1981

STATE OF ALASKA

LONG TERM ENERGY PLAN

Prepared For

Jay Hammond
Governor

By

Department of Commerce and Economic Development
Division of Energy and Power Development

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Clarissa Quinlan
Director

August 1981

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Prepared By:

Applied Economics Associates Inc.
And
Energy Analysis and Planning Inc.
Kirk Hall and Associates
Information Services of Alaska

For The:

State of Alaska
Department of Commerce and Economic Development
Division of Energy and Power Development
338 Denali Street
7th Floor, Mackay Building
Anchorage, Alaska 99501

August 1981

Acknowledgement

This report has been developed from material provided by Applied Economics Associates, Inc., and its subcontractors, Energy Analysis and Planning, Inc., and Kirk Hall and Associates as well as material provided by the Division of Energy and Power Development.

Many sections of this report would not have been possible to complete without the information and knowledge made available to us by numerous organizations, companies, agencies and individuals. I would like to express my thanks for the help received from everybody involved.

A few individuals from the Division of Energy and Power Development should be acknowledged for their special contributions; Mr. Don Markle, Mr. Dale Rusnell, Mr. Robert Shipley, Mr. Kyle Weaver, Mr. Greg Edblom, and Mr. Bob Williams, who acted as a consultant on the section of this report entitled *Royalty Oil and Alaska's Instate Oil Refining Industry*.

Without the effort put forward by all involved with this project, Alaska's Long-Term Energy Plan for 1981 would not have been possible.

Heinz W. Noonan,
Energy Economist,
Project Manager,
Division of Energy and
Power Development

Clarissa Quinlan
Director,
Division of Energy
and Power Development

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Foreword

Each year the Department of Commerce and Economic Development, Division of Energy and Power Development, with assistance from the Alaskan Power Authority, is required to prepare or revise a Long-Term Energy Plan for Alaska. This report is the first attempt to provide a statewide framework for energy development and use in Alaska. The format has been designed to give Alaskans a broad view of public and private energy activities. Major topics of the report include:

- A report on the "end-use" of energy in the state.
- A statewide energy resource development overview.
- An analysis of energy conservation activities and potential.
- A presentation of measures that the Governor could choose to implement in the event of an energy shortage.
- A report on areas or subjects of energy research, development and demonstration.

Taken as a whole, this document constitutes a comprehensive base of information, but to be worthwhile, the data and analysis must be linked to administrative and legislative decisions about individual energy projects and programs. Alaska's Long-Term Energy Plan intends to improve the decision making process within the state government. Coordination and standardization are required.

Alaska's energy policy issues are not the exclusive province of one agency or department. Energy issues, for example, are related to welfare programs, economic development, export policy, transportation planning, and many other aspects of Alaskan life. As this report is prepared, it is submitted to the Governor's office and agencies with energy related responsibilities. The acceptance of the report by Governor Hammond, and its transmission to the legislature, provides an annual means to focus and clarify the State's energy objectives. Setting state wide energy goals and objectives is the first step in ensuring that each energy project or program under consideration will have an even-handed and fair evaluation. However, this process of coordination could be further improved by linking the development of the Long-Term Energy Plan to the budget process of review.

Everyone in Alaska — legislators, utility managers, and private citizens — wants to know how energy projects and programs are selected. Every region of the state is heavily dependent on expensive petroleum products. How can this dependence be reduced? How can a community get State backing for an energy project? And, if it does, will it be the best choice? These are difficult questions to answer because almost all energy decisions are site specific, requiring individual evaluation. The process described later in this report is intended to clarify how projects are selected and how that process can be improved so that communities can begin developing their own resources to meet their own needs.

The State government is involved in many, if not most, of the energy projects and programs underway in Alaska. In some cases the State provides a direct subsidy. In other cases the assistance may be through financing or information programs. Furthermore, through the Alaska Power Authority's reconnaissance studies, and the proposed community energy assessments, the State government often takes on the role of proposing projects and programs.

Although the information generated from individual community studies is an important component of a state wide energy plan, Alaska's Long-Term Energy Plan should be kept distinct from primary research on specific projects and proposals. The most important role of Alaska's Long-Term Energy Plan, and those who administer it, should be that of evaluation and not advocacy. The Plan should ensure that all reconnaissance studies, feasibility studies, and community assessments — if they are to be used to select projects — have a coordinated, standardized approach and that their conclusions and recommendations have been adequately researched. If this is to become the role of the Long-Term Energy Plan, then some changes in the scope and administrative responsibilities of project evaluation are necessary.

Fundamentally, the purpose of this year's Long Term Energy Plan is to provide a centralized state wide overview of energy development and conservation programs. In so doing, the Plan will help avoid duplication, prevent existing programs from being misdirected, and ensure that the most cost effective energy projects are selected.

CHAPTER I

The Purpose of Alaska's Long-Term Energy Plan

Introduction

The primary purpose of Alaska's Long-Term Energy Plan is to provide an orderly process for making energy decisions. To be successful, the following must be accomplished:

- The Plan must be a statement of policy, and set the State's goals and objectives.
- The Plan must provide basic information about energy demand, the resource base, and energy technologies.
- The Plan must coordinate Alaska's ongoing energy activities.
- The Plan must standardize and coordinate the process of project/program selection.

Most of this report contains information and recommendations. Chapter II is a succinct statement of Governor Hammond's energy policy and an overview of the energy situation. Chapter III is an analysis of end-use energy demand and a forecast of how it may change. Chapter IV is a survey of Alaska's energy resource base and the present and future technologies which might be used to make those resources useful. Chapter V is a description and analysis of Alaska's energy conservation programs. Chapter VI is an introduction to emergency energy planning.

These components form the basis of a logical approach to meeting Alaska's present and future energy needs. The keystone is the availability of accurate and reliable information from which decisions are made. The importance of this element cannot be overemphasized. Major policy decisions impacting the conservation and development of conventional and renewable energy resources will be based on the analysis contained in the Long-Term Energy Plan and its annual updates.

Alaska's investments in hydroelectric and other alternative energy resources such as peat, coal, wind, geothermal, and solar are designed to improve reliability and reduce energy costs. Also of major importance is the State's ownership and disposition of its Royalty Oil.

Energy conservation efforts in Alaska are aimed at reducing the State's dependence on expensive petroleum products, minimizing the environmental impact of energy use and preserving resources for future generations. Energy conservation provides some of the "breathing room" while Alaska's communities develop local energy resources for the long-term.

The energy contingency planning requirement acknowledges Alaska's vulnerability to the possibility of oil supply disruptions. There are a number of events that might lead to supply disruptions, many of which are exogenous to activities within the State. Until dependence on imported petroleum supplies lessens, the State must be prepared to meet potential oil shortages.

Perhaps what makes the preparation of the Long-Term Energy Plan especially noteworthy is that Alaska is one of the few states with the key ingredients necessary to chart its own energy future. Revenue from petroleum and natural gas can be combined with a willing work force and vast energy resource potential to provide an array of local energy supply and conservation options. Since Alaska's population is less than one half of one percent of the U.S. total (at the same time that the State provides 10% of U.S. oil supplies), the Alaskan energy future can be managed to the benefit of all.

Most Alaskans are probably not aware of the State's many activities in energy development and conservation. Although these tasks are by no means finished, there have been many accomplishments. Energy activities, conservation investments, and development projects are being pursued in every region of the State. Public interest in energy is high and in a State as diverse as Alaska, private ideas and initiatives are often more important than government sponsored programs.

As Alaska's Long-Term Energy Plan evolves, criteria for energy decisions and the information base on which they are made will become more definitive. This year, considerable progress has been made in each of the major topic areas. The Long-Term Energy Plan, however, is by no means complete. As energy planning in Alaska is strengthened, and as the reliability and competitiveness of the various energy options become known, the Plan's strategy can be and should be revised.

At the present time, Battelle Pacific Northwest Laboratories is conducting a $1 million Railbelt Electric Power Alternatives Study. Due to be completed by April of 1982, the study assesses alternative energy options to the proposed Upper Susitna Hydroelectric Project. Because of the level of effort and partial overlap in subject matter, the 1981 Long-Term Energy Plan will not include substantive discussions of the Railbelt. The Plan contains preliminary energy demand projections for the region which will be revised upon receipt of more detailed analyses and projections by Battelle. Close coordination with Battelle is being maintained to assure compatibility of effects. Battelle's reserves will be incorporated into the centralized data base and used in succeeding annual Plans.

In this report the energy data base for the state has been updated and analyzed, using a standardized methodology. For the first time, Alaskans will have a comprehensive breakdown of historic energy consumption by region for the State. Despite this achievement, the data base is not yet perfect. For example, some end-uses of petroleum had to be estimated. Overall, however, a steady advance has been made.

In the last few years, there has been a worldwide debate over the superiority or inferiority of various energy resource options. To a large extent such discussions are sterile and unproductive. The "best" energy option is site specific, depending on public preference, the location of the resource, and the available technology. In this report an attempt has been made to draw together a specific description of the Alaskan resource base and the technologies available to transform or convert the energy. There is a brief description of energy development projects underway and many of those which have been proposed.

To date there have been a number of state and federally mandated energy conservation programs proposed and implemented. Information on the effectiveness of these programs is very limited, however. The major contribution of the energy conservation section in this report is to develop a framework for monitoring the effectiveness of existing programs as well as to provide some tentative estimates of the potential for saving energy.

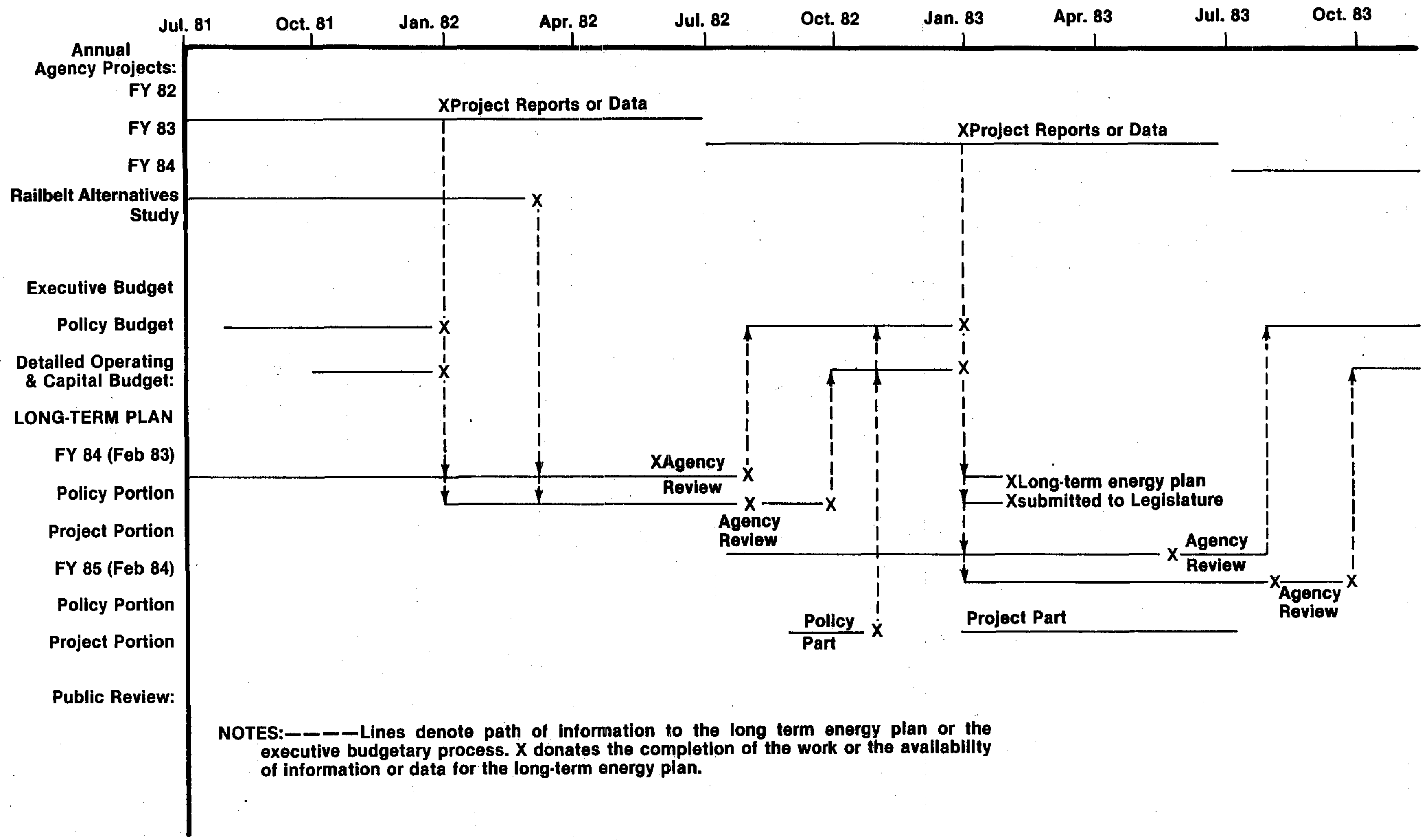
Alaska, unlike California and the East Coast, has yet to experience a serious disruption in energy supplies. (Of course, Alaskans — like everyone else — have faced a serious escalation in energy costs.) A major loss of U.S. oil imports has the potential to create shortages in Alaska. Despite the surplus of crude oil production, the State has a higher level of vulnerability than other regions because of the climate and remoteness of many Alaskan communities. Even a small oil shortage in Alaska could be very serious. This report investigates the nature of Alaska's vulnerability to oil supply disruptions and proposes some options that the Governor could implement in the event of an energy emergency. Over the next year this plan will be refined, in collaboration with federal, state and local officials, to produce a detailed emergency energy plan for Alaska.

No long-term energy plan would be complete without an energy demand and supply projection. While the techniques of econometrics and end-use forecasting may not predict the future, they do provide insight and a framework for decision making. For the first time in Alaska, a comprehensive energy demand model is being used to project energy end-use.

Energy models are never finished, and the one presented this year is no exception. The time allowed for econometric estimation was insufficient to ensure the degree of reliability that Alaska should expect in its energy demand forecasting capability. In addition, there is considerable uncertainty about many of the key assumptions which determine energy demand, and there was insufficient time to complete adequate research on many of these issues. Nonetheless, the model advances the State's understanding of how energy is used in Alaska and how it is likely to change over time. Furthermore, this ef-

BUDGETARY PLANNING PROCESS

FIGURE I-1



NOTES:————Lines denote path of information to the long term energy plan or the executive budgetary process. X donates the completion of the work or the availability of information or data for the long-term energy plan.

fort establishes an on-going energy supply and demand forecast capability for the State government and regional entities, which will be used again and again in individual project evaluation.

The Division of Energy and Power Development has divided the state into regions based upon the University of Alaska's Man-in-the-Arctic Program (MAP) regions. Each region is comprised of one or more whole U.S. Census divisions.

For purposes of this year's end-use analysis and forecasts, the Railbelt region has been separated from the Interior and Southcentral regions. This is because of the ongoing Railbelt Alternatives Study being conducted by Battelle. As shown in Figure I-1, the Interior no longer contains Fairbanks. The Kodiak and Cordova census divisions are what remains of the Southcentral region.

The primary reason for selecting the MAP model regional breakdown was to enable energy demand projects to be linked up to economic projections. The only long-term econometric model available for Alaska is the Institute of Social and Economic Research's MAP model. In following years, however, it is likely that the Alaska Native Claims Settlement Act (ANCSA) corporate regions will be adopted. These regions more realistically reflect the manner in which energy development within Alaska is likely to take place. It is generally believed that the regional native corporations will continue to be active participants in Alaska's future energy activities.

Each year the Department of Natural Resources makes an annual report on natural gas and petroleum use, as well as a forecast of future uses. This report is required by the legislature in order to evaluate the use of royalty oil and gas. In addition, the prospects of continued or expanded use of this gas in the Railbelt (for both direct uses and electrical generation) is a vital part of the study being conducted by Battelle on alternatives to the upper Susitna Hydro Project. Alaska's Long-Term Energy Plan is intended to be consistent with both of these activities through its economic forecast assumptions and a shared data base. In future years the forecasting effort will be consolidated.

The process of energy planning is constantly evolving. Specific energy decisions in the coming year will be made by the legislature, the Governor and Alaska's energy consumers and producers. The Long-Term Energy Plan should provide the framework for those decisions as well as offer guidance and insight in resolving conflicts or choosing among competing alternatives.

Today, Alaska's Long-Term Energy Plan is three things. First, it is a report designed to answer many of the basic questions about energy production and use in Alaska. Second, the Long-Term Energy Plan is a statement of policy. It condenses on an annual basis the energy policy positions of the Governor and the agencies of his administration. Finally, the Plan is an evolving capability of the Alaskan State government to provide analytical and data services to private individuals, companies, State agencies and the legislature involved in day-to-day energy decisions.

Coordinating and Standardizing Decisions

Ultimately, the vast majority of energy decisions are not made by State or local government. Consumers and private companies make many day-to-day decisions about which fuels to consume and which to produce. In addition to its role in developing specific community projects and programs, the Alaska State government's role is to guide individual private decisions. That guidance is made through fiscal and tax incentives, pricing, the regulatory process, and the State's energy programs. In other words, a clear, widely disseminated statement of Alaska's energy policy goals and objectives is often as important in bringing about desired changes as the State's participation in energy projects.

Although important, energy is but one facet of Alaska's economic and development policies. Some of the State's other objectives may conflict with its energy goals. If this is the case, the State's energy planners must identify and articulate the impact of a proposed policy change on energy development and use. The insight provided by such a process should aid the governor, agency heads and the legislature in making the best decision.

This year the Long-Term Energy Plan was prepared for the Division of Energy and Power Development and submitted to other agencies and the Governor's office for review. This process helps to ensure that the Administration has a coordinated position on energy. The give and take of agency review helps to inform and coordinate the disparate agency activities.

However, if Alaska's Long-Term Energy Plan is really to become an effective tool of decision making, its preparation must be tied to the budget process. Alaska Statutes require that the plan be submitted to the legislature no later than February 1 each year, and yet funding for the Plan is not available before the beginning of the fiscal year. Consequently the preparation of the plan does not coincide with the normal budget process of the State.

Because of the timing of preparation, the Governor and the Legislature are unable to review agency requests in the context of the policies enumerated in the Plan. The Plan is still in preparation during the period when the Administration is making decisions about specific project funding. As a result, the Plan is not the effective tool for policy coordination that it could be.

To remedy this problem, the Long-Term Energy Plan should be prepared in conjunction with the budget process. To do so will require that the Plan due in 1982 be presented as a progress report on the status and development of the 1983 (FY 1984) Plan. Figure I-2 presents a schematic view of the process.

Adopting such a process for the development of the next Long-Term Energy Plan would have three main advantages. It would allow the present study on alternatives to the Susitna project to be incorporated into the 1983 Plan. FY 1982 funding would provide sufficient gestation time for the Plan to provide well-researched new information. The policy portions of the Plan could be reviewed and agreed on prior to the recommendations for specific project funding.

