produced onshore and offshore in Upper Cook Inlet in the Southcentral Region where it is distributed to industrial, commercial and residential consumers in Anchorage and Kenai. Liquified natural gas (LNG) for export to Japan and petrochemicals (ammonia and urea) for export to several locations are produced at North Kenai. Natural gas is also "rented" for reinjection purposes (and stored) to improve the oil recovery of the Swanson River Oil Field located about 20 miles northeast of the Kenai Gas Field where the gas is produced. Natural gas is also being produced at Barrow, in the Arctic Region, for local village use. Other large natural gas production from Prudhoe Bay awaits construction of the gas pipeline. The proposed gas pipeline is expected to generally follow the trans-Alaska oil pipeline route and the Alcan highway route from Alaska through Canada to the midwest USA.

Coal

Alaska's coal resources are not well defined geologically and no current comprehensive estimates of coal resources for Alaska are presently available. The most recent is Coal Resources of Alaska by Farrell F. Barnes, a summary prepared of existing estimates for the United States Geological Survey in 1967. Barnes' compiled estimates include only identified resources; Alaska's hypothetical and speculative coal--the undiscovered resources--weren't included in his 1967 report. In an effort to bring the State estimates more up-to-date, recent investigations of a few of Alaska's coal districts have been combined with Barnes' estimates. (Barnes' work was used when recent estimates were lacking.) Unfortunately this method gives a somewhat uneven picture of Alaska's coal resources, especially as to estimates of undiscovered coal. The latter are not presently available on a statewide basis. Although all six regions of Alaska have coal deposits, estimates are only available for some beds in the Arctic, Interior, and South Central regions.

The estimates that are available point out that most of Alaska's coal deposits are subbituminous. Subbituminous coals are the most widely distributed in area and the largest in volume (tonnage). Huge lignite and bituminous deposits are also present, the latter with coking properties, at several locations. Small amounts of anthracite and semiantracite coal also occur at various locations in the State. Alaska coal deposits are low in sulfur. Oil well hole data have revealed substantial quantities of coal are located deep, at 10,000 feet depths, or so, indicating a need to explore in-site recovery methods for these deposits.

Total coal resources, that is, a total of identified and undiscovered coal, onshore and offshore, are estimated to range from 1.85 to 5 trillion short tons. Total undiscovered coal resources (hypothetical and speculative) are estimated to range from 1,719,346.8 - 4,849,946.8 million short tons.

Major coal production is presently underway at only one location in Alaska, the Usibelli Coal Mine, a surface operation in the Interior Region. Coal is shipped via the Alaska Railroad to Fairbanks and is burned both there and at the mine-mouth plant to produce some of the electric power produced by local utilities, the military, and the University of Alaska. Small quantities of coal are also still consumed for local residential-commercial use.

Hydroelectric

Throughout the years, several inventories of Alaska's hydropower potential have been prepared by federal agencies, principally the United States Forest Service, Bureau of Reclamation, Corps of Engineers, Geological Survey, and Federal Power Commission. No estimates prepared by the Alaska Territorial or State government before 1977 are known. The Alaska Division of Energy and Power Development compiled a listing of 379 names of Alaska's developed and potential hydro sites in 1977; however, some sites have different names for the same site; many have no estimates of energy and conflicting or alternate sites have not been estimated for this preliminary inventory.

Recently, estimates of Alaska's hydroelectric potential were prepared by the Alaska Power Administration (formerly the United States Bureau of Reclamation). Their 1977 hydropower inventory provides estimates of the hydropower potential with development cost indexes for 252 undeveloped hydro sites in Alaska. APA judges there are about 2,000 sites in the State which they have reviewed. Most of these were eliminated because of obvious physical limitations.

This inventory of 252 sites shows 212,963 million kilowatt hours per year of potential energy in Alaska, reduced due to conflicting and alternate sites by 19,178 million kilowatt hours which results in a net total of 193,785 million kilowatt hours for Alaska. Although additional sites are known to exist in all regions of Alaska, no estimates for these have been made. In addition, the estimates given do not include tidal power nor complete estimates of smaller waterways which might have the potential of producing less than 2,500 kilowatts of power. The 193,785 million kwh per year does include a number of these smaller sites, however.

Alaska's installed generating capacity at the end of 1976 was approximately 1.4 million kilowatts, with hydroelectric plants providing about 10 percent of the electric power generation needs of the State. Hydroelectric power projects have been developed in two Alaska regions: the Southeast region and the Southcentral region.

ALASKA, U.S. AND WORLD ENERGY RESOURCES: A COMPARISON

While the numbers cited in the previous section are impressive, additional perspective can be gained by comparing them to resource estimates for the U.S. and the World. Alaska covers 16.2% of the land area of the U.S. and has only 0.15% of the population. As can be seen in Figure 2-1 and in Table 2-2 Alaska's store of energy resource potential is disproportionately large. Further details of this comparison are given in the remaining pages of Chapter 2.

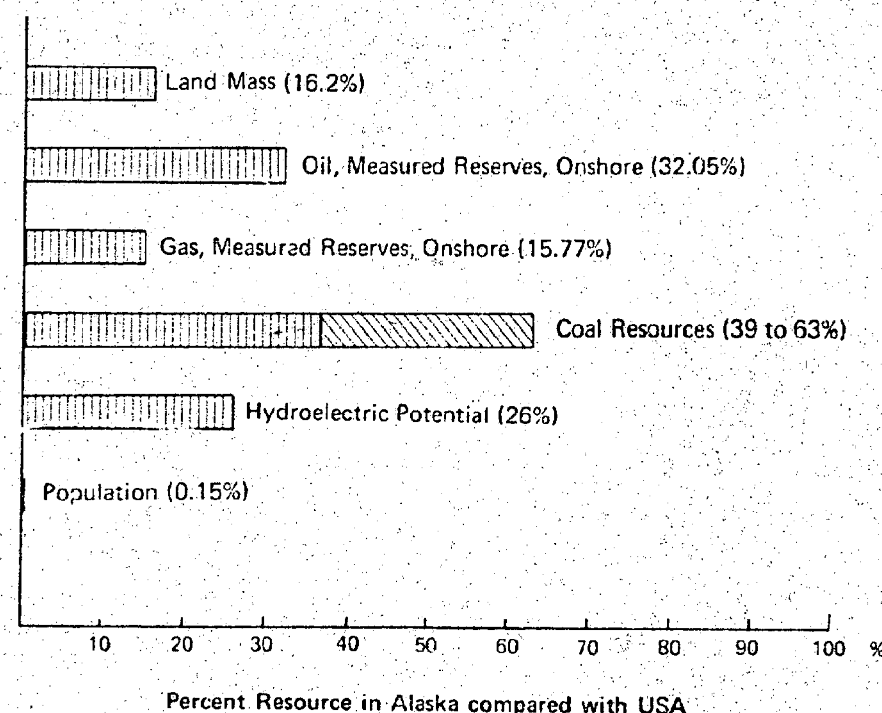


Figure 2-1 Key Energy Resources in Alaska

Table 2-2
ENERGY RESOURCES IN ALASKA, USA, THE WORLD

	Alaska	USA	World
Population (1970 census)* Percentage - Alaska	302,173	203,211,926 0.15%	4,019,000,000 0.0075%
Land Mass (sq. miles)* Percentage - Alaska	585,412	3,615,122 16.19%	196,988,000 0.30%
Sedimentary Rock Area (Onshore, sq. miles) Percentage - Alaska	252,000	2,549,900 9.89%	Not available
Sedimentary Rock Area (Offshore, sq. miles) Percentage - Alaska	318,200	551,600 57.67%	Not available
Coal Resources** (Trillion Short Tons) Percentage - Alaska	1.86 - 4.99	4.76 - 7.89 39% to 63%	18.36 - 21.49 10 to 23%
Hydroelectric Potential (MWh) Percentage - Alaska	176,290,145	675,133,838 26%	9,802,420,000 2%
Uranium Reserves (Thousand Short Tons) Percentage - Alaska	0%	267 0%	1,066 0%
Oil, Onshore Undiscovered Recoverable Resources (Billions of Barrels) Percentage - Alaska	6 - 19	37 - 81 16% to 22%	Not available
Oil, Offshore Undiscovered Recoverable Resources (Billions of Barrels) Percentage - Alaska	3 - 31	10 - 49 30% to 63%	Not available
Oil, Onshore Measured Reserves (Billions of Barrels) Percentage - Alaska	9.944	31.030 32.05%	Not available
Oil, Offshore Measured Reserves (Billions of Barrels) Percentage - Alaska	0.150	3.220 4.66%	Not available

Table 2-2 (Continued)

ENERGY RESOURCES IN ALASKA, USA, THE WORLD

	Alaska	USA	World
Total Oil (Onshore & Offshore) Measured Reserves (Billions of Barrels)	10.094	34.25	599***
Percentage - Alaska		29.47%	1.69%
Natural Gas, Onshore Undiscovered Recoverable Resources (Trillions of cubic feet)	16 - 57	264 - 506	Not available
Percentage - Alaska		6% - 11%	
Natural Gas, Offshore Undiscovered Recoverable Resources (Trillion cubic feet)	8 - 80	42 - 181	Not available
Percentage - Alaska		19% - 44%	
Natural Gas, Onshore Measured Reserves (Trillions of cubic feet)	31.722	201.176	Not available
Percentage - Alaska		15.77%	
Natural Gas, Offshore Measured Reserves (Trillions of cubic feet)	0.145	35.956	Not available
Percentage - Alaska		0.40%	
Total Gas (Onshore & Offshore) Measured Reserves (Trillions of cubic feet)	31.867	237.132	2,304
Percentage - Alaska		13.44%	1.38%

Sources:

*World Almanac and Book of Facts (1977) pages 231, 228, 414, 577, 180 and 763.

**See test for method used to obtain values.

***Business Week (June 27, 1977)

Additional Sources:

See text pages 11-14 for additional sources and assumptions information. Same source for State, USA and World were used wherever possible for calculate percentages, except for coal where numbers were modified to reflect findings of this study.

NOTE: More detail on complex definitions, which have changed with time, of reserves and resources for the various energy resources is given in the text. Briefly, reserves represent that part of the resource which can be produced economically with existing technology and resources include the total resource (including reserves) believed to be present.

Alaska's Oil and Gas Resources Compared with the USA and the World

Note from Table 2-3 that Alaska has produced only a small amount (less than 0.2 percent) of oil and gas onshore as compared with the entire USA as of December 31, 1974; however, in the future, based upon measured reserves, Alaska is in a position to supply the USA with 32 percent of the oil that is produced onshore. As for offshore, Alaska may supply the USA with somewhere between 33 to 63 percent of the oil (29 to 44 percent natural gas) that is produced based upon undiscovered recoverable resources. These percentages are very impressive when one considers that the population in Alaska is less than 0.2 percent of that of the USA. Note that all of these percentages in Table 2-3 are based upon the same source.

With respect to a comparison with the world, Alaska has 0.30% of the land mass but 1.69% of the total oil (onshore and offshore) measured reserves, which is a significant amount of the world's energy.

Table 2-3
ALASKA AND USA OIL AND GAS PRODUCTION, ESTIMATED RESERVES AND ESTIMATED RESOURCES

Alaska Percent As Compared with the USA

	Oil		Natural Gas	
	Onshore	Offshore	Onshore	Offshore
Cumulative Production	0.15%	7.48%	0.11%	1.24%
Measured Reserves	32.05%	4.66%	15.77%	0.40%
Undiscovered Recoverable Resources (Range)	16-22%	33-63%	6-11%	19-44%

Source: U.S. Geological Survey Circular 725 (1975)

Alaska's Coal Resources Compared with the USA and the World

While it would be better to compare 1977 Alaska values with USA and World 1977 values from the same source, this was not possible. Instead the USA and World coal resources were modified to reflect the increase in the Alaska values. As a result of the method used, the percentages shown (Table 2-4) must be considered very approximate; nevertheless, the magnitude of the coal resources (not reserves) in Alaska is significant when compared with both the USA (37-63 percent) and the World (9-20 percent). Also, some of the coal in Alaska is very low in sulfur (i.e., 0.2 weight percent as compared with western USA coal at about 0.6 percent which is considered low).

Table 2-4
ALASKA COAL RESOURCES COMPARED WITH THE USA AND THE WORLD

	Trillion Short Tons*		Percent, Alaska
	Paper 820**	This Report	
Alaska	0.3	1.86 - 4.99	
USA	3.2	4.76 - 7.89***	39% - 63%
World	16.8	18.36 -21.49***	10% - 23%

*Total of Identified and Undiscovered Coal remaining in the ground.

**United States Mineral Resources Geological Survey Professional Paper 820 (1973).

***USA and World Resources modified to reflect update in Alaska numbers. (Must be considered approximate, since depth used to obtain Alaska coal resources may be somewhat different than the 6,000 feet used in Paper 820.)

Alaska's Hydroelectric Resources Compared with the USA and the World

The magnitude of the power potential (MWh) in Alaska is about 26 percent of that of the USA and about 2 percent of that of the World (see Table 2-5). The potential is somewhat better than the percent of land area in Alaska as compared with that of the USA (i.e., 16 percent). Less than one percent of the hydroelectric potential in Alaska has been harnessed as compared with about 39 percent for the USA and 13 percent for the world.

Table 2-5
HYDROELECTRIC POTENTIAL IN ALASKA, USA, WORLD

	Total Potential Production, MWh	Percent, Alaska
Alaska	176,290,145*	
USA	675,133,838*	26%
World	9,802,420,000**	2%

*Hydroelectric Power Resources of U.S. Developed and Undeveloped, Federal Power Commission, P 43, January 1, 1976 page XII; this report gives 193,785,000 MWh for Alaska for potential undeveloped hydropower. The larger figure includes a number of projects excluded from the FPC listing by reason of economics.

**Energy Perspectives II, U.S. Department of the Interior (June, 1976) page 39.

Alaska's Uranium Resources Compared with the USA and the World

The uranium reserves in the USA are 25 percent of the world's (see Table 2-6). Note that the demand for uranium by the year 2000 is much greater than the nation's total resources, which helps explain the very active exploration now underway in the USA, especially in Alaska.

The current official uranium reserves in Alaska are zero and the percent of uranium resources in Alaska as compared with the USA is less than 0.3 percent which is strangely low since Alaska has 16 percent land area. However, if major exploration efforts now underway are successful (and many believe this will be the case), Alaska will again contribute to the uranium energy needs of the nation.

Table 2-6
URANIUM RESOURCES AND DEMAND IN ALASKA, USA, WORLD

(Thousand Short Tons Uranium)

	Reserves	Total Resources	Demand By Year 2000
Alaska	0	1*	0
USA	267	356	523-1200
World	1066	1864	1359-3207

*State of Alaska unpublished report gives 243,000 tone of U_3O_8 which is equivalent to about 206 thousand short tons U.

Source: Mineral Facts and Problems, Bureau of Mines Bulletin 667, U.S. Dept. of the Interior (1975) pages 1182 and 1196.

CHAPTER 3

THE POLITICAL, SOCIAL, ECONOMIC AND PHYSICAL ENVIRONMENT OF ALASKA ENERGY DEVELOPMENT

Some readers will be relatively unfamiliar with the physical, social, economic and political characteristics of the State of Alaska. For them, we have provided some background on the State and on potential problems associated with energy development.

CHAPTER SUMMARY

This chapter begins with a brief geographic description of the principal characteristics of the State's six major Regions, including the topography, climate, population and energy resources. Next is a discussion of some of the important political issues associated with energy development in the State, including land ownership problems, relationships between the Federal and State governments and branches of government. This is followed by a section summarizing the social and economic impacts of large energy developments in a state where infrastructure is often slight or non-existent (especially near promising energy resources), and the residents of villages depend, to varying degrees, on a subsistence lifestyle. A fourth section discusses the impact of the Alaska Native Claims Settlement Act (ANCSA), the expected impacts of the so-called Udall "d-2" land bill proposal, and the numerous forces which favor or oppose energy development. The final section addresses a number of major environmental issues associated with the development of Alaska's energy resources.

ALASKA GEOGRAPHY

Throughout this report, the State of Alaska is divided into six Regions based on the University of Alaska's Man-in-the-Arctic Program (MAP) regions, which comprise one or more whole census divisions. The original MAP regions have been modified here, due to the inclusion of the North Slope Borough which now constitutes a whole census division. The primary boundaries determining these Regions closely approximate major physical boundaries, such as major drainages. Each Region tends to differ quite distinctly from the other five in its general characteristics. The boundaries of the following Regions and the census divisions which comprise them, are shown on the next page (map, figure 3-1):

1. The Arctic Region
2. The Northwest Region
3. The Interior Region
4. The Southwest Region
5. The Southcentral Region
6. The Southeast Region

BLANK PAGE

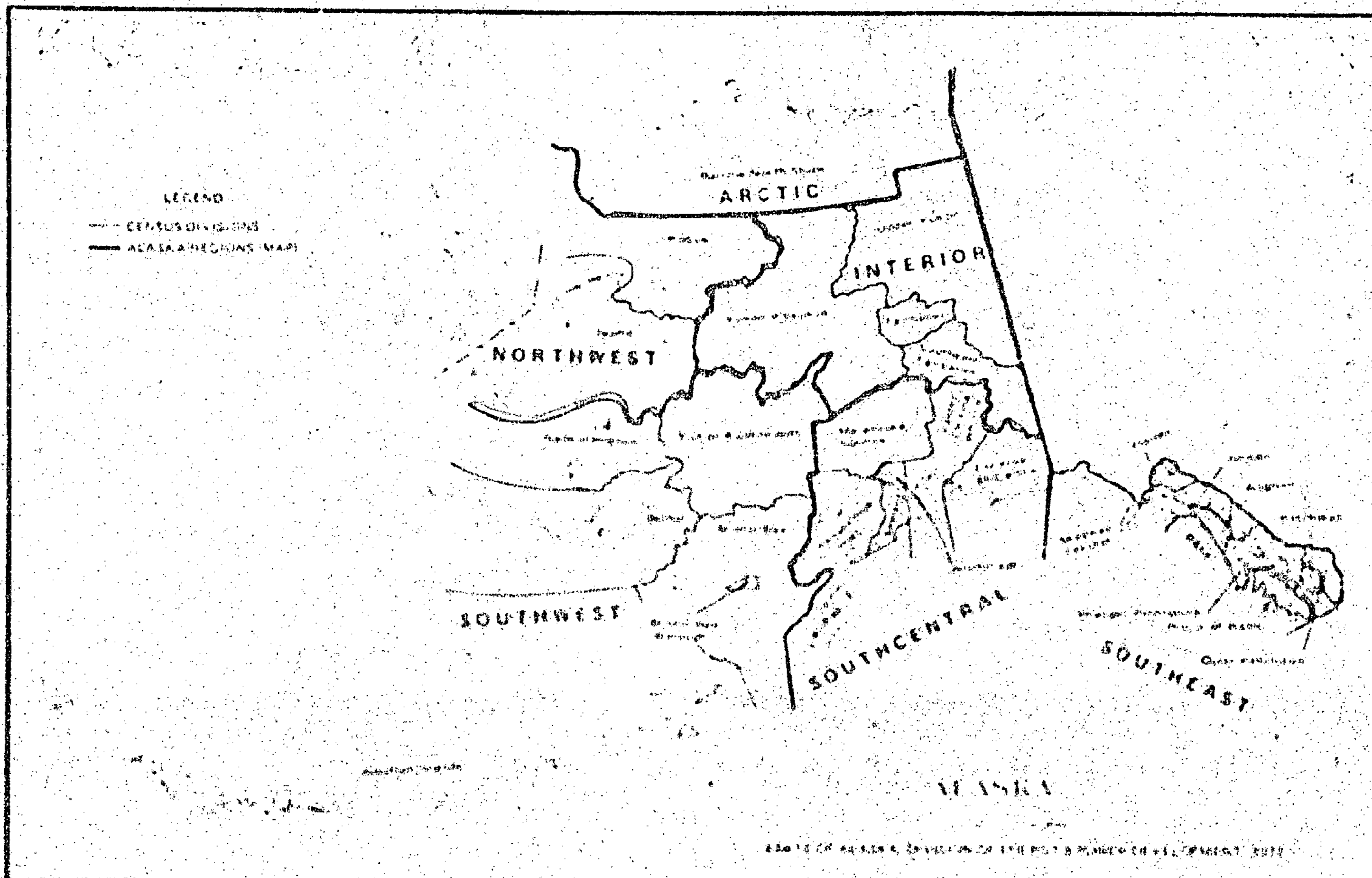


Figure 3.1 Census Divisions by Alaska Region

Source: State of Alaska, Department of Labor, and University of Alaska, Institute of Social and Economic Research.

The Arctic Region

The Arctic Region consists of the entire North Slope Borough which is comprised of one whole census division (the Barrow North Slope Division) and encompasses most of the drainage basins of all the rivers in the State flowing north from the divide of the Brooks Range into the Chukchi and Beaufort Seas of the Arctic Ocean. The area stretches more than 600 miles from the Canadian border west to Cape Lisburne on the Chukchi Sea, and nearly 250 miles from Point Barrow (the northernmost point in the U.S.), to the south line of the North Slope Borough, the approximate crest of the Brooks Range. The total land area is approximately 88,280 square miles, larger than the State of Idaho. It is the least populated region of the State, containing two percent of the State's population. More than half of the residents live in the village of Barrow. The overwhelming majority of the population are Inupiat Eskimos, and many still lead semi-subsistence lives as hunters and fishermen. As provided in the Land Claims Act, Natives in the Arctic Region are shareholders in the Arctic Slope Regional Corporation.

The climate of the Region is unique in the United States. Average temperatures are cold, and persistently strong winds blow over the northern half of the area. Although the lowlands are generally marshy, in the summertime consisting primarily of treeless tundra, precipitation is extremely low, generally averaging 6 inches or less during the year. Temperatures are usually extreme, with lows of -50 to -60 degrees Fahrenheit, and highs of 75 to 80 degrees Fahrenheit. Nighttime temperatures at or below freezing are not uncommon in midsummer. The Arctic Ocean to the north remains frozen throughout the summer; even in August there is only 20-40 miles of open water between the northern coast and the Arctic ice pack. In some summers, the ice pack barely recedes from shore. The "Land of the Midnight Sun" and the "Noon Moon", the Arctic Region has a period of approximately three months when the sun never dips below the horizon in the summer, and, conversely, never rises above the horizon for two months in the winter. The entire Region is within the zone of continuous permafrost, with permafrost in some areas as much as 1,300 feet thick.

The energy resources of the Arctic Region are as impressive as the extremes of its climate and topography. The region contains three major on-shore and three major off-shore oil provinces, all of which are considered to have excellent potential for oil and gas development. Some estimates show the Arctic Region may ultimately produce some 39 percent or even 80 percent of the State's oil, placing the region's undiscovered recoverable crude oil resources as high as 33 or 35 billion barrels. Future finds of natural gas are estimated to be 22 to 73 percent of the State's potential, with estimates for the Arctic ranging between 93 and 111 trillion cubic feet of natural gas.

The Arctic has high-grade bituminous and lower-grade subbituminous coals, located in one of the world's largest coal fields extending almost 300 miles inland from the shores of the Chukchi Sea. The offshore extent is unknown. The major portion of the field onshore varies in width from 25 to 100 miles, and much of it lies within the borders of the National Petroleum Reserve, Alaska (NPRA). Identified coal resources (measured, indicated and inferred) are estimated at almost 123 billion short tons with about one sixth of the total being bituminous--some with coking properties--and the remaining deposits subbituminous and lignite coals. Undiscovered coal resources (hypothetical and speculative) are estimated at 223 billion to 3.353 trillion short tons. Total resources (identified and undiscovered) are estimated at almost 346 billion to 3.475 trillion short tons--representing between 18% and 70% of the State's coal. Anthracite and semi-anthracite coals are also found near Cape Lisburne in the westernmost part of the region but no estimates have been made for these deposits.

Other energy resources, including oil shale are known to exist in substantial quantities and some geologists suggest uranium may also be discovered in the Region. Arctic Alaska is not favorable for geothermal or hydroelectric development--for the latter, the inventory studies did not find any sites with the necessary combinations of head, water supply, damsites, and reservoir potential, that would indicate potentially feasible hydro projects in this Region. A recent inventory of potential hydroelectric sites shows only three sites with an aggregate of 1,073 million kwh and these are in the higher priced index groups. The wind however is viable as a potential alternate energy source.

Major features of the Arctic Region which are significant to energy development are the giant Prudhoe Bay oil field located between two major Federal land withdrawals: the 23.1 million acre NPRA and the 8.9 million acre Arctic National Wildlife Range both administered by the U.S. Department of the Interior. In the former area, an intensive oil and gas exploration program is presently underway; in the latter no energy exploration is presently allowed, although certain areas are thought to be among the best for future petroleum production in the state.

The Trans-Alaska oil pipeline haul road, built to transport men and material to construct the pipeline, is the only road into the Arctic from outside the region. It has become a subject of some controversy over whether it should be opened to travelers or not. Current proposals call for limited use. The Trans-Alaska oil pipeline, built at an estimated cost of $7.7 billion is to be followed soon by a major gas pipeline. The gas line will generally follow the same route as the oil pipeline through the Arctic Region.

The Northwest Region

This Region generally includes the drainages of the Noatak and Kobuk Rivers and the Seward Peninsula as well as the 100 mile long St. Lawrence Island. It is bounded by the North Slope Borough line, approximating the Noatak River on the north; the Nulato Hills, Purcell Mountains, and Endicott Mountains on the south and east and the Chukchi and Bering Seas on the west. The Northwest Region consists of two whole census divisions: Nome and Kobuk. The terrain is mostly rolling hills and lowlands. The coast is very irregular, dominated by Kotzebue Sound to the north and Norton Sound to the south, with the large and mineral-rich Seward Peninsula extending into the Bering Straits, between. The closest point in the United States to the U.S.S.R. is Alaska's Little Diomede Island, centered in the Bering Straits, and separated by only two and one half miles of water from the Soviet Union's Big Diomede Island.

The climate inland tends to be continental, with substantial temperature extremes from winter to summer. The annual rainfall is less than 10 inches. The coastal climate is transitional in character, with less extreme temperatures and somewhat more precipitation. Wind levels, particularly along the coast, tend to be high. The population, predominately Inupiat Eskimo, is small--about 3 percent of the State's population. Subsistence fishing and hunting are major activities of the Native people, who are shareholders in either the Nana Regional Corporation, centering around Kotzebue, or the Bering Straits Native Corp., centering around Nome. Since there are no roads connecting to other areas in the State, regional transportation is predominately by air and water.

Energy resources in the Northwest Region have not been fully explored, but indications are that fossil fuel resources in this region are not as large as elsewhere in the State. No estimate of identified oil or gas resources is available for the region; however, future finds of oil and gas are thought to represent a maximum of eight or nine percent of the State's total recoverable oil and gas resources. Estimates of undiscovered recoverable crude oil vary from 0.7 to 6.8 billion barrels. Some estimates for onshore oil range between 0.05 and 1.8 billion barrels; and for offshore oil discoveries range between 0.7 and 4.9 billion barrels. Total undiscovered natural gas resources are estimated at 2.0 to 36.0 trillion cubic feet, of which an estimated 0.3 to 5.9 trillion cubic feet are expected to be found onshore and an estimated 1.7 to 30.1 trillion cubic feet are expected to be found offshore.

Although coal is known to be present near Unalakleet, on the Seward Peninsula and along the Kobuk River, no estimates of coal resources have been made for the Northwest Region. The Region, however, is considered to be one of the most promising areas in the State for uranium discoveries: the Seward Peninsula and Selawik areas appearing to be especially favorable geologically.

Hydropower development potential for the Region is not very good when compared to other Regions. This area is similar to the Interior Region with the hydro potential being only on the main stem of the rivers. Similarly, the runoff is relatively low. However, 11 undeveloped sites, 5 of them lower priced sites, have a total of 3,177 million kwh in the Region.

Geothermal resources are large and one of the three areas in the State designated a "Known Geothermal Area" is located north of Nome on the Seward Peninsula. There are numerous geothermal surface indications at several locations: on St. Lawrence Island; near the Village of St. Michael; on the Seward Peninsula and the area west of the Zane Hills, for example.

The Interior Region

The largest, in land area, of Alaska's six regions, the Interior Region extends from the Nulato Hills on the west to the Canadian Border and is bounded on the north by the North Slope Borough line which approximates the continental divide, and on the south by the north line of the Matanuska-Susitna Borough, the Alaska Range and the Wrangell Mountains. This Region consists of four whole census divisions: Yukon-Koyukuk, Upper Yukon, Fairbanks and Southeast Fairbanks. The dominate feature of this Region is the Yukon River, which drains its land area.

About 17 percent of the state's population resides in the Interior Region in communities ranging in size from small, primarily Athabascan Indian villages along the Yukon River and its tributaries, to the Fairbanks metropolitan area. Interior Indians are shareholders in Doyon Ltd., the Native Regional Corporation which centers on Fairbanks. Due to the whole census division constraints of the Regions, eight other Doyon Ltd. member villages (four each along the Yukon and Kuskokwim Rivers) extend into the Southwest Region. The non-Native population tends to be concentrated in Fairbanks and other communities in the Fairbanks-North Star Borough. Except for communities along the Alaska-Canadian (ALCAN) Highway and the railbelt, stretching south to Anchorage, much of the Interior Region has no road system. Nearly all the small communities, however, have an airstrip to accommodate the many bush planes that serve them and all interior villages are located on rivers or lakes. The residents use small boats extensively for intra-village travel during the summer and snowmachines and dog teams during the winter.

The climate of the Interior tends to have the greatest extremes in the state. It has recorded both Alaska's all-time high temperature (100 degrees Fahrenheit), and the all-time low (minus 80 degrees Fahrenheit). The Region has soil suitable for agriculture, but rainfall patterns tend to be somewhat unfavorable. Heaviest rains occur late in the growing season when crops are maturing, rather than earlier in the season during rapid growth periods. Winds in the region are generally light. The topography varies from relatively flat, well-forested lowland areas along the Yukon River to rugged hills and mountains in the north and south. Much of the lowland area is swampy in the summertime with underlying permafrost. The highest mountains of the Alaska Range, including Mount McKinley (the highest point in the United States at 20,320 feet) are located in the Region along the southerly boundary.

No estimates of identified oil and gas resources are available. Estimated potential oil and gas resources are thought to be low compared with estimates of petroleum believed to exist in other regions in the State. The Interior Region is estimated to have approximately four percent of the state's potential oil and gas. Estimates of undiscovered oil range between 0.2 and 3.7 billion barrels of oil, and undiscovered recoverable gas is estimated at 1.0 to 15.4 trillion cubic feet.

Coal reserves are significant, with several fields and outcrop occurrences. Remaining identified coal resources (measured, indicated and inferred) are estimated at 5.4 to 7.0 billion short tons. Remaining undiscovered resources (hypothetical and speculative) are estimated at 8.9 billion short tons. Total coal resources are estimated at 14.3 - 15.9 billion short tons. The Region contains the only major working coal mine in the state (at Usibelli, about 120 miles south of Fairbanks) which produces over 700,000 tons of coal annually. Coal is burned at the Golden Valley Electric Association mine-mouth plant and also shipped by the Alaska Railroad to Fairbanks and vicinity. Most of the coal is used to produce electricity but some is still used for residential space heating.

Although the Region contains the largest potential hydroelectric resource in the United States, in the Yukon River, hydropower development potential is not favorable because of environmental problems. The Interior Region has at least 48 sites totalling about 93,885 million kWh including the huge Ramparts site. Reportedly no sites have yet been developed for electrical power production in the Interior. Except for main stem developments, there aren't any good sites north of the Alaska Range. The northern slope of the Alaskan Range is too steep and lacks storage sites. There are only a few sites than can be physically developed in the Yukon Basin. According to the Alaska Power Administration, the total number of the better sites numbers only four on the main stem of the river, and six on the tributaries.

Uranium potential in the area is not well-defined at this time, but is considered to be relatively high. The Region also has sizable geothermal resources: especially notable are the many hot springs in the Region located in a belt trending east-west through the center of the Region.

The Southwest Region

This Region is the second largest area in the state and the most varied in topography and climate. It contains the huge delta created by the lower Yukon and Kuskokwim Rivers, and extends southwestward to include the shores of Bristol Bay, and the Alaska Peninsula. It includes St. Matthews, Nunivak and the Pribilof Islands. This region contains the following six whole census divisions: Kuskokwim, Wade Hampton, Bethel, Bristol Bay, Bristol Bay Borough, and Aleutian Islands.

A predominately coastal area, it tends to have a more narrow range of temperatures than further inland due to the moderating effects of the Bering Sea and the North Pacific Ocean; it is often cloudy and has substantial rainfall. Uplands tend to be heavily forested, while the lowland areas of the two major rivers are wet tundra. Probably 40 to 50 percent of the delta area is lake surface, providing critical waterfowl habit, but making land transportation virtually impossible during the summer. The Aleutian Island chain extends 1,100 miles and consists of more than 50 islands separating the North Pacific Ocean and the Bering Sea. Both the westernmost point in the United States, Amatignak Island (179° 10' W), and the easternmost point in the United States, Pochnoi Point (179° 46' E) are located in the Aleutian Islands. The climate is characterized by moderate temperatures, considerable rainfall and frequent fogs.

The population of the Region is small, with about seven percent of the State's population, almost entirely Native in origin. It consists of Yupik Eskimos, most of whom are shareholders in the Calista Corporation, centering on Bethel--and the Bristol Bay Native Corporation, centering on Dillingham; Aleuts, shareholders in The Aleut Corporation; and the Athabascan Indians who live inland along the Yukon and Kuskokwim Rivers (an area which includes shareholders of Doyon, Ltd.). Subsistence hunting and fishing, and commercial fishing and seafood processing, especially in Bristol Bay and along the Aleutian Chain, are the economic mainstays of the Region. There are no roads connecting the Southwest Region to the rest of the State, so all interregional travel is by air or water.

The Southwest's energy resource potential is unrealized at this time, but may become extremely significant, especially for oil and gas discoveries. Among the State's most promising petroleum provinces are located offshore in Bristol Bay and the Bering Sea. They are controversial for development, however, because of the possibility of conflicts with the fisheries. No estimates of identifed oil or gas reserves are available for the Region. Undiscovered oil resources (hypothetical and speculative) onshore, are estimated variously at 0.4 to 3.4 billion barrels; and offshore are estimated at 2.4 to 25.3 billion barrels. Total recoverable crude oil resources (undiscovered, onshore and offshore) are substantial and are estimated at 2.9 to 28.6 billion barrels for the Southwest Region. Estimates of undiscovered recoverable natural gas (hypothetical and speculative) onshore, vary from 1.5 to 12.3 trillion cubic feet; and offshore vary from 6.0 to 154.1 trillion cubic feet. Recoverable natural gas resources (undiscovered, onshore and offshore) are estimated to total 7.4 to 166.4 trillion cubic feet. The wide differences in oil and gas estimates reflects the lack of drilling information.

Coal deposits, some of high quality, are found on the Alaska Peninsula and in the Aleutians. However, no estimates of identified coal resources are available for the region. Remaining undiscovered coal is estimated at 3290 million short tons.

At least 23 undeveloped hydropower sites have been identifed in this Region with the potential of producing a total of 26,473 million kilowatt hours of energy. No inventory of smaller sites, sites capable of producing under 2,500 kw of continous power, has been made.

A very large geothermal potential exists in the Southwest due to the many volcanoes and other surface indications known and two areas designated "known Geothermal Areas" (KGRA's) are located on Umnak Island in the Aleutians. Uranium investigations indicate some potential may be present. The Region has an excellent wind power potential as there are strong winds in all seasons especially along the Aleutian Islands.

The Southcentral Region

The Southcentral Region includes all of the land draining to the Gulf of Alaska including Cook Inlet and Prince William Sound. It includes the Matanuska-Susitna Borough, the Municipality of Anchorage, the Kenai Peninsula Borough and the Kodiak Island Borough and consists of seven whole census divisions: Kodiak, Kenai-Cook Inlet, Seward, Anchorage, Matanuska-Susitna, Valdez-Chitna-Whittier, and Cordova-McCarthy.

Characterized by rugged, mountainous terrain, with the important exceptions of the lowlands bordering Cook Inlet, the lower Susitna Valley and the Copper River Plateau, this Region includes some of the highest mountains and the largest glaciers in the United States. The Region is one of great Tectonic activity, with frequent earthquakes and a number of major volcanoes. More than half of the land area in the Region is contained in the drainage basins of two rivers, the Susitna (which empties into Cook Inlet) and the Copper (which drains the area between the Talkeetna and Wrangell Mountains). The coastline of the Southcentral Region is roughly 11,500 miles long and includes 25 to 30 percent of Alaska's shoreline. This coast is the most complex in the State, including several ice fields, the island and fjord complex of Prince William Sound, and Cook Inlet and the fjords of the Kenai Peninsula. The climate is almost as varied as the topography, ranging from the relatively moderate, rainy marine climate of Kodiak Island and the eastern gulf coast to the more extreme dryer continental climates inland.

The Southcentral Region is the most populated area in Alaska containing more than 59 percent of the State's population, primarily concentrated in the Anchorage metropolitan area and along the railbelt of the Alaska Railroad. The population is predominately non-Native throughout the Region, but several Native groups are represented, Athabascan Indian, Eskimo and Aleuts and a very few Eyak Indians. Alaska Natives are shareholders in four Regional Corporations which represent the aboriginals which had traditional use and occupancy to land areas in the Southcentral Region: Koniag, Inc., representing the people living in the Kodiak Islands; Cook Inlet Region, Inc., representing the people living in the area bordering Cook Inlet; Chugach Natives, Inc., representing the people living in the Prince William Sound and the eastern Gulf of Alaska areas; and Ahtna, Inc. representing the people living in the Copper River area.

Anchorage is the largest commercial and distribution center of the Region, and of the State. The Southcentral Region contains most of the major ports in the State, including the Trans-Alaska oil pipeline terminus at Valdez. It is also served by a system of primary and secondary highways, the Alaska railroad, the marine highway ferry system and has several small boat basins. It has the largest international airport in the State (at Anchorage) as well as several other airports serving the smaller communities.

Economic activities in the Region are varied, including a substantial fishing and fish processing industry, the farming area of the Matanuska Valley and a major government sector, including two large military installations. The headquarters for most of the energy-related industries in the State, and the great majority of petroleum refining and petrochemical manufacturing in Alaska are located here.

Energy resource potential is also quite varied. Oil and gas are being recovered from Upper Cook Inlet, and federal oil and gas leases were sold in October of 1977 for Outer Continental Shelf lands in Lower Cook Inlet. The Southcentral Region is thought to have 8 to 11 percent of the State's recoverable oil potential. Total identified recoverable oil reserves are conservatively estimated at 0.8 billion barrels, almost equally divided between onshore and offshore deposits. Undiscovered oil resources (hypothetical and speculative) are estimated at 3.6 to 10.234 billion barrels, or more, of which 0.7 to 1.7 are estimated for onshore areas and 2.1 to 8.1 billion barrels are estimated for offshore areas.

Identified recoverable natural gas reserves (measured, indicated and inferred) are estimated at 3.7 to 8.8 trillion cubic feet, representing 22 to 45 percent of the State's known gas. Undiscovered recoverable gas resources (hypothetical and speculative, onshore and offshore) are estimated at 7.1 to 59.4 trillion cubic feet with substantially more gas expected to be found offshore than onshore. Total resources (identified and undiscovered, onshore and offshore) are estimated at 16.0 to 63.076 trillion cubic feet representing 13 to 15 percent of the State's gas potential.

There are several coal fields in the Region, principally the Susitna-Cook Inlet-Kenai and Matanuska Fields centering on Upper Cook Inlet as well as the Bering River Field near Cordova. Identified remaining coal resources (measured, indicated and inferred) are estimated at 10.66 billion short tons; and undiscovered remaining resources (hypothetical and speculative) are estimated at almost 1.5 trillion short tons--second only to the Arctic Region's coal resources. Development of the Beluga Coal Field, near Tyonek is in the early planning stages.

Also in the early planning stages is a major hydroelectric power project on the Susitna River which will produce about 1,600 MW of power and will serve the entire railbelt area. Conventional hydropower potential is substantial, with an estimated 52,137 million kwh of undeveloped hydropower potential in 107 sites, 23 of which are considered by the Alaska Power Administration to be lower priced sites. However, there are very few sites in the Southcentral areas as attractive for smaller hydropower development as those in the Southeast Region. Away from the coast, there is much lighter runoff and less steep topography. Farther inland where there are damsites on the larger rivers having larger flows, there are several significant, large power potentials, such as those on the Copper River and Susitna River.

Tidal power potential at Cook Inlet is among the most promising in the United States, comparing favorably with Passamaquoddy Bay in Maine, whose tidal range is among the highest in North America. The geothermal potential is considerable, particularly in the Wrangell Mountains to the east, and the Aleutian range in the west. Discoveries of uranium are thought to be very likely and opportunities are excellent for harnessing the wind along coastal areas, islands and mountain passes in the Southcentral Region.

The Southeast Region

The Southeast Region, sometimes called the Panhandle, is a narrow strip stretching nearly 600 miles from Cape Fairweather on the north to Dixon Entrance on the south along the Canada-Alaska border. The Region is the smallest in the State (42,000 square miles), and about 40 percent of the total land area is on large islands immediately off the mainland. The Region has a moderate marine climate with extremely heavy rainfall in many portions. The terrain is generally rugged and mountainous, with numerous glaciers, and the slopes of the mountains are heavily forested. The Southeast Region contains about 12 percent of the State's population; the largest population center is Juneau, the State's capital city. Land surface transportation is very limited due to the mountainous terrain. Ferries of the Alaska Marine Highway System provide service between most of the population centers. Population is predominately non-Native, but there are substantial populations of Tlingit and Haida Indians, who are shareholders in the Sealaska Corporation. Economic activity in the Region is dominated by government employment, fishing and fish processing, and lumbering and forest products manufacturing. Almost the entire land area of the Southeast Region is in the Tongass National Forest.

Energy resources consist of at least two hundred potential hydroelectric sites of which 60 sites having 17,051 million Kwh of developable power have recently been inventoried by the Alaska Power Administration. Hydroelectric power has been developed in the Region, with most of the major communities using some hydropower, with further development planned. Southeast has an abundance of relatively attractive, small hydroelectric potentials, most involving small drainage basins. High runoff rates for the Region enhance opportunities for hydro development.

A significant uranium potential exists here. The only uranium ever mined in Alaska was discovered on Prince of Wales Island at Bokan Mountain, and prospects are considered good for further finds nearby. Fossil fuel reserves in Southeast Alaska are considered to be slight. No identified oil or gas estimates are available for the Region, however, undiscovered recoverable oil is estimated at 0.6 to 2.9 billion barrels, representing less than 4 percent of the State's oil. Undiscovered recoverable gas is estimated at 1.5 to 17.7 trillion cubic feet, representing less than 5 percent of the state's potentially recoverable gas. Although numerous occurrences of coal are known, no coal resource estimates are available for the Region.

LAND OWNERSHIP AND LAND USE MANAGEMENT

Knowledge of the history and present status of land ownership and land use management policies in Alaska is essential to understanding many of the issues associated with energy development in the State. Of the 367.8 million acres of Alaska's uplands, 88 percent are owned by State and Federal governments. Ultimately, when State selections are completed, 60 percent are expected to remain in Federal ownership, while 28 percent of the total will be owned by the State. Approximately 10 percent will be held privately by the 12 for-profit Alaska Native Regional Corporations, their associated 200 village corporations, and individual Natives. Another one percent will be owned separately by the Native Village Corporations, which elected to retain their former Indian Reservations in-lieu of the benefits of the Alaska Native Claims Settlement Act. Only about one percent will be in other private hands. Clearly, the policies of the State and Federal governments, and of the Native corporations, will govern the future course of energy development in the State.

Federal Ownership and Policies

All federal lands in Alaska have either been withdrawn as reserves for particular purposes, withdrawn for Native selection, or withdrawn for classification. Public domain lands in Alaska are currently closed to entry under public land laws except for about 60 million acres of D-1 lands which are open to staking under the hard rock mining laws and the 20 million acres in the nation's forests which are also open to staking.

Until 1959 when Alaska became the 49th state, about 99 percent of Alaska was federally owned. Some of the federal landholdings were administered by the U.S. Forest Service, which managed the Tongass and Chugach National Forests; the Park Service, which operated Mt. McKinley National Park and Glacier Bay, Katmai, and Sitka National Monuments; the U.S. Fish and Wildlife Service, which managed a number of small wildlife refuges and the Kenai National Moose Range; and the military, which maintained major defense installations and Naval Petroleum Reserve No. 4 (now National Petroleum Reserve of Alaska). Eighty percent of the federal lands were under the jurisdiction of the Bureau of Land Management. These lands were, and are, the major part of the nation's public domain. Since

Statehood, the unreserved public domain in Alaska has been reduced by the creation, in 1960, of the 8.9-million-acre Arctic National Wildlife Range. As the result of these withdrawals from unreserved public domain lands, Alaska today has 11 percent (by acreage) of all national forests, 25 percent of all national parks, and over 70 percent of all lands reserved for national wildlife ranges and refuges.

State Lands

With the admission of Alaska as the 49th state, Congress was confronted with how this vast territory with its small population and remoteness from the centers of trade and commerce could become a viable member of the Union. It was believed by most that the development of such a new state must come from its natural resouces. To give it a resource base, Congress provided in the 1958 Statehood Act that 102.5 million acres of general grant lands from the "vacant, unappropriated and unreserved" lands of Alaska could be selected by the new state within 25 years. Alaska was also entitled to University and Mental Health Lands granted before Statehood, to 400,000 acres from the public domain, and to another 400,000 acres from the national forests for community development and recreation. Alaska also gained title to submerged offshore lands to the limits of the territorial sea and submerged lands of inland navigable lakes and streams.

To date nearly 72 million acres have been selected. The remaining entitlement must be chosen by 1984. While the State has never formally articulated a policy for land selections, it is clear from the pattern that has emerged that three principal objectives have been emphasized: (1) provision of lands to meet existing and future settlement needs; (2) control of lands along major highway corridors; and (3) selection of lands with high potential for natural resource development.

Inasmuch as the remaining State entitlement may be selected almost entirely from unreserved federal public domain, the designation of new "d-2" national interest lands, diminish state selection opportunities. However, Alaska economic development can proceed independently of federally-owned resources and federal resource disposal policies if other federal actions do not unduly inhibit development on State and Native lands, and if the remaining 33 to 36 million acres (depending on federal and Native action) of State entitlement can be selected. Revenues from petroleum development on State-selected lands are already a major source of revenue for the State, and are expected to remain so for many years to come.

Private Lands and the Alaska Native Claims Settlement Act (ANCSA)

Under provisions of the Alaska Native Claims Settlement Act (ANCSA), Alaska Native corporations have selected lands which have traditionally been used by them near villages along the coast and major rivers, and lands they have identified for their commercial resource values. Land entitlements of approximately 200 village corporations will encompass 22 million acres.

It should be underscored that once fee simple title is transferred, these lands will be privately owned by these for-profit Native corporations and not held in any kind of reservation status. Although stock cannot be sold until 1991, these corporations may divest themselves of land and interests in land at any time after transfer of title. Corporate land may also be distributed among individual stockholders.

Several corporations have exercised selection rights on potential oil-bearing lands or on other lands where the presence of timber and metallic and industrial minerals are known or suspected. In the event of a major oil discovery, not only would the owning corporation be benefited, but monies derived would be distributed among the State's entire Native population through the revenue-sharing provisions of Section (7)(i) of the Alaska Native Claims Settlement Act.

The designation of new national interest lands in Alaska could affect the economic viability of Alaska Natives in two ways: (1) the location and management designations of some national interest lands may restrict the transport of resources from Native lands to market; and (2) some management designations may inhibit availability of fish and wildlife resources to meet subsistence needs of Alaska Natives and other rural residents. While many lands have been selected by Native corporations because of their importance to subsistence, the range over which fish and wildlife are taken extends well beyond those lands that will be in private ownership.

Federal and State Land-Use Policies and Energy Development

The major issue associated with the ownership patterns of Alaska lands is land-use policy. Up until Statehood, and for some time thereafter, the great bulk of public lands in Alaska were in the so-called "public domain". That is, they were not reserved for special uses, nor were particular development activities proscribed. In fact, the mining laws established during the 19th century gave considerable advantage to those who wished to develop fuel and mineral resources on public lands. The major exceptions, which involved only a small percentage of Alaska's lands, were the national parks such as Mt. McKinley and Glacier Bay National Monument. Almost all of the federal land in Southeast Alaska was contained in the Tongass National Forest, but land-use policies on national forest lands emphasize multiple use and do not represent a serious impediment to development. Since that time, however, there has been a substantial shift in emphasis with regard to public land-use policy, with increasing emphasis on the preservation of lands in their natural state. This has been essentially true of federal lands in Alaska, viewed by many as America's last great wilderness and last opportunity to protect significant tracts of land from development for mineral and other resources.

Much of this policy orientation was developed prior to the oil embargo of 1973-74 and the ensuing energy crisis. Suddenly, the potential for development of fossil fuel reserves in Alaska became a matter of considerable national priority along with wilderness preservation. The pull and tug of national priorities now has created a situation in which (as expressed recently by Alaska's governor) Alaska is "called upon at once to be the oil barrel for America and national park for the world". The problems inherent in these conflicting goals are best illustrated by Congressional bill HR 39, sponsored by Congressman Morris Udall of Arizona. Under the terms of the Udall bill, 146.6 million acres of federal lands would be withdrawn to various categories of reserve status, including national parks, wildlife refuges, national forest lands, and wild and scenic rivers, with the bulk of the lands falling into the first two categories.

The principal orientation of the Udall bill is that the national interest is best served by reducing development of these federal lands to an absolute miniumum in order to preserve their natural quality for future generations. While the objectives of the Udall bill are desirable in principal, its passage intact could have some serious consequences for future energy development in the State. One of the major problems is that such a large proportion of the potential energy resources, particularly oil and gas, are still unexplored. It is not known precisely where the resources are located, and what transportation corridors may be required to recover them economically. Thus, placement of one-third or more of Alaska's land area in land-use categories which seriously restrict or preclude resource development before full knowledge of the possible trade-offs among land uses are known, could have a serious impact on the nation as a whole. For example, it is known that there are high quality coals on the Alaska Peninsula, at Herendeen Bay and Chignik, which may be of considerable value in the near future. Under the Udall bill, these coal beds could not be developed. Similarly, some of the greatest potential oil and gas reserves in the State lie offshore in the Chukchi Sea at the northwest corner of the State. A natural transportation corridor for this oil and gas, when developed, would be around the western edge of the Brooks Range. Current selections under the Udall bill, however, would block such a corridor. Those same selections, particularly the Selawik Lowlands, are believed to be an area with considerable uranium potential.

The implications of a measure that would preclude development on such a large proportion of Alaska's lands are clearly a matter of national concern. At least an alternative to HR 39 has been proposed in the Senate, with the support of Alaska's Governor, its Congressmen, and one of its two Senators. This is Senate bill S1787, the Alaska National Interest Lands Act. It would take a more moderate course in classifying Alaska's land, and would therefore not preclude future development.

Similar potential problems arise in the classification of Alaska State lands. At the present time, however, the State's plans do not appear to involve as large a proportion of acreage in restricted classifications. In fact, as noted above, one of the objectives of State land selections has been to acquire tracts where developable resources are believed to be present, with the ultimate objective of encouraging development for the benefit of the State, accompanied by adequate environmental safeguards. Thus, it appears at this time that the State's land use management policies have less potential for creating impediments to development than do federal policies.

Finally, of lesser but still significant importance, are the management policies of the Native Corporations. The subsurface rights to all Native lands are owned by the Native Regional Corporations under the terms of ANCSA (except individual Native allotments, where the subsurface is retained by the United States; the village corporations that retained their former Indian Reservations will also own the subsurface).

In general, the village corporations selected lands which were traditional sites of village subsistence hunting, fishing, and gathering. There may be some reluctance on the part of the villages to encourage the development of these subsurface resources. It is expected, however, that development of the subsurface estate generally will be approved by the Village corporations where such development can be accomplished without serious disruption of traditional subsistence life styles. Regional corporations able to select lands on their own behalf, however, tended to select on the basis of natural resource potential with a definite view toward future development. Here it is expected that the earliest and most significant Native land resource development will occur.

SOCIAL, ECONOMIC, POLITICAL AND ENVIRONMENTAL ISSUES

This phase of the Alaska regional energy resources planning project is not intended to provide a detailed analysis of the above issues. Rather, the purpose is to identify the more important issues and to prepare a plan for their future analysis. Such plans have already been prepared as part of Phase 2 of this project, and are discussed further in Chapter 9. Nevertheless, in the context of describing the major issues confronting energy development in the State of Alaska, some discussion of social, economic, political and environmental issues is necessary.

In dealing with the major social and economic impacts of development there is frequently a tendency to search either for effects which are generally beneficial or which tend to be harmful to the economy and society. In fact, of course, it is rare for impacts to be either all good or all bad. We hope to examine both sides of the question throughout our current and future work in this area.

State and Local Government Revenues and Services

The impact on State and local government revenues and services is one of the major two-edged blades of development. Energy development and associated industrial development can generate substantial revenues for State government from a variety of sources, including oil and gas property taxes, royalties, investment earnings on the sale or use of state resources, and oil and gas production severance taxes (see appendix E).

The discovery of oil and gas reserves on the Kenai Peninsula, and later at Prudhoe Bay on the North Slope, has drastically transformed the revenue flow into the State government. One of the immediate problems associated with this revenue flow is the nature of its source. The substantial revenues from lease sales and royalties at Prudhoe Bay are all based on nonrenewable resources, which have a limited life expectancy.

Given an estimated maximum flow of 2 million barrels of crude a day and an estimated Prudhoe Bay reserve of less than 10 billion barrels, these known reserves could be exhausted in 15 years. Although it may be presumed that other additional oil and gas reserves will be found, it must be recognized that Prudhoe Bay is extremely large, even by worldwide standards, and new finds may not approach the size of the present field. When the oil and gas is gone, that source of revenue will also end.

Recognizing this as a major issue facing the State (how to utilize this temporary revenue flow in the best interests of its citizens), a "Permanent Fund" was approved by the electorate during the 1976 general election. The State administration has encouraged a continuing dialog throughout Alaska in an effort to provide facts on the issue of oil and gas revenues and to solicit advice and direction from Alaskans on the best use of the money.

Municipalities have not received large royalty payments (although this may change), and have depended primarily on property taxes and, in some cases, on sales taxes to generate revenue flows. State law has set strict limitations on the power of municipalities to impose oil and gas property taxes (for oil and gas exploration and production and pipeline transportation properties). A municipality may levy and collect oil and gas property taxes, but only at the same millage as it taxes other properties within its boundaries, and the actual assessment of the properties is made by the State. The State also depends on this tax source—in FY 1976 the State Oil and Gas Property Tax provided nearly 12 percent of the State's unrestricted revenues. Alaska municipalities imposing the Oil and Gas Exploration, Production, and Pipeline Transportation Property Tax (AS 29.53.065) include the North Slope Borough, Fairbanks North Star Borough, Matanuska-Susitna Borough, Kenai Peninsula Borough, Municipality of Anchorage, City of Kenai, City of Soldotna, and the City of Fairbanks. The City of Yakutat is expected to impose the tax in FY 1978.

In addition, local government officials may not have the expertise to adequately deal with large scale energy development activities planned near their communities. To mitigate looming negative impacts and to maximize benefits expected through energy development, the Alaska Department of Community and Regional Affairs, funded by the State and Federal governments, has provided technical assistance to several communities such as Yakutat, Kodiak, Valdez, Delta Junction, North Pole, Fairbanks, Cordova and the Kenai Peninsula Borough, all communities faced with large scale energy developments.

Communities along the coast may qualify for special assistance as provided by the Federal Coastal Zone Management Act of 1972 and the Coastal Energy Impact Program of 1976, which provide financial assistance in the form of grants and loans to coastal states and local communities affected by energy facilities which are or will be located on the coast. The program will: (1) aid coastal states and local communities to finance public facilities and services needed in an energy site area; and (2) help protect or restore coastal environmental and recreational resources when other funds for such purposes are unavailable.

ISSUES OF THE ALASKA NATIVE CORPORATIONS

Associated with the issues of State and local government are the economic political, social and environmental issues of the Native Corporations as energy development proceeds. Changing conditions brought on by the passage of the Alaska Native Claims Settlement Act (ANCSA) are partially responsible for the pace of Alaska's energy resource development. Many of the issues relate to land ownership and management and, in one way or another, to ANCSA. Some are temporary problems that may be resolved very shortly; others are expected to take much longer.

Because energy resource production is tied to the land, it is necessary to understand the problems affecting Alaska Natives, who are destined to own about 11 percent of the lands within Alaska's boundaries. Further, the well capitalized Native corporations are expected to play an increasingly important part in energy resource development.

Settlement: Land and Money

The Claims Act, signed into law December 18, 1971, amended January 2, 1976, was designed to provide 40 million acres and about one billion dollars to Alaska's Indians, Eskimos, and Aleuts, by distributing the land and money to Native regional and village corporations. In addition, village corporations which elected to retain their Indian reservations are to receive fee title to 3.7 million acres, bringing the total to 43.7 million acres of land.

Twelve for-profit regional corporations formed under ANCSA and their 203 associated village corporations (see Figure 3-2) are receiving land and cash settlements under the Claims Act. (Many of these village corporations recently merged for business reasons--reportedly numbering about 180 at last count.) Additional village corporations are still waiting approval for ANCSA benefits. A 13th regional corporation, composed of eligible Natives living outside the State will receive no land settlement.

Eligibility for village and group participation in ANCSA has not been finally certified by the U.S. Department of the Interior; however,

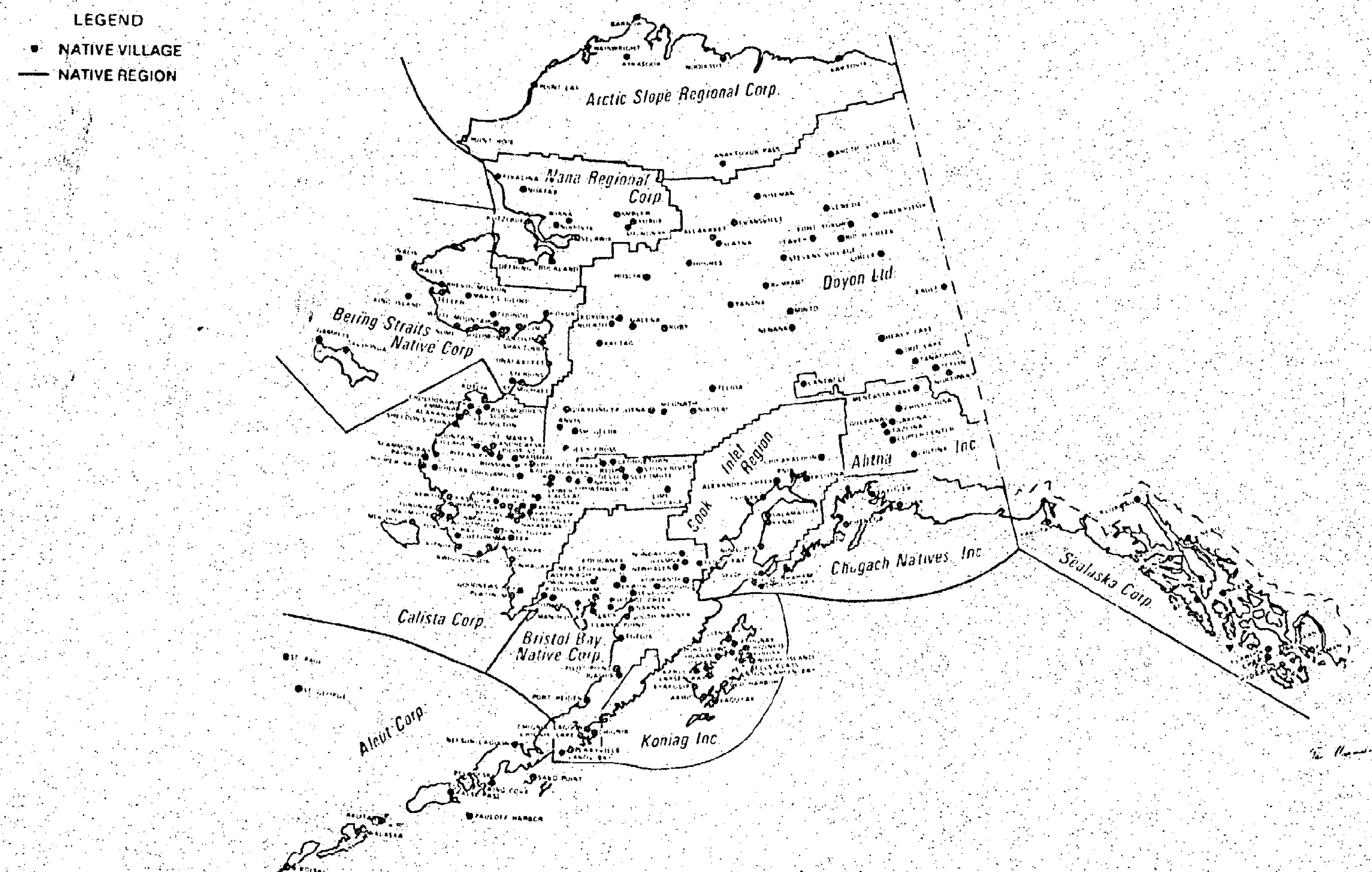


Figure 3-2 Alaska Native Villages & Native Regions

Sources: Alaska Petroleum & Industrial Directory 1977/78; University of Alaska, Institute of Social & Economic Research.

twelve Native villages in the Bering Straits, Cook Inlet and Koniag Regions; and up to 31 Native groups from all regions except Aleut, Arctic Slope and NANA regions were as of August 2, 1977, still pending certification of eligibility by the Secretary of the Interior. Each of the villages pending certification is eligible for entitlements of 69,120 acres; and each group is eligible for entitlements of 320 acres per individual up to a maximum of 7,680 acres per group.

To a varying extent, each of the corporations has substantial potential wealth in lands they will receive under ANCSA. The 12 Alaska regional corporations will receive the subsurface estate of their associated village corporations' lands. Six village corporations, in Bering Straits and Doyon regions (representing four Indian Reservations) have voted to retain their former reservations in-lieu of other ANCSA benefits and are to receive approximately 3.7 million acres of fee simple land; that is, both surface and subsurface estates. The corporations are: Elim Native Corporation, Neets'ai Corporation (Arctic Village), Venetie Native Corporation, Savoonga and Gambell Native Corporation (St. Lawrence Island), and Tetlin Native Corporation.

Individual Natives benefit as shareholders in the Native corporations, but cannot sell their shares of stock until 1991 (20 years after passage of ANCSA) and they enjoy certain tax advantages, paying no taxes on their stock until 1991. The corporations, similarly, are not taxed on their lands unless they sell or develop the resources before 1991; however, corporate profits are not exempt from taxation. All Native corporations are free to sell all or any part of their lands at any time, but none are known to be contemplating this. Leasing is preferred by the Native corporations at this time.

Misunderstanding of Claims

Both the money and land settlement are widely misunderstood. Even many Alaskans think each Native will receive his or her proportional share of the billion dollars and 40 million acres. With over 77,000 Alaska Natives enrolled (and the enrollment has been reopened since this figure was published), had the settlement been on an individual basis rather than going to the corporations, each Native would be expected to receive about $13,000 and 500 acres of land. But this is not how the money and land are being distributed. To date each "At-large" Native shareholder (member of a regional corporation, not enrolled to a village) has received about $2,250 in cash payments and each Village shareholder, (member of regional corporation and village corporation) has received about $410, since the Act passed in 1971. No further distribution to individual shareholders will be made from the Alaska Native Fund. The Land and money capitalize corporations and are managed for the individual Alaska Native shareholders.

Profit-Making Corporations and Non-Profit Associations

Misinformation about the settlement has caused serious problems for the Natives. While the regional corporations were established to be essentially the same as any other well-capitalized, land-based corporations, many Alaskans, including some Natives, think the Native corporations should be spending their money to correct the social problem of the people: control alcoholism, improve health, education and welfare, build free houses, improve transportation, and so forth. The trust responsibility of the regional corporations is to all shareholders (i.e., those enrolled to and living in the villages and the "at-large" shareholders), and for the most part prohibits such activity. Shareholders could be living anywhere, including outside Alaska or in foreign countries, and would not benefit from their share of corporate funds spent on social improvements for villagers.

For each profit-making Native regional corporation therefore, there is a non-profit Native regional association counterpart. These associations receive federal, State, and private funds and grants, and provide some health, education and social services to the people within their regions. However, government agencies at all levels continue to provide most services for native peoples. These Associations, of course, are not involved in management of the lands and resources.

Money Distribution

The Act provides for the establishment of the Alaska Native Fund in the United State's Treasury which will distribute money to the regional and village corporations and their shareholders based upon the number of shareholders enrolled in each regional corporation (Table 3-1). Philosophically, these monies represent additional lands which would otherwise have been returned to Native ownership and control, but were not.

- $462,500,000 in varying annual amounts for the eleven years subsequent to December 18, 1971.

- A maximum of $500,000,000 in mineral royalties from minerals owned by the State of Alaska and the federal government (chiefly based on oil and gas). The annual amount to be received and the period over which it is to be received is indeterminable.

The money received by Native regional corporations from the Alaska Native Fund must be distributed as follows:

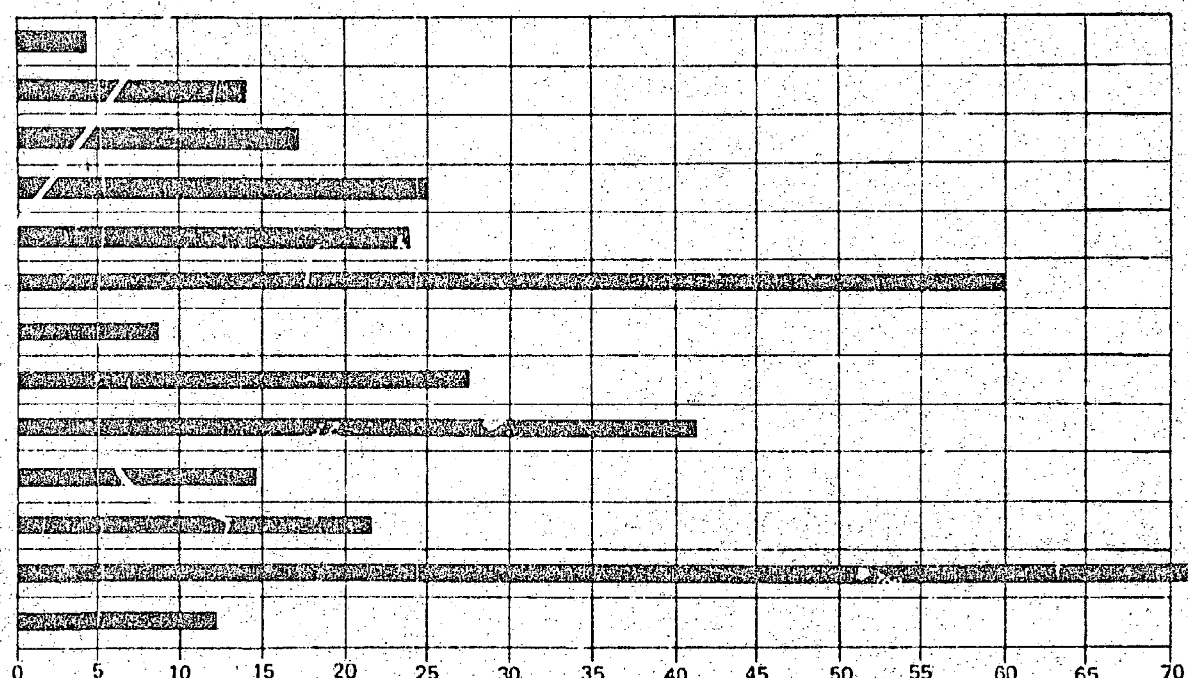
- 10% to individual shareholders for five years expiring December 18, 1976.

- 45% to village corporations and non-village residents for five years until December 18, 1976 and 50% thereafter; and

Table 3-1

PAYMENTS FROM THE ALASKA NATIVE FUND TO THE 12 REGIONAL CORPORATIONS AS OF SEPT. 30, 1977

NATIVE REGIONAL CORPORATION	DISTRIBUTED AS OF 9/30/77
AHTNA	$ 4,790,612.18
ALEUT	14,391,355.48
ARCTIC SLOPE	17,263,083.60
BERING STRAITS	30,198,213.48
BRISTOL BAY	24,220,784.30
CALISTA	60,053,215.02
CHUGACH	8,866,178.62
COOK INLET	27,531,214.87
DOYON	41,347,623.35
KONIAG	14,610,143.61
NANA	21,726,824.23
SEALASKA	71,606,944.42
THIRTEENTH	12,207,151.29
TOTAL	348,813,362.49



Source: "The Alaska Native Management Report" Vol. 6, Number 39, Oct. 15, 1977.

- 45% to be retained by the regional corporations for five years until December 18, 1976 and 50% thereafter.

<u>Money for the Four Listed Villages and Villages Retaining Their Former Indian Reserves</u>

Each of the four Native corporations formed to select and manage native lands for Juneau, Sitka, Kodiak and Kenai was granted $250,000; the six villages, Elim, Savoonga, Gambell, Tetlin, Venetie and Arctic Village, which elected to retain their former Indian Reservations (Elim, St. Lawrence Island, Tetlin and Venetie), were granted $100,000 each under terms of the Native Claims Omnibus Act P.L. 94-204 of January 2, 1976.

<u>Land Distribution</u>

Most land selections were made by December 13, 1974 and were 99 percent completed by December 18, 1975 (four years after ANCSA's passage). Table 3-2 shows a tabulation of lands the Native corporations will eventually receive from federal and State lands.

<u>Land Transfer Problems</u>

Lack of conveyance is the major deterrent to mineral and energy development on Native lands.

As of July 15, 1977, slightly over 10 percent of a total of 43.7 million acres of land had been transferred (4.44 million acres) to the Native corporations by the Bureau of Land Management, leading to charges by Native leaders that the value of the Native settlement was eroded, costing the corporations millions of dollars in lost economic opportunities.

Table 3-2
DISTRIBUTION OF 43.7 MILLION ACRES OF LAND TO NATIVES
ALASKA NATIVE CLAIMS SETTLEMENT ACT

22 million acres:	The village corporations are to own only the surface estate to lands they selected. Their ownership does not include the minerals below the ground; the rights to the minerals--the subsurface estate generally belongs to regional corporations. This is true for all 22 million acres selected, except in Naval Petroleum Reserve #4 and National Wildlife refuges. Once villages obtain title to their lands, they must transfer some tracts to individuals - Native or non-Native, some to organizations, and some to municipal, state or federal governments and can retain the remainder.
+	
16 million acres:	These lands were selected by regional corporations on the basis of land area within their regions, rather than population. Under a complicated land-loss formula, these lands were chosen by those 11 regional corporations which had small enrollments but large areas within their boundaries. Owing to the earlier Tlingit-Haida settlement, the southeastern region was not among the corporations eligible for this provision. Only six regions share in this sixteen million acres: Ahtna, Arctic Slope, Chugach, Cook Inlet, Doyon and NANA.
+	
2 million acres:	The remaining two million acres were set aside for grants of title of lands to special Native corporations organized in the non-Native cities of Sitka, Kenai, Kodiak, and Juneau (which had been historic Native places); for grants to groups of Natives or to individual Natives residing away from villages; for Native allotments which were claimed before the passage of the Act; and for cemeteries and historic sites.
+	
40 million acres:	Total entitlement for all categories, except for village corporations electing to retain their former Indian Reservations.
+	
Approximately 3.7 million acres:	Where villages on revoked reserves voted to acquire title to their former reserves they obtain fee simple title not only to its surface, but also to its minerals. They forego, however, other benefits under the Act. The villages of Gambell, Savoonga, Venetie, Arctic Village, Tetlin and Elim elected to retain their reservations in lieu of other land and money benefits in the Settlement Act.
Approximately 43.7 million acres:	Total lands to be conveyed to Alaska Natives.

Easement Issues

The major block to the passage of title is the so-called "easement question". So many easements and transportation corridors (for energy, fuel, natural resources, and related facilities) have been proposed that seven of the Native regional corporations filed a lawsuit against the Secretary of the Interior to prevent establishment of easements across their lands. The seven regions are: Calista, Chugach, Cook Inlet, Doyon, Koniag, NANA and Sealaska. The Department of the Interior has refused to convey lands subject to easements until the question is settled.

Major disagreement is centered on the resources corridors and the continuous shoreline easements extending 25 feet above mean high tide along much of the 33,400 mile coastline of the State; there is also unhappiness with the linear easements for recreation purposes on rivers and streams since wording of ANCSA does not give the Secretary of the Interior authority to reserve easements for this purpose, in the view of the Natives. Since nearly all Native villages in Alaska are located on waterways, the Native corporations feel their most valuable and productive village lands are being taken away from them under the guise of "easements". The Natives won the first round in the dispute in Federal District Court but this decision is expected to be appealed.

The lawsuit claimed that the Secretary of the Interior erred in not publishing the easement guidelines as required under the Administrative Procedures Act and, further, that he exceeded his authority relative to the easement provisions of the Alaska Native Claims Settlement Act in the published easement guidelines. The guidelines can be found in Secretarial Order (S.O.), No 2982 (local public easements), dated February 5, 1976, and in S.O. 2987 (transportation of energy, fuel, natural resources easements), dated March 3, 1976.

S.O. No. 2987 established policy for reserving a blanket easement "for the transportation of energy, fuel and natural resources which are the property of the United States or which are intended for delivery to the United States, or which are produced by the United States" (emphasis added); this appears to preclude the use of such easements by interests other than the United States government. Some observers speculate that this S.O. is intended to provide for transporting federally-owned resources (oil and natural gas) through a federally owned pipeline. The local easements Secretarial Order, S.O. 2982, does not deal with interregional pipeline problems. Mineral corridors include easements for roads, railroads, oil and gas pipelines, and slurry pipelines that would be built primarily to facilitate the transportation of minerals.

Payment for Easements

Most of the village and Regional corporations are willing to provide easements if they are paid for in the manner other private land is acquired. The Federal-State Land Use Planning Commission has studied the easement question and has suggested that, for interregional easements, the cost of easement acquisition would be very small, perhaps about 1/10 of one percent of the project cost for a major development.

Arctic Slope's Land Transfer

Arctic Slope Regional Corporation (ASRC), which never strongly opposed easements across their lands as have the other regions, has completed easement negotiations with the Secretary of Interior. Interim Conveyance (I.C.) No. 76 to cover more than 3 million acres of land was expected when over 50 protests were filed by individual oil and gas lease applicants. These applications date from the 1966-68 period, before the "big land freeze" which stopped the transfer of land claimed by Natives until Congress could act upon the claims. The application was overruled, and ASRC has received conveyance to the land to which it is entitled (over 4 million acres). It is the first Regional corporation to have received substantially all the land it is entitled to have.

The Arctic Slope Region is considered to have the greatest potential for oil, natural gas and coal development of any of the regions. Although Arctic Slope is prohibited by terms of the Act from getting title to the mineral estate of Naval Petroleum Reserve #4 (now called the National Petroleum Reserve Alaska), the Region has received "in-lieu" subsurface estate from elsewhere within the Region, which also has high crude oil, natural gas and coal resources.

Koniag Region Negotiates Easement Model

Koniag, a participant in the easement law suit against the Secretary of the Interior, has also been negotiating with the Department of the Interior to get interim conveyance to their lands. The results of the settlement announced November 13, 1976, may be the model for all other regions. The suit affects every region, even those that are not party to the easement suit. The Department of Interior does not want to negotiate differently for all Regions. The Court, of course, will decide on the merits of the easement case, and will probably modify any negotiations between the regions and the Secretary. Lawsuits however, are subject to considerable time delays and no timetable for the final adjudication of the case is available at this writing. In the meantime, the Natives hope to get interim conveyance to their lands through the Koniag settlement model. The agreement between Koniag and the Department of the Interior provides a mechanism for processing land selections in the region, and affecting conveyance of the land despite pending court challenges.

Exploration Activity on Native Lands

While private corporations are clearly more interested in working with private land owners (particularly large scale landowners like the regional

Corporations) rather than the state or the federal government--development, that is, drilling and production--cannot take place until the Natives actually have their land transferred to them by the U.S. Department of the Interior.

By the end of 1976 eight of the twelve Native regional corporations had entered into exploration and leasing agreements with seven major oil companies, seven regions had agreements with six mining companies (joint ventures or consortiums counting as one company each). However, development activity was sharply restricted because of lack of land ownership.