In addition to its coordinating role in setting policy, Alaska's Long-Term Energy Plan will undertake tasks not presently being done, which are related to better statewide coordination and standardization. These tasks include:

Developing a Centralized State Energy Data Base

Alaskans always want more and more information. So before designing a statewide data system it is vital to recall the advice of Sir Josiah Stamp: "Public agencies are very keen on amassing statistics — they collect them, add them, raise them to the nth power, take the cube root and prepare wonderful diagrams. But what you must never forget is that every one of those figures comes in the first instance from the village watchman, who just puts down what he damn pleases."

Energy data is presently being collected by a variety of federal and State agencies and private organizations. The methodologies of data collection, organization and display vary according to the reasons for collection. For example, the Alaskan Department of Revenue collects taxes on most petroleum products and thus has a record of monthly petroleum purchases. The Department of Revenue publishes its data only in aggregated form by month and fiscal year. A federal agency, the Alaska Power Administration, collects annual data on electricity production and end-use consumption based on the annual reports of each utility. But this agency publishes only a part of the data it collects. Chapter III of this report outlines Alaska's source of energy data and some of the problems in interpreting it.

Alaska has over $140 million in energy-related studies and projects underway, in addition to the countless studies and analyses that have been conducted over the last decade. Each time a major study is launched, a fresh effort must be made to pull the data base together. The result has been a monumental duplication of effort and a waste of money. Alaska needs a carefully planned central repository and coordination center for energy data and information, and it should be tied into the energy planning effort to ensure that the data being collected is relevant, usable and accessible.

Developing a statewide data base will also provide the methodology of data collection, presentation and manipulation to be adopted by the individual reconniassance studies and community assessments.

Preparing for a Statewide Energy Emergency

The potential for a major disruption of oil imports threatens Alaskans, just as it does all other Americans. Even with Alaska's vast crude oil reserves, the State is dependent on refineries in other states for 40 percent of its vital petroleum products. For example, aviation gasoline — essential for transportation and communication — is refined outside Alaska and distributed in-state primarily by a single company. Alaskans are not exempt from the possibility of gasoline lines and grounded airplanes.

Chapter VI contains a set of emergency measures under consideration. Some of these could be implemented in the event of oil disruptions in Alaska. Next year Alaska's emergency energy plan will be finalized and coordinated with local officials, other states, the federal government and other State agencies. This, too, is a vital part of the planning effort which supports Alaska's Long-Term Energy Plan.

Project/Program Selection

Energy decisions, and particularly ones related to development, are site specific. An annual report on state wide energy issues cannot, by itself, address all of the individual concerns of local utilities, industry, small businesses, regional authorities, municipalities, cities, boroughs, regional and village corporations, village councils, and nonprofit cooperatives.

Instead Alaska's Long-Term Energy Plan is meant to provide the information base and institutional framework to assist Alaskans in getting a local energy project or program off the ground. It is an essential part of the Long-Term Energy Plan to describe the process of how the State government selects projects or programs for funding and other State assistance.

The most clearly defined process of project selection concerns electric power development.

The Alaskan Legislature has established the Power Project Fund, under the Alaska Power Authority. This fund can be used by local communities and public utilities to finance power projects. Before construction can begin, however, proposed projects must go through a series of evaluations:

Reconnaissance Study

The first step in project selection begins with a community or regionally based reconnaissance study. These studies survey all of the power sources available and evaluate the alternatives, with regard to their economic viability and impact on the environment. The studies are to include public comment.

Study Review

The Division of Budget and Management in the Office of the Governor is responsible for the review of the reconnaissance studies for completeness and compliance with the legislative directive. If the study is disapproved, it will be returned to the Alaska Power Authority with an explanation for the disapproval. If the study is approved, a feasibility study and finance plan for the recommended project is conducted.

Feasibility Study

The feasibility study includes an in-depth look at the costs and benefits of the proposed project, its environmental impact and the availability of financing. The study will provide explicit information regarding key assumptions of fuel prices, interest rates and expected demand growth. It will also include a comparative analysis of reasonable alternatives and provide the basic information required for a license application to the Federal Energy Regulatory Commission. The study will also recommend the most appropriate means to finance the project.

Feasibility Study Review

The Division of Budget and Management in the Office of the Governor shall review the feasibility study. An independent evaluation may be obtained. The Division of Budget and Management will report to the Governor and the Legislature with a recommendation for approval or disapproval of the project.

Legislative Approval

The feasibility study and report by the Division of Budget and Management will be submitted to the

Legislature for its approval.

Project Construction

Once approved, the project can begin construction. If the project is constructed by the Alaska Power Authority, it shall be designed, acquired and constructed as a public work of the State.

There are three main limitations to the process of project selection. The first is the emphasis on electricity. Outside the Railbelt and Southeast, Alaska is almost entirely dependent on oil for transportation, heating and electricity generation. The cost of oil-generated electricity is so high that it is only used for lighting and basic appliances. The real issue for most of the Bush communities is the development of local alternative energy resources for space and process heating that do not rely on petroleum. (See Chapter III and the Appendix for a breakdown of regional energy end-use.)

For the foreseeable future, Alaska's transportation fuels will be based on petroleum, but everything else from space heating to most industrial processes could be shifted to alternative fuels. If this is to be accomplished, communities must be analyzed systematically. The analysis must include a comprehensive view of energy end-use and the effort would be enhanced if the data collection is standardized.

A second major problem at the moment is that community based research overlaps and is not standardized. Agencies, such as the Division of Energy and Power Development and Rural Alaskan Community Action Program (RURAL CAP), have responsibilities to provide community-by-community energy information. In addition, community assessments on conservation and energy development potential are planned. One of the primary missions of Alaska's Long-Term Energy Plan will be to ensure that different evaluations by different agencies will have a standardized approach. This can be accomplished by setting standards for evaluation and establishing a single methodology for information and data collection. Standardization can also help the problem of overlapping jurisdictions so that unnecessary duplication can be avoided.

The third problem that arises is that the Office of Budget and Management of the Governor's Office is responsible for reviewing the reconnaissance and feasibility studies, without extensive in-house energy planning capabilities. As a result, a thorough independent assessment can only be accomplished through outside consulting. Aside from the cost, this can result in considerable delay.

In the long term, Alaskans will be best served if a clear distinction is made between energy project/program advocacy and evaluation. In most states, private companies or utilities propose projects and the State government is responsible for evaluating the proposal through public hearings and internal review. In Alaska that process will not work because the State government is heavily involved in most of the projects.

In the coming years, the pace of project selection in Alaska will accelerate. It is essential that the State of Alaska has the capability to evaluate all of the proposals fairly and quickly. It would seem logical that this should become one of the more important functions of the Long-Term Energy Plan process.

As Chapter IV of this report reveals, Alaska has a wealth of energy options. And as long as oil revenues continue flowing into state coffers, there will be no shortage of money. Concurrently, there is also no shortage of visionaries and inventors. Unless projects are carefully scrutinized with regard to their technical and economic viability, Alaska could waste a lot of money.

Despite the perceived negative connotations, such project evaluation may accelerate rather than inhibit the decision process. "Rubber stamp" approval to energy project prosposals often has unforeseen consequences. For example, in Oregon, the siting council approved a plan for the Pebble Springs nuclear plant with little or no independent analysis and without setting standards. When the council's decision was appealed, the courts ruled that adequate standards of judgement had not been set by the State of Oregon. Everything had to be redone, and nearly a decade later, a decision on the plant still has not been made. Similar delays could occur in Alaska if inadequate attention is given to project standards, planning and evaluation.

One of the clear and present dangers of any ongoing planning function is the isolation of the planners from the real world. After a length of time, the planning develops an inertia and momentum of its own above and beyond the original purpose and objectives that created the function in the first place.

In order to prevent this and to develop as reasonable and realistic a plan as possible, regular contact and assistance is needed from outside the immediate planning sphere. The establishment of an Energy Advisory Council to obtain needed periodic input, critical review and recommendations from representatives of both the public and private sectors is needed. Council participants will be drawn from government, the fuels industries, utilities, environmental interests, consumers and business. The Council's recommendations and endorsements will be key elements in the planning process.

Recommendations

Alaska's Long-Term Energy Plan and the process of energy planning it is meant to represent could be greatly improved by the following changes:

- Shift the timing of the Plan to be compatible with and included as part of the state's budgetary cycle and process.
- Establish a clear delineation between planning, advocacy and evaluation and designate appropriate State agency responsibilities for each.
- Include within the Long-Term Energy Plan the responsibility for technical and economic review and evaluation of all State-financed energy projects above a minimum scale.
- During the first quarter of the coming fiscal year specific guidance as to the technical and economic criteria to be used in project review and evaluation should be developed.
- Establish an Energy Advisory Council to assist in the annual update and refinement of the Plan.

CHAPTER II

Alaska's Energy Policy

The Nature and Scope of Alaska's Energy Policy

The largest discovery of oil in the United States was made in Alaska at Prudhoe Bay: When this occurred in 1969, the Texas Railroad Commission was still holding back oil production in Texas and Louisiana. In addition, the federal government was administering the Mandatory Oil Import Program, which limited imports to a set quota and protected domestic oil producers from foreign competition and cheap Middle East oil.

In less than a decade the tables have been turned. Gasoline price wars, which were a fixture of the fifties and sixties, are now part of the nation's nostalgic folklore, along with Elvis Presley, crew cuts and bobby sox. Since 1973 the average price paid by refiners for crude oil has increased six-fold. The resulting escalation in heating oil and gasoline prices has been one of the principal causes of increased inflation.

Despite early warnings from the oil industry, Project Independence in 1973, the National Energy Plan in 1977, and the creation of a federal Department of Energy, the nation's dependence on foreign oil remains high — about 40 percent. To add insult to injury, consumers in the Lower Forty-Eight have had to suffer through two oil shortages, a natural gas crisis, a threatening coal strike, and a seemingly never-ending set of studies predicting gloom and doom. As a result, the general public, weary of pronouncements of "limits to resources," began searching for limits to politicans and bureaucrats.

The situation facing the United States, including Alaska, can be summarized as follows: the nation is dependent on foreign oil; the price and availability of this oil is presently set by the Middle East oil exporting countries. This makes the United States vulnerable to the threat of new oil disruptions and the economic dislocations associated with abrupt oil price increases.

The original goal of Project Independence, set in November 1973, was to eliminate all oil imports by 1980. Instead, the level of oil imports has remained the same and the level of domestic oil reserves in the United States has declined over twenty percent. Progress on achieving the nation's energy goals has been significantly slower than was originally imagined by national energy planners. Reasons for this lack of progress include regulatory constraints, oil price controls, technological delays, a poor tax climate, and declining oil and gas discovery rates. Many of these barriers and constraints can be altered by shifts in public policy. But some cannot be changed and the glaring lesson of the seventies is indisputable: resolving the United State's energy problems will prove to be a torturous and often thankless task.

The experience of "energy-poor" states in the Lower Forty-Eight is in sharp contrast to that of Alaska. Alaska has it all: oil, gas, coal, peat, hydro, geothermal, biomass, wind, and, despite rumors to the contrary, solar radiation. Alaska's energy resource base is far greater than the consumption capacity of its citizens in this century or the distant future.

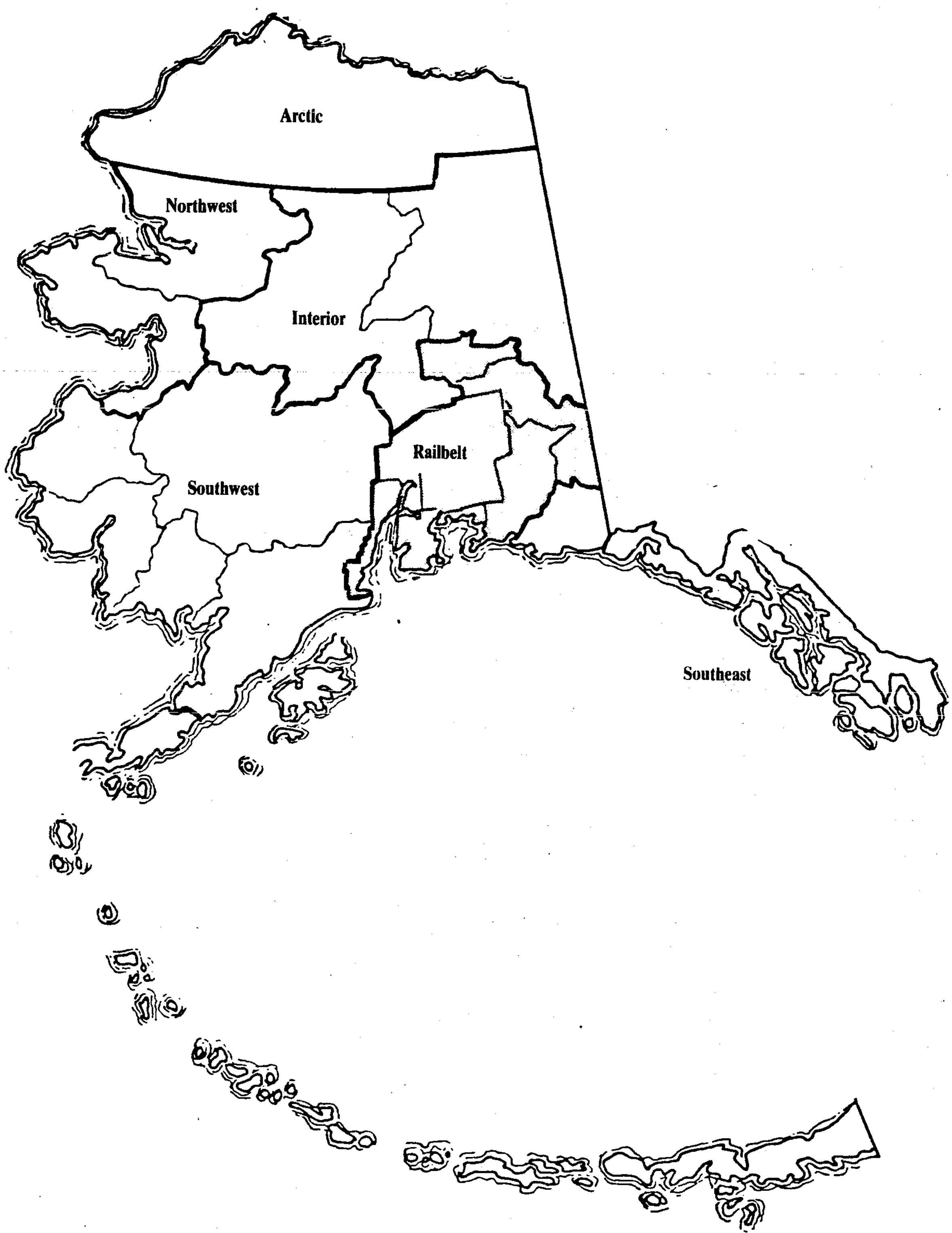
Unfortunately, an abundance of natural resources does not mean an energy problem does not exist. Energy seldom comes in a form which is directly usable; the resource has to be developed. And in the present climate, technical, and regulatory climate, this is not often easy. In Alaska it is also considerably more expensive.

Many of the economic constraints are very simple. If it would cost more to produce, transform, transport, and distribute a certain energy product than the public is willing to pay without subsidy, then some other option should be developed. In the next decade, the continued depletion of cheaper resources may make the more expensive ones attractive. Or unexpected technological changes may reduce the cost of providing usable energy with certain technologies. Economic constraints may be temporary. Delaying development to await an improved economic climate need not preclude the eventual production of the resource. It may just be good planning. Probably the most important single point concerning energy development in Alaska is that not every resource can, or should be, developed immediately.

Contrary to some popular opinions, the energy

FIGURE I-1

STATE OF ALASKA
MODIFIED MAN-IN-THE-ARCTIC (MAP) REGIONS



NOTE: Fairbanks is included as part of Railbelt. Kodiak and Cordova census divisions comprise the Southcentral Region.

problem is not one of resource limits; it is the problem of choosing among conflicting objectives. Broad national agreement on noble goals to reduce dependence on foreign oil, clean the fouled air and water, preserve the wilderness, and to cushion the aged and poor from higher energy prices are often inconsistent with each other and have resulted in contradictions in federal and state regulations. Alaska's Long-Term Energy Plan, and the process it is meant to implement, is aimed at resolving some of these conflicts. This report which aims at providing the State with a broad survey of energy use and of the potential for energy development and conservation, is the first step.

Setting Alaska's Energy Policy

As energy prices climb, New England's industrial base declines, while the sun belt and Western energy states boom. This is a fundamental fact of present economic and demographic changes occurring in the United States. Alaska, of course, is a net energy producer and should expect economic stimulation from higher oil and energy prices. Alaska's climate, remoteness from markets, geography, limited labor force, and small population make the state unique, and of necessity, make its energy policy different from any other state

Unlike the sun belt states, much of the windfall arising from higher oil prices has accrued to the Alaskan state government through severance taxes and royalties. These revenues provide the financial means to resolve many of the problems facing Alaskans. Although the windfall revenue may last somewhat longer than is presently forecast, the revenue will not last forever, because oil and gas deposits are depletable resources. Consequently, Alaska's energy and financial planning is intertwined. And there is a general consensus that the present high revenues should benefit both present and future generations.

To some Alaskans, moral values dictate that revenues from depleting resources should be spent on development of renewable resources. Certainly, that should be one of Alaska's long-term energy goals. In seeking to ensure that all present and future Alaskans will benefit from the sale of the State's oil and gas resources, however, all spending decisions should be judged on their individual merits. Even with an annual surplus of $6 billion, better roads, parks, and schools may be some of the things Alaskans forego in order to obtain renewable energy facilities, because in the short term there are manpower and materials constraints. If new energy facilities are plagued with ineffective organization, poor service, and large amounts of excess capacity, that would be a poor investment in Alaska's future.

The overriding energy policy of the State has been to attain the highest dollar value from the sale of its energy resources and to reinvest those dollars in a variety of areas, including the development of a renewable energy resource base. The intent of these energy investments is to provide the lowest possible energy costs over the long-run and to ensure that all Alaskans benefit equitably.

Alaska's energy policy encompasses six broad areas: leasing and production of energy resources, the price and availability of energy for Alaskans, the coordination of energy and economic activity, the promotion of energy conservation, the encouragement of alternative energy development, and improved coordination and administration of energy matters within the state government.

Alaska expects to continue leasing its land for oil and gas exploration at a moderate and steady rate. If oil and gas exploration is successful, this should help to offset the effect of declining state royalties from severance taxes associated with the depletion of the Prudhoe Bay oil field. Furthermore, a steady leasing rate should minimize disruptions associated with oil and gas development.

Alaska's energy policy is concerned about the availability of both electricity and petroleum products. The State's policy initiatives are aimed at ensuring that energy is reliably available at reasonable prices. The highest priority should be given to the disposition of royalty oil and gas within the State Emergency fuel assistance will be provided, in some hardship cases attempts will be made to reduce the high cost of fuel, and there will be loans for new bulk fuel storage facilities. Similarly, the State intends to accelerate the development of Alaskan hydropower and to offset some of the rising cost of electricity with a short-term subsidy program.

The Alaskan state government intends to moderate the economic and social impact of energy development in order to prevent the problems that arise from a "boom or bust" activity. Technical assistance will be provided to communities impacted by large scale energy development. The State will ensure that energy facilities are developed in an economically and environmentally sound manner.

Alaska is encouraging energy conservation through grants and loans. The State offers technical and educational assistance to individuals and communities. Energy conservation will be incorporated into the planning, design, and construction of state owned and funded facilities.

Alternative energy development in Alaska will be encouraged by research and development activities and by grant and loan programs.

The State government will improve administration and coordination by ensuring the availability of an adequate energy data base and analytical capability for decision makers. Coordination among all of the agencies involved in energy production, distribution and regulation is the responsibility of the governor's office.

In 1979 Governor Hammond confirmed these basic principles in a statement on Alaska's energy policy. In summary, his basic points were:

- Direct and equitable distribution of Alaska's energy resource wealth to all Alaskans.
- Improved efficiency in the production and distribution of electricity.
- Support for local energy needs by State planned and funded energy facility construction.
- Technical assistance for community improvement in energy conservation and management practice.
- Improved energy conservation practices in State government buildings and activities.
- Support for the development of locally-oriented energy technologies.
- Support for improved community petroleum product storage facilities.
- Public participation and local input in energy planning decisions.
- Priority for in-state uses of Alaskan energy resources.
- Procurement and delivery of fuels in emergency situations.

Energy Policies and Program Evaluation Criteria

How should Alaska develop criteria to evaluate its energy decisions? The resolution of the State's energy issues and the energy goals established by the Governor and the legislature should have six characteristics:

- Ideas should be *innovative*.
- Alaska's policy should be *flexible*.
- Decisions should be *pragmatic*.
- Alaskans should remain *optimistic*.
- The process of evaluation must be *objective*.
- The goals must be *balanced*.

Innovation

How energy will be used in the twenty-first century is guaranteed to be different from the way it is used today. This is because the present economy of the industralized world was based on the availability of cheap oil. That era is over. Energy development in Alaska should try new approaches and new ideas. Historic "rules of thumb" may no longer apply. Alaska's unique environment is likely to foster unique solutions, and decision makers should recognize this and be prepared to accept the risk.

Flexibility

The United States seems so dependent on oil because it was always cheap and plentiful. Furnaces and engines have all been designed to burn petroleum products because there was never a need to burn anything else. Everyone now recognizes that there is great uncertainty about the future availability and price of oil. That uncertainty can be dealt with, in part, by designing more flexible equipment. Alaska should place a premium on energy facilities that use dependable local resources or can easily switch to a variety of fuels. Furthermore, the Long-Term Energy Plan itself should be allowed to change as new information makes previous conclusions obsolete.

Pragmatism

To paraphrase a great Cambridge economist: To know anything, you have to know everything. But to say anything, you have to ignore a great deal. Energy planning can help to identify possible solutions that may have been overlooked. It also can help eliminate those energy projects which are clearly turkeys. But many energy projects are true policy choices: a variety of competing alternatives may be acceptable. Or as is sometimes the case in major energy projects, reasonably priced energy may create its own demand. The choice is about how fast the State *wants* to grow, not how fast it *will* grow. In making these choices, Alaska's decision makers must trust pragmatic common sense. In all cases, "black box" solutions that run counter to intuition should be carefully scrutinized.

Optimism

There is a great deal less knowledge about probable substitutes for cheap oil and gas than is commonly understood. There is certainly not a single technology or resource likely to replace these nonrenewable energy resources. Thus, Alaska should look to a variety of technologies and resources in its energy development, even though it may not be possible to ensure that every option has a proven track record, particularly with regard to the Alaskan environment. It may be worth remembering that when the industralized world made an energy transition from coal to oil, few of the benefits could be directly foreseen.

Objectivity

The answer to the energy question will not be found in terms of centalized vs. decentralized energy systems, or renewable vs. nonrenewable. In a state as diverse as Alaska there is room for all types of energy supply facilities and conservation programs. The "best" energy option is going to depend on the specific circumstances of each community, and each proposal must be evaluated on its individual merits.

Balance

This report is, of course, about Alaska's Long-Term Energy Plan. But the planning process cannot just focus on 21st century issues. Alaskanas have to live with their present energy system as well as make intermediate decisions. It is important to evaluate both future objectives and the means to achieve them. In practice this means designing policies that deal with short-term, medium-term and long-term issues.

CHAPTER III

Energy End-Use

Introduction

Alaska's energy end-use is dominated by the climate, low population density, and the fact that the state produces 18 times the final energy it consumes. Furthermore, energy end-use varies significantly within the state. Essentially, there are five independent energy systems — the Southeast, the Arctic, the Anchorage area, the Fairbanks area and the rest of the state.

Each of these energy systems have different resource opportunities and, therefore, different ways of using energy. In addition to the use of petroleum products, Southeast has abundant hydro and wood resources; Anchorage has natural gas and hydro; Fairbanks has coal; the Arctic has natural gas at Barrow and at Prudhoe Bay. The rest of Alaska almost totally depends on oil.

There can be no doubt that the Railbelt (Fairbanks/Anchorage) area dominates energy end-use. Only 14 percent of Alaska's end-use energy is consumed outside the Railbelt, despite the fact that 29 percent of the population lives in these regions. Even discounting the ammonia/urea plant on the Kenai Peninsula, which accounts for 25 percent of total state energy end-use demand, the Railbelt's per capita energy consumption is 78 percent higher than the average of the other regions.

Significantly, the per capita use of energy in every sector is higher than the U.S. average. On a per-capita basis, Alaskans consume twice the energy of their counterparts in other states. Every sector of per capita energy end-use in Alaska is higher than in the Lower Forty-Eight, and the highest, the combined transportation and marine sectors, are nearly three times the national average.

Overall, petroleum accounts for 56.8 percent of the end-use energy consumed in Alaska. This is slightly higher than the national average. Natural gas in Alaska is the second most important fuel, accounting for 34.9 percent of end-use energy. Coal is only 2.3 percent, and electricity is half the national average, accounting for only 5.9 percent of the total.

Energy demand growth in Alaska since 1970 has been erratic — in two years it actually declined and in another year grew by 24 percent. Over all it has grown at an average growth of about 7 percent, with the largest demand growth in natural gas. The figures reveal how sensitive the Alaskan energy picture is to major construction projects such as the Alyeska pipeline.

Demand growth for the next 25 years is expected to be lower than the past decade, reflecting a lower population growth and energy prices rising faster than the rate of inflation. From 1979 to 1985, energy demand growth is projected to be 5.3 percent for all energy end-use. After 1985, demand growth is expected to decline so that it averages 3.9 percent from 1979 to 2005. This is low by Alaskan standards, but over double the expected growth rate in the Lower Forty-Eight.

This year's forecast is a long-term forecast. It does not account for the income cycle, unexpected construction projects, or a cold winter. Thus, the results should be interpreted for what they mean, a long-term secular trend.

How Energy is Used

Consumers do not demand energy; they demand its services. Airlines buy jet fuel because their customers wish to move quickly between two cities. Similarly, homeowners buy heating oil because they want a warm home. The demand for energy is what economists call derived demand and this gives it special features.

Unlike an apple or an orange, energy is always purchased along with something else. For example, no one buys gasoline unless he has borrowed, rented, or purchased a car. Likewise, no one buys heating oil unless he has a furnace. Each consumer's decision about which fuel to buy and how much is determined by his immediate needs (to travel or get warm) and his past decisions (the size of his car or the type of furnace).

The demand for energy is tied to the type of furnaces, buildings, factories, airplanes, cars, ships, trains, and the design of modern life. Thus, when there are radical changes in the price or availability of a key fuel, the impact may be convulsive. It also means that policy measures aimed at shifting how energy is used must be pursued over many years to have an impact.

It is important to understand the nature of energy demand when analyzing Alaska's energy conservation potential and designing new conservation programs. Capital and labor can be substituted for the use of energy without a reduction in the standard of living. But, that substitution can take a long time.

To improve the State's understanding of how energy is used in Alaska, two things are required; good data reporting, and a strong methodology for collection, organizing, analyzing and displaying the data collected. This year the development of the data base for the Long-Term Energy Plan concentrated on the development of a methodology for data gathering and presentation, and a look at end-use energy consumption in 1979.

Table III-1 presents a comprehensive view of Alaska's energy consumption for 1979. The framework used for data organization and presentation is called an "energy balance." Once energy data has been organized into such a balance, it can easily be translated to diagrams such as Figure III-2, which is a visual description of energy flows in the state.

The logic of energy flow diagrams and energy balances is the same. It concurs with the discussion of conversion and transformation technologies contained in Chapter IV. In order to be useful, energy resources must be produced, converted or transformed, and distributed to consumers. All of these activities are captured in the diagram and table.

The point is often made that it takes energy to provide energy. And, an issue that often arises concerning new energy conversion technologies is that many of them require vast amounts of energy to provide useful energy. Energy balances are designed to help understand the flow of energy, from production to final use. In such balances the energy sector — electricity generation, energy production and transmission, and refineries — is kept separate from the end-uses of energy, which is what individual consumers demand. The separation of the energy sector from other end-uses is particularly important in analyzing conservation potential.

Another important feature of energy end-use analysis, particularly for demand forecasting, is that it avoids double counting. For example, fuels used for electricity generation are not included in end-use. If they were, double counting could only be avoided by not counting electricity.

Table III-1 contains the basic framework for all of the data presented in this report. There are three categories: primary energy requirements, energy conversion and transformation, and end-use. This methodology was developed at the International Energy Agency in order to provide realistic cross-sectional comparisons of all the member countries.

The first section on primary energy requirements accounts for all energy production, trade, and stock adjustments in Alaska. After all of these uses are accounted for, the total primary energy requirement (TPE) necessary to run the State can be estimated.

The second section on energy conversion and transformation shows how the State's primary energy requirements are converted and transformed into energy sold to consumers. After the energy is converted the total final consumption (TFC) can be estimated.

Final consumption, in this balance, is broken into six sectors; industry, transportation, commercial, marine, national defense, and residential. As Alaska's data base is improved and refined, sub-categories in each of these sectors can be identified. It is this section of the balance, which is refered to as "energy end-use."

Before proceeding with a description of how energy is produced, converted and transformed, and used in each of Alaska's regions, it is necessary to point out some of the deficiencies in the data base developed this year. Many numbers presented in these tables are approximations due to deficiencies in the available data. Consequently, some caution must be used in interpretion.

The key problem in developing an energy end-use data base in Alaska, as in every state, is in the petroleum sector. Natural gas and electricity are metered. Although that data is not always published, it does exist somewhere. Oil, on the other hand, is not sold through a fixed distribution system; for ex-

TABLE III-1

Preliminary Data
Alaskan Energy Balances
(in Billion Btu, 10^9 Btu)

1979

Fuel	Solids	Crude	Petro	Gas	Hydro	Electric	Total
(1) Production	15381	2965714		761377	5116		3747588
(2) Imports	-	27965	51637	-	-	-	+79602
(3) Exports	-	-2848986	-43311	66098	-	-	-2958395
(4) Stck/reinj	-60	-	-	-525770	-	-	-525830
(5) Total Primary Energy (TPE)	15321	144693	8326	169509	5116	-	342965
(6) Electricity	-10457	-	-10085	-40464	-5116	16503	-49619
(7) Energy Prod/tran	-	-12649	-3139	-52888		-3962	-72688
(8) Refineries	-	-131994	124765	-2558		-	-9787
(9) Stat. Dif.	-	-	-	-		-	-3
(10) Total Final Consumption (TFC)	4864		119867	73599		12538	210868
(11) Industry	62		3915	57494		3581	65052
(12) Transportation	-		80605	-		-	80605
(13) Commercial	825		5082	3368		3080	12355
(14) Marine	-		9315	-		-	9315
(15) Government	3846		2336	5505		1697	13384
(16) Residential	131		18614	7232		4180	30157

Explanation of the rows and columns of Alaska's energy balances.

- The first row, refers to the total energy produced, in its raw form, in Alaska in 1979. In order to make all of the diverse forms of energy comparable, the fuels are expressed in terms of British thermal units (Btus).

- Each column of the balance refers to a particular form of energy — solids, crude oil, petroleum products, natural gas, hydro power, electricity, and the total for all fuels.

- Rows two and three refer to the export/import sector for energy trade. These categories do not refer to international trade, but are the figures of net imports and exports sent to and from Alaska to other countries and other states. For the regional balances, exports and imports refer to the trade to and from each region.

- Row four is any stock adjustments. It also includes the reinjection of natural gas.

- Row five is total primary energy (TPE), by fuel, available for transformation or conversion in Alaska. However, to be useful, much of that energy will have to be converted and transformed.

- Rows six through eight account for the conversion of crude oil to petroleum products and fossil fuel to electricity, the transformation of hydro to electricity, and the major losses in transporting crude oil from the North Slope and transmitting energy.

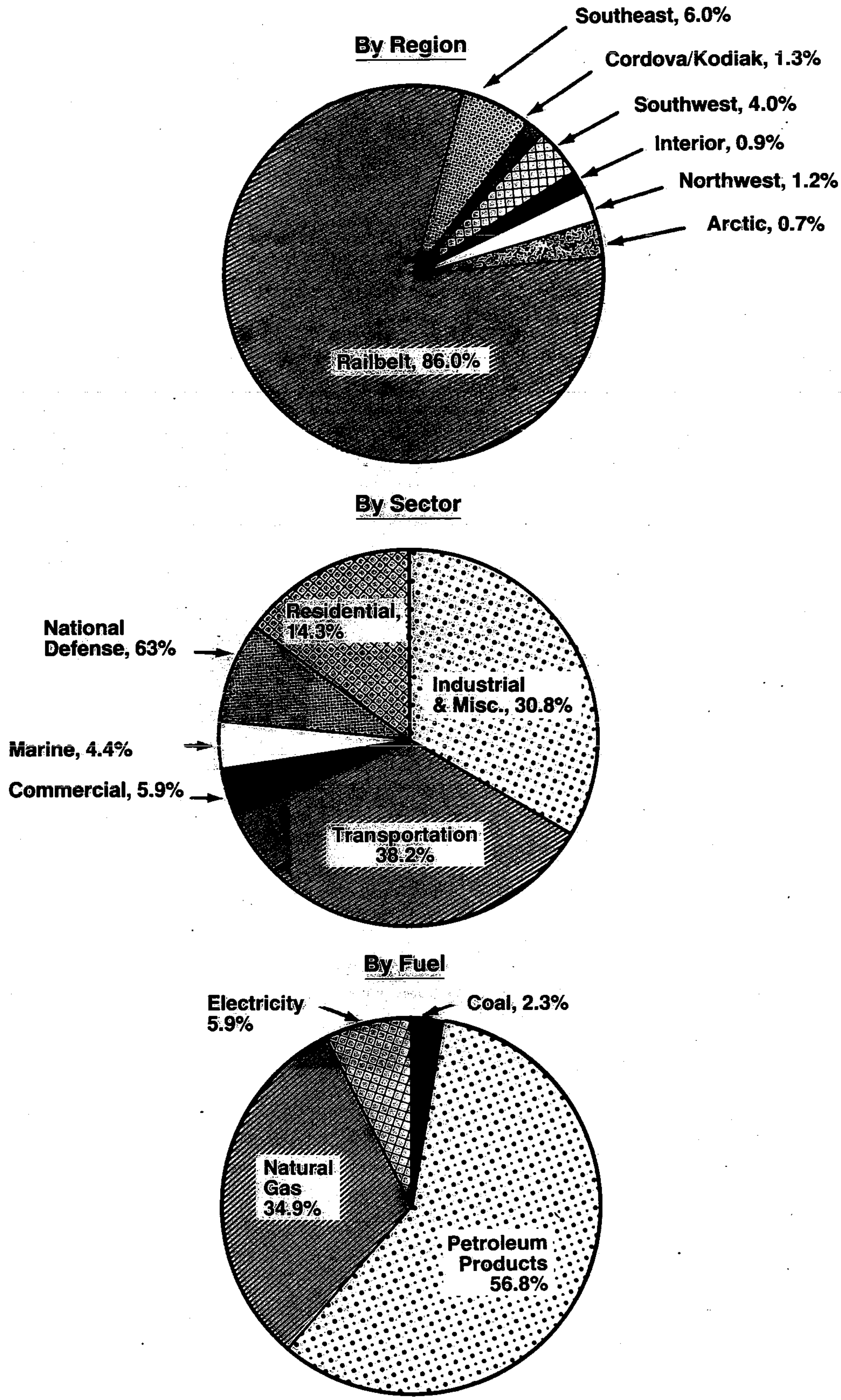
- Row nine, statistical differences, is needed to make the computer happy.

- Row ten, final energy consumption (TFC), is Alaska's end-use of energy. This is the form and quantity of energy sold to consumers.

- Rows eleven through sixteen break the final end-use down into the following categories: industrial, transportation, commercial, marine, government, and residential.

FIGURE III-1

ALASKA ENERGY END-USE, BY REGION, SECTOR AND FUEL
1979



ample, diesel sold at a marine terminal in the Southeast could actually be consumed elsewhere. Furthermore, most petroleum products are interchangeable in use. Diesel sold as heating oil could be used in the residential or commercial sectors; it might even be used by boats or trucks.

Alaska is heavily dependent on petroleum — it supplies 57 percent of the State's final end-use consumption and 45 percent of the primary energy. Thus, it is very important to understand how petroleum products are used. The Appendix on energy end-use and forecasting methodology contains a detailed itemization of the estimating techniques used this year as well as a description of how the estimation might be improved for future reports. Briefly the key points are:

- The State petroleum tax records maintained by the Department of Revenue could be used to improve the petroleum data base. However, the records are confidential and at present only Department of Revenue personnel are allowed access to primary data reports. This year's regional breakdown of petroleum consumption was estimated on the basis of published data as disaggregated by judicial districts, and an independent report by the U.S. Department of Energy and major petroleum fuel suppliers.
- There are three major gaps in the petroleum data base: off-highway diesel, propane (LPG) and residual oil. If the State data base is to be fully comprehensive, the Department of Revenue's reporting methods should be revised to include all of these fuels.
- Specific community-by-community data on the major end uses of petroleum products would be very helpful in improving the estimation of the regional breakdown.

Energy End-Use in Alaska in 1979

Figure III-2 shows the breakdown of energy end-use in Alaska by region, sector and fuel. The dominant region in the State is the Railbelt, the dominant fuel is petroleum, and the dominant sectors are transportation and industry.