Drilling Prohibited Without Land Ownership

No drilling can take place on Native-selected land without a lease, and the BLM cannot issue a lease to drill. Drilling activity on Native lands is therefore restricted to the land that has been transferred to the Natives by: (1) interim conveyance or (2) patent. The Natives are not supposed to issue a lease until they own the land. Until such time as a land transfer takes place, no drilling is to be done.

Doyon, Ltd., the regional corporation of Interior Alaska's Athabascan Indians, has received an interim conveyance to their lands in the Kandik Basin of the Yukon--Porcupine Province near the Canadian border and has been drilling exploratory wells for oil and gas.

Land Trades

In December of 1975, Cook Inlet Region, Inc. entered into a complicated land trade with the State (Division of Lands) and the federal government (Department of the Interior). It was approved both by Congress and the State legislature, and after lengthy litigation on State constitutional grounds, was finally resolved in the region's favor by the U.S. Supreme Court.

The State has made land trades of patented lands with Native corporations (Cook Inlet Region) and others and more exchanges are expected, particularly in Doyon's region. This is being done in an effort to consolidate lands and improve land management.

Regions with regional selections are first required to choose from lands withdrawn for the villages but not selected by the villages, in an checkerboard pattern (the odd townships, odd ranges, even townships and even ranges of the rectangular survey system). If this acreage was inadequate regional deficiency land was set aside by the Secretary of Interior for selection. In Doyon region the checkerboard pattern is the rule, making land more difficult to manage than compact and contiguous tracts would be.

Both the Natives and the State will be trying to improve their land base: the Natives to secure improved realty, timber, energy and mineral resources and the State to secure more of everything, including park land and fish and wildlife habitat. Agreements to exchange may be made prior to the Natives actually receiving interim conveyance. Land trades can also be made with the Department of the Interior (DOI) or with other Native corporations.

Energy Resources on Native Lands

The Cook Inlet trade was brought about because of the scarcity of productive lands for regional selection in Southcentral Alaska's railbelt (where 51% or more of the population lives). Cook Inlet received valuable oil, natural gas, and coal lands in exchange for their land selection rights under ANCSA.

Cook Inlet will receive five townships of State land on the Kenai Peninsula; the areas have coal, oil, natural gas, and uranium potential; up to 9.6 townships of the subsurface estate (oil, gas and coal by in situ gasification only) in the Kenai National Moose Range on the Kenai Peninsula; 13.5 townships having high-value coal potential, as well as oil and natural gas potential in the Beluga area; 1.2 townships of State lands in the Matanuska-Susitan Valley--of which 0.2 townships are in the Chickaloon area of the Matanuska Coal Fields; as well as other valuable lands in the region amounting to 26 townships or 599,040 acres. (Note: one township equals 23,040 acres.)

The surface estate of the 9.6 townships of subsurface estate in the Kenai National Moose Range (part of the National Wildlife Refuge System), will be managed by the federal government. The management agreement for mineral development is very restrictive. The Kenai Moose Range is well endowed with oil, natural gas, and coal deposits as well as moose, but the agreement with Cook Inlet Region restricts the development opportunities of minerals by the Region.

Over half of the region's estimated land entitlement of 55.6 townships is to be made outside the region with the consent of other affected Native regions and villages. One township of coal lands near Healy (outside the region) has been identified for selection based high coal resource values. Revenues received by the region for development of the energy resources on all their lands must be redistributed to the other Native regional corporations pursuant to Section (7)(i) of ANCSA, as explained below.

Mandatory Distribution of Revenues to Other Regions

A major deterrant to energy resource development on Native lands, besides the limited amount of land conveyed so far, will likely arise from Section (7)(i) of the Alaska Native Claims Settlement Act. This section (commonly referred to as the "70-30 split" provision) requires that 70% of all revenues received by each regional corportion from timber and development of the subsurface estate must be divided each year among all

12 regions according to the number of Natives enrolled in each region. This provision was made in an effort to level the effects of the unequal value of resources between regions.

Because of the large size of their regions relative to the Native population, only six regions had the option of selecting lands for their resource value:

Ahtna, Incorporated	Arctic Slope Regional Corporation
Chugach Natives, Inc.	Cook Inlet Region, Inc.
Doyon, Ltd.	NANA Regional Corporation

These six regions share 16 million acres of fee simple land. Some of these regions have shown an unwillingness to share what some observers consider to be a disproportionate share of their revenues with the other regions; others of them charge the term "revenues" is unclear and must be defined. Several lawsuits have ensued over various aspects of the (7)(i) provisions.

Native Regions' Subsurface Rights to Village Land

All twelve regional corporations, both those that have fee simple land rights and those that do not, receive title to the subsurface estate in the 22 million acres of lands selected by their associated villages (except for the National Petroleum Reserve of Alaska and National Wildlife Refuges, where in-lieu subsurface land elsewhere is available to the regions). In these cases of severed estates where the Native village corporations own the surface estate and the Native regional corporations own the subsurface estate, some of the problems are being resolved in federal courts; e.g., whether gravel is a surface or subsurface material and what constitutes the village boundaries relative to the village "veto power" on development.

The Settlement Act provides, "that the right to explore, develop, or remove minerals from the subsurface estate in the lands within the boundaries of the Native village shall be subject to the consent of the village corporation". This "veto power" of the village corporations over regional corporation's development plans is viewed as a threat to development by many of the regions. Some village corporations are expected to withhold approval to the regional corporations who want to develop the village subsurface estate. Resistance to development near villages is expected for a variety of reasons: (1) development could conflict with subsistence lifestyles; (2) development could conflict with the village's surface development plans; and (3) the impacts on the villages caused by development may not be worth the small revenues returned to village corporations under Section (7)(i).

Maintaining their subsistence lifestyle is considered especially important for many villages. Usually, the more remote the village the more likely that residents will view development nearby as harmful. For example, two-thirds of Doyon's villages not presently connected to the road system want no road connection to Fairbanks. Many villagers want roads tying villages together but do not want connections to urban centers. Roads bring unwelcome hunters and fishermen who put pressure on the wildlife the villagers depend on for subsistence living.

Unpatented Valid Mining Claims

The Settlement Act attempted to protect unpatented valid mining claims on lands selected by Native villages or regional corporations. Miners were required to file a mineral patent application or a mineral survey application with the Bureau of Land Management prior to December 1, 1976 (5 years after Congress approved ANCSA), to protect their possessory interests. A valid mining claim requires discovery of a mineral deposit so valuable that a prudent man would be justified in expending his time and money with the expectation of developing a paying mine. Many Native corporations attempted to identify unpatented mining claims on lands selected by them, but the mining claim records in Alaska were so poor (e.g., vague legal descriptions, locations not plotted on status maps as are other valid existing rights at the BLM, etc.) that the attempts were usually abandoned. The burden of proof rested with the miners.

Since the Native corporations were allowed to overselect their basic acreage to assure that sufficient land was identified to cover entitlement after navigable water determinations and surveys are completed, miners weren't certain that land encompassing their claims would ultimately be transferred to the Natives. This has caused serious concern to the miners. The work involved and capital outlay required to protect their interests may well exceed their ability to do so.

Native Allotments

About 7,500 applications for allotments of up to 160 acres each were filed by individual Natives under the Native Allotment Act of 1906. The Settlement Act of 1971, which revoked this earlier law, provided that applications for allotments before its revocation would be honored.

Specific subsurface (minerals) estates of all Native allotments such as oil, gas, and coal, if prospectively valuable, will belong to the Federal government; however, lands valuable for other minerals were not eligible for application. Mineral development, therefore, is unlikely on any Native Allotments.

Lands granted as Native allotments between 1971 and 1976 even though applied for under the 1906 law, are charged against the 40 million acre settlement. If all allotments are approved (an extremely unlikely event) more than one million acres will be transferred to individuals, including those approved before 1971 and after 1976.

Native Selection of State Lands

Native village corporations were allowed to select limited acreages of lands previously selected by the State if the land was not already patented to the State by the Federal government. Native regional corporations were not allowed to select such State lands, although the regions will receive the subsurface estate to their associated villages State lands.

Overselections by Natives Complicates State Selections

Native corporations were allowed to "overselect" as much land as they wished to assure their basic entitlement. The Interior Department has not yet confirmed the exact entitlement of each corporation. Overselection occurred because of uncertainties of exact acreages of unsurveyed lands being selected, mining claims not available and inland water bottoms already owned by the State. This has caused considerable confusion, since no one really knows precisely which 40 million acres will ultimately be patented to the Natives. The 3.7 million additional acres that will be conveyed to the village corporations electing to retain their former Indian reservations are, with minor exceptions, fairly easily defined, however, and except for the Tetlin Indian Reserve, do not involve State lands.

The State of Alaska, when attempting to file State preference rights selections for lands withdrawn for the Natives but not actually selected by the Natives late in 1976, discovered that land was not available at all in five Native regions (Nana, Cook Inlet, Bering Straits, Bristol Bay, Sealaska) where overselections had covered all of the land withdrawn for consideration. Very little land was available in a sixth region (Ahtna), due to a prohibitive federal land order which covered most unselected land. In addition, the State could not select land west of 161° West longitude because of a previous State-federal agreement.

State Inland Navigable Waters And Native Selections

State land selections, as provided for in the 1958 Statehood Act, have been seriously affected by the 1971 Land Claims Act. The "big land freeze" halted State selections from 1968 to 1976 (except for one special State selection made under an agreement with the Department of the Interior in 1972). The Statehood Act specifies a 25 year selection period, terminating in 1984, for the 104 million acre State Land Grant. Inland navigable waters were also granted to the State upon Statehood, but no one seems to know exactly which waters are navigable except those few so designated in court cases or having well documented and widely accepted historic commercial use. As it now stands this matter must be resolved before final Native land entitlements are conveyed. The Natives will receive patent to the beds of non-navigable lakes and streams, but as an incident of Statehood the State owns the beds of all inland navigable waters. The value to the owners of the beds of inland waterways is due to the potential value of the minerals beneath the waters such as the Colville River in the Arctic and the value of the legal right of access such waterways afford. Previously, lands patented to the State by the Bureau of Land Management sometimes included the area of navigable waters; these areas were charged against the State's 104 million acre entitlement, probably wrongly, since the beds of navigable waters were granted to the State outright at the moment of Statehood.

A streamlined approach to the navigable waters issue has emerged: the Interior Department is considering the option of conveying title to the corporations of most water bottoms without charging this acreage against their entitlements, provided the State and Native Corporations agree. Observers see agreement as generally the case.

Minerals Reserved to the United States

On much Alaska land patented under the federal homestead, small tract, trade and manufacturing, and homesite laws after 1956, some or all of the subsurface estate was reserved to the United States: (1) all minerals, including coals; (2) oil and gas; and (3) all fissionable materials (later repealed). The State of Alaska has also been granted patents under the Statehood Act to only these specific reserved interests (less than the full subsurface estate), yet charged as if it were the full fee title. The State also has issued third-party permits and leases to these interests. The Natives possibly can select the United States reserved interests to fill their entitlement of "in-lieu" subsurface to replace National Wildlife Refuge lands not available to them, but they would receive less than the full subsurface estate.

Additions to the Four National Systems - D-2 Lands-(National Interest Lands)

The Alaska Native Claims Settlement Act also includes Section 17(d) (2) commonly called "d-2", which allows the Secretary of the Interior to set aside up to 80 million acres of land (or more if Congress so decides) for study and possible addition to the "Four National Systems": National Wildlife System, National Forests, National Parks, and Wild and Scenic Rivers. Congressional hearings were held throughout Alaska during the summer of 1977, where discussion centered around two new proposals: the (Rep. Morris) Udall d-2 proposal, predominately a wilderness proposal for 146.6 million acres; and the Alaska Concensus proposal, a multiple-use plan for shared federal-state management of about half a 91-million-acre proposal. Until the November 1976 presidential election, the Nixon Administration's d-2 proposal was the frontrunner. With the change in administration (and the Secretary of the Interior) the issue has been opened up for more debate.

The d-2 question has polarized the environmentalists and the developers in Alaska since the passage of the Alaska Native Claims Settlement Act in 1971. Miners, Native Corporations, and other growth-oriented groups (including some State and federal agencies) concerned about the future growth of Alaska, are firmly opposed to passage of any d-2 legislation that will lock up millions of acres of lands they see as valuable. Conservation groups, preservationists, and other environmental interests (again including some State and federal agencies) are concerned about maintaining the environmental quality and preserving areas with unique wildlife and scenic grandeur for future generations. They firmly support locking up those same millions of acres of land.

Almost everyone agrees that certain special areas in the State should obviously be set aside as federal parks, forests, wildlife refuges, and wild and scenic rivers. Their wildlife and scenic values are clearly of national significance and few people challenge this national need.

However, three major land-use issues have recurred throughout the numerous d-2 meetings and discussions. The first is centered on wildlife, particularly with respect to meeting the needs of rural Alaskans, and whether the federal government or the State should manage the taking of fish and game in the d-2 areas. Currently, the State is responsible for the management of resident fish and wildlife species, except where preempted by federal law (as under the Marine Mammal Protection Act), or where hunting is prohibited (as it is in Mt. McKinley National Park). States have traditionally had primary control over wildlife within their borders, and federal management of subsistence hunting, fishing, and trapping on the d-2 lands could disrupt this authority.

The second issue arises because d-2 lands extend across regions where there is virtually no ground transportation system, and future transportation needs are uncertain. Some of the natural transportation routes which go through mountain passes or along rivers, for example, are located in areas that deserve the high level of enduring protection that might be provided by a park or wildlife refuge. However, consideration also must be given to the possible future needs for surface transportation in rural Alaska.

Exploration and development of minerals such as copper, chrome, and nickel to name a few of the possible minerals, is the third major land use issue. Despite the exclusion of many highly mineralized areas from d-2 study areas, some mineralized lands are included within or nearly surrounded by the proposed national parks and wildlife refuges. In some instances, their development may be of national interest in the future.

There are many other issues which will affect the management and use of these d-2 lands. For example:

- Important lowlands, natural transportation corridors, and essential wildlife habitat virtally related to the federal lands and the values they contain are, or will be, in State or private ownership.

- Many of the rivers proposed for the Wild and Scenic Rivers System run through areas of State and Native ownership.

- Approximately half of Alaska's coastline will remain in federal ownership, yet the tidelands and subsurface of the ocean within three miles of these coastal areas are in State ownership. State decisions about these areas will have an extensive impact upon adjoining lands.

- The legal and regulatory relationships of federal and State governments often will be overlapping.

ENVIRONMENTAL ISSUES

The environmental issues associated with resource development are invariably stated in terms of trade-offs between the quality of land, water, and air and the development process. One unfortunate tendency is to view all the changes of the natural environment as unfavorable to it. While often true (there is no known benefit from the silting and leaching associated with strip mining, for example), it is not necessarily true that all alterations of the environment associated with resource development are automatically harmful. Offshore oil platforms, for example, provide a form of man-made reef which often increases local fish populations and thereby the commercial and sport fisheries. Intelligent logging practices can increase the mammal and bird habitat in forested areas since these animals require the low growing bushes and plants which first appear after logging is completed. Similarly, the rights-of-way for power lines are often among the best wildlife habitats. Thus all discussions of environmental impacts must be tempered by the knowledge that alteration of the environment is not always harmful to all concerned and that energy development is not a process which automatically creates vast wastelands of raw rock and poisoned water and air.

Oil and Gas

The seriousness of many of the environmental impacts associated with energy development cannot be minimized. Since the potential impacts vary considerably from resource to resource, each of the energy resources considered in the study raises its own set of environmental issues. Major concerns of onshore and offshore oil and gas development, for example, are oil spills. These spills can be especially dangerous offshore, where cleanup and control of the effects are especially difficult. A major spill could be disastrous, for example, in the midst of the salmon runs in Bristol Bay, and even onshore the effects could be very serious in the midst of a major water fowl nesting area. There is the ever present danger of large spills onshore and offshore at collection points and along overseas transportation routes. The high seas which frequently occur in Alaskan waters, combined with the ruggedness and isolation of the Alaskan coastline, make the possibility of such a disaster seem especially acute. Additional offshore oil development impacts include the leakage of chemicals, drilling wastes, and foreign substances into surrounding waters. Onshore, oil and gas development tends to open previously inaccessible wilderness areas when access roads and airstrips are constructed. Additional impacts on the local ecology are created by construction and drilling camps and along pipelines and other transportation corridors.

Coal:

Surface coal mining, the most likely form of coal recovery in Alaska, is viewed as having some of the most serious impacts on the environment. Not only must substantial acreage be cleared and overburden set aside, but the process creates a great deal of dust and potential fouling of nearby waters with run-off. In addition, the transport demands of surface coal operations are large generally involving rail lines or heavy truck routes. Litter also tends to be prevalent, creating additional environmental impacts. Finally, there are the environmental problems associated with the burning of coal as fuel. One of the major problems with the use of coal as a fuel, the oxides of sulfur produced, is minimized in Alaska due to the low sulfur content of Alaskan coals. Nevertheless, the quantity of ash and other combustion by-products produced can be voluminous.

Hydropower:

Hydroelectric power, which has so many advantages in terms of air quality and renewability, has a number of serious environmental issues associated with its production. Dams and the result of flooding of large areas are essentially irreversible products of hydroelectric power development. No certain way has yet been found to eliminate the impact of dams on andromodous fish. Thousands of acres of river bottom for wildlife habitat are often lost due to flooding, to be replaced by frequently sterile reservoir systems. In addition, the construction of hydroelectric facilities requires a large labor force working over a protracted period. Cement plants may be required close to construction sites, with their additional environmental impacts. Finally, the considerable seismic activity characteristic of much of Alaska represents a continual danger of dam collapse, with the concomitant damage caused by an enormous and unpredictable flood.

Uranium:

Many of the problems associated with uranium development are similar to those associated with the development of coal. The favored mining method is surface mining. There can be radiation hazards in subsurface mines, and the ecological effects associated with surface mining are similar to those for the surface mining of coal. In addition, there is the possible local effect of increased radiation hazard as uranium ore is exposed during the mining process. Finally, if uranium is found in small proportions in the ores, primary processing in Alaska (an economic requirement), could create its own environmental burden, including tailings and other waste material and a substantial demand for electic power and water.

THE MODELING OF DEVELOPMENT IMPACTS

As noted earlier, one of the major tasks facing this project in succeeding phases is the detailed analysis of social, economic, political, and environmental issues associated with expected energy developments in the state. Also, it is expected that such development will stimulate additional industrial development, which can be said to be a direct outcome of energy development. It is relatively easy to determine the general nature of the issues and impacts associated with different types of energy development. A thorough analysis of these questions, however requires some methodology to generate quantitative measures of such variables as labor force requirements, energy demand, material demands, and potential pollutants. When these quantities are known it is possible to put quantitative measures on the development impacts.

Fortunately, by the time these analyses are begun a model estimating these types of measures will be available to the project team. At the present time, the Division of Economic Enterprise of the Alaska Department of Commerce and Economic Development is building a policy planning model which estimates the four basic measures mentioned above for a number of basic industries that presently exist or are likely to be developed in Alaska.

The labor requirements component of the model is especially important, since it will not only estimate gross labor but will also provide considerable detail on the skill levels required. Energy and material demands are obviously of considerable importance. They represent secondary development impacts which may otherwise be difficult to capture in an analysis which concentrates on energy developments alone. In many cases, these requirements for energy and material may generate industrial growth which has a more severe impact on the State's economy and environment than the energy development itself. The need for quantitative measures of pollutant production on an industry basis is obvious, but is not always otherwise available. The model thus will provide a more systemic method of analyzing environmental impact than otherwise might be possible.

CHAPTER 4

RECOVERABLE FOSSIL FUELS

OIL AND GAS

Recoverable Resource Sites (Onshore)

At present, there are only three onshore petroleum provinces in the State that, according to the U.S. Geological Survey (USGS), have measured reserves of oil and gas.* These are Cook Inlet, the Northern Foothills, and the Arctic Coastal Plain at Prudhoe Bay. Prudhoe Bay is by far the largest deposit, with measured reserves in 1975 of 9.967 billion barrels of recoverable oil and 27.193 trillion cubic feet of recoverable natural gas. Measured reserves for Cook Inlet (onshore) and the Northern Foothills are of much smaller magnitude, consisting of 0.262 billion barrels or oil and 4.463 trillion cubic feet of gas at Cook Inlet, and 0.08 billion barrels of oil and 0.315 trillion cubic feet of gas in the Northern Foothills (see Tables 2-5 through 2-8 in Volume 2, Chapter 2).

There is, however, considerable expectation that oil and gas will be found onshore in other sites in the State. Currently, there are fourteen onshore petroleum provinces in Alaska. The undiscovered recoverable resources, locations, approximate boundaries, and ranking of these provinces are shown on Table 4-1 and in Figure 4-1.

Since relatively little of the exploratory drilling in Alaska, so far, has occurred in areas other than the Arctic Coastal Plain, Alaska Peninsula, and in Cook Inlet, the evidence of the potential reserves contained in the other 12 onshore provinces is based primarily on what is known of their geology. Estimates based on this evidence have been compiled by the USGS and are given in Volume 2.

To secure the best and most recent available information on oil and gas, we asked several experts in the field to give us their impressions of the likelihood and probable timing of development in the various provinces. The experts questioned about onshore oil and gas sites were:

Patrick Dobey, Petroleum Manager
Department of Natural Resources
Division of Minerals and Energy Management
323 East 4th Avenue, McKay Annex
Anchorage, Alaska 99501

Frank B. Chmelik, Manager
Alaska Office
Tetra Tech. Inc.
909 West 8th Avenue, Suite 101
Anchorage, Alaska 99501

Irene Ryan, Consulting Geologist
Box 84 Star Route A
Anchorage, Alaska 99502
(907) 344-3189

Jerry Kreitner
Energy Development Analyst
Federal-State Land Use Planning Commission
733 West Fourth Avenue
Anchorage, Alaska 99501

*Measured reserves are that part of the identified resource which can be economically extracted using existing technology. The amount is estimated from geologic evidence supported directly by engineering measurement.

Table 4-1
ESTIMATES OF ALASKA ONSHORE UNDISCOVERED RECOVERABLE RESOURCES

ONSHORE PETROLEUM PROVINCES		OIL (Billions of Barrels)			GAS (Trillion Cubic Feet)		
Name	Area (sq. mi.)	Marg. 1/ Prob.	Range 2/	Stat. 3/ Mean	Marg. 1/ Prob.	Range 2/	Stat. 3/ Mean
Arctic Coastal Plain	25,570	1.0	3.0 - 10.0	6.48	1.0	7.0 - 25.0	18.51
Northern Foothills	29,495	1.0	1.0 - 6.4	2.84	1.0	2.3 - 15.0	7.1
Southern Foothills and Brooks Range	40,260	0.4	0 - 1.2	0.3	0.6	0 - 7.0	2.27
Selawik Lowlands	4,520	---	Negl.	Negl.	---	Negl.	Negl.
Yukon-Porcupine	20,480	0.3	0 - 0.4	0.1	0.3	0 - 2.0	0.39
Yukon-Koyukuk	64,735	0.25	0 - 0.4	0.07	0.4	0 - 1.5	2.29
Interior Lowlands	23,610	---	Negl.	Negl.	0.35	0 - 0.7	0.31
Bristol Bay Tertiary	9,670	0.4	0 - 0.7	0.16	0.7	0 - 2.4	2.38
Alaska Peninsula	14,531	0.4	0 - 1.1	0.24	0.4	0 - 2.0	0.41
Cook Inlet	6,275	1.0	0.2 - 0.8	0.44	1.0	0.7 - 2.8	1.53
Copper River	5,090	0.3	0 - 0.16	0.04	0.4	0 - 0.8	0.22
Gulf of Alaska Tertiary	4,510	1.0	0.1 - 0.5	0.27	1.0	0.2 - 0.8	0.44
Kodiak Tertiary	770	---	Negl.	Negl.	---	Negl.	Negl.
Southeastern Alaska	350	---	Negl.	Negl.	---	Negl.	Negl.

1/ The marginal probability: the fractional probability between 0 and 1 that some commercial discovery will be made in the province; based on a concensus of USGS sources.
2/ The low value of the range is the quantity associated with a 95% probability that there is at least this amount; The high value is the quantity with a 5% probability that there is at least this amount.
3/ Statistical mean: mean of the probability distribution used for the range, multiplied by the marginal probability. The raw mean of the probability distribution can be derived by dividing the value shown by the marginal probability.
Negligible - Less than 0.001 billion barrels of oil or 0.0001 trillion cubic feet of gas.

Source: United States Geological Survey; Unpublished data for Circular 725, "Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the U.S." (1975)

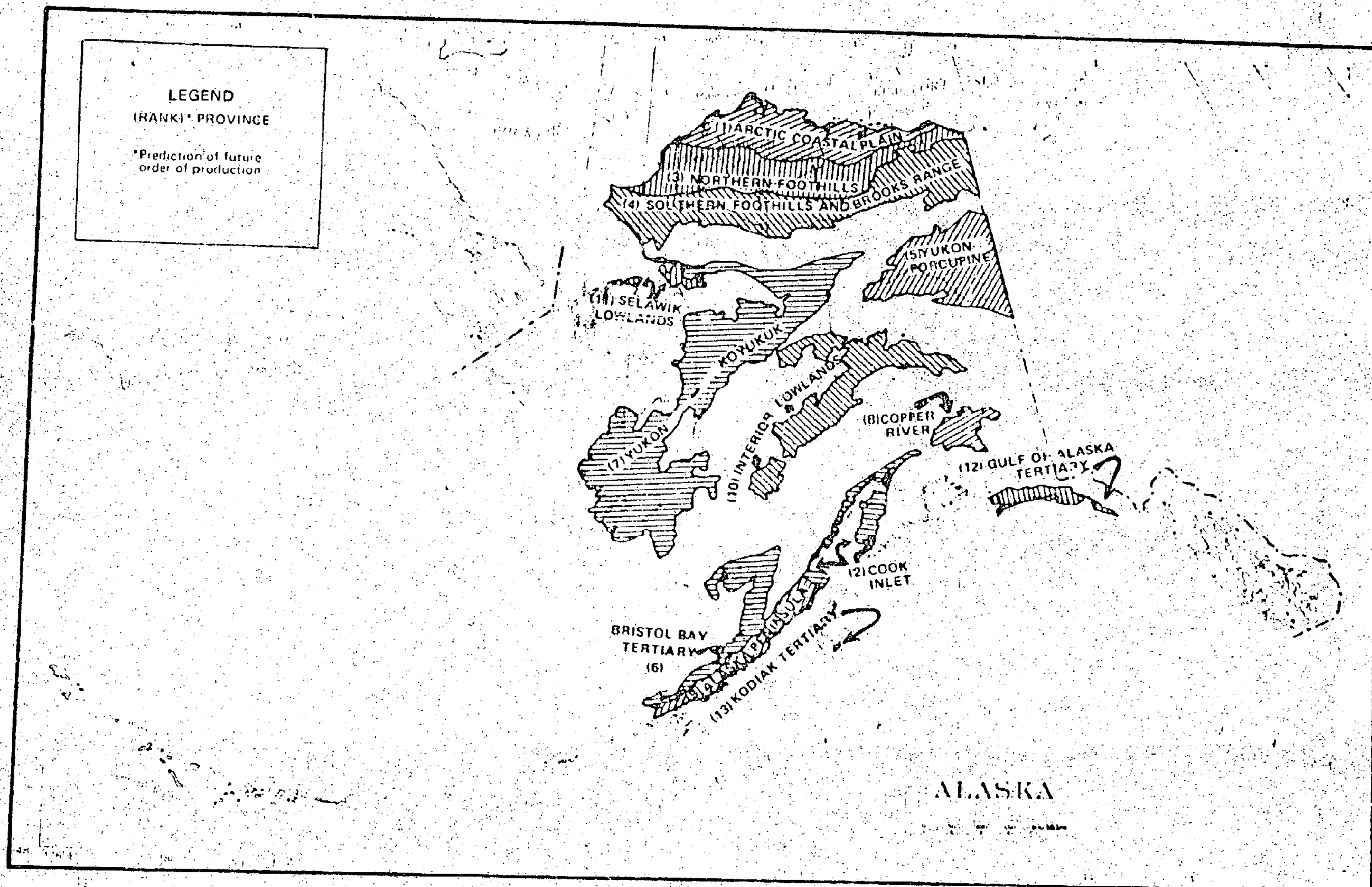


Figure 4-1 Onshore Oil & Gas Provinces

State of Alaska, Division of Energy & Power Development 1977

DGGS Staff
Department of Natural Resources
Division of Geological and
Geophysical Survey
3001 Porcupine Drive
Anchorage, Alaska 99501

Gil Mull, Geologist
Exploration and Strategies
ONPRA (Office of National Petroleum
Reserves in Alaska)
2525 C Street, Suite 400
Anchorage, Alaska 99503

Thomas E. Kelly, Consultant
Earth Sciences
700 H Street
Anchorage, Alaska 99501

Robert Sanders, Geologist
Federal Energy Administration
Federal Building; 605 West 4th Avenue
Anchorage, Alaska 99501

The results of the oil and gas site screening are in Table 4-2 and Figure 4-1 which give the ranking (i.e., prediction of the future order of production) of the oil and gas province as well as location, timing, and selected excerpts from comments by the experts. Also included are the size of the province and an estimate of the undiscovered recoverable oil (billions of barrels) and gas (trillions of cubic feet) (Ref: 4-1). Of the provinces listed, two of them (Arctic Coastal Plain and Cook Inlet) have recovery operations already underway; therefore, the remaining part of these two provinces were ranked along with the other provinces.

As might be expected, these experts generally considered expansion of oil and gas development on the Arctic Coastal Plain and in Cook Inlet to be the most likely event in the immediate future. Atlantic Richfield's recently announced plans for drilling in another formation near Prudhoe Bay supports this theory. Exxon's discoveries at Flaxman Island and Point Thompson are also from a different formation than Prudhoe.

ARCO presently has plans for two exploratory and two development wells in the Kuparuk River region. The drilling, to be done this winter, is the initial step by the firm to determine the oil potential in the Kuparuk River formation, located approximately 30 miles west of the ARCO side of the Prudhoe Bay field. The formation overlays the Sadlerochit formation, which is the source of oil now being produced by ARCO and British Petroleum at Prudhoe. Preliminary estimates show the Kuparuk's oil-bearing stratum to be rather thin, which may discourage immediate recovery. Should recovery be economical, ARCO's long-range plans presently under study include four drill sites, 32 wells, and a flow station, involving a total estimated cost of $220 million.

Other areas considered most likely to be developed are in the Northern and Southern Foothills petroleum provinces, broad bands lying south of the Arctic Coastal Plain on the northern slope of the Brooks Range.

A relatively large group of six provinces is considered to be substantially more speculative in terms of likelihood, timing, and probable scale of development. Almost every expert had a different favorite among this group, with opinions varying widely on rankings and timing. Considerably more

Table 4-2
OIL & GAS SITE RANKING (ONSHORE)
(Prediction of future order of production)

Ranking of Province (Region)	Area Mi^2 (Volume Mi^3)	Undiscovered Recoverable*: OIL billions bbls. Range	Undiscovered Recoverable*: GAS trillion cu.ft. Range	Timing	Excerpts from Comments by Experts
1) ARCTIC COASTAL PLAIN (Arctic)	25,570 (75,712)	3.0 - 10.0	7.0 - 25.0	1980 - 1993	"North of Barrow Arch best prospect; Close enough to use Prudhoe Bay infrastructure." "Established production; Large structure at Marsh Creek." "Kuparuk and Lisburne pools may be produced as oil prices rise." "Active program of exploration on-going in several areas."
2) COOK INLET (Southcentral)	6,275 (13,100)	0.2 - 0.8	0.7 - 2.0	1980-1990	"May be explored for gas." "Good gas potential by expanding known fields." "Fair to good prospects to be drilled in 1977-1978."
3) NORTHERN FOOT-HILLS (Arctic)	29,495 (133,350)	1.0 - 6.4	2.3 - 15.0	1980-2000+	"Good Cretaceous play in western part; production established." "Oil in deep part of basin; drilling costs high, structure not encouraging; political problems in wildlife range." "Exploration underway on good prospect."
4) SOUTHERN FOOT-HILLS (Arctic)	40,260 (183,570)	0 - 1.2	0 - 7.0	1980-2000+	"Gas potential fair." "Most promising of any area at this time."
5) YUKON-PORCUPINE (Interior)	20,480 (48,190)	0 - 0.4	0 - 2.0	- -	"Native controlled lands near pipeline; Possible production on Canadian side will keep interest." "First was not encouraging, lack of known reservoirs and source rocks." "Prospective area under exploration."
6) BRISTOL BAY TERTIARY (Southwest)	9,670 (13,480)	0 - 0.7	0 - 2.4	1990-1995	"Native interest will push exploration; Occurrence of oil seeps in surrounding areas." "No encouraging results to date; volcanics." "Testing so far has been discouraging; Probably will not produce." "Little chance for major discoveries."
7) YUKON-KOYUKUK (Southwest)	64,735 (100,000)	0 - 0.4	0 - 1.5	- -	"$20/bbl oil will move the area." "Bethel Basin probably only productive area: Many volcanics in western portion: Highly fractured & indurated cretaceous marine sediments." "Area around Delta has a chance; Most of area not geologically encouraging." "Big disappointment, but big area to explore."
8) COPPER RIVER (Southcentral)	5,090 (5,020)	0 - 0.16	0 - 0.8	1985-Never	"Gas, some oil, cheap to find; Five years should have discovery." "Native interests push development; Have been gas discoveries." "Excessive volcanics in eastern part of basin; Possibly very shallow gas." "Geology very poor; No reservoirs."

Table 4-2 (Continued)
OIL & GAS SITE RANKING (ONSHORE)
(Prediction of future order of production)

Ranking of Province (Region)	Area Mi^2 (Volume Mi^3)	Undiscovered Recoverable* OIL billions bbls. Range	GAS trillion cu.ft. Range	Timing	Excerpts from Comments by Experts
9) ALASKA PENINSULA (Southwest)	14,531 (46,730)	0 - 1.1	0 - 2.0	--	"Native interest will push exploration; Occurrence of oil seeps in surrounding areas." "No encouraging results to date; Volcanics." "Geology very poor." "Little chance for major discoveries."
10) INTERIOR LOWLANDS (Interior)	23,610 (9,170)	Negl.	0 - 0.7	1990-Never	"Shallow gas deposits, only for local consumption." "Thin tertiary section (5,000 feet max.) on metamorphics." "Very poor potential." "Little chance for major discovery."
11) SELAWIK LOWLANDS (Northwest)	4,510 (12,000)	Negl.	Negl.	--	"State leasing - gas, some oil." "Oil seeps unknown outside of Seward Peninsula." "Probably unproductive." "Fair prospects, but apt to be small."
12) GULF OF ALASKA (Southcentral)	4,510 (12,000)	0.1 - 0.5	0.2 - 0.8	1990-Never	"Maybe, but too broken up." "Best structures under glacier; very little success to date." "Structure too complex; Results of testing all negative." "Little chance for commercial discoveries."
13) KODIAK TERTIARY (Southcentral)	770 (600)	Negl.	Negl.	--	"No" "Tertiary section too thin." "Not enough basin onshore." "Little chance for major discoveries."
14) SOUTHEASTERN ALASKA (Southeast)	350 (715)	Negl.	Negl.	2000+ Never	"Marginal; Occasional drilling." "Maybe, southern end." "Geology not at all proper for oil and gas." "Little chance for major discoveries."

* Details of these resource estimates by U.S. Department of the Interior, Geological Survey, are given in Volume 2; where production is already underway in a province (i.e. Arctic Coastal Plain and Cook Inlet), the remaining part of the province was ranked.

concensus, however, was expressed on the last four provinces, in which, for various reasons (usually geology), development is considered unlikely.

The rankings on Table 4-2 thus reveal four groupings of provinces: (1) most certain (Cook Inlet, Arctic Coastal Plain); (2) highly probable (Northern and Southern Foothills); (3) probable, but with mixed opinions (six provinces): and (4) the very unlikely (Selawik, Gulf of Alaska, Kodiak and Southeast).

Recoverable Resource Sites (Offshore)

Lands offshore of Alaska, the Continental Margin, are part of the submerged extension of the North American Continent. They consist of the gently-sloping lands under the coastal waters called the Continental Shelf, the more steeply dipping Continental Slope, and the Continental Rise which extends from the base of the Continental Slope to the abyssal ocean floor (Figure 4-2, 4-3).

Jurisdiction over Alaska's continental shelf is divided between the federal government and the State of Alaska. The State owns the tidelands plus the three nautical mile coastal strip of the continental shelf; the United States owns the submerged lands seaward of the State's lands called the Outer Continental Shelf (OCS) to the 200 meter water depth. Management of the energy and mineral resources in the area under State jurisdiction (roughly estimated to be in excess of 20 million acres) is the responsibility of the Alaska Department of Natural Resources. OCS lands under federal jurisdiction are estimated to be in excess of 200 million acres out to a water depth of 200 meters, and are the responsibility of the United States Department of the Interior. No agreement has been reached on the exact line separating the two jurisdictions, causing potential dispute and litigation between the State of Alaska and the federal government.

The fact that the federal-State boundary and the outer limit of OCS are still not resolved may delay the sale of leases in many offshore oil and gas provinces. Additional delays in some areas may also occur due to questions regarding the continental margin boundaries between the United States an other countries. Most of the international offshore boundaries have not been determined between the United States and Canada, affecting potential lease sales in the most easterly part of the Beaufort province and, less importantly, the Southeast petroleum province. Much of the offshore boundary between the United States and the USSR also is undetermined, affecting the future lease sales of the Chukchi, Hope, and Navarin petroleum provinces.

Although some questions remain on the precise boundaries of Alaska's offshore lands, there is little doubt about their enormous resources. Thirteen sedimentary basins (or provinces), having potentially valuable petroleum deposits (shown in Figure 4-4), have been identified offshore of Alaska's coast within the continental shelf. Except for an occasional Continental Offshore Stratigraphic Test (COST) well for off-structure exploration, Cook Inlet

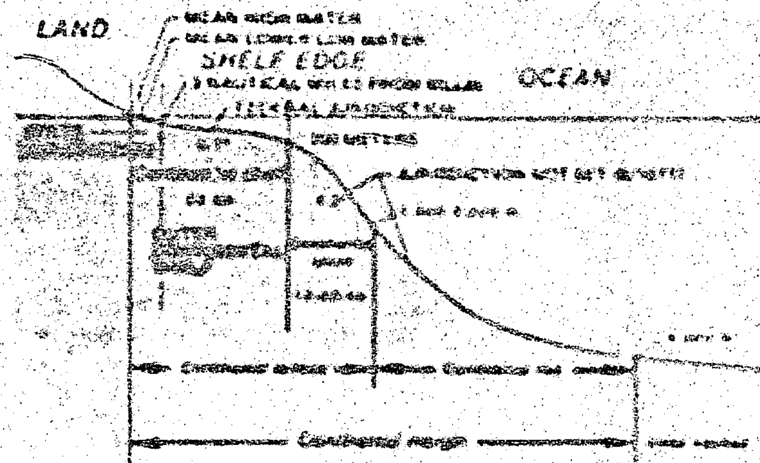


Figure 4.2 Profile of the Continental Margin Showing Lands Under State of Alaska, Federal and Undetermined Jurisdictions

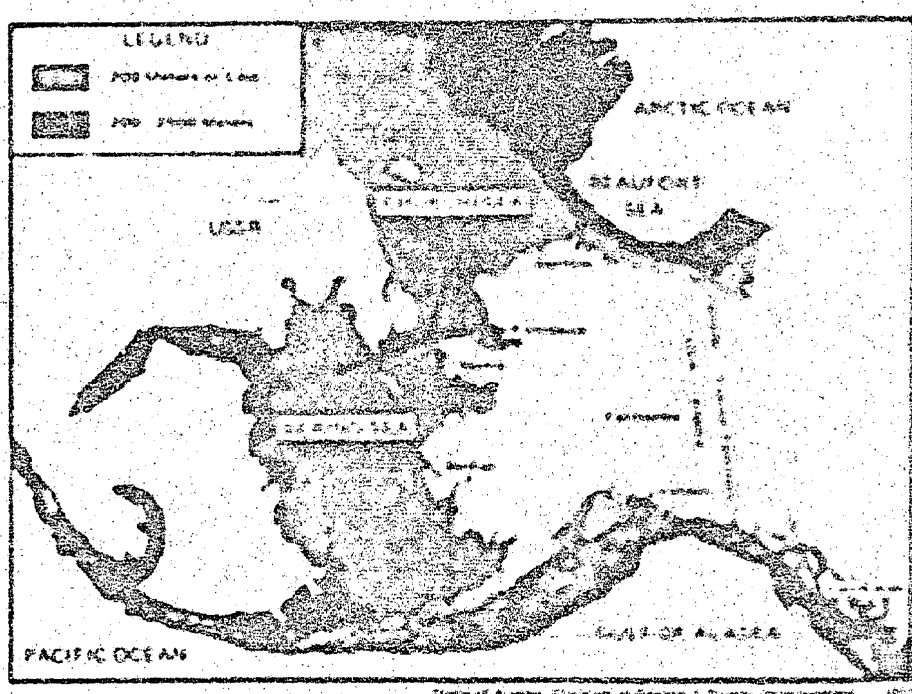


Figure 4.3 Alaska's Continental Terrace

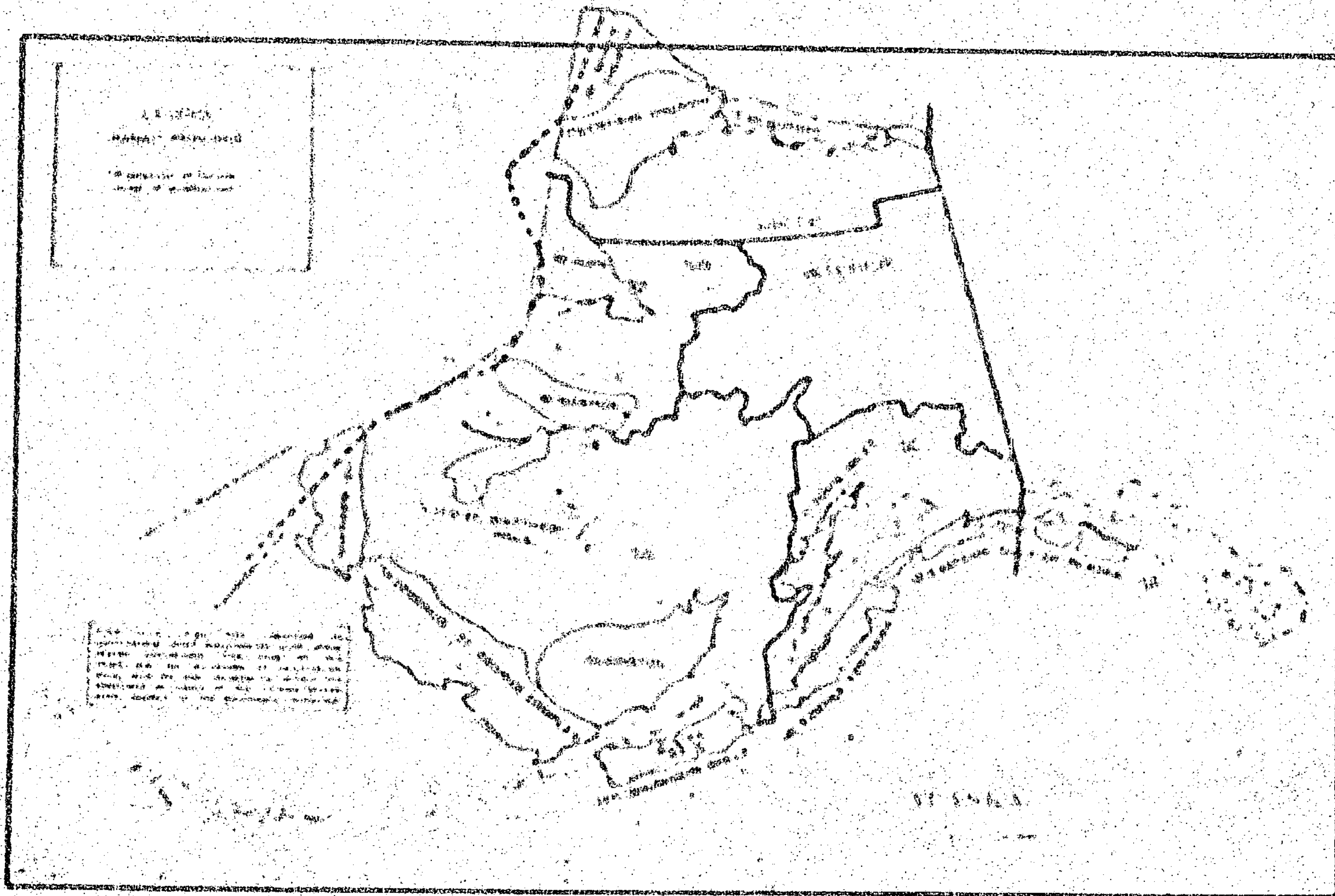


Figure 4.4 Offshore Oil & Gas Prospects

[illegible]

production, and unsuccessful* activity in the northeast Gulf of Alaska, these areas have seen little drilling.

Estimates of the oil and gas potential are based on geological evidence. The calculations of the U.S. Geological Survey are shown in Table 4-3.**

The timing of development of the offshore provinces depends on several factors, including the schedule of future oil lease sales by the State and the U.S. Bureau of Land Management (BLM), and the oil companies' expectations regarding the costs and returns to exploring in various sites at a given time. (These two factors are not independent, of course, since lease schedules are determined in part by oil company areas of interest).

---

*In early September 1977, after a year of what industry speculators called "a perfect batting average of .000" in the northeast Gulf of Alaska, Atlantic Richfield and partner Shell announced plans for a "temporary drilling halt" in that area. The two companies leased the SEDCO 706 semi-submersible drilling rig which then left Alaskan waters. The SEDCO was the first drilling rig to spud in the northeast Gulf (Sept. 1, 1976) after a lease sale for the area was held the previous April. ARCO also announced its release of the Ocean Ranger, the world's largest semi-submersible, following completion of its COST well in lower Cook Inlet in October. Both ARCO and Shell indicated plans to spend the next several months analyzing the "dry hole" information to determine whether further drilling is warranted.

**The USGS and the Bureau of Mines classify the oil and gas potential of the United States, including the Continental Shelf, in four categories. The oil and gas in discovered reservoirs which can be produced economically with existing technology are referred to as measured reserves. Indicated reserves are the additional quantities of crude oil in known reservoirs (in excess of the measured reserves) which are believed to be economically available by application of fluid injection, whether or not such a program is currently installed. Inferred reserves are quantities of oil and gas in known oil and gas fields that probably will be found by further drilling through extensions of producing horizons and discovery of new pay zones. From geologic data and theory, it can be deduced that oil and gas may exist in other specific parts of the earth's crust even though no wells have been drilled to determine what, or if reservoirs exist, how much oil and gas they may contain, and how much might be recovered. The estimates made from such geologic inferences are called undiscovered recoverable resources. Because only a small part of the U.S. Continental Shelf has been explored and drilled, most of its potential resources remain in the last category.

Table 4.3
ESTIMATES OF ALASKA OFFSHORE UNDISCOVERED RECOVERABLE RESOURCES

OFFSHORE PETROLEUM PROVINCES		OIL (Billions of Barrels)			GAS (Trillion Cubic Feet)		
Name	Area (sq. mi.)	Marg. Prob. 1/	Range 2/	Stat. Mean 3/	Marg. Prob. 1/	Range 2/	Stat. Mean 3/
Beaufort Sea	18,257	0.75	0 - 7.6	3.28	0.75	0 - 19.3	8.2
North Chukchi	22,880	0.6	0 - 6.2	1.89	0.6	0 - 19.5	5.67
Central Chukchi	38,215	0.7	0 - 11.9	4.41	0.7	0 - 30.0	11.0
Hope	22,621	0.3	0 - 0.6	0.13	0.5	0 - 3.3	0.86
Norton	16,768	0.4	0 - 2.19	0.54	0.6	0 - 2.8	0.65
St. Matthew-Hall	10,510		Negl.	Negl.		Negl.	Negl.
Bristol	46,039	0.5	0 - 2.5	0.71	0.5	0 - 5.4	1.64
Navarin	19,744	0.3	0 - 1.9	0.36	0.3	0 - 4.8	0.93
Zemchug-St. George Basin Complex	65,453	0.5	0 - 5.1	1.32	0.5	0 - 13.0	3.3
Cook Inlet (Total)	not avail.	1.0	0.5 - 2.3	1.19	1.0	1.0 - 4.5	2.39
Eastern Gulf of Alaska	14,354	0.7	0 - 4.4	1.13	0.7	0 - 13.0	3.39
Kodiak Territory	15,290	0.4	0 - 1.1	0.23	0.4	0 - 3.5	0.69
Shumagin Shelf	17,218	0.2	0 - 0.25	0.03	0.2	0 - 0.5	0.08

1/ Consensus probability of USGS resources that some commercial discovery will be made.
2/ The low value of the range is the quantity associated with a 95% probability that there is at least this amount. The high value is the quantity with a 5% probability that there is at least this amount.
3/ Mean of the probability distribution used for the range multiplied by the marginal probability. The raw mean of the probability can be derived by dividing the value shown by the marginal probability.
Negligible = Less than 0.001 billion barrels of oil or 0.001 trillion cubic feet of gas.

Source: United States Geological Survey. Unpublished data for Circular 725, Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the U.S. (1975).

In gathering the latest information on offshore oil and gas operations, those who assisted with the onshore portion also provided material on activity in costal waters. Each of the participating experts was supplied with the area of the province and the range of the estimated undiscovered recoverable oil (in billion barrels of oil) and gas (in trillions of cubic feet) and the OCS lease schedule, published by BLM in January 1977. The expert was requested to provide rankings of the order in which he expected development to occur in the different provinces, as well as likely dates of development. Relevant comments on such development were also sought. (A copy of materials sent to each expert is found in the Appendix.)

The BLM/OCS schedule of lease actions was revised subsequent to the request for informational screening. The most recently announced OCS schedule (August 23, 1977) calls for a total of 15 sales throughout the U.S., to be held from 1979 through 1981. The three year program is described by Interior Secretary Cecil Andrus as one which "will allow the states to participate in the leasing process, will call on all regions of the country to help meet domestic energy needs, and will balance energy potential with environmental costs".

Five of the sales will be for Alaska coastal areas, five are in the Atlantic, three are in the Gulf of Alaska, and two are in California waters.

Following the October, 1977, sale for lower Cook Inlet, no sales are planned until December, 1979, when a joint federal-State sale in the Beaufort Sea is scheduled.

A second sale in the Gulf of Alaska (where exploration so far has been unsuccessful) will be held in June, 1980. Also to occur in 1980 (October) is a rescheduled Kodiak area sale, initially set for November, 1977. The last two Alaska sales in the three-year program are a second Cook Inlet offering (March, 1981) and a Norton Sound lease sale (December, 1981).

Several areas previously included in Alaska's OCS program were withdrawn from consideration at the urging of State officials. Sales in the St. George Basin and in Bristol Bay, both marine sanctuaries, were postponed pending further study. Drilling in the Chukchi Sea, Norton Basin, and the Beaufort Sea ice pack were removed from consideration due to what officials described as "the lack of technological developments" needed to work safely in those (ice prevalent) areas".

The results of the oil and gas (offshore) screening are on the next two pages in Table 4-4. As the estimates in the table reveal, there is some uncertainty regarding the extent of offshore reserves. Nevertheless, with technology already proved in the North Sea, upper Cook Inlet and elsewhere (see section on technology), oil and/or gas appear to be potentially recoverable from most of these areas if discovered in sufficient quantity*. The

*Due to the high costs of recovery in many offshore locations, discovery itself is not sufficient to guarantee development. For example, company sources indicate that an oil field in the Gulf of Alaska must be expected to yield 100-150 million barrels before development platforms would be built. This figure would, of course, change over time depending on the relative rates of growth of oil prices and construction costs.

Table 4-4
OIL & GAS SITE RANKING (OFFSHORE)
(Prediction of future order of production)

Ranking of Province (Region)	Area Mi^2 (Volume Mi^3)	Undiscovered Recoverable* OIL billions bbls. Range	GAS trillion cu.ft. Range	Timing	Excerpts from Comments by Experts
1) COOK INLET (Southcentral)	——— (26,239)	0.5 - 2.3	1.0 - 4.5	1981-1995	"Interesting." "If the sale goes; More known of this area than others; Infrastructure and and technology available." "Established production in Upper Cook and Jurassic oil seeps; Good structure." "Good potential if sale is held."
2) EASTERN GULF OF ALASKA (Southcentral)	14,354 (29,133)	0 - 4.4	0 - 13.0	1980-1995	"May be too broken up." "Production five years after discovery, no infrastructure." "Moderate potential; If current development successful will be in production in five to ten years." "Results poor to date, but area is most promising."
3) BEAUFORT SEA (Arctic)	16,257 (48,620)	0 - 7.6	0 - 19.3	1982-1992	"Production at hand; State and Federal both want development; Infrastructure complete good geologic control." "Geology very good; Cost and technical problems are formidable."
4) KODIAK (Southcentral)	15,296 (35,792)	0 - 1.1	0 - 3.5	1983-2000+	"Interesting." "Production five years after discovery; No infrastructure; Strong fishing protests." "Thin tertiary section." "Some very difficult political obstacles remain unknown."
5) BRISTOL (Southwest)	46,039 (36,352)	0 - 2.5	0 - 5.4	1990-1995	"Interesting to me." "Heavy pressure against development by conservationists and fisheries people." "Thickest tertiary section in fish sanctuary; Too many volcanics; little success so far onshore. Political problems are great, timing unknown." "Geologically very favorable for source beds for hydrocarbons."

Table 4-4 (Continued)
OIL & GAS SITE RANKING (OFFSHORE)
(Prediction of future order of production)

Ranking of Province (Region)	Area Mi^2 (Volume Mi^3)	Undiscovered Recoverable* OIL billions bbls. Range	GAS trillion cu.ft. Range	Timing	Excerpts from Comments by Experts
6) NORTON (Northwest)	16,768 (14,077)	0 - 2.19	0 - 2.8	1990-2000+	"Infrastructure problems difficult. "Gas seep in Norton Sound reported by NOAA; Thick tertiary." "Too many unknowns."
7) CENTRAL CHUKCHI (Arctic)	38,215 (95,691)	0 - 11.9	0 - 30.0	1985-2000+	"Drilling technology barely adequate for ice operations." "Too many unknowns." "Deep cretaceous plays, may not be economical."
8) NORTH CHUKCHI (Arctic)	22,880 (42,231)	0 - 6.2	0 - 19.5	1985-2000+	"Distant - after 1985." Remaining comments are identical to Central Chukchi. "Very high potential - will be delayed by technological problems associated with exploration under ice pack."
9) HOPE (Northwest)	22,671 (42,231)	0 - 0.6	0 - 3.3	1990-2000+	"After Norton, one to three years." "Infrastructure problems difficult." "Negligible potential." "Good chance for tertiary production."
10) ZEMCHUG - ST. GEORGE (Southwest)	65,478 (66,097)	0 - 5.1	0 - 13.0	1985-2000+	"There is serious doubt if this area will ever be drilled, Produces 3% of the world total fish catch." "No information."
11) SHUMAGIN SHELF (Southwest)	17,218 (29,615)	0 - 0.25	0 - 0.5	1985-2000+	"Interesting." "Relatively unknown area."
12) NAVARIN (Southwest)	19,744 (56,829)	0 - 1.9	0 - 4.8	1985-2000+	"Too many unknowns." "Very little known; Probably many basalts and volcanic sediments as rumored by strat. test."
13) St. MATTHEW-HALL	10,510 (5,255)	Negl.	Negl.	1985-Never	"Oil price needs to be high; Norton needs to be developed first." "Numerous volcanic sediments and basalts on Nelson and Nunivak Islands." "Too many unknowns."

Negligible - Less than 0.001 billion barrels.

*Details of these res urce estimates by U.S. Department of the Interior, Geological Survey, are given in Volume 2
Note: Ranking was based on BLM lease schedule in effect January 1977. Where production is already underway in a province (i.e. Cook Inlet), the remaining part of the province was ranked.

real question is when such discovery and development will occur, particularly in view of recent federal lease schedule revisions.

As can be seen, timing estimates and comments by the experts we queried tend to be in relatively close agreement among the four most highly-rated provinces and among the several provinces ranked lowest. Frequent disagreement occurred, however, in the estimated rankings and timing estimates for the remaining half of the provinces in the middle. This disagreement was reflected in their comments as well.

Looking at what the future may hold for the areas now under consideration for development, it appears that the undiscovered reserves of oil and gas on Alaska offshore lands are potentially large and recoverable. Precisely where and when recovery will occur is uncertain. Further development will almost certainly occur in Cook Inlet and in the Beaufort Sea, since both provinces are associated with proven onshore and/or offshore reserves. Central and North Chukchi also appear to be strong candidates, while the Eastern Gulf of Alaska remains questionable pending further results of exploratory drilling. (See Appendix D.)

CURRENT PLANS FOR DEVELOPMENT

Exploration

Drilling for oil and natural gas on the North Slope in the Arctic region is taking place east and west of Prudhoe Bay and inland, southwest of the Prudhoe Bay field, as well as along the coast in the National Petroleum Reserve, Alaska (NPRA). Husky Oil NPR Operations, Inc., a subsidiary of Husky Oil Corporation, is in the second year of a five-year contract for exploring the huge federal petroleum reserve adjacent to Prudhoe Bay. On June 1, 1977, the reserve changed both its name (to NPRA) and management from the U.S. Navy to the Department of Interior. The Bureau of Land Management now has surface management authority, and the USGS is controlling subsurface activity.

The reserve covers 23 million acres; an area the size of Indiana. The oil and gas exploration program is the most ambitious ever undertaken on the North Slope. The 1977 seismic exploration program employed five 40-man crews and covered 2,830 line miles, the largest single onshore effort ever in North America in a single season. Discovery of a gas well about 10 miles east of Barrow, with a potential 7 million cubic feet per day flow rate, was announced February 17, 1977, by the Navy, thereby assuring a continued gas supply for the community of Barrow. About halfway between Barrow and Prudhoe Bay two wells (Cape Halkett drilled in 1975, and East Teshepuk Lake in 1976) were found to be non-commercial, with only a small showing of gas. If a commercial field is found later, Congress will decide whether it is to be for production. In 1976, the FEA recoverable resources in the reserve were estimated at 5 billion barrels of oil and 14.3 trillion cubic feet of gas.

The Arctic Slope Regional Corporation (ASRC) was not allowed to obtain title (under Alaska Native Claims Settlement Act) to the subsurface of its village lands here, but will receive in-lieu mineral estate elsewhere in the region. However, the four villages of Wainwright, Atkasook, Barrow, and Nuiqsut do have surface lands of 460,800 acres, most of which are in the Petroleum Reserve.

Another major area of exploration in the next few years will be for publicly-owned oil and natural gas reserves on the Outer Continental Shelf (OCS) of Alaska. Alaska's OCS is equivalent in size to the State (586,000 square miles), but only certain areas, nominated for their potential oil and gas values, have been designated in the scheduled lease sales. The first sale was conducted in April 1976 by the Bureau of Land Management for the Eastern Gulf area in the Gulf of Alaska. The lower Cook Inlet lease sale originally scheduled for February, 1977, was rescheduled for October 1977. Five other sales are to be held through 1981.

While the Eastern Gulf of Alaska initially appeared to be a prime candidate for development, exploratory drilling so far has been discouraging. After more than a year of drilling, no commercial shows of oil or gas have been reported. Lower Cook Inlet appears also to be a likely candidate, and there is considerable confidence that oil and gas will be found there before 1980. The semi-submersible Ocean Ranger recently completed a COST well 42 miles southwest of Homer. There is drilling presently going on in the upper Cook Inlet basin. One well, in the Swanson River oil field, is being drilled in an effort to learn more about the structure of the lower Cook Inlet for OCS bidding.

Several companies have expressed interest in portions of the Beaufort Sea. Comments from industry, as requested by the Department of Interior (June 1977), will give additional information regarding industry's plans. A major concern of the oil industry is the announced plan by the Department of Interior to enter into government-funded exploratory drilling.

Figure 4-5 locates known oil and gas exploration activity during 1976.

Recovery (Production)

In addition to exploration activity in the State, major production facilities have been in operation in Cook Inlet for over a decade, with both onshore and off-shore activity. Table 4-5 and Figure 4-6 summarize natural gas and oil production in Cook Inlet.

Collier Carbon and Chemical Corporation recently completed expansion of its Kenai ammonia/urea plant at a cost of approximately $230 million, doubling its capacity, to make it the largest nitrogen fertilizer complex on the West Coast.

Pacific Alaska LNG Company is awaiting licensing approval from the Federal Power Commission for construction of a liquefied natural gas (LNG) plant on the Kenai. The West Coast market is scheduled to begin receiving 80.3 BCF/year in 1982, and an additional 80.3 BCF/year in 1984.

The Phillips-Marathon LNG operation has been supplying Tokyo electricity and gas companies since 1969, and has no immediate plans for expansion. Should deregulation of natural gas occur, however, production may be increased from the present 61.9 BCF/year to 73 BCF/year beginning in 1978.

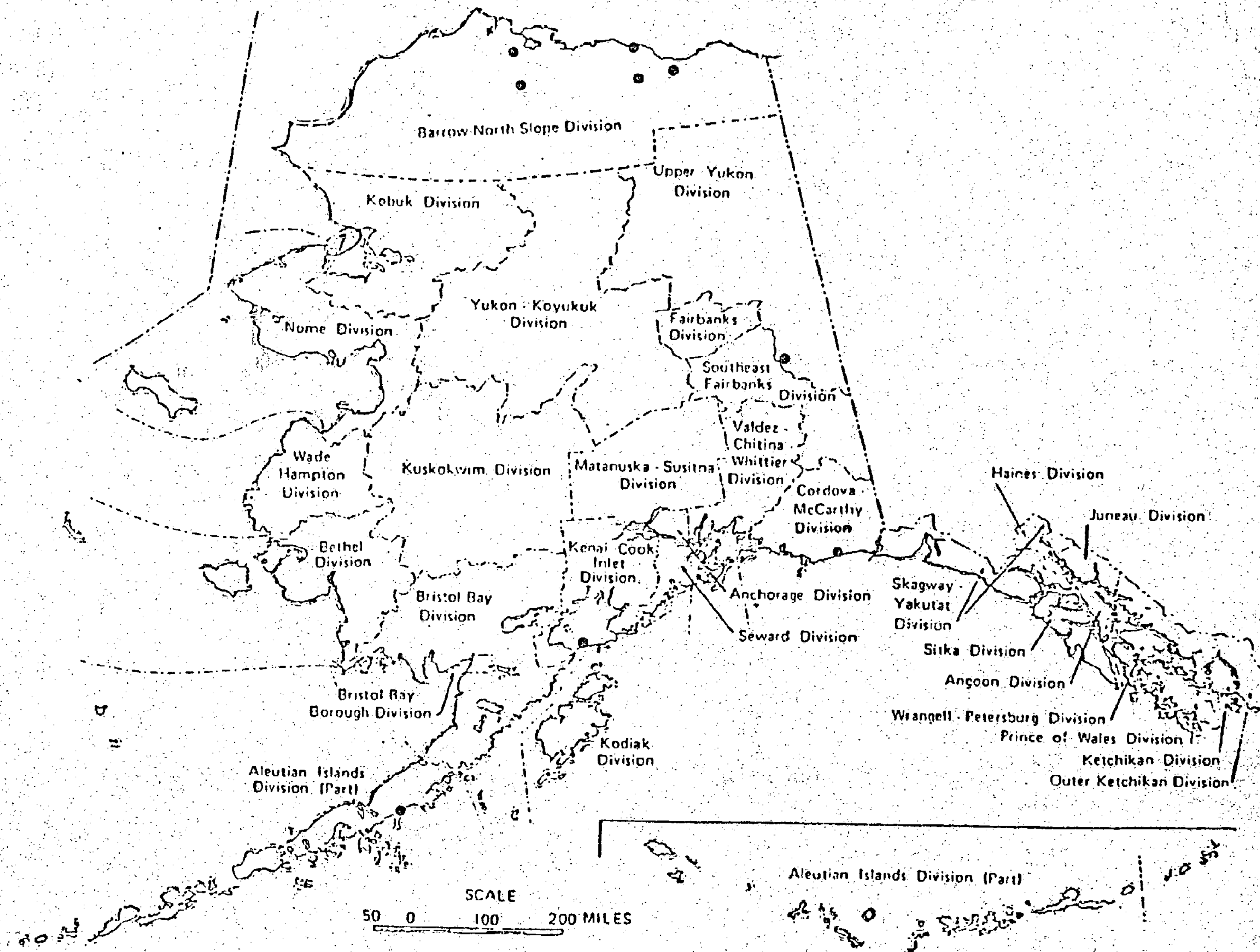


Figure 4-5. Known Oil and Gas Exploration Activity, 1976

TABLE 4-5
STATUS OF COOK INLET AREA GAS RESERVES – JANUARY 1977

Field	Estimated Reserves 1/1/75 BCF[1]	Production 1975 BCF[2]	Estimated Production 1976 BCF[3]	Estimated Remaining Reserves 1/1/77 BCF	Estimated Uncommitted Reserves 1/1/77 BCF[4]	Remarks[2,4,6]
Producing						
Beluga	818 (700)[6]	7.0	11.3	800	144	5 wells, 1 shut in Contracts: 456 BCF, Pacific Alaska LNG, 373 BCF Chugack Electric; Socal, Shell, ARCO
Kenai	2331	77.2	79.4	2174	692	33 wells, 1 shut in Union, ARCO, Marathon, Shell
North Cook	1456	45.6	45.1	1365	834	11 wells Phillips supplies LNG plant
Sterling	200	Negligible	Negligible	200	200	2 wells, 1 shut in Union, Marathon, production difficulties reported
Beaver Creek	400	0.2	0.2	400	200	2 wells, 1 shut in 200 BCF contracted to Pacific Alaska LNG; Marathon, Union
McArthur River	793	8.0	6.8	778	713	5 wells, 1 shut in 87 BCF contracted to Pacific Alaska LNG; ARCO, Marathon, Union, Amoco, Phillips, Skelly, Socal
Nicolai Creek	50	Negligible	Negligible	50	50	3 wells, 2 shut in Texaco
				5767	2833	
Shut In						
Albert Kaloa	N.A.	0	0	N.A.	N.A.	1 well, shut in Amoco, ARCO, Phillips, Socal
Birch Hill	20	0	0	20	20	1 well, shut in Socal, ARCO, Union, Marathon
Falls Creek	80	0	0	80	80	1 well, shut in ?
Ivan River	5	0	0	5	5	1 well, shut in Socal, ARCO
Lewis River	N.A.	0	0	N.A.	N.A.	1 well, shut in Cities Service
N. Middleground	125	0	0	125	125	1 well, shut in Mobil ?
North Fork	20	0	0	20	20	1 well, shut in Socal, ARCO, Sun Oil
Moquakie	173	0	0	173	173	2 wells, shut in ?
Swanson River	300	0	(14.0)[3]	314	314	6 wells, shut in Socal, ARCO, Union, Marathon; pressure maintenance by injection of Kenai Gas field
West Foreland	120	0	0	120	120	1 well, shut in Amoco, ARCO, Phillips, Skelly
West Fork	100	0	0	100	100	3 wells, shut in Socal, ARCO, Belco, Petroleum Corporation of Texas, Halbouty AK
			Grand Total	6724	3790	

1. D.P. Blasko, "Natural Gas Fields – Cook Inlet Basin, Alaska"; U.S. Bureau of Mines, Open File Report 35-74 (1974)
2. State of Alaska, Department of Natural Resources, Division of Oil and Gas, Statistical Report for the Year 1975
3. Personal Communication, J. Miller, January 31, 1977, Division of Oil and Gas
4. Summary of Gas Sales Contracts, Cook Inlet Area, March 15, 1976, Division of Oil and Gas Total from Field Original Recoverable Reserves
5. Reservoir pressure maintenance with Kenai Field Gas Injection
6. Lower value from "Oil and Gas Availability", Royalty Oil and Gas Board, undated report 1976

Source: Alaskan North Slope Royalty Natural Gas (Draft) – Battelle Pacific Northwest Laboratories – March, 1977.

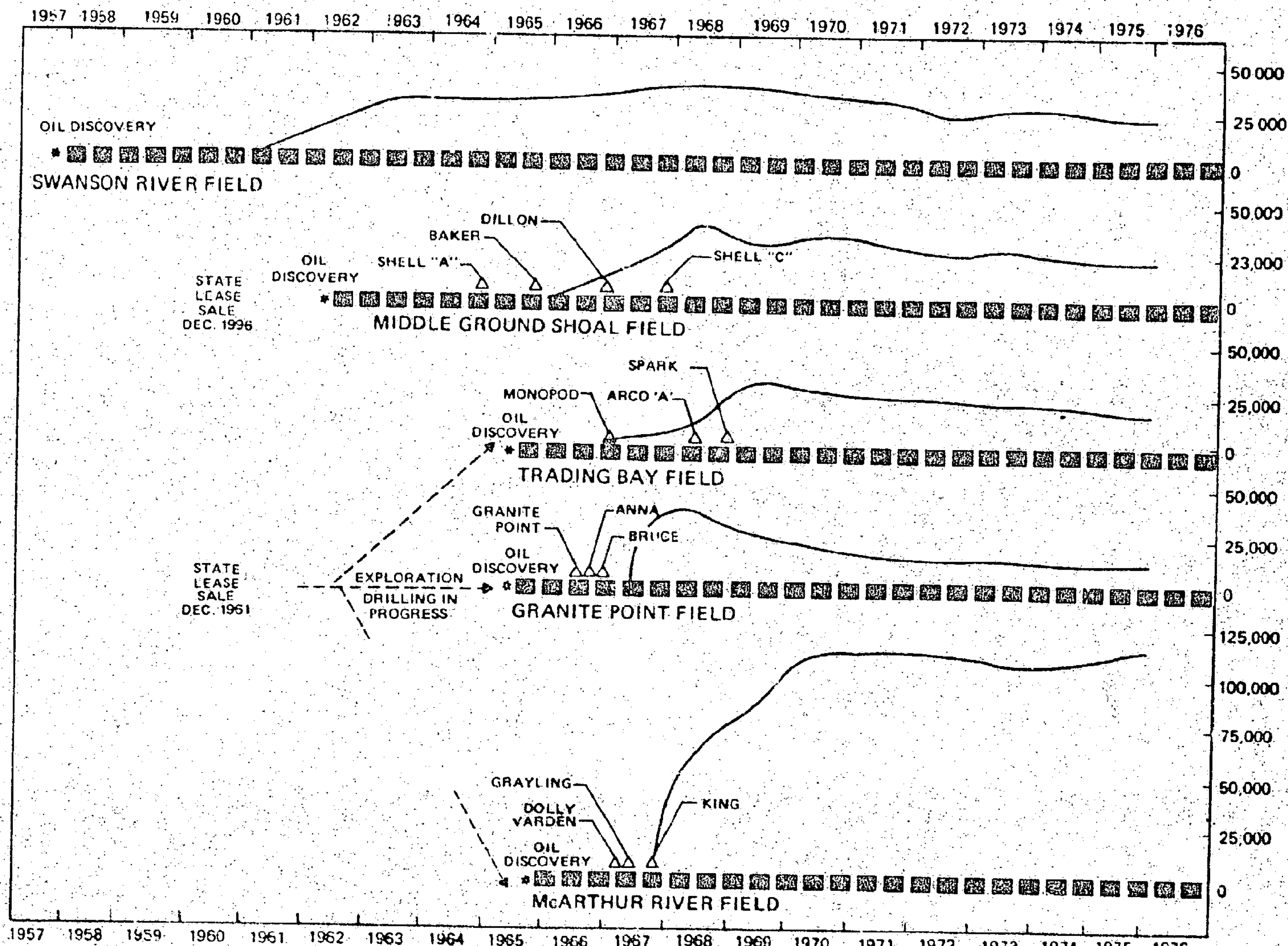


Figure 4-6 North Cook Inlet Oil Field Development History

Source: State of Alaska, Department of Natural Resources, Division of Minerals and Energy Management. An analysis of Future Petroleum Development of the Alaskan OCS, Lower Cook Inlet. November 1976.

The great interest in Prudhoe Bay oil was recently highlighted by several proposals submitted to the Alaska Royalty Oil and Gas Development Advisory Board, requesting purchase of the State's Prudhoe Bay royalty oil. Royalty oil is the one-eighth share of Prudhoe Bay production which, under terms of State oil leases, is owned by the State of Alaska. The State's 12.5 percent portion will total approximately 150,000 barrels per day (BPD) when the Trans-Alaska oil pipeline reaches full production of 1.2 million BPD (now scheduled for mid-1978). The State has the option of taking its oil "in kind" for sale to third parties or the wellhead value in cash. A total of 11 companies or joint ventures expressed interest in buying the oil from the state and submitted preliminary proposals to the Royalty Board for consideration.

The Fairbanks Municipal Utilities System wants oil for power generation; and new refinery at North Pole and Tesoro Alaska's Nikiski facility repeated earlier interest in purchasing a portion of the oil for local refining. Tesoro also submitted a proposal, later withdrawn, involving possible expansion.

Five groups submitted comprehensive offers; many within the industry expect the Board to recommend one of the five for purchase of the oil. All contracts must receive the approval of the Alaska Legislature.

Alaska Petrochemical Co. ALPETCO is considered by many to have the "best shot" for the royalty oil. The firm proposes a $1.5 billion fuel and petrochemical facility that would utilize 150,000 barrels of crude per day. Ownership includes the Alaska Interstate Company, Barbour Oil Company, and Alaska Consolidated Shipping, the latter a joint venture of six Alaska Native regional corporations and Sea-train Lines, Inc.

A second major proposal has been offered by Alaska Petroleum Company. APC would build a $400 million integrated refinery and petrochemical complex with a daily capacity of 150,000 barrels. The company is a subsidiary of Coastal States Gas Corporation of Houston.

Energy Resources, Inc., a subsidiary of U.S. International Energy Co. of Salt Lake City, would build a refinery-petrochemical facility for processing of 150,000 BPD.

Alaska Oil and Chemical Company (AOCCO) proposed a 100,000 BPD facility estimated to cost $950,000. AOCCO, a wholly-owned subsidiary of Guam Oil and Refinery Company of Dallas, describes their project as "a consortium effort, consisting of chemical companies, oil refineries, merchants and Native Alaskan investors."

The fifth detailed proposal was submitted by the H. J. Kaiser Co. of Oakland, California for "a number of substantial companies." The firms have since been identified as Kaiser Aluminum and Chemical Co., Southern California Edison, Dow Chemical Co., Pacific Resources, Inc., Pacific Gas and Electric Co., and Sealaska, a Native regional corporation.

The name of the representative company is Alaskan Petrofining Corporation. It plans a $1.25 billion integrated fuel-petrochemical complex, with a 250,000 BPD processing capacity. Two firms, Pacific Resources, Inc., and Commercial Realty Co., turned in less-detailed bids. PRI, a large marketer in the Pacific basin operating out of Honolulu, has since joined with Alaska Petrofining. Commercial Realty, a Los Angeles company involved in oil land and oil purchasing and trading, proposes a topping plant having initial crude oil requirements of about 50,000 BPD.

Included among the criteria to be used by the Board in evaluating the proposals are guarantees of jobs for Alaskans and lower Alaskan product costs. Following analysis of the proposals, the Royalty Board will make recommendations to the Alaska State Legislature which must concur with the Board's position before the sale is finalized.

Transportation Systems

Receipt of crude oil from Alaska's North Slope at the tanker terminal in Valdez, July 1977, marked the successful completion of the largest privately-financed construction project in history. The Trans-Alaska Pipeline System (TAPS) will not, however, reach its maximum 1.2 million barrels per day capacity until mid-1978, due to the destruction of the pump house at Pump Station #8, following an explosion three weeks after start-up. The design capacity of the TAPS is 2 million barrels per day.

The pipeline has had a profound effect not only on Alaska's economy but on the very fabric of the Alaskan way of life. It is not within the scope of this study to describe the project in detail or to attempt to evaluate all of its effects on Alaska. Chapter 3 has, however, addressed the social and economic issues associated with the pipeline construction and their relationship to future energy development in the State. (Hundreds of articles and reports have been written about the project, and some of these are referenced in the bibliography in Volume 2.)