Tables III-2 and III-3 are summaries of energy end-use derived from the regional energy balances in the Appendix of this report. Some of the highlights of the data include:

- Energy end-use is dominated by the transportation and industrial sectors. In the Lower Forty-Eight, 34 percent of end use energy is consumed in the transportation sector; in Alaska it is 43 percent (transport and marine). Alaska's industrial sector is slightly lower than the Lower Forty-Eight: 31 percent compared to 33 percent.
- Alaska has an unusual feature compared to other states and countries — it has a large national defense sector, which accounts for over 6 percent of the state's energy use.
- Alaska's residential and commercial sectors account for only 20 percent of the State's end-use, well below the average in the U.S. of 34 percent.
- The share of petroleum end-use consumption is just slightly above the national average; the per capita consumption is double.
- The share of natural gas is 34 percent higher than the national average, and per capita consumption is almost three times.
- The share of electricity, at 5.9 percent, is only one half the national average, although the per capita consumption is just about the same.
- The Railbelt contains 71 percent of Alaska's population, but consumes 86 percent of end-use energy. The energy system is dominated by natural gas in Anchorage and in Fairbanks coal consumption is important for electricity generation and space heating.
- The Southeast is the only region to use biomass for electricity. Wood and woodwaste is used to heat homes and generate electricity. Hydroelectricity supplies 40 percent of the region's electrical generation.
- The Arctic has 1 percent of the state's population, and with Prudhoe Bay produces over two thousand times the end-use energy consumed. Natural gas is used at Barrow for electricity and

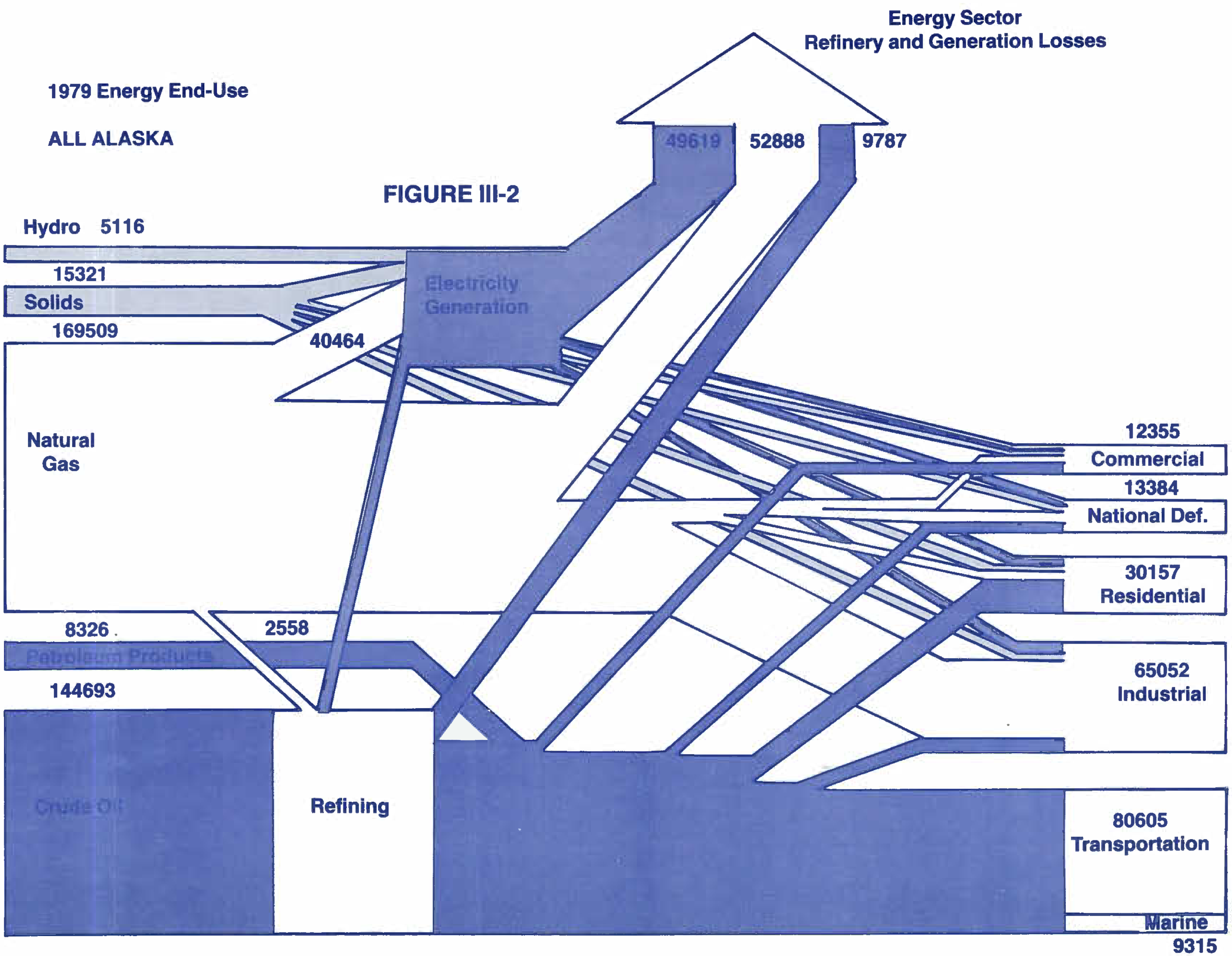

Energy Sector
Refinery and Generation Losses
1979 Energy End-Use
ALL ALASKA
49619
52888
9787
FIGURE III-2
Hydro 5116
15321
Solids
169509
40464
Electricity Generation
Natural Gas
12355
Commercial
13384
National Def.
30157
Residential
8326
2558
Petroleum Products
144693
65052
Industrial
Crude Oil
Refining
80605
Transportation
Marine
9315

TABLE III-2

1979 End-Use Data
Regional End-Use Preliminary Data
(Billion Btu Per Capita)

Region	Industry & Misc.	Trans-portation	Commercial	Marine	National Defense	Residential	Total	Percentage
Southeast	1794 (.0335)	4418 (.0824)	1098 (.0205)	1748 (.0326)	—	3589 (.0669)	12,647 (.2359)	6.0%
Cordova	248 (.0203)	1008 (.0824)	219 (.0179)	399 (.0326)	467 (.0382)	374 (.0306)	2715 (.2218)	1.3%
Southwest	330 (.0110)	5560 (.1890)	428 (.0143)	102 (.0034)	1637 (.0547)	199 (.0066)	8356 (.2790)	4.0%
Interior	80 (.0125)	1290 (.1889)	122 (.0191)	—	—	472 (.0738)	1883 (.2942)	0.9%
Northwest	194 (.0172)	1160 (.1028)	222 (.0197)	97 (.0086)	350 (.0310)	516 (.0457)	2539 (.2251)	1.2%
Arctic	150 (.0361)	427 (.1026)	195 (.0469)	36 (.0087)	405 (.0974)	201 (.0483)	1414 (.3399)	0.7%
Railbelt	62,256 (.2202)	66,723 (.2360)	10,071 (.0356)	6,933 (.0245)	10,525 (.0372)	24,806 (.0877)	181,314 (.6414)	86.0%
AK TOTAL	65,052 (.1625)	80,605 (.2013)	12,355 (.0309)	9,315 (.0233)	13,384 (.0334)	30,157 (.0753)	210,868 (.5267)	100%
Percentage	30.8%	38.2%	5.9%	4.4%	6.3%	14.3%	100%	

TABLE III-3

Total Sector Preliminary Data

Region	Coal & Wood Residuals	Petroleum Products	Natural Gas	Electricity	Total	Percent
Southeast	—	10603	—	2044	12647	6.0%
Cordova/Kodiak	—	2391	—	324	2715	1.3%
Southwest	—	7786	—	570	8356	4.0%
Interior	—	1841	—	42	1883	0.9%
Northwest	—	2379	—	160	2539	1.2%
Arctic	—	610	720	84	1414	0.7%
Railbelt	4864	94257	72879	9314	181314	86.0%
Alaska Total	4864	119867	73599	12538	210868	100.0%
Percentage	2.3%	56.8%	34.9%	5.9%	100.0%	

NOTE: Small scale and local use of coal and wood for space heating hot reflected in available data.

space heating and at Prudhoe Bay for oil related activities.

- The rest of Alaska (Northwest, Southwest, Interior, and Cordova/Kodiak) is dependent on oil for all end-users and electricity generation, with only insignificant exceptions.

Residential Sector

Table III-4 reveals the consumption of energy in the residential sector by region and fuel type. The table indicates that with the exception of the Railbelt almost all of Alaska is dependent on only two energy

TABLE III-4

End-Use Energy Consumption in the Residential Sector (In Billions of Btus, Btu 10^9)

Region	Coal	Oil	Natural Gas	Electricity	Total	Percent
Southeast	—	3149	—	440	3589	11.9%
Cordova/Kodiak	—	309	—	65	374	1.2%
Southwest	—	151	—	48	199	0.7%
Interior	—	458	—	14	472	1.6%
Northwest	—	485	—	31	516	1.7%
Arctic	—	85	107	9	201	0.7%
Railbelt	131	13977	7125	3573	24806	82.3%
Alaska	131	18614	7232	4180	30157	100.0%
Percent	0.4%	61.7%	24.0%	13.9%	100.0%	

TABLE III-5

1979 Energy End-Use Data Commercial Sector (In Billions of Btus, 10^9 Btu Units) Natural

Region	Coal	Oil	Natural Gas	Electricity	Total	Percent
Southeast	—	764	—	334	1098	8.9%
Cordova/Kodiak	—	169	—	50	219	1.8%
Southwest	—	338	—	90	428	3.5%
Interior	—	111	—	11	122	1.0%
Northwest	—	198	—	24	222	1.0%
Arctic	—	21	147	27	195	1.6%
Railbelt	825	3481	3221	2544	10071	81.5%
Alaska Total	825	5082	3368	3080	12355	100.0%
Percent	6.7	41.1%	27.3%	24.9%	100.0%	

forms — oil and electricity.

The table understates the dependence on oil, because in most regions diesel fuel is used to generate electricity. The only exceptions are the use of natural gas in the Arctic and the hydro-electricity and pulp used to generate electricity in Southeast.

Overall Alaskan per capita consumption in the residential and commercial sector is higher than the national average by 22 percent. The comparison is limited, because Alaska has much colder weather. On the other hand, Alaska's consumption in these sectors is 48 percent higher than in Sweden. This suggests that there is considerable potential remaining for energy conservation in the residential and commercial sectors.

In general, electricity is not used for home heating, except in the Railbelt and Southeast. The concentration of oil for space heating throughout the state is higher than the national average.

Commercial Sector

Table III-5 shows energy end use in the commercial sector. In general the regional breakdown is very similar to that of other sectors — the Railbelt clearly dominates with over four fifths of the energy consumed. Petroleum usage is somewhat lower than in the residential sector, but this is due to the importance of Railbelt natural gas in the commercial sector.

Transportation-Marine Sector

As already mentioned, the transportation sector, and its 100 percent dependence on petroleum, dominates Alaska's energy end-use. As can be seen in table III-6, the Railbelt is by far the most important region, consuming 82 percent of Alaska's transport fuels.

The use of fuels in Alaska is very different than in the U.S. as a whole: 57 percent of transport consumption was for unbonded jet fuel. Highway gasoline accounted for 28 percent of the total, but some of this is used for snowmobiles and off-highway vehicles. Highway diesel accounted for only 13 percent, once again illustrating Alaska's unique transport system. Aviation gasoline was only 3 per cent of the total.

In the marine sector, diesel is the dominant fuel, amounting to 89 percent of the total marine consumption. Overall, marine fuels account for only 10 percent of the combined transport and marine sector.

The dominance of air travel in transportation limits the effectiveness of traditional energy conservation programs in this sector. Other than an evaluation of airline schedules not a lot can be done to improve the efficiencies in the short term. In the longer term, new, far more efficient, jetliners will be available.

However, even though highway gasoline accounts for 28 percent of the total, Alaska's per capita consumption is just as high as the national average.

Industrial and Other

The figures in Table III-7 indicate clearly the dominance of the Railbelt in the industrial uses of energy, some 96 percent. Except for the Arctic and Southeast, almost all of Alaska's industry is located there. Some caution should be used in interpreting these figures. They do not include energy sector uses (the energy used to produce, convert and transport) nor do these figures include oil and liquified natural gas which are exported from the State. The figures do include petrochemicals — the ammonia/urea plant near Kenai.

Alaska's petrochemical industry accounts for 82 percent of total industrial end-uses of energy. Without petrochemicals, Alaska's industrial sector shrinks to only 6 percent of the State's total energy end-use.

When the petrochemical and energy industries are included, the industrial sector is very important — over 62 percent of Alaska's primary energy use.

National Defense

The National Defense sector is only 6 percent of the State total, and energy conservation programs are the responsibility of the federal government. It is, however, worth mentioning by way of example.

Most of the military bases have combined production of electricity and space heating, which is a very efficient means to use energy. As a result, the State has a number of prime examples of such energy systems, which have been working in the Alaskan environment for years.

Table III-8 shows the breakdown of the National Defense sector by fuel and region.

Energy End-Use in Alaska – Historical Perspective 1970-79

Table III-9 and Table III-10 provide a historical perspective on the growth of energy end-use demand in Alaska from 1970 to 1979. Table III-9 presents end-use demand by sector and Table III-10 by fuel.

TABLE III-6

1979 Energy End-Use
Transporation and Marine Sectors
(In Billions of Btus, 10^9 Btu)

Region	Petroleum Products Trans-portation	Petroleum Products Marine	Total	Percent
Southeast	4418	1748	6166	6.9%
Cordova	1008	399	1407	1.5%
Southwest	5660	102	5762	6.4%
Interior	1209		1209	1.3%
Northwest	1160	97	1257	1.2%
Arctic	427	36	463	0.5%
Railbelt	66723	6933	73656	81.9%
Alaska Total	80605	9315	89920	100.0
Percent	89.6%	10.3%	100.0%	

TABLE III-7

1979 Energy End-Use
Industry and Other Sectors
(In Billions of Btus, 10^9 Btu)

Region	Coal	Oil	Natural Gas	Electricity	Total	Percent
Southeast	—	524	—	1270	1794	2.8%
Cordova/Kodiak	—	120	—	128	248	0.4%
Southwest	—	293	—	37	330	0.5%
Interior	—	63	—	17	80	0.1%
Northwest	—	110	—	84	194	0.3%
Arctic	—	41	102	7	150	0.2%
Railbelt	62	2764	57392	2038	62256	95.7%
Alaska Total	62	3915	57494	3581	65052	100.0%
Percent	0.1%	6.0%	88.4%	5.5%	100.0	

These tables are summaries of the energy balances contained in the Appendix.

Overall, energy demand growth in Alaska has been high — over double the growth in other states. From 1970 to 1979, demand in all sectors averaged over 7 percent per year. The sector experiencing the greatest growth was industry, with marine, residential and commercial close behind. The national defense sector has the smallest rate of growth.

Sector demand growth has not been consistent, as is evident from Table III-9. Following the oil crisis

TABLE III-8

1979 Energy End-Use
National Defense Sector
(In Billions of Btus, 10^9 Btu)

Region	Coal	Oil	Natural Gas	Electricity	Total	Percent
Southeast	—	—	—	—	—	—
Cordova/Kodial	—	386	—	81	467	3.5%
Southwest	—	1242	—	395	1637	12.2%
Interior	—	—	—	—	—	—
Northwest	—	329	—	21	350	2.6%
Arctic	—	—	364	41	405	3.0%
Railbelt	3846	379	5141	1159	10525	78.6%
Alaska Total	3846	2336	5505	1697	13384	100.0%
Percent	28.7%	17.5%	41.1%	12.7%	100.0%	

TABLE III-9

Energy End-Use in Alaska
Historical Perspective 1970-79
Estimated Historical Energy End-Use
(In Billions of Btus, 10^9 Btu)

Year	Ind.	Trans.	Comml.	Marine	Natl. Defense	Res.	Total
1970	23547	50000	5258	3500	10581	12940	105826
1971	24951	52281	6610	3977	12480	17321	117620
1972	27580	56853	6162	4463	12364	15264	122684
1973	27431	44195	7132	6357	12699	17814	115628
1974	30264	71875	6968	4991	12617	17598	144313
1975	33789	92824	7790	6003	13421	18248	172075
1976	34615	91652	8685	6195	13462	22245	176854
1977	40131	83695	11176	6900	14089	23891	179882
1978	61851	90716	12122	8139	14752	27660	215240
1979	65052	80605	12355	9315	13384	30157	210868
Average Annual Rate of Growth	10.7%	4.9%	8.9%	10.3%	2.4%	8.8%	7.1%

TABLE III-10

Historical Energy End-Use Growth by Fuel (In Billions of Btus, 10^9 Btu)

Year	Solids	Petroleum Products	Gas	Electricity*	Total*
1970	4260	68789	29476	3321	105826
1971	5074	76763	31918	3865	117620
1972	5049	78642	34781	4212	122684
1973	5039	70371	35580	4638	115628
1974	5191	70371	35580	4638	144313
1975	5190	119781	41642	5462	172075
1976	5038	122135	43014	6667	176854
1977	4804	115991	47454	11633	179882
1978	4954	128725	69090	12471	215240
1979	4864	119867	73599	12538	210868
AARG	1.3%	5.7%	9.6%	9.1%	7.1%

*From 1970 to 1976 electricity estimates do not include self generation by industry. The annual average rate of growth (AARG) of utility generation from 1970 to 1979 was 9.1%, the figure cited in the above table. In general, historical date from 1970 to 1978 will require extensive development to make it fully consistent with 1979. The above data is correct in trend, but is not precise.

in 1973, demand growth declined. Growth increased very rapidly from 1974 through 1976 during the build up of construction on the Trans-Alaska pipeline. By 1978, when construction was completed, demand leveled off. It was followed by the 1979 oil shortages and price increases so that from 1978 to 1979 demand decreased. From 1973 to 1974, demand grew at its swiftest pace — 24 percent in a single year.

The demand for end-use natural gas had the highest growth rate; 9.6 percent from 1970 to 1979. Electricity generation by Alaska's utilities was close behind with a growth rate of 9.1 percent. Oil end-use demand growth was 5.7 percent, below the average for all fuels and reflecting the rapid increases in price. Demand growth for solids (primarily coal) was by far the slowest; it grew at only 1.3 percent through the decade.

Energy Demand Forecast 1979-2005

Table III-11 shows projected demand growth by fuel from 1979 to 2005. Similar tables have been prepared for each of the regions and are contained in Appendix C.

This year's forecast is a composite of two independent efforts. The first, for electricity outside the Railbelt and statewide for natural gas and petroleum products, was completed by Applied Economics Associates for this report. The second, on Railbelt electricity demand, was completed in 1980 by the Institute for Social and Economic Research. Since electricity demand growth is an important issue being addressed by Battelle Pacific Northwest Laboratories in their study of alternatives to the Susitna hydro project, an attempt was made not to duplicate their effort. When the Battelle Forecast model is available, it will be adapted for use in the next Long-Term Energy Plan.

The statewide composite forecast projects that

TABLE III-11

Applied Economics Associates, Inc.
Alaska Long-Term Energy Plan
Regional Forecasting Model – Alaska State

Units are billions of Btu's (10^9 Btu)

Electric	**1979**	**1985**	**1990**	**1995**	**2000**	**2005**	**AARG**
Residential Total	4181.3796	5439.9896	6242.6388	7620.4022	9283.6865	10666.5020	3.6674
Commercial	6623.6907	9000.3685	10000.4915	12885.3329	15923.2007	18825.7616	4.0994
Industrial	1369.3988	1616.8869	1764.5456	1980.6554	2173.0447	2367.2875	2.1276
Other	364.8200	430.2500	481.5801	575.8872	673.3846	763.9710	2.8836
Total Electric	12539.2891	16487.4950	18489.2560	23062.2778	28053.3165	32623.5222	3.7460
Petroleum	**1979**	**1985**	**1990**	**1995**	**2000**	**2005**	**AARG**
Diesel							
Residential Heating	20949.1300	24998.2704	27231.8560	31059.1866	34765.6112	38915.6112	2.4105
Commercial Heating	5079.5400	6912.8875	7381.4599	8148.9098	8703.0783	9105.3366	2.2702
Industrial	3914.7100	5343.1990	5698.5498	6280.1357	6704.1935	7002.0670	2.2616
Transportation	18611.0000	26735.0260	29745.4146	37949.0771	45621.8544	54826.0155	4.2430
Total Diesel	48554.3800	63989.3829	70057.2803	83437.3093	95794.6141	109849.0303	3.1899
Gasoline							
Total Gasoline	25706.0100	32587.9979	34399.0225	40042.9838	44503.0329	49506.8977	2.5528
Jet Fuel							
Total Jet Fuel	45578.2200	73331.9577	79474.2755	89740.2219	97998.0914	101867.9731	3.1416
Total Petroleum	119838.6100	169909.3384	183930.5784	213220.4350	238295.7384	261223.9011	3.0424
Natural Gas	**1979**	**1985**	**1990**	**1995**	**2000**	**2005**	**AARG**
Total Natural Gas	73599.000	95589.8459	118867.3797	147823.2150	183843.5790	228653.5890	4.4564
Total Energy Consumption for the Region							
All Fuels	**1979**	**1985**	**1990**	**1995**	**2000**	**2005**	**AARG**
	205976.8991	281986.6793	321287.2141	384105.9278	450192.6338	522501.0123	3.6451

← ← ← ←

overall energy demand will grow at an average annual rate of 3.8 percent, from 1979 to 2005. The fastest growth, of 4.5 percent, is projected to occur to natural gas, reflecting its lower relative prices. Next, is petroleum with a growth rate of 3.8 percent and electricity with 3.7 percent.

Energy demand growth in the first six years, from 1979 to 1985, is forecast at 5.3 percent, with petroleum at 6.2 percent, electricity at 4.7 percent, and natural gas at 4.5 percent.

Regional energy demand growth, from 1979 to 2005 varies from an average annual rate of 4.2 percent in the Railbelt to 2.4 percent in the Southwest. Outside the Railbelt, and away from the natural gas market, petroleum demand tends to grow slightly faster than electricity demand.

Electricity demand outside the Railbelt tends towards the projected population growth rate for each region for two reasons. First, a reliable regional data base on economic and demographic variables is not yet available. Therefore, a fully comprehensive econometric demand estimation could not be performed in the time frame this year. Secondly, the variables likely to cause an increase in per capita energy consumption — rising real income or declining energy prices — may not be realistic assumptions for Alaska's non-urban areas.

The most interesting result is the projected increase in oil demand. Despite real increases in petroleum product prices — an average of over 3 percent per year — oil demand growth continues. This is the challenge to Alaska's Long-Term Energy Plan. The increasing dependence on more and more expensive oil can only abated by action in energy conservation and energy development, the subjects of Chapters IV and V.

Forecasting Methodology and Its Limitations

Energy demand forecasts do not foretell the future — nothing mortal can. Instead, they use computers to analyze the relationship between energy demand and the key variables that determine it. Econometric and end use models establish relationships between the amount of energy consumed and income, price, population, transportation structure, appliance saturation, etc. Then, if you can forecast how these variables will change, energy demand can be forecast with some precision.

In the fifties and sixties, the U.S. enjoyed a period of low energy prices and high per capita income growth. Throughout this period energy demand growth was steady and reliable. Energy planning was easy; facilities were built to meet the unfaltering trend. But, in the seventies life has not been so easy for economic and energy planners. Economic growth and energy price changes have been erratic. Planning facilities to meet demand, without too much excess capacity or, worse, intermittent shortages, is a real task.

Alaska has, of course, had more erratic energy demand growth than in other parts of the U.S. Such turbulent demand patterns present a real challenge to the art of energy demand forecasting. This year some advances have been made in the state's energy demand modeling capability. But there are real limits to what can be achieved in a few months with a limited data base.

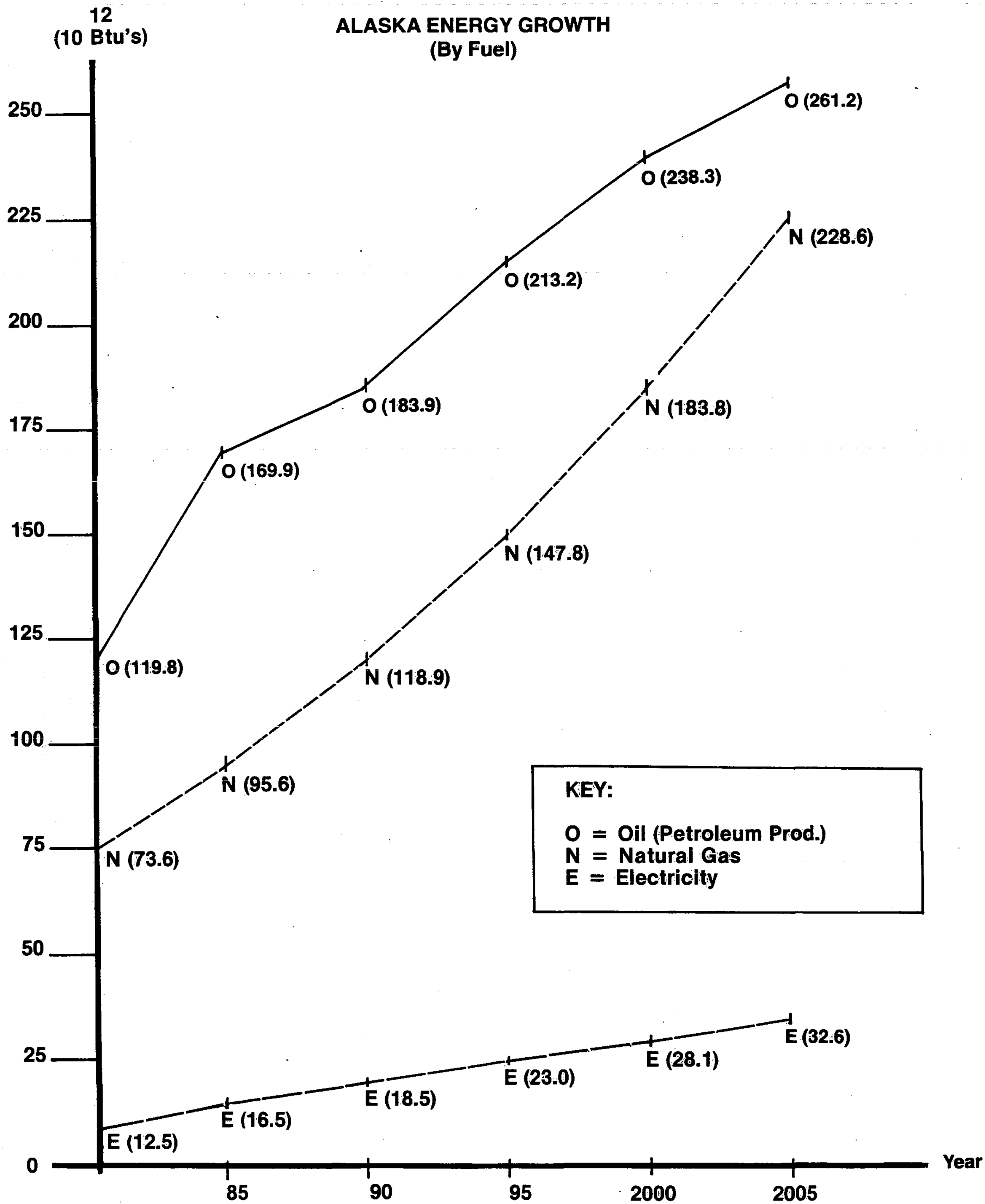
The technical Appendix on Energy Demand Forecast and Methodology contains a description of the present model and how it can be improved.

Recommendations

- The end-use data base should be improved further, particularly on a regional basis from 1970 to the present. Access to Department of Revenue records and other supplementary data will be required. Reconnaissance studies and community energy assessments end-use data should be standardized and incorporated into the centralized data base.
- A comprehensive economic and demographic forecasting model with a regional breakdown is required. At the present time, the Institute of Social and Economic Research (ISER) has the only Alaska long-term econometric model. Following analysis by Battelle in the Alternatives Study of the ISER model, a determination should be made of its adequacy for use in the long-term energy planning process.
- Reliable regional economic and demographic variables should be developed for use in the energy end-use sectoral analysis and demand forecasting.
- In-depth analysis of natural gas and electricity pricing should be conducted. This year an oil price forecast based on OPEC's proposed oil price index was used to generate the expected changes in key petroleum product prices.

FIGURE III-3

ALASKA ENERGY GROWTH
(By Fuel)



CHAPTER IV

Energy Development

Introduction

In contrast to the preparation of energy conservation strategies which can be developed on a statewide basis to a large degree, energy development must be addressed in Alaska on a community and regional level.

This is particularly true for electrical power, where no statewide energy grids exist today. The only sub-regional power system in place is in the Cook Inlet area where Chugach Electric Association produces electricity for the Kenai Peninsula, the Matanuska-Susitna Valley, and Anchorage. Although the future may include regional power systems such as the proposed link between Fairbanks and Anchorage, the planning for these begins at the community and regional level.

An example of this concept is seen in the reconnaissance studies now being conducted through Alaska by the Alaska Power Authority. This work will result in recommended community and regional power development strategies and the further investigation of specific alternative energy supply options. This "bottom up" approach to planning also helps assure that the development of power supplies more closely track with forecasted energy needs. While solid fuels are similarly dependent upon local considerations, the supply of liquid fuels is less constrained by regional lines. Petroleum products originating both in-state and outside Alaska are delivered statewide via existing air, land and water transportation systems. Although also related to community specific energy consumption patterns, they can be more easily examined on a statewide basis.

Because of the site specific nature of energy development, no project recommendations will be included in year one of the Long-Term Energy Plan. As community energy assessments and reconnaissance studies are completed, the Long-Term Energy Plan will include proposed project evaluations and recommendations. The 1981 funding level and timing did not permit this type of in-depth analysis this year. With the completion of data base and evaluation standards and procedures in FY82 the process will begin.

The 1981 development component includes a status report on project development, descriptions of additional and alternative energy resource options available in Alaska and recommendations for future work in these areas.

Oil

Resource Description

Since its discovery in 1859, oil has played an increasingly important role in our national development. While in the 1940s oil replaced coal as the primary energy source, this occurrence understates the impact petroleum has had on our lives. Its use in transportation, medical drugs, and synthetic fibers and other materials are basic elements of our industrialized society which are dependent on petroleum products.

In addition to the wide variety of products derived from oil, it has the advantage of being relatively inexpensive to transport. Thus, many areas which might have otherwise used local energy resources for heating and industrial processing have been able to import petroleum fuels, sometimes from halfway around the world. Even Alaska, with its impressive petroleum reserves, has imported crude oil from Indonesia and continues to import refined products from California and Puget Sound.

A current issue is the creation of artificial islands for drilling operations off the Arctic coast. Similarly, end-use technologies are well established, but efforts to increase efficiency (such as fuel cell development) still continue.

The process of delivering petroleum products to the consumer begins with exploratory activities to locate oil reservoirs. Regional surveys are conducted from the air or from boats to identify irregularities in the earth's magnetic field or gravity. Where warranted, more detailed surveys are undertaken employing seismic mapping and core drilling. Finally, exploratory wells are drilled in geological formations believed to contain oil or gas. Cuttings from the drill face are examined to determine if oil is present. The cuttings are removed by circulating a fluid called "drilling mud" through the drill pipe and back to the surface. The mud also maintains pressure to prevent "blowout,"the uncontrolled flow of gas or liquids from the well.

If sufficient oil is discovered, development wells are drilled, casing is set in the hole with cement, and pipe is installed to carry the oil to the surface. Offshore platforms generally contain a number of wells drilled directionally into different parts of the reservoir. The crude oil is brought to the surface by natural pressure or by pumping. Natural gas or water can be injected into the reservoir to enhance recovery as the natural flow diminishes.

Natural gas, salt water, sand and other impurities are removed from the crude oil in the field before it enters a pipeline for shipment to a refinery. The crude oil from each field differs widely in its makeup, being a mixture of over a thousand different hydrocarbons. These composition characteristics and content of impurities including sulfur, nitrogen and salts determine the potential products and the specific refining equipment requirements. For example, high-sulfur (sour) crude from Prudhoe Bay requires a refinery design distinctive from a refinery using low-sulfur (sweet) crude from Cook Inlet as feedstock.

A refinery uses a combination of processes to convert crude oil into principal products including gasoline, jet fuels and kerosene, diesel and fuel oils, lubricants, waxes and solvents, petrochemical feedstocks, and asphalt. The crude is first distilled and separated into fractions based on boiling points ranging from 250° F to 900° F (Table IV-5). Since the relative volume of each fraction derived from a particular crude may not meet the market demands, the hydrocarbons may be split, united or rearranged to better satisfy those needs. Catalytic cracking, hydrocracking and thermal cracking are processes which split large molecules into smaller molecules with high energy content. Reforming, alkylation, and isomerization are techniques employing catalysts to rearrange hydrocarbon molecular structure to form high octane compounds for gasoline manufacture.

Transportation

One of the major advantages of oil is that it is comparatively inexpensive to transport. With the exception of railroads, all of the major forms are used in Alaska. Crude oil is piped down the Trans-Alaska Pipeline to Valdez, where it is transferred to supertankers for shipment to the Lower Forty-Eight. Refined products are transported from the Chevron and Tesoro refineries on the Kenai Peninsula to Anchorage via a pipeline under Turnagain Arm. Other parts of the State are served by tanker, barge, tank trucks, and even by air. Table IV-2 summarizes the general areas of distribution for Alaska's six prime suppliers.

Resource Availability

Figure IV-1 maps the petroleum provinces of the State. Estimated remaining recoverable oil resource producing fields are presented in Table IV-1. Of all the fields except Prudhoe Bay, the Cook Inlet fields together account for only 2.4 percent of the 8,577 million remaining recoverable resource.

In addition, there are an estimated 19,200 million barrels of undiscovered recoverable reserves in the state. Of these, 6,900 million barrels are onshore and 12,300 are offshore.

Despite the size of Alaska's oil reserves, the State imports about 40 percent of its refined petroleum products. Thus, a large portion of the supply is not dependent on local resources. Small remote communities which normally receive only one or two fuel shipments per year must depend upon weather and other conditions which affect transportation.

Technology

Technologies for the extraction, processing and utilization of petroleum are well developed. However, new techniques are still being developed as oil resources are depleted, making it economical to tap less accessible reserves. The Trans-Alaska Pipeline System, transporting 1.5 million barrels per day, is an example.

Environmental Consideration

There are environmental hazards throughout the process described above. During exploration and extraction there is a possibility of major spills despite precautionary measures and equipment such as blow out preventers. Chronic pollutants and wildlife dis-

TABLE IV-1

Estimated Remaining Recoverable Oil Reserves From Producing Fields as of January 1, 1980

Field	Total (Million BBLS)	State Royalty (Percent)	State Royalty (Million BBLS)
Beaver Creek	1	0	
Granite Point	21	12.5	2.6
McArthur River	118	12.5	14.8
Middle Ground Shoal	36	0	
Prudhoe Bay	8,375	12.5	1,046.9
Swanson River	22	0	
Trading Bay	4	12.5	.5
TOTAL	8,577		1,064.8

SOURCES: Alaska Oil and Gas Conservation Commission; 1979 Statistical Report; *1980.*

Scott Goldsmith and Kristina O'Connor; Alaska Historical and Projected Oil and Gas Consumption*; Institute of Social and Economic Research and Alaska Division of Minerals and Energy Management; January 1981.*

TABLE IV-2

Petroleum Fuel Distribution May 1978 – April 1979

Distributors	General Service Area
Chevron U.S.A., Inc.	Statewide
Mobil Oil Corporation	Southeast
North Pole Refining	Fairbanks and surrounding areas
Shell Oil Company	Highway System
Tesoro Alaska Petroleum Company	Highway System
Union Oil Company of California	Highway System, Southeast, Kodiak

Calculated from Prime Supplier's Monthly Reports.
Alaska Division of Energy and Power Development.

ruptions are also considerations. Refining discharges to water may include dissolved solids (salt), suspended solids (oily sludge), and nondegradable organics (oil and phenols). Air emissions from refineries are primarily NOx, SOx and also hydrocarbons from storage facilities. Transportation and consumption of oil poses the threat of major spills and chronic discharges of hydrocarbons, particulates, NOx, SOx, CO and aldehydes.

Oil Use in Alaska

Annual oil production is over 20 times the State's own oil consumption. But this does not mean that Alaskans are exempt from the energy problems which arise from over-dependence on petroleum. As explained in Chapter VI, Alaskans may face the same risk of oil shortages as that faced by all Americans. Furthermore, although the state has benefited from the revenue increases associated with higher oil prices, its citizens have not been sheltered from the higher cost of heating oil, gasoline and electricity generated from oil.

Alaska has three refineries in the Railbelt, a topping plant in the Arctic and Alyeska refines some diesel for turbine fuel along the pipeline. Table IV-1 presents the input and output of petroleum consumption and refining in Alaska in 1979.

TABLE IV-3

Petroleum Consumption and Refining – 1979
In Barrels Per Day

	Alaskan Consumption	Alaskan Refineries						
Petroleum Product Type	Estimated State use	Railbelt Ref.	North Slope Ref.	Pipeline	Total Ref.	Export	Import	Percent Import Dependence
Motor Gasoline	12360	8550	-	-	8550	-	3810	30.8%
Aviation Gasoline	1102	-	-	-	-	-	1102	100%
Jet Fuel	27007	16905	-	-	16905	-	10102	37.4%
LP Gas	334	334	-	-	334	-	-	-
M.d. Distillates (Heating oil, etc.)	33978	13299	1889	5930	21118	-	12860	37.8%
Residual Fuel	-	18874	-	-	18874	18874	-	
Miscellaneous Non-Energy	-	1115	-	-	1115	-	-	
TOTAL	74781	59077	5930	1889	66896	18874	27874	
PERCENT	100%	79.0%	7.9%	2.5%	89.5%	25.2%	37.3%	

The first column is estimated petroleum consumption. The majority of these figures are derived from the Alaskan Department of Revenue. As explained in Chapter III, however, consumption of diesel had to be estimated from both state and federal data sources.

The second column refers to the combined refinery output of the three refineries in the Railbelt — Chevron and Tesoro on the Kenai Peninsula and Northpole near Fairbanks. The data is reported monthly to the U.S. Department of Energy and is aggregated into a state and national total.

The third column is an estimate of the refinery output from the small topping plant maintained by ARCO at the North Slope. The fourth column is an estimate of the turbine fuel used by the Aleyeska pipeline.

The fifth column is the combined refinery output in Alaska. It can then be compared to the first column to determine the net import dependence, and the level of exports. Table IV-1 reveals that the State is very dependent on outside refineries for all of its major petroleum products.