Another major energy transportation question was recently answered when President Carter selected the Alcan proposal to move North Slope natural gas from Prudhoe Bay to the Lower 48. Three major companies and routes competed for the authority to build the line:

1) Alaskan Arctic Gas Company, the first firm to enter the competition, planned a route eastward from Alaska's North Slope to the gas field of the MacKenzie River Delta in Canada, then south to U.S. midwest markets. Canada's rejection of Arctic's northern Yukon routing made it a two-way race between the other two companies.

2) El Paso Alaska Company proposed to follow the existing oil pipeline corridor with a liquifaction facility constructed at Gravina Point not far from the Valdez tanker terminal on Prince William Sound. LNG was to be transported by tanker to markets on the West Coast and elsewhere.

3) Alcan Pipe Corporation, the "compromise" proposal and eventual winner, filed to construct a pipeline along the Trans-Alaska oil pipeline to Delta Junction, Alaska, and then roughly follow the Alcan Highway through Canada to the United States.

Somewhat higher consumer costs and pressure by eastern and midwest Congressmen for a pipeline to "Middle America" are partially credited with selecting the LSC plan.

Considering the time necessary for the route selection procedural process, the time needed for assembling construction capital (several billion dollars) and establishing marketing contracts, and the time required for line construction, the initiation of gas production and transmission most likely will occur somewhere in the 1983-85 period.

The actual flow rate of North Slope natural gas has not as yet been determined by the Alaska Department of Natural Resources. DNR, under statute, will set the maximum allowable rate of extraction to ensure that conservation practices will maximize the associated oil production. Current indications are that the maximum allowable flow from the primary Sadlerochit formation will be in the range of 2.0 to 2.5 BCF per day. Final determination may be deferred until several years of reservoir operating experience are obtained. (Reference: "An Analysis of Needs and Opportunities for In-State Use", Alaska North Slope Royalty Natural Gas, Battelle Pacific Northwest Laboratories, March 1977 (draft)).

APPLICABLE TECHNOLOGY

Exploration

The combination of a favorable geologic history, source rocks, reservoir rocks, traps and economic transportation to market makes a given area a good candidate for drilling. Geophysical exploration is required to locate most geologic structures that are favorable for the accumulation of petroleum. A description of geophysical exploration including magnetic, gravity, and seismic surveys, is given in the reference [illegible].

Geophysical data is augmented by geologic data obtained by analysis of rock outcrops, well samples and well logs. An analysis determines the age of the rocks and whether the rocks are volcanic, igneous intrusive, or sedimentary. This information is used for regional stratigraphic correlation.

Magnetic, seismic and gravity surveys can only suggest possible oil locations. Until some type of reliable and economic surface method is found, the actual locating of the oil must be accomplished by the very expensive process of exploratory drilling.

Alaska has had considerable experience with the problems of onshore drilling in very cold weather. An early difficulty encountered was the freezing of drilling mud left in the casing annulus which expanded and collapsed the casing. A non-freezing fluid is now being left in the casing annulus to eliminate this problem.

Offshore drilling is [illegible] more costly than onshore, requiring mobile platforms such as barges, jackups, drill ships, semisubmersibles and concrete, gravel and ice islands. Semisubmersible drilling vessels are the preferred offshore facility for exploration. Support expenses for the semisubmersibles averaged about $[illegible],000 per day in the Gulf of Alaska in [illegible].

The semisubmersible Ocean Ranger (Figure [illegible]), the world's largest drilling rig, has probed several of the State's potential oil [illegible]. The Ranger's first drilling assignment, following its June [illegible] delivery from a Japanese shipbuilding firm, was in St. George Basin, where it began drilling a [illegible] foot COST (information) well for several oil companies on July [illegible].

In [illegible], the self-propelled Ranger moved to a [illegible] location in the Gulf of Alaska, where it did some exploratory work for Atlantic Richfield. After eight months of "dry hole" drilling, the Ranger was moved to Lower Cook Inlet, where it began a second COST well in June [illegible] in preparation for the federal oil and gas lease sale for the area. The Ranger completed its work [illegible] and was released to Atlantic Richfield.

The rig is well-suited for drilling in Alaskan waters. Built to withstand simultaneous [illegible] mph winds, 110 foot waves and a 3 knot current, the vessel has already experienced near maximum winds and 50 foot waves.

Dimensions of the giant rig are impressive. A main deck measuring [illegible] feet by 250 feet covers an area equal to the length and width of 1 1/2 football fields, with room to spare. The deck is mounted on twin hulls and twelve [illegible] foot columns. A [illegible] mooring system utilizes [illegible] pound anchors secured by 3 1/2 inch diameter wire rope and chain.

Alaska has unique seafloor soils in some parts of offshore Alaska that prevent the use of conventional structures which have equipment necessary for offshore drilling. About half of the Gulf of Alaska OCS sale is covered by a thin layer of soft marine clay or glacial drift material (Ref 4-1). The soft layer varies from a few feet to about 100 feet. For areas with up to 20 feet of soft soils a massive tripod structure can be used to support the base directly on hard clay. For areas with deeper soft soils, a novel watertight base that floats in the soft soils at the interface between the water and the seafloor is used.

Recovery (Production)

Once oil is discovered by exploratory drilling, the well is tested to determine the possible oil flow rate and additional wells are drilled to determine the size of the reservoir. If the reserves calculated from these data and other [illegible] information are large enough to warrant commercial production, the reservoir is developed. Development includes drilling a number of wells to drain the reservoirs.

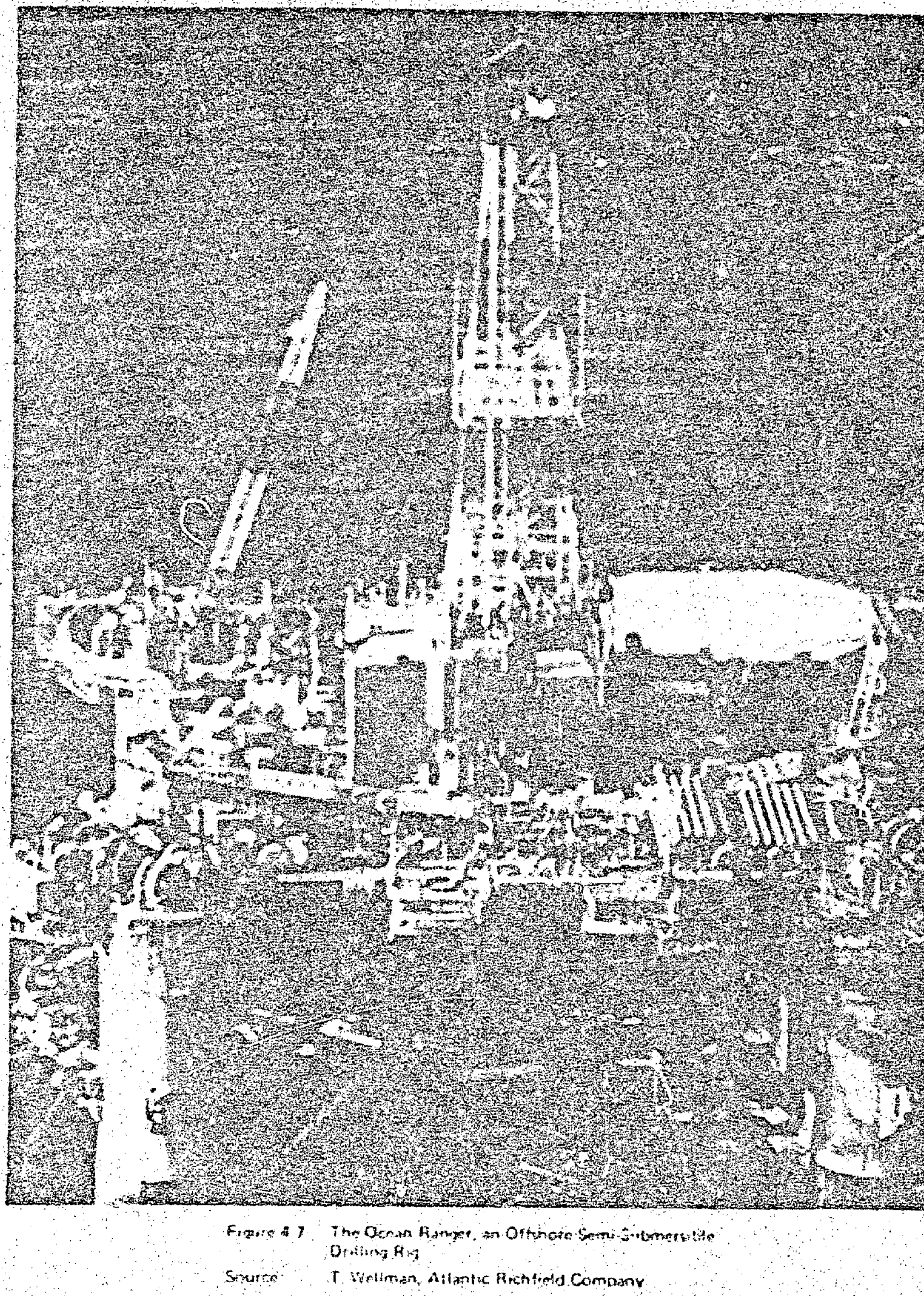


Figure 4.7 The Ocean Ranger, an Offshore Semi-Submersible Drilling Rig

Source: T. Wellman, Atlantic Richfield Company

The deepest onshore well in Alaska, Soldotna Creek Unit #33-33 in the Swanson River field, is only 17,000 feet as compared with other 30,000 foot wells in the Lower 48. Offshore, drilled from the Ocean Ranger, a well reached 17,921 feet on June 7, 1977, in the Gulf of Alaska.

In order to minimize the cost of drilling, and therefore the cost of recovering oil, it is now possible to cover an area with a radius of about two miles from a single drill rig surface location if the oil is deep enough below the surface (about 10,000 feet). For example, at Prudhoe Bay one well at 7,100 feet veers off at angels of 30° to 60° and proceeds to depths of 9,000 feet. Already this rig has drilled 13 wells from one drilling pad at various angles, and plans are to eventually have 20 wells from this one pad.

Even though the water in Cook Inlet is only 60 to 150 feet deep where the oil platforms are located, consideration was given originally to some type of subsurface completion valves or piping on the floor of the inlet. Operation history has now shown that platforms that were constructed to extend above the water's surface were actually over-designed for winter ice conditions. The huge ice pads, four feet thick and 500 feet in radius and moving at 5 knots, are said to do more damage to the nerves of the operators than to the platforms when the pads are split with a grinding noise by the support structure.

Until a few years ago, little consideration was given to platforms in water over 200 meters (600 feet) deep because of OCS criteria. Today, North Sea platforms are in 476 feet of water where 100 foot waves are expected, and California's Hondo field will probably see an Exxon platform in 850 feet of water soon. Both Exxon and Tenneco have efforts underway for subsea completions at depths to 2000 feet.

In Alaska, the platform problem is not so much of water depth as it is of the moving surface ice (see Figure 4-8). As it stands today, industry has the technology for drilling in the Beaufort Sea and the Chukchi Sea in water depths to 50 feet. Exploratory drilling has been done on ice islands. Cone shaped platforms which would cause the ice to slide up and break are also being considered.

The Beaufort Sea, set for a federal-State lease sale in late 1979, poses drilling conditions far different from those in Cook Inlet. The current in the Inlet may run 8 to 10 knots, while the maximum in the Beaufort Sea is about 2 knots. However, ice in the Beaufort Sea freezes all the way to the ocean floor where the water is shallow (9-10 ft). Moving ice in Cook Inlet may be two to four feet thick, but in the Beaufort Sea it can be as thick as four or five feet.

If exploratory drilling shows that the Chukchi Sea has sizeable oil and gas reserves, undersea completions may again be considered. The gathering systems may be trenched in the ocean floor to prevent damage from iceberg scouring. Subsea operating experience will soon be available as a result of an installation that is scheduled to begin operating in late 1977 offshore of Brazil (Petroleum Engineer International, June 1977).

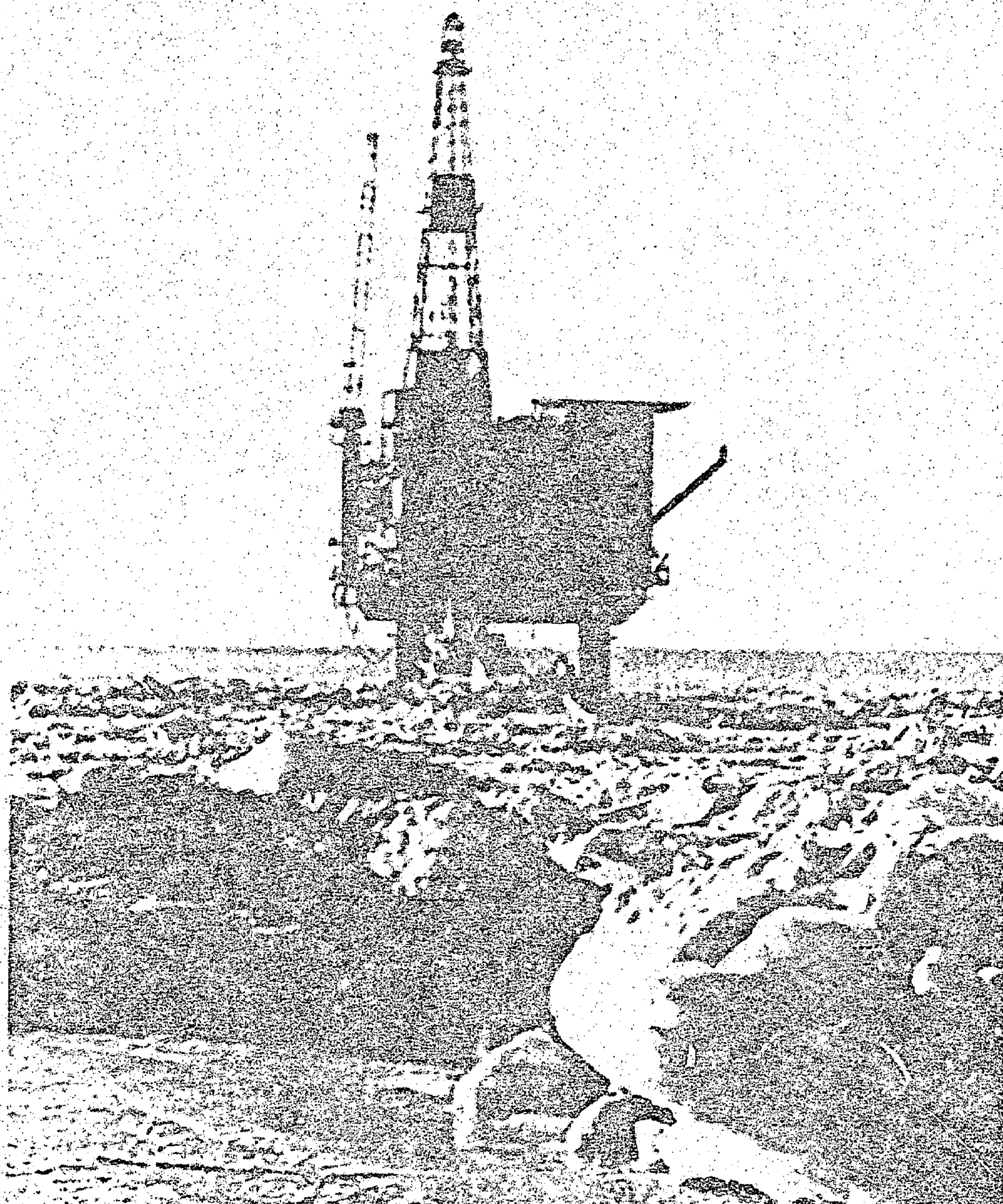


Figure 4-8 The Spark Platform, an Offshore Oil Production Facility, Cook Inlet, Alaska

Source: T. Wellman, Atlantic-Richfield Company

Enhanced Recovery

When the natural flow of oil has diminished, additional oil may be recovered from the reservoir through the use of enhanced recovery techniques called secondary and tertiary recovery (References 4-4, 4-5, 4-6). A common method of secondary recovery is water flooding—the pumping of water down selected wells in the field to force up oil in other wells in the field. This technique has been used in all stages of the productive life of a reservoir to extend potential production. Injection of several barrels of water for each additional barrel of oil recovered is common.

In offshore Cook Inlet, water flooding is currently used for secondary recovery. The Cook Inlet water is filtered, the particulate matter is removed, and the water is injected into the reservoir. Pump discharge pressure of about 2500 to 6000 pounds per square inch, is needed to inject water into reservoirs at depths of approximately 8500 feet to 11,500 feet. With water flooding, the amount of oil recovery increases to approximately 30-45% from a non-flooding recovery rate of 15-18%.

Enhanced oil recovery can also consist of repressurizing a reservoir by gas injection. Onshore at Swanson River, high pressure gas is injected in order to get better recovery of the oil. Normally the oil recovery would be approximately 18%; by utilizing gas injection it is increased to approximately 48%. The high pressure gas will then be used in later years as a fuel source.

Some tertiary recovery techniques are: polymer flooding, CO_2 injection, and thermal processes. In <u>polymer flooding</u> a high molecular weight polymer is dissolved into water and injected into the reservoir. The polymer increases the viscosity of the water closer to that of oil. The result is a better sweep of the oil as the water passes through the oil reservoir.

<u>Surfactants</u> are chemicals that act very much like soap when added to water. Injected into reservoirs, they help to wash the oil from the surface of the rock. The CO_2 injection process lowers the viscosity of the oil and increases its mobility. Preliminary finds indicate that greater than 90% of the original oil in some fields might be removed by this process.

<u>Thermal</u> techniques use heat to thin the crude oil for easy recovery. Heat is most often provided by injecting steam into the reservoir, but in-situ (in-place) combustion of part of the oil has also been used in some locations. There is little need for in-situ heating for the Alaskan oils because they are not the heavy viscous type of oil that one would find in, say, California, so this technique has not been used and there are no plans to use it in the future.

Once an oil field has been in production for a number of years and is then shut down and the equipment moved, tertiary recovery is seldom viable; it should be planned toward the final production of an oil field. In Alaska, where wells have already been abandoned, it will be difficult, if not impossible, to apply tertiary treatment. There is no tertiary recovery underway and no plans for tertiary recovery at this time in Alaska.

Processing

Once the crude oil has been obtained, its ultimate destination is a facility for converting it into end-products. Crude may be a mixture of more than a thousand different hydrocarbons, together with trace quantities of compounds such as sulfur and nitrogen.

The crude is first separated by distillation into fractions selected on the basis of their boiling point. The relative volume of each fraction is determined by the type of crude used. Since the relative volume of each fraction produced by merely separating the crude may not conform to the relative market demand for each fraction, some of the separation products are converted into products having a greater demand by splitting, uniting or rearranging the original molecules.

Processes used in a refinery to accomplish the above conversions include distillation, sulfur removal, cracking and reforming. Each refinery design is a unique combination of types and capacities of these processes. The feedstock for refineries is crude oil. There is a limited range of crudes that a particular refinery can process efficiently. Thus, early in the design of a new refinery, an effort is made to insure that feedstocks will be sufficient to allow efficient refinery operations for a maximum length of time. The important feedstock characteristics are density, sulfur content, and the quantities of other impurities such as nitrogen and salts. If an appropriate feedstock is not available from a single source, different crudes are blended to obtain the desired characteristics.

Considerable processing of Cook Inlet oil and gas is done in Alaska. The Tesoro refinery at Cook Inlet has a "reforming" unit which permits the production of motor gasoline as well as jet, diesel, and other fuel oils. These products are transported by pipeline, barge, railway tank car, and trucks to terminals at Kenai, Anchorage, Fairbanks, and Valdez. The company has more than 70 service stations in southcentral and interior Alaska. The oil that is fed to the Tesoro refinery comes from the State of Alaska (about 25,000 BPD) and Indonesia (about 15,000 BPD).

The Kenai gas field has 7 sites with 4 single wells (4 strings) and 16 duals (32 strings), with a total of 20 wells varying in depth from 4,237 feet to 10,092 feet. Some of the gas is piped to the Swanson oil field for storage for later use or repressurization, and about 20 billion cu. ft. per year goes to the Collier Carbon and Chemical's ammonia and urea plant near Kenai.

The first petrochemical plant in Alaska started operation in July 1960, and was a fertilizer complex costing about $60 million. The ammonia plant is owned by Collier, a wholly-owned subsidiary of Union Oil of California. The urea plan is jointly owned by Collier and Mitsubishi Gas Chemical Co., Inc. The plant uses air, water, and about 20 BCF of methane gas from the Kenai gas field to produce ammonia and about 350,000 tons of urea pellets per year.

The Alaskan Refinery (Standard) at Kenai, Alaska, uses the oil from both the Swanson River field and the offshore platforms (5 to 22 miles away) to produce jet fuels, diesel, and furnace fuels, distillate fuel oil, and asphalt.

The $10 million refinery went on-stream in 1963, and another $1 million in new equipment was added in 1967, which included asphalt production facilities.

On November 5, 1969, the tanker "Polar Alaska" docked at Yokohama, Japan, and discharged the first commercial shipment of LNG ever exported from North America. The Phillips Petroleum Company used cryogenic technology to design and operate the liquefied natural gas plant at Kenai, Alaska. The cost of the plant was $38 million (1969). The high-purity gas comes from the wells of the most northern platforms in upper Cook Inlet. Japan uses the gas for gas turbines to produce electricity. The plant has a production capacity of 185 million CFPD.

A small refinery has been in operation at Prudhoe Bay since October 1969, and is designed to produce diesel fuel and gasoline for local use. The crude capacity of the plant is 13,000 BPD; production is about 2,600 BPD of useable products. The residue goes into the TAP line. Gas from the first stage of the three-phase production separators is dehydrated in a conditioning plant and used as fuel for the refinery, power generation, and heating for the Atlantic Richfield/Exxon Operations Center.

A small amount of Prudhoe crude (about 20,000 BPD) is shipped through a 3 mile, eight inch diameter line to Energy Company of Alaska's North Pole refinery near Fairbanks. The new custom refinery facility, which began production in September 1977, is scheduled to refine annually approximately 100 million gallons of heating/diesel fuel #1 and #2 (30 and 25 million gallons, respectively), JP-4 (30 million gallons) and custom turbine fuel (20 million gallons).

Direct sales will be to government, utility, and heavy industrial customers in the Fairbanks, Nenana, Delta and Tok areas.

Transportation

Discussions of movement of large quantities of Alaskan oil inevitably lead to the Trans-Alaska oil pipeline (Figure 4-9). On June 20, 1977, North Slope crude flowed into Pump Station One (PS1) on its way to the Valdez marine terminal 800 miles to the south. To get there, it crossed three major mountain ranges and several hundred streams and survived an explosion that destroyed the pump house at PS8.

Originally scheduled to reach a daily throughput of 1.2 million barrels by September, the line is now expected to reach that total in mid-1978 when the facilities at PS8 are rebuilt. During its anticipated 25 to 30 year peak period, the pipeline will carry an estimated 9.6 billion barrels of oil to Valdez for shipment to Lower 48 refineries.

An informative schematic of the pipeline, is shown on the following page.

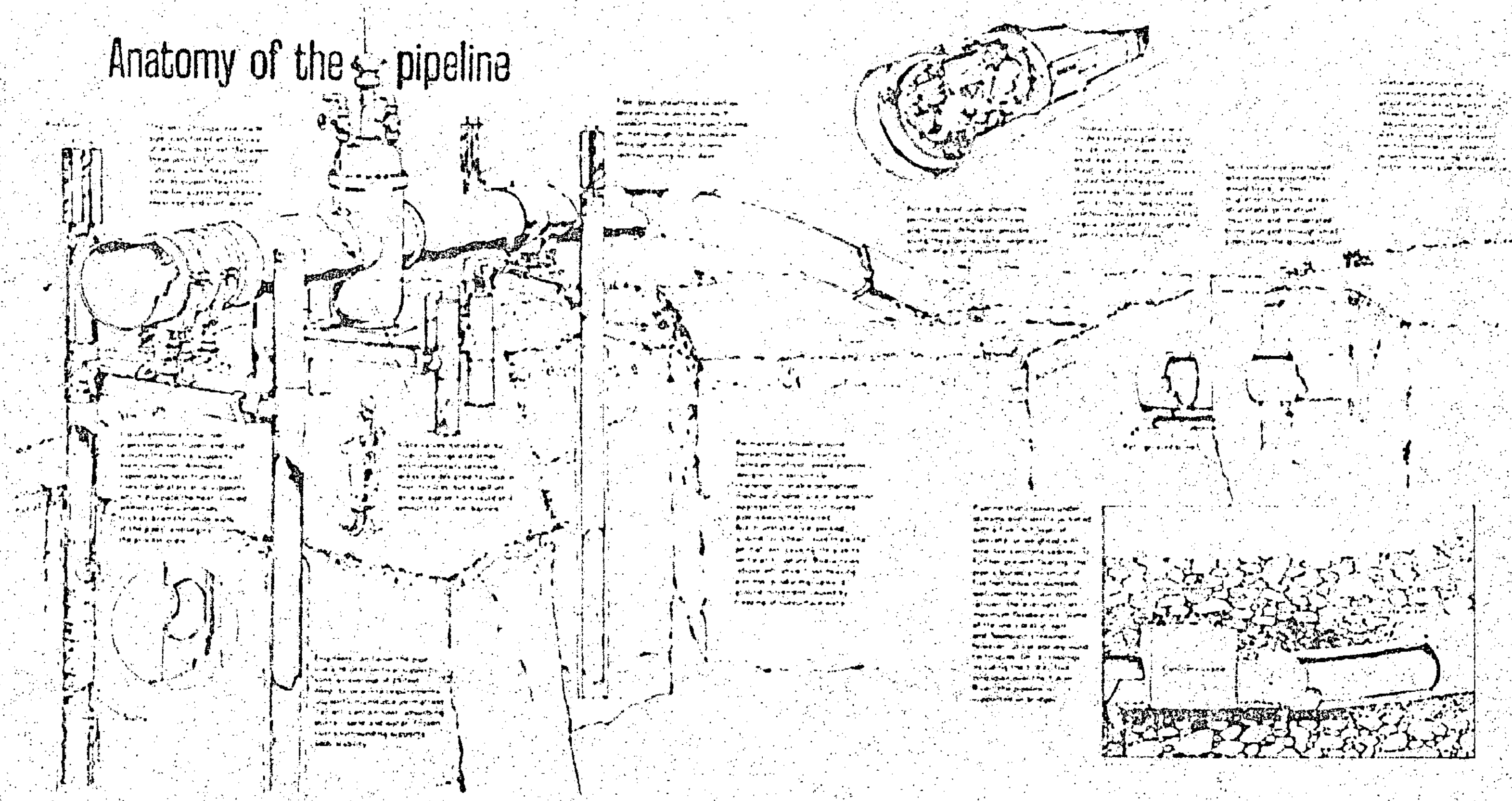


Figure 4.9 Anatomy of the Pipeline

Source: National Geographic, November 1976

Use

In Alaska, where the cost of gas has been comparatively low in some areas, gas turbines have been used for base load electrical generation. Gas turbines are installations in which either gas or oil is fired in a turbine which drives a generator. Simple cycle units release exhaust combustion gases directly into the atmosphere. Units, using a regenerative cycle, channel the hot exhaust gases through a heat exchanger, which transfers some of the waste heat in the exhaust to the combustion air, raising the overall efficiency of the unit above that of the simple cycle.

Simple cycle gas turbine efficiencies range from 12,000 to 16,000 Btu/kwh, depending upon size, and regenerative cycle gas turbine efficiencies are between 9,500 and 13,500 Btu/kwh. The efficiency of gas turbines is sensitive to inlet air temperature; that is, the lower the temperature, the higher a given unit's power output. With the cold weather in Alaska, an appreciable increase in efficiency is noted.

Diesel generating units are internal combustion diesel engines directly connected to an alternating generator. These units are built as an integral whole and may be mounted on skids for transport to their place of use.

Five hundred kw and larger power plants with good operation and maintenance procedures can approach efficiencies of 13 kwh/gallon, or 10,800 Btu/kwh, which is competitive with larger steam plants. Remotely-located, 75 to 250 kw diesels may have efficiencies as low as 7 kwh/gallon or 20,000 Btu/kwh. (Ref. 4-7)

The use of diesel generating units to produce electricity in rural communities of Alaska presents some problems; e.g., lack of trained operators and readily-available replacement parts. Since, in many rural communities, delivery of the oil is made only from about mid-June to mid-October, larger fuel storage capacity is needed.

Similar problems face users of petroleum products for home heating. Limited facilities for safely storing enough fuel to last throughout the winter exist in nearly all rural communities.

COST ISSUES

The cost of fuels to the U.S. electric utility industry has increased by many factors since 1968. As seen in Figure 4-10 on the next page, the cost of oil has multiplied by more than five times.

This increase made development of Prudhoe Bay economical. In view of the July 1977 ICC approval of a $4.91 per barrel tariff for movement of ARCO oil through the line, a $2-$3/barrel fuel cost figure would yield a poor return.

The tariff amounts to .61 cents per barrel per mile. By comparison, the 70-mile pipeline from Nikiski to Anchorage has a tariff of .69 cents, or one cent per mile per barrel for transportation.

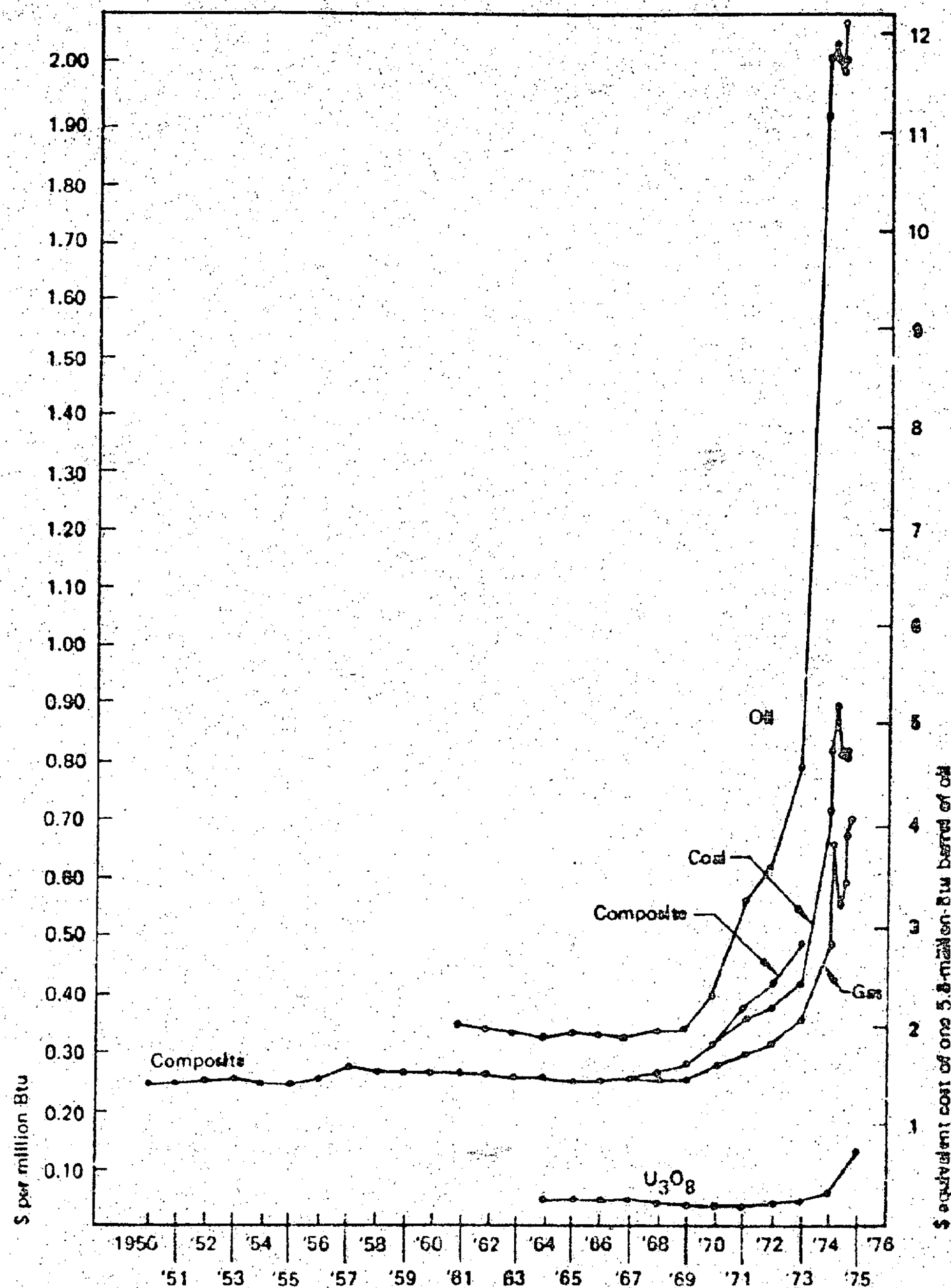


Figure 4-10 Cost of Fuels to US Electric Utility Industry

Source: Electrical World, November 1, 1975

The Trans-Alaska oil pipeline tariff issue is not settled. The initial tariffs filed by pipeline owners ranges as high as $6.44 per barrel. To add to the confusion, the oil companies now have new grounds for requesting new rates. Pipeline production will not exceed 800,000 barrels per day until mid-1978, due to the loss of pump station 8. This has reduced the throughput by one-third.

To Alaska, the cost of moving oil and gas is very important, because the higher the tariff charges (which represent the cost for getting crude oil from the North Slope to Valdez) the lower the wellhead value. A lower well-head price for the oil means the State collects less in production taxes and receives less money for its one-eighth royalty share of the North Slope production.

The wellhead price is calculated by working backwards from the refinery. Assume North Slope oil will sell for $13.70 per barrel at the refinery. If it costs 70 cents to ship the oil from Valdez to a West Coast refinery, the value of the oil at Valdez is $13.00 per barrel. If the tariff charged for moving the oil to Valdez from Prudhoe Bay is $6, the wellhead value at Prudhoe Bay is $7. If the tariff is $6.40, the wellhead value would be $6.60. That would be the figure the State would use to base its taxation on, and it is also the price the State would receive for its one-eighth share of the oil. State officials estimate that for each cent increase in the pipeline tariff, Alaska State revenues fall by $1 million per year.

As for natural gas in Alaska, Figure 4-11 shows why electrical costs in Anchorage are so low at this time. The discovery of Cook Inlet area natural gas a few years ago, coupled with municipal long-range contracts, provide many in the Anchorage area with very low costs for electricity, hot water, and space heating as compared with the rest of the nation. In time, federal government regulations may limit the use of natural gas; combined with diminishing supplies, this will likely start closing the gap between Anchorage and the rest of the nation.

The various fees, rentals, bonuses, and royalty charges for oil and gas exploration and production on State lands are given in Table 4-6.

EXTERNAL MARKET ISSUES

As in the case of social, economic, political and environmental issues, this phase of the project does not attempt a detailed analysis of the impacts of markets external to the State on energy development. It is, however, still important to analyze some of the principal issues regarding these markets for several of Alaska's energy resources.

In many respects, analysis of the potential impact of external markets on Alaska oil and gas has been greatly simplified by the constraints imposed by law and regulation. With the exception of liquid natural gas already being shipped to Japan, no Alaska oil or gas may be sold abroad. Thus, the only external market is the remainder of the United States. Analysis of that market is circumscribed by the fact that the wellhead prices for both crude

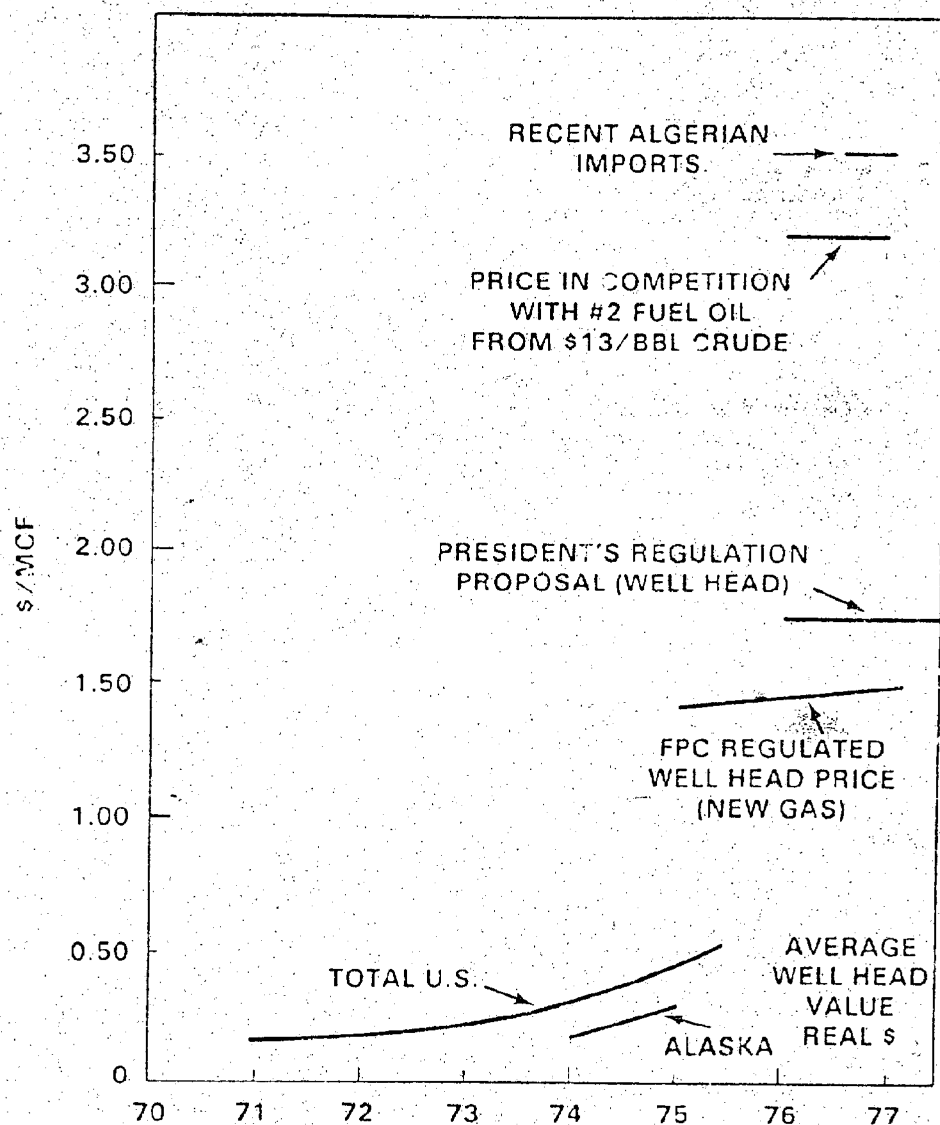


Figure 4-11 Examples of Natural Gas Prices

Source: Courtesy of Battelle Northwest Laboratories (1977)

Table 4-6
OIL AND GAS LEASE FEES ON STATE LANDS

Permit, Lease or Claim	Fees, Rentals, Bonuses and Royalties	Area (Acres)	Term (years)	Comments
Non-Competitive Lease	\$20 filing fee plus 50¢/acre/year rental plus \$20 for extension of term. After production, royalty of no less that 12½% in-kind (oil & gas) or in-value (money) of production amount.	2,560	5 years plus 5 year extension. After production, term is life of of field.	Term applies only prior to production of oil and gas.
Competitive (onshore or offshore) Lease	Bid bonus plus \$1/acre/year rental. After production, no less than 12½% royalty in-kind (oil & gas) or in-value (money) of production amount.	2,560 (onshore) or 5,760 (off-shore)	10 years with no extension (except Cook Inlet - No less than 5 years and no more than 10 years.) After production, term is life of field.	Term applies only prior to production of oil and gas.

Source: State of Alaska, Department of Natural Resources, Division of Minerals and Energy Management. March 1977 oil and natural gas presently are regulated by the Federal Energy Administration and the Federal Power Commission, respectively. At the present time, the market price for North Slope oil delivered to lower 48 ports is determined by the price of imported oil; transportation costs are so high that the wellhead value of the oil is below current FEA ceilings.

The major question associated with the U.S. market for Alaska's oil is where it will ultimately go. Alaska crude is produced in excess of current West Coast demands, primarily because the refining capacity is not geared to the relatively heavy, high sulfur product being shipped from Prudhoe Bay. As the capacity of the pipeline increases, much of the oil will be shipped through the Panama Canal to the Gulf or East Coasts. Eventually, perhaps within 5 to 8 years, it is expected that pipeline facilities will be available to transport Alaskan oil east of the Rockies, either to the "Northern Tier" states, to the Gulf Coast, or both.

Although FEA price regulation does not affect North Slope oil development, it could have considerable impact on oil development in Cook Inlet. Transportation costs are substantially lower, and wellhead price ceilings could come into effect. The wellhead price of natural gas from Alaska's North Slope is yet to be determined by the FPC. A decision is expected soon, now that the route of the pipeline has been selected.

FURTHER INFORMATION NEEDS

1) Improved technology for clean-up for both onshore and offshore oil spills in Alaska is needed.

2) Techniques used in other industries, especially nuclear, to assure verbatim compliance of operation procedures are needed on the pipeline and on offshore platforms in order to reduce oil spills.

3) More information is required on enhanced recovery techniques for oil and gas for Alaskan conditions. Additional information is also needed on technology of ocean floor completions to replace platforms in Artic offshore areas.

4) To date, the potential for "used oil" recycling is a little examined method of conserving energy.

5) Social, economic, and environmental impact statements of a petrochemical plant in Alaska are needed.

Alaska Oil and Gas Resources
Key Contacts

Donald P. Blasko
Petroleum Engineer
Alaska Field Operations Center
Anchorage Office
United States Bureau of Mines
Suite 100, Professional Center Bldg.
221 E. Northern Lights Blvd.
Anchorage, Alaska 99501
(907) 265-5206

Patrick Dobey
Petroleum Manager
State of Alaska
Department of Natural Resources
Division of Minerals and Energy Management
MacKay Anex, 323 E. 4th Avenue
Anchorage, Alaska 99501
(907) 274-8542

George Gryc, Chief
ONPRA
United States Geological Survey
345 Middlefield Road
Menlo Park, California 94025
(415) 323-8111, ext. 2214

Hoyle Hamilton
Chief Petroleum Engineer
State of Alaska
Department of Natural Resources
Division of Oil and Gas Conservation
3001 Porcupine Street
Anchorage, Alaska 99501
(907) 279-9565

Jerry D. Kreitner
Energy Development Analyst
Federal State Land Use Planning Commission
733 West 4th Avenue, Suite 400
Anchorage, Alaska 99501
(907) 279-9565

Irene Ryan
Consulting Geologist
Box 84, Star Route A
Anchorage, Alaska 99502
(907) 344-3189

Tom Marshall, Chief Petroleum Geologist
State of Alaska
Department of Natural Resources
Division of Oil and Gas Conservation
3001 Porcupine Street
Anchorage, Alaska 99501
(907) 279-1433 or 274-8602

Bob McMullen
Area Geologist
United States Geological Survey
Conservation Division
800 A Street
Anchorage, Alaska 99501
(907) 278-3571

Gil Mull
Geologist
Exploration and Strategies
ONPRA
United States Geological Survey
345 Middlefield Road
Menlo Park, California 94025
(415) 323-8111

Robert B. Sanders, Geologist
U.S. Department of Energy
605 West 4th Avenue
Room G-11, Federal Office Bldg.
Anchorage, Alaska 99501
(907) 265-5361

DGGS Staff
State of Alaska
Department of Natural Resources
Div. of Geological & Geophysical Surveys
3001 Porcupine Street
Anchorage, Alaska 99501
(907) 272-8602

Rodney Smith, Geologist
United States Geological Survey
Conservation Division
800 A Street
Anchorage, Alaska 99501
(907) 278-3571

Alaska Oil and Gas Resources
Key Contacts (Cont.)

Thomas E. Kelly, Consultant
Earth Sciences
700 H Street
Anchorage, Alaska 99501

Frank B. Chmelik, Manager
Alaska Office
Tetra Tech, Inc.
909 West 9th Avenue
Anchorage, Alaska 99501

Joe Jones, Conservation Manager
U.S. Department of the Interior
Geological Survey
Conservation Division
P.O. Box 259
Anchorage, Alaska 99510

Ward H. Swift
Associate Manager
Water & Land Resources Department
Battelle Pacific Northwest Lab.
Battelle Boulevard
Richland, Washington 99352
(509) 946-2229

Becky S. Pfanner
Public Relations Representative
Atlantic Richfield Company
Public Affairs Division
P.O. Box 360
Anchorage, Alaska 99510
(907) 277-5637

Loyd M. Hodson
General Manager
Alaska Village Electric
Co-operative, Inc.
999 E. Tudor Road
Anchorage, Alaska 99503
(907) 277-6632

R.D. Grimm, President
Chief Executive Officer
Intermountain Gas Company
555 So. Cole Road
Boise, Idaho 83705
(208) 375-1361

Elmore Holerman, Jr.
Resident Manager
Waste-to-Oil Experimental Facility
Bechtel Corporation
2300 Liberty Street
Albany, Oregon 97312
(503) 926-0940

C.W. Wilson, Area Foreman
Producing Department
Chevron U.S.A.
Swanson River Oil Field
P.O. Box 529
Soldotna, Alaska 99669
(907) 283-4551

George E. Day
Manager, Alaskan Refinery and Pipe Lines
Manufacturing Department
Chevron U.S.A.
Alaskan Refinery P.O. Drawer "F"
Kenai, Alaska 99611
(907) 776-8161

Cary G. Vlahovich
Community Services Representative
Alyeska Pipeline Service Company
1835 South Bragaw Street (99504)
P.O. Box 4-Z (99509)
Anchorage, Alaska
(907) 265-8325
Telex: 090-25-127

J.R. Williamson, Operations Supervisor
Exploration & Production Department
Production Division
Phillips Petroleum Company
Kenai LNG Plant
Drawer 66
Kenai, Alaska 99611
(907) 776-8166

George L. Ford
Plant Manager
Collier Carbon & Chemical Corp.
Kenai, Alaska 99611

Alaska Oil and Gas Resources
Key Contacts (Cont.)

Katharine Varnes, Geologist
Frances Lennartz, Cartographer
Resources Appraisal Group
Branch of Oil & Gas Resources
U.S. Geological Survey
Denver Federal Center
Mail Stop 971
Denver, Colorado 80225
(303) 234-5235

John D. Amundsen
Operations Technician
Alaska District
Union Oil Company of California
Union Oil and Gas Division
P.O. Box 7600
Kenai, Alaska 99611
(907) 283-7505

K.W. Lewis, Dist. Production Supervisor
South Alaska District
Atlantic Richfield Company
No. American Producing Division
P.O. Box 1400
Kenai, Alaska 99611
(907) 283-7147

C.R. Knowles, Jr.
District Drilling Superintendent
South Alaska District
Atlantic Richfield Company
North American Producing Division
P.O. Box 360 Anchorage, Alaska 99510
(907) 277-5637

Tom Schoder
Natural Resources Specialist
Bureau of Land Management
555 Cordova Bldg.
Anchorage, Alaska 99501

James V. Coan, Pet 4 Coordinator
Bureau of Land Management
State Office
555 Cordova Bldg.
Anchorage, Alaska 99501

Mike Holland
El Paso Natural Gas
716 West 4th Avenue
Anchorage, Alaska 99501
(907) 279-6501

Bob Hoekzema, Geologist
State of Alaska, Division of Minerals & Energy Management
Department of Natural Resources
Mackay Annex, 323 E. 4th Avenue
Anchorage, Alaska 99501
(907) 274-8542

Glen Jackson
Tesoro Refinery
P.O. Box 3691
Kenai, Alaska 99611
(907) 776-8191

E. R. "Rod" Bouchard
North Pole Refinery
Energy Company of Alaska
Box 5028
North Pole, Alaska 99705
(907) 488-2741

Oil & Gas

References

4-1 U.S. Department of the Interior. Division of Geological Survey. "Geological Estimates of Undiscovered Recoverable Oil and Gas Resources in the United States." Circular 725. 1975.

4-2 U.S. Department of the Interior. Bureau of Land Management. Alaska Outer Continental Shelf Office. Final Environmental Impact Statement - OCS Proposed Oil & Gas Leasing in the NORTHERN GULF OF ALASKA, OCS Sale #39 - four volumes. 1976.

4-3 Knowles, C.R. (Atlantic Richfield Co., Anchorage, Alaska) and Schuh, F. J. (Atlantic Richfield Co., Dallas, Texas). Drilling Operations in the Gulf of Alaska. Paper presented at the 1977 Annual Meeting Production Department, American Institute, Hyatt Regency Hotel, Houston, Texas, 4-6, April 1977.

4-4 U.S. Energy Research and Development Administration. Management Plan For Enhanced Oil Recovery. Appendices, February 1977.

4-5 U.S. Energy Research and Development Administration. Division of Oil, Gas and Shale, in cooperation with the University of Tulsa and the Oil & Gas Journal. Proceedings of a Symposium on Enhanced Oil & Gas Recovery. Volume 1 - Oil; Volume 2 - Gas. Camelot Inn, Tulsa, Oklahoma.

4-6 Tetra Tech, Inc. Navy Energy and Natural Resources Research and Development Office. Energy Fact Book - 1976. Virginia : Tetra Tech, Inc., 1976.

4-7 Alaska, University of Alaska, Institute of Social and Economic Research. Electric Power in Alaska, 1976-1995. August 1976.

Recoverable Resources By Site

Alaska's potential coal resources are enormous but are widely dispersed throughout the State and vary considerably in quality and potential recoverability. Deposits are known to exist in Southcentral and Southwest Alaska from the Bering River region to the Aleutian Islands. In the Interior, deposits are known to exist in a dozen locations, ranging from near the Canadian border to the Alaska Range southwest of Fairbanks. The largest deposits are found on the North Slope, extending eastward in a broad band from the shores of the Chukchi Sea through and beyond the National Petroleum Reserve, Alaska.

In evaluating the potential recoverability of these resources, experts were requested to rank 12 coal fields in terms of likelihood of development prior to the year 2000, and to estimate when development might occur. The coal fields analyzed are shown on the accompanying map (Figure 4-12). In addition, each expert (listed below) was asked to identify other areas in the state which may be of development interest:

James Callahan
U.S. Dept. of the Interior
Div. of Geological Surveys
Box 2373
Casper, Wyoming 82602

Robert B. Sanders, Geologist
Federal Energy Administration
Federal Building, G-11
605 W. Fourth Avenue
Anchorage, Alaska 99501

Robert G. Bottge, Mining Engineer
Alaska Field Operation Center
U.S. Dept. of the Interior
Bureau of Mines
P.O. Box 550
Juneau, Alaska 99802

Ernest N. Wolff
Mineral Industry Research Laboratory
University of Alaska
Fairbanks, Alaska 99701

DGGS Staff
State of Alaska
Dept. of Natural Resources
Div. of Geological & Geophysical Surveys
3001 Porcupine Street
Anchorage, Alaska 99501

The rankings of the coal fields are given in Table 4-7, which begins on the following page. This table also includes the magnitude and quality of the coal resources, as well as selected excerpts from comments by the experts.

In evaluating the responses to our request, we found general concensus among the experts that three areas in the state would almost certainly be developed or developed further before year 2000. These were, in order of timing: the Nenana field, Susitna field and the Jarvis Creek field. In addition, several of the experts were impressed with the possibility of development in the Matanuska field and at Herendeen Bay and/or Chignik on the Alaska Peninsula. Agreement on these fields, however, was not as strong. Those consulted

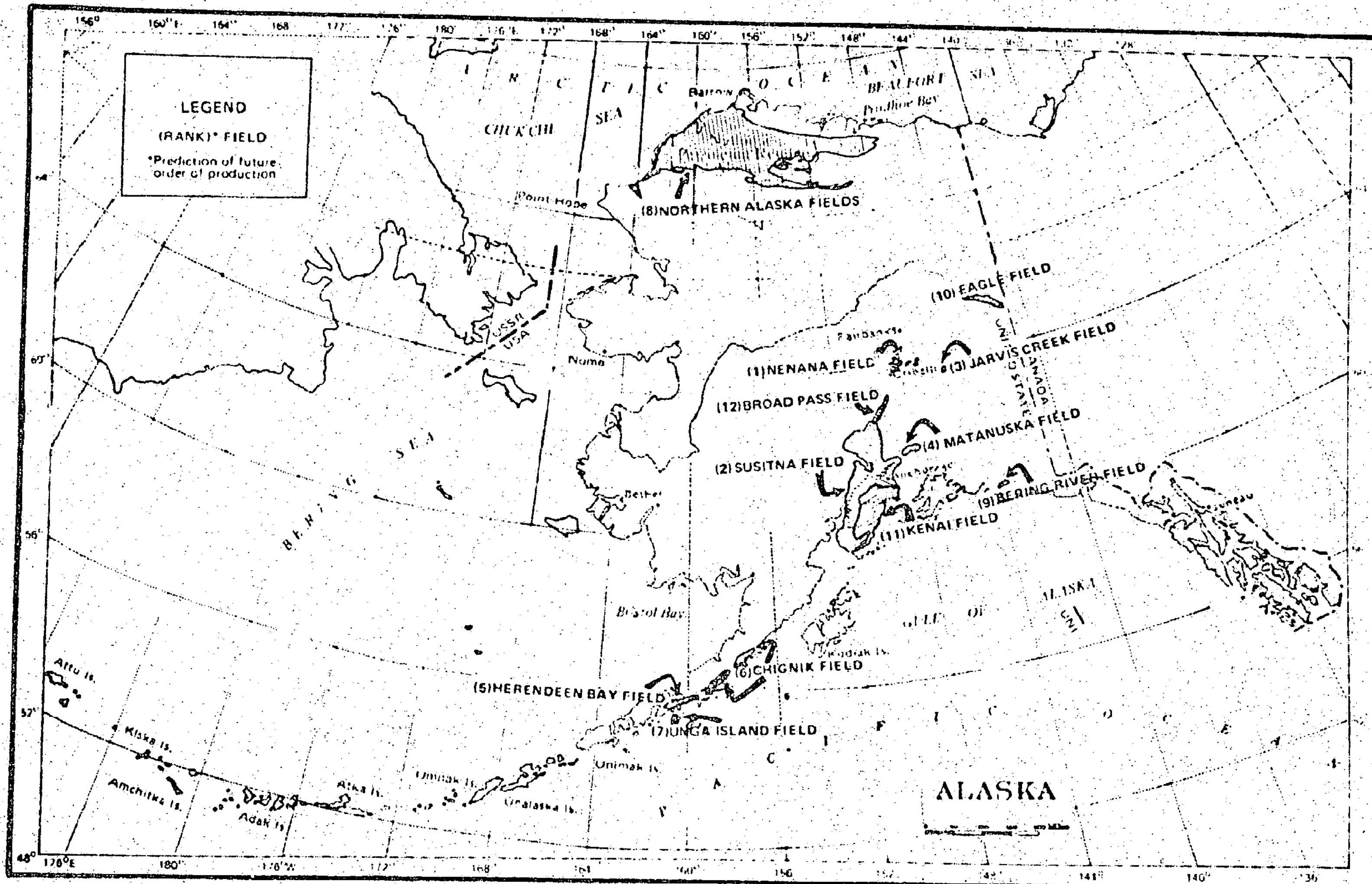


Figure 4-12 Coal Fields

State of Alaska, Division of Energy & Power Development 1977

Table 4-7
COAL SITES RANKING*
(Prediction of Future Order of Production)

RANKING OF COAL FIELD (Region)	ESTIMATED TIMING (By Experts)	COAL RANK AND QUANTITY** (Millions of Short Tons)	EXCERPTS FROM COMMENTS BY EXPERTS
1) NENANA (Interior)	Now	Subbituminous and Lignite (6938)*** (Note private communications from Cleland Conwell "all reports rank Nenana coals as lignite. All of the more recent analysis and all of the work I have done rank the coal at least subbituminous C")	"Already producing 700,000 tons/year." "The proven reserves exceed 120 million tons with an equal inferred reserves in the area near Healy. The resource is certainly several billion tons, the coals are thick, No. 1 seam may reach 100 feet in thickness. The coal is subbituminous B, with a calorific value of about 8,200 Btu and this, with distance from tidewater does not have an immediate chance for export; there is a chance to expand production in this field. The Golden Valley Electric Association states they would like to have a 150 megawatt power plant on the line by 1985 (updated to 1983 recently). The serious drawback in the Nenana field is the EPA regulation of nondeterioration air quality within 60 miles of a national park."
2) SUSITNA (Southcentral)	1980-1985	Subbituminous and Lignite (2395)***	This area is No. 1 for potential development of a large (5 million ton/year) mine. (Chuitna-Beluga area). The Susitna field is relatively unexplored. Coals within the field are probably subbituminous B, although they may rank up to high volatile bituminous C. One known seam 25 feet thick does have a calorific value of 9,000 Btu. The major deterrent to development in the area is the vegetation coverage which makes exploration difficult. Other deterrents are probable high faults, steeply dipping beds, environmental considerations, and the general social political problems that would be associated with the development in this particular area. The Beluga Coal field has active leases, but the low rank of coal, and cost of a port facility are deterrents to development. "A small mine for export is hard to justify because of very high harbor construction cost, a minimum of 5 million tons per year may be necessary for export" comment by Benno Patsch, Place-Amex, as part of document review process. A major mine-mouth power plant will be built if the Susitna project continues, a smaller mine may be working for export. The Susitna Coal Field is based on coals in three geologic formations deposited over a long time span, hence the great variation in rank and properties between the older Beluga Coals and the much younger coals of the northern part of the Kenai. The older, higher rank coals do occur in the Northern Kenai, but only at depth.
3) JARVIS CREEK (Interior)	1985-2000+	Subbituminous and Lignite (76)***	Eventually will be product in conjunction with coals. New small group will start drilling shortly - has been mined in past 10 years. Perhaps local markets. The Jarvis Creek field is small and probably stripping reserves will not exceed 60 million tons. Total resource, of course, is several times this but not of major significance in compared with other coal fields in the state. The coal is subbituminous B, calorific value approximately 8,200 Btu. There is one possible development in this field; A local group has been drilling and exploring the field at the present time with a consideration of a mine mouth power plant, possibly 50 megawatts, which would supply power to two or three pumping stations along the pipeline and backfeed power to Golden Valley Electric Assoc.

Table 4-7 (Continued)
COAL SITES RANKING*
(Prediction of Future Order of Production)

RANKING OF COAL FIELD (Region)	ESTIMATED TIMING (By Experts)	COALRANK AND QUANTITY** (Millions of Short Tons)	EXCERPTS FROM COMMENTS BY EXPERTS
4) MATANUSKA (Southcentral)	-	Bituminous (137)***	Area will require underground mining at high costs. Production will be established only if significant local industry is established. Cannot open cut - could go underground if economics permit. Good coal. Strictly cost possibility between now and year 2000. Not enough coal use around Palmer. Owner - Paul Olmin - flooded in 1970 - 1971. The Matanuska field produced coal for a great number of years (until 1967). There may be 100 million tons of coal left for strip mining and a possible resource of merely a billion tons. The Castle Mountain seam is of a coking quality which would bring a premium price on the market. The railroad still maintains right-of-ways into the field. There is a better than average chance that this field could be placed back into production this century inasmuch as a washed product would be produced. With exception of local "sniping," I foresee almost no future. Highgraded to the ruination of the field. The Chickaloon area has some possibilities.
5) HERENDEEN BAY (Southwest)	1990-1995	Insufficient Data	I am suggesting the Herendeen Bay field be dropped and the entire region lumped into the Chignik field because the coals are found in the coal member of the Chignik formation. There are no minable reserve in the field although the resource may be as high as 20 billion tons. The coal beds vary greatly in thickness and there is a great deal of irregularity, both parallel and transverse to the beds. The ash content is high, production of the coals would require washing, however, a wash product would be a high-quality steaming coal (plus 12,000 Btu) and the coals are ranked as high volatile bituminous B. For export market, including West Coast, USA.
6) CHIGNIK (Southwest)	1990+	Insufficient Data	Lack Data - possibly significant production if a good resource base can be established. Important only for local use. Possibly developed by Natives for local use and limited export.
7) UNGA (Southwest)	1990-1995	Insufficient Data	Not significant - small resource base of lignite coal. Important only for local use. The Unga Island field is very small. The coals have both a high moisture and high ash content; are either lignite or no higher grade than subbituminous B, calorific value less than 8,000. I would conclude there are no immediate prospects for developing this coal field. Possibly developed by Natives for local use and limited export.
8) NORTHERN ALASKA (Arctic)	1990+	Bituminous (19,292) Subbituminous and Lignite (100,905) TOTAL (120,197) Identified (120,000) Hypothetical (115,000-3,700,000) Speculative (110,000-1,000,000) TOTAL (345,000-4,700,000+) or 345 billion to 4.7+ (trillon tons) (Note: The above 120,197 tons were reported as identified resources in USGS Bulletin 1242 - B(1967); but the 345 billion to 4.7+ trillion tons were reported as potential resources in "Focus on Coal '75", by I.L. Tailleur and W. P. Brosge, p. 226.)	Very large potential production but only when price becomes significantly higher. Depends on coking coal situation - beds not all thin some 8 to 20 feet thick. Area handicapped by lack of knowledge. The Northern Alaska Coal Fields are great. There is one USGS report that I believe gives a theoretical resource of over 3 trillion tons; In general, the coals are of fair quality. There are excellent steaming coals in this area. In addition, in the western region, there are known coking coals. Although this resource is large by any standard you wish to use, the inhospitable climate, Native land claims, environmental and transportation all will combine to delay any large scale development in the area; Historically the village of Barrow and Wainwright used coal as a fuel; There are several reasons why I do not believe this practice will be revived. However, when you consider the economics, coal would be certainly a much cheaper

Table 4-7 (Continued)
COAL SITES RANKING*
(Prediction of Future Order of Production)

RANKING OF COAL FIELD (Region)	ESTIMATED TIMING (By Experts)	COAL RANK AND QUANTITY** (Millions of Short Tons)	EXCERPTS FROM COMMENTS BY EXPERTS
8) NORTHERN ALASKA (continued)	See	previous page	and a more dependable fuel than oil. Here is one consideration for you - I have discussed the possibility at various times with BP and ARCO, there have been Canadian developments related to transportation coal in a slurry with oil as a carrying liquid. Therefore, it is not inconceivable that coal could be mined and transported through the pipeline after the peak oil production in the area has passed.
9) BERING RIVER (Southcentral)	2000+	Insufficient Data	Very complex geology - production will require more effective means of mining. Good coal but too broken up - structure just impossible. Will never go anyplace. Pipe dreams. Real good coal but botched up, beds cannot follow. Japanese looked at it, but no. The Bering River field coals grade from lignite through anthracite, depending on the amount of folding and faulting the coal beds have been subjected to. This fact makes projection of coal beds very difficult and would be unfavorable in attempting to mining plan. Possible test area for Bore hole hydraulic operation or as a pilot of in-situ techniques testing.
10) EAGLE (Interior)	2000+	Insufficient Data	Not significant - lacks data - only a few coal out crops known. No way - not even local use - 4 ft. thickness maximum. The Eagle field is an interior field. It is not at the present time at least, close to transportation corridors and there is little present demand for the coal within the immed ate area. The coal is subbituminous B, calorific value is approximately 8,000 Btu.
11) KENAI (Southcentral)	2000+	Subbituminous and Lignite (318)***	Anticipate production along Deep Creek- but more in the sourth Kenai. Coal only about 6 ft. thick, operations at Homer until middle 1960's; Do not believe Kenai coal is the same as Beluga, not a good Btu, not as thick. The Kenai coals rank from lignite to subbituminous B, high moisture and high ash content. The resource appears very large, but the actual reserves are very small. Consolidation Coal has a prospective permit in the area and may develop a sizeable reserve. The disadvantage of the coal is quality, and the seams (2 to 7 feet). The advantage of the field that is very close to tide-water and it would not be as expensive to construct a moorage facility as on the west side of the Cook Inlet. Land claims and environmental factors could delay production from the field for a great number of years. With exception of Homer subsistence use, there is little hope.
12) BROAD PASS (Southcentral)	--	Subbituminous and Lignite (64)***	Not significantly small resource base of lignite coal. No way - low grade. Broad Pass coals are near surface, within easy access to the Alaska Railroad. Unfortunately the coals rank as lignite to subbituminous B, with a calorific value of less than 8,000 Btu. A serious deterrent to development of the field is its close relationship to McKinley National Park.

* Where production is already underway in a field (i.e. Nenana), the remaining part of the field was ranked.

** An up-to-date coal detail inventory has not been completed. For example, Gary Player, Consulting Geologist for the Bureau of Mines, reports (Jan. 5, 1977), thick coal beds (at least 120 feet) near Farewell (Interior)... "The important conclusion to be reached from these fragmentary but related bits of data is that coal resources in the interior lowlands north of the Alaska Range, may be enormous."

*** USGS Bulletin (1242-B (1967) page B9: Additional information in Alaska Open File Report No. 51, Table 1.

generally were in agreement that the other coal fields in the state are not likely to be under significant development prior to the year 2000. Although all were agreed that the Northern Alaska fields had enormous resources, they also felt that the cost of recovery, and particularly, the cost of transportation to market, would probably slow development to well beyond ~~the year~~ 2000. Several other areas were classified as having coal which would be difficult to recover economically before the year 2000. The reasons for these conclusions are discussed further below.

Among the areas considered almost certain to be developed, the Beluga district of the Susitna field is by far the largest. The total Susitna field covers almost 6,000 square miles, and is estimated to contain 400 to 700 million tons of coal recoverable by strip mining with modern technology. The coal varies somewhat in quality, ranging from subbituminous to lignite. Beluga coals are among the higher grades in the field, and are of subbituminous quality, with heating values ranging between 6,300 and 8,900 Btu's per pound, as received, but 9,400 Btu dried to 10 percent moisture.

The other major coal field almost certain to be developed further is the Nenana field southeast of Fairbanks along the north flank of the Alaska Range. Extractable reserves of coal in this field are estimated at 95 million tons. The coal is subbituminous in quality and low in sulfur, with heating values ranging from 7600 to 9400 Btu's per pound. Recoverability of this coal is already well-proven. The Usibelli mine has been operating in the Nenana field for nearly forty years, supplying coal to Fairbanks, the University of Alaska, and military facilities in the area. Operations in the Nenana Field are expected to expand over the next 20 years to supply the increased demand for electric power in the Fairbanks area.

The third coal field that may be developed is Jarvis Creek, which lies east of the Nenana field on the north flank of the Alaska Range, close to the Alaska pipeline route. Its location is the one reason for its potential development. Coal from Jarvis Creek could be used to generate power for the pumps along the pipeline, particularly those required to lift the oil over the Alaska Range. The field is quite small, containing only minor reserves of potentially recoverable coal. Much of the coal is in steeply-dipping beds, which may lend themselves to in-situ (in-place) gasification (see Technology section). The coal is of subbituminous quality with heating values ranging from 7800 to 9400 Btu's per pound.

The Matanuska coal field, although not highly ranked by the experts, did impress some as a possible site for coal recovery before the year 2000. The coals are of higher quality than those described above, ranging from bituminous to semi-anthracite. The sulfur content is low, and heating values range from 10,400 to 14,000 Btu's per pound, approaching the range of high grade coking coal. Reserves are not large, however, and there is some concern regarding the economic feasibility of recovering the coal.

The final areas given some chance for development before the year 2000 are Chignik and Herendeen on the Alaska Peninsula. These two fields may in fact be part of one larger field, although there is some disagreement on this point. The quantity of coal is not large, but the quality is bituminous grade with heating values ranging from 9600 to 12,400 Btu's per pound. Sulfur content is somewhat higher than other Alaskan coals, ranging up to 2.3% for some Chignik coal. The potential for development at Chignik and Herendeen derives primarily from the quality of the coal and its ready access to a deep-water port.

Remaining areas in the state, as noted earlier, were generally considered by the experts to have little chance for development prior to the year 2000. Reasons for this vary from area to area. The northern Alaska fields represent an enormous resource. Development in the area, however, is seriously handicapped by the logistics of transporting the coal to market (Ref. 4-8). Deep-water ports along the coast of northern Alaska are virtually non-existent, and as the Alaska pipeline has demonstrated, surface transport is extremely costly.

Other possibilities do exist, however, for future coal development in northern Alaska. Some coal might be mined for electric power generation and/or heating for some of the villages on the North Slope and for oil and gas recovery activities. In addition, there is a possibility that in the future, North Slope coal could be finely ground and transported through the Alaska pipeline in a slurry mixed with petroleum. This would have the additional bonus of extending the life of the petroleum fields, the pipeline, and activities at Valdez. Some have suggested that the feasibility of a petrochemical industry in northern Alaska should be examined.

Problems with most of the remaining fields are due largely to the geology of the coal deposits. In the Kenai, for example, the deposits are generally thin, and thus do not lend themselves to economical surface mining. In the Bering River area, there are numerous small deposits of very high quality coal, but the coal seams are so broken up and scattered that economical mining is not considered feasible. The Eagle coal field has many of the same geological problems as Kenai, and is also very remote. The Unga Island field is small, and the coal is of low quality. Broad Pass is low grade, and the close proximity to National Parks would discourage development.

In addition to the original set of 12 coal fields described above, two of our experts each mentioned one additional field with significant potential. One is the Kobuk River field in central Alaska, which could be used to supply power for possible copper development in the area, provided adequate coal reserves are confirmed. Exploration for copper is now underway, and the area is thought to have very significant potential. The other field is a discovery on the Tonzona River west of Mount McKinley National Park, which is believed to be large, with a coal section up to 120 feet thick, including noncoal partings up to 10 feet thick. (Ref. 4-9.)

APPLICABLE TECHNOLOGY

Recovery

About half the nation's coal is produced by surface mining from seams lying fairly close to the earth's surface. The earth and rock above the coal seam are scraped off and placed to one side to be later back filled; the exposed coal is broken up and removed.

Alaska's one producing coal mine (at Usibelli) is a surface mine. At one time, water was used to remove overburden at Usibelli. The overburden is now stripped by a load-haul method; i.e., the overburden is shot and then loaded into trucks with front-end loaders. Crawler tractors then grade the over-burden to the desired shape, the surface is planted with seeds and the land is restored to productive use.

Machines used in surface mining in other areas range in size from trucks, bulldozers and front-end loaders to gigantic power shovels and draglines which are the largest mobile land machines in the world. The big shovels and draglines lay the seam bare so it can be loaded by small shovels. The biggest dragline currently available picks up 180 cubic yards in each bite.

Usibelli is currently using front-end loaders with a capacity of 10 yards. However, plans have been finalized to use a dragline (see Figure 4-13) with a capacity of 33 cubic yards.

Equipment designs feature mechanical, rather than hydraulic fluid, technology sometimes in cold climates because of the obvious potential of fluids freezing.

In addition to more traditional mining methods, it is also possible to recover coal by in-situ (in-place) gasification.

Beneficiation

Coal is often prepared, or beneficiated, before being used. Beneficiation, which may be done at (or near) the mine or at the point of use, consists of any or all of the following steps:

1. Crushing and screening to a desired maximum size.

2. Cleaning to remove dust and noncoal materials.

3. Drying to prepare the coal for shipping or use.

At the Usibelli Coal Mine the coal is crushed and screened to 4 inch minus. About 10-15% of the coal is washed depending upon customer specifications which vary from customer to customer.

Storage

Coal may be stored in large or small quantities, and at little or no cost. It can be stockpiled indoors or out, under water or on any surface. Whether a few tons or millions of tons are to be stored, there are methods of doing the job correctly.

Spontaneous Combustion

Coals vary a great deal in their natural tendency to absorb oxygen. The tendency is relatively low for bituminous coals and extremely low for anthracite. The tendency is higher for coals of high bed-moisture content,

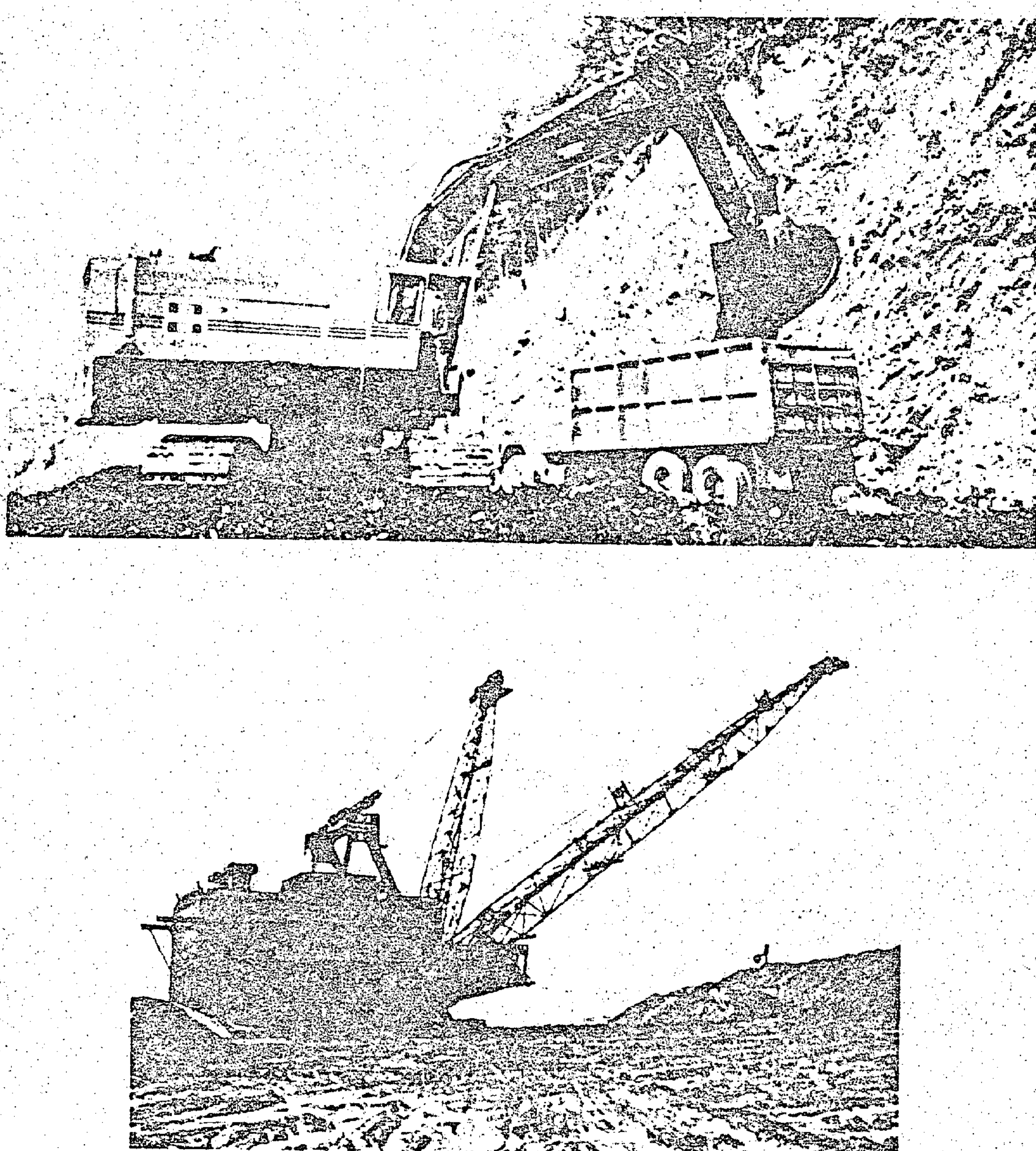


Figure 4-13. Coal Mining Type Equipment; Loader and Hauler (above), Dragline (below).

Source: Bucyrus–Erie, Pocatello, Idaho

high oxygen content and high volatile content, all of which characterize the low-rank coals. The reaction between coal and oxygen is considered to double for each 15 degrees F. If the temperature of the coal is 60 degrees F., and is raised to 90 degrees F., the rate at which oxygen unites with coal increases four times.

Spontaneous heating is caused by coal uniting with oxygen; it is the same as the burning process in the furnace except that it proceeds at a much lower rate. When adequate attention has been paid to the building and thorough compaction of a stockpile, spontaneous combustion is practically eliminated since oxygen is not as available for chemical reaction. Oxidation ~~is then~~ reduced and heating value does not deteriorate as rapidly (i.e., about .1% per year rather than greater than 1% per year).

Transportation

Coal moves to market by at least 6 methods - rail, barge, ship, truck, conveyor and pipeline - or by combinations of two or more.

Rail:

In Alaska, much of the coal mined currently moves to market by rail (i.e., Usibelli to Fairbanks). The rail cost (1976) of 4.6¢ per ton-mile is somewhat greater than in the Lower 48.

There has been some talk of unit trains in Alaska, but thus far no plans have been made to initiate the service. Occasionally the train from Usibelli moves only coal, which is described as a "trainload" shipment.

Slurry Pipelines:

Slurry pipelines, carrying a mixture of water and ground coal, may be very important to Alaska in the future as a mechanism to transport coal. Oil, rather than water for the transporting fluid, is considered "very feasible and very desirous, but it would take quite a bit of oil."*

Mixing pulverized materials with water to form a slurry, then pumping it through a pipeline, is not new. The technology has become well-developed and proven since the first patent for pumping coal and water was issued in 1891. The industry was firmly established in 1957 when the 108-mile Consolidation Coal line began operation in Ohio and the 72-mile American Gilsonite line was initiated in Utah. The Black Mesa Pipeline in Arizona is the world's largest slurry operation. The pipeline has been carrying coal from the Black Mesa Mine to a power plant at the southern tip of Nevada since 1970. Its record of better than 99% availability has confirmed the efficiency and reliability of slurry technology.

By their nature, slurry systems are capital intensive and highly automated. Therefore, once the pipelines are installed, approximately 70% of operations

*Robert Jacques, "Focus on Alaska's Coal," 1975, page 108.

costs related to capital investment are fixed. Only the remaining 30% related to labor, electric power and supplies are variable and thus subject to inflation. For this reason, operating costs are relatively stable over long periods.

Slurry pipelines have problems other than economic. Not only must a water source and dewatering implications be addressed, but the ability to use the power of eminent domain for right-of-way has not been settled.

Belt/Barge:

In the future, near tidewater in Alaska, the conveyor belt/barge transportation system may be of interest. The greatly-increased capacity of barge-type vessels has encouraged movement of large quantities of coal by this means, a common transportation practice in the Lower 48. Towboats of improved power and design move such clusters of coal cargo along inland waterways at low cost. One system in western Kentucky utilizes the world's longest single conveyor belt - a 10 mile stretch. The covered belt is designed to carry about 140,000 tons of coal in a week from two new mines to a barge loading dock on the Ohio River. River tows take the coal to a new power plant of the Tennessee Valley Authority near Clarksville, Tennessee (Ref. 4-10).

Trucks:

In Alaska, trucks are the prime method of moving coal from the mine to the rail points and to a mine-mouth electric generating station. Also, the roads are better in the winter at Usibelli and, with less friction, the coal trucks actually operate more efficiently. Off-highway trucks, capable of hauling over 200 tons of coal, are currently used in some "lower 48" mines although the largest at the Usibelli mine is 50 tons.

Transmission:

In Alaska, the Healy power plant is located near the Usibelli mine and supplies electricity to Golden Valley Electric for distribution in the Fairbanks area over 100 miles away. Thus, the energy from coal is transported by an electrical transmission line.

Use

Electricity from Coal Using Current Technology:

About 62% of all of the coal mined in the United States today, from both underground and surface mines, is burned in coal-fired boilers installed in "power plants." (Ref. 4-11) The old method for burning coal on grates has given way to the practice of burning pulverized (powdered) coal which is blown into the boiler furnace of a modern steam generating plant at rates as high as 330 tons per hour for the largest units. (However, the rates in Alaska are much lower. For example, the Healy plant has a maximum rate of 20 tons per hour, using two 10 ton pulverizers, for this 25 megawatt facility.)

In some boiler furnaces, about 50% of the ash in the coal goes up the stack with the hot combustion gases; however, electrostatic precipitators collect most of the fly ash in the stack effluent. The other 50% falls to the floor of the chamber and is drawn off, sometimes as a molten slag. The temperature of the inside of the modern steam boiler usually reaches 3000 degrees F. The boiler contains the coal dust, flame, and smoke.

The walls and ceiling of the boiler furnace are lined with hundreds of tubes; the floor is reserved for ash collection. Through these "tubes," whose temperature is directly affected by the flames nearby, water is pumped and steam is thereby produced. The steam issues from the boiler at pressures commonly as high as 3500 pounds per square inch and at a temperature of 1000 degrees F. The steam is led into a steam turbine where, entering through nozzles, it impinges on row upon row of turbine blades, causing the turbine to spin at 3,600 revolutions per minute. The shaft of the turbine is connected to the rotor of the generator and, as the turbine spins, so does the rotor and electricity is generated.

As a rough estimate, it takes about four to five million tons of coal per year to supply a 1000 MW plant. In Alaska, the entire electrical production from coal is less than 200 MW so that the in-state use of coal is less than one million tons per year at this time. The Usibelli Coal Mine supplies a mine-mouth plant near Usibelli and the fuel for several power plants in the Fairbanks area. Renewed interest in coal-fired boilers has been shown recently in the Anchorage area.

Electricity from Coal Using Gas Turbine Technology:

Interest has been expressed by a Fairbanks utility in a 32 MW coal-fired combustion turbine concept which has some of the characteristics of a natural gas fired combustion turbine.

Coal is very finely ground (5 micron) in a mill and is exhausted to a coal combustor. Low pressure air exhausted from the turbine at elevated temperatures is used to burn the finely pulverized coal in the combustor. The hot products of combustion exiting the combustor traverse a heat exchanger, heat the compressed turbine operating air, and are discharged at a lower temperature. Atmospheric air is drawn into the compressor and is compressed to discharge pressure. Compressed air traverses a heat exchanger wherein it is heated to turbine inlet temperature. Hot compressed air is expanded through expansion turbines to low pressure, driving the air compressor and the load.

One should note that while the components (i.e., combustor, the heat exchanger and the gas turbine) have been tested with years of production experience, the entire system does not have any operating history as a unit. At least one company is in the process of marketing these coal-fired combustion turbine power systems from 2 MW to 32 MW in size.

Electricity from Coal using Advance Technology:

Since commercialization of such advance technology as magnetohydrodynamic generators (Ref. 4-12) and fluidized bed combustors is not expected for the next few years, the Alaska role will probably be one of following the advance of the technology or perhaps participation in a demonstration unit at a later date.

Liquids from Coal:

Using coal to produce a synthetic liquid fuel is not new. The Berguis process was used in 11 of Germany's World War II synthetic fuel plants, which were jointly responsible for producing 90% of the aviation fuel demand during the peak of the Luftwaffe activity. After the war, synthetic fuel plants in Germany were shut down.

The type of liquid fuel that can be produced from coal depends on the coal and the process. The Berguis process and the Fisher-Tropsch process are the chief "old" techniques. The new processes are in various stages, from laboratory-scale experiments to pilot-plant construction.

From the viewpoint of the chemist, one merely needs to take coal* ($CH_{0.9}$), with some impurities of sulfur, nitrogen ash and moisture, and add hydrogen to get liquid hydrocarbons. For example, jet fuel is CH_2 and gasoline is $CH_{2.1}$. (See Table 4-8). The coal formula shows that each atom of carbon in coal has almost one atom of hydrogen. To obtain jet fuel and/or gasoline, hydrogen must be a little more than doubled and changed in molecular configuration by some method. All liquification and gasification processes are variations (by temperature, pressure catalysts) in the way of adding extra hydrogen to carbon atoms.

The actual complexity of the known techniques for producing a liquid hydrocarbon from coal can be gained by a brief description of the Berguis process.

Berguis Process:

The coal is first dried in an inert-gas atmosphere, to prevent any preprocess burning, and then ground to a power. The dried, powdered coal is mixed with a "pasting oil" (a recycled product of the process itself) and a catalyst. The resulting liquid, containing some 40% coal, is mixed with a hydrogen-rich gas, and pumped into a three-stage preheater where the temperature is raised to 800 degrees F.

From the preheater the hot liquid moves to a series of reactor chambers, vertical pipes three feet in diameter and 60 feet high. It is in these reactors, at a temperature near 900 degrees F. and at a pressure of 10,000 pounds per square inch (psi), that the combination of carbon and hydrogen, called "hydrogenation," is accomplished.

---

*Actually coal is not a uniform substance. It consists of ulmified and carbonized remains of ancient vegetation and no two coals are the same in every respect.

Table 4-8
EQUIVALENT CHEMICAL FORMULAS FOR VARIOUS FEEDSTOCKS AND LIQUID HYDROCARBON PRODUCTS

Feed Stocks	
Bituminous Coal	$CH_{0.9}O_{0.1}S_{0.02}N_{0.01}$ + Ash + Moisture
Sub-bituminous Coal	$CH_{0.9}O_{0.2}S_{0.001}N_{0.002}$+Ash + Moisture
Coal Derived Syncrude (Il-Coal)	$CH_{1.5}O_{0.02}S_{0.001}N_{0.002}$
Paraffin Crude Oil	$CH_{2.0}$
Naphthene Crude Oil	$CH_{1.6}N_{0.01}S_{0.003}$
Products	
Gasoline	$CH_{2.1}$
Jet Fuel	CH_2
Light Fuel Oil	$CH_{1.8}$
Heavy Fuel Oil	$CH_{1.3}S_{0.002}$

Source: Energy Fact Book, TT-A-642-76-211, Tetra Tech, Inc.; February 1976.

The products from the reactors are roughly separated by reducing pressure in steps, which allows the products with the lowest boiling points to be removed first, then the "heavier" ones in succession. In this way a gas, a liquid called "middle oil," and a sludge-like residue are recovered.

Coal Liquefaction Objectives:

The objectives of the federal government's Liquefaction Program are:

1. To develop and demonstrate, in cooperation with industry by 1982-1985, second generation technology necessary for construction of commercial scale plants for coal liquefaction processes.

2. To convert domestic coal to environmentally acceptable, economically competitive substitutes for petroleum-derived liquid boiler fuels, transportation fuels, distillate fuels and chemicals.

3. To perform laboratory studies and process development of third generation liquefaction processes.

With the huge low sulfur coal resources that exist in Alaska, success of objective number two could mean that Alaska may become a significant source of liquid fuel for centuries both for in-State use and for export.

Solvent Refined Coal:

In the Solvent Refined Coal (SRC) process, crushed coal is slurried with a hydrogen donor solvent and exposed to 1,000 psi and 800 degrees F. in a hydrogen atmosphere. Under these conditions the coal dissolves into the solvent and picks up hydrogen. The solution is filtered, removing most of the ash and some undissolved coal. The remainder is a liquid containing solvent, dissolved coal, and a light oil--a product of the reaction of coal with hydrogen. In a vacuum-flash operation the pressure of the mixture is reduced quickly, the solvent boils off, and the material is left solidified at about 350 degrees F. The solid has a considerably lower ash and sulfur content than the original coal. A variety of other products result as well, including fuel oils and high-BTU gas. To manufacture a predominantly liquid product, an additional hydrogenation step is necessary.

The results of some recent experiments on a high sulfur coal and a western low sulfur coal at the SRC pilot plant in Wilsonville, Alabama, are given in Table 4-9 (Ref. 4-13). Since Beluga area coal has a sulfur content of only 0.2 percent by weight, but contain relatively high ash, the advantage of solvent refined products would be in a very low ash clean boiler fuel for power generation near population centers. A preliminary analysis of the potential for developing Alaskan coals for clean export fuels indicates that "these synthetic fuels may compete favorably with other clean fuels at current prices" (Ref. 4-14). However, a later report indicates "the cost of solvent refined products will probably be significantly more expensive than alternate fuels" (Ref. 4-15).

Table 4.9
TYPICAL ANALYSIS OF SOLVENT REFINED COAL

Feed Coal	Illinois		Wyoming	
	Before	After	Before	After
State	Illinois	Illinois	Wyoming	Wyoming
Seam	No. 6	No. 6	Roland-Smith	Roland-Smith
Mine	Monterey	Monterey	Belle Ayr	Belle Ayr
Company	Monterey	Monterey	Amax Coal	Amax Coal
Proximate Analysis (dry basis), Wt%				
Volatile Matter	44.04	72.1	54.16	51.7
Fixed Carbon	45.81	27.8	38.07	48.2
Ash	10.15	0.1	7.77	0.1
Moisture	6.22		6.36	
Heating Value, Btu/lb.	12,215	15,300	11,307	15,900
Ultimate Analysis, wt%				
Carbon	64.80	87.1	67.95	80.4
Hydrogen	5.39	6.0	4.94	5.6
Nitrogen	1.20	1.9	1.06	1.7
Chlorine	0.07	----	0.01	----
Sulfur	4.25	0.8	0.62	0.1
Ash	10.15	0.1	7.77	0.1
Oxygen	14.14	4.1	17.65	4.1
Sulfur Forms, wt%				
Pyritic	1.14	0.07	0.06	0.01
Sulfate	0.19	0.01	0.03	0.00
Organic	2.92	0.75	0.53	0.11
Melting Point, Degrees F.		300		335

Source: Everett L. Huffman, Operations at the Wilsonville SRC Pilot Plant, Proceedings of Third Annual International Conference on Coal Gasification and Liquefaction. University of Pittsburgh. Pittsburgh, PA. August 3-5, 1976.

Here again, research underway in the Lower 48 is significant to Alaska because solvent-refined coal products could someday be important to the economy of Alaska.

Gasification of Coal In-Situ:

Gasification of coal in-situ (in original place) is not a new idea. It was suggested in technical literature in England in 1868, and in Russia by D. I. Mendeleyev in 1888; experiments in both countries were initiated before World War I. In the 1930's the Soviet Union resumed work and, after World War I, other European countries initiated experiments. Following World War II, major field tests were run in England, the Soviet Union and in the United States at Gorgas, Alabama, between 1946 and 1958. Soviet Union development, however, was extensive, and in the 1950's it encompassed industrial uses. Three coal gasification plants are now operating in Russia for electric power generation; one of these is in a steeply-dipping bed.

Gasification of coal in-situ generally involves converting underground coal to gaseous fuels by first selecting a suitable coal bed and then preparing it by providing needed holes and casing, increased permeability, and linkage between holes. The next steps are installing surface facilities (including instrumentation), recovering the valuable (and volatile) material, initiating underground combustion, introducing process air or oxygen, and finally, withdrawing and processing the product gases.

Four different field experiments are already underway in the U.S.; three by ERDA and one by industry. One project, being conducted by ERDA's Laramie Energy Research Center (LERC) in the Hanna Basin of Wyoming, is primarily aimed at moderately thick, slightly dipping, subbituminous coal beds. A second ERDA project is being conducted by Lawrence Livermore Laboratory (LLL), in the Powder River Basin of Wyoming and is designed to exploit very thick beds found quite deep.* The ERDA project being conducted by Morgantown Energy Research Center (MERC) in West Virginia is designed to exploit thick coal beds found throughout much of the eastern United States. The Texas Utilities Company has a project to gasify some lignite beds in east Texas. None of these four active developments involves steeply-dipping coal beds.

In-Situ Gasification of Coal (Steeply-Dipping Bed):

The technical information on the Steeply Dipping Bed (SDB) Concept (which follows) is of interest in Alaska because such beds are found in the state.

Slant holes are drilled through the coal bed at a slight angle to the dip. A channel is formed in the coal connecting the lower ends of the slant holes by the most economical method applicable to the particular coal bed (i.e., directional drilling, hydrofracture, electrolinking, countercurrent burning, etc.). Depending on subsidence considerations, local geological

*With the numerous and thick beds below the water in Cook Inlet, the results of the Powder River basin research will be of special interest to Alaska ~~(Ref.~~ 4-16).

factors and drilling costs, injection holes can be drilled either vertically or slanted underneath the coal bed for a portion of the way. Gasification is initiated at the bottom of each input hole and proceeds along the horizontal channel and up the exhaust holes. Product gases are withdrawn through the slant holes in the coal bed midway between the injection holes. If the production wells are uncased near the lower end, some reducing reactions may occur on the surface of these uncased exhaust holes in the coal bed. As the coal above and along the horizontal hole burns away, the fire zone advances updip. Ash and any portion of the roof which may fall collects in the space below and behind the fire zone. Thus, the burning coal face is kept free of ash accumulation and the air flow is maintained in contact with the burning coal. Some degree of induced fracturing of the coal may be required. Local conditions such as dip angle of the bed, depth involved, type of overburden, and coal properties (e.g., permeability), plus drilling and casing costs, would dictate the specific drilling pattern.

The Soviets have demonstrated in-situ coal gasification on a large scale. Their systems, both flat-lying and steeply dipping beds, were successful technically, however little is known about the economic feasibility (Ref. 4-17).

Gas from Coal (Low and High Btu):

In the early coal-gas plants, coal was first heated in a closed tank, using an external source of heat. When the desired temperature was reached, steam was piped into the tank and a reaction took place. The resulting "gas" was a mixture of carbon monoxide with some hydrogen, some nitrogen, a little carbon dioxide, a little methane, and a small amount of other volatile ingredients from the coal. The heating value of this gas ran as low as 100 Btu per cubic foot, or in the best cases by modifying conditions, as high as 550 Btu per cubic foot. (Natural gas runs about 1,000 Btu per cubic foot).

The first of a new generation of gas-from-coal plants that will be built in the next few years will utilize the techniques and proven processes already on hand, such as the Lurgi system. Lurgi gasifiers have been in use for several years around the world. Gas from the Lurgi gasifier will have to undergo an additional processing called "methanation" to bring the Btu value up to the 950 to 1,000 range.

In the meantime, a number of new "advanced" processes are being developed. These new concepts, some of which are already in the pilot-plant stage, attempt to produce a high-quality synthetic gas from coal. In general, this group of processes attempt, each in a slightly different manner, to utilize higher temperatures and higher pressures, not to mention new pressure containers and high-temperature-resistant alloys, to attain high efficiencies and reliable performance.

Synthane:

An example of a Btu gasification effort is the synthane process (Ref. 4-18). In this procedure, coal sized to pass through a 200-mesh screen is mixed with steam and oxygen in a pretreatment pressure vessel at 1,000 psi at

800 degrees F. In this pretreatment state the coal is partially oxidized and volatile matter is driven off. The coal and gases from the pretreater are introduced at the top of the gasifier, and additional steam and oxygen are introduced at the bottom. Partial combustion of the coal increases the temperature of this process to 1,800 degrees F. After the coal passes through the fluidized bed portion of the gasification vessel it exits as char at the bottom. The char is then burned to produce steam for the pretreater and gasifier.

The raw gas is cleaned of tars, char, and water and then undergoes a shift conversion. Following those operations, the gas is bubbled through hot carbonate to remove carbon dioxide and sulfur and is then methanated.

The Synthane process achieves a high Btu raw gas output with a relatively simple high pressure gasification system. However, all the coal entering the gasifier is not burned, and the remaining high sulfur char must be burned for process heat.

The role Alaska will play in the near term will probably be one of keeping informed on the federal government-supported programs--both the high Btu gasification research and the low Btu gasification projects.

Reclamation

In addition to the visual pollution and water erosion problems associated with surface mining, another major concern is the particulates generated by wind erosion. Dust generated during production generally comes from dry roads and is suppressed with water. The mine site problems may be solved by revegetation, leaving reclaimed surface land as attractive and productive as it was before mining.

At a coal conference in Fairbanks, Joe Usibelli, owner of Usibelli Coal Mine, was asked to discuss his reclamation experiences on his mine in interior Alaska. He stated:

> "We have gone back into areas where we have mined since 1918 and we have something growing on all of that now. We use an aircraft to broadcast a seed mixture, which varies from year to year, but is very complex, and a lot of fertilizer. And if your timing is right and you use the right fertilizer and the right seed, you can get four feet of top growth in a year. We're getting grass primarily - grasses and legumes. We have alfalfa growing down there now that has an estimated 20-foot tap root. So we think it is highly successful. There are some areas where it is not quite as successful as others, but we have not had any areas that were total failures. And it is just that simple. You just throw out some seed and fertilizer. That's just the way that Ma Nature does it if you think about it." (Ref. 4-16)

The success of the Usibelli reclamation project is shown in Figure 4-14 where Dall Sheep are shown grazing on reclaimed land.

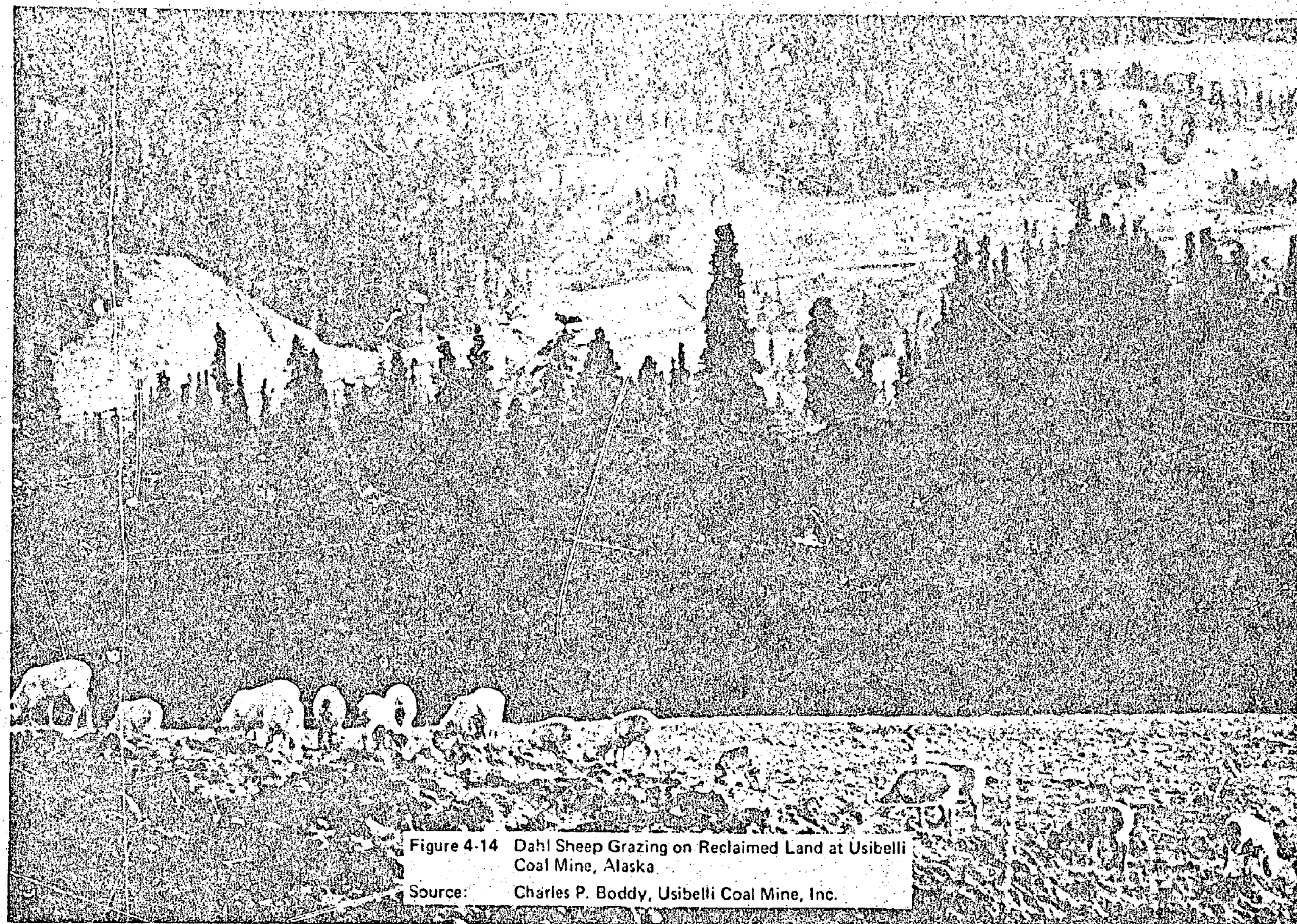


Figure 4-14 Dahl Sheep Grazing on Reclaimed Land at Usibelli Coal Mine, Alaska.

Source: Charles P. Boddy, Usibelli Coal Mine, Inc.

CURRENT PLANS FOR DEVELOPMENT

Plans are currently underway for expansion or development of three of Alaska's coal fields: the Beluga district of the Susitna field; the Nenana field, and Jarvis Creek field. In all three cases, however, current plans are still preliminary and subject to change.

In the Nenana field the Usibelli operation expects to increase production over the next several years, primarily to provide additional fuel for the Golden Valley Electric Association. They have already committed to buy a large dragline which will greatly facilitate their ability to clear over-burden. The 2000-ton excavator will remove 33 cubic yards of material per scoop aided by a boom that is 325 feet in length. According to Usibelli superintendent Ed Poor, the boom is a limiting factor: "If we could use a shorter one our bucket could be much larger than the 33 yards we now have." The dragline will be powered by electricity and will require seven to eight megawatts to operate. Poor expects the unit to be in use by August 1978.

The general feeling among those consulted is that the Usibelli operation could be operating at twice its annual production of 700,000 tons per year within the next five to ten years. The Golden Valley Electric Association states that they would like to have a 150 megawatt power plant on line by 1985 using coal as the power source. The only potential deterrent to this development is the Environmental Protection Agency regulation on the non-deterioration of air quality within 60 miles of a national park (in this case, Mt. McKinley).

Production plans at the Jarvis Creek field are still very tentative at this time. There is interest on the part of a local group to install a 50 megawatt, mine-mouth power plant in the Jarvis Creek field to supply power to two or three pumping stations along the pipeline and to back-feed power to the Golden Valley Electric Association.

Another important development currently under consideration is for the Beluga district near Cook Inlet. The major moving force of this development is Placer Amex Inc., which is interested in developing the field for power generation for the Anchorage area or shipment to the U.S. West Coast. Contacts have been made with all West Coast utilities from the San Diego Electric Utility in the south to several Washington State private and public utility districts. It is believed that a minimum shipment of 5 million tons per year is required to make the Beluga operations economic and competitive. Given the numbers currently under discussion, one or two large customers would probably be sufficient to move plans forward rapidly. Some Japanese purchasers have expressed interest in Beluga coal for steam electric plants.

In addition to the probability of export of Beluga coal to the Lower 48, there is also some discussion of the possibility of an aluminum smelter and a sponge iron processing operation in the Beluga area. Both would be powered by electricity generated at a Beluga mine mouth power plant.

COST ISSUES

A comparison of the cost of coal (since 1950) with the cost of oil, gas and uranium to the U.S. electric utilities, is given in Figure 4-10 under the Oil and Gas section of this chapter.

If one does his own truck transportation from the Usibelli Coal Mine near Fairbanks, the cost of coal is only $10 per ton (1976); however, a major issue with respect to Alaskan coal is the cost and availability of transportation.

Even when interior railway transportation is available the cost is very high; 4.6¢ per ton mile (1976). (See comparison of transportation in Table 4-10.) Since the energy in 2.83 barrels of crude oil is the same as the energy in a ton of Usibelli subbituminous coal, a transportation cost is calculated of about 1.6¢ per barrel (energy equivalent) per mile which can be compared with the transportation cost of pipeline oil in Alaska, i.e. about 1¢ per barrel per mile for the small Nikiski pipeline and about 0.6¢ per mile for the Trans-Alaska pipeline. Longer distances and high volumes of coal movement would bring lower prices per ton-mile.

The transportation economics of coal resources of the Northern Slope coal fields have been studied by Clark (Ref. 4-19). The report concludes:

> "If the coal must support the entire transportation system cost, the transportation of coal from th North Slope of Alaska to Japan appears to be economically feasible only from easily mined areas which are close to an ocean shipping port. In the case of the transportation cost sharing by other users, or by government subsidization, the prospects of the northern coal exploitation would be enhanced."

One recent report by Hennagin (Ref. 4-20) evaluates the mining and transportation costs of the Beluga coal deposits. The assumption taken for these cost calculations are: (1) the surface mine site is 15 miles from tidewater; (2) the coal is mined, washed, slurried and transported by pipeline to tidewater where it is loaded on ships as a settled marine slurry; and (3) the coal is shipped to northern Washington, reslurried and pumped off the ship to dewatering facilities. The conclusion was "...Beluga coals may become an economical energy source in the not too distant future."

One cost issue of great importance to Alaska is the cost of a sulfur scrubber. One report estimated that the generation cost of electricity will be increased by about 18% as a result of the addition of a scrubber (Ref. 4-21). With the low concentration of sulfur in Alaska coals, air standards can be met without this expense.* An excellent overview on the complex subject of flue-gas desulfurization is given by Hollinden and Wells (Ref. 4-22).

The economics of solvent refined coal has been evaluated by Chastain (Ref. 4-23). The 30-year levelized energy cost in mills/kwh were determined for 18 case studies. The conclusion was:

*Recent Clean Air Act (1977) Amendments apparently will place serious limitations in the economic use of Alaska's low sulfur coal.

Table 4-10
COSTS OF COAL TRANSPORTATION OUTSIDE COMPARED WITH ALASKA
(1972 Estimates)

Type	Distance Assumed (miles)	Cost Per Ton-Mile (cent per ton-mile)
Unit Train	300	0.7
Conventional Train	300	1.3
Usibelli to Fairbanks * (Alaska)	115	2.9
River Barge	300	0.3
Slurry Pipeline	273	0.6
Trucking	10	4.5
Conveyors	5	7.6

* Information added to "Energy Alternatives" for comparison. Note that the cost per ton/mile by train in Alaska (2.9 cents) is over twice that in the Lower 48 (1.3 cents). Recent updated (1976) information for Alaska (4.6 cents) indicates that this very high, unfavorable ratio still exists.

Source: Energy Alternatives: A Comparative Analysis. Science and Public Policy Program, University of Oklahoma, May 1975.

"In view of the apparent technical and economic attractiveness of using solvent refined coal as a utility boiler fuel, it appears that every effort should be made to move this technology toward commercialization so that it will be available to play a part in supplying future energy needs."

The various fees, rentals, bonuses, and royalties charges for coal exploration and production on State lands are given in Table 4-11.

EXTERNAL MARKET ISSUES

There are two major potential export markets for Alaskan coal: The U.S. West Coast and Japan. The U.S. market is more favorable at the present time, given the government policy of forcing conversion of all oil-or-gas-powered electrical generating systems to coal. The Japanese currently are purchasing large quantities of coking coal from Australia to supplement their own domestic supplies; however, Japan could turn to Alaska as a supply source for steam coal in the future. All discussions of a project to supply coal to Japan have been tentative so far. A product of particular interest to the Japanese would be high grade steaming or coking coal. The closest available source of such coals in Alaska are the Herendeen Bay/Chignik areas on the Alaska Peninsula and, possibly, the Matanuska field near Cook Inlet. The former field is small, undeveloped and may be tied up in federal selections for "national interest lands". The coals would have to be developed by underground methods and would have to be washed to reduce ash. Thus, neither of these developments appears to be very likely in the near future.

Analysis of the West Coast market for Beluga coal is only just beginning, with studies being performed by Stanford Research Institute, Batteile Institute and some private companies. Work is still preliminary and further work will be done by this project team in the second phase of the project.

Since rail transportation is higher in cost than water transport for equal distance, it is believed at present that the transportation cost comparisons between Beluga and Rocky Mountain coals are close. Until complete research is performed, however, it is difficult to determine whether there is a net cost advantage of Alaska coal to West Coast users, considering all cost. Also, ocean shipping costs are less escalable over time than rail shipping costs. Long term shipping contracts can be written for ocean transportation, but not so for rail transportation.

Ocean transportation is one factor that is advantageous for Beluga coal in San Diego Gas and Electric's consideration of a major coal fired facility in Baja California across the Mexican border. The Mexican government appears to consider potential pollution problems bearable given the opportunities for employment such a facility would create in Mexico, as well as providing extra electric power for a water desalination plant which is needed in Baja. Additional potential users of Beluga coal appear to be utilities in Washington and Oregon, with possible plant sites at or near existing port facilities on the Columbia River. Again, water-borne transport would have a noticeable advantage over existing rail links.

Table 4-11
COAL PROSPECTING PERMIT & LEASE FEES

March 1977

Permit, Lease or Claim	Fees, Rentals, Bonuses and or Royalties	Area (acres)	Term (years)	Comments
Prospecting permit	\$20 filing fee plus \$20 for extension of term	5120	2 years plus 2 year extension	If permittee can prove workable deposits of coal, prospecting permit can be converted to coal lease.
Lease	\$20 filing fee plus 25¢/acre for first year 50¢/acre for 2-5 years; \$1.00/acre for 6 and all succeeding years or royalty if producing (various amounts) ranging from 5¢ to 30¢ per ton	So much of the land as can be proven to contain workable deposits of coal	Indeterminate	Rentals and royalties are reviewed at least every 20 years or more frequently as Commissioner of State Department of Natural Resources may decide. Royalties to be no less than 5¢ per ton. State can't cancel coal lease without taking it to court.

Source: "Regulations and Statutes Pertaining to Coal and Other Leasable Minerals on Alaska Lands as Contained in the Alaska Administrative Coal and the Alaska Statutes" State of Alaska, Department of Natural Resources, Division of Lands, September 1975, Reprinted Sept. 1976.

In conclusion, it appears that external market issues associated with coal development in Alaska are extremely important. Although Alaska can use its own coal successfully for electric power generation, the Alaskan market is small but still significant. Considerable attention should be given to to in state and export markets in future phases of this project.

FURTHER INFORMATION NEEDS

With the substantial coal export possibilities that exist in Alaska, much information is needed in order to assure growth that is both economically and environmentally sound. A number of these requirements are listed below:

1. Market studies of the Columbia River basin to the new seaport at Lewiston, Idaho, as well as Pacific Rim countries should be intensified, not only for raw coal, but for processed coal (high Btu) and solvent refined coal products.

2. More information is needed on Alaska's relevant environmental issues and their impact on coal development.

3. The various land tenure issues that might affect Alaska coal development need to be catalogued.

4. Information on reclamation in Alaska is currently limited to the Usibelli area and, more recently, the seeding program long the pipeline. More information is needed for other areas of the State that have different climate and soil conditions.

5. Sulfur scrubber technology and costs are needed for Alaska's very low sulfur coals. National regulations may require scrubbers even if air standards for sulfur emissions can be met. The advantages of using Alaskan low sulfur coal in fluidized bed burners and magneto-hydrodynamic plants should be determined.

6. Since a strong interest in a coal-fired combustion turbine has been noted in Alaska, more information is needed on the operating history of grinding coal to a 5 micron size and burning it in a combustor. Information is especially needed on the operating history of the heat exchanger, as well as on the operation of all components as a single system.

7. A review needs to be made of all coal recovery, storage, transportation, processing and generation technologies; those that are applicable to the Alaskan environment should be identified.

8. Information is required on the relative costs of different technological solutions to the problems of recovering, transporting, and generating electrical power using Alaskan coal, with special attention to the significant advantage associated with the low sulfur content.

9. Coal research underway in the Lower 48 is frequently not directly applicable to the Alaskan low sulfur, high moisture coal. For example,

solvent refined coal yields products (liquids and solids) very low in sulfur and ash and more economic to transport, which are very important to Alaska. Eastern coals and Wyoming coals have been solvent refined and analyzed in a plant in Alabama (Southern Service Company, Inc.), but not Alaskan coals. Samples of Alaskan coals should be sent to Alabama (or to the SRC pilot plant at Ft. Lewis near Tacoma, Washington) for refining and analysis, with special attention to obtaining technology suited for Alaskan coals. An operating temperature, pressure or catalyst modification, or perhaps an equipment design change emphasizing ash removal might be applicable to Alaskan coals. Alaska is so close to a major coal export situation that a technological breakthrough could pay dividends to the State long after Prudhoe Bay oil is gone.

10) For the long term, the feasibility of an Arctic petrochemical industry based on coal for electricity, spaceheating, process heating and as the raw material for various synthetic chemicals should be examined.

11) The low-volatile, high energy content, bituminous coals on the Lisburne Penninsula should be studied for possible local use.

12) More geologic field work needs to be done to identify coal fields, their aerial extent, quality of the coals and a better estimate of the actual reserves. Our biggest lack is a good information base.

COAL
KEY CONTACTS

Carl H. Marrs
Land Manager
Cook Inlet Region, Inc.
1211 West 27th Avenue
Anchorage, Alaska 99503
(907) 274-8638

William S. Ginn
President
Combustion Turbine Power, Inc.
405 GSB Building
1 Belmont Avenue
Bala-Cynwyd, PA 19004
(215) 667-3590

M. C. Titus
Consultant
805 West Glenn Drive
Phoenix, Arizona 85021
(602) 944-3935

J. D. Barnes
Vice President
Marketing
Combustion Turbine Power, Inc.
405 GSB Building
1 Belmont Avenue
Bala-Cynwyd, PA 19004
(214) 667-3590

Hugh J. Matheson
Vice President Exploration
Placer Amex Inc.
One California Building
Suite 2500
San Francisco, CA 94111
(415) 986-0740

C. E. McFarland
Vice President
Placer Amex Inc.
One California Building
Suite 2500
San Francisco, CA 94111
(415) 986-0740

Jim Callahan
U.S. Department of the Interior
Division of Geological Surveys
Box 2373
Casper, Wyoming 82602

Robert Sanders, Geologist
U.S. Department of Energy
Federal Building, G-11
605 W. Fourth Avenue
Anchorage, Alaska 99501

Ross Schaff, Don McGee & William Lyle
Geologists
Department of Natural Resources
Div. of Geological & Geophysical Surveys
3001 Porcupine Drive
Anchorage, Alaska 99501

A. J. (Jim) Movius
Senior Engineer
R & M Consultants
P.O. Box 2630
3550 Geraghty Avenue
Fairbanks, Alaska 99707
(907) 452-1655

Cleland Conwell
Mining Engineer
Department of Natural Resources
Division of Geological & Geophysical Surveys
Box 80007
College, Alaska 99701

Marco A. Pignalberi
Executive Assistant to the President
Alaska International Industries
P. O. Box 60029
Fairbanks, Alaska 99701
(907) 452-7171

Gary F. Player
Geologist
Arctic Environmental Information
and Data Center
707 A Street
Anchorage, Alaska 99501
(907) 279-4523

P. D. Rao
Associate Professor of
Coal Technology
Mineral Industry Research Laboratory
University of Alaska
Fairbanks, Calaska 99701
(907) 479-7135

Irvin L. Tailleur & William Brosge
Geologist
U.S. Geological Survey
Alaskan Geology Branch
345 Middlefield Road
Mail Stop 17
Menlo Park, CA 94025
(415) 323-8111

Joseph E. Usibelli
President
Usibelli Coal Mine, Inc.
Usibelli, Alaska 99787
(907) 683-2226

Robert Warfield
Mining Engineer
United States Bureau of Mines
Alaska Field Operations Center
P.O. Box 550
Juneau, Alaska 99802
(907) 364-2111

Ernest N. Wolff
Director
Mineral Industry Research Laboratory
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7135

Robert Bottge
Mining Engineer
U.S. Bureau of Mines
Alaska Field Operation Center
P.O. Box 550
Juneau, Alaska 99082
(907) 364-2111

Benno J.G. Patsch
Placer Amex Inc.
One California Building
Suite 2500
San Francisco, CA 94111
(415) 986-0740

References

4-8 Kaiser Engineers. Phase I: Technical and Economic Feasibility of Surface Mining Coal Deposits on the North Slopes of Alaska. Report No. 76-91-RE Kaiser Engineers prepared for U.S. Bureau of Mines, Colorado. 1976.

4-9 Player, Gary F. The Little Tonzona Coal Bed Near Farewell, Alaska--An Important Extension of the Coal Fields North of the Alaska Range. Alaska: Gary Player Ventures, January 1977.

4-10 National Coal Association. Coal Facts. Washington, D.C.: National Coal Association, 1974-1975.

4-11 "Electricity From Coal". Energy Perspectives Number 4, Battelle Energy Program, November 1971.

4-12 Tetra Tech, Inc. Navy Energy and Natural Resources Research and Development Office. Energy Fact Book--1976. Virginia: Tetra Tech, Inc., 1976.

4-13 Everett L. Huffman. Operations at the Wilsonville SRC Pilot Plant. Proceedings of Third Annual International Conference on Coal Gasification and Liquefaction. University of Pittsburgh. Pittsburgh, Pennsylvania, August 3-5, 1976.

4-14 "The Potential for Developing Alaskan Coals for Clean Export Fuel". Work Performed by Stanford Research Institute for Office of Coal Research Phase 1. December 1974.

4-15 Stanford Research Institute. Clean Energy from Alaskan Coals. FE-1516-2 Final Report. January 1976.

4-16 Rao, P. Dharma and Wolff, Ernest N. Focus of Alaska's Coal 1975. Proceedings of the Conference held at the University of Alaska, Fairbanks. October 15-17, 1975.

4-17 D. R. Stephens and S. K. Madsen. LLL in-situ Coal Gasification Program. Annual Report Fiscal Year 1976, Lawrence Livermore Laboratory, February 2, 1977.

4-18 Tetra Tech, Inc. Energy from Coal. Virginia: Tetra Tech prepared for Energy Research and Development Administration (ERDA 76-67), 1976.

4-19 Alaska, University of Alaska, Mineral Industry Research Laboratory. Transportation Economics of Coal Resources of Northern Slope Coal Field, Alaska, by Paul R. Clark. M.I.R.L. Report No. 31. 1973.

4-20 Hennagin, Brian David. Cook Inlet Coal: Economics of Mining and Marine Slurry Transport. Washington: University of Washington, 1977.

References (Continued)

4-21 Fast, E., and Rutledge Gene P. Analysis of the Economics of Coal Versus Nuclear for a Power Plant Near Boise, Idaho. Idaho: Office of Nuclear Energy Development, 1976.

4-22 Hollinden, G. A., and Wells, W. L. Flue Gas Desulfurization. Tennessee: Tennessee Valley Authority, 1976.

4-23 Chastin, Richard H. The Economics of Solvent Refined Coal. Alabama: Southern Company Services, Inc., 1976.

CHAPTER 5

NON-FOSSIL FUEL RESOURCES

INTRODUCTION

In addition to the large reserves of fossil fuels described in the previous chapter, Alaska has a substantial potential for development of a wide variety of non-fossil fuels. Because so much of Alaska's mountain terrain is exposed to a marine or transitional climate, the hydroelectric potential of the State is enormous. Many areas around the State, including both sedimentary and hard rock zones, are considered to have substantial potential for uranium development, although exploration has only just begun. Alaska's position astride one of the most active tectomic zones in the world creates considerable potential for geothermal energy. Much of Alaska's coastline and some inland areas are exposed to winds in excess of 10 knots throughout the year creating a major opportunity for the development of wind-generated electric power for remote areas. Daily tides running over 30 feet along the Southcentral coast create still another possible energy resource.

Not all of these energy resources, of course, are likely to be developed simultaneously over the next 20 to 25 years. We have tended to concentrate our attention primarily on those resources which are likely to be most significant in the next two decades. Nevertheless, Alaska has the opportunity to develop a diversity of non-fossil energy resources, many of them renewable, in years to come.

BLANK PAGE

HYDRO

RECOVERABLE RESOURCE DESCRIPTION BY SITE

Alaska's untapped hydroelectric power resources far exceed those of any other state in the U.S. Along an arc extending from Southeast Alaska to the Alaska Peninsula in the Southwest, moisture-laden marine air strikes mountain ranges on or near the coast. The result is thousands of rivers and streams which flow at high speed to the sea. Interior mountain ranges in the Yukon watershed provide additional hydroelectric potential. Relatively little of this potential has been utilized so far. Only about 12% (1975) of the State's electricity needs comes from hydropower. Existing hydroelectric sites of 2.5 megawatts or greater are listed below:

Community Serviced	Hydropower Site	Site (Megawatts of Installed Capacity)
Anchorage	Cooper Lake	15
	Eklutna	30
Juneau	Snettisham (Speel River)	47.2
	Annex Creek	2.8
	Salmon Creek	2.8
Sitka	Blue Lake Dam	6.0
Ketchikan	Beaver Falls	5.2
	Ketchikan	4.2
Metlakatla	Purple Lake	3.0

Inventories have been made of additional potential hydroelectric sites of all sizes as discussed and documented in Volume 2. For example, the Alaska Power Administration, in a 1968 study, determined that there were 76 lower-priced hydroelectric sites of 2.5 megawatts and larger which could generate a total of 170 billion kilowatt hours (kwh) of electricity. This list resulted from a review of 2,000 sites in the state where hydropower could be produced.

To limit our analysis to a reasonable number of potentially recoverable sites, we began by concentrating our attention on the 39 undeveloped hydro sites that had been recently (August 1976) identified and analyzed by the Institute of Social and Economic Research (ISER) at the University of Alaska. These sites and their probable size and cost* are shown in Table 5-1 (Ref. 5-1)

*The Alaska Power Administration advises that: (1) in its view, the cost data presented in this table are misleading, particularly with respect to several of the smaller projects on the list which, based on previous evaluations, would be much more costly to develop then the Upper Susitna Project for which ISER has doubled or tripled costs determined in a thorough feasibility study by the Corps of Engineers; and (2) based on demands, additional projects such as Wood Canyon, Yukon-Taiya, Woodchopper, and Chackachama should be considered as "potentially recoverable sites" in context of the present study.

Table 5-1 Capacity and Cost of Key Hydroelectric Projects

Region/Area/Project	Capacity (KW)[1] Installed	Capacity (KW)[1] Prime	Prime Energy (MWH)	Total (000$)	Capital Cost Per[2] Prime KW	Capital Cost Per[2] Installed KW
Anchorage-Fairbanks						
Susitna Project						
Watana	792,000	353,880	3,099,908	2,297,700	6,493	2,901
Devil's Canyon	776,000	344,750	3,020,010	1,234,100	3,580	1,590
Total	1,568,000	698,630	6,119,598	3,531,800	5,055	2,252
Southcentral–Anchorage–Fairbanks–Cordova–Valdez–Glennallen						
Tebay Lakes	64,000	30,150	204,114	--	--	--
Power Creek	12,000	3,725	32,631	11,610	3,117	967
Sheep River Lakes	4,000	2,540	22,250	6,530	2,587	1,648
No Name Creek	5,000	2,550	22,338	3,970	1,557	794
Solomon Gulch	12,000	4,440	38,877	19,972	4,498	1,664
Total	97,000	43,405	380,210			
Kenai Peninsula						
Nellie Juan Lake	40,000	21,000	184,000	45,555	2,169	1,139
Snow River	60,000	31,900	279,000	57,705	1,809	962
Bradley Lake	125,000	51,400	450,000	89,835	1,748	719
Total	225,000	104,300	913,000			
Kodiak						
Terror Lake	20,000	7,220	63,250	40,370	5,591	2,018
Southeast						
Metlakatla						
Purple Lake Rehabilitation	1,400	400	17,520	1,134	2,835	810
Hassler Lake	4,000	2,000	16,980	6,830	3,415	1,708
Total	5,400	2,400	34,500			
Ketchikan						
Upper Mahoney Lake	10,000	4,700	41,172	9,035	1,922	903
Swan Lake	15,000	7,700	67,500	32,990	4,283	2,199
Lake Grace	20,000	11,000	94,000	39,351	3,577	1,968
Total	45,000	23,800	202,672			
Petersburg-Wrangell						
Anita	4,000	2,100	18,396	5,871	2,796	1,468
Anita and Kunk Lakes	8,000	3,030	33,550	9,128	2,383	1,141
Virginia Lake	6,000	3,000	26,280	7,070	2,357	1,178
Sunrise Lake	4,000	2,400	21,024	4,174	1,739	1,043
Ruth Lake	16,000	7,950	69,660	23,355	2,938	1,460
Crystal Lake Expansion	2,500	400	3,504	4,400	11,000	1,760
Cascade Creek I	15,000	5,100	44,781	22,955	4,501	1,530
Cascade Creek II	36,000	17,900	156,672	21,335	1,192	593
Scenery Lake	18,000	9,100	79,716	22,310	2,452	1,239
Total	105,500	51,780	453,583			

Table 5-1 (continued)

Region/Area/Project	Capacity (KW)[1] Installed	Prime	Prime Energy (MWH)	Total (000$)	Capital Cost Per[2] Prime KW	Installed KW
Southeast (continued)						
Juneau						
Snettisham Expansion I	27,000	11,758	103,000	22,000	1,871	815
Snettisham Expansion II	–	18,607	162,997	16,000	860	---
Total	27,000	30,365	265,997	38,000	1,251	
Sitka						
Lake Irina	3,000	1,790	15,680	3,665	2,047	1,222
Green Lake	14,000	6,600	57,816	18,050	2,735	1,289
Lake Diana	10,000	4,585	40,165	9,705	2,117	970
Milk Lake	16,000	8,000	70,080	18,750	2,321	1,172
Four Falls Lake	6,000	3,000	26,280	4,265	1,417	711
Carbon Lake	18,000	6,830	59,832	19,200	2,811	1,067
Takatz Lake	20,000	10,000	87,600	26,600	2,660	1,330
Total	87,000	40,805	357,453			
Haines						
Unnamed Lake	9,000	4,640	40,640	10,435	2,249	1,159
Skagway						
Goat Lake	9,000	4,450	38,982	9,140	2,054	1,016
Total Region	287,900	157,840				
Northwest						
Unalakleet						
Anvik River	14,000	6,800	59,568	19,725	2,901	1,409
Southwest						
Dillingham						
Lake Elva	2,500	1,240	10,820	6,690	5,395	2,676
Bethel						
Kisaralik River	36,000	18,200	159,222	74,485	4,093	2,069
Total	38,500	19,440	170,042			
Total Region	1,910,000	853,555	7,477,142			
STATEWIDE TOTAL	2,250,400	1,037,635	9,093,187	– –		

1. "Installed capacity" is the total of capacities as shown on the nameplates of similar kinds of apparatus such as generating units, turbines or other equipment in a station or system. It is also described as the "design limit of the facility". "Prime capacity" is based on the lowest water available over a number of years, i.e., the hydroelectric power available from a plant on a continuous basis under the most adverse hydraulic conditions.

2. All costs were based upon 1976 construction rates.

Source: Electric Power in Alaska, 1976-1995, Institute of Social and Economic Research, University of Alaska, Alaska: August, 1976.

Electricity consumption in the State in 1976 was approximately 3½ billion kwh, with projected consumption estimated to reach 10 to 22 billion kwh/year by 1995 (Ref. 5-1) and 15 to 58** billion kwh/year by 2000 (Ref. 5-2). The resource obviously is in excess of Alaska's needs for the foreseeable future. In this context, the term "recoverable" resource takes on a new meaning, since what is technically and/or economically feasible is far beyond the range of in-State demand well into the twenty-first century.

To assist us in ranking hydroelectric sites and in predicting where hydroelectric generation may occur before the year 2000, a number of recognized authorities were consulted. While 39 projects were used as a starting base, the communication to the experts carefully noted that they were not limited to these 39 projects and were requested to add any that they felt would be appropriate. Many potential site locations were added by the participants. Specific sites expected to have capacities of less than 2.5 megawatts were included. Experts who participated in this analysis were as follows:

James V. Williamson, Assistant Manager
Western Design Office
R. W. Beck and Associates
200 Tower Building
Seattle, Washington 98101
(206) 622-5000

George R. Robertson (and staff)
Colonel, Corps of Engineers
District Engineer
Department of the Army
Alaska District
P.O. Box 7002
Anchorage, Alaska 99510

Carl Steeby, Consulting Engineer
Retherford Associates
6927 Old Seward Highway
Anchorage, Alaska 99502

Robert Cross, Administrator
Alaska Power Administration
Box 50
Juneau, Alaska 99802

Dale Rusnell, Chief
Power Development
Dept. of Commerce & Economic Development
Div. of Energy and Power Development
7th Floor, Mackay Building
338 Denali Street
Anchorage, Alaska 99501

While the experts made a number of comments on specific hydroelectric sites, there were additional general comments made on hydroelectric energy generation in Alaska, Some excerpts are given below:

**This 58 billion includes possible energy intensive industry plus National Defense System plus utilities but ISER report included only utilities.

"The list is our assessment of those projects which may or may not be developed prior to the year 2000. Had you asked my opinion of those projects which would be on line prior to the turn of the century, the listing would change considerably. Obviously, the future of hydro-electric development in Alaska is dependent upon a number of ever changing variables. The answer is not simply that of economics. There are many projects which we believe to be economically feasible. However, political and environmental considerations, or financial constraints may preclude development of these projects. The present d-2 land proposals before Congress could have a profound effect on projects which may otherwise be quite feasible. In addition, it is essential to keep in mind that the present national commitment to solving our energy problems may indeed spawn energy alternatives not only to thermal generation but to hydroelectric as well. This was certainly the case with the Bradley Lake hydro project which looked very promising before the natural gas discoveries in lower Cook Inlet."

"The listing of 39 hydro projects obtained from the 1976 Institute of Social and Economic Research (ISER) study does not consider the load demand of a specific area. For instance, there are nine projects listed which could provide energy for the Petersburg-Wrangell area and yet the energy growth rate of the area is not sufficient to require even a quarter of the energy potential of these sites prior to the year 2000. Consequently, our conclusion would be that at least seven of those projects would not be developed within the duration of this century. In addition to your list, we have added some other projects which may have potential for development."

"I must summarize that there is sufficient hydropower potential within Alaska to satisfy our energy needs for a considerable number of decades. At least 700 potential sites have been previously identified. Realization of this resource, however, is dependent on a number of elements over which we have little control."

Of the 39 projects listed in Table 5-1, ten were eliminated because not one single expert thought that these projects would be developed for electrical generation before year 2000. For all ten projects listed below there was either insufficient demand and/or the need for long, expensive transmission lines to a small load center:

Hydro Power Site	Community Served	Capacity (kilowatts) Installed	Prime
Tebay Lakes	Cordova	64,000	30,150
Anita Lake	Wrangell	4,000	2,100
Ruth Lake	Petersburg	16,000	7,950
Scenery Lake	Petersburg	18,000	9,100
Lake Irina	Sitka	3,000	1,290
Lake Diana	Sitka	10,000	4,585
Milk Lake	Sitka	16,000	8,000
Four Falls Lake	Sitka	6,000	3,000
Carbon Lake	Sitka	18,000	6,830
Anvik River	Unalakleet	14,000	6,800

Continuing with the process of elimination, an additional seven projects were determined to be highly unlikely for production of electricity before the year 2000 because better hydroelectric options are available in the area under consideration, insufficient demand was predicted, or other reasons. Of the seven projects listed, only one of five experts felt that electrical production might occur before the year 2000:

Hydro Power Site	Community Served	Installed	Prime
Sheep River Lakes	Cordova	4,000	2,540
No Name Creek	Fairbanks	5,000	2,550
Nellie Juan Lake	Seward	40,000	21,000
Snow River	Seward	60,000	31,900
Anita and Kunk Lakes	Petersburg/Wrangell	8,000	3,830
Cascade Creek II	Petersburg/Wrangell	36,000	17,900
Snettisham Expansion II	Juneau	---	18,607

The remaining 22 projects were grouped according to the number of experts who believed development would occur before the year 2000, then further ranked based on the comments of the experts. The results of these rankings, along with a sampling of their comments, are shown in Table 5-2. (A number of additional hydroelectric sites were identified by three of the experts participating in the screening process as potential development sites before year 2000. Those projects are listed in Table 5-3).

The hydroelectric projects listed in Tables 5-2 and 5-3 are shown on the map in Figure 5-1.

CURRENT PLANS FOR DEVELOPMENT

The State of Alaska has been involved in the development of hydroelectric projects through its Water Resources Revolving Loan Fund (WRRLF) since fiscal year 1977. The first loan ($450,000) was approved in October 1976, for feasibility investigations and to prepare the documentation required for Federal Power Commission (FPC) licensing for the Green Lake Project near Sitka. Recently, the Legislature approved an additional $1.6 million loan for the initial engineering design and construction of the Green Lake project during fiscal year 1978. Additional loan applications are pending for:

Petersburg ($900,000), for the expansion and repair of the Blind Slough Project.

Juneau ($500,000), to upgrade and automate their electrical distribution system.

Ketchikan ($420,000), for feasibility investigations and FPC licensing documentation for Upper Mahoney Lake, Swan Lake and Grace Lake, with major interest in Swan Lake.

Kodiak ($420,000), for Terror Lake.

Petersburg and Wrangell ($420,000), for a feasibility study of the possibility of using some lakes (Sunrise, Virginia and Thomas ~~Bay~~) between the two communities and constructing a power intertie.

Table 5-2
HYDROELECTRIC SITES SCREENING

	Project (Location) Region	Yes	(MW)	Earliest & Latest Estimate Decade for Development	Excerpts from Comments by Experts
1.	Bradley Lake (Kenai) Southcentral	5	125	1980-2000	"Could be exclusively for Kenai or interconnection with Anchorage."
2.	Watana (Susitna) Southcentral	5	792	1980-2000	"Only apparent single project on the Susitna River which is economically feasible by itself."
3.	Devil's Canyon (Susitna) Southcentral	5	726	1980-2000	"Economically feasible only in conjunction with other upstream development.
4.	Solomon Gulch (Valdez) Southcentral	4	12	1980-1990	"One of the better sites in Valdez area" "Awaiting FPC Liscense"
5.	Lake Grace (Ketchikan) Southeastern	4	20	1970-1990	"Ketchikan load growth may require this expensive project."
6.	Green Lake (Sitka) Southeastern	4	14	1980-2000	"Insufficient demand." "Green Lake should supply Sitka power needs to year 2000."
7.	Snettisham Expansion I (Juneau) Southeastern	4	27	1980-2000	"Future increase in fuel may make electric heat viable and require accelerated construction." "Not if Capital moved."
8.	Purple Lake Rehabilitation (Metlakatla) Southeastern	4	14	1970-1990	"Insignificant amount of energy."
9.	Goat Lake (Skagway) Southeastern	3	9	1980	"Best alternative for Skagway." "Only alternative to thermal, but demand may be insufficient."
10.	Terror Lake (Kodiak) Southcentral	3	20	1980-1990	"The only apparent alternative in Kodiak to high cost thermal generation."
11.	Hassler Lake Southeastern	3	4	1980-2000	"Construction should follow closely after completion of Chester Lake."

Table 5-2 (Continued)
HYDROELECTRIC SITES SCREENING

	Project (Location) Region	Yes	(MW)	Earliest & Latest Estimate Decade for Development	Excerpts from Comments by Experts
12.	Swan Lake (Ketchikan) Southeastern		15	1980-1990	"Load growth may require this expensive project."
13.	Upper Mahoney Lake (Ketchikan) Southeastern	3	2	1980-2000	"Perfectly valid project, but not as attractive as Swan and Grace."
14.	Takatz Lake (Sitka) Southeastern	3	20	1990-2000	"Perhaps following Green Lake."
15.	Cascade Creek I Petersburg-Wrangell) Southeastern	3	15	1990-2000	"Actually believe Cascade Creek will be developed in single stage."
16.	Virginia Lake (Petersburg-Wrangell) Southeastern	3	6	1980-2000	"Seriously question merit." "If damand dictates."
17.	Sunrise Lake (Petersburg-Wrangell) Southeastern	3	4	1980	"Presently being considered."
18.	Lake Elva (Dillingham) Southwestern	2	2.5	1980	"Question economics" "Expensive, but the only alternative to diesel."
19.	Kisaralik River (Bethel) Southwestern	2	36	1980	"May be good project to replace thermal in Bethel area." "Question econimics."
20.	Unnamed Lake (Haines) Southeastern	2	9	1980	"The only alternative to thermal in the area, but demand may be insufficient."
21.	Crystal Lake Expansion (Petersburg-Wrangell) Southeastern	2	2.5	1980-1990	"Presently being considered." "Petersburg has rejected the proposed expansion of Crystal Lake."
22.	Power Creek (Cordova) Southcentral	2	12	1980-1990	"Difficult slope stability problems."

Table 5-3
ADDITIONAL HYDROELECTRIC SITES IDENTIFIED BY EXPERTS

	Project	(MW)	Timing	Comments*
23.	Chester Lake (Annette Island)	**	1970's	Definite project report nearly completed
24.	Black Bear Lake (Prince of Wales Is.)	**	1980's	Preliminary appraisal scheduled 1977. To serve Klawock, Craig, Hydaburg.
25.	Reynolds Creek (Prince of Wales)	11	1990's	Preliminary appraisal scheduled 1977.
26.	Tazimina River (Southwest)	51	1980's	Preliminary appraisal scheduled 1977.
27.	Chackachama (Southcentral)	366	1990's	Would follow Susitna development.
28.	Crescent Lake (west of Cook Inlet)	41	1990's	Could tie in with Chackachama location.
29.	Mineral Creek (Valdez)	**	1990's	Could follow Solomon Gulch. To serve Valdez.
30.	Goat Creek (Petersburg-Wrangell)	20	1980's	Could fill long range energy growth for Petersburg-Wrangell area.
31.	Crescent Lake (Seward)	6	1980's	Energy for Seward maybe, however, lake is being used for recreation. May conflict.
32.	Grant Lake (Seward)	**	1980's	To serve Seward.
33.	West Creek (Skagway)	21	1980's	To serve Skagway.

*One expert reports a strong indication that either Wood Canyon, Yukon-Tiaya or Woodchopper will be needed and justified by the year 2000. Another suggests Lowe River could be a small run-of-the-river project.

**Projects are small - about 2.5 to 10 megawatts.

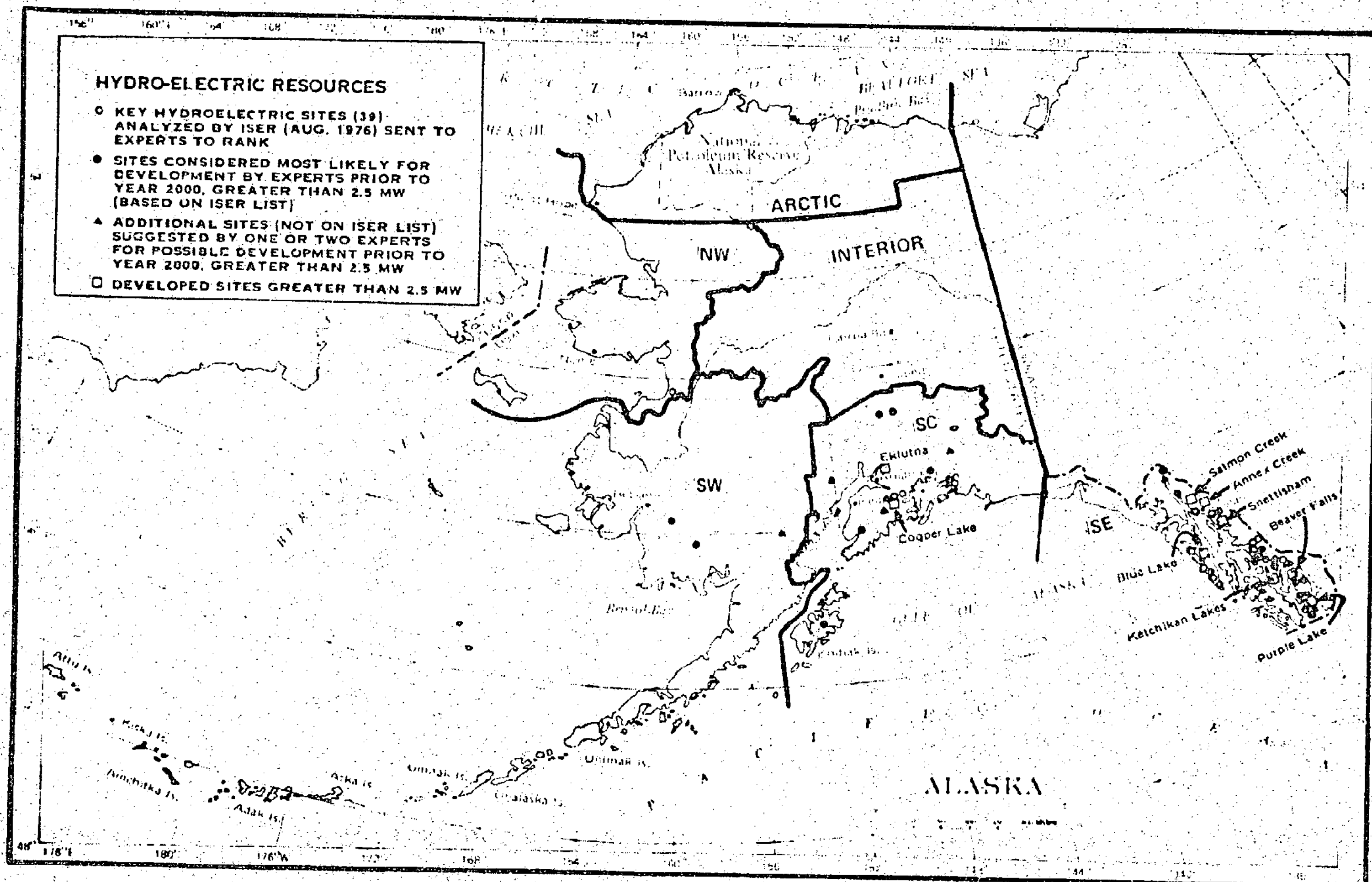


Figure 5-1 · Hydro-Electric Resources

State of Alaska, Division of Energy & Power Development, 1977.

The State of Alaska is also very interested in the hydroelectric potential of the Susitna River. The Federal Water Resource Development Act gives the Army Corps of Engineers statutory authority to study the feasibility of the Susitna Project up to $25 million. A unique section of the Act allows State financing of the project, although the Corps does the work.

There are several concepts for the Susitna Hydroelectric Project. The Corps of Engineers concept has two stages. The first stage requires the construction of an 810-ft. earth-fill dam near Watana Creek about 46 miles upstream from the Gold Creek station of the Alaska Railroad. Installed capacity would be 792 megawatts. The second stage would consist of a 635 foot concrete thin-arch dam at Devil Canyon, 15 miles upstream from Gold Creek. The installed capacity would be 776 MW, thereby giving a total installed-megawatt capacity of 1,568 MW. The power would be transmitted to Anchorage using a 345 KV double circuit line and to Fairbanks via a 230 KV single circuit line.

The Kaiser concept of the Susitna Project involves three stages. The first is an 800-ft. concrete faced, rock-filled dam about 20 miles upsteam from Gold Creek. Installed capacity would be 700 MW. The second stage would consist of an 185-ft. rock fill dam near Portage Creek, 12 miles upstream from Gold Creek, with an installed capacity of 163 MW. The final stage would involve construction of a 600-ft. rock-filled dam below Vee Canyon, about 65 miles above Gold Creek. The installed capacity of stage three would be 445 MW, yielding a total capacity for this concept of 1,308 MW. Power would be transmitted to Anchorage via a 230 KV double circuit line and to Fairbanks via a 230 KV single circuit line.

A third proposal, offered by the Harza Engineering Company, involves four stages - the initial (Watana) stage would yield an installed capacity of 500 MW. The second, Devil Canyon, phase would have 600 MW of installed capacity. The third stage - Vee, Denali - would add installed capacity of 400 MW to the project. The fourth or "ultimate" stage would double the total initial installed capacity to 3,000 MW. According to Harza Vice President Richard Harza, the project "should be of a size compatible with the anticipated growth and the repayment capacity of the Railbelt utility companies. No dependence should be placed on special loads".

In terms of its size and cost, and of its effects on the most heavily populated part of Alaska, the Susitna Project is extremely important. On June 16, 1977, the Alaska Power Authority (APA) agreed to award $100,000 to the Corps of Engineers for a "Plan of Study" and to fund jointly with the Division of Energy and Power Development, an analysis of energy economics in the Railbelt corridor along the Alaska Railroad right-of-way between Anchorage and Fairbanks, at a total budget not to exceed $70,000.

APPLICABLE TECHNOLOGY

The era of great dams was initiated in 1936 with the construction of the Hoover Dam. It represented a bold concept challenging advanced technology available at the time. It was 20 years before any higher dams were completed. Leadership shifted to Switzerland, then to Italy, Canada, India and to Colombia. Today, 40 years later, still higher dams are under construction in the Soviet Union and Mexico (Ref. 5-3).

Leadership in the construction of unusually large and important dams moves from country to country, with no claim for the monopoly in technology by any one country. Dam technology has also advanced with regard to materials and type of dam. In the earlier structures, materials locally available were placed by hand or horse-drawn scrapers. Later, as mechanized draglines and bulldozers appeared on the scene, larger and larger quantities were used. The engineers involved in the Hoover Dam solved the technical problems associated with the use of mass concrete. The rise in the cost of cement and labor soon resulted in the decline in popularity of massive gravity concrete structures but concrete remains the ideal material for thin arch dams (Fig. 5-2).

Outside of Alaska, dams are now smaller, on the average, with 77% being between 15-30 meters high, 21% being 30-100 meters high, and only 2% above 100 meters. Of the dams being built, more than half are for water conservation and supply, and 20% for municipal water supply. Only 5% are for hydroelectric and pump storage schemes. While there is a downward trend in dam building in the United States as a whole, it is quite possible that in Alaska the trend will be just the opposite. As shown in the screening of hydroelectric sites, it was noted that the experts felt that over 20 hydroelectric sites might be built for electrical energy generation in Alaska between now and year 2000.

In the United States, approximately 100 new dams are being constructed annually. Of these, 98% are of the earth and rock-fill embankment types (see Figure 5-3). Only 2% of the dams are constructed with concrete. However, in Alaska there is a special interest in the possible design of a thin arch concrete dam for the Susitna Project. The major advantage of thinness is the economy, resulting from the reduced quantity of concrete needed (Figure 5-4).

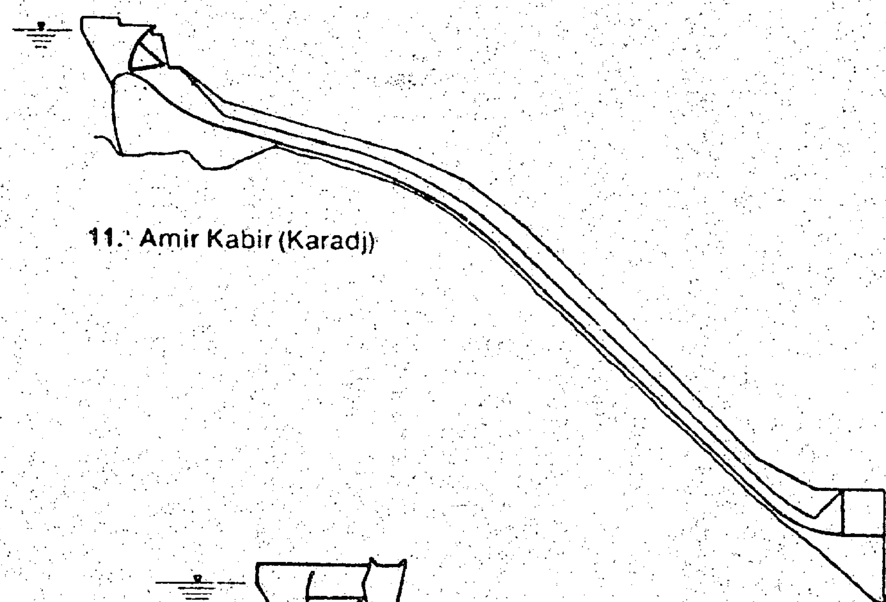
The first prestressed, arched dam in the United States was built at Nambe Falls, located in the New Mexico highlands approximately 25 miles north of the capital city of Santa Fe; the structure uses technology of possible interest to Alaska.

A unique method of prestressing the arch dam to reduce the tensile stresses involved embedding flatjacks (manufactured by Freyssinet Company, France) within the mass of the dam and inflating them (400 lbs./sq. in.) to obtain the required prestress loading. The final design configuration was an arch dam with a thin, double curvature structure. (Ref. 5-4)

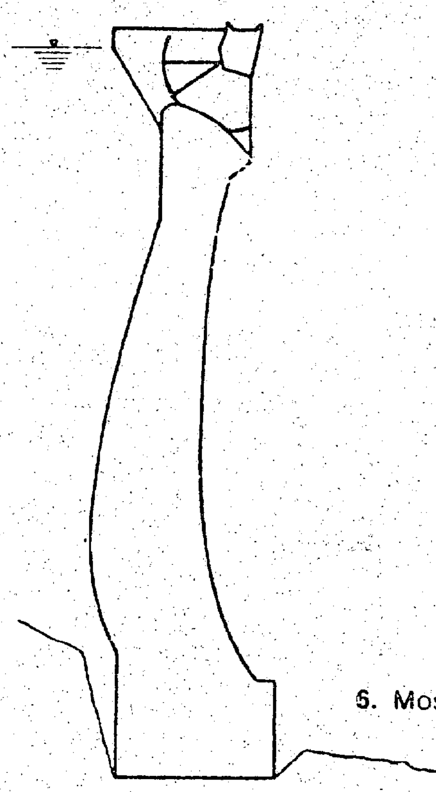
Once water is stored behind a dam it can be released at controlled intervals through conduits called penstocks or power intakes. The conduits direct the stored water to turbines where the force exerted by the water on the turbine blades drives the turbines, which in turn drive generators to product electricity. So, a hydroelectric project harnesses the potential energy of a river's gravitational fall.

Today's technology is adequate for projects now under consideration in Alaska and any likely near-future technological breakthrough would involve only minor refinement of existing technology.

A very serious problem has been encountered with respect to the transmission of electrical power in Alaska. Transmission lines for the Snettisham project near Juneau were originally constructed on Salsbury Ridge. Winds in excess of 200 mph have been recorded on the Ridge; also, heavy icing was a severe problem.