Overall 37.3 percent of Alaska's petroleum products have to be imported from the international market or from refiners in the Lower Forty-Eight. This figure understates the true dependence because it includes oil refined and used by the energy sector. For energy end use, the state depends on outside refineries for 43.1 percent of its petroleum products (see Table IV-3).

There are also some significant regional differences — the Northwest, Southwest and Southeast depended on imported oil to a much larger extent than the Interior or Southcentral regions.

The import dependence varies depending on the product: 30.8 percent for motor gasoline, 37.4 percent for jet fuel, 37.8 percent for distillates, and 100 percent for aviation gasoline.

There are considerable regional differences with regard to the dependence on oil. Without a doubt, the Bush needs special attention because those communities are almost 100 percent dependent on oil. In most villages petroleum does everything — it heats homes, runs the snowmobiles, generates electricity and delivers the fuel itself.

In some Alaskan villages oil can only be delivered by air. In such circumstances delivery costs can be more than the cost of the fuel itself. When diesel oil is used to generate electricity in remote areas the costs can be extraordinarily high, above $.50 per kWh.

Royalty Oil and Alaska's Instate Oil Refining Industry

Summary

This section briefly reviews Alaska's in-state refining industry. It provides a description of each refinery (Alpetco, Chevron, Tesoro, and North Pole) along with their product slates, expansion plans and crude oil supplies. The descriptions are meant to familiarize the reader with Alaska's refining industry. The material presented in this report was collected from a variety of different public and private sources. Much of the material was provided verbally by the refineries themselves. The rest was laboriously culled from State memorandums and scattered public reports.

The diversity of the data sources and the difficulty in obtaining them should be of concern to State officials. As will become apparent, this is a critical time for Alaska's refining industry. Cook Inlet production, the mainstay crude oil supply for Chevron and Tesoro, is declining. These refineries are both looking to the State for long-term Alaska North Slope (ANS) royalty oil contracts to replace dwindling Cook Inlet supplies. Also, the Department of Natural Resources (DNR) must finally decide the fate of the controversial Alpetco (Charter Oil Company of Florida) contract. Finally, in the State's recent solicitation for statements of interest regarding purchase of ANS royalty oil, total requests exceed 500,000 bpd. Even assuming the Kuparuk field is on-line by 1982, the State only has 90,000 bpd of ANS royalty oil to sell. The need for reliable data is paramount, if State officials are to make sound decisions.

The expansion of Alaska's refinery capacity will not eliminate the need for imports. No refiner has yet made plans to refine aviation gasoline. Also, it is not clear whether products refined in-state will back out products delivered to Western Alaska from California by Chevron and other prime oil companies. In other words, Alaska may have a refining industry that processes almost 200,000 bpd of crude oil, but still cannot supply all of the State's petroleum product requirements. This leads one to the inevitable conclusion that Alaska's refining industry is not based solely on local market considerations, but also upon secure long-term royalty oil contract with the State.

Chevron U.S.A., Inc.

Chevron's Kenai refinery is being scaled down to run a reduced volume of Alaska North Slope (ANS) crude. The Chevron refinery, originally constructed in 1963, was designed to run 22,000 bpd of "sweet" Cook Inlet crude. Chevron, however, has announced the Kenai refinery will be shut-down from April 1981 to May 1981 to undergo some minor modifications. The modifications entail plugging off trays to reduce the height of the distillation column

— total cost will be approximately $150,000. When the refinery re-opens, it will run 12,000 bpd or less, if possible, of "sour" ANS crude.

Chevron originally constructed the Kenai refinery because of a substantial equity interest in Swanson River and Middle Ground Shoals — two large Cook Inlet oil fields. The company bought a 50% working interest in Swanson River and obtained 1/3 ownership of two Shell platforms and 10% of Amoco's production from Middle Ground Shoals. In 1969, production from these two fields averaged 76,035 bpd. Chevron's equity share of this production was more than adequate to supply their Kenai refinery.

With production from Cook Inlet declining rapidly, however, the supply situation for Chevron's refinery has become tenuous. In 1970, average daily production from Cook Inlet oil fields (Granite Point, McArthur River, Middle Ground Shoals, Swanson River, and Trading Bay) was 225,791 bpd. In 1979, production averaged 117,791 bpd, and it is expected to decline to 40,638 bpd by 1985. Chevron's equity production from Swanson River and Middle Ground Shoals was approximately 7,500 bpd during 1980 — less than they need to run the Kenai refinery.

Facilities

The Kenai refinery went on-stream in August 1963. The facility is a simple distillation unit (topping plant) refinery, with a rated capacity of 22,000 bpd — although it has run as high as 25,000 bpd. In 1967, some minor modifications were made (addition of a vacuum system) for asphalt production at a cost of approximately $1 to $2 million.

In April 1981, the plant will be shut-down for some minor modifications. The basic configuration of the refinery, however, will not change. The modifications (plugging of trays) will reduce the height of the distillation column, and allow the refinery to run ANS crude more efficiently. The refinery will, however, still be a topping plant refinery.

Chevron's plans for the future are uncertain. They have submitted a request to the State to purchase 30,000 bpd of ANS royalty crude. If successful, the company plans to invest approximately $20 million in changes to the Kenai refinery. The modifications to the refinery include JP-4 caustic treating facilities, jet fuel salt driers and clay treaters, a larger diesel reboiler and additional pumps. The basic configuration of the refinery, however, would not change — it would still be a topping plant refinery.

In addition, Chevron owns and operates three very large and "complex" refineries in California — El Segundo (426,000 bpd) — Richmond (385,000 bpd) — Bakersfield (127,000 bpd). According to a Chevron spokesperson, the refineries are only operating at 70 percent capacity. Crude oil is available; however, demand on the West Coast for petroleum products is slack.

Feedstock

As mentioned, Chevron's Kenai refinery was originally designed to run Cook Inlet "sweet" crude, and production from Chevron's Cook Inlet fields was sufficient to supply the Kenai refinery with all of its crude charge. During the first half of 1980, Chevron ran approximately 13,000 bpd of straight Cook Inlet crude. During the latter half of 1980, the refinery ran approximately 30% ANS crude and 70% Cook Inlet. Approximately 7,500 bpd of this was from their own interest in Swanson River and Middle Ground Shoal. The remainder was obtained from other Cook Inlet producers. In June 1980, Chevron received a short-term contract for ANS royalty oil, approximately 4,200 bpd. This increased the average daily through-put to 16,700-17,000 bpd for the second half of 1980. Chevron bid in the December ANS royalty auction, however, was not successful in obtaining any oil.

This mixing of crudes was a factor in Chevron's decision to shut down in April 1981 and modify the refinery to run strictly ANS crude. Mixing crudes, particularly "sweet" Cook Inlet crude with "sour" ANS crude, basically contaminates the higher quality crude. In essence, the result is the lowest common denominator in terms of quality between the two crudes, and represents inefficient use of the higher quality crude.

Since the decision to run straight ANS crude, Chevron has swapped their 7,500 bpd of production from Swanson River and Middle Ground Shoal to Tesoro for similar type crudes in the Lower 48. While negotiating for a long-term royalty contract with the

State, Chevron plans to run 12,000 bpd of ANS crude through the Kenai refinery. The 12,000 bpd is being diverted from their West Coast refineries, to keep the Kenai refinery operating. Chevron's equity interest in Prudhoe Bay production is also 12,000 bpd. Chevron buys a substantial portion of Sohio's ANS production.

Products

Chevron's product slate, during the period they processed strictly Cook Inlet crude was (JP-4, Jet A-50, and diesel fuel). Approximately 50% of the barrel was sent south. The residuals were sent to the Richmond refinery which has a vacuum fractionator and a hydrocracker. The light straight run gasolines were sent to El Segundo and processed into benzene or blended into gasoline.

While Chevron is negotiating with the State for ANS royalty crude, average daily through-put at the plant will be 12,000. The product slate will be approximately 1,6000 bpd of Jet A-50 (13%), and 2,500 bpd of diesel (21%). The JP-4 cut (6%) will either be shipped south or be exchanged with Tesoro. Residual fuel oil (55%) will go south to Richmond and be cracked into lighter products. The straight run gasoline (4 1/2%) will be shipped to El Segundo and processed into benzene or blended off as fuel.

If Chevron is successful in obtaining 30,000 bpd of ANS royalty oil, they will once again use the heavy naphtha to process JP-4. At 30,000 bpd, the JP-4 cut would be (6%), Jet A-50 (13%), and #1 and #2 diesel (21%). The per-barrel light product yield would be roughly (40%). Chevron would still process asphalt, and ship its residual fuel and light naphtha to California.

North Pole Refinery

North Pole refinery, a division of MAPCO Alaska, Inc., began operation in 1977 with a 25,000 bpd refinery designed to use 100% ANS crude. The refinery, located in Fairbanks, is ideally situated to tap crude oil from the Trans Alaska Pipeline (TAPS). Because of their location, and the reduced pipeline tariff ($3.72), North Pole enjoys a considerable advantage in crude oil acquisition costs over other West Coast refiners. This advantage, according to a spokesperson, is roughly $2.00 per barrel. North Pole maintains that in 1979 its product prices for domestic heating oil were the lowest in the United States, however it should be mentioned this was primarily due to the favorable treatment of ANS production under the crude oil entitlement program.

Since 1977, North Pole has increased the capacity of their refinery to 47,000 bpd, although they only refine 40% of the barrel into product. North Pole has been successful in backing out most products delivered from Anchorage by Chevron or Union, or so they claim. They now supply nearly 100% of the jet-fuels and distillates to interior Alaska. North Pole does not refine or market any gasoline products.

Facilities

Initially, the North Pole refinery was a $38.5 million distillation unit (fractionator) with a 25,000 bpd through-put capacity. By June 1980 North Pole had increased the capacity of their refinery to 32,000 bpd, and had on-line a $1.6 million naphtha stabilizer. The naphtha stabilizer increased production capability of naphtha products (JP-4 and potentially gasoline). A smaller volume of light ends, C3 & C4, are liquified and then re-injected back into the pipeline along with the residuals.

By October 1980, North Pole had increased capacity to its current level — 47,000 bpd. They completed a "de-bottle necking" project at cost of $9.2 million, fine tuning the plant for better product yield. The improvements included new heat exchangers, adding a stream stripper and a flasher. The net result was to increase per barrel yield of product by approximately 5%. Total investments to date are $55.4 million.

North Pole is now considering adding a naphtha reformer. With a reformer, North Pole will be able to make and market gasoline. A naphtha reformer takes low octane feedstock and converts it into high octane naphtha. The higher octane naphtha can then be used to make gasoline. North Pole has spent $60,000 and now is preparing a $200,000 plus or minus 5% cost analysis. It is expected the reformer could be on line in 18 months assuming their study concludes it to be a worthwhile investment.

For the future, North Pole is considering expanding to 80,000 bpd. Details on the expansion are sketchy, but North Pole plans a more elaborate explanation when it submits its royalty proposal to the State. The expansion depends on a rapid increase in the growth of interior markets.

While North Pole has expanded and improved their facilities, the refinery is still a distillation unit (topping plant) refinery. Disposal of residual oil poses a significant constraint on adding "complex" downstream facilities such as a hydrocracker. North Pole re-injects its resid into TAPS. ANS crude is about 27° API and Alyeska Pipeline requires that resid re-injected into the pipeline be not less than 17 API°. Currently North Pole averages resid of about 19° API, well above Alyeska's minimum specifications.

If North Pole were to add a hydrocracker to extract lighter products from heavy gas oils, the gravity of the residual fuels could fall below 17° API. This would create an enormous problem in terms of disposing of their residuals, as there is no market in Alaska for residual fuel oil. As it stands, North Pole pays a $.15 per API degree per barrel penalty for the resid which is pumped back into TAPS. North Pole retrieves a like quantity of pipeline quality crude at the Valdez Inlet. Most of this is delivered to Delta Refining Company in Memphis, Tennessee. As it stands, it may be possible to pull out an additional 6,000 bpd of heavy gas oils by adding a vacuum tower — and still meet the 17° API specification.

Feedstock

North Pole refinery runs strictly ANS crude, and is totally dependent on it. North Pole has a contract for 28,125 bpd of Prudhoe Bay royalty production. Of this, 3,000 bpd belongs to Golden Valley Electric Cooperative (GVEA). GVEA's allotment increases to 5,000 bpd (1,200,000 per year maximum) on December 15, 1981. GVEA's option expires December 1983. GVEA is selling their royalty oil to North Pole and buying back roughly 600 bpd of #4 diesel.

In addition to the State royalty oil, North Pole has contracts with two North Slope producers. The contracts total 21,500 bpd, and expire in mid 1982 and mid 1983. Whether these contracts or contracts with other ANS producers can be negotiated in the future is problematical at this time. ARCO is a net buyer of crude and paid substantial spot market premiums during the first quarter of 1980. Exxon, since the Iranian Revolution, has been a net buyer of crude oil and has been cancelling other contracts with Alaskan refiners. Sohio's production from Prudhoe Bay far exceeds their domestic refining capacity. British Petroleum, however, is a net buyer of crude oil world wide and owns 50% of Sohio.

Products

Since the "de-bottlenecking project," North Pole will refine approximately 40% of the barrel into light products. The naphtha cut (10%) will be used for JP-4 and Jet-B unless North Pole goes ahead with the reformer. With the reformer approximately (4.3%) will be used for gasolines, and (5.7%) for jet fuel. The kerosene cut (18%) will be used to blend #1 diesel, arctic heating diesel and Jet-A. The #2 diesel fuel cut is (6%) and #4 diesel fuel cut is also (6%). It should be noted that these are mid-point cuts and there may be some overlap. Distillation is not a totally precise operation.

North Pole sees demand for JP-4 increasing substantially with the addition of a squadron of A-10 aircraft at Eielson Air Force Base. North Pole expects commercial jet fuel for cargo planes to increase about 3% per year. If the company proceeds with the naphtha reformer, the market for gasolines is expected to be approximately 2,400 bpd. The refinery is not expecting the market for heating fuel to increase much, because recent price increases have curbed demand.

Tesoro, Alaska's Refinery

Tesoro Alaska Petroleum Company began operation of its Alaskan refinery in 1969. The initial plant had a throughput capacity of 17,500 bpd. Between 1969 and 1980 the refinery has undergone substantial modifications. Today it is the largest and most sophisticated refinery operating in Alaska. Its current throughput capacity is 48,500 bpd and Tesoro is the only in-state refiner that produces and markets gasoline products.

Tesoro, like Chevron, is feeling the crunch of dwindling Cook Inlet crude oil supplies. Tesoro currently has a state royalty contract for Cook Inlet oil until 1983. They also purchase Cook Inlet oil from other producers and receive supplies from Indonesia. They have been running approximately 10% - 15% ANS crude, but that is the limit of "sour" crude they can process.

In addition to refining, Tesoro is a major marketer of refined petroleum products. They own and operate a 10 inch refined products pipeline between Kenai and Anchorage. In 1979 the average throughput of that pipeline was 20,790 bpd.

Currently Tesoro is negotiating with the State for a long-term contract of royalty oil. If successful, the refinery would be retrofitted to run "sour" ANS crude.

Facilities

The Tesoro refinery began as a simple distillation unit (topping plant) with a throughput capacity of 17,500 bpd in 1969. From 1969 to 1975 the capacity was increased (by stages) to 38,000 bpd. In 1975, Tesoro added a 6,000 bpd catalytic naphtha reformer. This enabled them to refine gasolines.

Since 1975 the capacity of the plant has been increased to its current level of 48,500 bpd. By January, 1981, Tesoro had on line a 7,500 bpd hydrocracker. The Company also expanded the capacity of the naphtha reformer to 12,000 bpd. These improvements will allow Tesoro to market 5,000 bpd of additional gasoline products, and 4,000 bpd more Jet-A.

Tesoro is currently considering expanding the capacity of the refinery to 70,000 bpd. The expansion program would entail additional reformer and hydro cracker capacity, and the addition of desulfurization units. The expansion would allow the Kenai refinery to use 100% "sour" ANS crude. Total cost would be approximately $250 million in 1980 dollars.

In addition to the refinery at Kenai, Tesoro operates a refinery in Carrizo Springs, Texas. The Carrizo Spring refinery has reforming and cat hydrotreating equipment, and can run as high as 27,000 bpd. According to Tesoro's annual report, the refinery processed an average of only 13,781 bpd in 1979.

Feedstock

In October, 1979, Tesoro submitted a report to the State entitled, *Report on Current and Projected Supply Deficiencies for the Kenai Refinery*. In that report Tesoro listed the following expected crude supplies for the Kenai refinery during 1980: Cook Inlet Royalty 11,650 bpd, private exchange agreements with Cook Inlet producers 18,000 bpd, and Indonesia crude 3,150 bpd. This totals 33,400 bpd and left a short-fall of 15,100 bpd, according to the report. The report was a solicitation to the State for ANS royalty oil. The actual average throughput during calendar year 1980 was approximately 44,000 bpd.

In a January, 1978, memorandum from Tesoro to the Alaska Royalty Oil and Gas Development Advisory Board, regarding an extension of the Cook Inlet royalty oil contract, Tesoro listed their supplies as: Sohio ANS 6,500 bpd, Indonesian (Sanga Sanga/Tarakan) 5,000 bpd, Cook Inlet royalty oil 16,500 bpd, Marathon Oil Company 9,500 bpd of Cook Inlet crude, Atlantic Richfield 3,000 bpd of Cook Inlet, and 3,500 bpd of Cook Inlet oil from Shell Oil Company — total 44,000 bpd.

Tesoro's current crude oil sources are as follows: 7,500 bpd of Cook Inlet oil from Chevron pursuant to an exchange agreement (already explained), 19,500 bpd of Cook Inlet oil from ARCO in exchange for ANS royalty oil obtained during the seventeen day window period before Alpetco began lifting oil, 11,000 bpd of Cook Inlet royalty oil, and one lot, (approximately 5,000 bpd) of ANS royalty crude from the December 1980 royalty oil auction.

Tesoro is currently requesting to buy 35,000 bpd of ANS royalty oil beginning July, 1982. Upon completion of the expansion plans, Tesoro has requested an additional 35,000 bpd — for a total of 70,000 bpd of ANS royalty crude. The existing royalty oil contract with the State for all of the Cook Inlet royalty expires in 1983. By that time the State's royalty share from Cook Inlet will be approximately 7,250 bpd.

Tesoro is also a crude oil producer. According to the 1979 Annual Report, net crude oil production in fiscal 1979 averaged 36,068 bpd. Approximately

31,000 bpd of this product is owned by Trinidad Tesoro Petroleum Company and the majority interest in this company is owned by the governments of Trinidad and Tobago. They have directed that their share of this production be used to supply a local refinery.

At present Tesoro cannot run more than 15% ANS crude. Tesoro markets residual fuel oil in California to San Diego Gas and Electric. The sulfur content must be less than 0.5% to meet California air quality guidelines. Also, Tesoro mixes ANS crude with Cook Inlet crude, because ANS alone is too corrosive to run through the plant.

Products

According to information provided to the State prior to the December auction, Tesoro's sales from October 1979 through September 30, 1980 were: approximately (18.5%) gasoline, (6.5%) JP-4 and Jet B, (13.6%) Jet A, (8.6%) diesels. These products represent sales and may not be the same as total refined product. Throughput for the same period was 42,514 bpd. These data were provided before expansion of the naphtha reformer and addition of the hydrocracker. With these modifications Tesoro expects 5,000 bpd more gasoline and 4,000 bpd more Jet-A.