11. Amir Kabir (Karadj)



5. Mossyrock

Figure 5-2 Concrete Arch Dams and Spillways

Source: Harza Engineering Company

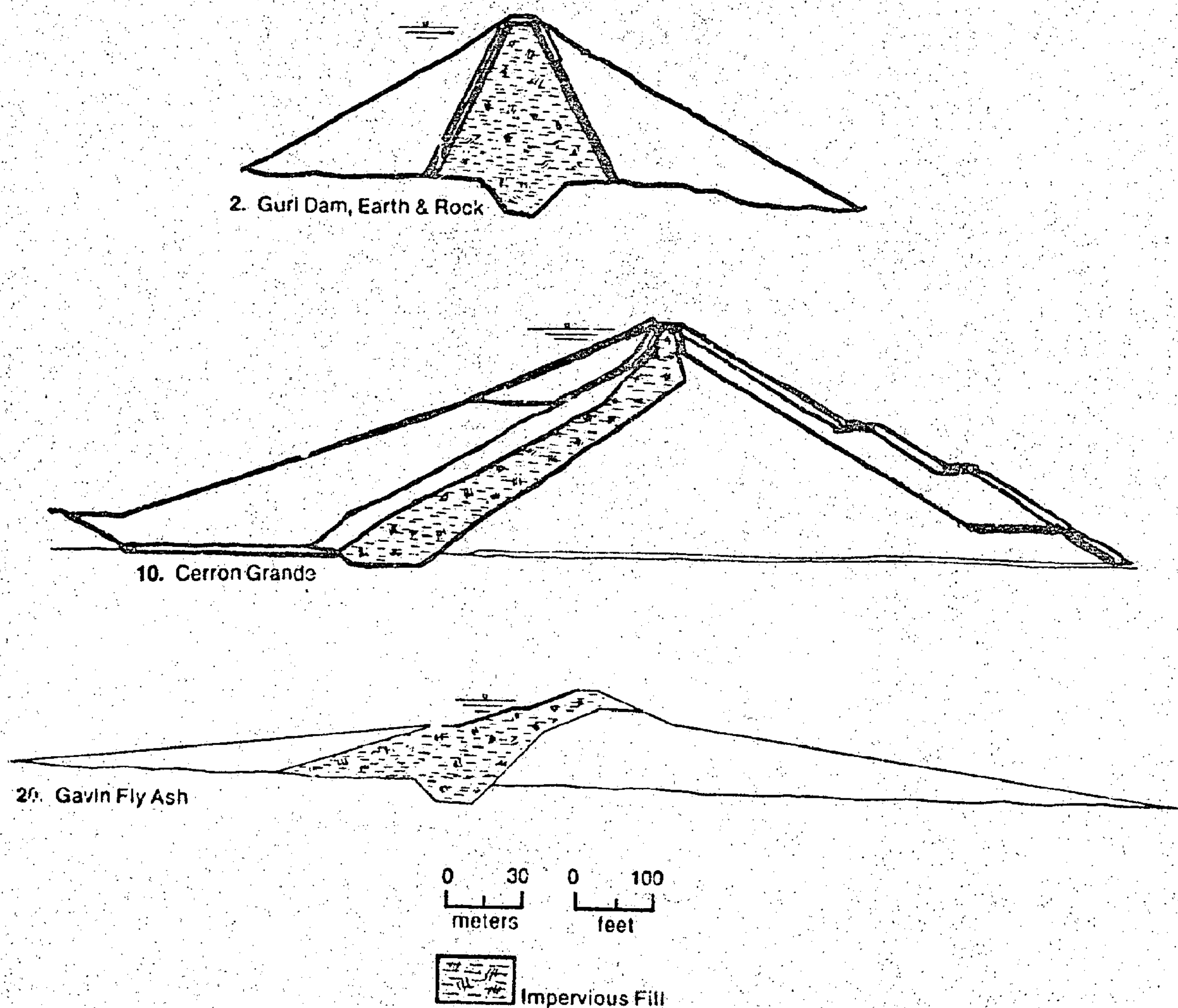


Figure 5-3 Fill Dams

Source: Earthfill and Rockfill Dams, Harza Engineering Company

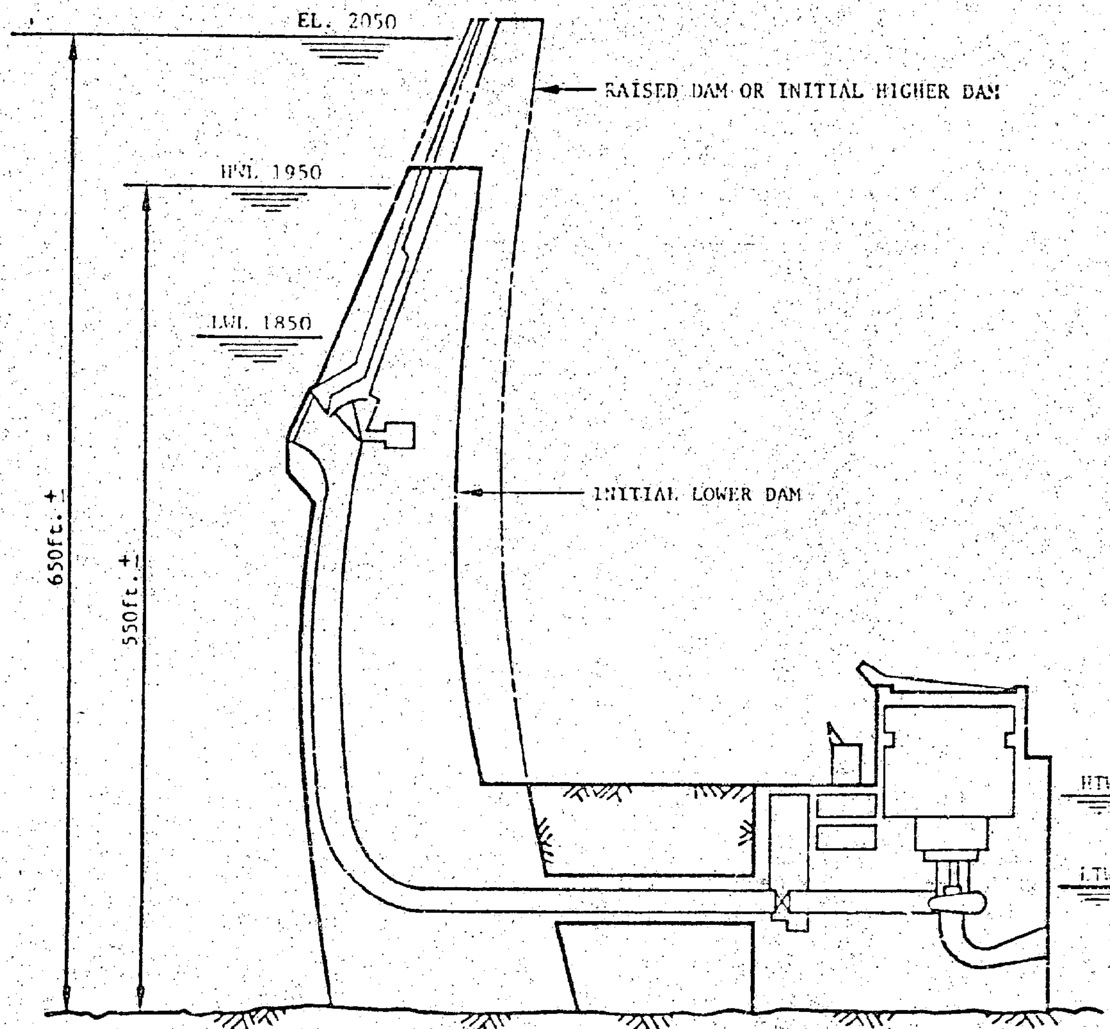


Figure 5-4 Watana Project State Development Concrete Arch Dam

Source: Harza Engineering Company

Even before the lines were completed the towers on the Ridge suffered wind damage and then, shortly after they came on line, three towers collapsed. Juneau was forced to rely on other energy sources from February 1974 to September 1974. The situation was so severe that it was necessary to relocate the transmission lines to a lower elevation.

Even with the relocation, problems are still significant. On April 7, 1976, power was interrupted again and inspection revealed that an avalanche had toppled a tower about 5 miles from the power plant. While the Salsbury Ridge problem was basically an engineering design error, not an inadequacy of current technology, it should be noted that electrical transmission of energy in Alaska requires special attention.

Advances in transmission technology represent a key element in the possible development of major Alaskan hydroelectric power. It has been proposed by responsible scientists, for example, that it may be possible to transmit power over long distances by use of satellite. If, indeed, this form of transmission does become technologically feasible it could solve in-State transmission problems and perhaps make Alaska a major electricity exporter. However, satellite transmission technology is far beyond use in Alaska during this century, the time period of this report.

There is another method by which hydroelectric energy can be transmitted, namely in the form of an industrial, finished product, for example, aluminum. As the availability of electricity becomes increasingly scarce in the Lower 48, energy intensive industries are expected to examine the possibility of using Alaska hydroelectric resources in the near future.

COST ISSUES

Many years ago dams were built throughout the Tennessee Valley for flood control, financed to a great extent by federal government funding. The electrical energy generated and recreation values were considered by-products. As a result, the Tennessee Valley residents enjoyed very low hydroelectric costs. Other watersheds, such as the Columbia River Basin, also enjoyed low government interest rates and multiple use (i.e., irrigation, flood control, etc.), and again hydroelectric energy was considered "cheap" energy and indeed to the consumer - the farmer, the industrialist, the homeowner - the electrical power bills were very low.

If a dam is built today for hydropower only, the cost of the energy will be very high even though the "fuel" is "free" and operating costs are reasonable. The front end capital costs are extremely large.

As for cost estimates for future hydroelectric sites in Alaska - both small and large - one thing is certain: namely, a lack of agreement on published cost estimates. The hydroelectric costs in Table 5-1 are from a recent publication Electric Power in Alaska 1975-1995, published in August 1976; however, the Alaska Power Administration and others sharply disagree with some of these published estimates. Perhaps the only conclusion is to be very skeptical of hydroelectric cost estimates.

Nevertheless a recent tabulation has been made of estimated Alaskan hydroelectric project costs for ten projects which are given in Table 5-4. Note that the estimates range from 21.1 to 42.0 mills per kilowatt hour for Upper Susitna and the estimates for the nine smaller hydro projects range from 35 mills to over 100 mills per kilowatt hour.

In summary, there are three major costs associated with electrical energy production in general: (1) fixed costs resulting from capital outlay; (2) operation and maintenance costs; and (3) fuel costs. For hydroelectric projects, fuel costs are zero, operation and maintenance costs are low, but the capital outlay costs are very great.

FURTHER INFORMATION NEEDS

Hydroelectric power represents a major alternative to oil and gas as an energy source. Although hydroelectric power does not represent a potential Alaska energy export to the rest of the United States at this time, increased availability and use of hydroelectric power in Alaska can assist the rest of the nation in meeting energy substitution goals.

Additional information is needed in several areas for the hydropower option:

1. To what extent can hydroelectric energy replace the present and projected energy use of natural gas, oil and coal? Significant examples include energy pumps for oil pipelines and gas pipelines, the wood products industry, and the petrochemical industry. Also, more information is needed in the potential of hydroelectric energy for transportation use and electric heat.

2. To what degree can the Alaska use of hydropower for major energy-intensive industries lessen the energy crunch in the Lower 48?

3. Upper Susitna is in a class by itself--a very large new source of hydro energy. The State and the Congress of the United States have determined that the project has sufficient merit to proceed with detailed design, engineering, and environmental studies. The informational need is to pursue the detailed studies, including all factors that bear on the decision, and decide in three or four years whether or not to construct the project.

4. An inventory is needed of potential hydroelectric power sites selection on the basis of community needs and opportunities. This listing should include ~~small~~ (10 to 2,500 kilowatt) hydro sites, small hydro sites with exceptionally high-head, and low-head hydro sites.

5. Site specific information is needed for selected projects that have a good chance for construction. Land tenure, environmental concerns, applicable technology and regulatory problems should be addressed.

6. How applicable are small hydroelectric units for Alaskan use; are they technologically feasible? What special problems are presented by the widely varying cold climates?

RECENT ALASKAN HYDROELECTRIC PROJECT COST ANALYSIS

Project	Installed Capacity MW	Average Energy Million KWH	Interest Rate - %	Repayment Period-Years	Inflation Rate Assumed	Plant On Line Date	Total Cost $ Million	Price Base	$/KW	Rate Mills/KWH	Data Source and Remarks
Upper Susitna	1,568	6,800	6-5/8	50 yr (after each powerplant is built	none	1986 &1990	1,576	Jan 75	1,005	21.1	Southcentral Railbelt Area, Alaska Upper Susitna River Basin Interim Feasibility Report, Corps of Engineers, pages G-83&88. Costs include transmission to Anchorage and Fairbanks. Inflated costs are from Bradley Lake Power Market Analysis, Review Draft, August 1977, Alaska Power Administration.
			7.0		5%		2,736	1986 &1990		42.0	
(Note: From Corps of Engineers Plan of Study dated September 28, 1977, total project is estimated at $2.1 billion, September 1977 price base.)											
Bradley Lake Near Homer (Two Plans)	70	307	6-5/8	50 yr	none	1985	137	Jan 75	1,957	35.0	Bradley Lake Project Power Market Analysis, Review Draft August 1977, Alaska Power Administration pages 1, 46, & 47. The 70 MW plan includes transmission costs to Kenai & Homer. The 118 MW plan has additional costs for the larger powerplant and additional transmission to Anchorage.
			(7.0)	50 yr	(5%)					(49.7)	
	118	311	6-5/8	50 yr	none		170	Jan 75	1,508	44.5	
			(7.0)	50 yr	(5%)					(63.2)	
(Note: Corps of Engineers cost estimate for a revised Bradley Lake plan is now being prepared.)											
Green Lake Near Sitka	16.5	64.9	5.0	50 yr less 4 yr construction period	7% To Jan 79	1981	38.6	Jan 77	2,338	47.6	Green Lake Evaluation Report, June 1977, R. W. Beck & Associates. Costs include transmission to Blue Lake and upgrading the line between Blue Lake and Sitka.
Thomas Bay, Near Petersburg Initial Phase	20.2	70.8	5.0	40 yr	*	1983	75.8	Jan 80	3,754		Thomas Bay Project Appraisal Report, Nov. 1975, R. W. Beck & Associates. Cost include submarine and overhead transmission to Petersburg & Wrangell. *Inflation costs assumed to vary from 12% to 7% between 1975 and 1980.
(Note: Capacity of second phase development would be more economical than first phase.)											
Virginia Lake Near Wrangell	12.0	44.0	5.0	50 yr	7%	1983	57.0	Jan 77	4,749	92.3	Virginia Lake Project Appraisal Report, Aug. 1977, R. W. Beck & Associates. Costs includes 44 miles of overhead and underwater transmission to Petersburg and Wrangell.
Anita & Kunk Near Wrangell	8.6	28.7	5.0	50 yr	7%	1983	49.1	Jan 77	5,710	123.8	Virginia Lake Project Appraisal Report, Aug. 1977, R. W. Beck & Associates. Includes 54.4 miles of overhead and underwater transmission to interconnect the two power houses and Petersburg and Wrangell.
Sunrise Lake	4.0	13.5	5.0	50 yr	7%	1983	22.7	Jan 77	5,665	118.9	Virginia Lake Project Appraisal Report, Aug. 1977, R. W. Beck & Associates. Includes 46.3 miles of overhead and underwater transmission to interconnect Petersburg and Wrangell.
Mahoney Lake Near Ketchikan	10.0	49.7	5.0	50 yr	7%	1983	31.3	Jan 77	3,130	45.0	Swan Lake, Lake Grace, and Mahoney Lake Hydroelectric Appraisal Report, June 1977, R. W. Beck & Associates. Includes transmission to Ketchikan.
Lake Grace Near Ketchikan	26.7	105.2	5.0	50 yr	7%	1983	83.7	Jan 77	3,135	57.0	Swan Lake, Lake Grace, and Mahoney Lake Hydroelectric Appraisal Report, June 1977, R. W. Beck & Associates. Includes transmission to Ketchikan.
Swan Lake Near Ketchikan	22.0	88.0	5.0	50 yr	7%	1983	64.4	Jan 77	2,927	53.0	Swan Lake, Lake Grace, and Mahoney Lake Hydroelectric Appraisal Report, June 1977, R. W. Beck & Associates. Includes transmission to Ketchikan.

ource: Letter from Robert Cross, Department of Energy, Alaska Power Administration to Gene Rutledge, Division of Energy and Power Development (October 31, 1977).

7. A compilation of hydropower costs, including a cost comparison with other energy options for applicable communities would be desirable. Usually the smaller and more remote the community, the more costly the energy.

8. More information is required on the interface between small hydroelectric units and diesel systems.

9. When will technology involving transmission of electricity by satellite be available for use in Alaska?

10. What are the engineering feasibility and costs of tidal power projects for Southcentral Alaska (follow-up to the 1977 Stone and Webster study and other recent work on the harnessing of Alaska's tides)? Tidal power could contribute to a mix of power-generating sources for the Railbelt, an area projected to have the greatest population growth through the year 2000.

11. More information is needed concerning the water content of the snow in various Alaskan watersheds. The applicability of telemetered profiling isotopic snow gauges should be examined.

REFERENCES

5-1 Electric Power in Alaska, 1976-1996, Institute of Social and Economic Research, University of Alaska. August 1976.

5-2 Alaska Power Survey, Report of the Executive Advisory Committee to the Federal Power Commission, December 1974.

5-3 Water Power and Dam Construction, February, 1976. p. 17.

5-4 "First Prestressed Arch Dam in the United States", Water Power and Dam Construction, J. Legas, Feb. 1976. p. 21.

HYDROELECTRIC
KEY CONTACTS

Archie A. Stone
Executive Vice President
Engineering
International Engineering Company, Inc.
220 Montgomery Street
San Francisco, CA 94104
(415) 544-1401

Philip Perdichizzi
Vice President
TAMS
2000 Port Road
Anchorage, Alaska 99501
(907) 274-6619

Thomas F. Broady, Jr.
Consulting Associate
Robert W. Retherford Assoc.
Consulting Engineers
P.O. Box 6410
Anchorage, Alaska 99502
(907) 344-2585

J. I. Mills
Engineering Specialist
EG&G
P.O. Box 1625
Idaho Falls, Idaho 83401
(208) 522-4400, ext. 362

Jesse L. Colbert
Area Hydraulic Engineer
U.S. Geological Survey
Conservation Division
P.O. Box 2967
Portland, Oregon 97208
(503) 234-4796

Robert J. Cross
Chief
Project Development Division
Alaska Power Administration
P.O. Box 50
Juneau, Alaska 99802
(907) 586-7405

Eric Yould
Hydraulic Engineer
U.S. Army Corps of Engineers
Alaska District
P.O. Box 7002
Anchorage, Alaska 99510
(907) 752-3224

Col. George R. Robertson
Distric Engineer
U.S. Army Corps of Engineers
Alaska District
P.O. Box 7002
Anchorage, Alaska 99510
(907) 752-2605/279-1132

Dale W. Rusnell
Chief
Power Development
Division of Energy & Power Dev.
7th Floor, Mackay Building
338 Denali
Anchorage, Alaska 99501
(907) 276-0508

LtC. Vernelle T. Smith
Deputy District Engineer
U.S. Army Corps of Engineers
Alaska District
P.O. Box 7002
Anchorage, Alaska 99510
(907) 752-5233/279-1132

URANIUM

RECOVERABLE RESOURCE SITES

To date, there has been only one uranium deposit rich enough to mine discovered in Alaska. This mine was located 35 miles southwest of Ketchikan near Bokan Mountain on Prince of Wales Island. The mine produced approximately 1,000 tons of U_3O_8 (yellowcake) between 1957 and 1971. For more information on the history of production of uranium in Alaska, refer to Volume 2, Uranium Resources Inventory.

About 20 sedimentary basins in Alaska have been identified as having uranium potential, but information on actual uranium concentrations in these basins is very scarce. Evaluation of recoverable uranium sites consists primarily of estimating where, among the potential uranium sites, discoveries of economically recoverable ore are most likely to occur. These estimates are complicated somewhat by the definition of "economically recoverable". The Bokan Mountain deposit was small, but was high grade enough to justify shipping the raw ore to the Lower 48 for processing. Such a find, however, is relatively unusual. More commonly, uranium is found in much lower concentrations, but in sufficient quantity to build concentrating facilities nearby. Transportation problems in Alaska are complicated by the almost complete lack of any transportation infrastructure in many of the more inland remote areas. A discovery may have to be very large to justify the substantial capital expenditures required to remove and concentrate the ore.

Ranking/predicting uranium sites where ore production could occur before year 2000 was done with the assistance of several experts:

Warren I. Finch, Chief
Branch of Uranium and Thorium Resources
Geological Survey
U.S. Department of the Interior
Denver, Colorado

William D. Collins
Chief Geologist
Wyoming Mineral Corporation
3900 So. Wadsworth
Lakewood, Colo. 80235

DGGS Staff
Alaska State Division of Geological
and Geophysical Surveys
P.O. Box 80007
College, Alaska 99701

Charles C. Hawley
C. C. Hawley and Associates, Inc.
Anchorage, Alaska

Robert B. Forbes
Senior Geological Consultant
Geophysical Institute
University of Alaska
Fairbanks, Alaska

The results of the predictions are given in Table 5-5 and Figure 5-5. While comments are shown in the table on a site by site basis, a number of interesting general comments are given below:

> "The best thing you could do would be to state that Alaska's uranium potential is not determined, and cannot be determined unless prospecting activity continues on most of Alaska's land."

> "The ranking of such provinces has to be a somewhat arbitrary and subjective process. My decisions are all based on 30 years of

experience in Alaska geology, including field work in many of the areas on the list."

"The Geological Survey deals with assessment of quantities and quality (grade) of uranium resources that might be discovered in a given region. We are knowledgeable about geologic factors related with undiscovered uranium resources. Your survey questionnaire has only two questions, and they are about the production capability of the named region, i.e., ranking of the most probable order of production and estimating when production is most likely to take place. These two things do not depend solely on geologic factors..."

"Of the 12 areas listed, Bokan Mountain is the most favorable for finding uranium ore, and the Seward Peninsula is second. The sedimentary features of Cook Inlet Basin lack some important aspects to make it a favorable region for uranium exploration, whereas Copper River Basin seems more favorable. The other regions are too poorly known to me to make any judgments."

The consensus was that the Southeastern area, expecially Bokan Mountain and other dikes, plutons and mineralized wall rocks on Prince of Wales Island, appeared to be the most likely location for a recoverable uranium discovery in the immediate future. Only three of the experts were willing to estimate how soon recovery would occur in any of the sites, but all were in substantial agreement that uranium recovery was likely to occur in that area during the 1980's.

The second area considered most promising by the experts questioned was the Seward Peninsula. Exploration teams have discovered radioactive anomalies on the Peninsula. However, no actual discovery of commercial grade has been announced. The three experts willing to estimate the time period during which uranium recovery might begin on the Seward Peninsula were in some disagreement. Two suggested as early as the 1980-85 period, while the other thought that the early 1990's might be more probable.

The third area rated highly by the experts, and very close to the Seward Peninsula, was the Selawik area. The exploration situation there is similar to that on the Seward Peninsula, with discoveries of anomalously radioactive rocks but no actual ore-grade deposits known as yet. The three experts who set time periods for development suggested that it might occur in the mid-to-late 1990's. Experts' comments were virtually identical to those on the Seward Peninsula, and the two areas were frequently lumped together.

Areas beyond the three considered most likely for development were viewed quite differently by various experts. The Cook Inlet area, especially near Beluga Lake, has received considerable attention from Wyoming Minerals Company, a subsidiary of Westinghouse, which have been drilling in the area. One expert ranked this area as the third most likely to be developed, two others as seventh and ninth most likely. Interior Lowlands was also ranked third by one expert.

Two of the experts suggested other areas not listed on the original screening list: namely, Zane Hills, Yukon-Porcupine, and the Alaska Range. While these three areas were not ranked higher than the top three just discussed, they were considerably higher than the lower seven sites.

Table 5-5
URANIUM SITE RANKING

Uranium Site (Region)	Timing	Excerpts from Comments by Experts
1) SOUTHEAST ALASKA Including Bokan Mtn. (Southeast)	1980 - 2000+	"Proximity to a known deposit and favorable geology at several localities seem to offer good possibilities for small deposits similar to Bokan Mountain." "Exploration is in very early stages, whether or not any production will ensue is very problematical." Bokan: "Only uranium production in Alaska--exploration is continuing; good chance for another small mine in near future." "Intermittent small production (a few thousand tons) by leasers and and small operators." "New U reserve reportedly discovered during 1977 by underground drilling in the Ross-Adams Mine at Bokan Mtn. by Standard Metals. Details not available."
2) SEWARD (Northwest)	1980 - 1992	"A lot of exploration still to be done; whether or not deposits will be operated depends on grades of ore found." "A number of granitic bodies are abnormally radioactive, suggesting a uranium province."
3) SELAWIK (Northwest)	1990 - 2000	"Favorable geology and radioactive anomalies are widespread in granites but no significant discoveries yet." "A lot of exploration still to be done; whether or not deposits will be operated depends on grades of ore found."
4) COOK INLET (Southcentral)	1985 - 1997	"Basin has favorable rock types, but no uranium has been encountered in the region; ERDA report due soon." "A lot of exploration still to be done."
5) INTERIOR LOWLANDS (Interior)	1985 - 2000+	"Including a very large portion of central Alaska; recent surveys by ERDA, USBM, and Industry greatly increases the outlook for this area." "Exploration is in very early stages; whether or not any production will ensue is very problematical." "See USBM open-file report 130-77 by James C. Barker and Karen Clautice Anomalous Uranium Concentrations in Artisian Springs and Stream Sediments in the Mount Prindle Area, AK. (caused a staking rush in September 1977); big claim staking during 1977 in Melozitna quadrangle for U, especially around Kokrine Hills."

Table 5-5 (Continued)
URANIUM SITE RANKING

Uranium Site (Region)	Timing	Excerpts from Comments by Experts
6) ZANE HILLS (Interior)	1990 - 1995	Site added to original screening list by one expert.
7) YUKON-FLATS (Interior)	1985 - 2000+	"Unexplored, but possibility for sedimentary uranium deposits considered fair to poor." "Exploration is in very early stages; whether or not any production will ensue is very problematical." Yukon- Porcupine added to list by two experts.
8) ALASKA RANGE (Interior)	1990 - 1995	Site added to original screening list by two experts. "Uranium assays from the Purkeypile prospect in the eastern Alaska Range among the best reported in Alaska."
9) ARCTIC SLOPE (Arctic)	1990 - 2000	"Little information, but some encouragement was reported by a cursory investigation by industry." "Exploration is in very early stages; whether or not any production will ensue is very problematical."
10) EAGLE (Interior)	1995 - 2000+	"Favorable rock types, but limited exploration has not been encouraging." "Exploration is in very early stages; whether or not any production will ensue is very problematical."
11) GULF COAST (Southcentral)	1990 - 2000+	"Geology fairly well known and suggest some potential, but drilling by petroleum companies has not produced any shows." "Exploration is in very early stages; whether or not any production will ensue is very problematical."
12) COPPER RIVER BASIN (Southcentral)	1990 - 2000+	"Investigations by the State Geological Survey and the University of Alaska (Geophysical Institute) under ERDA contracts, produced negative results." "Exploration is in very early stages; whether or not any production will ensue is very problematical."

Table 5-5
Uranium Site Ranking (Continued)

Uranium Site (Region)	Timing	Excerpts from Comments by Experts
13) BRISTOL BAY (Southwest)	1995 - 2000+	"No information; basins may have some potential for sedimentary uranium." "Exploration is in very early stages; whether or not any production will ensue is very problematical."
14) YUKON-KUSKOKWIM DELTA (Southwest)	1995 - 2000+	"Information not available and exploration would be difficult." "Exploration is in very early stages; whether or not any production will ensue is very problematical."

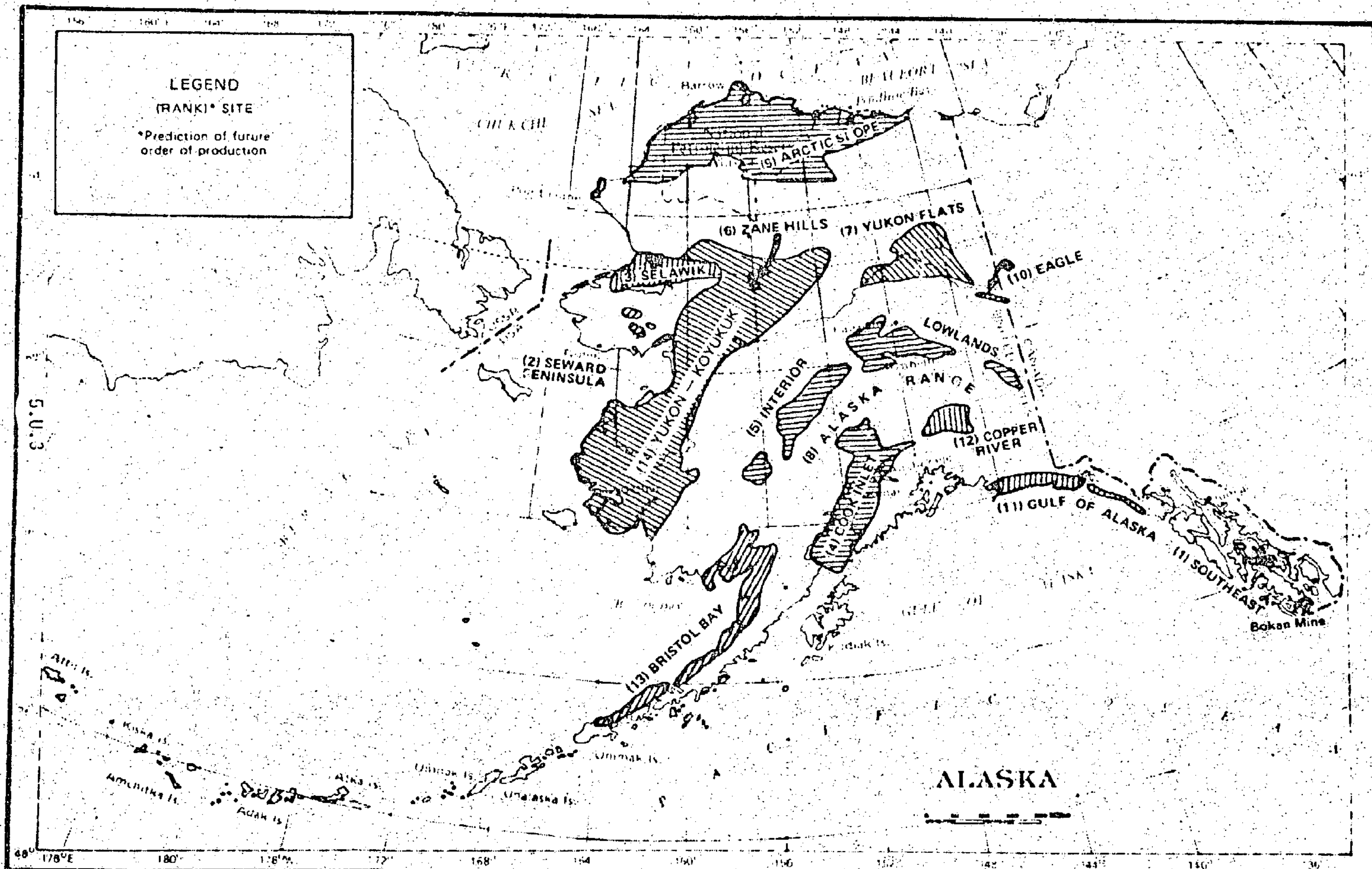


Figure 5-5 Uranium Sites Ranked by Experts

State of Alaska, Division of Energy & Power Development, 1977

CURRENT PLANS FOR DEVELOPMENT

The only known plans at present are for continued exploration. A substantial number of companies, including Portland General Electric, Union Carbide, Cotter Corp., Standard Metals, Exxon, Wyoming Minerals, and two German Firms, Urangesellschaft, USA Inc. and Uranerz, USA Inc. are known to be exploring in various sites in the State. Also, Research Associates of Alaska (Fairbanks) is conducting a drilling program in the Alaska Range, which includes uranium objectives.

Considerable interest in uranium has been noted by a number of the Alaska Native Corporations. In addition, ERDA (now DOE) has a major uranium province definition project underway in Alaska as part of the National Uranium Resource Evaluation (NURE). Bendix Corporation has the contract to manage the DOE program which includes Alaska and the Lower 48 Bendix contracts, airborne radiometric surveys, geologic and other studies as required. Los Alamos Laboratories has the mission to conduct hydrogeochemical surveys in the State. The University of Alaska Geophysical Institute has completed surface studies of anomalies uncovered in the Copper River Basin by the Texas Instruments surveys. A major milestone of the NURE program will be the publication of a comprehensive report in 1981. In the interim, updated uranium reserve and potential resource statistics will be published yearly. More information on the NURE program is given in Volume 2, Uranium Resources Inventory.

The U.S. Bureau of Mines discovery of anomalous radioactivity near Mt. Prindle in the Circle quadrangel last summer created a small uranium claim staking rush. Also, a number of claims were staked by various industrial groups in the Melozitna quadrangle during 1977 which suggests some uranium potential in this area.

The U.S. Geological Survey had three active projects dealing with uranium in 1977. These included detailed mapping and petrologic studies of the Bokan Mountain area in southeastern Alaska, a study of the tertiary rocks in the Cook Inlet and Copper River Basins in terms of their suitability for uranium deposits, and a reconnaissance study of potential hardrock uranium provinces in western Alaska. Work on these three projects will continue in 1978.

APPLICABLE TECHNOLOGY

The nuclear fuel cycle involves several complex steps (see Figure 5-6); however, only a few of these steps are of serious interest to Alaska.

Nuclear Power Plants in Alaska

While some interest has been expressed in a nuclear power plant reactor for commercial use in Alaska, it is unlikely that such a power plant would be in operation before the year 2000 because of the long lead time and the competition such a plant would get from hydro and coal energy. Alaska did have a nuclear power plant at Fort Greely; however, operations were discontinued March 13, 1972. This 20.2 megawatt (thermal) facility was fueled by highly enriched uranium oxide and water was used as both the moderator and coolant.

Nuclear Enrichment Plant

Approximately 1.85 billion years ago uranium in the earth's crust contained about 97% of the isotope U-238 and about 3% of the isotope U-235. With this relatively high proportion of the fissionable isotope U-235, it was possible for nature to have its own nuclear chain reaction. Recent discoveries by French scientists in Gabon, Africa, indicate that a nuclear chain reaction indeed occurred and lasted for over 100 000 years. Today, due to the difference in half-lives of the two uranium isotopes, radioactive decay has reduced the concentration of the isotope U-235 to only 0.7 percent an enrichment which is not adequate for commercial nuclear power plants that are currently designed in the United States. Present designs call for an enrichment of, interestingly enough, approximately 3 percent. (However, some early research and plutonium production reactors used 0.7 percent, i.e. natural uranium, for test reactors and other uses. Enrichments of 93 percent have been and now being used.)

In the early days of atomic energy development, three enrichment plants were constructed to supply military needs. Today, these three plants still exist, but are used primarily for the production of nuclear fuels for commercial power plants.

As it stands today, the capacity of all the enrichment plants in the United States has been sold. Future estimates indicate that a major expansion of enrichment facilities will be needed by mid-1980 to sustain growth in our nuclear power industry. Our three present plants are located near Oak Ridge, Tennessee; Paducah, Kentucky; and Portsmouth, Ohio. These plants use a process known as gaseous diffusion which, in simple terms, pumps a gas, UF_6, through a filter in order to achieve separation. The plants cost approximately a billion dollars each and require about 2,000 MW of power for the pumps.

Enrichment in Alaska

Some preliminary discussions were held concerning the possibility of an enrichment plant in Alaska since the diffusion process would require an enormous amount of energy and Alaska has abundant energy resources. Also the end product, enrichment uranium, can be easily transported with very little cost. However, a follow-up study was never concluded.

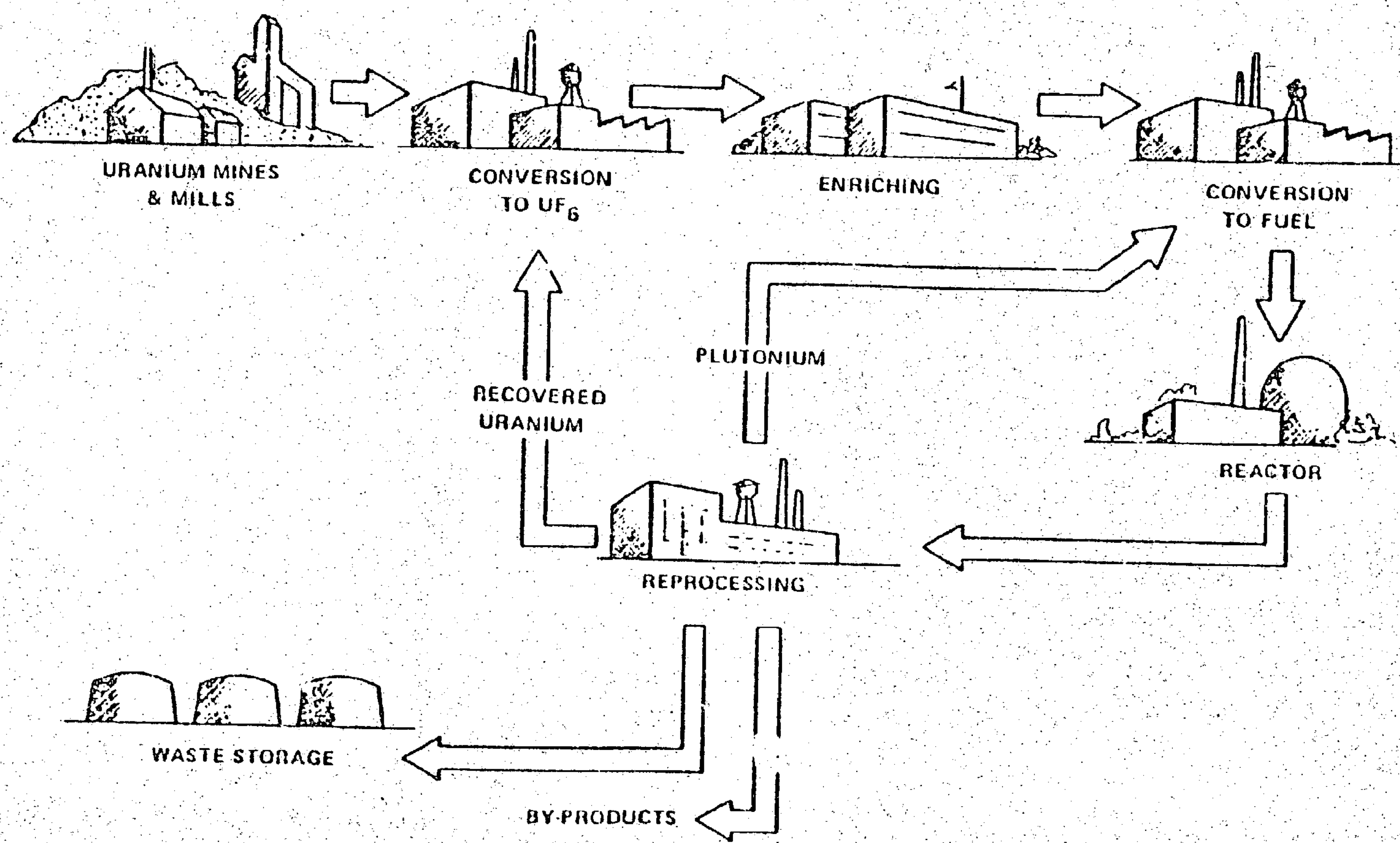


Figure 5-6 The Nuclear Fuel Cycle

Source: The Nuclear Industry, USAEC Report, Wash. 1174-73, p. 14, Dec. 1973.

Since the diffusion process is so energy intensive, a close look is being taken, on a national level, at the centrifuge process which requires much less energy. The centrifuge process utilizes the principle of the cream separator. Alaska has not addressed the problems and/or opportunities associated with a centrifuge plant in this state.

Solution Mining

Uranium ore has been mined in Alaska before and the potential for mining in the future is considerable. A technology that may be of special interest to Alaska is solution mining.

Most people associate the word "mining" with either large holes sunk into the ground or large excavations resulting in masses of waste rock around the mine site. Solution mining process involves neither of these.

The solution mining technique was developed to take advantage of extracting underground deposits that would be uneconomical to remove by conventional mining methods. Figure 5-7 shows a typical uranium roll front which exists in a sandstone layer of the earth's crust. A typical solution mining test pattern of injection and production wells might occupy a piece of ground no larger than an acre. Four-inch wells are sunk from 200 to 400 feet; three wells (injection wells) form a triangle with 40-foot sides. In addition, there is one centrally-located production well. Three wells around the perimeter of the test pattern serve as monitors for movement of the leaching reagents.

To start production, a solution of bicarbonates and hydrogen peroxide is injected at relatively low pressure into the upper sandstone layer. Because the mineralized zone consists of one-third void space and is open to flow, the body of water underground moves horizontally and the injected leach solution dissolves the uranium, which is pumped out of the production well. The pumping technique involves creation of an equilibrium pressure within the entire volume of the well field so that water does not leak into it; at the same time the dissolved uranium cannot leave the field. Thus, there is a hydraulic balance and the leaching solution is confined to the immediate area of the field. Flow rates are about 30 gallons per minute for small testing rigs to 800 gallons per minute for a production plant of medium size.

The leaching solution pumped from the ground is stripped of its uranium by chemical reaction in two ion exchange columns commonly used in the chemical processing industry. Tests indicate that at least 70 percent of the uranium is recovered. The solution is carried to a precipitation tank where the end product, yellowcake (ammonium diuranate), is separated chemically. The yellowcake is hauled off-site to a drying plant before shipment to fuel manufacturers for the remaining processes.

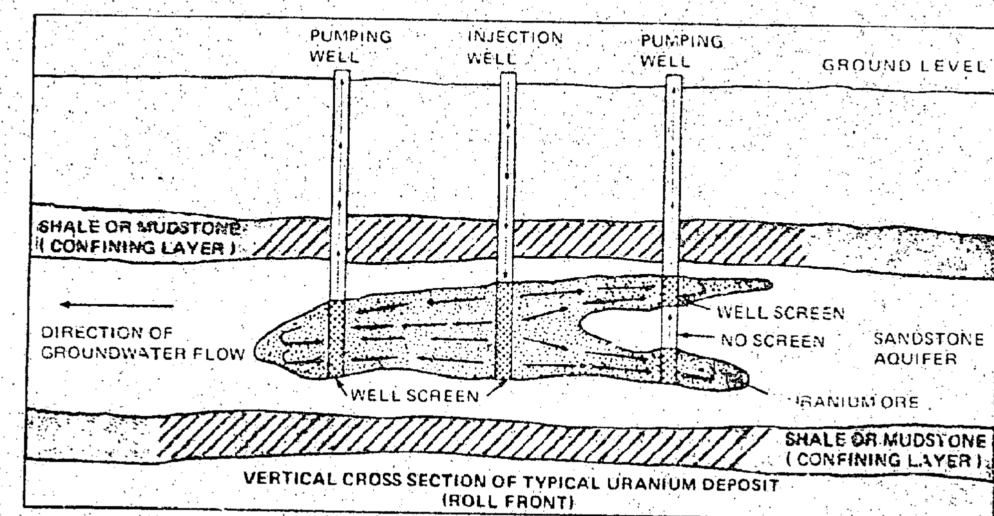


Figure 5-7 Vertical Cross Section of Typical Uranium Deposit (Roll Front)

Source: Westir house Electric Corporation Uranium Solution Mining, a booklet (copyright 1975).

Some features of the solution mining technique are:

- Small acreage is required, only about the size of the ore body.
- Chemicals used are low level, commonly known carbonates and bicarbonates; reconstituted leaching solutions are harmless to humans or livestock, and could even be used as dilute fertilizer for agriculture.
- There is virtually no processing waste; therefore, no tailings disposal area is required.
- The process is environmentally acceptable. At the end of work all structures are removed; piping is cut below ground level and cemented. Thus, in one growing season the site returns to its original appearance and use.
- There is no waste disposal to streams.
- All processing involves only solutions or slurries, thus, eliminating the possibility of radioactive solids (dust) to the air.

Currently, Westinghouse is developing sites in Wyoming and Texas; one site in Texas will be a full-scale production demonstration plant. Other areas are being evaluated for operational sites. Solution mining can only be used in permeable terrains, e.g. secondary deposits in sandstones and conglomerates and primary deposits such as Bokan could not be recovered using this technique.

Open Pit Mining

Open pit uranium mining techniques are quite similar to the surface coal mining techniques, the main differences being that they may be deeper than surface mines and do not cover as wide an area. In open pit mining in the Lower 48, each truckload of uranium ore is graded and checked for radioactivity as it leaves the mine, after which the ore is deposited at one of the stockpiles near the mine. By separating the ore into grades it can be fed into the processing mill in a more economical and efficient manner. (Ref. 5-5.)

With respect to activity in Alaska, a small amount of uranium was open pit mined at Bokan Mountain in the Southeast Region (see Volume 2, Uranium Resources Inventory for more information). However, the ore was trucked downhill and barged to the Lower 48 for processing without any separation into grades.

Underground Mining

Underground uranium mining techniques are also quite similar to underground coal mining, the differences being related to the size of the seam and ventilation systems. Uranium ore has no set or definite pattern of occurrence, so many adaptations of routine coal mining techniques are required. Both the equipment and mining operations must be easily moved from one site to another, as the seam at any one site may be mined rapidly.

Following the 1957 open pit mining in Alaska, underground mining occurred in 1963-64 and then again in the 1968-72 period at Bokan Mountain. (Refer to Volume 2, Uranium Resources Inventory, for more information.)

Exploration

Much searching and exploration is necessary before any attempt is made to mine for uranium. In Alaska at the present time, there is considerable exploration activity underway. Initial investigations include the collection and review of available data and reports, as well as a study of aerial photographs for selected areas. This preliminary work helps identify uranium host rocks.

In the case of uranium ore, radioactivity aids in its detection. Instruments that measure the radiation emitted as the radioactive elements decay are the: 1) Geiger counter; 2) scintillation counter; and 3) gamma-ray spectrometer. All three types of instruments may be designed in small hand units or larger carborne or airborne units. All three types of instruments are used to probe exploration drill holes. The Geiger counter detects both gamma-rays and beta particles (electrons), or gamma-rays only. A scintillation counter counts only gamma-rays, is more sensitive, and can be made to respond faster than the Geiger counter.

The gamma-ray spectrometer, which has been developed in recent years, distinguishes between uranium, thorium, and the radioactive isotope potassium-40 by measuring gamma radiations at particular energy levels. With this instrument, the contents of uranium, thorium, and potassium can be measured in a few minutes at an outcrop, or it may be used to survey large areas from an airplane.

Radioactivity is effectively masked by water or vegetation and this poses a special problem in Alaska due to the muskeg and water-saturated tundra that is on top of many of Alaska's sedimentary basins.

Another way to explore for uranium is to analyze the uranium concentrations in lake and stream waters and sediments from selected sites. The water samples are analyzed by fluorometry and sediment samples by delayed neutron counting or chemical methods. The results of a hydrogeochemical survey for uranium in the waters and sediments of the Susitna River basin was completed by the Los Alamos Scientific Laboratory (LASL) and released April 15, 1977.*

The LASL study is part of the National Uranium Resource Evaluation which includes the development and compilation of geologic and other information with which to assess the magnitude and distribution of uranium resources and determine areas favorable for the occurrence of uranium in the United States.

The final step in the exploration for uranium is, of course, the actual drilling into the ore deposit which is usually done with rotary or pneumatic equipment. This makes possible two final assessments: scintillometer measurements at various depths and geochemical testing and analysis of material brought to the surface. The total information obtained determines the uranium concentration at various depths. (For the various steps involved in uranium exploration, see Figure 5-8.)

---

*ERDA News release, No. 77-38, April 15, 1977.

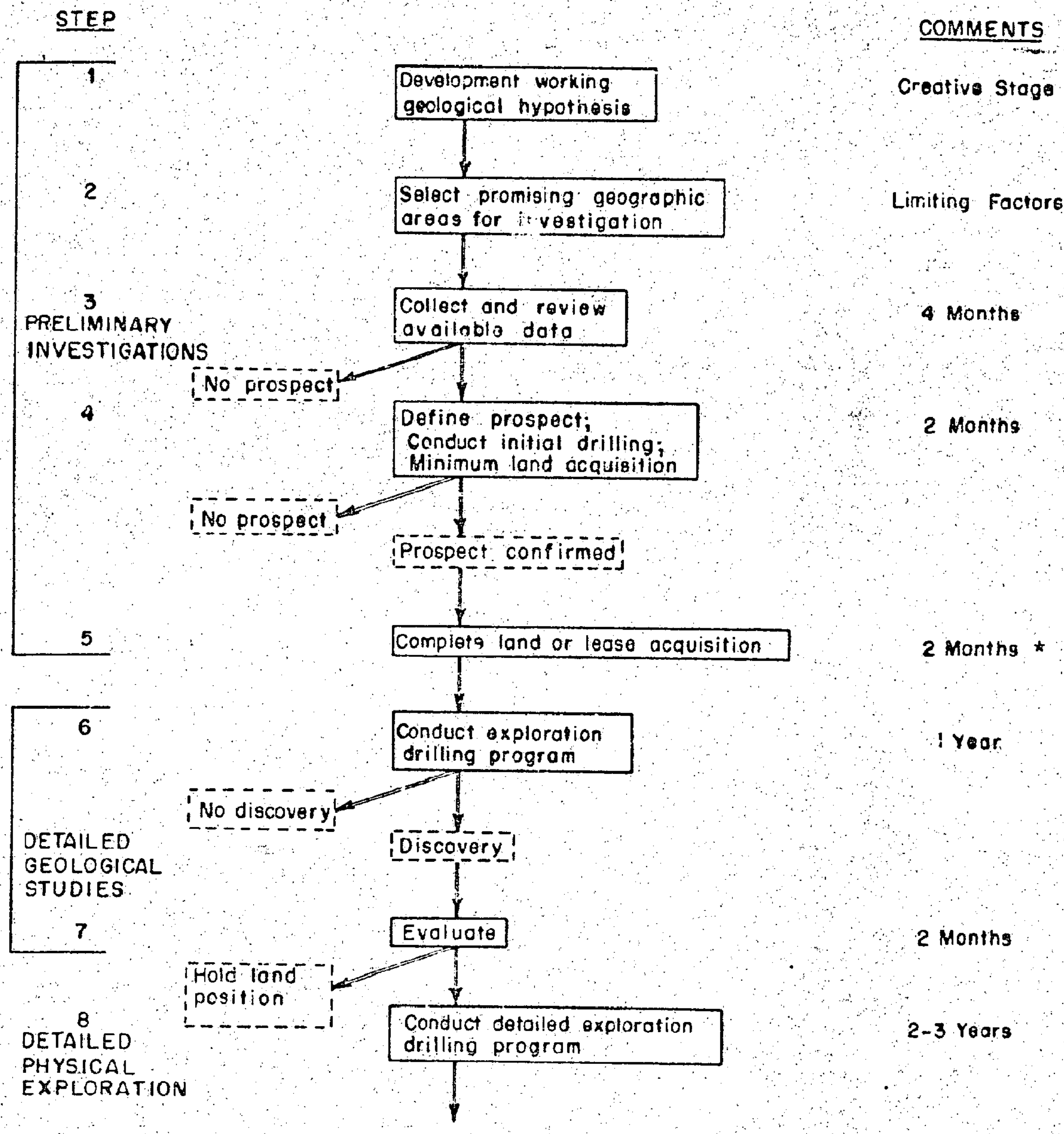


Figure 5-8 Uranium Exploration

*Some of these steps may require a longer time in Alaska.

Source: Energy Alternatives: A Comparative Analysis by the Science and Public Policy Program, University of Oklahoma, Norman, Oklahoma, May, 1975.

COST ISSUES

The increase in the cost of uranium oxide since 1973 has been huge; over 600% (Figure 5-9; Ref. 5-6). The reason for this degree of increase is not exactly known, but several related situations are of interest. Uranium as well as oil, gas, and coal, represents energy. Oil costs have increased many fold since 1973 (see Figure 4-10). To what extent the cost of the British thermal unit (Btu) in uranium are merely following the Btu cost of oil is difficult to determine.

It is clear that the break in the curve representing a sharp rise in the cost of uranium did not occur until well after the break in the curve for oil, gas and coal.

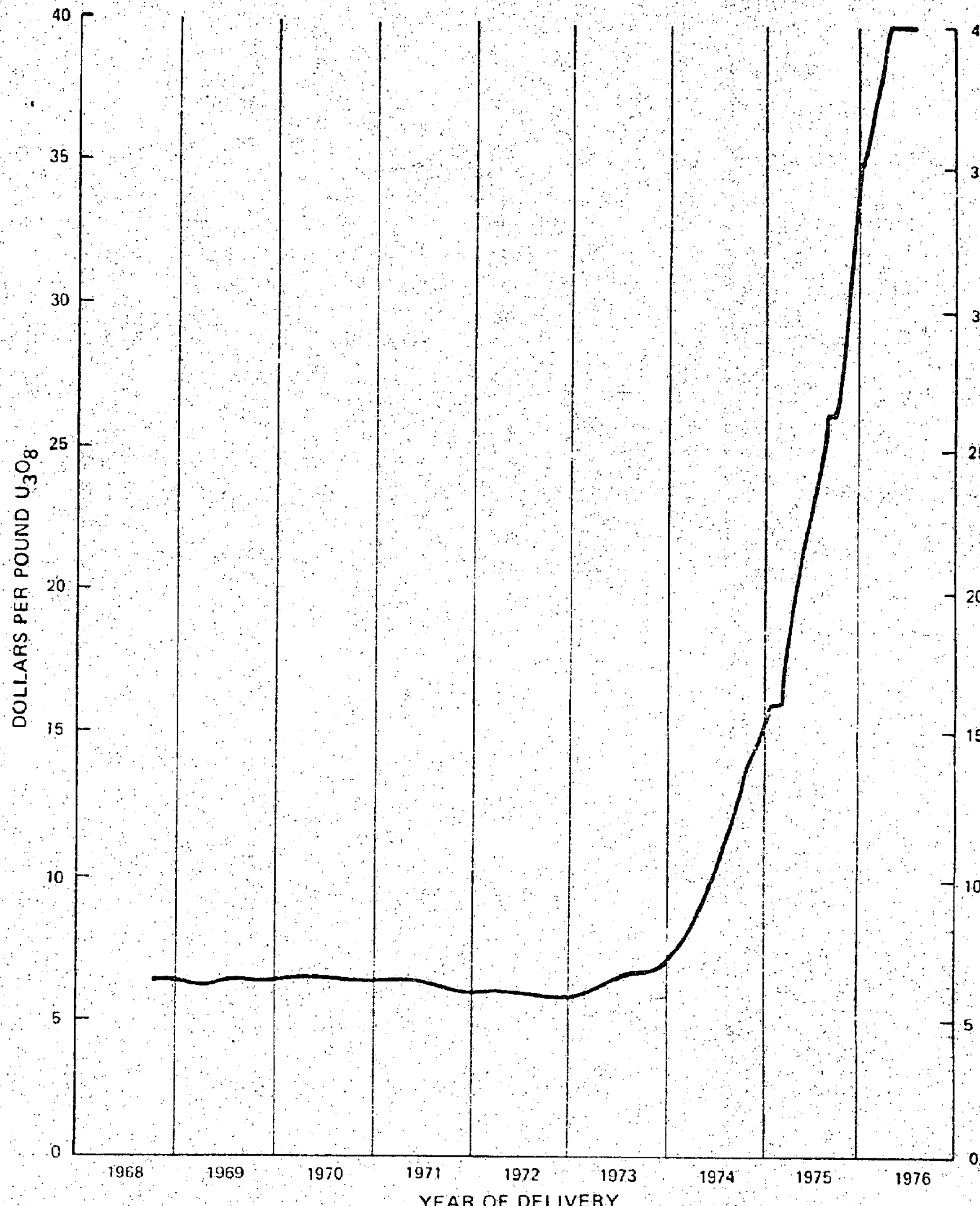
The uranium cost issue was further complicated on September 8, 1975, when, Westinghouse Electric Corporation announced its claim of Legal Excuse, Section 2-615 of the U.S. Uniform Commercial Code, from commitments to deliver upwards of 70 million pounds of yellowcake to its uranium-buying customers and described the U_3O_8 shortfall as "an unforeseen difficult situation". Section 2-615 is known as the "commercial impracticability" clause. As one might expect, the utility customers sued to compel Westinghouse to meet contractual uranium supply commitments. (Ref. 5-7.)

In May of 1977, at a meeting of the IAEA (International Atomic Energy Agency), the claim was made that there is not going to be a uranium shortage because uranium stocks are tied up in unwanted enrichment (a nuclear processing step prior to fuel manufacture for the nuclear reactors) contracts. Also, if the enrichment needs were directed to actual plant needs, rather than overblown estimates for which there is no need because the world projections of nuclear power capacity additions are constantly being reduced, there would be adequate supplies (Ref. 5-8).

Adding to the complex supply-demand situation, it was recently announced that the U.S. reserves of uranium must be nearly doubled in the next 13 years to meet the demand resulting from President Carter's decision to abandon the breeder reactor program. This means that the presently identified reserves of 600,000 tons of uranium must be increased by another 400,000 to 500,000 tons, according to Charles D. Masters, Chief of the USGS Office of Energy Resources, in a report to a USGS uranium-thorium research and resource conference in Golden, Colorado (Ref. 5-9).

Other factors relating to uranium demand are: increased exploration restrictions proposed by the U.S. Forest Service and the Bureau of Land Management, and the suspension of most Canadian deliveries, sending non-U.S. buyers into the U.S. market.

There are some who believe that "uranium needs in this century appear capable of being met from resources producible at less than $20/lb." This view was given by Vince Taylor in a paper entitled "The Myth of Uranium Scarcity" (Ref. 5-10). Taylor suggests that spot market prices of $40/lb. greatly overstates the real, present price for uranium and that cost-saving technological improvements in uranium mining and milling techniques are likely to be instituted.



NOTE. This figure has been reproduced from the NUEXCO monthly report, No. 107, June 30, 1977, by special permission

Figure 5-9 Historical U_3O_8 Exchange Value for Immediate Delivery 1968-1976

At any rate, whether the market will demand \$40/lb. or \$20/lb., either value is much greater than the \$6/lb. paid in 1972.

The Carter Administration's announced nuclear power goals and the degree to which they are achieved will have a substantial impact on the future uranium demand in the United States. The current announced goal is 380,000 MWe in operation by the year 2000. Of this total, 44,000 MWe are presently in operation and 146,000 are on order or under construction for a total of 190,000 MWe or half of the Administration's goal.

Assuming the time cycle from plant order to commercial operation is 10 years, completion of an additional 190,000 MWe by 2000 will require an average ordering rate of 14,000 MWe per year between 1978 and 1990 (Ref. 5-2). However, at the present time, utilities are not ordering nuclear units. Net orders since 1974 (new orders less cancellations) have been essentially zero because of declining load growth projections, licensing and other regulatory delays, and environmental resistance.

In 1970, exploration represented about 13 percent of the total cost of yellowcake (U_3O_8). In turn, the yellowcake represented only 6 percent of the total mills per kilowatt-hour nuclear electric generation cost that year (Ref. 5-5).

While there are no plans at this time to construct a nuclear power plant in Alaska, a comparison of the costs with coal are of interest. The calculations (Ref. 5-11) for a plant to start operation in 1984 in Boise, Idaho, give 33.2 mills/kwh for a coal plant without scrubber, 35.1 for a nuclear plant, and 39.2 for a coal plant with scrubber. To get nuclear costs this low, the plants must be large (about 1,000 megawatts); somewhat large for Alaska at this time.

The fees, rentals, bonuses and royalty charges for uranium resource exploration and production on State lands is given in Table 5-6.

Table 5-6
URANIUM MINING CLAIM FEES
March 1977

Permit, Lease or Claim	Fees, Rentals, Bonuses and Royalties paid to the State	Area (acres)	Term (years)
Mining Claim (locatable minerals)	No fees (but claimant must do annual assessment work on the claim of \$200/year per claim)	Up to 40 acres	Indeterminant, Claim in force as long as the annual assessment statement is filed each year
Mining Lease (uplands)	Annual rental not determined as yet.	- - -	- - -

Source: State of Alaska, Department of Natural Resources, Division of Minerals and and Energy Management, March 1977.

EXTERNAL MARKET ISSUES

External market issues relating to uranium development in Alaska are extremely difficult to evaluate at this time, primarily because there is so little knowledge of the nature and extent of Alaska's uranium resources. The current market price of uranium is very high by historical standards, generating substantial incentives for exploration and development.

This price incentive could be changed, however, by several developments. One is the discovery elsewhere of alternative supplies of such magnitude as to greatly reduce the current market price. Given the extent of uranium exploration already completed in the Lower 48 and elsewhere in the world, however, this does not appear likely in the immediate future. Another major potential impact is the anti-nuclear movement. Although the success of this movement has so far been limited, it is always possible that reservations regarding the safety of nuclear power could be dramatically enhanced by a nuclear accident in the United States or abroad. A radical reduction in the nuclear power development program in the United States could seriously depress the market price of uranium ore. Still a third contingency is the fate of the fast-breeder reactor program. At the present time, it is federal policy to slow development of fast-breeder reactors and the production of plutonium as an alternative fuel. The lack of a plutonium alternative for nuclear power production will tend to keep the price of uranium high; any acceleration of nuclear power development will lead to further price increases. In addition, there is also a potential foreign market for Alaska uranium. At the present time there is no specific restriction on the export of uranium ore, although a substantial export program might cause some concern in Congress.

The present and immediate future market for uranium in the U.S. and abroad is probably sufficient to maintain the market price in the face of substantial Alaska production. The major question that remains is whether or not uranium resources of sufficient quality will be found to allow such production.

FURTHER INFORMATION NEEDS

1) More information is needed on the technology for the extraction of uranium from seawater. Japan has expressed interest in a plant that will recover over 900,000 kilograms of uranium from the sea per year using an extraction process that (reportedly) uses titanic acid as an absorbent. Ion exchange technology should be evaluated for possible Alaska use, especially for the Cook Inlet area.

2) Cost information on a medium size nuclear plant (about 600-900 megawatts) should be obtained in order to compare with coal and/or hydro costs in the 1985-1995 time frame.

3) The possible investment and employment opportunities associated with a centrifuge uranium enrichment plant should be evaluated.

4) The future role that Alaska may play in thorium production, especially as a by-product, should be examined.

5) Up-to-date information is needed on success and/or problems of uranium solution mining.

6) Catalog environmental problems associated with production of uranium in Alaska.

URANIUM
KEY CONTACTS

C. C. Hawley
C. C. Hawley and Associates, Inc.
Consulting Economic Geologists
Box 78D, Star Route A
Anchorage, Alaska 99507
(907) 344-6114

R. J. Warchola
Project Geologist
Exploration and Mining Division
Wyoming Mineral Corporation
1215 16th Street West
Suite 22
Billings, Montana 59102
(406) 248-3119

Robert Forbes
Geological Consultant
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701

William D. Collins
Chief Geologist
Wyoming Mineral Corporation
3900 So. Wadsworth
Lakewood, Colo. 80235
(303) 988-8530

Warren Finch
Supervisory Geologist
Branch of Uranium & Thorium Resources
U.S. Department of the Interior
Division of Geological Surveys
Building 25, Mail Stop 916
Federal Center
Denver, Colorado 80225

Wayne Roberts
U.S. Department of Energy
Federal Building
600 W. 4th
Anchorage, Alaska
(907) 265-5421

Jule Anderson
Senior Geologist
Bendix Field Engineering Corp.
Federal Building, Room 52
Anchorage, Alaska 99501
(907) 265-5420

Gil Eakins
Geologist
State of Alaska
Department of Natural Resources
Div. of Geological & Geophysical Surveys
Box 80007
College, Alaska 99708
(907) 479-7606

Thomas P. Miller
Geologist in Charge
Branch of Alaskan Geology
U.S. Geological Survey
1209 Orca Street
Anchorage, Alaska 99501
(907) 272-8228

REFERENCES

5-5 Energy Alternatives: A Comparative Analysis by the Science and Public Policy Program, University of Oklahoma, Norman, Oklahoma, May, 1975.

5-6 Monthly Report to the Nuclear Industry No. 107, Nuexco, June 30, 1977.

5-7 Nucleonics Week, Volume 18, No. 4, January 27, 1977.

5-8 Nucleonics Week, Volume 18, No. 19, May 12, 1977.

5-9 Nucleonics Week, Volume 18, No. 18, May 5, 1977.

5-10 Nucleonics Week, Voume 18, No. 20, May 19, 1977.

5-11 Analysis of the Economics of Coal versus Nuclear for a Power Plant Near Boise, Idaho, Rutledge, Gene P. and E. Fast, Idaho Nuclear Energy Commission, March 1976.

GEOTHERMAL

RECOVERABLE RESOURCE SITES

The Alaskan geothermal resource sites are identified below as a function of temperature and those most likely for recovery are given special attention. Because of Alaska's position astride the shifting edges of two of the earth's major tectonic plates, the geothermal potential is great. The two major Alaskan volcanic regions are the Aleutian Chain and the Wrangell Mountains.

The two major Alaska volcanic regions are the Aleutian Chain and the Wrangell Mountains.

Hot Igneous Systems (Magma) (>650°C)

There were 88 volcanic calderas reported in Alaska prior to 1975 (Ref. 5-12). These volcanic systems are identified as a function of area, location, composition at last eruption, age, size, and solidification state (Ref. 5-13). Of these 88 locations, the heat content has been identified for 16, with values running as high as 345 x 10^{18} calories for Mt. Emmons. Mt. Drum in the Wrangell Mountains has an estimate of 230 x 10^{18} calories. Mt. Edgecumbe 144 x 10^{18} calories, but no estimates for Mt. St. Augustine which has seen very recent activity. (For comparison - 3 x 10^{18} calories represents enough energy for a 100 MWe plant to operate for 100 years.)

Because of the technical problems of heat transfer, it is unlikely that energy from these igneous systems will be utilized to any extent prior to the year 2000, even though research and development is warranted.

Two previously unreported volcanoes in the Aleutian volcanic arc were found during the summer of 1975 (Ref. 5-14). The first discovered was Mt. Kialaguik on the Alaska Peninsula. The other volcano, named Hayes Volcano, is at the foot of Mt. Gerdine, 150 km west of Anchorage and about 90 km north of Mt. Spurr, which had been considered the easternmost volcano in the 2,600 km-long Aleutian volcanic arc.

Hot Dry Rocks (<650°C)

This type of resource is abundant in Alaska, but no quantative inventory is available. While research is well underway in the Lower 48 on the hot dry rock concept, there is little likelihood that energy will be recovered in Alaska from hot dry rocks prior to the year 2000.

Geopressured-Geothermal Systems (15° to ~ 300°C)

It is possible to get energy three ways from a geopressured-geothermal system where fluid pressures may vary from 3,000 to 14,000 psig: (1) high pressure water is applied directly to a water turbine to generate electricity; (2) methane gas, which is in solution, can be extracted as a valuable natural gas energy resource; and (3) the water, which is still hot, can be either flashed or passed through an organic fluid heat exchanger for the generation of more electricity.

Not too much is known about geopressured-geothermal systems in Alaska. Most of the work to date has centered around the Gulf of Mexico, where much knowledge has been gained from the many holes that have been drilled. It is possible that this energy resource will be identified in the Gulf of Alaska, as well as other offshore and onshore Alaskan locations during the next few years as drilling gets underway.

Vapor-Dominated Systems (~ 240°C)

A vapor-dominated geothermal system produced commercial power in Lardello, Italy, in 1904. However, since that time, only two other locations have generated electrical power from such a system - the Geysers in California and a field in Matsukawa, Japan. These systems are somewhat like a pressure cooker - water boils at depths under an impermeable caprock.

Only two other vapor-dominated systems have been identified in the entire United States - Mt. Lassen National Park, California, and Mud Volcano System at Yellowstone National Park, Wyoming.

While there are no known vapor-dominated systems in Alaska, increased exploration may uncover such a system in the future.

Water-Dominated Systems (>150°C) (High Temperature)

Hot water systems are dominated by circulating liquid which transfers heat and largely controls subsurface pressure. The geologic structure of vapor-dominated and water-dominated reservoirs are the same. The reservoirs differ basically in the amount of fluid present in the reservoir.

There have been four hot water convection systems with indicated subsurface temperatures about 150°C identified in Alaska. A tabulation is given below (Ref. 5-12):

Location	Heat Content (Calories)
Geyser Bight	0.9×10^{18}
Hot Springs Cove	0.3×10^{18}
Shakes Springs	0.2×10^{18}
Hot Springs Bay	0.2×10^{18}

With temperatures this great, all four locations can be candidates for electrical energy generation as well as space heating. Geyser Bight has an electrical potential of 30 megawatt centuries and Hot Springs Cove, 8 megawatt centuries (Ref. 5-12).

Water-Dominated Systems (90°C - 150°C)

There are 24 identified hot water convection systems with indicated subsurface temperatures from 90°C to 150°C. Geothermal sites in this temperature range are discussed further in Current Plans for Development. At a temperature below 150°C, it is difficult to generate economic electrical power, but these temperatures are most suitable for efficient direct heat applications and constitute a major geothermal resource of the United States as such.

These 24 systems are listed according to name, location, temperatures, and reservoir size, and heat content in the U.S. Geological Survey's Circular 726 (Ref. 5-12).

Water-Dominated Systems (Ambient - 90°C)

This low temperature heat resource can be used for direct applications such as space heating, agricultural needs, and recreation.

Of the approximately 95 known Alaskan thermal springs (Ref. 5-13), about 71 are in the temperature range ambient to 90°C. The many known surface indications of this low temperature geothermal water are a significant energy resource in Alaska.

Normal Gradient Systems

From any surface location on earth, if a hole is dug deep enough, a geothermal resource will be located. A normal heat gradient is about 3°C per 100 meters below the earth's surface. Some heat gradients as high as 15° to 18°C per 100 meters have been observed in geothermal areas.

Economical extraction of the heat from a normal heat gradient location depends upon the cost of competing forms of energy in addition to the cost of the geothermal development. With electrical energy costs as high as 300 mills/kwh in 48 villages in Alaska, close attention to a normal gradient geothermal resource is warranted. Such a study is now underway by the Alaskan office of Pacific-Sierra Research Corporation. This company is investigating the economics of normal gradient hydrothermal resources of Alaska for non-electrical, multiple-use applications in Barrow, Kiana, Huslia, Nikolski, Wrangell, and Nome.

Drilling in an expected normal gradient location, the definite possibility exists that the gradient may be above normal in Alaska, and there is even the possibility of a repeat of the Hungarian experience - discovery of oil and gas during geothermal exploration.

CURRENT PLANS FOR DEVELOPMENT

A number of hot springs in Alaska have been used in the past for space heating and recreation. These and other uses of Alaskan thermal springs was given special attention at the Alaska Geothermal and Wind Resources Planning Conference held in Anchorage, Alaska, July 7-8, 1975 (Ref. 5-13). Since that conference, geothermal consultant and Alaskan resident William Ogle has traveled extensively throughout the state to visit Alaskan hot springs. He has written several excellent reports (Ref. 5-15 - 5-18), which include a brief description of the resources, their present utilization, and numerous color photographs of the following sites:

1) Bailey Hot Springs (Lat. 55°59'N, Long. 131°39.5'W)
2) Bell Island Hot Springs (Lat. 55°56'N, Long. 131°34'W)
3) Chief Shakers Hot Springs (Lat. 56°44'N, Long. 132°03'W)
4) Manley Hot Springs (Lat. 64°00'N, Long. 150°38'W)

5) Melozitna Hot Springs (Lat. 65°08'N, Long. 154°40'W)
6) Circle Hot Springs (Lat. 65°29'N, Long. 144°38'W)
7) Clear Creek Hot Springs (Lat. 64°51'N, Long. 162°18"W)
8) Pilgrim Hot Springs (Lat. 65°06'N, Long. 164°55'W)
9) Serpentine Hot Springs (Lat. 65°51'N, Long. 164°43'W)
10) Hot Springs Cove (Lat. 53°15'N, Long. 168°22'W)
11) Ophir Hot Springs (Lat. 61°12.1'N, Long. 159°51.5'W)
12) Geyser Bight (Lat. 53°12.6'N, Long. 168°27'W)

Some of the trips were in connection with the selection of a site for the possible installation of a small binary geothermal electric generating plant. However, no such installation is planned in the immediate future. Several of the geothermal hot springs sites in Alaska are expanding the use of the springs for space heating and recreational use, however, the total kilowatts involved will be very small compared with total energy used in Alaska.

The primary objective of an aquaculture study that is underway is to survey Alaskan thermal springs and to determine those which may be feasible for a fish hatchery. The general decline in salmon abundance in Alaska is of great concern, and hatcheries and artificial propagation could play key roles in restoration efforts. This study is administered by the Alaska Division of Energy and Power Development.

As of July 1977, the "Bailey/Bell Island area appears to have the most promising thermal spring sites for hatchery development, and has been recommended for further evaluation."*

APPLICABLE TECHNOLOGY

Technology of heat transfer for geothermal systems covers a wide range of data and information, since temperatures from ambient to greater than 650°C are involved, and since applications include both space heating and electrical generation.

Hot Igneous Systems (Magma) (>650°C)

The economic removal of heat from molten igneous magma systems is expected to be difficult. However, it is also difficult to remove the heat from the reacting plasma and fusion blanket of a fusion reactor. Considerable work is underway on fusion heat transfer and the technology developed may have some applicability to geothermal energy extraction. For example, a report entitled The Fusion Program and the Idaho National Engineering Laboratory (Ref. 5-19) says

> "the advantages of the fluidized bed technology should be applied directly to fusion blanket design. These advantages include relatively uniform temperature distribution, high heat transfer rates between the fluid and the particles of the bed, and high heat transfer rates between the in-bed heat exchangers and the bed itself. One can envision a fusion blanket design based on a bed...of particles fluidized by relatively low velocity flow helium. The bed would be capable of removing heat from the first wall (volumetric heating

*Monthly Progress Report, William C. McConkey, Division of Energy and Power Development to ERDA (EY-76-C-06-1624), July 26, 1977.

of 10-20 watts/cm^3/sec and surface heating of 10-20 watts/cm^2/sec) without requiring a high pressure coolant there. Heat exchangers in the bed would then remove the heat from the bed to the primary coolant."

Alaskan resource specialists are communicating with fluidized bed scientists from Idaho regarding the use of technology of this type in or near one of the 88 volcanic calderas in the State.

Fluidized beds have unique features that make them attractive for applications involving heat and mass transfer in solids, gas, and liquid systems. The basic mode of fluidization is the flow of a fluid, either gas or liquid, upward through a bed of solids at velocities which suspend the solids in the fluid. Quicksand is an example of a naturally occurring fluidized bed in which water flows upward through sand particles and suspends the sand. The entire mixture of solids and fluids behaves as a fluid and has properties characteristic of fluids. The suspended solids move about vigorously in the fluid and provide a very effective means of mass and heat transfer in the system. Uniform temperatures and precise temperature control are readily obtainable in fluidized beds. Also, the solids frequently and randomly collide with solid surfaces located within the containing vessel and the wall of the vessel. Stagnant films of fluid at the solid boundaries are therefore disrupted and the resulting resistance to heat transfer is reduced several-fold. Because they have no moving parts, fluidized bed systems are easily adaptable to systems requiring low maintenance and remote operations.

Hot Dry Rocks (<650°C)

The Los Alamos Scientific Laboratory has been actively investigating the potential for, and problems associated with, extracting geothermal energy in those parts of the United States that contain dry, hot rock at moderate depths.

In the Los Alamos concept, a man-made geothermal reservoir would be formed by drilling into an identified region of suitably hot rock, and then creating within the rock a very large surface area for heat transfer by use of large-scale hydraulic-fracturing techniques. After a circulation loop is formed by drilling a second hole into the top of the fractured region, the heat contained in this reservoir would be brought to the surface by the buoyant circulation of water. The water in the loop would be kept liquid by pressurization at the surface, thereby increasing the rate of heat transport up the withdrawal hole compared to that possible with steam.

While this technology is of interest to Alaska, it is unlikely that it will be applied in Alaska prior to the year 2000.

Geopressured-Geothermal Systems

A recent (July 1976) Louisiana Energy report gives a suggested geopressure system that extracts energy from a geopressure-geothermal resource by three methods. An excerpt of this report describes the process:

"First, high pressure water arriving in the well head at the surface is applied directly to a water turbine to generate electricity. Second, methane gas is removed from the saturated water by high- and low-pressure separators, one before and the other after the pressure has been applied to the water turbine. The gas can be burned [illegible] electricity, or it can be used to heat the well water even higher for the third process. Third, the water, still at 260°F, is passed through a freon boiler which generates freon "steam" to run a gas turbine, generating more electricity. The freon is then cooled, liquefied, and recirculated to the boiler. Water leaving the boiler is disposed of in shallow, normally-pressured sands or in the Gulf or its bays."

Research underway within and near the Gulf of Mexico should be followed closely for possible application to areas in Alaska which might have this resource.

Vapor-Dominated Systems (~240°C)

Since this geothermal energy source has not been identified in Alaska, technology for "dry" steam geothermal energy is of little local interest at this time.

Water-Dominated Systems (>150°C)

One method of using intermediate temperature geothermal water to generate electrical power is to flash it to steam, separate the steam from the liquid and then use the steam to drive "conventional" steam turbines. One must determine for a given site the advantages and disadvantages of flashing once, versus twice, versus several times. These calculations have been made by Dr. Tal Neill (Ref. 5-20) for the geothermal power plant under consideration in Raft River, Idaho.

The maximum turbine work from two flash stages (20.1×10^6 Btu/hr or 5.9 Mw's) is significantly higher than that obtainable from a single flash stage (15.4×10^6 Btu/hr or 4.5 Mw's). Neill suggests that optimizing the three stage system would produce more than 22×10^6 Btu/hr or 6.4 Mw's, a gain which would probably not be economic. However, one would need to offset the expense of a third flash in terms of capital outlay versus the additional energy gained. Going from one flash to two will result in a gain of 4.7×10^6 Btu/hr, but from two flashes to three only an estimated 1.9×10^6 Btu/hr is gained, making additional piping and turbine components more difficult to justify.

The use of a binary power cycle has been suggested as perhaps the best method to generate power from geothermal heat sources. Such cycles generally involve the direct transfer of heat between the hot geothermal water and an organic working fluid. The major advantages of such a power cycle are the minimum handling of the geothermal water and the smaller turbines required with the organic vapors.

One of the first questions to arise when considering a binary power cycle is which working fluid is best. There is a surprising variety of organic and other fluids which have the required thermodynamic properties such as critical temperature, critical pressure and vapor pressure. Other properties such as toxicity, flammability, chemical compatability, thermal stability, and cost also determine the choice of the working fluid. Some of these fluids are freon-21, freon-211, propane, ammonia, supercritical freon-12, supercritical propane, isobutene, and supercritical isobutene.

A number of calculations on the potential output from several working fluids and power cycle concepts have been made by Neill (Ref. 5-21); however, energy output is only one factor that is used by the engineers to determine the fluid to be used.

Water-Dominated Systems (90°C - 150°C)

For the production of electricity, the technology described in the previous section on water dominated systems above 150°C would be applicable for the production of electricity. However, a rule of thumb says that for every 20% drop in operating temperature range from the source to the "sink" (the condenser) temperature, the power plant and energy supply system (well and pipeline) costs will increase 50%. Therefore, it is difficult to obtain economic electrical power at temperatures below 150°C, considering present technology and the price of competing electrical generation.

COST ISSUES

Many paper studies have been done on the costs of generating electrical energy from geothermal systems, but few are based on actual operating experience. If geothermal fluids can be used in a direct manner, such as home heating and swimming pool use, the economics are frequently very favorable, since costly electrical generating equipment is not necessary.

In water-dominated systems at temperatures greater than 150°C, only four locations in the world have cost information based on electrical generating experience. These locations, with costs in 1972 dollars, are tabulated below (Ref. 5-22):

Location	Mills/Kwh
Wairakei, New Zealand	5.1
Namafjall, Iceland	2.5 to 3.5
Pauzhetsk, USSR	7.2
Cerro Prieto, Mexico	4.1 to 4.9

At and near 150°C it is difficult to generate economic electricity; nevertheless, research is underway at this time at Raft River, Idaho, in an effort to obtain cost information in this temperature range.

While it is difficult to get economic energy from geothermal hot waters by electrical generation, the situation with respect to using the energy for non-electrical generation is more favorable. Geothermal hot water is used to pasturize milk in Klamath Falls, Oregon, and to heat 170 homes in Boise, Idaho. Several hot springs in Alaska are used for recreation and space heating use. Such use supports the view that with the rising cost of fuels, the use of many geothermal sites may become increasingly viable.

A number of people have addressed the subject of geothermal cost issues. Bloomster published an article in July 1976, "Economic Analysis of Geothermal Energy" (Ref. 5-23). Witner determined the "Costs of Alternative Sources of Electricity" including geothermal energy also in July 1976 (Ref. 5-24).

In Alaska, calculations have been made for both a 10 MW and a 25 MW "steam-geo-turbine" project. Busbar costs of 16.98 mills/kwh and 12.45 mills/kwh, respectively, were calculated. Also, costs were calculated for a geothermal binary hot water plant for a 10 MW and a 25 MW plant and busbar costs of 25.38 mills/kwh and 19.19 mills/kwh, respectively, were calculated (Ref. 5-25). These cost calculations must be viewed with great care since Alaska has had no operating experience with electrical generating geothermal systems of this type.

FURTHER INFORMATION NEEDS

1. Alaska, as well as most locations throughout the U.S., needs more exploration in order to determine, in a quantitive manner, the energy in Alaska's geothermal resources (aquifers, basins, etc.). A Megawatt Reservoir Assessment (MRA) program needs to be implemented. Whether a site will support a 10 megawatt plant for 20 years or a 1,000 megawatt plant for 100 years must be known before a utility can commit capital outlay funds for construction.

2. Geothermal aquifer pressures follow a lunar pattern (recent Raft River measurements) and research needs to be considered on evaluating the possibility that these pressure measurements could assist in earthquake predictions. Perhaps such pressure measurements during a tremor could assist in the MRA study.

3. Buildings having forced air systems can be directly converted to geothermal heating by installing a new hot water coil in existing ductwork. More of this type of information is needed. More practical information on geothermal space heating design for Alaskan locations is needed. (State and federal office buildings in Boise, Idaho are being designed to use geothermal water for space heating. The estimated savings are $200,000 per year in fossil fuel costs equivalent to 16,000 barrels of oil per year.

4. More information is needed on the potential advantage of geothermal water on agricultural crops in Alaska. Increased crop yields, length of growing season, uptake of geothermal water minerals, and quality of produce need to be measured. An inventory of agricultural lands that might benefit from geothermal energy needs to be completed. Agriculture-geothermal experiments underway at Malta, Idaho need to be evaluated for Alaskan use. In a similar manner, more information is needed on the potential for geothermal energy to improve aquaculture production.

5. According to a Louisiana energy report, pressure in excess of 9,000 lbs per square inch exists in underground hot water reservoirs along the coast of Louisiana; such a fluid, when expelled at the surface, would "produce the equivalent energy of a theoretical waterfall 4 miles high." Alaska needs more information on geopressured-geothermal resources.

6. More information is also needed on the advantages and disadvantages of a binary system vs. multiple flash steam systems for electrical power production as the technology relates to the Alaska situation.

7. The State needs additional data on construction materials for piping, valves, and pumps associated with the movement of geothermal fluids for space heating, recreational, agricultural, and aquacultural use, with special attention to the Alaskan environment.

8. More information is needed on fluidized bed technology, as this relates to possible use in the economic transfer of the heat from Alaska's volcanoes.

9. The State of Hawaii has a long-range objective to "develop techniques, materials and components for the recovery of useful energy from molten magma." Alaska should consider working with Hawaii and scientists from the National Laboratories on the fluid bed concept.

ALASKA GEOTHERMAL RESOURCES

KEY CONTACTS

William Ogle
Consultant
3801 West 44th Avenue
Anchorage, Alaska 99502
(907) 277-7285

Charles E. Brockway, P.E.
Assistant Research Professor
Dept. of Civil Engineering
Snake River Research Center
University of Idaho
Kimberly, Idaho 83341
(208) 423-5582

E. S. Grimmett
Associate Scientist
Allied Chemical
550 Second Street
Idaho Falls, Idaho 83401
(208) 522-4400, ext. 3339

John B. Burnham
Program Director
Regional Assessment Programs
Battelle Pacific Northwest Laboratories
Battelle Boulevard
Richland, Washington 99352
(509) 946-2476

C. J. Phillips
Nome, Alaska 99762

Pat Kirkwood
Principal Investigator
Pacific Alaska Research
4510 International Airport Road
Anchorage, Alaska 99503
(907) 243-1942

GEOTHERMAL

References

5-12 U.S. Department of the Interior. Division of Geological Survey. Assessment of Geothermal Resources of the United States, by D. E. White and D. L. Williams. Survey Circular 726. 1975.

5-13 University of Alaska, Geophysical Institute and The Alaska Energy Office, Office of the Governor. Geothermal and Wind Power... Alternate Energy Sources for Alaska, Proceedings of the Alaska Geothermal and Wind Resources Planning Conference held in Anchorage, Alaska, July 8-9, 1975.

5-14 U.S. Department of the Interior. Division of Geological Survey. The U.S. Geological Survey in Alaska: Accomplishment During 1975, Circular 733. 1976.

5-15 Ogle, William E. Report of a Visit to Ophir Hot Springs (White Bear Lodge). September 1976.

5-16 Ogle, William E. Report of a Visit to a Number of Alaskan Hot Springs to Aid in the Selection of a Site for the Possible Installation of a Small Binary Geothermal Electric Generating Plant. July 1976.

5-17 Ogle, William E. Baranof - An Example of Hot Springs' Originated Geothermal Space Heating in Alaska. May 1976.

5-18 Ogle, William E. Report of a Visit to Bell Island Hot Springs. May 1976.

5-19 Conn, Robert W. The Fusion Program and the Idaho National Engineering Laboratory. Idaho: Idaho Nuclear Energy Commission, October 1974.

5-20 Neill, D. T. and Roustaiyan, Saeed. Study of Multiflash Steam Systems for Geothermal Use. Report to the Idaho Nuclear Energy Commission. Idaho: October 23, 1975.

5-21 Neill, D. T. Organic Fluid Turbines and Power Cycles. Final Report to the Idaho Nuclear Energy Commission. Idaho: October 23, 1975.

5-22 Oklahoma, University of Oklahoma. Energy Alternatives: A Comparative Analysis. Washington, D.C. Government Printing Office, May 1975.

5-23 Bloomster, C. H. Economic Analysis of Geothermal Energy. Battelle Pacific Northwest Laboratories, Washington. July 1976.

5-24 Witner, Jeffrey G. Costs of Alternative Sources of Electricity. Stanford Research Institute, Palo Alto, California. July 1976.

5-25 University of Alaska, Institute of Social and Economic Research, Electric Power in Alaska 1976-1995, August 1976.

WIND

RECOVERABLE RESOURCE DESCRIPTION BY SITE

Wind is the movement of the atmosphere in a pair of gigantic loops. One loop is in the northern hemisphere and the other in the southern hemisphere. The basic flow is along the surface of the earth from the polar regions to the tropics. Here the flow is heated and rises and then returns at high altitude toward the poles where it cools, sinks, and returns again along the surface to the tropics, completing the cycle (Ref. 5-26).

Cool air from the Arctic flows southwest and meets the warmer moist air moving north. The air accumulates, this time at the earth's surface where it is forced upward by temperature gradient effect. This air mass divides in the upper atmosphere, part flowing north and part south. This zone of upward moving air varies between 50 and 60 degrees latitude and provides the conditions for storms that form in the northern and western Pacific Ocean and move eastward to the south of the Aleutian Island chain into the Gulf of Alaska (Ref. 5-27).

The earth's atmosphere is broken into numerous high and low pressure cells. The speed of moving air is related to the difference in pressure over a given distance; the greater the pressure difference, the greater the wind speed.

With the world surface estimated at 1.965×10^8 mi.^{2} (or 5.10×10^{14} m^2) and the wind energy (up to 1,100 meters of the atmosphere) at 1130×10^2 watts, the Alaska portion is 3.6×10^6 megawatts taking Alaska as 0.30% of the earth's total area. If one assumes that 1/1000 of the kinetic energy in the air above Alaska could be extracted by windmills, a "practical annual mean wind power potential of Alaska is about 3,400 megawatts" (Ref. 5-28).

Coastal regions in Alaska typically have high average wind, as do islands and mountain passes. However, mean wind speeds are only one consideration in determining the practicability of wind-generated power. The entire wind regime, velocity by percent of total time and other considerations, determine the extractable wind energy. Time percentages and wind distribution must be inventoried before the real practicability of wind power sites can be determined. Nevertheless, since many of Alaska's small, remote communities lie in high wind areas, wind power does represent a local energy source of considerable economic and social potential. Table 5-7 gives the location and speed of several Alaskan wind power sites.

Table 5-7
SELECTED ALASKAN WIND POWER SITES

Yearly Mean Speed		Site	Region
Knots*	Miles per hour		
18.3	21.0	Amchitka Island	Southwest
14.9	17.1	Cold Bay	Southwest
14.9	17.1	Tin City	Northwest
12.8	14.7	Port Heiden	Southwest
11.1	12.8	Kotzebue	Northwest
9.5	10.9	Nome	Northwest
8.1	9.3	Big Delta	Interior
7.4	8.5	Juneau	Southeastern
7.0	8.1	Yakutat	Southeastern
6.6	7.6	Valdez	Southcentral
4.6	5.3	Anchorage (Merrill Field)	Southcentral
5.7	6.6	Anchorage (Elmendorf AFB)	Southcentral
6.6	7.6	Sitka	Southeastern
4.3	4.9	Fairbanks	Interior

*Knot is a unit of speed of one nautical mile (6,076.10 feet) an hour; one statute mile is 5,280 feet.

Source: Geothermal Energy and Wind Power—Alternate Energy Sources for Alaska, University of Alaska. Geophysical Institute and the State of Alaska Energy Office. July, 1975. p. 78-79.

CURRENT PLANS FOR DEVELOPMENT

The present applications for wind power are primarily areas where conventional power is not available; e.g. remote cabins, mountain top communications installations, or rural homesites where cost of powerlines is expensive. While there is little market for home use in urban areas, William Barnes, Jr., proprietor of Windlite Alaska, does have a windmill in his backyard in Anchorage that lights his home.

Three locations in Alaska are getting special attention with respect to windpower: Ugashik and Nelson Lagoon, located on the northern coast of the Alaska Peninsula in the Southwest region; and Kotzebue in the Northwest Region.

Ugashik

The Ugashik windmill, erected 100 miles southwest of Naknek, was constructed under the direction of Dr. Tunis Wentink, Jr., of the University of Alaska through a grant from the Energy Research and Development Administration.

The unit was destroyed in 1975 as a result of the failure of a safety system and high winds. A replacement was shipped to Alaska, but no installation date has been established.

Nelson Lagoon

Nelson Lagoon, a fishing village located 100 miles northeast of Cold Bay, has 12 homes, a community center and a school, all of which receive their electricity from two 75 kw diesel generators.

In February 1977, the Division of Energy and Power Development funded the installation of an electrical distribution system that connected two diesel generators (originally used by the school) with all the homes in the village.

Prior to the hookup, individual diesel generators were used. The Division then purchased a 20 kw Grumman wind system, which was tied into the grid (via a synchronous inverter) in October 1977. If additional funding is obtained, a second wind generator will be purchased. ERDA is providing support to the project through the funding of a data logger and assisting with analysis of the data collected.

The Nelson Lagoon work is a demonstration project with two primary goals: 1) determine the technical feasibility of using wind generators in remote Alaskan villages; and 2) identify their economic viability.

Additional information on the Nelson Lagoon activity is available in two recent reports (Ref. 5-29 and 5-30), which contain general requirements for installation and data on currently manufactured wind-powered generator equipment.

Kotzebue

The Division of Energy and Power Development, under contract with the University of Alaska, is also financing the installation of a 2 kw Dunlite wind generator at the new community college building at Kotzebue. A synchronous inverter was installed with the generator and both units were in operation in October 1977.

The emphasis of the project is to develop an operation and maintenance curriculum for Alaska Natives to help them utilize wind generators in their communities.

Other Uses

The National Weather Service recently purchased two wind generators to test for possible use with their remote automatic weather observing stations. Tests were conducted near McHugh Creek, just south of Anchorage. According to NWS facilities maintenance supervisor Sigfred Johnson, high and turbulent winds "blew them to pieces". A French model, the Aero-watt, was replaced by the company, and Johnson plans to reinstall it and raise the blocks to a height of 30 feet to avoid the turbulence encountered at a 10-foot altitude. Johnson hopes to come up with a system to replace solar panels at some of the northernmost stations. Wind generators such as the Aero-watt, would furnish a 3 to 4 amp trickle current to charge the batteries that power the remote instruments.

Alyeska Pipeline Service Co. has also purchased some wind generators to provide backup power for communications along the pipeline.

An increasing number of Alaska residents, particularly in more remote areas, are finding units such as the Dunlite to be a practical means of meeting their basic electrical needs.

APPLICABLE TECHNOLOGY

Man has long recognized and utilized the energy in the wind. Windmills were known in China and Japan as early as 2000 B.C. and have been in common use for at least 700 years in parts of Europe; wind energy systems were in wide use in the western United States until about 1950. Some are still to be found in rural areas, pumping water into stock tanks or generating electricity for individual farm houses.

Some people feel that, had the windmills in the rural communities been installed higher with more energy available at the greater wind velocities, the acceptance of wind energy in rural America would have been much greater.

During the period from 1935 to 1955 a number of large experimental wind-powered generators were constructed. Most of these units were located in Europe; the Smith-Putnam unit at Grandpa's Knob, Vermont, was the only U.S. effort. On October 19, 1941, this unit was the first ever to feed wind-generated power synchronously into a utility power grid. Rated at 1250 kw in a 30-mile per hour wind, it was operated on an experimental basis for 1100 hours over a four and one-half year period. Put out of commission by a blade failure in March 1945, the project was discontinued for economic reasons.

Windmill Designs: Horizontal and Vertical Axis

The many patterns of wind turbines fall into two basic concepts: horizontal axis designs and vertical axis designs. The horizontal axis designs include the oldest, most common types, and generally have been the most comprehensively studied, whereas the vertical axis design dates only from around 1930 and has not been studied as thoroughly. Horizontal axis turbines are typified by the American farm wind turbine commonly used to pump water in the western United States.

The Dutch four-armed windmill was used to pump water and for light industrial purposes in the Netherlands. The modern propeller designs with two or three blades are commonly used on small generator systems. Recent large-scale experimental power generation systems have used propeller designs almost exclusively (see figure 5-10).

All three types of horizontal axis designs require some means of keeping the turbine oriented into the wind, the most frequent device being a tail or vane. Another system uses a small auxiliary horizontal-axis turbine (fantail) mounted perpendicular to the primary turbine and geared to drive the primary turbine into the wind while driving itself out of the wind. By coning the blades - the turbine can be made to track downwind without the use of a vane.

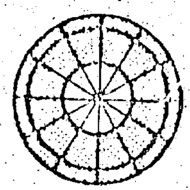
Vertical axis turbines do not require orientation to the wind because they are omni-directional, with the axis of rotation perpendicular to the wind regardless of the wind's direction. This omni-directional characteristic and a capability of delivering power directly to ground level are their primary assets. Figure 5-10 presents the Darrieus and the Savonius or S-Rotor. No vertical axis wind turbine has yet been applied to large-scale or commercial projects although the Savonius rotor has been used as an ocean current meter and for hand-held anemometers. Although the Darrieus rotor is not currently self-starting, it has been combined with the Savonius rotor in experiments at Sandia Laboratories in Albuquerque, New Mexico, to become self-starting.

Regardless of the configuration, all rotors share some common design problems; they must endure certain stresses and forces induced during operation. Resonance and vibratory forces may be minimized by careful design engineering of the rotor driven machinery and supporting structure, but aerodynamic and inertial forces must be countered by strength and rigidity. Aerodynamic loads are generated by the nonuniformity of wind speed. The mean axial wind component generates thrust forces which deflect the blades downwind (forced coning) and variations in wind speed induce variations in the angle of coning (flapping). Gradients in axial velcoity (primarily vertical due to the boundary layer effect) tend to ~~tilt the~~ rotor disk with respect to the shaft, contributing to flapping and aggravating resonance problems at certain rotor speeds. Uneven loading of the blades also induces twisting stresses in the blades. Velocity components perpendicular to the rotor axis produce disk tilting and high harmonic loadings.

Wind Speed and Power

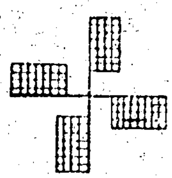
The essential quantity of interest is the energy flux in watts per unit area, measured normal to the wind direction. This is a power-density and can be

Horizontal Axis



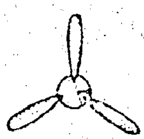
FARM

High torque, low rpm, high losses, high weight/power output ratio. Must be turned parallel to high winds for protection.



DUTCH

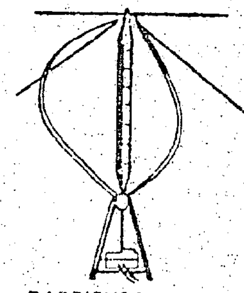
High torque, low rpm, inefficient blade design. Fabric cover may be removed from arms for protection in high winds.



MODERN PROPELLER

Low torque, high rmp, efficient blade design. Three-blade units generally limited to smaller applications. Two-blade units of 200 feet diameter are feasible. Variable pitched blades allow speed regulation, feathering for protection.

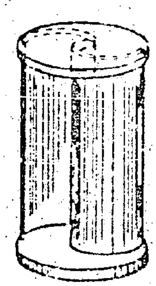
Vertical Axis



DARRIEUS ROTOR

Patented in 1931 (U.S. and France)

Currently under study at National Aeronautical establishment, Ottawa, Canada; AEC's Sandia Laboratories in Albuquerque, N.M.; and NASA's Langley, VA. Laboratories.



S-ROTOR

Patented in 1929 (U.S. and Finland) by S.J. Savonius.

Currently used as an ocean current meter Other applications shown feasible Developmental alternatives not fully investigated.

Figure 5-10
Wind Turbine Characteristics (Rotortype)

Source: Energy Fact Book 1976. Tetra-Tech, Inc. Feb., 1976.

reported in watts per square meter (w/m^2). The energy flux is the maximum power that can be obtained by any device of any design whatsoever. Thus, it is the basis for all efficiency calculations. The power-density is given by $P = (1/2)\ \rho V^3$ (Ref. 5-31).

If "P" is the air density in grams per cubic centimeter, and "V" is the wind speed in meters per second, the "P" will be in Kw/m^2. The density will vary with altitude and with barometric pressure. Note that upon doubling the windspeed the power increases by a factor of eight.

Electricity Schemes

Although in the earliest applications of wind energy there was direct mechanical coupling of the wind turbine to the driven machinery or water pump, such applications place severe limitations on site selection and system configuration and are of limited potential today. Consequently, all current large-scale experimental systems are designed to generate electricity. There are several different methods by which wind energy can be utilized to make electricity. Six schemes are presented in Figure 5-11.

Energy Storage

When wind-generated power is used to supplement a power grid, the energy-storage problem is reduced to the existing fuel storage problem; but in a self-sufficient wind-power system, excess energy must be stored when available and retrieved during periods of insufficient wind. The characteristics of several technical options are given in Table 5-8.

COST ISSUES

With the cost of power so high in the rural areas of Alaska, wind energy stands a good chance of satisfying an increasing share of the electrical and non-electrical energy.

The major competition of wind energy will be diesel generators, but with the skyrocketing cost of crude oil, wind energy is becoming more attractive and may be economic in some areas of Alaska in the near future.

Wind Cost "Paper" Calculations

Jeffery C. Witner of the Stanford Research Institute calculates the cost of energy from a wind energy conversion system in a fuel-saver mode based on some General Electric studies involving 1.5 MW wind generator (Ref. 5-32). This system, designed for an 18-mph mean wind speed, would reach its rated (1.5 MW) output at a wind speed of 25 mph.

The wind generator would have a 180-foot diameter, two blade rotor. The blades would be made of a filament-wound composite. The generator would be mounted on top of a 140-foot steel truss tower. Sixty-cycle AC power at 4 kw would be generated.

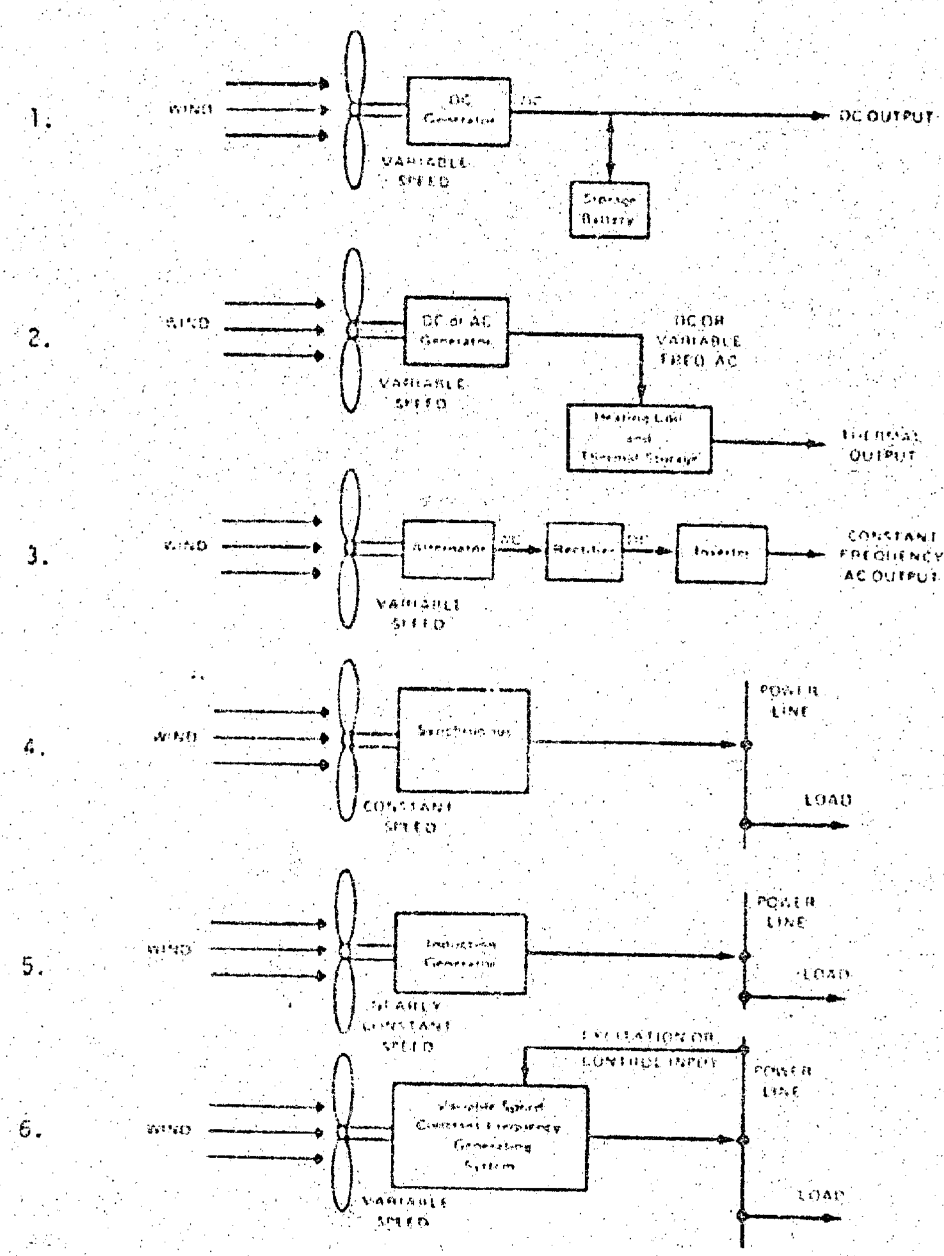


Figure 5-11
Methods to Use Wind Energy

Note: Nelson Lagoon will employ #4 to harness wind energy as a supplementary electrical energy source.

Source: Energy Fact Book 1976. Tetra Tech, Inc. Feb., 1976

Table 5-8
CHARACTERISTICS OF ENERGY STORAGE TECHNOLOGY

Technology	Typical Economic Module (MWe)	Characteristics Earliest Commercial Availability	Storage Efficiency (%)	Remarks
Batteries	1	1975-82	70-80	Proven Technology
Flywheels	1	1985	70-90	
Hydrogen/Fuel Cells	1	1985	40-60	Storage options for Hydrogen
Compressed-Air (Adiabatic)	10 (30 MwH)	1982	70-80	High-Grade Thermal
Compressed-Air (Isothermal)	10	1975	NA	Required Fuel
Pumped Hydro	100 (?)	1975	70-75	Special Situations
Superconducting Magnets	500	1995	90	

Source: Energy Fact Book 1976. Tetra-Tech, Inc. Feb., 1976.

The cost of power was estimated to be from 17 to 30 mills/kwh for the time period 1985 to 1995. The capital cost investment was assumed to be $500/kw in 1985 and $450/kw in 1995. Even if the above costs are doubled in Alaska during that time frame, the costs look very attractive for wind energy in remote areas of Alaska.

Wind Energy Costs in Alaska

Very little information is available concerning wind energy costs in Alaska. Some calculations have been made for certain Alaskan areas which indicates that a wind energy system "would require 5.9 years to pay off through fuel oil savings" (Ref. 5-28). One should also note that: (1) the oil saved could be used elsewhere, and (2) wind is replenishable.

Once operating experience is gained on the wind energy system at Nelson Lagoon, some cost numbers can be developed.

FURTHER INFORMATION NEEDS

1. Wind velocities must be obtained for the site under consideration. Data should be obtained for at least a year and maximum wind velocities must be determined. Therefore, Alaska needs more site-oriented wind information for those locations where a current (or possible future) interest exists for wind power.

2. The cost of wind energy needs to be determined for various site-specific locations based upon actual operating experience.

3. Once a wind-powered generator (WPG) has been selected, it is necessary to obtain appropriate interface equipment for the utility grid. More information from actual operating experience is needed on such equipment. Examples of interface equipment that may be required to parallel an AC generator (i.e., Dunlite or Grumman) with a utility distributing system are: (1) rectifier network; (2) voltage regulator; (3) input filter/interface circuits; (4) synchronous inverter; (5) output filter/interface circuits; (6) overcurrent protection; (7) metering; and (8) automatic disconnect.

4. More data is also needed on detailed methods of storing wind energy. Of special interest is the dissociation of water and the storage of energy as hydrogen.

ALASKA WIND RESOURCES
KEY CONTACTS

Robert Swanson
S&S Electric, Inc.
P.O. Box 4-2439
Anchorage, Alaska 99509
(907) 344-0022

Ken Spieser
Grumman Energy Systems
4175 Veterans Memorial Highway
Ronkonkoma, New York 11779
(516) 575-6205

John Kuller
Boeing Computer Services, Inc.
Western District
P.O. Box 24346
Seattle, Washington 98124
(206) 773-8683

Gerald V. Neubert
Associate Director for Planning
Department of Facilities Planning
and Construction
University of Alaska
Room #2, Bunnell Building
Fairbanks, Alaska 99701
(907) 479-7591

John E. Nickles
Associate Director of Construction
Office of the Director of Construction
University of Alaska
Box 95502
Fairbanks, Alaska 99701

William A. Barnes
Windlite - Alaska
Box 43
Anchorage, Alaska 99510
(907) 272-2205

Dr. Tunis Wentink, Jr.
Professor of Physics
Geophysical Institute
University of Alaska
Fairbanks, Alaska 99701
(907) 479-7607

William C. McConkey
Director
Division of Energy and Power
Development
Department of Commerce and Economic
Development
338 Denali St., 7th Floor MacKay
Bldg.
Anchorage, Alaska 99501
(907) 272-0527

REFERENCES

5-26 Energy Fact Book 1976, Tetra Tech, Inc., TT-A-642-76-211, Feb. 1976, Page XVIII-1.

5-27 Alaska Regional Profiles, Southcentral Region, Lydia Selkregg, University of Alaska, Arctic Environmental Information and Data Center.

5-28 Geothermal Energy and Wind Power - Alternate Energy Sources for Alaska. University of Alaska. Geophysical Institute and the Alaska Energy Office. Proceedings of the Geothermal and Wind Resources Planning Conference held in Anchorage, Alaska, July 8-9, 1975.

5-29 Wind Power Demonstration Programs for Alaska Energy Office, Phase I Report, Boeing Engineering and Construction, Nov. 15, 1976.

5-30 Supplemental Wind Powered Electrical Generation for Selected Alaskan Communities, Final Report, Phase II, Boeing Computer Services, Inc., June 1977.

5-31 Project Aquilo, A Wind Inventory Survey in Southern Idaho, Robert G. Nisle, Idaho Nuclear Energy Commission.

5-32 Costs of Alternative Sources of Electricity, Jeffrey G. Witner, Stanford Research Institute, July 1976.

ADDITIONAL ENERGY RESOURCES

There are a number of energy resources in Alaska in addition to the oil, gas, coal, hydroelectric, uranium, geothermal and wind resources already discussed. These additional energy resources include tides, wood, peat, the sun, oil shale, the thermal gradients in the ocean and, of special importance from a conservation viewpoint, refuse and waste heat.

With so many energy issues, operations, and resources that needed to be addressed in Phase I of this study, it is not possible to treat these resources in any detail. Nevertheless, a brief discussion of tidal and wood energy follows.

Tidal Power

The principle tidal power sites under consideration are in the Cook Inlet basin and at Angoon in southeastern Alaska. Inlet tides at Anchorage have a mean range of 26.7 feet and are even higher at the north end of the Knik Arm of the Inlet. The long-term potential for tidal power development of Cook Inlet, of which Knik Arm is but a small segment, is estimated to be 8,560 megawatts. The Knik Arm is of special interest since there is a possibility that a crossing will be constructed from Anchorage to Willow, which was selected to be the new capitol site by the voters of Alaska on November 2, 1976. Estimates of Wilson and Swales (1972) indicate 685 MW of power can be obtained at Knik Arm. A similar situation exists at Turnagain Arm, where outer continental shelf development will cause pressure for improved transportation to the Kenai Peninsula, resulting in the possible combination of a crossing with tidal energy installations. Turnagain has a power potential twice that of Knik.

The Division of Energy and Power Development is intent upon obtaining funds to develop a Knik Arm and/or a Turnagain Arm crossing design that will permit the later installation of tidal energy units as the demand justifies. Whether or not this design will be chosen is not known, but it is very important that such a design be considered so that future tidal energy will not be lost by default. The high cost of retrofitting dictates that consideration for tidal energy facilities at Knik, and Turnagain Arms be addressed prior to construction of any crossing.

Wood

Interior Alaska has about 100 million acres that are forested; of this amount, 21 percent is classified as commercial. The forested area of Coastal Alaska is about 13 million acres, about 50 percent of which is classified as commercial.

The volume of wood harvested in Alaska from lands administered by the U.S. Forest Service and the State was 510,000,000 board feet in 1976, according to the year-end report of The Alaska Economy. Since wood has about 10 to 11,000 Btu's per pound, wood is a large energy resource in Alaska.

Not only are wood products made in Ketchikan and Sitka, but the wood waste is used both for industrial process heat and to make electricity in steam boilers. Indeed, several megawatts are generated in the State. The wood waste in Coastal Alaska has a high moisture content and, therefore, oil is added in order to get combustion. Recent fluidized bed technology has been used to burn wood wastes in Northern Idaho and it is possible now to burn wood with a moisture content as high as 62%.

CHAPTER 6

ALASKA ENERGY NEEDS AND OPPORTUNITIES

The emphasis of the preceding chapters has been on Alaska's future as an energy-producing state. Given the potential extent of Alaska's recoverable fossil and non-fossil fuels and their importance to the entire nation, this emphasis is understandable. It is also important to recognize the needs and opportunities of Alaska as an energy consumer. Alaska is increasing its annual oil and gas consumption. A comparison of 1975 United States and Alaska consumption indicates that petroleum and natural gas comprise a higher percentage of the total energy demand in Alaska than in the U.S. as a whole:

	Percent of Total Demand	
	United States	Alaska
Petroleum Liquids	47.0	58.0
Natural Gas	28.0	34.0
Coal	19.0	6.0
Hydroelectric	4.0	2.0
Nuclear Power	1.8	0.6
Miscellaneous	0.2	0.0*

(*Not measured)

The most recent total energy demand estimates for oil and gas are contained in Energy Report 3-77, Historic and Projected Demand for Oil and Gas in Alaska: 1972-1995, prepared by the Alaska Division of Minerals and Energy Management (DMEM).

The above table illustrates Alaska's heavy dependence on oil and gas. It does not, however, show that Alaskans have been increasing their consumption of oil and gas at an average rate of 10 percent per year since 1972, compared to a nation-wide average annual increase of two percent. Alaska per capita consumption in 1975 was approximately seven gallons of petroleum products per day; during the same period, Americans as a whole used about 4 gallons per day.

Figures 6-1 and 6-2 present an historical comparison of Alaskan oil and gas consumption between 1972 and 1976. Residential and commercial demand rose over 11 percent per year (1.64 to 2.19 million barrels of oil equivalent (MBOE), and industrial use of natural gas rose almost 10 percent per year (5.68 to 7.45 MBOE). Total non-electric oil and gas consumption increased from 22.07 MBOE in 1972 to 30.31 MBOE in 1975, a four-year increase of 37 percent.

Figure 6-3 dramatically points out the dominance of the transportation sector in the consumption of energy. The 1975 Alaska State energy mix is as follows:

BLANK PAGE

Transportation	38.4%
Electric Generation	21.6
Residential and Commercial	20.1
Industrial and Military	19.9
TOTAL	100.0%

Figure 6-4 presents three oil demand projections to 1990 prepared by DMEM. If the moderate growth curve is chosen, total oil demand in the State will increase from 22.4 MBOE in 1975 to 42.5 MBOE in 1985 to 63.9 MBOE in 1995. This represents an average growth rate of over eight percent per year.

Natural gas demand, as shown in Figure 6-5 would increase at an average annual rate of 8.5% from 81.1 Billion Cubic Feet (BCF) in 1975 to 219.2 BCF annual consumption in 20 years.

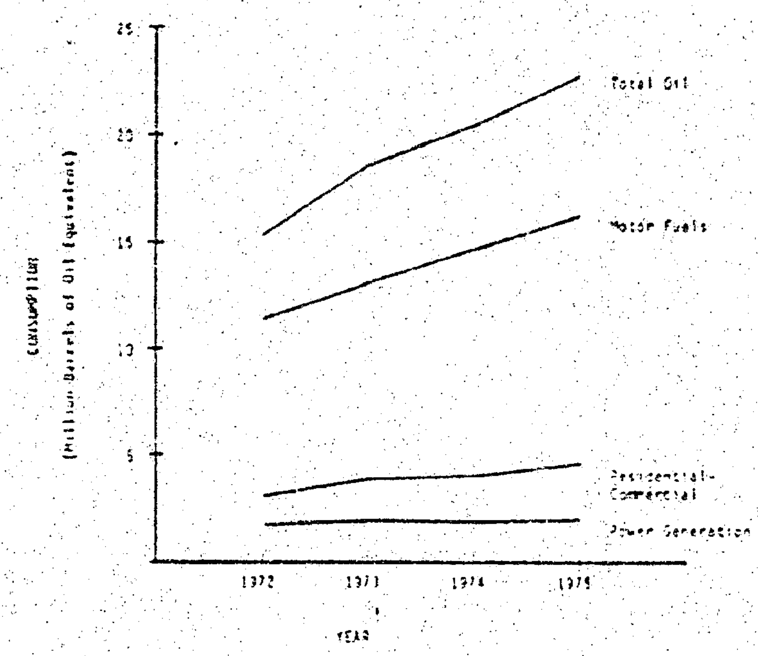


Figure 6-1
Historic Alaskan Oil Consumption: 1972-1975

Source: State of Alaska Department of Natural Resources. Division of Minerals and Energy Management. Report 3-77.

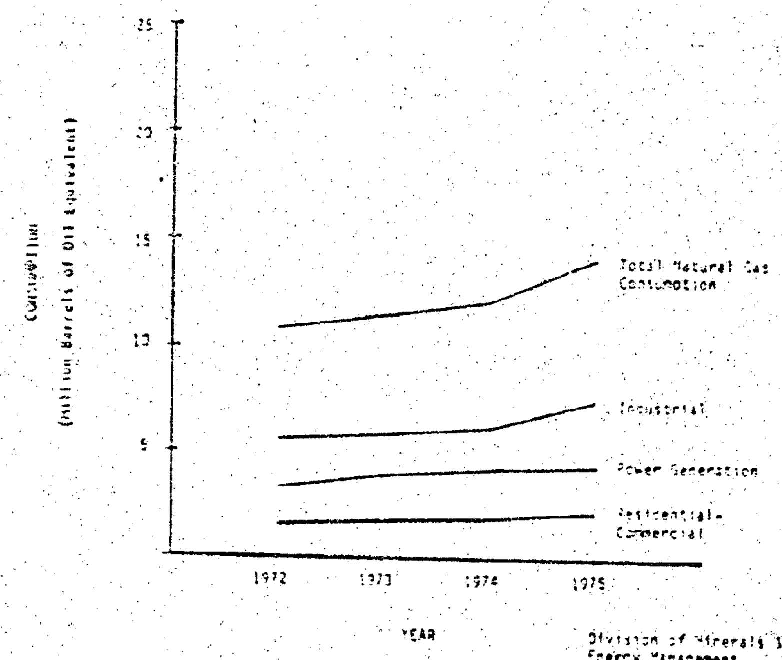


Figure 6-2
Historic Alaskan Natural Gas Consumption: 1972–1975

Source: State of Alaska. Department of Natural Resources. Division of Minerals and Energy Management. Report 3-77.

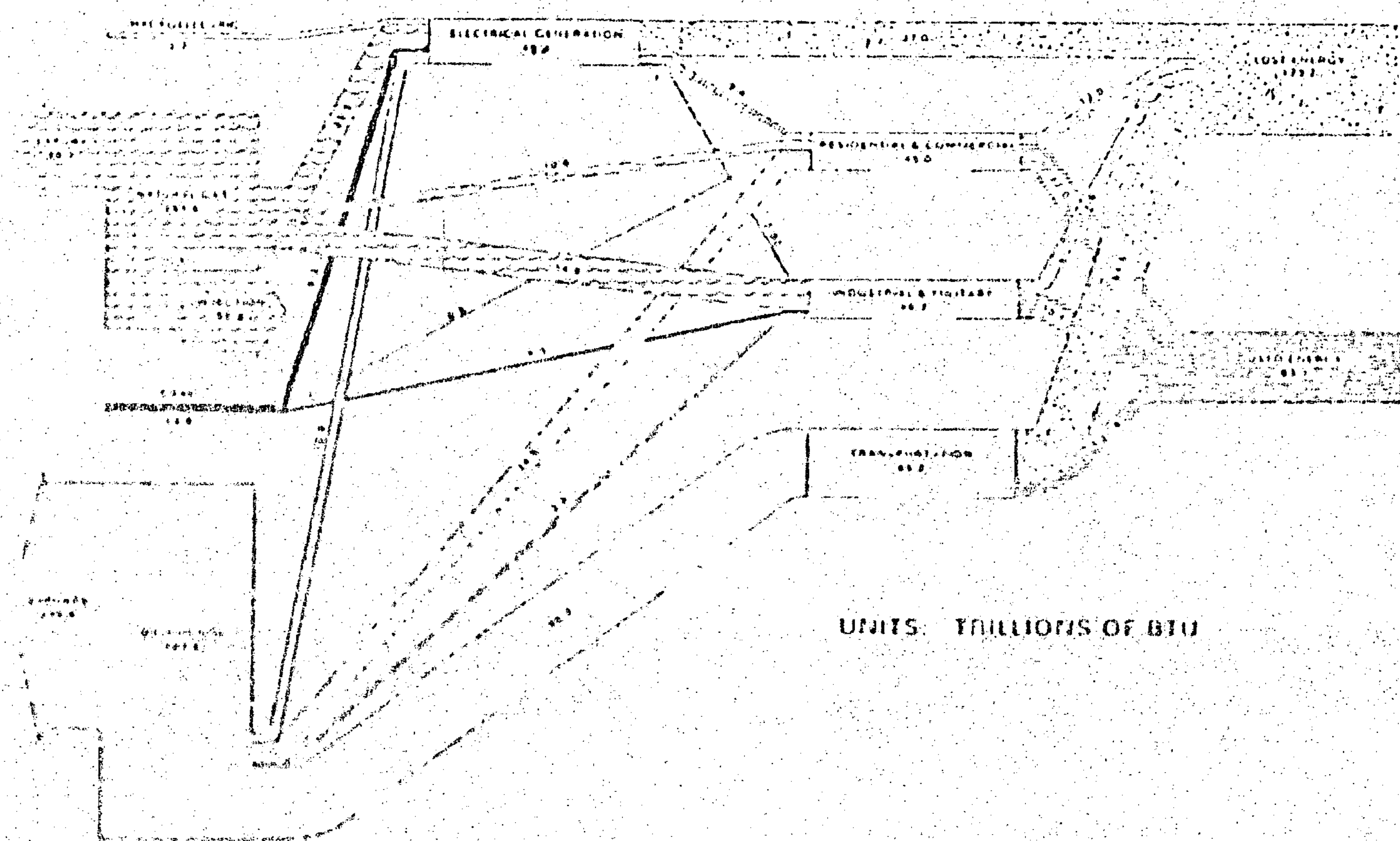


Figure 6.3
Alaska State Energy Balance - 1975

Source: [illegible]

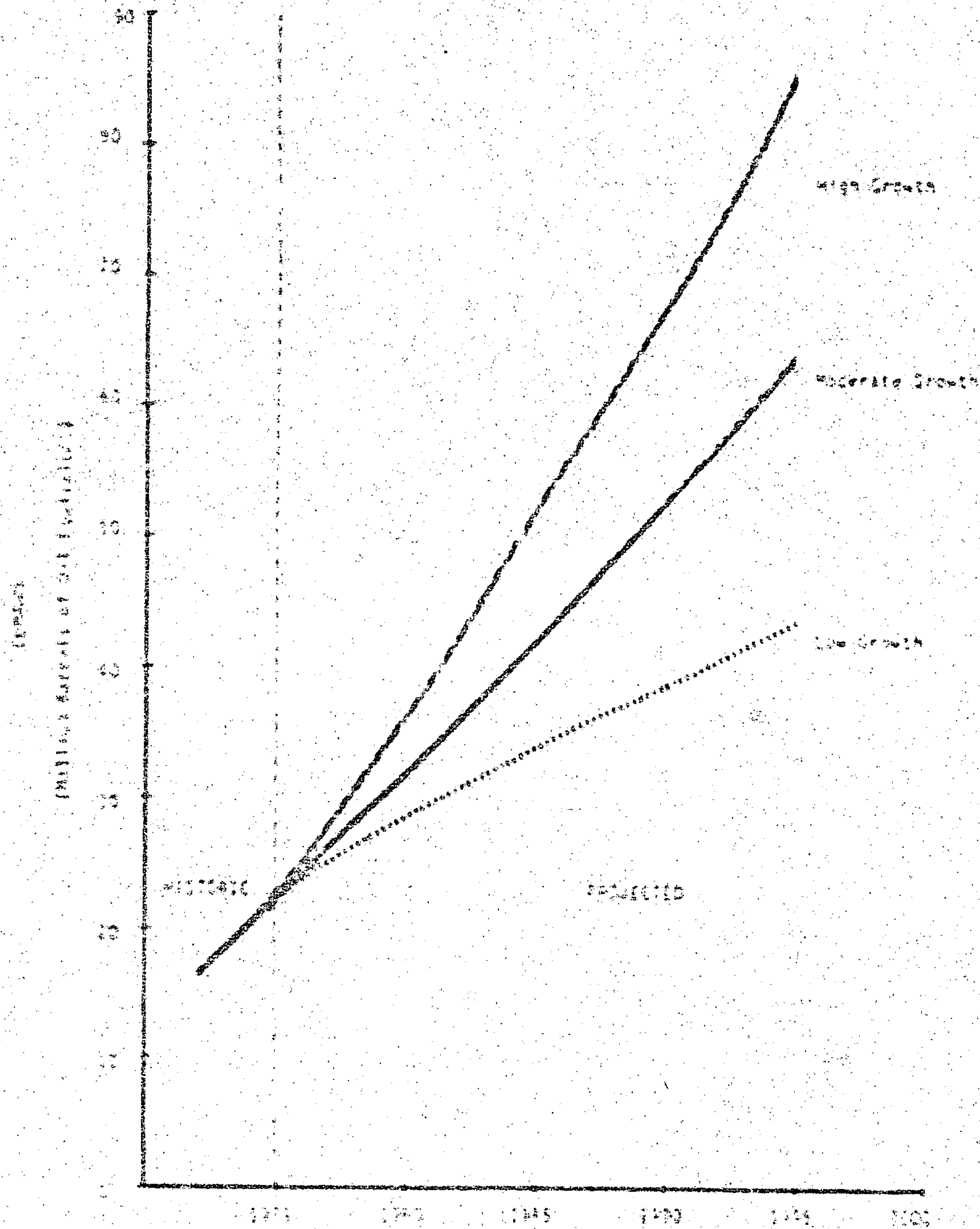


Figure ?.6 Projected Alaska Oil Demand to 1995

Source: State of Alaska, Department of Natural Resources, Division of Minerals and Energy Management, Report ? 77

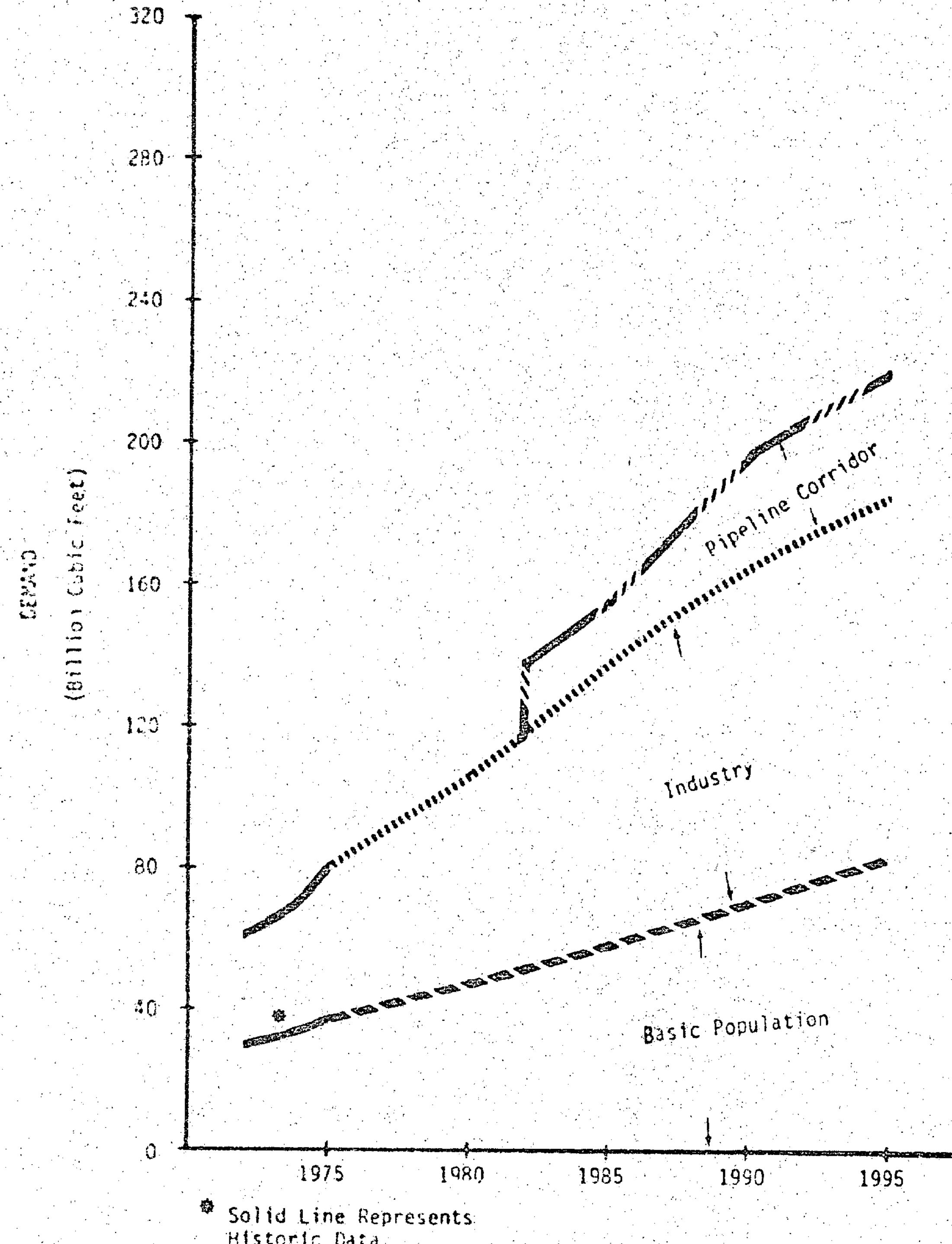


Figure 6.5 Moderate Projected Alaskan Natural Gas Demand to 1995

Source: State of Alaska, Department of Natural Resources, Division of Minerals and Energy Management, Report 3-77.

OPPORTUNITIES

Most of this chapter has been centered on meeting present and future energy needs as determined through various growth and economic development trends. With such abundant resources, however, many opportunities exist for developing Alaskan energy resources in the most efficient and effective manner possible, and ensuring that Alaskans receive adequate energy and power at the least cost.

Alaska's abundant energy potential provides three significant opportunities. The first is to improve the standard of living through adequate energy availability; the second is to provide employment opportunities for Alaskans; the third is to provide for the State's financial needs.

Alaska's largest cities, i.e. Anchorage, Fairbanks, Juneau, Ketchikan, Sitka, Petersburg, Wrangell, Homer, Kodiak, Valdez, Cordova, as well as many smaller villages, are located near hydro and/or coal field sites. Each of these has the serious potential for clean and relatively inexpensive all-electric cities. With the use of wind, geothermal energy, and fuel cells many rural villages have similar opportunities.

Alaska, with its energy resources alone, or combined with its many other natural resources has several opportunities to diversify its economy. The State is rich in minerals, fertile soils, fisheries and timber, as well as in coal, oil, gas, and water. The potential development of these industries as well as energy intensive industries provide Alaskans with a favorable employment and economic future.

Finally, if managed carefully, all of these can mean a full financial reward to the State and its people. The future is promising if these resources and monies are managed carefully.

ENERGY NEEDS, ELECTRICAL

Statewide electrical demand projections have been prepared by two organizations: the Institute for Social and Economic Research (ISER) of the University of Alaska and the Alaska Power Administration (APA) of the U.S. Department of the Interior.

APA's future electrical demand estimates contained in the Alaska Power Survey of 1974, are shown on Figure 6-6. Superimposed upon this projection are the estimates developed by ISER in their 1976 report, Electric Power in Alaska, 1976-1995. As can be seen, there is a wide spread between the low range and high range predictions after 1985, but prior to that both estimates are fairly close. Due to the wide range of growth options which exist in Alaska, demand projections beyond 1985 vary greatly. Table 6-1 gives electrical power production as a function of the Regions of the State and the resources for calendar year 1975. Table 6-2 and Figure 6-7 present current and future electricity demand by Region through 1995 using the accelerated economic scenario with lowest and highest projections.

The energy mix in the State for electrical production is estimated at: oil, 20 percent; natural gas, about 50 percent; coal, approximately 18 percent; and hydroelectric power, 12 percent. Rural areas rely almost exclusively on diesel fuel to power their electric generators, although natural gas is used in Barrow, the State's northern-most community. The Anchorage and Kenai areas in the Southcentral Region have been blessed with inexpensive and abundant natural gas for electrical power generation; however, expiration of long-term contracts, limited uncommitted reserves, possible deregulation of natural gas, and bans on additional natural gas generation systems indicate that a change in this situation within the next few years. In the Interior, the Fairbanks vicinity power needs are met by coal-fired steam plants; the coal is supplied from the Usibelli Coal Mine near Healy and by a mine-mouth plant at the mine itself. Back-up diesel systems help meet peak demand in the area.

It is difficult to predict the electrical energy mix for the year 2000. Studies in progress to determine the extent to which remote areas will be able to use alternate energy sources such as wind, geothermal, solar, and small low-head hydro will help.

In larger communities, the location will, in large part, dictate the alternatives. Fairbanks, for example, is surrounded with options with its proximity to a large active coal mine, to the trans-Alaska oil pipeline, to ~~the~~ future North Slope natural gas line, and to a possible major hydroelectric project on the Upper Susitna River.

Anchorage and the Southcentral Region's future power alternatives include some continued use of natural gas, coal-fired plants ~~using Beluga~~ coal, the Upper Susitna Dam hydropower project and harnessing of the tidal power of Cook Inlet. With the Railbelt area (the heavily-populated areas of the Southcentral and Interior Regions) expected to account for over 90 percent of the State's total electrical energy usage by 1995, special focus and immediate attention must be given to determine the future supplies ~~which~~ will meet this energy demand. Geothermal energy may also hold some potential in the Interior Region (Mt. Drum and Mt. Wrangell areas) and in the Southcentral Region (Mt. Spurr, Mt. Iliamna, Mt. Redoubt and Mt. St. Augustine).

In contrast to the majority of states in the Lower 48, most regions of Alaska are fortunate to have one or more alternatives available to meet present and future energy demand. There exists either fossil fuel substitution choices or other alternative, even renewable, energy resources. The ability of Alaska to meet these needs will depend, to a large degree, on the ability to identify and analyze the options available and to prepare a program for controlled and orderly development of the State's energy resources.

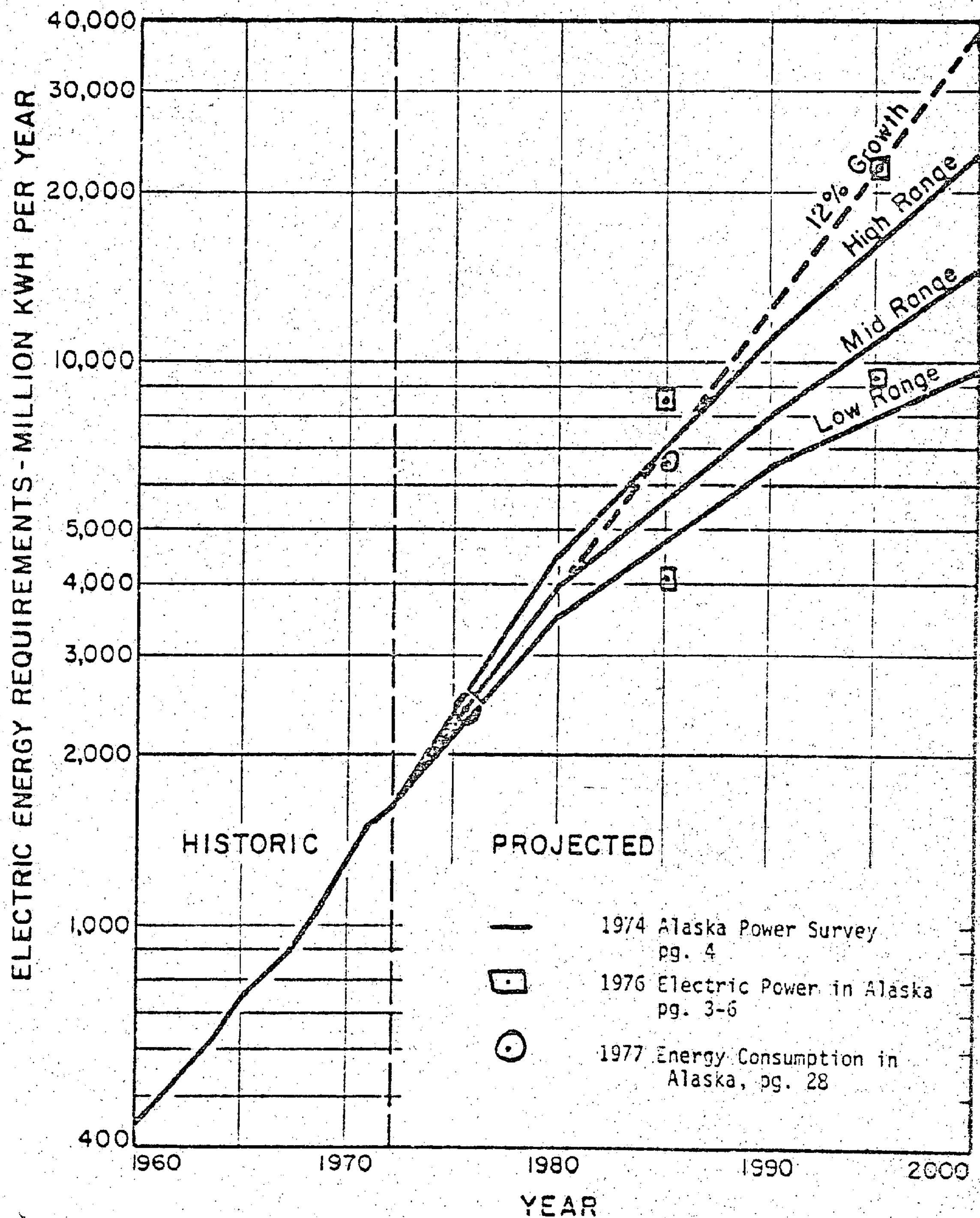


Figure 6-6 Utility System Power Requirements: 1960–2000

Table 6-1
ENERGY SOURCES FOR ELECTRIC POWER
Alaska Utility and National Defense System
Calendar Year 1975

Region of State	Estimated Power Production, Million kwh					
	From Oil	Natural Gas	From Coal	Hydro Power	Total	Percent
Southeast	102	---	---	194	296	10
Southcentral	96	1426	---	163	1685	59
(Interior) Yukon	155	---	512	---	667	23
Balance of State	230	4	---	---	230	8
Total	583	1430	512	857	2878	100
Percent	20	50	18	12	100	

Source: Alaska Power Administration, April 26, 1977.

Table 6-2
ELECTRICITY REQUIREMENTS IN ALASKA

Anchorage and Southcentral Alaska

Year	Capacity Required (MW)		Total Energy (Million KWH)		Growth Rate (Annual Percent)	
	low	high	low	high	low	high
1974	261	261	1149	1149		
1985	702	1394	3095	6523	9.4	17.1
1995	1672	4162	7004	18 141	9.0	14.0

Fairbanks Region

Year	Capacity Required (MW)		Total Energy (Million KWH)		Growth Rate (Annual Percent)	
	low	high	low	high	low	high
1974	76	76	319	319		
1985	144	297	602	1244	5.9	13.2
1995	260	677	1088	2843	6.0	11.0

Southeast Alaska

Year	Capacity Required (MW)		Total Energy (Million KWH)		Growth Rate (Annual Percent)	
	low	high	low	high	low	high
1974	48	48	215	215		
1985	93	112	417	505	6.2	8.0
1995	141	184	634	827	5.3	6.6

Northwest and Southwest Regions

Year	Capacity Required (MW)		Total Energy (Million KWH)		Growth Rate (Annual Percent)	
	low	high	low	high	low	high
1974	8	8	31	31		
1985	9	21	36	86	1.3	9.7
1995	10	31	44	127	1.6	6.9

Source: Electric Power in Alaska, 1976-1995. Institute of Social and Economic Research, University of Alaska. August 1976.

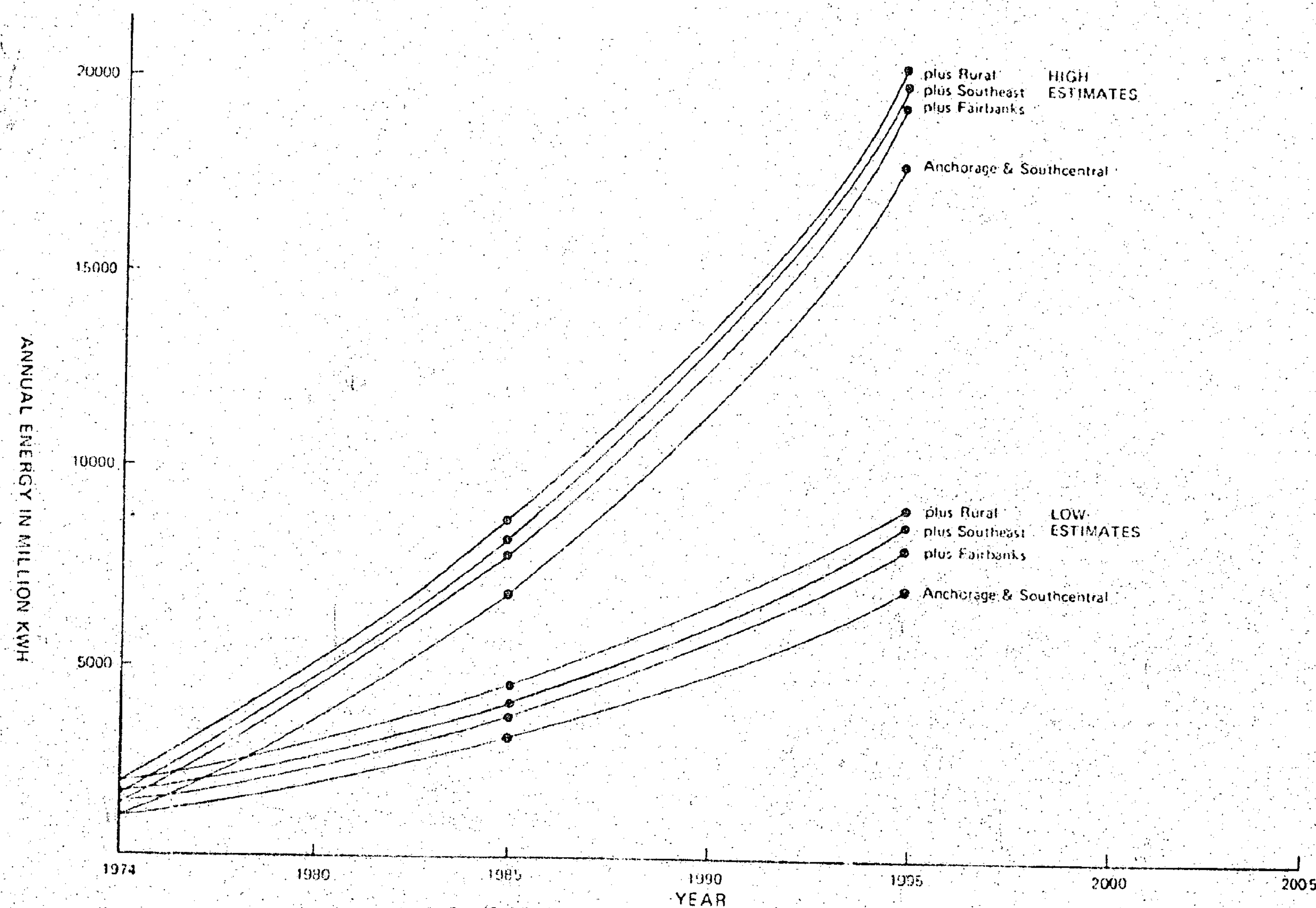


Figure 6-7 Electricity Requirements

Source: Electric Power in Alaska, 1976-1995. Institute of Social and Economic Research. University of Alaska. August 1976.

CHAPTER 7

ENERGY DEVELOPMENT SCENARIOS

The purpose of this chapter is to provide scenarios of the most probable course of Alaska's energy resources development through the year 2000. Primary attention is given to the major resources: oil, gas, coal, uranium, and hydroelectric power.

By necessity these scenarios are speculative, involving a number of assumptions regarding further resource discoveries, development costs, market prices, and related events. In effect, they are a "best guess" based on the knowledge gained by the project team thus far in the study. These scenarios will be subject to considerable change as they are overtaken by events in the future; but once they are established, and their assumptions made explicit, their modification to accommodate events as they occur is a relatively simple process. Thus, the scenarios become a type of a baseline against which to measure future circumstances and their implications for energy development in the State.

The scenarios themselves are done on a Regional basis, primarily because there are frequent interactions between resource development in a given area. There are six scenarios, one for each of the major geographic (and political) subdivisions of the State. A brief chronology has been prepared of the events which seem most likely to occur in view of the information available at this time. In addition, the scenarios are based on a number of assumptions relating to each of the major resources. These assumptions are discussed in detail before the six Regional chronologies are described.

In preparing the chronologies, no attempt was made to identify every possible outcome, or to date events with great precision. Only the broad outlines of the major elements of future energy development are depicted.

SCENARIO ASSUMPTIONS

Onshore and Offshore Oil and Gas

The assumptions made regarding the background for development of onshore and offshore oil and gas in Alaska include the following:

1) Imported crude oil prices will remain high and continue to rise, but the rate of price ~~increase~~ will probably not exceed the general rate of inflation in the U.S.

2) Federal controls on the wellhead prices of oil and gas will probably ease, and will have a minimal effect on exploration for, and further development of, Alaska oil and gas. ("Old" oil in Cook Inlet is one exception.)

3) The ban on further exports of U.S. petroleum and gas will remain in effect.

BLANK PAGE

4) One or more oil pipelines will be built to transport Alaskan crude oil across the lower 48 states, and will be in operation by 1985 or sooner.

5) A natural gas pipeline along the Alcan Highway route will be operating before 1985.

6) Environmental considerations will limit development in certain sensitive areas, such as those in or near major fisheries and wildlife refuges.

7) The use of oil and gas as a feedstock for a petrochemical facility or refinery will occur within Alaska.

8) The State's leasing policies will be promulgated on schedule in order to permit orderly and responsible leasing of State lands with appropriate environmental safeguards.

The rationale behind most of these assumptions is straightforward. Imminent collapse of the Organization of Petroleum Exporting Countries (OPEC) cartel is not predicted, but neither is it believed that OPEC's control over prices is absolute. The present price level has already led to increased petroleum exploration and development in non-OPEC nations, and will continue to do so. Many of the OPEC nations have found that their exports are falling below expectations, generating some strain within the cartel. Further attempts to increase crude oil prices more rapidly than the overall price level would further increase incentives for non-OPEC oil to come on stream, and for importing nations to resort to increasingly stringent measures to stem the outflow of petrodollars.

As part of the process of attempting to diminish reliance on OPEC, the U.S. government is trying to find politically palatable ways of increasing domestic production. This must lead to decreased restraint on wellhead prices of oil and gas, particularly oil and gas which result from new exploration. Alaska already has been treated as a special case due to the high cost of exploration and development; there is every reason to expect this policy to continue, thus minimizing the impact of federal controls on Alaskan wellhead prices. A continued ban on further U.S. exports of oil and gas is entirely consistent with this policy of increasing U.S. self-sufficiency.

The environmental problems associated with energy development in certain parts of the State are extremely serious. Examples are numerous. Oil and gas is thought to lie beneath the waters of Bristol Bay. But, at the same time, Bristol Bay is host to one of the largest red salmon runs in the world. Similarly, the Navarin-Zemchug-St. George petroleum provinces are thought to have substantial oil and gas resources; the area is also reported to supply about three percent of the world's bottomfish. The potential conflict between these two resources is obvious. Similar problems are associated with a number of wildlife refuges, especially the Arctic Wildlife Refuge in the northeast corner of the State on the shores of the Beaufort Sea.

The assumption regarding the State leasing policies requires little explanation. The State is in the process of establishing its leasing policies right now, and there is no reason to believe that there will be any significant delays in publishing these policies in the future.

Assumptions for Coal Development

The assumption on which the scenarios for coal development are based are largely site-specific. This is because different circumstances apply to development at each of the major coal fields at which development is likely to occur. These major sites are the Beluga district of the Susitna, and the Healy River district of the Nenana field, and Jarvis Creek field. The assumptions for each are as follows:

Beluga

1) National Energy Policy will continue to emphasize conversion to coal for electric power generation and other industrial uses.

2) Construction of the Upper Susitna roject will not be started before 1982 or 1983, and the project will not be generating power before 1990.

3) Natural gas prices in the Cook Inlet will continue to rise, increasing demand for alternate power sources.

4) Placer-Amex and Cook Inlet Region, Inc. will continue to favor development of Beluga.

5) The state government will continue to favor orderly and environmentally-sound coal development.

6) Markets will be assured with one or more West Coast utilities.

7) Coal freight rates from east of the Rockies to the West Coast will not be subsidized to reduce the delivered cost of Rocky Mountain coals.

The core of these assumptions is that there will be a definite market for Beluga coal on the West Coast of the United States during the 1980's. In addition, there will be a smaller, but growing, market for Beluga coal in the upper Cook Inlet region. So far, all evidence points to the validity of these assumptions. The other major set of assumptions, involving Placer-Amex, Inc., the Cook Inlet natives, and the state government, is that these major landholders want to develop the coal and there will be no resistance to the project sufficient to impede its development.

Nenana

The major market for Nenana coal, primarily from the Usibelli mine, will continue to be the Golden Valley Electric Association. This utility is expected to expand its coal-fired generating facilities over the next two decades, both to serve the immediate Fairbanks area and to provide the "railbelt intertie" which is expected to be developed in the next 10-15 years in connection with the Susitna Dam hydroelectric project. Even if such a dam were not built, an intertie is still probable based on coal-fired generating plants at Beluga (serving Upper Cook Inlet) and at Healy (serving the Fairbanks area). An additional source of potential power demand in the Fairbanks area is mineral development. Although Alaska's hardrock minerals have only begun to be exploited, the potential appears to be enormous. Much of this development can be expected to be centered in the Fairbanks area.

Jarvis Creek

The only assumptions required for Jarvis Creek development are that the project is sufficiently sound economically to obtain financing, and that there are no environmental or political issues of sufficient magnitude to stop the project. In addition, the number of pipeline pump stations are scheduled to be increased in order to increase the rate of flow of crude oil from the North Slope. This would further enhance the economic viability of the Jarvis Creek project. Finally, there appears to be some likelihood of agricultural development and population growth in the Delta area, which includes Jarvis Creek. There could be a demand for power locally, especially if large-scale irrigation is required for the agricultural development.

Hydroelectric Power Assumptions

Hydroelectric power development in the State takes a number of forms, ranging from the massive Upper Susitna River project, which may involve as many as four large dams, to a large number of relatively small projects with generating capacities of less than 17 MW. The same basic assumptions, however, apply to all of these various projects. These are as follows:

1) Oil and gas will remain expensive, and federal policy will continue to discourage their use for electric power generation.

2) The State government will continue to favor and encourage orderly and environmentally sound hydroelectric power development.

4) There is no change in federal monetary or fiscal policies which would lead to radical changes in rates of inflation, interest rates, or those that would otherwise impede financing of these projects.

5) Environmental and cost trade-offs between coal and hydroelectric power will generally favor hydro or some mix of hydro and coal-fired generation.

The general thrust of these assumptions, of course, is that hydropower will be a [illegible] means of supplying electricity in [illegible] areas. The oil and gas price assumptions are especially important, since the discovery of abundant gas supplies in the Cook Inlet was one of the reasons for postponing [illegible] hydroelectric development in the Anchorage area. This gas, of course, has been committed for sale elsewhere and there is now some question as to how long Anchorage will be able to rely on gas as a fuel source for electric power generation. The remaining assumptions regarding financial feasibility of each of the hydroelectric power projects to be discussed must remain assumptions simply because the detailed financial studies have not been performed in most cases. Thus, it is not possible to say definitively at this time that all of these projects are economically feasible or technically [illegible].

[illegible]

The prospects for uranium development in the state are quite limited. First, uranium must be discovered in economically [illegible] quantities. Economic recoverability, in turn, depends on the price of uranium [illegible] and this depends on future events in the uranium market. The principal assumptions are that there will not be any discoveries of major uranium [illegible] that would seriously depress the current market by greatly increasing supply, and that plutonium produced through a fast breeder reactor program will not be produced in large quantities as an alternative reactor fuel. It is also assumed that nuclear energy development in the [illegible] world will continue at a sufficient pace to maintain, or increase, uranium prices.

Uranium development in Alaska may take one or both of two forms. The first is typified by the Bokan Mountain deposit. There the ore was extremely rich, but the deposit itself was quite small. The most economical procedure was to [illegible], without [illegible] intermediate refining, by [illegible]. Similar small, but very rich, deposits in the state would probably be handled in a like manner. This is [illegible] type of uranium development. More typically, ores are found with much lower concentrations and the only economical procedure is to [illegible] refining at or near the mine site. This form of development has more potential impacts of an environmental, social and/or economic nature. At present, there is no way of determining precisely which course of development is likely to occur, but the probability appears to favor the former, with occasional [illegible] of single extraction and shipment of small deposits of [illegible] ore.

Miscellaneous Scenario Assumptions

In addition to the specific sets of assumptions for the major energy resources likely to be developed in Alaska before the year 2000, there are a number of assumptions to be applied to other potential energy sources. These include the following:

1) There will continue to be strong interest in Alaska in alternatives to refined petroleum products as the basic power source in smaller communities in the State. The alternatives being given serious consideration include wind power, geothermal energy, and small-scale hydroelectric power.

2) Energy demand in the State will continue to grow rapidly as a result of population growth, increasing incomes, and growth in extractive industries such as minerals, forest products and fisheries.

3) Energy sources such as geothermal energy and waste heat will continue to be experimented with as a means of improving and expanding basic Alaskan industries such as fish hatcheries and agriculture.

SCENARIOS

We have prepared six basic chronologies, one for each of the six major divisions of the State: the Arctic Region, the Northwest, the Interior, the Southwest, the Southcentral and the Southeast. The boundaries of these Regions are shown on the accompanying map (Figure 7-1). Within each scenario, we have divided the years between the present and the year 2000 into four major time periods: 1977-1980, 1981-1985, 1986-1990, and 1991-2000. For each of these time periods are described the major energy developments and other related events which current information indicates are likely to occur.

The Arctic Region

Events in the Arctic Region between the present and the year 2000 can be expected to be dominated by the exploration for, and development of, oil and gas resources. The three onshore Arctic oil and gas provinces (the Arctic Coastal Plain and the Southern and Northern Foothills) contain the largest potential undiscovered onshore resources in the State. Similarly, the Beaufort Sea and the Central and North Chukchi provinces also are believed to contain the largest undiscovered potential offshore resources. As noted earlier, exploration and development in these areas is not without problems. Unresolved borders with the USSR and Canada, boundary questions between State and federal lands, and d-2 land withdrawals may slow development. We have assumed that the incentives for Arctic oil and gas development are sufficiently powerful to lead to an orderly resolution of these problems. Nevertheless, these issues could have significant impacts on our scenario for the Arctic Region, and are noted where they occur.

Our scenario for the Arctic Region is as follows:

1977-1980 The trans-Alaska oil pipeline which began flowing in June 1977 starts pumping 1.2 million barrels of oil per day by mid-1978.

Exploration in the Arctic Coastal Plain and the Northern Foothills continues, particularly in the National Petroleum Reserve, Alaska (NPRA).

Oil and gas exploration begins offshore in the Beaufort Sea on federal and State lands.

Uranium exploration under the National Uranium Resource Evaluation (NURE) Program begins in 1978 and continues into the 1980's.

1981-1985 Oil and gas development continues, with expansion of development on the Arctic Coastal Plain and with new development in the Northern and Southern Foothills and in the Beaufort Sea.

Exploration begins in Central and Northern Chukchi offshore provinces. All of this exploration will tend to be close to shore due to the potential boundary problems with the USSR. (This element of the scenario may be altered by the d-2 withdrawals. See below.)