Tesoro has not provided a product slate pursuant to their expansion program. The 1979 solicitation to the State, however, lists the following products, based on the assumption that plant throughput in 1986 would be 70,000 bpd of ANS crude: gasolines 16,000 bpd, diesel 16,000 bpd and aviation fuel 21,000 bpd. Fuel oil product would be 16,000 bpd. This product slate may or may not be accurate, as it was not corroborated verbally.

Alaska Oil Company (ALPETCO)

Alpetco was originally awarded a contract for 150,000 bpd of Alaskan royalty oil. The contract entitled *Agreement for the Sale and Purchase of State Royalty Oil*, February 22, 1978, (amended May 1, 1978) was awarded to Alpetco in return for a promise to construct a "Petrochemical Plant." At the time the contract was signed, the Legislature and the Department of Natural Resources (DNR) believed Alpetco would construct an olefins (petrochemical plant). The primary product would be ethylene and its derivatives. The contract also required that the facility be designed to process 30,000 bpd of crude oil into energy fuels for intrastate distribution, unless those energy fuels would be surplus to in-state needs.

The specific terms of the contract allowed delivery of 85% of royalty production from Prudhoe Bay — not to exceed 150,000 bpd. Alpetco also had an option on 70% of the production from "other leases" if State deliveries of royalty oil fell below 145,000 bpd for two consecutive months. In no case, however, would Alpetco receive more than 150,000 bpd.

Under the terms of the contract, Alpetco could receive delivery of the crude oil after complying with the "benchmark provision" under section 10.2 (3) of the contract. The most critical of these was Sec. 10.2 (3)(d) which stated, Alpetco must

"(d) Obtain or cause contractually bound third parties to obtain written commitments to lend or invest at least one billion five hundred million ($1,500,000,000.00) in the aggregate for payment of total project costs."

In December, 1980, Alpetco submitted a letter from Thyssen Engineering, a German engineering firm, that stated Thyssen would "attempt" to arrange financing for the project. The Commissioner of Natural Resources approved Alpetco's submission of the letter from Thyssen engineering as satisfying the benchmark provision under Sec. 10.2 (3)(d). DNR, however, admitted the submission was on the low-end of the scale in terms of acceptability.

The incident raised a furor in the Legislature, and ultimately resulted in the contract being amended. During a legislative hearing, it was also brought out that Alpetco had no intention of constructing a petrochemical facility. Alpetco maintained the term "petrochemical" was not defined in the contract and hence there was no specific obligation to construct a "Petrochemical Plant."

The resolution of the conflict was to change the terms of the contract. In June of 1980, according to the amended contract, Alpetco was allowed to take delivery of 75,000 bpd of royalty oil. Upon completion of the facility, in 1985 or 1986, this amount would increase to 100,000 bpd. Alpetco is allowed

TABLE IV-4

North Slope Crude Oil Production and Alaska Royalty Oil (Thousands of Barrel Per Day)

Year	Prudhoe Bay (a) Production (Gross)	Prudhoe Bay (a) Production (Royalty)	Kparku (b) Production (Gross)	Kparku (b) Production (Royalty)	Alpetco's Royalty Oil (c)	North Pole's Royalty Oil (d)	Uncommitted Royalty Oil (e)
1980	1500	187.5			75.0	28.1	0.0
1981	1500	187.5			75.0	28.1	0.0
1982	1474	184.3	70	8.8	75.0	27.6	90.5
1983	1447	180.9	80	10.0	75.0	27.1	88.8
1984	1427	178.4	100	12.5	75.0	26.8	89.1
1985	1545	193.1	150	18.8	75.0	29.0	107.9
1986	1545	193.1	150	18.8	100.0	29.9	82.9
1987	1545	193.1	150	18.8	100.0	29.0	82.9
1988	1336	167.0	150	18.8	100.0	25.0	60.8
1989	1130	141.3	150	18.8	100.0	21.2	38.9
1990	875	109.4	150	18.8	100.0	16.4	11.8
1991	815	108.9	150	18.8	100.0	16.3	11.4
1992	705	88.1	150	18.8	84.3	13.2	9.4
1993	595	74.4			63.3	11.2	0.0
1994	505	63.1			62.9	9.5	0.0
1995	435	54.4			46.2	8.2	0.0
1996	370	46.3			39.4	6.9	0.0
1997	315	39.4			33.5	5.9	0.0
1998	265	33.1			28.1	5.0	0.0
1999	225	28.1			23.9	4.2	0.0
2000	195	24.4			20.7	3.7	0.0

85% of Prudhoe Bay production with an option of 50% of production from other leases. Total crude deliverable to Alpetco shall not exceed 100,000 bpd.

The drama with Alpetco, however, may not be over. Pursuant to the "Second Amendment" dated May 30, 1980, the Commissioner of Natural Resources must finally approve or disapprove the contract on or before December 31, 1981. Sec. 10.2.2 allows the Commissioner, "sole and absolute discretion" to approve or disapprove the contract.

Facilities

According to the latest submission, Alpetco is contemplating a "complex" fuels refinery. The process units, according to Alpetco, include an atmospheric crude unit, a vacuum distillation unit, a hydrocracker, a hydrotreater, a hydrogen plant, sulfur plants, and a flexicoker." The plant will process 100,000 bpd of ANS royalty crude.

According to Alpetco's "Progress Report #28" an economic feasibility study prepared by PACE was close to being completed and would be published by February 20, 1981. The PACE study, however, is still not available.

Feedstock

The feedstock will be 100% ANS crude, unless Alpetco enters into a time exchange of oil. This possibility was discussed during the 1980 contract negotiations as a means of assuring an adequate crude supply since the refinery would not come on line until Prudhoe Bay production was starting to decline.

Products

The latest product slate, according to an Alpetco official, is 20,000 bpd of Jet Fuel, 26,000 bpd of diesel and 40,000 to 50,000 bpd of gasolines.

Recommendations

- The State of Alaska should closely coordinate its royalty oil policies and programs to assure compatibility with in-state refinery product slates and projected Alaskan fuel requirements.
- Options for using Alaska's royalty oil policies as a buffer to decrease the State's vulnerability to externally caused fuel shortages should be examined. Background information is also contained in Chapter

(a) The Prudhoe Bay production curve is from H.K. Van Poolen's report entitled Three Dimensional Reservoir Study Sadlerochit Formation Prudhoe Bay Field, March 1980, prepared for the State of Alaska, Oil and Gas Conservation Commission. The figures are from "Case D" which assumes maximum take-off is 1.5 million bpd, gas sales beginning in mid 1985 at 2 billion cubic feet per day, and source water injection beginning in 1985.

(b) The production curve for Kuparuk is taken from a draft of the "Development Plan for Royalty Oil and Gas" prepared by the Alaska Royalty Oil and Gas Advisory Board, State of Alaska, Department of Commerce and Economic Development, March, 1981. No production forecasts beyond 1992 were given.

(c) Alpetco receives 75,000 bpd until start-up of their refinery when they begin taking 100,000 bpd. According to the "Second Amendment", May 30, 1980, Alpetco can receive 85% of the royalty oil produced from Prudhoe Bay. In addition, Alpetco has an option on 50% of the royalty production from "other" North Slope leases – in this case (Kuparuk). In no case, however, may they receive more than 100,000 bpd.

(d) North Pole's contract (Mapco Alaska, Inc.) gives North Pole 15% of royalty on oil production from Prudhoe Bay. Currently 3,000 bpd of North Pole's total allotment belongs to Golden Valley Electric Cooperative (GVEA). December 15, 1981 GVEA's share increases to 5,000 bpd, however, the total GVEA may not exceed 1,200,000 per year. GVEA's contract expires December, 1983.

(e) This is the royalty oil the State has left to sell. No oil becomes available until July 1982, when the contracts from the December 1980, auction expire. As shown, the requests for royalty oil from existing in-state refiners exceeds the supply (Chevron 30,000 bpd Tesoro 70,000 bpd, and North Pole's plan to expand to 80,000 bpd).

TABLE IV-5

Distillation Cut Points and Products (a)

Temperature Cut Points (degrees F.)	Distillation Products	Refined Products	Distillate Type
less than			
100			
150	straight	gasoline	
200	run gasoline	JP-4	light
250			distillates
300	naphtha	Jet-A	
350			
400			
450	kerosene	#1 diesel	middle
500		#2 diesel	distillates
550			
600	light gas oil	#4 diesel	
650		#6 diesel	
700			heavy
750	heavy gas oil	bunker fuels	distillates
800			
850			
900			
950	residual		
1000			
	coke		

(a) Taken from a draft report entitled Existing Alaskan Refineries, prepared by House Research, Legislative Affairs Agency, State of Alaska.

V - Emergency Energy Planning.

- The Long-Term Energy Plan should include an assessment of the reliability, efficiencies, and associated costs of the existing Alaskan fuels transportation systems.

Natural Gas

Natural gas exists, as the name implies, in a natural state in petroliferous basins throughout the world. Natural gas is often found with oil and exploration for the two fuels cannot actually be separated. Unlike oil, natural gas cannot be easily transported, since it must either be piped or compressed. As a result, when oil was found in a remote region, the natural gas associated with the production often was flared simply because it was too expensive to transport to a market.

Once natural gas does arrive at a market, however, it is a premium fuel. It does not require refining and burns clean and efficiently. As the Dutch say, it is friendly to the environment. Moreover, once installed, a natural gas distribution system is inexpensive to operate and does not require a lot of maintenance. Because it is not easily transported, natural gas is used primarily for space and water heating, industrial processes, electricity generation and petrochemicals. In Alaska, the majority of the natural gas extracted is reinjected to increase oil recovery and to store the natural gas until market delivery systems from Prudhoe Bay are constructed.

Natural gas is being extracted in three areas of Alaska. The Prudhoe Bay oil field, of course, contains associated gas. In addition, there are four significant gas fields in the vicinity. In total, there are about 29,000 billion cubic feet (bcf) of recoverable natural gas deposits around Prudhoe Bay. Most of this gas has been earmarked for transport to the Lower Forty-Eight via the proposed natural gas pipeline. Alaska owns 12.5 percent of the gas as part of its royalty agreement and the Legislature is studying how that gas might be used in-state. In the meantime, however, some of the natural gas is being used for electricity generation and by the oil facilities and pipeline at Prudhoe Bay. By and large, gas produced at Prudhoe Bay is re-injected.

Another major source of natural gas is Cook Inlet, located near the population center of Anchorage. Recoverable gas reserves in the area total 3,766 bcf. Gas from Cook Inlet is being used to produce ammonia and urea, generate electricity and is sold for direct use to the gas utility and the military bases. One-third of the Cook Inlet gas, net of reinjection, is being exported as liquified natural gas to Japan. The Department of Natural Resources estimates indicate that recoverable reserves are insufficient to meet needs through the year 2000. The future use of our inlet gas is a major subject of the Battelle Pacific Northwest Laboratories' study of alternatives to the proposed Susitna hydro project.

Natural gas deposits at Barrow total 25 bcf of recoverable reserves. The gas is being used to generate electricity and is also used directly by government and private facilities for space heating and appliances.

The economics of natural gas utilization is tied directly to oil pricing. Since the explosion in crude oil prices, the natural gas market has changed radically. In previous decades, gas was shut-in or flared. Now, higher oil prices make the utilization of remote deposits much more attractive. In addition, the shifting economic climate is stimulating a variety of new technologies designed to better utilize the worldwide natural gas resource base. Of the two technologies which stand out, liquified natural gas (LNG) can be considered traditional. The other (under considerable study by energy firms) is the liquifaction of the gas to produce methanol and from it gasoline. The development of these technologies is very important because it will help determine the demand for Alaskan natural gas. This in turn will determine the expected price and availability of natural gas within Alaska.

The technology of LNG is fairly well known. Natural gas is liquified by compression and cooled and then shipped in special cryogenic tankers. The process is expensive and capital intensive, which tends to bind producers and consumers into long-term contracts. As mentioned, oil prices are critical in determining the viability of the projects. In the Phillips/ Marathon LNG export facility, the effective wellhead price is $2.07 per mcf.

There are huge deposits of natural gas throughout the world which are not being utilized because they are too far from natural gas markets. However, the gas could be utilized by converting it to methanol. Once in liquid form, it could be transported by slightly modified tankers and pipelines and eventually converted to gasoline. The development of this process is tied to the research and development on synthetic fuels. The estimated costs of such processing and transportation are thought to be similar to LNG.

Either of these technologies could be used to transport natural gas from Alaska to the point of consumption. More importantly, however, these technologies will set the price producers will expect to receive. For the near future, Alaskans living close to natural gas deposits can expect to pay less than consumers elsewhere. Economic theory would predict that the discount would be just about the cost of pro-

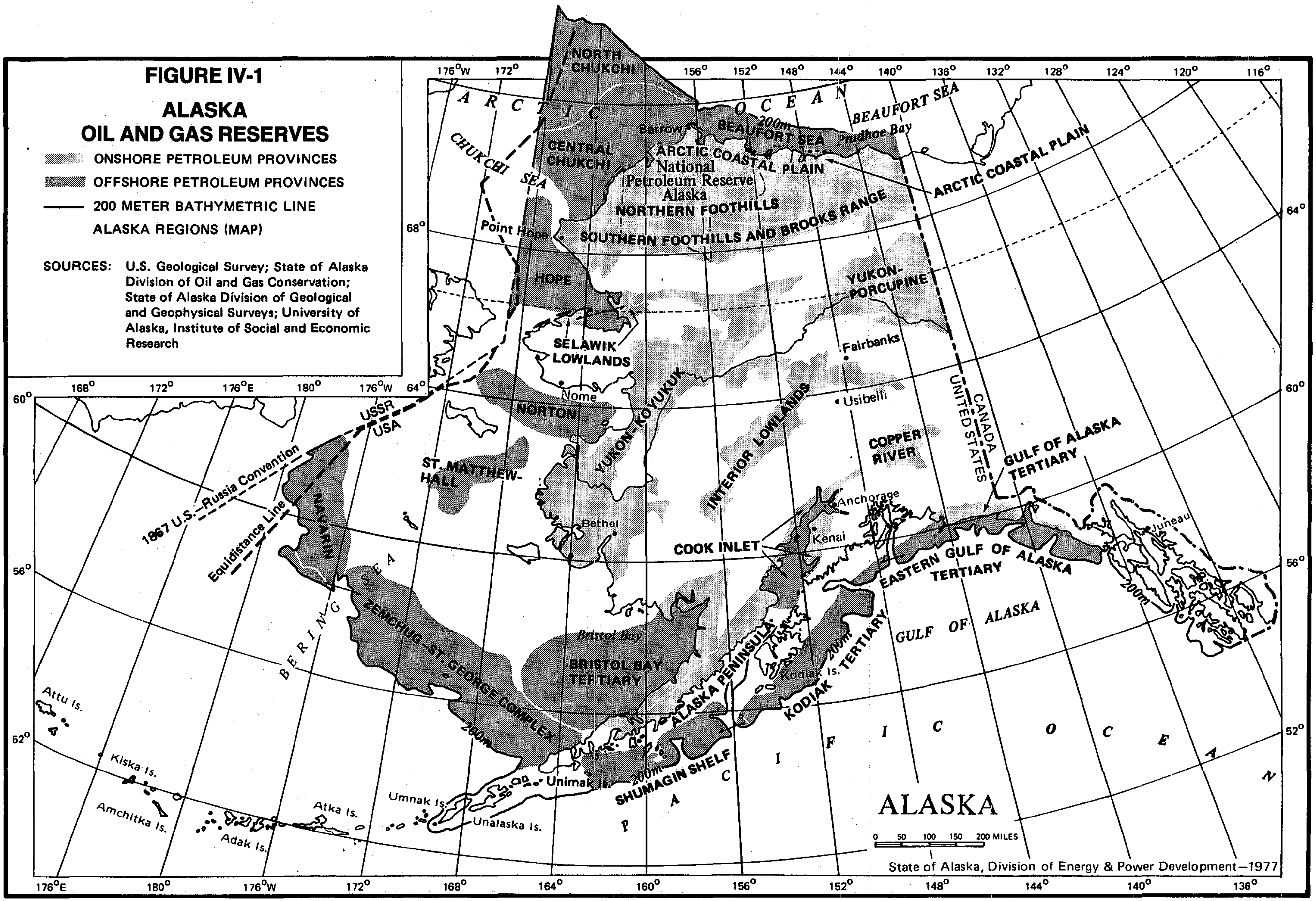


FIGURE IV-1

ALASKA OIL AND GAS RESERVES

- ONSHORE PETROLEUM PROVINCES
- OFFSHORE PETROLEUM PROVINCES
- 200 METER BATHYMETRIC LINE
- ALASKA REGIONS (MAP)

SOURCES: U.S. Geological Survey; State of Alaska Division of Oil and Gas Conservation; State of Alaska Division of Geological and Geophysical Surveys; University of Alaska, Institute of Social and Economic Research cessing and shipping the gas to another market. But as oil prices rise, natural gas prices in Alaska will also increase. This is a very important issue in Alaskan energy development and will be a major component of the Battelle study of the Railbelt.

Without the development of procesing and transport technologies summarized above, or other technologies such as fuel cells, natural gas use in Alaska is primarily dependent on the location of the discoveries. The deposits at Barrow can be used locally, but are unlikely to be transported elsewhere. Once the Prudhoe Bay reserves are tapped with the Alaskan natural gas pipeline, a natural gas market could develop in Fairbanks. A natural gas market is not likely to develop in other areas unless new discoveries are made in close proximity, or a State project can be piggybacked to a major project aimed at exporting gas.

Recommendations

- No recommendations are presented for the Railbelt pending completion of the Railbelt Alternatives Study in 1982.
- The potential for community utilization of natural gas from the proposed natural gas pipeline system from the North Slope should be determined immediately. Emphasis should be placed on the use of natural gas for space heating and electric power generation. Assessments underway of gas liquids and petrochemical potential do not address this specific issue.

Coal

Coal, like oil and gas, is an exhaustible hydrocarbon. Found in each of the state's regions, Alaskan coals range from lignite through subbituminous and bituminous to anthracite. These could be used for generating electricity, space heating, or metallurgical processes.

While future exploration will certainly result in revised estimates, it is clear that Alaska's coal resources are truly vast. The Division of Energy and Power Development estimates the total State coal resources to be between 1,860 and 4,990 billion tons. The Division of Geological and Geophysical Surveys estimates likely recoverable reserves to total 110 billion tons — an amount two to three times greater in energy content than Saudi Arabia's proven oil reserves.

The largest portion of these recoverable reserves are located in the Arctic, where distance from population centers and extremes of climate constrain major development. As shown in Figure IV-2, the second area having large deposits is Cook Inlet.

Fields along the Alaska Railroad were developed and provided coal for the towns served by the railroad. After the Alaska Railroad switched to diesel in the early 1950s and the Anchorage military bases converted to natural gas in 1968, the Usibelli Mine was left as the only major operating coal mine in the state. Located near Healy in the Nenana coal field, it primarily supplies coal to two Fairbanks utilities and the U.S. military for electricity generation. The annual rate of extraction has grown slowly since 1971 and remains near 700,000 tons. Late last year, a Korean firm purchased an additional 33,000 metric tons to test for import potential.