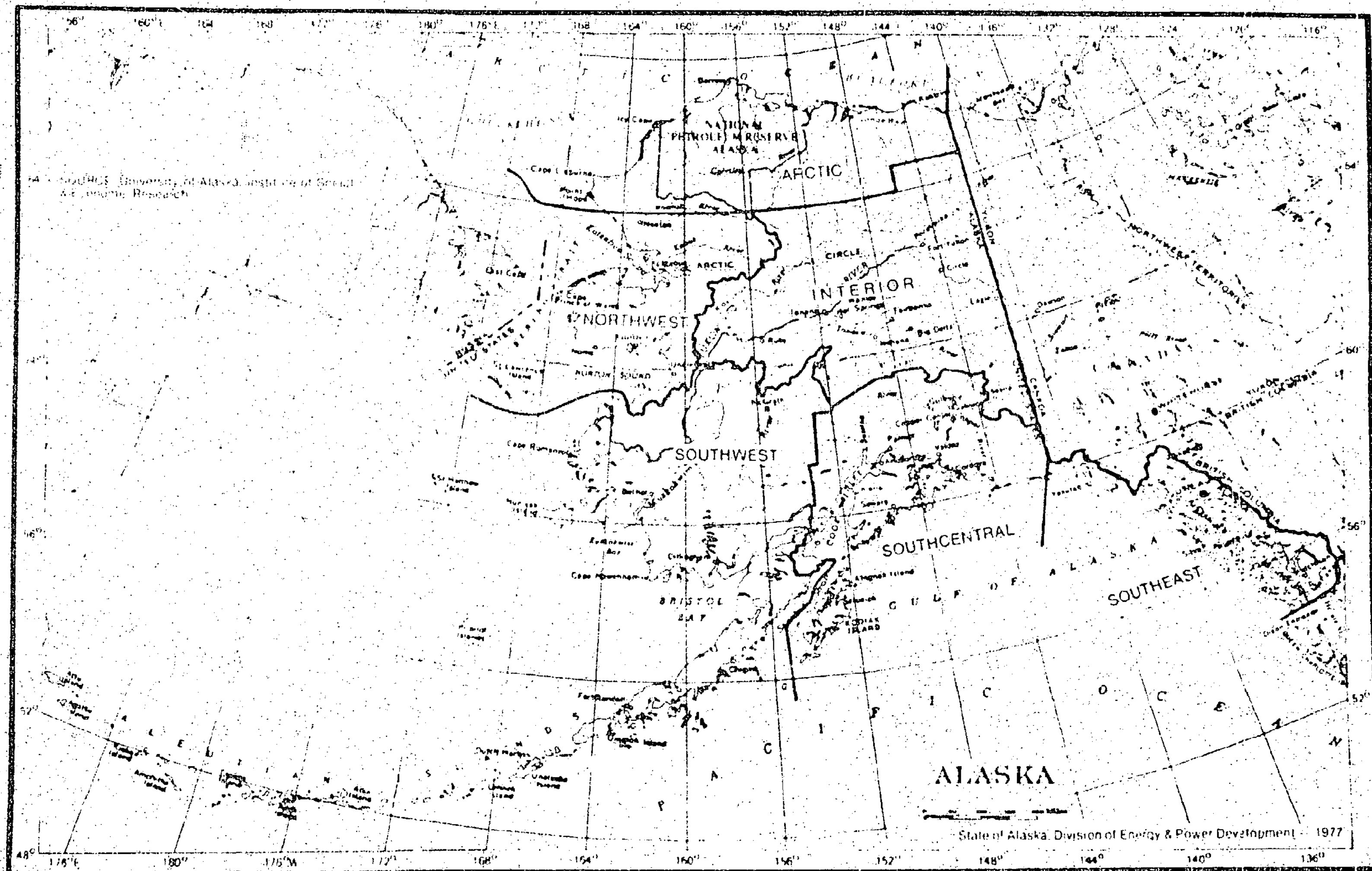


Figure 7-1 Alaska Regions

Source: University of Alaska, Institute of Social & Economic Research

Offshore boundary with Canada extending into the Arctic Ocean will be determined.

Experimental work will begin on wind-powered generation of electricity for isolated Arctic communities.

The Alcan gas pipeline will be completed.

1986-1990 Onshore and offshore development and exploration continue. Discoveries are made in the two Chukchi offshore provinces and onshore in the western portions of the Arctic Coastal Plain and the Northern and Southern Foothills.

Construction begins on transportation facilities to linkup with the trans-Alaska oil pipeline. The route chosen will depend on the existance of d-2 transportation easements near the northwest coast and the extent of development north of the Brooks Range between the west coast and Prudhoe Bay.

The border problems with the Soviet Union will be resolved and oil and gas exploration and development will proceed offshore in the Chukchi Sea.

Construction of wind-powered generators for isolated communities will begin.

1991-2000 All of the above oil and gas developments will continue, along with completion of an oil and gas transportation network.

Experimentation will begin on oil-coal slurries, using Arctic coals from districts west of the National Petroleum Reserve, Alaska.

As noted above, the present plan for d-2 withdrawals has a potential serious impact on the scenario for oil and gas development (and later, coal development) in the Arctic Region. Under current d-2 proposals, a broad band extending virtually across the entire State at the latitude of the Brooks Range and slightly to the south, will be included in the national parks, national wildlife refuges and wild and scenic rivers systems. The only current exception is the corridor for the trans-Alaska oil pipeline. With the possible exception of the Selawik Lowlands, east of Kotzebue Sound, none of this area is expected to contain much oil or gas. However, development in the northwest portions of the Arctic and offshore in the Chukchi Sea can be seriously affected because of the lack of a transportation corridor west of the Brooks Range through the Selawik Lowlands. This route is by far the more economical route to follow, unless there is substantial oil and gas development running across the Arctic Coastal Plains and Brooks Range foothills between the current pipeline and the West Coast. In other words, if a utility corridor is allowed near the West Coast to skirt the Brooks Range, exploration and development are very likely to proceed rapidly offshore on the Chukchi Sea and onshore south and west of Barrow. If such a corridor is not permitted, then there is a greater likelihood that development will proceed more slowly, tending to concentrate on areas closer to the current pipeline route before developing the more westerly portions of the Region. Since the offshore provinces in the Chukchi Sea appear to be among the most promising of any in the State, the latter course of development could be a costly one in the long run.

The Northwest Region

This Region of the State does not appear likely to experience energy development on the scale of the Arctic Region. Current geological information suggests that there is very little fossil fuel potential in this portion of the State. The oil and gas provinces in the Northwest are considered among the least likely to experience significant development. Coal is also not evident in large quantities. On the other hand, the Northwest Region could contain a major energy transportation corridor, with oil and gas pipelines (and possibly a coal slurry pipeline) running through the region toward the Interior from the western portion of the Arctic Region. The most important potential energy development in this region appears to be uranium. At present, both ERDA and private companies consider the Seward Peninsula as one of the most promising areas in the State for uranium development. Another area located in the Northwest Region with some uranium promise is the Selawik Lowlands. Development in this area appears likely to be precluded by d-2 selections, however. Finally, the area contains considerable quantities of geothermal energy, some of which may be developed for local use or as a power source for uranium development and pipeline pumping stations.

Because of the uncertainties associated with uranium discovery and the d-2 selections, a scenario for the Northwest Region is necessarily more tentative than for almost any other region in the State. The scenario we expect, however, is as follows:

1977-1980	Uranium exploration continues. Evaluation of Northwest Region geothermal resources continues. Exploration and evaluation of the potential development of other minerals in the Northwest Region continues.
1981-2000	The scenario for the Northwest Region for this 20-year period depends almost entirely on two contingencies. The first is that uranium is discovered in economically-recoverable quantities, and the second is that transportation easements are allowed through d-2 lands east of Kotzebue Sound. If neither of these events occurs, energy development in this Region will probably consist of little more than the installation of some wind-powered generating facilities and the development of geothermal energy for space heating in a few small communities. If, however, both of the above occur, then the Northwest will contain one of the major energy transportation corridors in the State, including oil and gas pipelines and, ultimately, a coal slurry pipeline running east of Kotzebue Sound. In addition, or alternatively, there may be one or more ports developed on Norton Sound to transport

oil, gas, coal and/or uranium (either raw or semi-refined) to the Lower 48. A major uranium find on the Seward Peninsula would also lead to the construction of a major uranium refining facility, probably near a potential port facility on Norton Sound.

Interior

Because of its central location, the Interior Region automatically becomes a focal point of energy transportation corridors. The trans-Alaska oil pipeline is only the beginning. Construction will be underway in 1979 or 1980 on a gas pipeline (Alcan) crossing into Canada at the eastern border of the region.

Assuming easements in the Northwest on d-2 lands, an additional transportation corridor running east and west through the region will probably occur south of the Brooks Range, linking up with the north-south corridor, north of Fairbanks. In addition, the Interior contains all or part of three oil and gas provinces (Yukon-Porcupine, part of Interior Lowlands, and part of Yukon-Koyukuk), substantial coal reserves (particularly in the foothills of the Alaska Range), geothermal resources, and a small amount of hydroelectric potential (excluding such massive projects as damming of major rivers). Energy resource development is likely to be an important component of the future of the Alaskan Interior.

The scenario we currently envision for the Interior is as follows:

1977-1980 The Alaska oil pipeline reaches 1.2 million barrels per day capacity by 1978.

The Energy Company of Alaska refinery at North Pole expands its operation in 1978.

Expansion of the Usibelli coal operation in the Nenana field begins, and plans get underway for development of the Jarvis Creek field.

Evaluation of Little Tonzona coal continues.

Exploration for oil and gas continues, particularly in the Yukon-Porcupine province, and possibly in Yukon-Koyukuk.

Planning for the Susitna hydroelectric project gets underway (this project is located in the Southcentral Region, but is ultimately planned to serve Fairbanks and other railbelt communities in the Interior).

Some experimental analysis and demonstration of waste heat as an energy source will begin.

1981-1985	Exploration for oil and gas continues with probable development of discoveries close to the pipeline route.
	The gas pipeline is constructed either along an Alcan route or directly south to Cordova.
	Further industrial development occurs in the Fairbanks area to utilize oil and gas as raw materials, particularly gas. A major component of this development may involve the production of fertilizers for agricultural development of the Interior, and for the reclamation of coal mine sites.
	Further potential coal development in the Interior for local power generation in more remote areas will be examined, particularly by means of in-situ gasification.
	Research will begin on the possible exploitation of geothermal energy for small communities in the Interior, particularly those uses related to development of parks and other recreational areas for tourism.
1986-1990	Exploration and development of the two Yukon oil provinces will continue with development of Yukon-Kuskokwim, dependent on a transportation corridor west of the Brooks Range through d-2 lands.
	If the transportation easement through d-2 lands is granted, construction will begin on a pipeline running west of the Brooks Range then south.
	Development of Interior timber may begin, generating its own energy requirements through the burning of wood wastes.
1991-2000	All of the above developments will continue into the 21st Century.

It must be reemphasized that any scenario for the Interior depends heavily on two decisions still pending. One is the question of transportation corridor easements through d-2 lands, and the other is the route finally selected for Alaska's gas pipeline. D-2 transportation easements are required in order to achieve development of the potential oil and gas resources of the western portion of the Arctic Region, both onshore and offshore. If such pipelines are built, the development of the Yukon-Kuskokwim is likely to occur much sooner. The choice of the Alcan gas pipeline route determines the scale and location of impacts on the eastern portion of the Interior. Any industry utilizing natural gas as a feedstock is more likely to locate in the Fairbanks area with the gas pipeline turning east from Fairbanks toward Canada.

Southwest Region

The primary source of major energy development in this Region will be offshore oil and gas. The Region has some coal resources with potential, particularly in the Herendeen Bay-Chignik area, but current d-2 proposals could preclude development of these fields. Other coal development may be possible, however. On a more local level, there is considerable likelihood of development of wind power and geothermal energy for small communities on the Alaskan Peninsula and the Aleutian Islands.

The prospects for the Southwest appear to be as follows:

1977-1980 Exploration for oil and gas on-shore continues by the Bristol Bay Native Corporation.

Wind power and geothermal research and development and evaluation continue.

Evaluation of Alaska Peninsula and Aleutian coal continues.

1981-1985 Exploration for oil and gas on-shore and off-shore continue. If discoveries are made, a gathering point and transshipment port will be developed on the Alaska Peninsula or one of the Aleutian Islands.

Controversy over off-shore exploration for oil and gas in the Bristol Bay area probably prevents development in this province, unless confidence in the technology of blow-out and spill prevention increases substantially.

Some development of small hydroelectric power for local use begins.

1986-1990 Given the high probability of some oil and gas discovery off-shore, as well as on-shore, port development for oil and gas shipment will be completed during this time period. Shipment of some coal for export begins if port facilities for oil and gas development are in place.

1991-2000 Occurrences in this decade depend entirely on the results of oil and gas exploration and development during the 1980's. If sufficient finds are made to allow significant development, this area may become a satellite growth center dependent on oil and gas, and to some extent coal.

Southcentral Region

The Southcentral Region is the most heavily-populated in the State of Alaska, containing the Municipality of Anchorage, a substantial stretch of the railbelt in the Matanuska-Susitna Valleys between Anchorage and Fairbanks, and the relatively heavily-populated (for Alaska) Kenai Peninsula. The Region also contains a substantial amount of energy resources including: oil and gas, coal, hydropower, wind power, some uranium potential, potential geothermal energy sites, and several potential tidal power locations on Cook Inlet. The combination of this resource base and a large and growing population base virtually guarantees that energy development will proceed more rapidly in this Region than in any other in the State, with the possible exception of the Arctic.

The probable course of this development is as follows:

1977-1980 Exploration and development for oil and gas begin in Lower Cook Inlet, both onshore and offshore. Exploration offshore continues in the eastern Gulf of Alaska.

Development plans for the Beluga Coal District of the Susitna Coal Field continue.

Initial feasibility studies for the Susitna Power Project are completed.

1981-1985 Additional oil and gas development proceeds in lower Cook Inlet.

Either significant oil and gas finds are made offshore in the Gulf of Alaska, or the province is essentially abandoned.

An additional petrochemical facility and/or refineries will go on-stream if oil and gas finds are made.

Initial construction begins on the upper Susitna hydroelectric project.

Infrastructure is completed for the development of the Beluga Coal Field, including a road to the West Coast of Cook Inlet, port facilities designed to handle coal, a mine-mouth power plant, and transmission lines around the Knik Arm of Cook Inlet.

Preliminary analysis performed on developing the potential geothermal power in the region.

Further analysis will be performed on the possibilities of in-situ gasification of coal beds in the Cook Inlet area, especially near the new capitol site at Willow.

1986-1990 Generation of power begins at the mine-mouth power plant at Beluga. Shipment of coal to the West Coast begins reaching full production early in this period.

The railbelt power tie-line connecting the Interior and South-central is completed.

Construction continues on the Susitna hydroelectric project, with some power coming on-stream in 1990 or shortly thereafter.

Investigation begins of the possibilities of harnessing tidal power coupled with a vehicular causeway across the Knik Arm.

Development of industrial sites for the refining of aluminum and sponge iron, using the abundant electrical power, begins.

Other industrial development and population growth continue in the Cook Inlet sub-region, with some additional development in the Valdez and Cordova areas.

1991-2000 All of the developments described above continue or are completed.

The Southeast Region

The Southeast is characterized by a scarcity of fossil fuel energy resources. There is very little coal in recoverable quantities, and prospects for oil and gas development are considered to be among the least-promising in the State. The Southeast, however, does have substantial hydroelectric potential because of the enormous rainfall and the steep gradient created by the coastal mountains. In addition, the Southeast is the site of the one uranium mine in the State that has yielded commercial quantities and prospects are considered very good for further commercial discoveries. There is also some geothermal potential in the Southeast. Thus, scenarios for the Southeast consist primarily of the development of energy resources to serve other industries in the Southeast, rather than energy exploration, recovery and transportation being a major driving force in the region's economy.

Energy development scenarios for the Southeast are as follows:

1977-1980 Uranium exploration continues.

Study is continued, and Federal Power Commission licenses are sought for the hydroelectric projects for Ketchikan, Juneau, Petersburg and Wrangell. (See Current Plans for Development of Hydroelectric Power, Chapter 5.)

1981-1985 Construction begins on hydroelectric projects for Ketchikan, Metlakatla, Petersburg-Wrangell and Sitka. Expansion of Juneau hydroelectric power is postponed due to capitol move.

Uranium development depends entirely on uranium finds, none of which are known to be pending at this time.

1986-1990 Construction is completed on the hydroelectric sites described above. Additional hydroelectric planning is continued (all of these hydroelectric sites are small).

Some uranium is undoubtedly found, but development depends on the size of the find and the quality of the ore.

Geothermal research continues.

1991-2000 All of the above continue. Because of the lack of major energy resources for export (with the possible exception of uranium), the scenario for energy development in these later years depends almost exclusively on other non-energy related elements, particularly forestry and fisheries products and minerals development.

CHAPTER 8

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

SUMMARY AND CONCLUSIONS

This Alaska Regional Energy Planning Project report is the first of five planned reports funded by the Energy Research and Development Administration (now the Department of Energy) and administered by the Alaska Division of Energy and Power Development (DEPD).

This report sets the stage for a five-year project that will eventually address all the energy resources in Alaska: oil and gas, coal, hydro-electric, uranium, geothermal, wind, tides, wood, solar energy, oil shale, peat and other energy resources including waste heat. The five-year effort will not only identify all of the numerous energy resource sites in the state that are significant, but will also address the energy operations from exploration to the decommissioning of an energy facility and/or the reclamation of disturbed land. Other energy operations given attention are recovery, storage, transportation, processing and use of the energy resources.

An attempt is underway to analyze the various energy issues (economic, social, environmental, governmental, conservational and technological) as functions of each energy operation and many of the energy sites. Since energy issues related to each resource are numerous and complex, and available funding and time finite, an effective planning effort must limit itself to an analysis of energy sites and operations most likely to be developed.

While this first year report gives considerable information on Native land issues, economic, social, environmental, governmental, conservational and technological issues, the major thrust has been toward an inventory of the key energy resources: oil and gas, coal, hydroelectric power and uranium, followed by a screening and ranking of the sites considered most likely for development between now and the year 2000.

Energy Resources and Energy Areas

Alaska's energy resources are vast and can play a major role in helping to meet the nation's future energy needs. Alaska has 0.2% of the nation's population, 16.2% of the land mass, 32% of the onshore measured oil reserves, 16% of the onshore measured natural gas reserves, 37% to 63% of the coal resources and 26% of the hydroelectric potential. Large differences in Federal and State energy resource estimates are due, in part, to limited, inadequate, and sometimes unavailable data. Reliable resource data are small and generally restricted to the few areas where extensive development or exploration have taken place.

Given the size of Alaska, the uniqueness of its physical and political geography, and the highly variable conditions facing energy development in different parts of the State, it has been useful throughout this study to divide Alaska into six major regions similar to those used by the University of Alaska's Man-in-the-Arctic Program (see Chapter 3 for details). We continue this procedure for the summary of energy resources which follows on the next several pages. In addition, Table 9-1 shows the specific areas in the State (oil and gas provinces, coal fields, etc.) where expert opinion in each energy resource indicates that energy production is most likely to occur by the year 2000.

Arctic Region

Populated with predominately Inupiat Eskimos, the Arctic Region has the smallest numbers with about two percent of the State's population; more than half of the people live in the village of Barrow.

Onshore and offshore, the Arctic Region has the largest known and potentially recoverable quantities of fossil fuels in Alaska. The giant Prudhoe Bay oil field containing recoverable reserves of about 10 billion barrels, is the state's largest producing field. Crude oil is transported from the field to Valdez in Southcentral Alaska via the $7.7 billion recently completed 800-mile Trans-Alaska pipeline. A gas pipeline has been approved for construction through Canada to transport the field's gas. Natural gas is also produced for local consumption near Barrow.

An intensive oil and gas exploration program, administered by the U.S. Department of Interior, is now being conducted in the 23.3 million acre National Petroleum Reserve, Alaska (NPRA), [illegible] west of Prudhoe Bay. Part of the 8.9 million acre Arctic National Wildlife Range, located between Prudhoe Bay and the Canadian border, is believed to have excellent oil and gas potential and accordingly, a part of the range has been recently identified by the State of Alaska for selection to partially fulfill its statehood entitlement, as was, similarly, a portion of NPRA. No petroleum exploration is allowed at this time in the Wildlife Range by the Interior Department.

Identified recoverable oil resources in the Arctic exceed 10 billion barrels, all onshore. Undiscovered recoverable oil resources, onshore and offshore are estimated at 13 to 24 billion barrels. Total recoverable oil resources, identified and undiscovered, are estimated at 23 to 34 billion barrels representing from 35 to 40 percent of Alaska's total recoverable oil, onshore and offshore.

The Arctic's identified recoverable gas resources exceed [illegible] trillion cubic feet, all onshore. Future finds of recoverable gas, onshore and offshore, are estimated at 52.2 to 93.4 trillion cubic feet. Total recoverable gas resources, identified and undiscovered, are estimated to range between [illegible] and 111.6 trillion cubic feet, or approximately 37 to [illegible] percent of the state's total recoverable natural gas resources, onshore and offshore.

One of the world's largest coal fields is located in the Arctic Region. It extends almost 300 miles inland from the shores of the Chukchi Sea and although it extends offshore under the bed of the Chukchi Sea the eastward

Table B-[illegible]

[illegible]

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

*Based on a survey of energy experts conducted early in 197[illegible] by State of Alaska, Division of Energy and Power Development extent is unknown. The major portion of the field onshore varies in width from 25 to 100 miles, with much of it lying within the borders of NPRA. Identified coal resources in the Arctic Region exceed 122 billion short tons, all onshore. One sixth of the deposit is bituminous -- some with coking properties -- and the remaining beds are subbituminous and lignite coals. Undiscovered coal resources, onshore and offshore (limited to the area within the three nautical mile limit in the Chukchi Sea), are estimated at 346 billion to 3.5 trillion short tons -- representing somewhere between 18 and 69 percent of the State's remaining coal. Although anthracite and semianthracite coals are found in the Lisburne Field (Point Hope) on the westernmost part of the Arctic, no estimates have been made for these deposits.

Other energy resources include sub-economic oil shale deposits and some geologists suggest uranium may be discovered in the region. Arctic Alaska is not favorable for geothermal or hydroelectric development. A statewide waterpower inventory did not find any hydro sites with the necessary combinations of head, water supply, damsites and reservoir potential that would indicate potentially feasible hydro projects for the Arctic. Although three sites, totalling 1,073 million kwh were found, all are in the higher priced index groups. The wind, which blows strong and persistent in the northern half of the region, is a potential renewable energy resource which might be harnessed.

Northwest Region

Centering around Kotzebue and Nome, the Northwest Region has approximately three percent of the State's population, made up predominately of Inupiat Eskimo people.

No oil or gas discov-ries have been made in the Region and estimates for future finds are modest. Estimates of undiscovered recoverable oil vary from 0.7 to 6.8 billion barrels, representing an estimated two to eight percent of the total crude oil expected to be recovered onshore and offshore of Alaska. Estimates of potential natural gas deposits range from 2.0 to 36.0 trillion cubic feet, representing two to nine percent of the State's potentially recoverable gas, onshore and offshore. Of these, the largest oil and gas deposits are expected to be found offshore.

The coal areas in this Region are generally classified as occurrences and little is known about the extent of the resource and no known coal resource estimates are available for the Region. However, coal outcrops are known to exist along the Kobuk River in at least six locations, on the Seward Peninsula along at least four streamcuts and at two sites near Unalakleet.

Future discoveries of uranium resources on the Seward Peninsula and in the Selawik area are thought to be very favorable. Several locations with exceptionally high radioactivity have been found in the Northwest Region.

As in the other northern regions of the State, hydroelectric potential is not good, primarily because of a realtively low runoff and the hydro sites being located only on the main stem of rivers. A total of 11 undeveloped sites with 3,177 million kilowatt hours of potential have been identified. Five of these are considered as lower priced sites by the Alaska Power Administration.

Geothermal resources are abundant. Many geothermal springs are found in the area near the village of St. Michael, on St. Lawrence Island, on the Seward Peninsula, and in the Purcell Mountains. Pilgrim Hot Springs north of Nome on the Seward Peninsula is one of three "Known Geothermal Resource Areas" (KGRA's) in the State.

Interior Region

Approximately 17 percent of the State's population lives in the Interior Region. Communities range in size from small, primarily Athabascan Indian villages along the Yukon River and its tributaries to the Fairbanks metropolitan area.

Because no commercial discoveries of oil or gas have been found in the Interior Region, no estimates of identified resources are available. Potential recoverable oil resources are considered small when compared with estimates for other regions in the State. Estimates vary from 0.2 to 3.7 billion barrels of recoverable oil, representing 0.4 to 4.3 percent of the State's total oil resources, onshore and offshore. Estimates of natural gas resources vary widely from 1.0 to 15.4 trillion cubic feet, representing anywhere from 1.2 to 13.8 percent of the State's total onshore gas and 0.8 to 3.8 percent of the State's total onshore and offshore natural gas. Some crude oil from the Arctic Region is refined at North Pole, near Fairbanks, transported by the Trans-Alaska pipeline, which is routed through the Region.

Coal resources in the Interior Region are significant (albeit small compared to the Arctic and Southcentral Regions) with several coal fields and outcrop occurrences. Remaining identified coal resources (measured, indicated and inferred) are estimated 5.4 to 7.0 billion short tons, representing 3.9 to 5 percent of the State's total remaining identified coal resources. Total undiscovered remaining resources are estimated at 9 billion short tons, representing less than one percent of the State's total undiscovered remaining resources. Total remaining coal resources (identified and undiscovered) are estimated at 14.3 to 15.9 billion short tons or less than one percent of the State's total remaining coal resources. The State's only major producing coal mine is located in the Interior Region at Usibelli, about 120 rail miles south of Fairbanks. Production from the surface mining operation -- about 724,000 short tons in 1976 -- is from the Healy District of the Nenana Coal Field and is used primarily to produce electricity for Fairbanks and vicinity.

Although the Yukon River is the largest potential hydroelectric resource in the United States, hydropower development is not favorable due predominately to serious potential environmental problems associated with development. The Interior Region, with at least 48 undeveloped sites totaling 93,885 million kwh includes Rampart at 34,200 million kwh, Kaltag at 13,100 million kwh, and Woodchopper at 14,200 million kwh of firm energy. The three sites noted contain 66 percent of the Region's hydro potential. Except for main stem developments, such as the sites listed above, there are no good potential water power sites north of the Alaska Range. Northern slopes of the Alaska Range are too steep and lack storage capacity. According to the Alaska Power Administration, only a few sites can be physically developed in the Yukon Basin: four on the main stem of the Yukon River and six on its tributaries. No known hydro-electric sites have been developed in the Interior Region.

Uranium potential in the area is not well-defined at this time, but is considered to be relatively high. The Region also has sizable geothermal resources: especially notable are the many hot springs in the Region located in a belt trending east-west through the center of the Region.

Southwest Region

Almost entirely Native in origin, the Southwest Region has about seven percent of the State's population. It consists of Yupik Eskimos living in villages surrounding and including Bethel and Dillingham, Aleuts living in villages scattered along the Aleutian Islands and Athabascan Indians who live inland in villages along the lower Yukon and Kuskokwim Rivers. By far the largest number of small villages in Alaska are located in the Southwest Region.

Oil and gas resources, thought to be very large in the Region, are untapped at this time. Offshore petroleum provinces in Bristol Bay and the Bering Sea are among Alaska's most promising for future petroleum discoveries, however, because of a potential negative environmental impact on the fisheries, development may pose serious problems.

Because no oil and gas discoveries have been made, no estimates of identified oil or gas reserves are available for the Region. However, undiscovered recoverable oil resources, onshore and offshore, have been estimated at 2.9 to 28.6 billion barrels, representing a range of 6.6 to 33.3 percent of the total recoverable oil resources of the State. By far, the largest deposits of oil and gas are expected to be found offshore. Undiscovered recoverable gas resources, onshore and offshore, are estimated at 7.4 to 166.4 trillion cubic feet, representing from 6.2 to 40.6 percent of the State's potential recoverable gas. Marked differences in estimates, especially noteworthy in this Region, are due to the absence of exploratory drilling data.

Deposits of lignite, subbituminous and bituminous coals are scattered throughout the Region. Coal fields are located on Unga Island and at Herendeen Bay and Chignik and there are occurrences at Little Tonzona, Etolin Straits and in the lower Kuksokwim and lower Yukon River Basins. Although no known estimates of identified resources are available, undiscovered remaining coal resources have been estimated at 3290 million short tons, representing less than one percent of the total remaining coal resources, identified and undiscovered, of the State.

Due to its small population and therefore low electric power demand, the Southwest Region has not been studied intensively for its waterpower potential. At least 23 undeveloped hydroelectric sites have been identified in this region, however, with the potential of producing a total of 26,462 million kilowatt hours of energy, including the huge Holy Cross site, at 12,300 million kwh. No inventory of smaller sites, those capable of producing under 2,500 kw of continuous power, has been made for this region.

A very large geothermal potential exists in the Southwest Region due to the many volcanoes and hot springs. Two of the three areas designated "Known Geothermal Resource Areas" (KRGA's) in Alaska are located on Umnak Island in the Aleutians. Uranium investigations indicate some potential may be present. The Region has an excellent wind power potential as there are strong winds in all seasons especially along the Aleutian Islands.

Southcentral Region

Containing more than 59 percent of the State's population, the Southcentral Region's inhabitants are concentrated in the Municipality of Anchorage--the State's largest incorporated community -- and in settlements along the railbelt of the Alaska Railroad as well as the coastal communities centering around the cities of Kodiak, Kenai, Soldotna, Seldovia, Seward, Homer, Valdez, Cordova and Glennallen. The population is predominately non-Native, but several Native groups are represented, including Athabascan Indian, Eskimo, Aleuts and a very few Eyak Indians.

The headquarters for most of the energy-related industries in the State, two of the three petroleum refineries and all the petrochemical manufacturing in Alaska, and the terminous of the Trans-Alaska oil pipeline are located in the Southcentral Region. Oil and gas are being recovered onshore and offshore of the upper Cook Inlet area and federal oil and gas leases have been sold for Outer Continental Shelf lands in lower Cook Inlet and along the Eastern Gulf of Alaska where exploratory drilling is underway.

Total identified recoverable oil reserves are conservatively estimated at 0.8 billion barrels, almost equally divided between onshore and offshore deposits. Undiscovered oil resources (hypothetical and speculative) are estimated at 3.6 to 10.0 billion barrels, or more, of which 0.7 to 1.7 billion barrels are estimated for onshore areas and 2.1 to 8.1 billion barrels are estimated for offshore areas. The Southcentral Region is thought to have eight to 11 percent of the State's recoverable oil potential.

Identified recoverable natural gas reserves (measured, indicated and inferred, onshore and offshore) are estimated at 3.7 to 8.8 trillion cubic feet, representing 12 to 17 percent of the State's known gas. Undiscovered recoverable gas resources (hypothetical and speculative, onshore and offshore) are estimated at 7.1 to 59.4 trillion cubic feet with substantially more gas expected to be found offshore than onshore. Total gas resources (identified and undiscovered, onshore and offshore) are estimated at 16 to 63 trillion cubic feet representing 13 to 15 percent of the State's total onshore and offshore gas potential.

There are several coal fields in the Region, principally the Susitna - Cook Inlet - Kenai Fields, Matanuska Field, and Broad Pass Field, all centering on Upper Cook Inlet, as well as the Bering River field near Cordova. Identified remaining coal resources (measured, indicated and inferred) are estimated at 10.7 billion short tons. Undiscovered remaining resources (hypothetical and speculative) are estimated at 1.484 trillion short tons. Total remaining coal resources, estimated at 1.495 trillion short tons, represent from 29 to 79 per cent of the State's total remaining coal resources, identified and undiscovered. Development of the Beluga Coal field, near Tyonek, is in the early planning stages.

Also in the early planning stages is a major hydroelectric power project on the Susitna River which will produce about 1,600 MW of power and will serve the entire railbelt area and over 80 percent of the State's population. Two existing hydroelectric projects are located in the Region at Eklutna and Cooper Lake. Conventional hydropower potential is substantial, with an estimated 52,137 million kwh of undeveloped hydropower potential in 107 sites, 23 of which are considered by the Alaska Power Administration to be lower priced sites. Away from the coast, there is much lighter runoff and less steep topography. Farther inland where there are damsites on the bigger rivers having larger flows, there are several significant, power potentials, such as those on the Copper River and Susitna River.

Tidal power potential at Cook Inlet is among the most promising in the United States, and could serve the electrical needs of the entire Southcentral Region in years to come. The geothermal potential is considerable, particularly in the Wrangell Mountains to the east, and the Aleutian range in the west. There are several dormant and active volcanoes in the area, but geothermal springs are limited in number. Discoveries of uranium are thought to be very likely and opportunities are excellent for harnessing the wind along coastal areas, islands and mountain passes in the Southcentral Region.

Southeast Region

Approximately 12 percent of the State's population live in the Southeast Region. Although the population is predominately non-Native, a substantial number of Tlingit and Haida Indians as well as some Tsimshian Indians are residents. The largest population center is Juneau, the State's capital city. There are no overland road connections between any of the Region's major cities, Juneau, Haines, Sitka, Petersburg, Wrangell or Ketchikan.

Petroleum resources in Southeast are thought to be small. No known oil and gas reserve estimates are available. However, undiscovered recoverable oil is estimated at 0.6 to 2.9 billion barrels. Undiscovered recoverable gas is estimated at 1.5 to 17.7 trillion cubic feet. This represents less than five percent of the State's total potentially recoverable oil and gas, identified and undiscovered, onshore and offshore.

Although several occurrences of coal are known, such as on the mainland between Icy and Yakutat Bays, on Admiralty Island at Kootznahoo Inlet and Murder Cove, on Prince of Wales Island at Kasaan Bay, on Kupreanof Island at Hamilton Bay and on Kuiu Island at Port Camden, no resource estimates are available. Most of the coals are lignite, but previously mined beds of bituminous coal are found at Kootznahoo Inlet.

The most significant of the Region's energy resources is the hydroelectric potential. Over two hundred potential hydro sites have been identified. Sixty sites inventoried by the Alaska Power Administration could produce 17,051 million kilowatt hours of energy. Potential small hydroelectric sites are numerous due to the existance of many small drainage basins with high runoff rates. Most major communities are using hydropower and further development is planned.

Possessing the only uranium actually mined in the State, at Bokan Mountain, the Region has a significant uranium potential and prospects are considered good for further finds nearby.

The geothermal potential is substantial, especially on Chichagof Island and on the mainland along the Stikine River and northeast of Bell Hot Springs. Other geothermal occurrences are known at Lituya Bay, Prince of Wales-Kosciusko Islands and Zarembo Island.

Wind resources along the rugged, unsheltered portions of the coastline are significant.

Key Energy Issues

Alaska has a mix and abundance of energy resources that are very large compared with other states. However, a resource is one thing; the development of that resource is quite another.

The uncertainty of Alaska's land tenure has, and will continue to have, an adverse effect on energy development. Alaska Natives are awaiting title from the federal government to most of the 44 million acres of land selected to settle their aboriginal claims. The State of Alaska is seeking title to the remaining 30-33 million acres of lands selected to fulfill its 104 million acre Statehood entitlement, and the State's organized Boroughs, which are similar to counties elsewhere in the U.S., have filed suits to get title conveyed to 10 percent of the State lands that are within their borders. The Federal government is seeking to settle the D-2 lands issue--affecting as much as 147 million acres of Alaska land -- to determine which lands will be set aside for addition to or creation of the nation's forests, parks, wildlife refuges and wild and scenic rivers in Alaska. Land easements and energy corridor decisions alone can make or break Alaska as an energy source for the nation.

Large energy development is dependent upon a major market. With such a small population within the State, the large energy markets are predominantly out-of-state and many miles removed from Alaska. In addition to added transportation costs resulting from large distances to market, Alaska also has very high construction costs and high facility operation and maintenance costs. Economic issues in Alaska are different from the Lower 48 and must be approached accordingly. For example, an energy resource development considered large in the Lower 48 may actually be much too small to be economically viable in Alaska.

Just like other items, the cost of social services delivered to Alaska's citizens is extremely high. With a population widely scattered over a huge rugged land mass, transportation and, therefore, food and materials prices are the highest in the nation. Yet most residents of these remote rural communities are probably the least able to afford these high costs because of the absence of a viable economic base in their communities.

Of all the States, only in Alaska is the hunting of whales a serious international food issue; only in Alaska are "honey buckets" a current human sewage disposal method; and only in Alaska does the socio-educational scenario exist which could produce the "Molly Hootch case", a class-action suit to bring secondary educational services to even the smallest, most remote village. Further, climatological conditions such as excessive amounts of winter darkness have contributed to the growth of crime, alcoholism and suicide.

Of important social concern is the future lifestyle options of Alaskans, especially the Natives. The Alaskan Natives are likely to play a very important role in any major energy development because of their large land holdings as a result of the Native Claims Settlement Act. Native Corporations are very interested in obtaining revenue from their energy resources to increase the standard of living of their stockholders. Many of the Natives have enjoyed a lifestyle of subsistence hunting and fishing with little outside interference. Energy development within or near their lands will tend to affect, for better or worse, their lifestyle. Possible cultural impacts and the need for different social services must be examined before energy development is undertaken in many parts of Alaska.

Transportation remains a critical element governing the ability of Alaska's energy resources to compete with those of the Lower 48. Exploration, recovery and production costs are all dependent on the transportation systems required to carry out those activities. For example, existence of an oil or gas pipeline from Northern Alaska to Lower 48 markets enhances the feasibility of additional exploration in other northern parts of the State. Similarly, the lack of such transportation systems may preclude recovery of all but the largest finds.

In our planning efforts, the enhancement of our environment, the abundance of wildlife, and the social betterment and increase in the standard of living of Alaskans are goals as important as the development of economic feasibility of energy resource recovery. Careful and detailed planning is necessary as energy producers address themselves to the issues which energy resource development generates.

RECOMMENDATIONS

Expansion of Surface and Sub-Surface Exploration Activities

As shown earlier in this report, some energy resource estimates vary widely. Actual known or proven reserves are small compared to what is believed to be the energy potential of the State. Alaska is still a frontier state, but there is little doubt that large quantities of oil, gas, coal and uranium await discovery in onshore and offshore areas.

In recent years, however, Alaska Statehood and Native land claims selections have been made based on limited energy resource data. Additionally, withdrawal of millions of acres of "D-2" land may soon be initiated by Congress also based on a limited energy resource data base.

A major increase in energy resource exploration (surface and sub-surface) should be initiated immediately. Without adequate knowledge of the magnitude, quality and location of Alaska's energy resources, these issues and other critical energy related development questions cannot be properly addressed by governmental and private decision makers.

Technology for Large-Scale Energy Operations

Technological advances have been especially important to Alaska in energy recovery as illustrated by construction of oil and gas platforms in Cook Inlet and in transportation by the completion of the 800-mile Trans-Alaska Pipeline.

Attention must now be given to technologies which could either extend the recovery life of a specific resource site or would enable development in areas which are otherwise marginal or uneconomic. For example, declining oil production in Cook Inlet will soon make some platforms uneconomical to operate. The utilization of advanced (secondary and tertiary) recovery methods for oil and gas will be needed in the near future.

Modifications to the solvent refined coals (SRC) process should be examined to determine optimum temperature, pressure and catalyst for processing Alaska's low sulfur coal with the goal of high Btu products with very low ash content. In-situ coal gasification advances and fluidized bed technology as a heat transfer mechanism for both geothermal and coal energy should be examined.

Alternate Energy Systems for Rural Communities

Remote rural communities throughout Alaska pose special problems. Many of these villages have the highest per capita energy costs in the nation, yet their residents have subsistence lifestyles and are often below the poverty income level.

An inventory of the energy resources near these villages should be conducted. Wind and hydro and, particularly, resources that can be burned such as coal, peat, wood, garbage, and sewage should be inventoried. Technologies to match the resources should be evaluated (i.e., small hydro systems where adequate flow and head exists and small fluidized units for space heat and waste disposal of combustible materials). The possible use of fuel cells, heat pumps and wind systems need to be examined on a community-by-community basis. Waste heat recovery potential should also be analyzed.

Planning

As Alaska's energy resources are inventoried and primary energy development sites are identified, the collection of economic, social and environmental baseline data should be initiated immediately. Also, impact analyses must be undertaken at an early date. It is crucial that all future energy development activities in Alaska take place with adequate understanding of the probable short and long term impacts specific development will bring.

Land and environmental issues alone make progress on the path from recovery to transportation a major challenge. The results of site specific as well as regional planning efforts must provide users with a full understanding of key decision points in the developmental process including the implications of alternative decisions.

Energy Needs

Three markets for Alaskan energy exist -- foreign, the Lower 48 and in-State. Because of the abundance of our energy resources, there appears to be no reason, at this time, why both needs cannot be met.

In order to meet the long term needs of Alaska, it is recommended that attention be given to providing a balanced energy mix within each region with emphasis on the use of alternative energy sources such as hydro, geothermal, tidal and wind. In the Cook Inlet areas, for example, coal, hydroelectric and tidal energy could possibly meet even the highest demand projections.

It is also recognized that Alaska will be called upon to help solve the current energy crisis. It is recommended that Alaska do its share in meeting the energy demands of the nation and use the opportunity to alleviate some of our own problems such as unemployment and to expand our economic base. Subsequent energy development must be carried out in such a manner that growth is controlled and reasonable and the Alaskan lifestyle is retained and enhanced. Good planning, assessment of impacts, and governmental and private cooperation are important aspects of the transfer of Alaskan energy to the Lower 48.

The foreign part of the Pacific Rim may be a future market for Alaskan coals. It is recommended that Alaska address the potential for shipment of coal to Japan, Korea and Australia.

Conservation and Renewable Resources

As elsewhere in the country, Alaskans must also develop a conservation ethic in their energy use. Opportunities for cogeneration and waste heat utilization should be identified for both new structures and retrofit of older facilities. Construction of energy-efficient buildings in all sectors should be ensured.

The abundance of renewable energy resources sets Alaska apart from her sister states. Small and low-head hydro power, wind and geothermal energy, particularly, should be given immediate attention as possible alternative energy sources. This assessment should also include the potential conversion or expansion of existing systems as well as the planning of new facilities.

CHAPTER 9

PLANS FOR ADDITIONAL STUDY

Preliminary conclusions reached in Phase One of the Alaska Regional Energy Resource Planning Project reveal that more information on Alaska energy resources is urgently needed in order to properly plan for the energy needs of Alaska and the nation.

Purpose and Objectives of Additional Study

One of the purposes of the Alaska Regional Energy Resource Planning Project is to collect, assemble, and evaluate data and information on alternative Alaskan energy resource development operations, and on a wide variety of issues related to that development. More specifically, the objectives of the project are to:

1) Identify Alaska's recoverable energy resources and relate the resource estimates to Alaska's energy needs in order to meet the requirements of the general welfare of the people of Alaska and the commercial and industrial life of the State, with due regard for the protection of the environment and the conservation of natural resources.

2) Collect appropriate information that identifies the energy opportunities of the State of Alaska with respect to meeting national energy requirements.

3) Collect appropriate information that identifies Alaska energy opportunities associated with in-State processing of energy resources.

4) Examine and evaluate new technologies to reduce waste, foster recycling, upgrade the environment, increase efficiency, and encourage conservation practices.

5) Determine programs, policies, and strategies for Alaskan energy development which will take into account environmental, economic, and social costs.

6) Recommend appropriate policy measures and actions to State and national officials that will further the above objectives.

The users of this project will be many. Federal agencies may use the information as part of their required annual progress report to the Congress. The Division of Energy and Power Development will use the results in planning the support for the Alaska Power Authority and in supporting economic development activities within the State. Electrical utilities may use the reports to determine the potential feasibility of alternate energy sources and technology options for electrical energy production. Unversities may use the reports as input for courses on energy and for research. Industry may examine the reports for significant conservation and environmental benefits resulting from identified technologies. Financial institutions may use the results in their portfolio planning. Many groups and individuals will

BLANK PAGE

benefit from the land tenure information that will be collected and analyzed. The approach taken to quantify and compare social parameters and development impacts, together with mitigating options, may be utilized by the state government, local communities, and Native groups.

Comprehensive Energy Planning Elements

In order to provide an appropriate structure for Alaska's energy [illegible] planning, the project team divided the program into five major planning elements: (1) energy resources; (2) energy development operations; (3) energy issues; (4) levels of analysis; and (5) information collection and exchange. Thorough analysis of each of these planning elements for each energy resource would require efforts far beyond the scope of this project. Thus, future study will focus on a subset of these elements. Choice of the specific elements for further analysis has been dictated by several factors, including: relative importance, relevance to current Alaska and/or national issues, lack of specific work by others directly applicable to Alaska, and potential for coordinating work with other on-going or prospective research activities. The comprehensive energy planning elements are tabulated in Table V-1.

Near Term Plans for Additional Study

Current near term plans include: (1) preliminary environmental, social and economic impact assessment of Beluga Coal Field development; (2) Alaskan coal development analysis; (3) Alaskan hydroelectric power development; (4) Alaskan energy alternatives; (5) energy waste utilization, conservation and [illegible]; (6) extension and update of the preliminary Alaska Energy Resources Inventory; (7) government regulations and procedures for energy development; and (8) planning and reporting. More information on the content of the above tasks are given below.

(1) Preliminary Environmental and Market Impact Assessment of the Beluga Coal Field

Battelle Pacific Northwest Laboratories (BNW), in Richland, Washington, is currently conducting market analyses and site investigation activities in the Beluga Coal Field under the auspices of the National Coal Utilization Assessment Program. Close coordination between the Division of Energy and Power Development and BNW will be maintained to ensure that all activities are complementary in nature. Much of BNW's work will be used in preparing specific development options for Beluga coal.

In addition, Argonne National Laboratory plans to conduct an environmental assessment and monitoring program pertaining to Alaskan coal development and the Beluga Coal Field in particular. Their identification of environmental parameters, establishment of a baseline data monitoring program, and development and [illegible] of relevant reclamation technologies will provide [illegible] with valuable information and analysis which otherwise would not have been possible under existing budget constraints.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]

[illegible]

- [illegible]
- [illegible]
- [illegible]

[illegible]

Because these separate but related efforts tie in closely with the work being conducted in the Alaska Energy Resources Planning Project, their findings will be included to meet our objective of identifying, in a preliminary manner, the completion of a Beluga Coal market analysis.

Preliminary Social and Economic Impact Assessment of the Beluga Coal Field

During the past year, under the Pacific Northwest Regional Assessment Program, PNL-Seattle has developed a methodology for assessing the social impacts of energy related development using quality of social life indicators. A cooperative effort between PNL and DEPD will be implemented to validate the methodology and to utilize the same model in identifying social impacts associated with future development of the Beluga Coal Field in Cook Inlet, Alaska.

(2) Alaska Coal Development Analysis

A major policy objective of the present Administration and the Congress is to maximize the use of the Nation's coal reserves, substituting coal for increasingly scarce oil and gas. Given the lack of coal close to the major population centers of the West Coast and the enormous reserves of low sulfur coal potentially available in Alaska, a careful examination of the possible shipment of Alaskan coal to the U.S. West Coast, as well as use within Alaska, needs to be undertaken. The objective of this task is to plan for the timely and environmentally acceptable recovery and transportation of large quantities of Alaskan coal.

(3) Alaska Hydroelectric Power Development

Hydroelectric power, like coal, represents a major alternative to oil and gas as an energy source. Although hydroelectric power does not represent a potential Alaska energy export to the rest of the United States at this time, increased availability and use of hydroelectric power in Alaska can assist the rest of the Nation in meeting energy substitution goals: first, the extent that hydroelectric power can be used to substitute for oil and gas consumption in Alaska, thereby releasing more oil and gas for export; second, the availability of reliable and abundant hydroelectric power in Alaska which could lead to the migration of electric power intensive industries, such as aluminum, to Alaska, thereby lessening the demands on electric power generation in the Lower 48; finally, from the point of view of quality of life in Alaska, the potential development of hydroelectric power on a smaller scale can make it possible for many communities in less populated areas of the state to greatly reduce the costs of their power. The objective therefore is to do the planning that is necessary for greater utilization of hydropower in Alaska.

(4) Alaska Energy Alternatives

At present, most small communities and remote villages in the State of Alaska are dependent upon, at great cost, gasoline or diesel operated generating units for electric power. Fuel oil in various forms, all very expensive, is also a major energy source for home heating. The welfare and quality of life of these communities would be vastly improved if lower cost alternatives for providing these energy needs can be proved to be technically and economically viable. The objective is to determine alternate energy options that merit consideration for installation in a given area. Windpower, fuel cells, very small hydroelectric generating units and low temperature geothermal energy for home space heating will be studied.

(5) Energy Waste Utilization, Conservation and Conversion

The major objectives of the national energy policy are to do the necessary planning in order to conserve energy, to better utilize waste energy and to convert oil and gas use to coal and renewable energy resource use. Study will include the potential for capturing and utilizing waste heat generated by a number of major energy users in the State, such as the trans-Alaska oil pipeline, the North Kenai petroleum complex, the State's electric utilities (especially in Anchorage and Fairbanks), and the Alaska Village Electric Cooperative's 48 generating sites. Another area to be examined is the potential for utilizing the wood waste generated by Alaska's forest industries as a potential energy source, not only for the industries themselves, but also for the communities associated with these industries. Petroleum conservation and conversion is a third topic in this area which requires close examination. The trans-Alaska oil pipeline uses a substantial quantity of the oil transported as the energy source for pumping stations. This will also be the case with the Alcan gas pipeline unless measures are taken to utilize alternative energy sources, such as hydroelectric power, enabling more of the product to reach its final destination. To release more oil and gas into the Lower 48, it is important to shift more of the power suppliers in the State to hydroelectric power and coal. Thus, this area of analysis is closely intertwined with the hydroelectric and coal studies described in other tasks. The principal area of analysis under this topic will be the technology of oil and gas pipeline transportation and the potential for conversion to alternative energy resources.

(6) Extension and Update of the Preliminary Alaska Energy Resources Inventory

An up-to-date inventory of Alaska's energy resources has been one of the principal objectives of this project. It is vital that the inventory be continually expanded and updated to fill in any gaps and to accommodate new data as they become available. The objective, therefore, is to identify and document Alaska's potentially recoverable energy resources. The emphasis will be on coal, hydropower, geothermal energy, wind, waste heat and wood.

(7) Government Regulations and Procedures for Energy Development

A major objective of national energy policy nationwide is, wherever possible, to design a procedure leading to sound energy development. This procedure includes relations between federal, state and local policies and regulations; jurisdictional, land tenure and ownership matters; and political interactions between different levels of government. In order to provide for the smoothest possible path to rational economic development, it is vital to catalogue and describe all of the different decision points which might arise out of these different policies, regulations and ownerships. The objective is to list and identify problem areas in the federal, State and local permits, licenses and written approvals required for various coal and hydropower development operations on public and private lands in Alaska.

(8) Planning and Reporting

The essential objective of this task is to satisfy the need for information exchange arising out of this project. The analysis and findings of the project team must be made readily available to other government agencies and to the public; various reports and plans will be published to this end.

Other Study Plans

Subsequent phases of the energy resource planning project include Phase Two, to be completed in October 1978 and Phases Three through Five, set for 1979 through 1981.

Phase Two will emphasize coal, hydroelectric and waste heat energy. The detailed work plan for Phases Three and Four will be developed each spring and will reflect the knowledge gained in the previous phases. Phase Five will give special attention to the capsulization of the final Alaska Energy Resource Assessment Report.

APPENDICES

APPENDIX A

APPROXIMATE CONVERSION FACTORS FOR CRUDE OIL *

FROM \ INTO (MULTIPLY BY)	Metric Tons	Long Tons	Short Tons	Barrels	Kiloliters (Cubic Meters)	1,000 Gallons (Imp.)	1,000 Gallons (US)
Metric Tons	1	0.984	1.102	7.33	1.16	0.256	0.308
Long Tons	1.016	1	1.120	7.45	1.18	0.261	0.313
Short Tons	0.907	0.893	1	6.65	1.05	0.233	0.279
Barrels	0.136	0.134	0.150	1	0.195	0.035	0.042
Kiloliters (cubic meters)	0.863	0.849	0.951	6.29	1	0.220	0.264
1,000 Gallons (Imperial)	3.91	3.83	4.29	28.6	4.55	1	1.201
1,000 Gallons (U.S.)	3.25	3.19	3.58	23.8	3.79	0.833	1

*Based on world average gravity (excluding natural gas liquids).

Source: Energy Fact Book, Tetra Tech, TT-A-642-76-211 (Feb., 1976)

BLANK PAGE

BRITISH THERMAL UNIT HEAT VALUES*

		Crude Petroleum (42 Gal. Barrel)	An-Thracite Coal (Short Ton)	Bitumi-nous Coal (Short Ton)	Natural Gas–Dry (1000 Cu. Ft.)	Distillate Fuel Oil (42 Gal. Barrel)	Re-sidual Fuel Oil (42 Gal. Barrel)	Liquefied Pet. Gas (42 Gal. Barrel)
Crude Petroleum	42 Gal. Bbl. equals	—	0.228	0.221	5.604	0.996	0.923	[illegible]
Anthracite Coal	Short Ton equals	4.379	—	0.969	24.541	4.361	4.040	[illegible]
Bituminous Coal and Lignite	Short Ton equals	4.517	1.031	—	25.314	4.498	4.167	[illegible]
Natural Gas – Dry	1000 Cu. Ft. equals	0.178	0.041	0.040	—	0.178	0.165	[illegible]
Distillate Fuel Oil	42 Gal. Bbl. equals	1.004	0.229	0.222	5.628	—	0.927	[illegible]
Residual Fuel Oil	42 Gal. Bbl. equals	1.084	0.248	0.240	6.074	1.079	—	[illegible]
Liquefied Petroleum Gas	42 Gal. Bbl. equals	0.692	0.158	0.153	3.875	0.689	0.638	—
*B.T.U. Heat Values As Used	1000s	5,800	25,400	26,200	1,035	5,825	6,287	[illegible]

Other Refined Products' B.T.U. Values (1000s): Gasoline 5,248; Kerosine 5,670; Lubricants 6,064.8; Wax 5,537.3; Asphalt 6,636; Miscellaneous 5,796; Natural Gasoline 4,620 Per 42 Gallon Barrel.

Source: Annual Statistical Review, Petroleum Industry Statistics, 1964-1973, API, Sept. 1974.

HEATING VALUES OF SELECTED SOLIDS

SOLID		APPROX. BTU PER LB. AS RECEIVED
Anthracite (coal)	(3% moisture)	13,000
Bituminous A	(6% moisture)	9,700
Sub-Bituminous A	(18% moisture)	8,500
Lignite & Brown Coal	(39% moisture)	7,200
Peat	(dry)	9,000
Wood - Pine	(dry)	11,000
Bagasse	(sugar cane residue)	8,500
Cow Dung	(dry)	4,000

Source: Stone & Webster Chart

SELECTED CONVERSION FACTORS

To Convert From	To	Multiply By
Barrel	Gallon	42
	Quart	168
BTU	Kilowatt-Hour	.000293018
Horsepower	Kilowatt	.745702
	Number of Men (Equiv.)	5
Kilowatt	Watt	1000
Kilowatt-Hour	BTU	3412.874
Lumen	Watt	.00147
Meter	Feet	3.280833
	Centimeter	100
Micron	Millionth of Inch	39.37
	Centimeter	.0001
Watt	BTU/Hour	3.4128
	Kilowatt	.001

Also:

Centigrade Degree (x1.8 + 32) = Fahrenheit Degree

Fahrenheit Degree (-32) x .55 = Centigrade Degree

APPENDIX B

Libraries in Alaska with Energy Resource Information

ANCHORAGE

Alaska District, U.S. Corps of
Engineers Library (micro-film)
P.O. Box 7002
Anchorage, Alaska 99510
Barbara Berg Ph: 752-4910

Alaska Resources Library
U.S. Department of Interior
733 West Fourth Avenue
Anchorage, Alaska 99510
Martha Shepard Ph: 265-5477

Southcentral Region Coordinator
3211 Providence Drive
Anchorage, Alaska 99504
Katherine Laiblin Ph: 272-5522

Z. J. Loussac Public Library
427 "F" Street
Anchorage, Alaska 99501
Dorothy Shaver Ph: 272-2538

Arctic Environmental Information
& Data Center
University of Alaska
707 "A" Street
Anchorage, Alaska 99501
P. Brommelsiek Ph: 279-4523

British Petroleum Alaska, Inc.
3111 "C" Street
P.O. Box 4-1379
Anchorage, Alaska 99509
C. A. Petty Ph: 279-0644

Cities Service Mineral Corp.
1016 West 6th Ave., Suite 420
Anchorage, Alaska 99501
D. Stevens-Dist. Geologist
Ph: 272-9441

Mobil Exploratory Library
3300 "C" Street
Pouch 7-003
Anchorage, Alaska 99510
P. Hopkins

Southcentral Regional Resource Center
650 International Airport Road
Anchorage, Alaska 99502
John Stamm Ph: 276-4524

U.S. Department of Interior
Alaska Outer Continental Shelf Library
800 "A" Street
Anchorage, Alaska 99501
Irma Nelson Ph: 279-4578

U.S. Geological Survey Library
Public Inquiries Office
508 West 2nd Avenue
Anchorage, Alaska 99501
M. Erwin Ph: 277-0577

U.S. Naval Petroleum Reserve
Calais Office Center
3201 "C" Street
Anchorage, Alaska 99501
J. Bickerton

University of Alaska, Anchorage Library
3211 Providence Drive
Anchorage, Alaska 99504
N. Lesh, Asst. Dir. Technical Serv.
Ph: 272-5522

Elmendorf Air Force Base Library
Elmendorf Air Force Base
Anchorage, Alaska 99506
Jeane Moore Ph: 752-4287

BARROW

Naval Arctic Research Laboratory Library
University of Alaska
Barrow, Alaska 99723
Marge Benser

FAIRBANKS

Alaska Geology Research Library
University of Alaska
Fairbanks, Alaska 99701

Alaska State Library
Northern Region Coordinator
Elmer E. Rasmuson Library
University of Alaska
Fairbanks, Alaska 99701
Mary Matthews Ph: 479-7422

<u>JUNEAU</u>

Alaska Division of State Libraries
State Office Building, 8th Floor
Pouch G
Juneau, Alaska 99811
Phone: 465-2910

Alaska Power Administration Library
P.O. Box 550
Juneau, Alaska 99802
Darlene Edwards

Bureau of Mines Library
P.O. Box 550
Juneau, Alaska 99802
M. Mattson Ph: 364-2111

Source: <u>Alaska Library Directory, 1977</u>. Alaska State Library, Pouch G, Juneau, Alaska 99811, Phone: 465-2910; and Alaska Library Association, a State-Federal program under the Library Service and Construction Act, P.L. 91-600.

APPENDIX C

KEY ALASKAN ANNOTATED BIBLIOGRAPHIES

TITLE: ENERGY & MINERAL RESOURCES OF ALASKA & THE IMPACT OF FEDERAL LAND POLICIES ON THEIR AVAILABILITY. OIL & GAS. PART I.

AUTHORS: Robert M. Klein, William M. Lyle, Patrick L. Dobey, and Kristina M. O'Connor.

ORGANIZATION: State of Alaska, Department of Natural Resources

SIZE OF REPORT: 24 pages

DATE: June 1974

ANNOTATION: The estimates given in this report differ from the estimates given in the USGS report, which is given in detail in another appendix in this volume. These estimates, given by the Division of Geological and Geophysical Survey, are believed to be the only documented State estimates in existence. In Part II of this report, an attempt was made to document the affect of previous and proposed public land withdrawals on the oil and gas potential land in Alaska. This part of the report contains several multicolored overlays and identifies the sedimentary basins. However, because of the rapidly changing situation with respect to D-2 Lands and Congressional action, Part II is out of date even though it is only three years old.

TITLE: HISTORIC AND PROJECTED DEMAND FOR OIL AND GAS IN ALASKA 1972-1995. (Energy Report 3-77)

AUTHOR: Kristina O'Connor

ORGANIZATION: State of Alaska, Department of Natural Resources

SIZE OF REPORT: 49 pages

DATE: April 1977

ANNOTATION: The report includes: (1) the historic oil and natural gas consumption from 1972 through 1975 (only data through 1975 was available--data from 1976 will be available soon and may be compiled for a mid-year report); (2) the projected demand for oil and natural gas to 1995 (high-growth, moderate-growth, and low-growth projections are made); and (3) an addendum tabulating existing oil and gas fields and resources in Alaska. Two tables have plastic overlays; however, the tables are difficult to understand without carefully studying the text. Note the recent publication date, which makes the report very timely.

TITLE: THE NORTH SLOPE: PARADISE LOST

AUTHOR: Thomas W. O'Shea

ORGANIZATION: Drexel Burnham and Company; 60 Broad Street, New York, New York, 10004.

SIZE OF REPORT: Pages are not consecutively numbered, but the report contains eight chapters plus an appendix.

DATE: April 1976

ANNOTATION: The report examines the geological, institutional, economic, and financial factors that will govern the profitability of future oil and gas production on the North Slope of Alaska. The report is difficult to read, but has a wealth of information contained in it, especially on cost and taxes. The report includes interesting information on the prospects for tertiary recovery from the Prudhoe Bay Field and estimates of the capital cost of developing the [illegible].

TITLE: IN PLACE VOLUMETRIC DETERMINATION OF RESERVOIR FLUIDS SADLEROCHIT FORMATION PRUDHOE BAY FIELD

AUTHORS: H. K. van Poollen and Associates, Inc., and State of Alaska, Division of Oil and Gas.

ORGANIZATION: State of Alaska, Department of Natural Resources, Division of Geological and Geophysical Surveys.

SIZE OF REPORT: 41 pages plus exhibits

ANNOTATION: The report includes a color photograph of a model of the Prudhoe Bay Field, Sadlerochit Reservoir, and its limits. The report gives the technical details of the Prudhoe Bay Oil Field.

TITLE: ALASKA'S OIL AND GAS TAX STRUCTURE

ORGANIZATION: State of Alaska, Department of Revenue

SIZE OF REPORT: 7 chapters

DATE: February 1977

ANNOTATION: This report gives an overview of oil and gas severance [illegible], Alaska's present tax structure, history of revenues and expenditures, revenue and expenditure projections, and problem areas in the present tax structure. It also gives [illegible] for the [illegible] severance tax, production tax, property tax, and reserves tax. The report is only [illegible] and [illegible]. Detailed examples are used throughout to explain the tax.

TITLE: A SOCIAL AND ECONOMIC IMPACT STUDY OF OFFSHORE PETROLEUM AND NATURAL GAS DEVELOPMENT IN ALASKA

AUTHORS: Mathematical Sciences Northwest, Inc. and Alaska Consultants, Inc.

ORGANIZATION: Department of the Interior, Bureau of Land Management

SIZE OF REPORT: [illegible] pages

DATE: October [illegible], [illegible]

ANNOTATION: The report analyzes demographic data, labor force and employment data, income trends, community facilities and services, transportation facilities and services, land use, land ownership and housing conditions, [illegible] and community financial data. The report also [illegible]

TITLE: ALASKA PETROLEUM & INDUSTRIAL DIRECTORY

AUTHORS: [illegible], Editor

ORGANIZATION: Alaska Directory, a division of [illegible] Information Corporation, a subsidiary of [illegible] Company

SIZE OF REPORT: [illegible] sections

DATE: [illegible]

ANNOTATION: This directory gives a comprehensive listing of all companies and individuals directly connected with, or engaged in, Alaskan industry, [illegible]

TITLE: [illegible]

AUTHORS: Stanford Research Institute, Menlo Park, California [illegible]

ORGANIZATION: United States Energy Research and Development Administration, [illegible] Energy, Washington, D.C.

SIZE OF REPORT: [illegible] pages

DATE: January 1978

ABSTRACT: The report used specialists in mining and resource development, conceptual process design, economic analysis, transportation and distribution, market research, and energy analysis. The conclusion was that a solvent refined coal product would probably be significantly more expensive than alternate fuels. However, nonfuel uses for solvent refined coal may exist, but such uses were not investigated in this report. A very significant conclusion was that delivered prices for the Beluga low-sulfur coal on the U. S. West Coast may fall within the competitive price range for alternative low-sulfur western coals.

TITLE: MINERAL RESOURCES OF ALASKA AND THE IMPACT OF FEDERAL LAND POLICIES ON THEIR AVAILABILITY (COAL) (ALASKA OPEN-FILE REPORT 51)

AUTHORS: Don L. McGee and Kristina M. O'Connor

ORGANIZATION: State of Alaska, Department of Natural Resources, Division of Geological & Geophysical Survey

SIZE OF REPORT: 57 pages

DATE: March 1975

ABSTRACT: The report is divided into two parts. Part I indicates where known and hypothetical coal resources are located and estimates how much of the resource can be economically produced. One table presents the coal field; the demonstrated, inferred, and hypothetical resources; the grade; the heat content; and analyses for moisture, ash, and sulfur. A color map in this report shows the coal areas, including an offshore area. Part II discusses the availability of coal in Alaska with regard to present and proposed land use policies. Several color overlays are used in the maps.

TITLE: TRANSPORTATION ECONOMICS OF COAL RESOURCES OF NORTHERN SLOPE COAL FIELDS, ALASKA

AUTHOR: Paul R. Clark

ORGANIZATION: Mineral Industry Research Laboratory, University of Alaska, Fairbanks, Alaska

SIZE OF REPORT: 136 pages

DATE: May 1973

ABSTRACT: This report analyzes the economics of transporting coal from the North Slope of Alaska. Several transportation systems were evaluated: railroad, truck, slurry pipeline, belt conveyor, and barging and shipping.

The report concludes that, under certain assumptions, part of the North Slope coal is economically competitive with Japan's present coking coal suppliers. The cost numbers are rather out of date in that inflation has soared since 1973; nevertheless, this report should be studied prior to any update in the economics of transportation of coal in Alaska.

TITLE: FOCUS ON ALASKA COAL '75

EDITORS: P. Dharma Rao and Ernest N. Wolff

ORGANIZATION: School of Mineral Industry, University of Alaska, Fairbanks and Federal Energy Administration, Anchorage.

SIZE OF REPORT: 281 pages

DATE: October 15-17, 1975

ANNOTATION: Anyone interested in coal in Alaska should read this report, which is based on the proceedings of a conference held at the University of Alaska in Fairbanks in October 1975. The report gives an excellent overview for those interested in the development of Alaskan coals.

TITLE: PHASE I TECHNICAL AND ECONOMIC FEASIBILITY - SURFACE MINING COAL DEPOSITS NORTH SLOPE OF ALASKA (No. [illegible])

AUTHORS: Kaiser Engineers

ORGANIZATION: Prepared for Bureau of Mines, Denver, Colorado

SIZE OF REPORT: Eight sections

DATE: December 1976

ANNOTATION: This report is not the final report and is not complete. The final report will be published in September 1977. The overall tone of the report is pessimistic toward the economic feasibility of surface mining operations for Northern Alaska coal deposits; for example, "severe climate," "reserves not well defined," "thin seams," "transportation will be difficult," "coal will not command high prices," and "deposits apparently having the greatest potential for development are located in environmentally sensitive areas."

TITLE: COAL RESOURCES OF ALASKA - GEOLOGICAL SURVEY BULLETIN 1242-B

AUTHOR: Farrell F. Barnes

ORGANIZATION: U. S. Department of the Interior, U. S. Geological Survey

SIZE OF REPORT: 36 pages with a plate (in pocket) showing distribution of coal-bearing rocks

DATE: 1967

ANNOTATION: Even today, a decade after publication of this report, Barnes's work is considered the best inventory available in coal resources of Alaska. Other reports have supplemented his work, but no report has replaced it. The major problem with information on coal resources in Alaska is that still so little is known, and much more exploration, including drilling, needs to be done.

TITLE: ALASKA POWER SURVEY - 1974

AUTHORS: Committee of 27 members plus assistance from their staffs

ORGANIZATION: Federal Power Commission

SIZE OF REPORT: Five bound volumes

- Report of Executive Advisory Committee
- Economic Analysis and Load Projection
- Resources & Electric Power Generation
- Coordinated Systems Development & Interconnection
- Environmental Consideration & Consumer Affairs

DATE: 1974

ANNOTATION: This report is one of the most important reference documents on energy in Alaska. J. T. House, Administrator of the Alaska Power Administration, served as chairman of the Executive Advisory Committee for the Federal Power Commission Alaska Power Survey. While A.P.A. staff contributed in a significant manner to this report, a major balance was obtained by input from the other 26 committee members who represented utility, state, military, natives, and other federal organizations.

TITLE: ELECTRIC POWER IN ALASKA, 1976 - 1995

AUTHORS: The Institute of Social & Economic Research, University of Alaska, in cooperation with [illegible] Miller, Robert W. Retherford Associates, [illegible] and Associates, Inc. and National Economic Research Associates, Inc.

ORGANIZATION: A Report for the House Finance Committee, Second Session, Ninth Legislature, State of Alaska

SIZE OF REPORT: Eight chapters with appendices

DATE: August 1976

ANNOTATION: This report contains a wealth of information on electric power in Alaska. With input from so many different sources, it is sometimes difficult to readily locate desired information. A number of people believe that the projected electricity requirements in this document are too conservative--even the high range of the estimates are considered too low. The projected future costs of power (mills per kWh) must be used with great care. Nevertheless, anyone interested in energy in Alaska, i.e. demand, technology, energy resources, and financing will find this compilation a readable reference.

TITLE: ALASKA ELECTRIC POWER STATISTICS - 1960-1975

AUTHORS: Staff of Alaska Power Administration

ORGANIZATION: United States Department of the Interior - Alaska Power Administration

SIZE OF REPORT: 45 pages

DATE: July 1976

ANNOTATION: This report is the fourth in a series of electric power data summaries compiled by the Alaska Power Administration. A later report covering statistics through the spring of 1977 will be issued soon. This very useful report gives installed capacity, generation data, transmission systems, and market data including typical monthly residential electric bills. The report is not limited to hydroelectric energy.

TITLE: INVESTIGATION OF ALASKA'S URANIUM POTENTIAL

AUTHORS: Gilbert R. Eakins & Robert B. Forbes

ORGANIZATION: State of Alaska, Department of Natural Resources, Division of Geological and Geophysical Surveys (published under ERDA contract in 1975)

SIZE OF REPORT: Part 1, 331 pages; part 2, 41 pages.

DATE: 1976

ANNOTATION: An exhaustive literature search revealed six regions that offer encouragement for the possibility of a uranium find in Alaska and three areas that may be favorable for the presence of uranium. Part 1 of the report places emphasis on nonmarine sedimentary rocks in structural basins. Part 2 gives a scale map of the felsic rocks in Alaska with accompanying analytical data and age determinations. This report is a must for those seeking uranium in Alaska.

TITLE: GEOTHERMAL ENERGY AND WIND POWER...ALTERNATE ENERGY SOURCES FOR ALASKA

AUTHORS: Prepared by Geophysical Institute, University of Alaska and Alaska Energy Office, William C. McConkey, Director and edited by Robert B. Forbes.

ORGANIZATION: Supported by National Science Foundation

SIZE OF REPORT: 144 pages plus 7 appendices

DATE: July 8-9, 1975

ANNOTATION: This report is based upon the proceedings of the Alaskan Geothermal and Wind Power Resources Planning Conference held in Anchorage in July 1975. Alaska's geothermal and wind energy potential is given excellent treatment. The report contains a section on recommendations for future action. This very valuable reference document has one drawback--it is sometimes difficult to find needed information because of the manner in which the material is grouped.

TITLE: "THE D-2 BOOK," LANDS OF NATIONAL INTEREST IN ALASKA

AUTHORS: Not identified

ORGANIZATION: Federal-State Land Use Planning Commission for Alaska

SIZE OF REPORT: 190 pages

DATE: May 1977

ANNOTATION: The Joint Federal-State Land Use Planning Commission acts as an advisory body to both governments. One of their duties is to make recommendations concerning areas planned for permanent reservation in Federal ownership. While it is a valuable general reference document on energy and land, the exact purpose of this report was not clearly identified. It apparently gives background information leading up to the Commission recommendations. The report has 37 excellent maps and charts. This publication has been distributed in limited quantities, but an illustrated version will be available in a few months.

TITLE: ALASKA REGIONAL PROFILES

AUTHORS: Prepared by Lidia L. Selkregg

ORGANIZATION: The Joint Federal-State Land Use Commission of Alaska

SIZE OF REPORT: 18" x 15" and about 1" thick (separate profile for each region [6])

DATE: Commission formed in 1971, profiles still being updated.

ANNOTATION: The following six Regions each have a profile publication: Arctic, Northwest, Southcentral, Southeast, Southwest, and Yukon. Coverage is given in each Region to both the natural environment and to the man-made environment. The natural environment includes: climate, topography, geology, water, soils, and the biotic communities and marine environment. The man-made environment includes: the people, the land, and the services. These popular and informative regional profiles with outstanding maps, photographs, and artwork are publications in a class all their own.

TITLE: ALASKA NATIVE LAND CLAIMS

AUTHORS: Robert D. Arnold assisted by a staff of eight with Foreword by Emil Notti.

ORGANIZATION: The Alaska Native Foundation

SIZE OF REPORT: A bound book of 348 pages

DATE: 1976

ANNOTATION: The book is much broader than the topic of the Alaska Native Land Claims Settlement itself. The 1971 Act, Public Law 92-203, 92nd Congress, H. R. 10367 are the events around which the book is organized. For one who needs to understand the complex land settlements concerning the Natives in Alaska, this book will be of great assistance, but remember that the land claims in Alaska are still years from settlement.

APPENDIX D

PETROLEUM DRILLING IN ALASKA (1977)

Location	Contractor	Driller
Cook Inlet	Amoco	Parker Drilling
North Slope	Arco	Rowan Drilling
North Slope	Arco	Rowan Drilling
Cook Inlet	Arco	Parker Drilling
North Slope	Arco	Parker Drilling
Lower Cook Inlet	Arco	ODECO/Ocean Ranger (Strat Test)
North Slope	BP Alaska	Nabors Drilling
Swanson River	Chevron	Brinkerhoff Drilling
Gulf of Alaska	Exxon	Alaskan Star
North Slope	Exxon	Loffland Brothers Drilling
Gulf of Alaska	Gulf Oil	Aleutian Key
Gulf of Alaska	Shell Oil	Sedco 706
Kodiak OCS	Sun Oil	Sedco 708 (Strat Test)
Gulf of Alaska	Texaco	ODECO/ Ocean Bounty
North Slope	Texaco	Challenger Drilling
Cook Inlet	Union Oil	Parker Drilling

APPENDIX E

REVENUE SOURCES OF THE STATE OF ALASKA
Actual Collections 1976

	($ million)
Oil Reserves Taxes (scheduled to expire December 31, 1977)	223.1
Individual Income Taxes	146.2
Oil & Gas Property Taxes	83.4
Royalties on the Sale or Use of State Resources	43.3
Investment Earnings on the Sale or Use of State Resources	31.7
Corporate Income Taxes	31.1
Oil & Gas Production Severance Taxes	28.0
Highway Fuel Taxes	20.2
Alaska Business Licenses	19.1
Ferry Systems - Southeast	14.0
Motor Vehicle Titles & Registrations	10.8
Alcoholic Beverages Taxes	7.8
All Others	51.1
Total Unrestricted Revenues	709.8

Source: State of Alaska, Department of Revenue, Revenue Sources FY 1976-1978, compiled by Research Section, Juneau, January 1977.

APPENDIX F

METHODOLOGICAL NOTES

Resource Inventories

Several methodological considerations were important to the development of the energy resource inventories. One of the most important was the decision to attempt, as much as possible, to go beyond the most recent published data available on Alaska's energy resources. This decision proved to be invaluable with respect to two of the major resource categories: oil and gas, and hydroelectric resources.

A major problem with much of the published data on oil and gas resources in the State of Alaska was the lack of geographical detail. Resource estimates by the United States Geological Survey (USGS), in particular, were highly aggregated and were given only for major regions of the State. The State of Alaska, Department of Natural Resources estimates also were aggregated, but on a different basis than Federal estimates. To put estimates by State and Federal authorities on comparable bases, it was necessary to obtain unpublished materials. This was done in the case of USGS data by obtaining unpublished tabulations by petroleum province that were used to generate the aggregate numbers published in USGS Circular 725. In addition, copies of USGS maps depicting their most recent estimates of the boundaries of the State's onshore and offshore petroleum provinces were obtained. These boundary definitions are generally considered to be the best that are currently available.

In the case of hydroelectric power, it was necessary to go beyond the most recently published inventories of potential resource sites. In 1968, the Alaska Power Administration (APA) identified 76 potential sites for hydroelectric power development, with a heavy emphasis on larger sites located near major potential load areas. In 1976, the Institute of Social and Economic Research (ISER) at the University of Alaska identified 39 major sites, only ten of which were also on the APA list. Neither of these inventories, however, recognized the growing need in Alaska for hydroelectric power development in smaller load zones, particularly areas in the more remote parts of the State. By going back to older inventories prepared in the 1950s and early 1960s by the Bureau of Reclamation (now the Alaska Power Administration), the United States Geological Survey (USGS), the U. S. Forest Service, and the licensing of applications of the Federal Power Commission, other sites, including smaller sites suitable for those more remote potential load zones were identified. Although many of the latter sites are not immediately economically viable, an inventory that did not include them would have been biased and incomplete.

Another major component of the resources inventory was the compilation of the data on a regional basis. The State of Alaska is so large, and varies so widely in its geographic, climatic, social, and economic characteristics, inventories by a subdivision other than the State as a whole was necessary.

BLANK PAGE

To determine the appropriate regional basis for the inventories, the study team consulted with the State of Alaska, Office of the Governor, Division of Policy Development and Planning (DPDP) early in the study. At that time, DPDP was in the process of establishing six geographical subdivisions as the basic planning regions for the state. These regions are a slightly modified version of the regions used in the University of Alaska's Man-in-the-Arctic Program, developed prior to the North Slope Borough's incorporation as a local government unit. The modification consists primarily of making the regional boundaries consistent with Census division boundaries, which follow local government boundaries. A prime benefit of the use of these particular boundaries is that all of this resource data is now available to State and Federal planners on the same basis as most other regionalized planning data.

A minor methodological problem associated with the resources inventories was the establishment of a consistent nomenclature including spelling for Alaska place names. Many of these place names have changed over the years. In some cases, when using older data sources, the place names given differed from current usage. All place name disputes were resolved by using the most recent edition of "The Dictionary of Alaska Place Names."

Finally, information on energy resources obtained from published and unpublished sources frequently was supplemented by visits by project team members to a number of the resource sites. These site visits were invaluable because the project team was able, on many occasions, to obtain the latest and best information available from individuals working directly with a particular resource in the field. In addition, the study team learned the names of other key contact persons.

Identification of Potential Development Sites

A major concern of the study team was to develop an appropriate methodology for determining the resource sites in Alaska that are most likely to be developed before the year 2000, and to obtain some estimate of the timing of such development. In view of the study team's lack of previous expertise in most of the resources involved, it was determined to take advantage of the best available expert opinion for each of the resources.

Initially, the study team attempted to obtain information on the likelihood and timing of resource development through informal telephone contacts with a small number of known experts on each of the energy resources. It was quickly found, however, that there was considerable difficulty in obtaining consistent impressions from different experts via the telephone, and that individuals tended to have considerable knowledge on a resource in a particular area of the State, but less expertise with respect to that resource elsewhere.

Thus, it was decided that a questionnaire or survey form was required that could be sent to many individuals known to be knowledgeable on a given resource in Alaska. The actual format of the questionnaire varied from resource to resource, but generally consisted of a list of known or most likely resource sites broadly defined (such as oil and gas provinces or coal fields).* The experts on a given resource were requested to rank the resource sites in order of most probable development, and to give estimates of the timing of such development. In addition, each expert (except for coal) was requested to explain the degree of his familiarity or expertise in each of the resource sites listed. Finally, in the case of coal, uranium, and hydroelectric power, the experts were asked to supply the names of any additional sites, beyond those supplied to them, that they considered to be particularly likely prospects for development, and when such development might occur. Experts were usually selected from Federal or State agencies because of the concern for vested interest that industry people might be subject to. (See questionnaires at the end of this section.)

The response to our questionnaires was generally excellent, and included many comments in addition to the rankings and estimated dates of development. (Summaries of these comments are included in chapters 4 and 5 of Volume I.) In evaluating the returned questionnaires, however, the study team found considerable variation in experts' expectations regarding the probability and timing of development at different sites. To obtain concensus rankings, the most weight was usually given to the opinions of those who considered themselves to be most expert on particular resource sites. Inconsistent information was usually ignored when the expert considered that he was not particularly qualified to comment on a given site. In the case of hydroelectric power, the problem was complicated by the fact that several sites were often given for a particular load zone, but could not all be developed. That is, the resource sites in question were often mutually exclusive. In this case, the sites were ranked on the basis of the number of experts who agreed that a site was likely to be developed.

Other Methodological Considerations

A note of importance is the study team's reliance on responses to the first draft of this report. The draft was circulated to all the experts who assisted during the project and to many other interested parties. The comments by these individuals as incorporated into the text greatly enhanced the quality of the final report. Clearly this report could not have been made without their help - see Key Contacts in both Volumes 1 and 2.

---

* The lists of oil and gas provinces for onshore and offshore oil and gas were accompanied by maps showing their locations. In addition, oil and gas experts received a copy of the prospective outer continental shelf (OCS) lease schedule as of January 1977, and a map showing the areas scheduled for the sale.

APPENDIX A

[illegible] TO THE

[illegible] ALASKA NATIVE [illegible] SETTLEMENT [illegible]

BLANK PAGE

STATE OF ALASKA

DEPARTMENT OF COMMERCE & ECONOMIC DEVELOPMENT

[illegible]

April [illegible], 197[illegible]

Dear

Because you are a recognized authority on Alaska's oil and gas resources, we are asking you to assist us in ranking [illegible] the future order of production in onshore and offshore provinces [illegible] Alaska's potentially recoverable petroleum resources, before and after the year [illegible]. We need your analysis for use in our Regional Energy Resources Planning Project. You are one of the few experts to whom we are making this request.

We ask that you number the following provinces according to the most probable order of production (your best guess), that is, when the oil and gas will be transported from the well, provide your estimate of when recovery is most likely to take place, and that you list your reasons under "Comments". We also recognize that not all experts are knowledgeable about all [illegible] provinces, so we have provided a place for you to indicate this.

Of the provinces identified, two of them (Arctic Coastal Plain and Cook Inlet) have recovery operations already underway. Therefore, the remaining part of these two provinces are to be ranked along with the other provinces.

We know the nomenclature of oil and gas provinces and basins and their configurations is not consistent among geologists in the oil and gas industry and federal and state agencies. However, we had to choose some system and decided upon the United States Geological Survey's. It would be appreciated if you would provide us with your nomenclature, provinces configurations and estimates, if you disagree with those made by U.S.G.S.

Attached are: (1) oil and gas experts' survey form to rank onshore and offshore petroleum provinces; (2) U.S.G.S.'s map showing Alaska's onshore oil and gas provinces; (3) U.S.G.S.'s map showing Alaska's offshore oil and gas provinces; (4) U.S.G.S.'s tables giving the estimates of undiscovered recoverable oil and gas resources and demonstrated reserves by province; (5) the proposed OCS lease planning schedule dated January 1977; and, (6) OCS's map of scheduled sales.

We are fully aware that the information we are requesting is very subjective and highly speculative in nature, but your best guess is one of the best we can think of. Please return the form by May 6th to our office. You may retain the accompanying materials. Your assistance will be greatly appreciated.

Sincerely,

Dee Lane Gene Rutledge
Alaska Regional Energy Resources Planning Project

SURVEY OF ALASKAN OIL & GAS EXPERTS
RANKING OF PRODUCTION OF POTENTIALLY RECOVERABLE PETROLEUM RESOURCES
ONSHORE & OFFSHORE PROVINCES
BEFORE & AFTER THE YEAR [illegible]
(See page 2 for footnote explanation)

Rank 1/	Timing 2/	Offshore Major Petroleum Provinces	Degree of Interest 3/	Comments 4/
		Beaufort Sea		
		North Chukchi		
		Central Chukchi		
		Hope		
		Norton		
		St. Matthew - Hall		
		Bristol		
		Navarin		
		Zhemchug - St. George		
		Cook Inlet		
		Eastern Gulf of Alaska		
		Kodiak Tertiary		
		Shumagin Shelf		

Rank 1/	Timing 2/	Onshore Major Petroleum Provinces	Degree Exper. 3/	Comments 4/
		Arctic Coastal Plain		
		Northern Foothills		
		Southern Foothills		
		Selawik Lowlands		
		[illegible]		
		Yukon Flats		
		Interior Lowlands		
		Bristol Bay Tertiary		
		Alaska Peninsula		
		Cook Inlet		
		Copper River		
		Gulf of Alaska		
		Kodiak Tertiary		
		Southeastern Alaska		

1/ Your ranking of the most probable order of production (e.g. "1," 2, etc.) for both onshore and offshore provinces.

2/ Your estimate of when production is most likely to commence (e.g., 1980-85, 1985-90, 1990-95, 1995-2000, after 2000).

3/ Indicate degree of your knowledge about oil and gas prospects, e.g. K = very knowledgeable, A = average, U = little or no knowledge.

4/ Your reasons for ranking and timing.

Name

Title

Company or Agency

Phone Number

Please return to Alaska Regional Energy Resource Planning Team - Division of Energy and Power Development, 7th Floor MacKay Bldg., 338 Denali St., Anchorage, AK 99501. Attn: [illegible]
Phone: 272-0527 or 271-6912

January [illegible]
[illegible] Schedule

PROPOSED OCS PLANNING SCHEDULE

SALE AREA	1976	1977	1978	1979	1980
44 Gulf of Mexico	F N S				
CI Cook Inlet	P F	N S			
41 Gulf of Mexico	E P	F N S			
42 North Atlantic	E P	F N S			
43 South Atlantic		E P F N S			
46 Kodiak		E P F N S			
45 Gulf of Mexico		T E P F N S			
48 Southern California	C D	T E P F	N S		
49 Mid Atlantic	C	D T E P	F N S		
Beaufort Sea (near shore)		State - Federal Sale	1/		
51 Gulf of Mexico		C D T E	P F N S		
53 Central Pacific		C D T	E P F N S		
54 S. Atlantic-Blake Plateau		C D T	E P F N S		
50 Beaufort Sea 2/		C D T	E P F	N S	
55 Eastern Gulf of Alaska		C D	T E P	F N S	
52 North Atlantic		C	D T E P	F N S	
56 South Atlantic			C D T	E P F N S	
58 Gulf of Mexico			C D T	E P F N S	
57 Bering - Norton			C D T	E P F N S	
59 Mid Atlantic			C D	T E P F	N S
60 Bering Sea St George			C D	T E P	F N S
61 Cook Inlet				C D T E	P F N S
62 Gulf of Mexico				C D T	E P F N S
63 General Pacific				C D T	E P F N S
64 Kodiak - Aleutian				C D T	E P F N S

C - Call for Nominations
D - Nominations Due
T - Announcement of Tracts
E - Draft Environmental Statement
1/ State May Conduct Sale

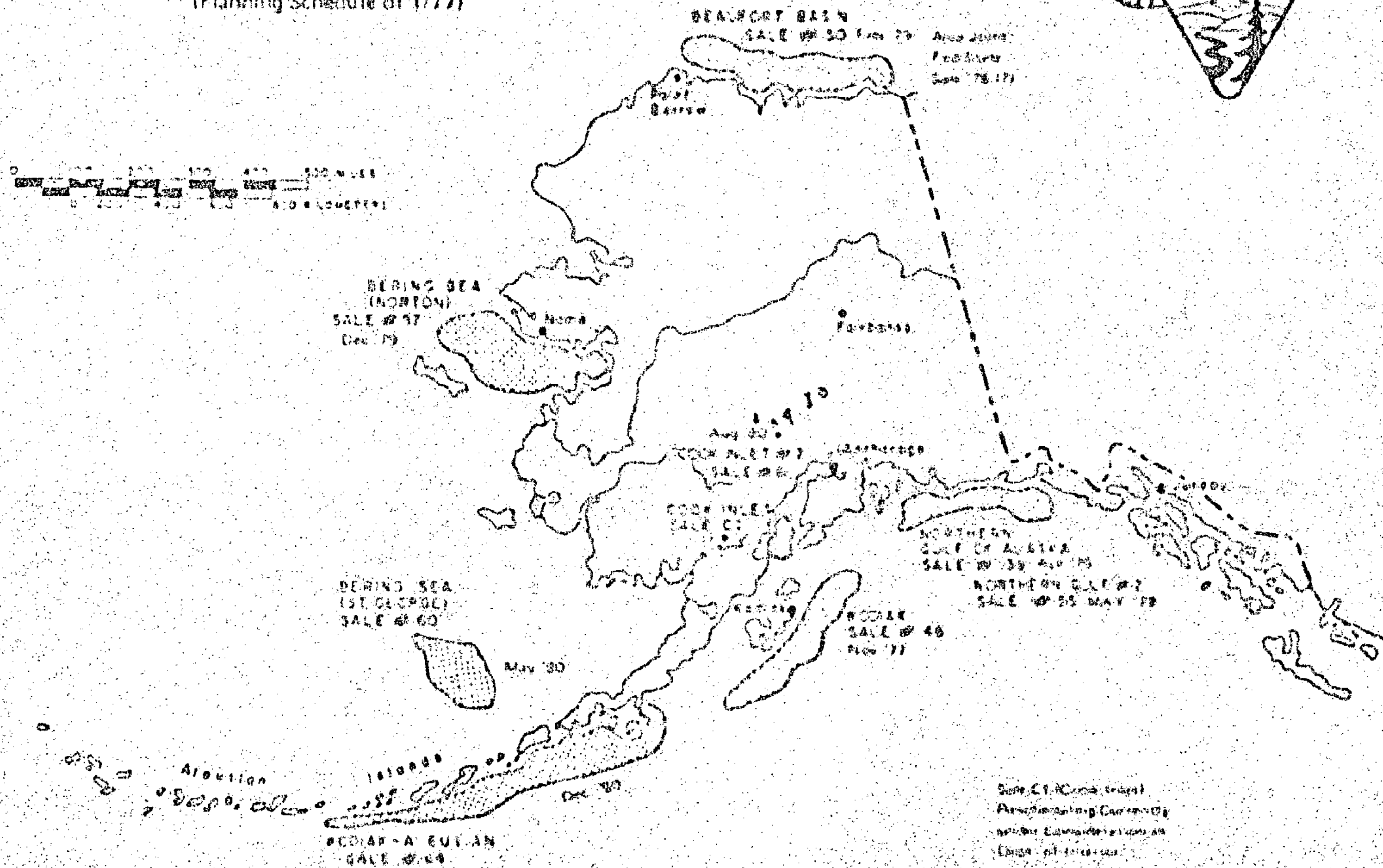
P - Public Hearing
F - Final Environmental Statement
N - Notice of Sale
S - Sale
2/ [illegible]

ALASKA

OUTER CONTINENTAL SHELF

Areas Under Consideration For Leasing

(Planning Schedule of 1/77)



Source: State of Alaska Department of [illegible] January 1977

United States Department of the Interior

GEOLOGICAL SURVEY
Box 25046
Denver Federal Center
Denver, Colorado 80225

Office of Energy Resources
Branch of Oil and Gas Resources
Resource Appraisal Group

GAS

(In Trillion Cubic Feet)

Number	Province Name	Area (mi²)	Volume (mi³)	Cumulative Production	Demonstrated Reserves: Measured Reserves	Demonstrated Reserves: Total	Inferred Reserves	Undiscovered Recoverable: Statistical Mean	Undiscovered Recoverable: Marginal Probability	Undiscovered Recoverable: Range[2]
Reg. 1A	Alaska Offshore									
	Arctic Ocean Subregion									
48	Beaufort Sea	15,237	45,626	0	0	0	0	(12.33) 9.2	0.75	0 - 19.3
49	North Chukchi	22,880	42,731	0	0	0	0	(9.45) 5.67	0.6	0 - 19.5
50	Central Chukchi	38,215	95,631	0	0	0	0	(55.21) 11.0	0.2	0 - 30.0
51	Hope	23,671	12,631	0	0	0	0	(1.13) 0.26	0.5	0 - 3.3
	Bering Sea Subregion									
52	Norton	18,768	34,032	0	0	0	0	(1.42) 0.85	0.6	0 - 2.8
53	St. Matthew-Hall	12,510	5,355	0	0	0	0	Negl.[1]		Negl.
54	Bristol	44,039	35,652	0	0	0	0	(3.55) 1.74	0.5	0 - 5.4
55	Navarin	19,744	55,813	0	0	0	0	(3.09) 0.22	0.3	0 - 4.8
56	Zhemchug-St. George Basin Complex	65,572	55,022	0	0	0	0	(6.67) 3.3	0.5	0 - 13.0
	Pacific Margin Basin Subregion									
57	Cook Inlet		26,233	(0.393)	1.561	1.554	0.733	2.33		1.0 - 5.5
58	Eastern Gulf of Alaska	16,354	23,139	0	0	0	0	(4.34) 3.33	0.7	0 - 11.6
59	Kodiak Tertiary	15,135	35,791	0	0	0	0	(1.32) 0.65	0.4	0 - 3.5
60	Shumagin Shelf	17,218	19,615	0	0	0	0	(0.42) 0.16	0.3	0 - 0.5

1 Negligible -- less than 0.001 trillion cubic feet.

2 The low value of the range is the quantity associated with a 95 percent probability [illegible] that there is at least this amount. The high value is the quantity with a 5 percent probability [illegible] that there is at least this amount. Totals [illegible] statistical methods.

United States Department of the Interior

GEOLOGICAL SURVEY
Box 25046
Denver Federal Center
Denver, Colorado 80225

Office of Energy Resources
Branch of Oil and Gas Resources
Resource Appraisal Group

GAS
(in Trillion Cubic Feet)

Number	Province Name	Area (mi²)	Volume (mi³)	Cumulative Production	Demonstrated Reserves: Measured Reserves	Demonstrated Reserves: Total	Inferred Reserves	Undiscovered Recoverable: Statistical Mean	Undiscovered Recoverable: Marginal Probability	Undiscovered Recoverable: Range
Reg. 1	Alaska Onshore									
	Northern Alaska Subregion									
1	Arctic Coastal Plain Subprovince	25,570	75,712	0.016	27.193	27.212	12.552	15.51		7.2-25.0
2	Northern Foothills Subprovince	29,595	133,350	0	0.315	0.315	0.364	2.1		1.3-5.0
3	Southern Foothills and Brooks Range Subprovince	40,369	193,520	0	0	0	0	(1.33) 2.27	0.6	0 - 7.0
4	Selawik Lowlands Province	4,570	4,280	0	0	0	0	negl.		negl.
	Central Alaska Subregion									
5	Yukon-Porcupine Province	20,445	49,193	0	0	0	0	(1.31) 0.39	0.3	0 - 2.0
6	Yukon-Koyukuk Province	44,735	102,563	0	0	0	0	(0.72) 0.29	0.4	0 - 1.5
7	Interior Lowlands Province	23,410	9,120	0	0	0	0	(0.6) 0.21	0.35	0 - 0.7
8	Bristol Bay Tertiary Province	9,610	13,423	0	0	0		(1.26) 0.88	0.7	0 - 2.4
	Southern Alaska Subregion									
9	Alaska Peninsula Subprovince	14,537	46,730	0	0	0	0	(1.03) 0.41	0.4	0 - 2.0
10	Cook Inlet Subprovince	6,775	13,100	0.899	4.463	5.352	2.026	1.13		0.7 - 2.5
11	Copper River Subprovince	5,093	5,022	0	0	0	0	(0.55) 0.22	0.4	0 - 0.8
12	Gulf of Alaska Tertiary Subprovince	4,510	12,000	negl.	0	0	0	0.44		0.2 - 0.5
13	Kodiak Tertiary Subprovince	770	600	0	0	0	0	negl.		negl.
14	Southeastern Alaska Subprovince	550	715	0	0	0	0	negl.		negl.

Negligible = less than 0.001 trillion cubic feet.

NOTE: Parentheses = indicate statistical mean without marginal probability applied.

United States Department of the Interior

GEOLOGICAL SURVEY
Box 25046
Denver Federal Center
Denver, Colorado 80225

Office of Energy Resources
Branch of Oil and Gas Resources
Resource Appraisal Group

OIL
(In billion barrels)

Number	Province Name	Area (mi^2)	Volume (mi^3)	Cumulative Production	Demonstrated Reserves: Measured Reserves	Demonstrated Reserves: Indicated Reserves	Demonstrated Reserves: Total	Inferred Reserves	Undiscovered Recoverable: Statistical Mean	Undiscovered Recoverable: Marginal Probability	Undiscovered Recoverable: Range
Reg. 1A	Alaska Offshore										
	Arctic Ocean Subregion										
48	Beaufort Sea	16,257	45,528	0	0	0	0	0	(4.37)3.28	0.75	0 - 7.6
49	North Chukchi	22,880	42,231	0	0	0	0	0	(3.15)1.85	0.6	0 - 6.2
50	Central Chukchi	33,215	95,691	0	0	0	0	0	(6.30)4.41	0.7	0 - 11.9
51	Hope	22,671	18,451	0	0	0	0	0	(0.44)0.13	0.3	0 - 0.6
	Bering Sea Subregion										
52	Norton	16,769	14,077	0	0	0	0	0	(1.36)0.54	0.4	0 - 2.19
53	St. Matthew-Hall	14,510	5,255	0	0	0	0	0	Negl.		Negl.
54	Bristol	46,019	36,652	0	0	0	0	0	(1.42)0.71	~0.5	0 - 2.5
55	Navarin	19,744	56,829	0	0	0	0	0	(1.21)0.36	0.3	0 - 1.9
56	Zhemchug-St. George Basin Complex	65,473	66,032	0	0	0	0	0	(2.64)1.32	0.5	0 - 5.1
	Pacific Margin Basin Subregion										
57	Cook Inlet		26,239	0.354	0.212	0.028	0.634	0.131	1.19		0.5 - 2.3
58	Eastern Gulf of Alaska	14,354	29,133	0	0	0	0	0	(1.61)1.13	0.7	0 - 4.4
59	Kodiak Tertiary	15,295	35,792	0	0	0	0	0	(0.57)0.23	0.4	0 - 1.1
60	Shumagin Shelf	17,218	29,615	0	0	0	0	0	(0.20)0.04	0.2	0 - 0.25

Negligible -- less than 0.031 billion barrels

United States Department of the Interior

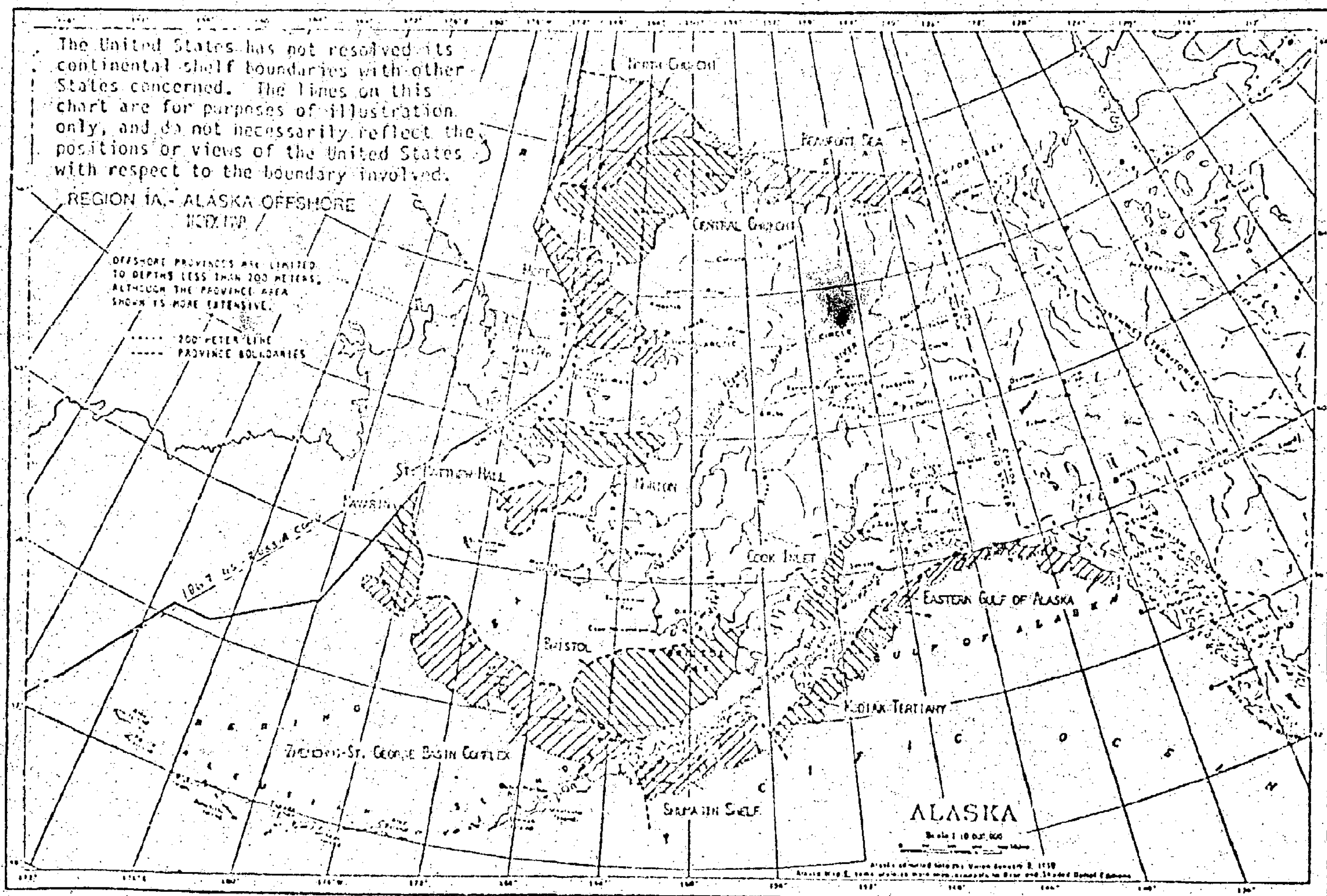
GEOLOGICAL SURVEY
Box 25046
Denver Federal Center
Denver, Colorado 80225

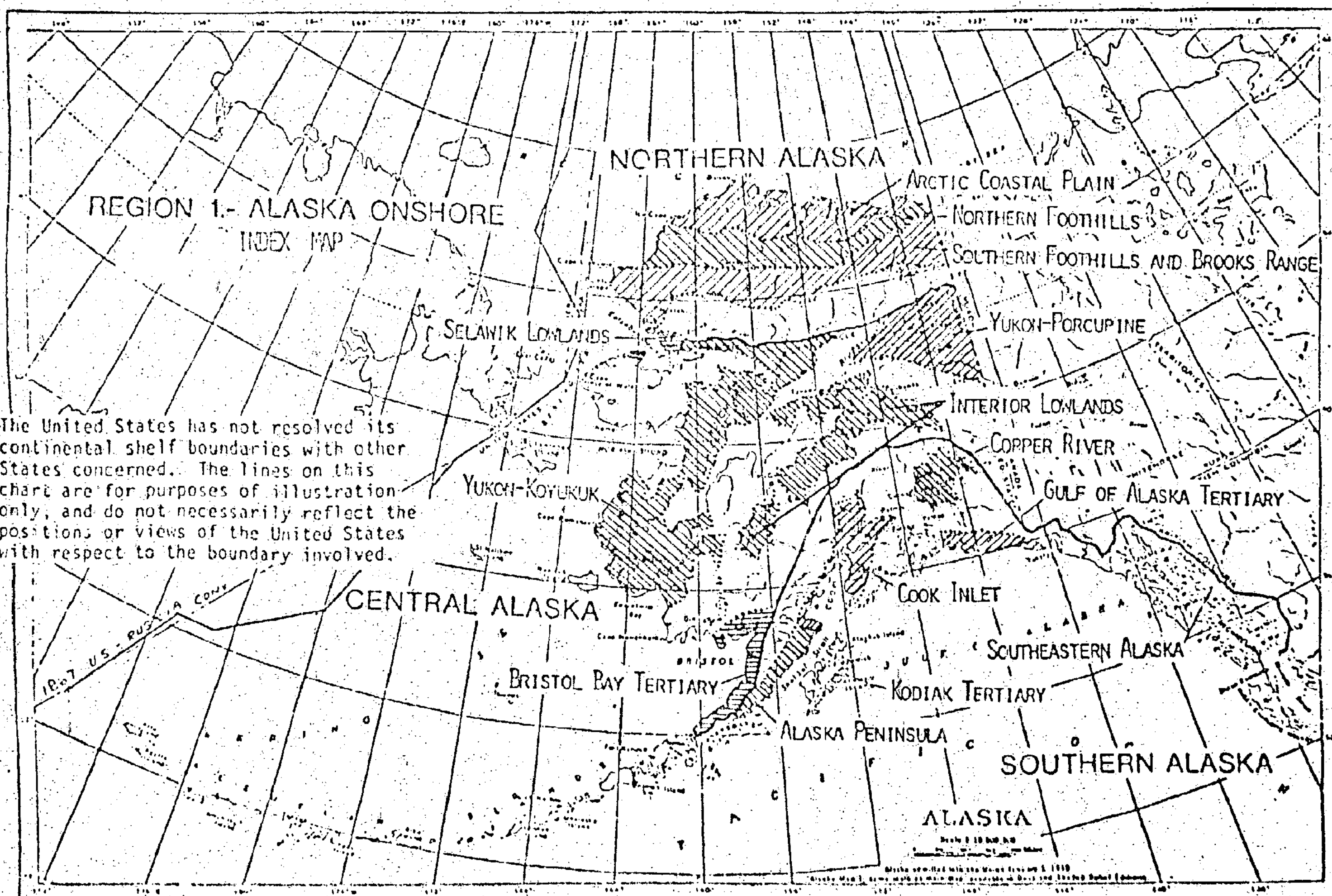
Office of Energy Resources
Branch of Oil and Gas Resources
Resource Appraisal Group

OIL
(in billion barrels)

Number	Province Name	Area (mi²)	Volume (mi³)	Cumulative Production	Demonstrated Reserves: Measured Reserves	Demonstrated Reserves: Indicated Reserves	Demonstrated Reserves: Total	Inferred Reserves	Undiscovered Recoverable: Statistical Mean	Undiscovered Recoverable: Marginal Probability	Undiscovered Recoverable: Range
Reg. I	Alaska Onshore										
	Northern Alaska Subregion										
1	Arctic Coastal Plain Subprovince	25,570	75,712	2.005	5.927	0	5.922	6.15	6.45		3.0-10.0
2	Northern Foothills Subprovince	23,555	133,350	Negl.	0.63	0	0.69	0.725	2.59		1.0-5.4
3	Southern Foothills and Brooks Range Subprovince	40,250	153,370	0	0	0	0	0	(0.75) 0.3	0.4	0 - 1.2
4	Selawik Lowlands Province	4,520	4,230	0	0	0	0	0	Negl.		Negl.
	Central Alaska Subregion										
5	Yukon-Porcupine Province	20,420	48,450	0	0	0	0	0	(0.33) 0.1	0.3	0 - 0.4
6	Yukon-Koyukuk Province	54,730	100,530	0	0	0	0	0	(0.27) 0.07	0.25	0 - 0.4
7	Interior Lowlands Province	23,640	9,470	0	0	0	0	0	Negl.		Negl.
8	Bristol Bay Tertiary Province	5,570	13,450	0	0	0	0	0	(0.42) 0.15	0.4	0 - 0.7
	Southern Alaska Subregion										
9	Alaska Peninsula Subprovince	14,531	45,730	0	0	0	0	0	(0.59) 0.24	0.4	0 - 1.1
10	Cook Inlet Subprovince	6,275	13,100	0.145	0.262	0.012	0.419	0.162	0.44		0.2 - 0.8
11	Copper River Subprovince	5,090	5,020	0	0	0	0	0	(0.12) 0.04	0.3	0 - 0.16
12	Gulf of Alaska Tertiary Subprovince	4,510	12,000	0	0	0	0	0	0.27		0.1 - 0.5
13	Kodiak Tertiary Subprovince	770	600	0	0	0	0	0	Negl.		Negl.
14	Southeastern Alaska Subprovince	350	215	0	0	0	0	0	Negl.		Negl.

Negligible = less than 0.001 billion barrels


The United States has not resolved its continental shelf boundaries with other States concerned. The lines on this chart are for purposes of illustration only, and do not necessarily reflect the positions or views of the United States with respect to the boundary involved.
REGION IA.- ALASKA OFFSHORE
OFFSHORE PROVINCES ARE LIMITED TO DEPTHS LESS THAN 200 METERS, ALTHOUGH THE PROVINCE AREA SHOWN IS MORE EXTENSIVE.
200-METER LINE
PROVINCE BOUNDARIES
BEAUFORT SEA
CENTRAL CHUKCHI
HOPE
NORTON
ST. MATTHEW-HALL
NAVARIN
COOK INLET
EASTERN GULF OF ALASKA
GULF OF ALASKA
BRISTOL
KODIAK-TERTIARY
SHUMAGIN SHELF
ST. GEORGE BASIN COMPLEX
ALASKA


REGION 1.- ALASKA ONSHORE
INDEX MAP
NORTHERN ALASKA
ARCTIC COASTAL PLAIN
NORTHERN FOOTHILLS
SOUTHERN FOOTHILLS AND BROOKS RANGE
YUKON-PORCUPINE
SELAWIK LOWLANDS
INTERIOR LOWLANDS
COPPER RIVER
YUKON-KOYUKUK
GULF OF ALASKA TERTIARY
CENTRAL ALASKA
COOK INLET
SOUTHEASTERN ALASKA
BRISTOL BAY TERTIARY
KODIAK TERTIARY
ALASKA PENINSULA
SOUTHERN ALASKA
ALASKA
1867 U.S.-RUSSIA CONV.
The United States has not resolved its continental shelf boundaries with other States concerned. The lines on this chart are for purposes of illustration only, and do not necessarily reflect the positions or views of the United States with respect to the boundary involved.

08-H1LH

STATE OF ALASKA

JAY S HAMMOND
GOVERNOR

DEPARTMENT OF COMMERCE &
ECONOMIC DEVELOPMENT
DIVISION OF ENERGY & POWER DEVELOPMENT

7TH FLOOR MACKAY BLDG
338 DENALI STREET
ANCHORAGE, AK 9950?

May 6, 1977

Dear

Because you are a recognized authority on Alaska's coal resources, we are asking you to assist us in ranking (predicting) the future order of production by coal field, of Alaska's potentially recoverable coal resources, before and after the year 2000. We need your analysis for use in our Regional Energy Resource Planning Project. You are one of the few experts to whom we are asking this request.

We ask that you number the coal fields according to the most probable order of production (your best guess); that is, when the coal will be mined; provide your estimate of when mining is most likely to take place; and that you list your reasons under "comments". We also recognize that not all experts are knowledgeable about all coal fields, so we have provided a place for you to indicate this.

Some information on quantity and quality of Alaska coal is attached even though it is not recent (1967) data. Additional up-to-date information would be appreciated.

Of the coal fields identified, one of them (Nenana) has significant mining operations currently underway.

We are fully aware that the information we are requesting is very subjective and highly speculative in nature, but your best guess is one of the best we can think of. Please return the form by May 17 to our office. Your assistance will be greatly appreciated.

Sincerely,

Dee Lane Gene Rutledge
Alaska Regional Energy Resources Planning Project

Attached: 1) Survey form - two pages
2) Excerpts from Coal Resources in Alaska by F.F. Barnes (1967)
3) Maps (2)

SURVEY OF ALASKAN COAL EXPERTS
RANKING OF PRODUCTION OF POTENTIALLY RECOVERABLE COAL RESOURCES
BEFORE AND AFTER THE YEAR 2000

Rank1/	Timing2/	Major Coal Fields	Degree Expert3/	Comments4/
		Matanuska Field		
		Kenai Field		
		Bering River Field		
		Chignik Field		
		Herendeen Bay Field		
		Unga Island Field		

SURVEY OF ALASKAN COAL EXPERTS
RANKING OF PRODUCTION OF POTENTIALLY RECOVERABLE COAL RESOURCES
BEFORE AND AFTER THE YEAR 2000

Rank 1/	Timing 2/	Major Coal Fields	Degree Expert 3/	Comments 4/
		Northern Alaska Fields		
		Eagle Field		
		Jarvis Creek Field		
		Nenana Field		
		Broad Pass Field		
		Susitna		

1/ Your ranking of the most probable order of production (i.e. 1,2,3, etc.)

2/ Your estimate of when production is most likely to take place (i.e. by 1980-85, 1985-90, 1990-95, 1995-2000, after 2000)

3/ Indicate degree of your knowledge on each oil and gas province - V-very knowledgeable, A-average, 0-little or no knowledge.

4/ Your reasons for ranking and timing.

Please return to Alaska Regional Energy Resource Planning Team - Division of Energy & Power Development, 7th floor MacKay Bldg., 338 Denali St. Anchorage Alaska 99501 Attn: Gene Rutledge or Dee Lane Phone: 272-0257 or 279-6832

Name ____________________

Title ____________________

Company or Agency ____________________

Phone number ____________________

of minable thickness are exposed at several points; the Alaska Peninsula, containing three little-known coal fields of considerable extent; the Bering River field, which contains many beds of high-rank coal but is so structurally complex that it may not be possible to mine much coal economically; and many other smaller areas. Furthermore, the figures given in table 3 are known to be incomplete for several of the areas listed, as indicated in the descriptions of individual coal fields in the following section. For example, the figure given for the Homer district of the Kenai field represents less than 100 square miles of the 750-square mile area probably underlain by coal-bearing rocks, and those for the northern Alaska and Susitna coal fields include only the coal within specified distances of widely spaced outcrops, separated by much larger areas that are probably coal bearing. Additional fieldwork and subsurface information are needed before the total coal resources of these incompletely known areas can be adequately evaluated.

COAL FIELDS OF ALASKA

Coal deposits are widely distributed in many parts of Alaska (pl. 1), mainly in Cretaceous and Tertiary rocks. At two places small, probably unimportant deposits occur in rocks of late Paleozoic age.

The principal coal fields of the State occur in five major areas: (1) northern Alaska, including several extensive but inadequately known coal fields on the Arctic Slope north of the Brooks Range; (2) central Alaska, including the important Nenana coal field on the north flank of the Alaska Range and scattered occurrences of coal-bearing rocks along the Yukon River and some of its major tributaries, on the Kobuk River, and on the Seward Peninsula; (3) the Cook Inlet-Susitna region, including the Broad Pass, Susitna, Matanuska, and Kenai coal fields; (4) the Alaska Peninsula, including the Herendeen Bay, Unga Island, and Chignik coal fields; and (5) southeastern Alaska, including the Bering River coal field and several minor coal localities to the southeast on the mainland and on islands of the Alexander Archipelago.

Each of the Alaskan coal fields is briefly described on the following pages; the reader will find more detailed information in the publications listed at the end of this report. Detailed estimates of original resources of bituminous coal and of subbituminous coal and lignite are given in tables 4 and 5. Analyses of most of the samples of Alaskan coals taken prior to April 1, 1945, were published by the U.S. Bureau of Mines (Cooper and others, 1946). Analyses of representative coals are summarized in table 6.

TABLE 4.—*Estimated original resources of bituminous coal in Alaska*

[In millions of short tons]

Coal field and district	Overburden (feet)	Measured resources: Bed thickness (inches)				Indicated resources: Bed thickness (inches)				Inferred resources: Bed thickness (inches)				Total resources: Bed thickness (inches)			
		14–28	28–42	>42	Total	14–28	28–42	>42	Total	14–28	28–42	>42	Total	14–28	28–42	>42	Total
Northern Alaska:																	
Corwin Bluff-Cape Beaufort district	0–1,000					25.1	9.0	21.9	56.0	119.6	38.9	78.8	237.3	144.7	47.9	100.7	293.8
	1,000–2,000									158.4	52.5	106.9	317.8	158.4	52.5	106.9	317.8
	2,000–3,000									183.0	61.9	126.3	371.2	183.0	61.9	126.3	371.2
Kukpowruk River	0–1,000					31.2	75.7	140.6	247.5	351.6	276.4	820.5	1,448.5	382.8	352.1	961.1	1,696.0
	1,000–2,000									100.9	118.2	435.8	654.9	100.9	118.2	435.8	654.9
	2,000–3,000									126.1	139.6	448.7	714.4	126.1	139.6	448.7	714.4
Kokolik River	0–1,000					10.4	10.8	77.7	98.9	71.9	184.2	663.3	919.4	82.3	195.0	741.0	1,018.3
	1,000–2,000									90.5		513.6	604.1	90.5		513.6	604.1
	2,000–3,000									106.9		606.8	713.7	106.9		606.8	713.7
Utukok River	0–1,000					12.8	8.5	69.5	90.8	409.9	54.9	1,055.0	1,519.8	422.7	63.4	1,124.5	1,610.6
	1,000–2,000									34.8	69.7	409.3	513.8	34.8	69.7	409.3	513.8
	2,000–3,000									41.2	82.3	490.0	613.5	41.2	82.3	490.0	613.5
Meade River	0–1,000					6.1	12.1	84.4	102.6	62.7		1,128.0	1,190.7	68.8	12.1	1,212.4	1,293.3
	1,000–2,000									75.7		682.6	758.3	75.7		682.6	758.3
	2,000–3,000									89.5		807.2	896.7	89.5		807.2	896.7
Colville River	0–1,000					71.2	121.6	49.4	242.2	1,561.5	1,829.5	427.1	3,818.1	1,632.7	1,951.1	476.5	4,060.3
	1,000–2,000									327.6	783.2	503.3	1,614.1	327.6	783.2	503.3	1,614.1
	2,000–3,000									361.7	711.5	474.4	1,547.6	361.7	711.5	474.4	1,547.6
Total	0–1,000					156.8	237.7	443.5	838.0	2,577.5	2,383.9	4,172.7	9,134.1	2,734.3	2,621.6	4,616.2	9,972.1
	1,000–2,000									787.9	1,023.6	2,651.5	4,463.0	787.9	1,023.6	2,651.5	4,463.0
	2,000–3,000									908.4	995.3	2,953.4	4,857.1	908.4	995.3	2,953.4	4,857.1
Total northern Alaska						156.8	237.7	443.5	838.0	4,273.8	4,402.8	9,777.6	18,454.2	4,430.6	4,640.5	10,221.1	19,292.2
Matanuska coal field:																	
Wishbone Hill	0–2,000	0.1	0.7	5.8	6.6	1.2	9.5	41.0	51.7		10.0	43.7	53.7	1.3	20.2	90.5	112.0
Chickaloon	0–2,000							.7	.7			24.3	24.3			25.0	25.0
Total Matanuska	0–2,000	0.1	0.7	5.8	6.6	1.2	9.5	41.7	52.4		10.0	68.0	78.0	1.3	20.2	115.5	137.0
Total Alaska	0–1,000					156.8	237.7	443.5	838.0	2,577.5	2,383.9	4,172.7	9,134.1	2,734.3	2,621.6	4,616.2	9,972.1
	1,000–2,000									787.9	1,023.6	2,651.5	4,463.0	787.9	1,023.6	2,651.5	4,463.0
	2,000–3,000									908.4	995.3	2,953.4	4,857.1	908.4	995.3	2,953.4	4,857.1
	0–2,000	0.1	0.7	5.8	6.6	1.2	9.5	41.7	52.4		10.0	68.0	78.0	1.3	20.2	115.5	137.0
Grand total		0.1	0.7	5.8	6.6	158.0	247.2	485.2	890.4	4,273.8	4,412.8	9,845.6	18,532.2	4,431.9	4,660.7	10,338.6	19,429.2

TABLE 5.—*Estimated original resources of subbituminous coal and lignite in Alaska*

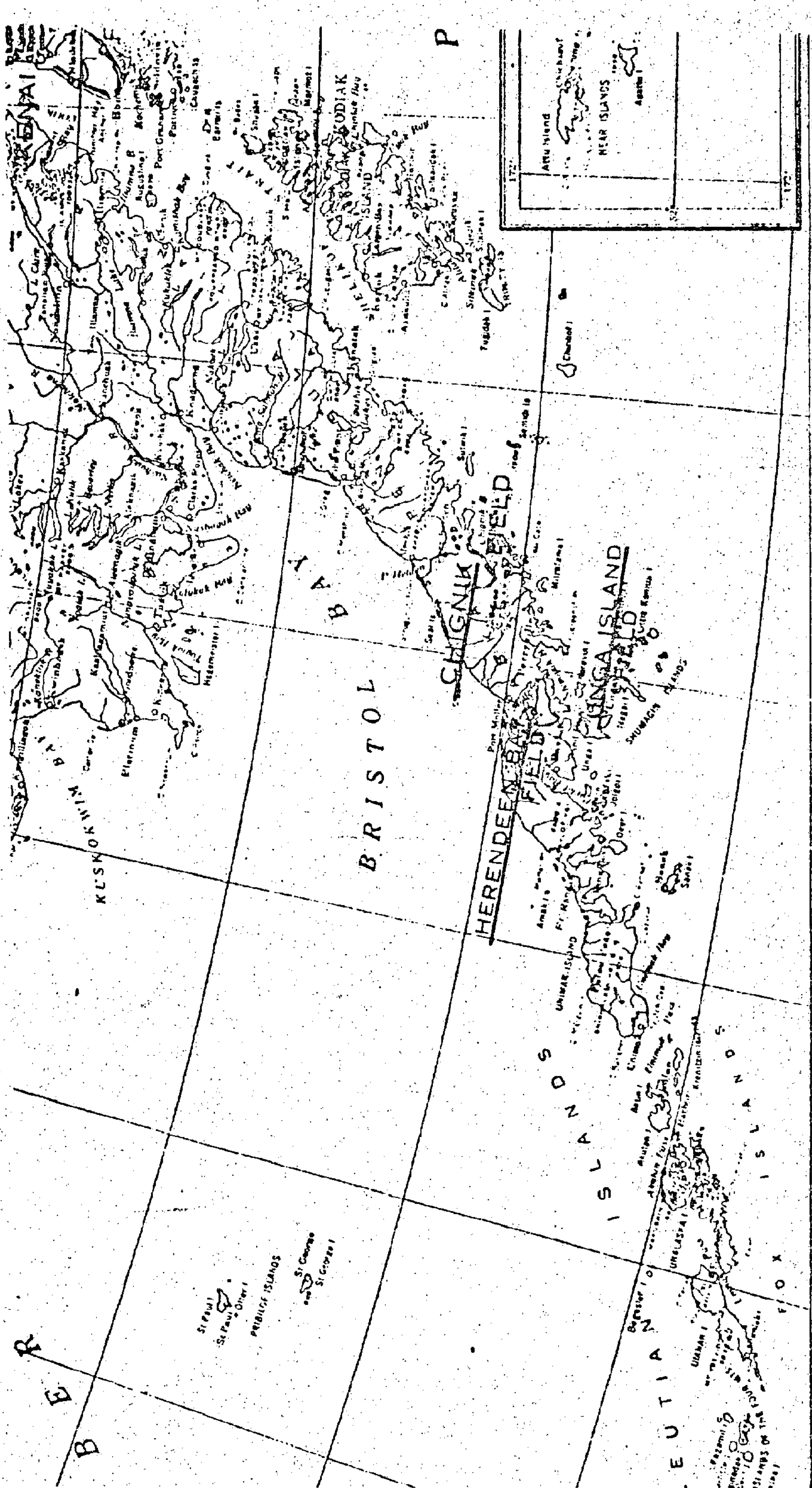
[In millions of short tons]

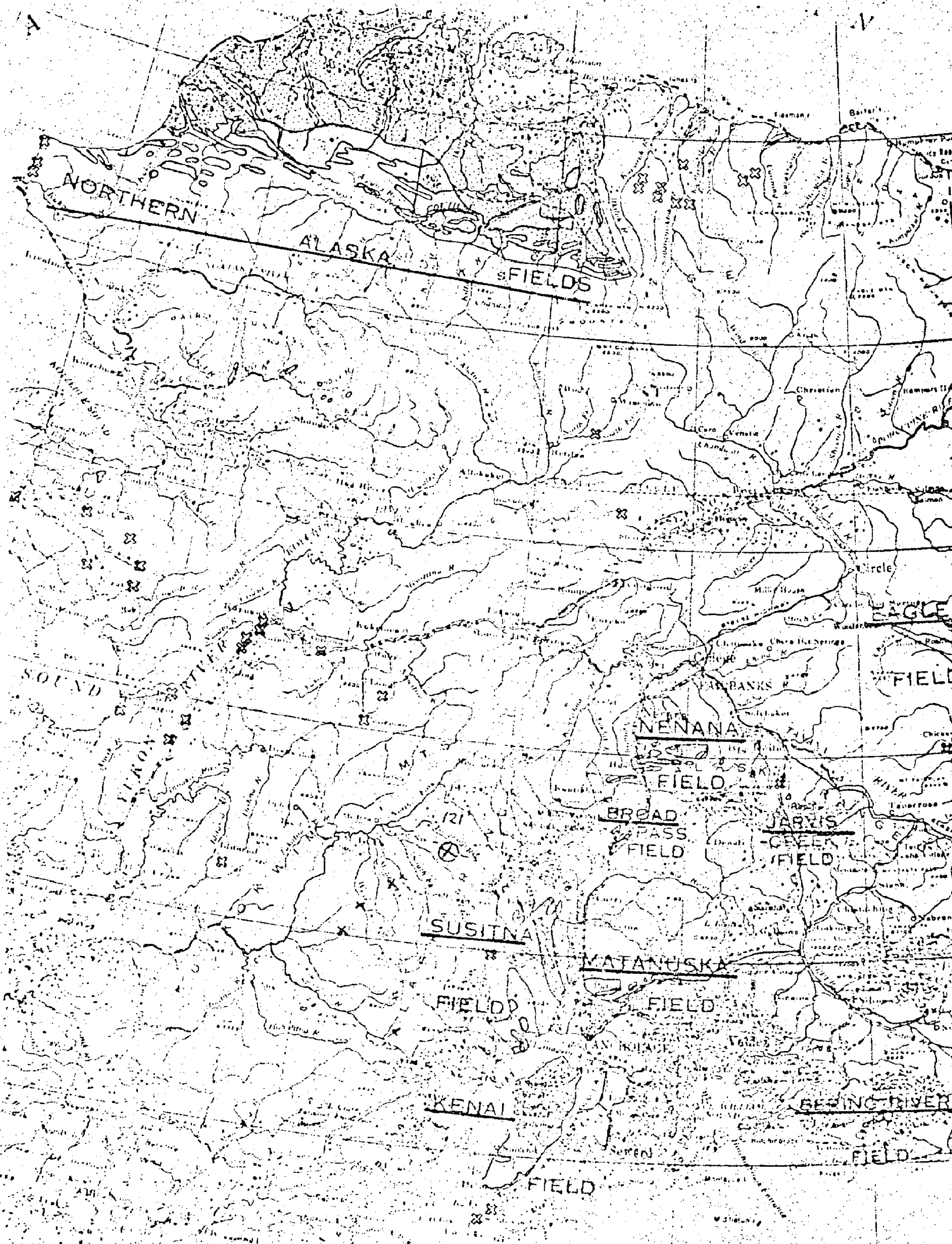
Coal field and district	Overburden (feet)	Measured resources: Bed thickness (feet) 2½-5	5-10	>10	Measured Total	Indicated resources: Bed thickness (feet) 2½-5	5-10	>10	Indicated Total	Inferred resources: Bed thickness (feet) 2½-5	5-10	>10	Inferred Total	Total resources: Bed thickness (feet) 2½-5	5-10	>10	Total
Northern Alaska:																	
Utukok River	0-1,000					8.2	40.6	21.2	70.0	41.2	223.7	725.8	990.7	49.4	264.3	747.0	1,060.7
	1,000-2,000									54.3	81.7		136.0	54.3	81.7		136.0
	2,000-3,000									64.1	96.5		160.6	64.1	96.5		160.6
Kaolak Test Well 1	0-3,000					29.8		71.0	100.8	2,400.0	14,980.1	25,900.0	43,280.0	2,429.8	14,980.0	25,971.0	43,380.8
Kuk River (Wainwright)	0-1,000					15.6	20.8	26.2	62.6	496.1		899.0	1,395.1	511.7	20.8	925.2	1,457.7
Kugrua River (Peard Bay)	0-1,000						44.2		44.2		796.0		796.0		840.2		840.2
Meade River	0-1,000					160.0	34.5		194.5	5,063.8	1,098.0		6,161.8	5,223.8	1,132.5		6,356.3
Meade Test Well 1	0-3,000					14.2	120.8	462.0	597.0	1,010.0	8,319.0	23,474.0	32,803.0	1,024.2	8,439.8	23,936.0	33,400.0
Ikpikpuk River	0-1,000					28.9	14.7	36.8	80.4	751.0	138.0		889.0	779.9	152.7	36.8	969.4
	1,000-2,000									361.0	153.0		514.0	361.0	153.0		514.0
	2,000-3,000									59.5	117.0		176.5	59.5	117.0		176.5
Titaluk Test Well 1	0-3,000					17.0			17.0	947.0			947.0	964.0			964.0
Colville River	0-1,000					166.2	265.3		431.5	2,724.5	4,285.2		7,009.7	2,890.7	4,550.5		7,441.2
	1,000-2,000									794.5	1,024.0	1,920.0	3,738.5	794.5	1,024.0	1,920.0	3,738.5
	2,000-3,000									106.9			106.9	106.9			106.9
Umiat Test Well 11	0-3,000					11.4			11.4	191.1			191.1	202.5			202.5
Total	0-1,000					378.9	420.1	84.2	883.2	9,076.6	6,540.9	1,624.8	17,242.3	9,455.5	6,961.0	1,709.0	18,125.5
	1,000-2,000									1,209.8	1,258.7	1,920.0	4,388.5	1,209.8	1,258.7	1,920.0	4,388.5
	2,000-3,000									230.5	213.5		444.0	230.5	213.5		444.0
	0-3,000					72.4	120.8	533.0	726.2	4,548.1	23,299.0	49,374.0	77,221.1	4,620.5	23,419.8	49,907.0	77,947.3
Total northern Alaska						451.3	540.9	617.2	1,609.4	15,065.0	31,312.1	52,918.8	99,295.9	15,516.3	31,853.0	53,536.0	100,905.3
Nenana coal field:																	
Rex Creek	0-1,000						9.5		9.5	23.0	79.8	10.7	113.5	23.0	59.3	19.7	123.0
Tatlanika Creek	0-1,000						4.0	113.4	117.4	31.2	8.9	37.0	77.1	31.2	12.9	150.4	194.5
	1,000-2,000										2.4	74.0	76.4		2.4	74.0	76.4
Wood River	0-1,000		15.0		15.0		12.0		12.0		201.0	40.0	241.0		228.0	40.0	268.0
	1,000-2,000						15.0		15.0						15.0		15.0
	2,000-3,000						18.0		18.0						18.0		18.0
California Creek	0-1,000		4.0	2.0	6.0		27.0	206.6	233.6	12.3	60.6	317.0	379.9	12.3	81.6	525.6	619.5
	1,000-2,000						1.0	6.0	7.0		11.0	121.0	132.0		12.0	127.0	139.0
Lignite Creek	0-1,000		16.0	250.6	266.6		93.0	1,326.0	1,419.0	29.0	279.3	1,043.0	1,351.3	29.0	388.3	2,619.6	3,036.9
	1,000-2,000						7.0	458.0	465.0	3.0	52.0	226.0	281.0	3.0	59.0	684.0	746.0
	2,000-3,000											327.0	327.0			327.0	327.0
Healy Creek	0-1,000			300.0	300.0		1.0	93.5	94.5		27.0	114.2	141.2		28.0	507.7	535.7
	1,000-2,000			274.0	274.0		1.0	63.0	64.0		21.0	112.4	133.4		22.0	449.4	471.4
	2,000-3,000							245.0	245.0		23.0	87.8	110.8		23.0	332.8	355.8
Savage River	0-1,000										12.0		12.0		12.0		12.0
Total	0-1,000		35.0	552.6	587.6		146.5	1,739.5	1,886.0	95.5	658.6	1,561.9	2,316.0	95.5	840.1	3,854.0	4,789.6
	1,000-2,000			274.0	274.0		24.0	527.0	551.0	3.0	86.4	633.4	622.8	3.0	110.4	1,334.4	1,447.8
	2,000-3,000						18.0	245.0	263.0		23.0	414.8	437.8		41.0	659.8	700.8
Total Nenana field			35.0	826.6	861.6		188.5	2,511.5	2,700.0	98.5	768.0	2,510.1	3,376.6	98.5	991.5	5,848.2	6,938.2
Jarvis Creek coal field	0-1,000					0.8	5.1		5.9	45.0			45.0	45.8	6.1		50.9
	1,000-2,000									25.6			25.6	25.6			25.6
Total Jarvis Creek field						0.8	5.1		5.9	70.6			70.6	71.4	5.1		76.5
Broad Pass coal field:																	
Broad Pass	0-1,000						0.3		0.3		63.3		63.3		63.6		63.6
Costello Creek	0-1,000					0.3			.3					0.3			.3
Total Broad Pass field						0.3	0.3		0.6		63.3		63.3	0.3	63.6		63.9
Susitna coal field:																	
Yentna River	0-1,000					19.4	8.6	27.9	55.9					19.4	8.6	27.9	55.9
Skwentna River	0-1,000					6.6	2.5	113.9	123.0					6.6	2.5	113.9	123.0
Beluga River	0-1,000					17.4	44.6	198.1	260.1					17.4	44.6	198.1	260.1
Capps Glacier district	0-1,000						8.9	396.9	405.8						8.9	396.9	405.8
Chuitna River	0-1,000					16.3	25.5	1,498.7	1,540.5					16.3	25.5	1,498.7	1,540.5
Beach southwest of Tyonek	0-1,000					3.1	6.3		9.4					3.1	6.3		9.4
Total Susitna field						62.8	96.4	2,235.5	2,394.7					62.8	96.4	2,235.5	2,394.7
Kenai coal field (Homer district)	0-1,000					264.2	54.0		318.2					264.2	54.0		315.2
Total Alaska	0-1,000		35.0	552.6	587.6	707.0	722.4	4,059.2	5,488.6	9,217.1	7,262.8	3,186.7	19,666.6	9,924.1	8,020.2	7,798.5	25,742.8
	1,000-2,000			274.0	274.0		24.0	527.0	551.0	1,238.4	1,345.1	2,453.4	5,036.9	1,238.4	1,369.1	3,254.4	5,861.9
	2,000-3,000						18.0	245.0	263.0	230.5	236.5	414.8	881.8	230.5	254.5	659.8	1,144.8
	0-3,000					72.4	120.8	533.0	726.2	4,548.1	23,299.0	49,374.0	77,221.1	4,620.5	23,419.8	49,907.0	77,947.3
Grand total			35.0	826.6	861.6	779.4	865.2	6,364.2	7,028.8	15,234.1	32,143.4	55,128.9	102,606.4	16,013.5	33,033.6	61,619.7	110,696.8

TABLE 6.—*Range in composition and heating value of representative Alaskan coals*

[On "as received" basis]

Location	Source of samples	Rank of coal	Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Heating value (Btu)
			Percent					
Northern Alaska Region:								
Corwin Bluff-Cape Beaufort district	Outcrop	Bituminous	3.0- 5.9	28.8-40.1	47.8-58.0	4.1-11.6		
Kukpowruk River	do	do	0.8- 9.9	31.4-35.6	52.6-56.1	2.5-15.0	0.2- .3	11,910-12,880
Kokolik and Utukok Rivers	do	do	1.7- 6.2	33.1-37.4	46.8-57.9	2.3-17.4	.2- .6	11,630-13,640
Kuk and Kugrua Rivers	do	Subbituminous	17.8-26.7	29.1-31.9	40.5-42.5	2.3- 9.8	.2- .3	8,780- 9,510
Meade and Ikpikpuk Rivers	Mine	do	14.4	33.5	47.3	4.8	.6	10,330
	Outcrop	do	8.3- 9.9	32.4-35.5	37.7-40.9	6.4-20.0	.2- .8	7,700-10,720
	do	Bituminous	3.4	36.5	46.8	13.3	.7	11,660
Colville River	do	do	2.5- 6.6	30.1-43.7	39.3-62.8	2.6-24.3	.3- .7	10,420-13,450
	do	Subbituminous	5.2-16.4	28.3-31.6	41.9-49.2	11.8-23.4	.3- .7	8,450- 9,390
Central Alaska Region:								
Kobuk River	do	Bituminous	10.5	29.0	52.9	7.6	.4	10,534
Koyukuk River (Tramway Bar)	do	do	4.5	34.2	44.3	12.9		
Chicago Creek (Seward Peninsula)	Mine dump	Lignite	34.8	39.9	19.2	7.1		6,825
Ruby-Anvik district (Yukon River)	Mine	Bituminous	4.0-11.2	24.8-40.5	49.9-65.0	3.5-22.6	.2- .6	
Rampart district (Drew mine)	do	do	9.5	40.1	37.4	13.0		
Eagle-Circle district:								
Washington Creek	Outcrop	Subbituminous(?)	11.1-13.5	42.6-43.7	39.7-44.2	2.1- 3.1	.2- .3	
Nation River	Mine dump	Bituminous	1.4	40.0	55.6	3.0	3.0	
Nenana coal field	Mine	Subbituminous	17.8-27.1	33.2-42.0	27.1-35.3	3.5-13.2	.1- .3	7,570- 9,430
	Outcrop	do	11.7-32.7	31.2-42.9	22.7-36.6	3.3-15.9	.1- .4	6,320-10,385
Jarvis Creek coal field	do	do	20.0-23.0	35.1-43.4	24.1-35.3	5.2-13.1	.3-1.4	7,815- 9,415
Cook Inlet-Susitna Region:								
Broad Pass coal field:								
Costello Creek district	Mine	do	8.7-18.8	32.0-43.4	23.2-42.2	6.0-21.2	.3- .6	7,985-10,600
Broad Pass district	Tunnel and trench	Lignite	21.8-35.8	27.8-34.5	20.7-28.3	10.6-21.0	.2- .3	5,410- 7,040
Susitna coal field	Outcrop	Subbituminous	19.7-28.2	30.1-39.9	28.7-40.6	2.0-14.2	.1- .4	8,060- 9,520
	do	Lignite	31.6-33.1	22.9-37.6	26.4-29.1	2.1- 7.6	.1- .3	7,030- 8,020
Beluga Lake district	Drill hole	Subbituminous	11.3-19.3	27.8-37.9	25.8-34.6	13.3-30.5		6,290- 8,690
	Trench	do	24.4	30.1	28.7	16.8	.2	7,160
Matanuska coal field:								
Little Susitna district	Mine	do	17.4-20.3	31.6-32.5	36.6-38.9	9.2-13.5	.4	9,160- 9,210
	Outcrop	do	14.1	31.3	34.1	20.5	.4	8,460
Wishbone Hill district	Mine	Bituminous	2.7- 8.6	31.6-44.6	35.4-51.0	4.4-21.7	.2-1.0	10,390-13,190
Chickaloon district	do	do	1.1- 4.1	13.8-22.9	59.1-72.2	5.8-19.5	.4- .7	11,960-14,380
Anthracite Ridge district	Outcrop	do	1.9- 6.8	14.3-31.5	47.4-78.4	2.4-17.2	.5- .7	11,300-14,210
	do	Semianthracite	3.1- 8.7	6.6-10.5	64.3-80.6	7.0-21.0	.2- .7	10,720-13,425
Kenai coal field (Homer district)	do	Subbituminous	21.2-27.7	31.2-38.1	24.1-33.7	3.2-22.0	.2- .4	6,550- 8,600
	do	Lignite	27.1-30.4	31.8-41.3	24.5-30.3	3.8-15.7	.1- .2	6,640- 7,540
	Mine	Subbituminous	16.5-21.6	30.3-38.1	31.2-41.1	9.1-12.1	.3- .4	8,380- 9,020
Alaska Peninsula Region:								
Herendeen Bay coal field	Tunnel	Bituminous	7.5- 8.0	32.1-33.6	48.8-51.4	7.1-11.6	.3- .4	11,260-11,790
	Outcrop	do	4.2- 6.7	35.2-38.6	47.2-53.0	5.0-12.0	.4- .6	11,150-12,420
Unga Island coal field	do	Lignite	23.3	25.4	25.1	26.2	.5	5,810
Chignik coal field	Mine or prospect	Bituminous	5.0-10.8	27.2-34.3	39.6-45.4	14.9-25.3	.7-2.3	9,640-11,240
Southeastern Alaska Region:								
Bering River coal field	Mine	do	1.0- 8.6	13.1-17.4	65.0-91.1	2.1-18.0	.6-3.4	11,000-15,000
	do	Semianthracite	2.9- 6.0	10.8-13.0	60.3-76.1	4.9-22.2	.6-4.9	12,350
	Outcrop	Bituminous	1.5- 7.7	10.9-15.4	58.1-81.7	1.2-25.4	.7-1.4	10,440-14,860
	do	Semianthracite	1.6- 9.4	8.7-13.6	60.9-84.7	1.7-24.8	.5-4.1	9,880-15,020
	do	Anthracite	3.0- 8.3	5.0-13.3	66.0-82.5	2.1-20.5	.6-2.9	11,890-12,790
Kootznahoo Inlet (Admiralty Island)	Mine	Bituminous	3.8- 6.4	34.3-35.2	36.3-39.6	21.4-23.0	.9-1.3	9,930-10,630


BRISTOL BAY
KODIAK
CHIGNIK FIELD
HERENDEEN BAY FIELD
UNGA ISLAND FIELD
SHUMAGIN ISLANDS
PRIBILOF ISLANDS
St Paul
St George I
NEAR ISLANDS
Attu Island
UNIMAK ISLAND
UNALASKA I
UMNAK I
FOX ISLANDS


NORTHERN ALASKA FIELDS
NENANA FIELD
BROAD PASS FIELD
JARVIS CREEK FIELD
SUSITNA FIELD
MATANUSKA FIELD
KENAI FIELD
BERING RIVER FIELD
EAGLE FIELD
FAIRBANKS
Circle
SOUND
YUKON RIVER

08-H1LH

STATE OF ALASKA

JAY S. HAMMOND
GOVERNOR

DEPARTMENT OF COMMERCE & ECONOMIC DEVELOPMENT
DIVISION OF ENERGY & POWER DEVELOPMENT

7TH FLOOR MACKAY BLDG
338 DENALI STREET
ANCHORAGE, AK 99501

May 20, 1977

Dear

Because you are a recognized authority on Alaska's hydroelectric resources, we are asking you to assist us in ranking (predicting) the hydroelectric sites where electrical generation may occur, before the year 2000. We need your analysis for use in our Regional Energy Resource Planning Project. You are one of the few experts to whom we are making this request. Please complete the attached Form 1. Your comments will be most welcome.

We decided to use the 39 potential hydroelectric projects identified in Table 5.1 of the report "Electric Power in Alaska, 1976-1995" by the Institute of Social and Economic Research (August 1976) as a starting base. (See page 5-15 to 5-36 and appendix H). However, do not be limited by these 39 projects, add any that you think are appropriate.

We are interested in the small (less than 1mw) hydroelectric potential in Alaska and low head hydro (including tides), but this request for you to complete this Form 1 does not include these resources.

We are fully aware that the information we are requesting is subjective and speculative in nature, but your best guess is the best we can think of. Please return the form by May 26th to our office. You may retain the accompanying materials. Your assistance will be greatly appreciated.

Sincerely,

Dee Lane Gene Rutledge
Alaska Regional Energy Resource Planning Project

Attached: 1) Excerpts from "Electrical Power in Alaska, 1976-1995" (ISER) August 1976 Pages 5-20 and 5-21

2) Form 1 Hydroelectric Sites - Estimated Dates of Electrical Generation

CAPACITY AND COST OF KEY HYDROELECTRIC PROJECTS

Region/Area/Project	Capacity (KW) Installed	Capacity (KW) Prime	Prime Energy (MWH)	Total (000$)	Capital Cost Per* Prime KW	Capital Cost Per* Installed $
Anchorage-Fairbanks						
Susitna Project						
Watana	792,000	353,880	3,099,988	2,297,700	6,493	2,901
Devil's Canyon	776,000	344,750	3,020,010	1,234,100	3,580	1,590
Total	1,568,000	698,630	6,119,998	3,531,800	5,055	2,252
Southcentral-Anchorage-Fairbanks-Cordova-Valdez-Glennallen						
Tebay Lakes	64,000	30,150	264,114	--	--	--
Power Creek	12,000	3,725	32,631	11,610	3,117	967
Sheep River Lakes	4,000	2,540	22,250	6,590	2,587	1,648
No Name Creek	5,000	2,550	22,338	3,970	1,557	794
Solomon Gulch	12,000	4,440	38,877	19,972	4,498	1,664
Total	97,000	43,405	380,210			
Kenai Peninsula						
Nellie Juan Lake	40,000	21,000	104,000	45,555	2,169	1,139
Snow River	50,000	31,900	279,000	57,705	1,809	962
Bradley Lake	125,000	51,400	450,000	89,835	1,748	719
Total	225,000	104,300	913,000			
Kodiak						
Terror Lake	20,000	7,220	63,250	40,370	5,591	2,018
Southeast						
Metlakatla						
Purple Lake Rehabilitation	1,400	400	17,520	1,134	2,835	810
Hassler Lake	4,000	2,000	16,980	6,830	3,415	1,708
Total	5,400	2,400	34,500			
Ketchikan						
Upper Mahoney Lake	10,000	4,700	41,172	9,035	1,922	903
Swan Lake	15,000	7,700	67,500	32,980	4,283	2,199
Lake Grace	20,000	11,000	94,000	39,351	3,577	1,968
Total	45,000	23,800	202,672			
Petersburg-Wrangell						
Anita	4,000	2,100	18,396	5,871	2,796	1,468
Anita and Kunk Lakes	8,000	3,830	33,550	9,128	2,383	1,141
Virginia Lake	6,000	3,000	26,280	7,070	2,357	1,178
Sunrise Lake	4,000	2,400	21,024	4,174	1,739	1,043
Ruth Lake	16,000	7,950	69,660	23,355	2,938	1,460
Crystal Lake Expansion	2,500	400	3,504	4,400	11,000	1,760
Cascade Creek I	15,000	5,100	44,781	22,955	4,501	1,530
Cascade Creek II	36,000	17,900	156,672	21,335	1,192	593
Scenery Lake	18,000	9,100	79,716	22,310	2,452	1,239
Total	105,500	51,780	453,583			

* All costs calculated based on construction beginning early 1976.

Region/Area/Project	Capacity (KW) Installed	Prime	Prime Energy (KWH)	Total (000$)	Capital Cost Per* Prime KW	Installed KW
Southeast (continued)						
Juneau						
Snettisham Expansion I	27,000	11,758	103,000	22,000	1,871	815
Snettisham Expansion II	–	18,607	162,997	16,000	860	---
Total	27,000	30,365	265,997	38,000	1,251	
Sitka						
Lake Irina	3,000	1,790	15,680	3,665	2,047	1,222
Green Lake	14,000	6,600	57,816	18,050	2,735	1,289
Lake Diana	10,000	4,585	40,165	9,705	2,117	970
Milk Lake	16,000	8,000	70,080	18,750	2,321	1,172
Four Falls Lake	6,000	3,000	26,280	4,265	1,417	711
Carbon Lake	18,000	6,830	59,832	19,200	2,811	1,067
Takatz Lake	20,000	10,000	87,600	26,600	2,660	1,330
Total	87,000	40,805	357,453			
Haines						
Unnamed Lake	9,000	4,640	40,640	10,435	2,249	1,159
Skagway						
Goat Lake	9,000	4,450	38,982	9,140	2,054	1,016
Total Region	287,900	157,840				
Northwest						
Unalakleet						
Anvik River	14,000	6,800	59,568	19,725	2,901	1,409
Southwest						
Dillingham						
Lake Elva	2,500	1,240	10,820	6,690	5,395	2,676
Bethel						
Kisaralik River	36,000	18,200	159,222	74,485	4,093	2,069
Total	38,500	19,440	170,042			
Total Region	1,910,000	853,555	7,477,142			
STATEWIDE TOTAL	2,250,400	1,037,635	9,093,187			

FORM 1

Hydroelectric Sites - Estimated Dates of Electrical Generation
Note: Please refer to attached Table 5.1 for Location, Capacity and Costs

PROJECT	Do you think that Electrical Generation may occur before the year 2000? (YES OR NO)	Estimated Decade you think Electrical Production may occur	COMMENTS
1. Watana			
2. Devil's Canyon			
3. Tebay Lakes			
4. Power Creek			
5. Sheep River Lakes			
6. No Name Creek			
7. Solomon Gulch			
8. Nellie Juan Lake			
9. Snow River			
10. Bradley Lake			
11. Terror Lake			
12. Purple Lake Rehabilitation			

FORM 1

Hydroelectric Sites - Estimated Dates of Electrical Generation
Note: Please refer to attached Table 5.1 for Location, Capacity and Costs

PROJECT	Do you think that Electrical Generation *may* occur before the year 2000? (YES OR NO)	Estimated Decade you think Electrical Production *may* occur?	COMMENTS
13. Hassler Lake			
14. Upper Mahoney Lake			
15. Swan Lake			
16. Lake Grace			
17. Anita			
18. Anita and Kunk Lakes			
19. Virginia Lake			
20. Sunrise Lake			
21. Ruth Lake			
22. Crystal Lake Expansion			
23. Cascade Creek I			

FORM 1

Hydroelectric Sites - Estimated Dates of Electrical Generation
Note: Please refer to attached Table 5.1 for Location, Capacity and Costs

PROJECT	Do you think that Electrical Generation may occur before the year 2000? (YES OR NO)	Estimated Decade you think Electrical Production may occur?	COMMENTS
24. Cascade Creek II			
25. Scenery Lake			
26. Snettisham Expansion I			
27. Snettisham Expansion II			
28. Lake Irina			
29. Green Lake			
30. Lake Diana			
31. Milk Lake			
32. Four Falls Lake			
33. Carbon Lake			
34. Takatz Lake			

FORM 1

Hydroelectric Sites - Estimated Dates of Electrical Generation
Note: Please refer to attached Table 5.1 for Location, Capacity and Costs

PROJECT	Do you think that Electrical Generation may occur before the year 2000? (YES OR NO)	Estimated Decade you think Electrical Production may occur?	COMMENTS
35. Unnamed Lake			
36. Goat Lake			
37. Unalakleet			
38. Lake Elva			
39. Kisaralik River			
40. OTHER			
41. OTHER			
42. OTHER			
43. OTHER			
44. OTHER			
45. OTHER			
46. OTHER			

08-H1LH

STATE OF ALASKA

DEPARTMENT OF COMMERCE & ECONOMIC DEVELOPMENT

DIVISION OF ENERGY & POWER DEVELOPMENT

JAY S. HAMMOND
GOVERNOR

7TH FLOOR MACKAY BLDG
338 DENALI STREET
ANCHORAGE, AK 99501

June 15, 1977

Dear

Because you are a recognized authority on Alaska's uranium resources, we are asking you to assist us in ranking (predicting) the future order of production of Alaska's potentially recoverable uranium resources, before and after the year 2000. We need your analysis for use in our Regional Energy Resource Planning Project. You are one of the few experts to whom we are making this request.

We ask that you number the uranium sites according to the most probable order of production (your best guess); that is, when uranium will be mined and transported from the site; provide your estimate of when recovery is most likely to take place; and that you list your reasons under "comments". We also recognize that not all experts are knowledgeable about all areas, so we have provided a place for you to indicate this.

To our knowledge, of the areas identified, only Bokan Mountain has recovered uranium.

We are fully aware that the information we are requesting is very subjective and highly speculative in nature, but your best guess is one of the best we can think of. Please return this form by June 23. Your assistance will be greatly appreciated.

Sincerely,

Dee Lane Gene Rutledge
Alaska Regional Energy Resource Planning Project
DL:GR/dss

Enclosure

Survey of Alaskan Uranium Experts
Ranking of Production of Potentially Recoverable Uranium Resources
Before & After the Year 2000

Rank 1/	Timing 2/	Uranium Site	Degree Expert 3/	Comments 4/
		Bokan Mountain		
		Other Southeast Alaska		
		Seward Peninsula		
		Cook Inlet Basin		
		Arctic Slope		
		Eagle		
		Copper River Basin		
		Yukon Flats		
		Yukon-Kuskokwim Delta		
		Gulf Coast		
		Interior Lowlands		

Survey of Alaskan Uranium Experts
Ranking of Production of Potentially Recoverable Uranium Resources
Before & After the Year 2000

Rank 1/	Timing 2/	Uranium Site	Degree 3/ Expert	Comments 4/
		Bristol Bay		
		Selawik Area		
		Other		
		Other		
		Other		
		Other		
		Other		

1/ Your ranking of the most probable order of production (i.e. 1, 2, 3, etc.)

2/ Your estimate of when production is most likely to take place (i.e. by 1980, 1980-85, 1985-90, 1990-95, 1995-2000).

3/ Indicate degree of your knowledge on each uranium site - V - very knowledgeable, A - average, O - little or no knowledge.

4/ Your reasons for ranking and timing.

Please return to Alaska Regional Energy Resource Planning Team - Division of Energy and Power Development, 7th Floor MacKay Bldg., 338 Denali St. Anchorage, AK 99501
Attn: Gene Rutledge or Dee Lane Phone: 272-0527 or 279-6832

Name

Title

Company or Agency

Phone Number