Interest in using coal continues to grow throughout the state. While Beluga and Nenana may offer the greatest promise of near-term large scale development, most of the other large fields have also generated interest from local, state, international, public, and private groups. The Nulato Field on the Yukon River, Jarvis Creek on the highway near Delta Junction, Bering River on the coast east of Cordova, and other coal fields are being examined for their potential.

Table IV-6 summarizes Alaska's coal resource by region. It must be noted, however, that the potential for coal utilization implied by the table is somewhat understated. Small local occurrences may be suitable for community utilization. For example, in a recent study for the Alaska Power Authority, Dames and Moore identified 49 coal occurrences in the Northwest which call for further investigation. The second phase of the study will address the economics of coal transportation and utilization and recommend areas for detailed drilling and evaluation.

Since 1943, virtually all coal mining in Alaska has been by surface rather than by underground methods. All proposed major new mines will continue to use surface mining. Small-scale community min-

TABLE IV-6

Summary of Estimates
Remaining Coal Resources[1] By Alaska Region
(Millions of Short Tons)

(a) Rank of Region by Size of Total Coal Resources	(b) Region 2/	IDENTIFIED				(g) Total Identified (e) + (f)	UNDISCOVERED		(j) Total Undiscovered (h) + (i)	(k) Total Resources (g) + (j)	(l) Region as Percent of Statewide Total Coal Resources
		(c) Measured	(d) Indicated	(e) Demonstrated (c) + (d)	(f) Inferred		(h) Hypothetical	(i) Speculative			
1 or 2	Arctic	35.0	2,759.4	2,759.4	120,197	122,990	123,000 to 2,303,000	100,000 to 1,050,000	223,000 to 3,353,000	345,990 to 3,475,990	18.6 to 69.6%
5 or 6	Northwest	—	—	—	—	—	—	—	—	—	—
3	Interior	861.6*	2,705.9*	2,023.9* or 3,567.5	3,384.1 or 3,447.2	5,408 or 7,014.7*	8,897.8	—	8,897.8	14,305.8 or 15,912.5	0.8 to 0.3%
4	Southwest	—	—	—	—	—	3,290	—	3,290	3,290	0.2 to 0.1%
1 or 2	Southcentral	6.6*	2,447.7*	2,811*	7,852 to 7,878	10,663 to 10,689	184,159 to 184,759	1,300,000	1,484,159 to 1,484,759	1,494,822 to 1,495,448	80.4 to 30.0%
5 or 6	Southeast	—	—	—	—	—	—	—	—	—	—
Statewide Total		903.2	7,912.7	7,629.3 or 9,172.9	131,433.1 to 132,522.2	130,346.8 to 140,693.7	319,346.8 to 2,499,946.8	1,400,000 to 2,350,000	1,719,346.8 to 4,849,946.8	1,858,407.8 to 4,990,640.5	100%

1/ Coal estimates are 100 percent of remaining in-the-ground coal.

2/ University of Alaska, Institute of Social and Economic Research, Man-in-the-Arctic Program Regions (MAP).

Two numbers in a column indicate a low and high range for the estimate.

—No resource estimates are available for the classificationn.

★ The table above reflects a combination of estimates from the sources listed below. Estimates cited are generally the most recent available, sometimes filled-out with older estimates, particularly in the "measured" and "indicated" classifications. None of the estimators have provided estimates for all classifications (e.g. Barnes, 1967, gives only identified, no undiscovered resources; McGee and O'Connor, 1975, gives only demonstrated and inferred-no measured and indicated, although they do give some hypothetical and speculative; Tailleur and Brosge, 1976, give no identified, only hypothetical and speculative, etc.). This lack of uniformity in estimating led to inherent errors in the above estimates.

Sources: Barnes, USGS Bulletin 1242 B & E, 1967.
Callahan, Focus on Alaska's Coal, 1975.
McGee & O'Connor, State of Alaska, DGGS, Open File Report #74, 1975
Sandlers, Focus on Alaska's Coa, 1975.
Tailleur and Brosge, USGS Circular 733, 1976.

ing is likely to be conducted on a seasonal basis, especially in northern parts of the state.

Traditionally, coal has been used for space heating, process heating, electrical generation, and steam production. These uses require minimal, relatively low cost processing such as crushing, screening, cleaning, and drying. These direct uses of coal may provide an important source of energy as petroleum prices rise, especially in remote areas where fuel transportation costs are high.

There may be some advances in fluidized-bed, small boiler, and stove designs. However, most technologies directly utilizing coal are well established. Highly sophisticated technicians are not required for their operation. As an example of possible application, Alaska Power Authority is currently studying the feasibility of using coal for use in Northwest Alaskan villages.

Coal development in regions with sparce populations, such as the Arctic and Northwest, should be combined with flexibility in power generating equipment and furnaces. In some circumstances, a coal outcropping could be exploited for several years before the extraction became expensive or difficult. Then, it might pay the community to switch to another resource, such as peat or biomass. If the local energy facilities have flexible designs, this would be possible.

There is considerable interest in the potential for coal exports, particularly for some of the deposits found in the Beluga and Healy areas. If this development occurs, it will open the way for the extended use of coal in Alaska for both power generation and direct use by industry. In a recent study by Battelle Pacific Northwest Laboratories for the Division of Policy Development and Planning, it was concluded that the Beluga Coal Field is likely to be developed for the export market in the early eighties, and for internal use within the decade.

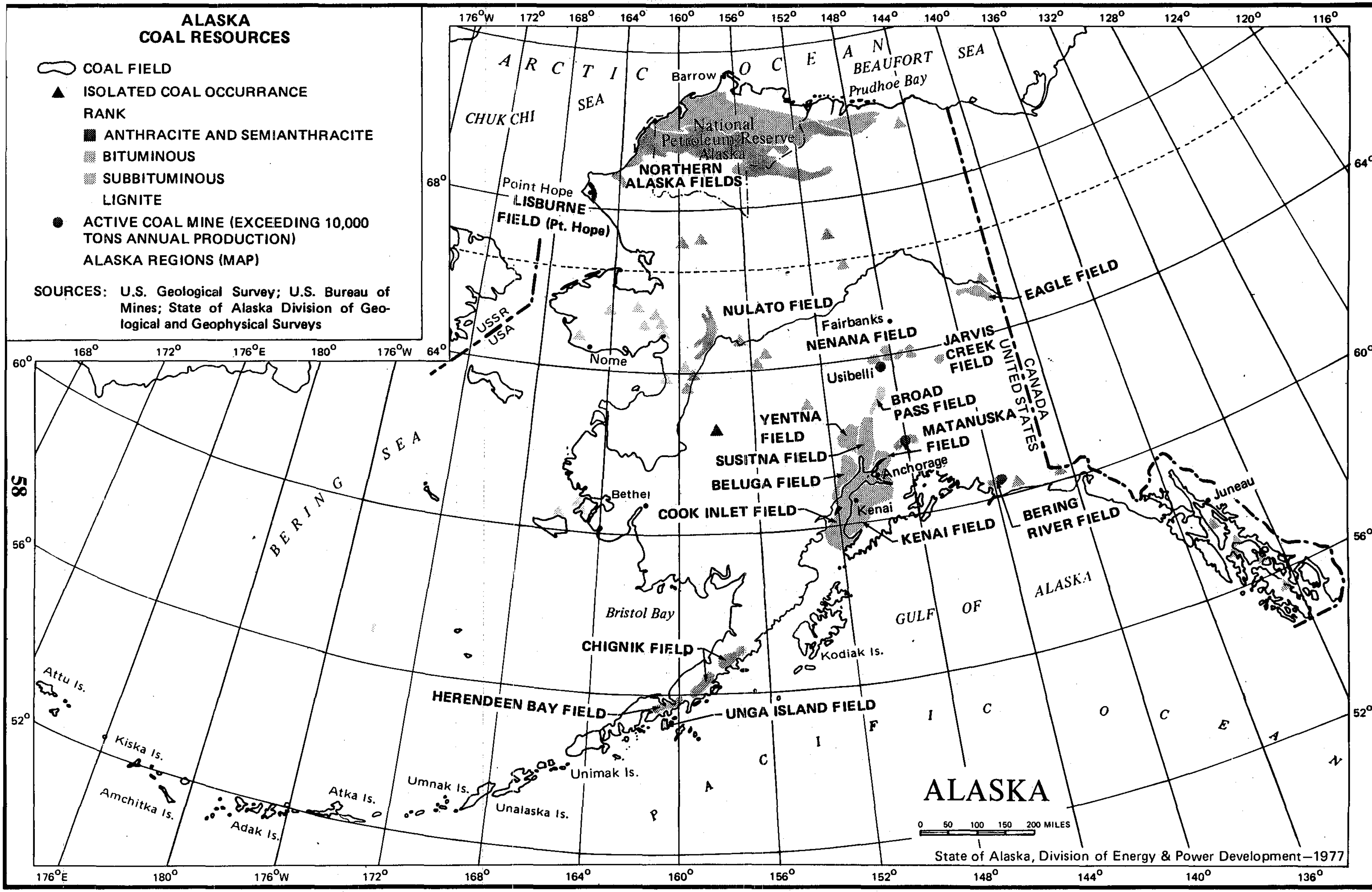
The current emphasis on developing and implementing technologies to convert coal to "synthetic" liquid or gas fuels may also have a major impact on Alaska. Cook Inlet Region, Inc. and Placer Amex, Inc. are conducting a U.S. Department of Energy funded feasibility study of converting 20,000 tons of Beluga coal per year to methanol. The 54,000 barrel per day facility could replace approximately 23,000 bpd of oil. The economics of scale constrain the prospects for methanol or other synthetic fuel development for in-state use. However, internal use might be linked to projects aimed at exporting fuels derived from coal.

While coal utilization may provide economic advantages through lower fuel costs and increased local employment, the environmental impacts can be significant. Emissions include sulphur dioxide, heavy metals, and low level radiation. In Fairbanks, coal-fired generators contribute to ice fog conditions. Emission control technologies exist but are costly. Conversion to synthetic fuels may permit the separation of many of the impurities in coal, but carbon dioxide emissions increase and wastes still require disposal. Finally, the impacts of the mining and costs of reclamation must be considered.

Recommendations

- Pending positive results from on-going coal use studies in the northwest portion of the State, the development of coal-based community energy systems should continue.
- Alaskan export oriented coal development should be encouraged. Auxiliary benefits of export based coal production may enhance the feasibility of in-state coal and coal-derived fuels usage.

FIGURE IV-2


ALASKA
COAL RESOURCES
COAL FIELD
ISOLATED COAL OCCURRANCE
RANK
ANTHRACITE AND SEMIANTHRACITE
BITUMINOUS
SUBBITUMINOUS
LIGNITE
ACTIVE COAL MINE (EXCEEDING 10,000 TONS ANNUAL PRODUCTION)
ALASKA REGIONS (MAP)
SOURCES: U.S. Geological Survey; U.S. Bureau of Mines; State of Alaska Division of Geological and Geophysical Surveys
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
Barrow
Prudhoe Bay
National Petroleum Reserve Alaska
NORTHERN ALASKA FIELDS
Point Hope
LISBURNE FIELD (Pt. Hope)
USSR
USA
NULATO FIELD
Fairbanks
NENANA FIELD
EAGLE FIELD
JARVIS CREEK FIELD
Nome
Usibelli
BROAD PASS FIELD
YENTNA FIELD
MATANUSKA FIELD
SUSITNA FIELD
BELUGA FIELD
Anchorage
UNITED STATES
CANADA
Bethel
COOK INLET FIELD
Kenai
KENAI FIELD
BERING RIVER FIELD
Juneau
BERING SEA
Bristol Bay
GULF OF ALASKA
CHIGNIK FIELD
Kodiak Is.
Attu Is.
HERENDEEN BAY FIELD
UNGA ISLAND FIELD
Kiska Is.
Amchitka Is.
Adak Is.
Atka Is.
Umnak Is.
Unalaska Is.
Unimak Is.
PACIFIC OCEAN
ALASKA
0 50 100 150 200 MILES
State of Alaska, Division of Energy & Power Development—1977

Hydroelectricity

Although not uniformly dispersed throughout the State, Alaska is endowed with topography and climate which give it abundant hydropower energy potential. However, characteristically, hydro projects are extremely expensive to install and require that considerable sums of money be spent before the feasibility or even definitive cost estimates can be determined. Additionally, in Alaska the peak demand of most electric utility systems occurs during the winter months at at time when rainfall and runoff are at a minimum. This often means that considerable investment must be made in construction for water storage if the hydro facility is to be justified as an alternative and not just a supplement to a conventional thermal cycle facility. Consequently, development of Alaska's hydroelectric potential has not been as rapid as might be expected.

Because permit, study and mobilization costs generally vary only slightly with project size, the larger projects usually cost less per unit of capacity. Also, once committed, it is usually more economical to develop a civil works project to its maximum potential as opposed to limiting it to the requirements of the load to be served. Mechanical and electrical equipment can be added as load requires. Sufficient energy from the facility must be sold to cover the annual capital and operating costs of the project. Since much of Alaska's hydro potential is contained in large projects, increased use of electricity and interties may also be necessary to establish a market large enough to justify construction of a particular project.

The difficulty of matching the project size to the existing or projected loads further complicates establishing a project's feasibility. Since civil construction usually represents the major cost of a hydroelectric facility, it is believed that equal attention should be given to assessing the feasibility of the smaller and the "run-of-the-river" projects. Hydroelectric power facilities are, where technically and economically feasible, conducive to remote operation and normally require relatively little maintenance. Some small hydro facilities might be economically justifiable merely on the cost of the fuel they save. This is becoming increasingly likely as the cost of diesel fuel rises.

The State contains numerous potential hydro sites and the interest in small scale uses of energy generated from hydro is high. In some cases, small to moderate amounts of energy can be extracted from water without major environmental impact and in some cases at moderate cost.

One in particular is the use of the run-of-the-river concept whereby the elevation difference of the water is concentrated, usually by diverting a portion of the stream via a canal to create the head necessary for the operation of the turbine, without controlling (regulating) stream flow for energy production considerations. In a run-of-the-river system, the size of the system has to be evaluated with consideration to the flow of the river. It is usually practical if stream flow is either 1) greater than the energy capacity of the generator at all times or 2) that when the flow curtails output, the energy will not be needed during the time of deficient flow. In other words, a flow of the river facility is similar to a wind machine or solar water heater — all need the resource in abundance to be a sole source energy producer.

In most conventional dammed river systems, the dam is used to store water as well as develop head thereby allowing the facility to have a greater flexibility in the production of electricity. The demand of the electrical system usually determines the release of the water rather than precipitation and runoff.

In Alaska most hydroelectric projects have utilized perched lakes. While storage and head may be enhanced by a dam at the outlet, the natural impoundment of the lakes is the primary reservoir. Since these high mountain lakes are usually small, projects have generally been located in Southeast or Southcentral Alaska, regions with high precipitation.

Despite widespread interest in small-scale hydro for use on an individual and community level, all potential sites have not been identified in power development studies by Federal and State agencies. The Division of Energy and Power Development is presently preparing a small hydro handbook to assist interested parties. A preliminary determination of the development potential of individual sites can be made by the layman. The State then provides technical assistance and financing recommendations when warranted.

Micro hydro packages are now being sold and used throughout the world. Some of these are less sophisticated than many systems offered in the U.S. Because of the Alaskan small hydro potential and interest in this area, additional research of these less expensive alternative systems is needed.

In making economic comparisons, it must be remembered that the physical life of a conventional hydroelectric facility is usually in excess of 50 years, whereas the normal life of a thermal cycle plant is generally 25 to 30 years. (High speed diesel engine life can be 5 to 10 years.) Additionally, the hydroelectric facility is essentially a free fuel and inflation-proof project. A thermal facility is subject to both fuel cost escalation and replacement cost inflation. The variables, particularly inflation, must be evaluated fairly and service life must be properly accounted for. Despite the land that may be inundated and in some cases a potential danger inherent in the rather remote possibility of a dam failure, hydropower offers the greatest potential for long-term inexpensive electric power in Alaska. The State government continues to invest heavily in hydroelectric development throughout much of Alaska. With the probability that many of these projects will be constructed, another related phenomenon will likely occur — fuel substitution. This refers to the displacement of traditional fuels such as heating fuel oil and gasoline by electricity for space heating and transportation. In Juneau, for example, heating alone with hydro produced electricity will soon be competitive with the cost of heating with oil. The use of heat pumps as a means of increasing the efficiency of hydro based electrical heating is now being demonstrated by the Alaska Power Administration in Juneau. Another technology which has yet to become commercial is the use of electric powered cars.

Regional Overview

The Arctic Region has very limited hydroelectric development potential due to harsh climatic conditions and lack of head, reservoir sites, and water supply. An estimated two percent of the State's population reside in the Arctic Region. The Army Corps of Engineers has identified several potential hydroelectric sites. However, they are not considered viable alternatives at this time because the sites would be difficult and expensive to develop.

The Interior Region is characterized by low rolling hills and expansive valleys. The potential for hydro power facilities exist along the Yukon River system and its primary tributaries. Two large potential hydro sites have been identified in the region, namely Rampart (5040 MW) and Woodchopper (2160 MW). It is doubtful that either will be developed in the near future because of environmental concerns. Due to the lack of adequate storage sites there are no definite hydroelectric facility projects under consideration.

Fairbanks, the State's second largest city, is serviced by two electric utilities from oil-fired gas turbine generation and coal-fired generation. The surrounding and outlying communities in the area are primarily dependent upon diesel engine generation for their electrical power needs. The proposed Susitna hydroelectric project would serve Fairbanks.

The hydroelectric facility potential for Northwest Region is primarily limited to large river systems, similar to what was described in the Interior Region. Approximately three percent of the State's population lives in this region, the largest communities being Kotzebue and Nome. Diesel generation systems supply virtually all electrical power requirements.

The Southeast Region is generally typified as very mountainous with relatively small drainage basins that lead directly to the ocean. The high precipitation with extremely high runoff rates provides the opporutnity for many large and small scale hydro developments. The State's capital, Juneau, is located in the region. Along with numerous smaller population centers and communities, the area represents approximately 13 percent of the State's population. Electrical generation for few of the large communities is through hydroelectric power facilities, supplemented with diesel generation. The smaller communities depend entirely upon diesel generation.

TABLE IV-7

Hydropower Sites – Existing, Under Construction

Existing – 1980

Region	Name	Region Served	MW	GWH
Southcentral	Copper Lake	Anchorage	15	66
	Eklutna	Anchorage	30	164
		Subtotal	45	164
Southeast	Gold Creek	Juneau	1.6	
	Annex Creek	Juneau	3.5	50
	Upper Salmon Creek	Juneau	2.8	
	Dewey Lakes	Skagway	0.4	—
	Pelican Creek	Pelican	0.5	—
	Ketchikan Lakes	Ketchikan	4.2	
	Silvis	Ketchikan	7.1	66
	Purple Lake	Matlakatla	3.0	10
	Crystal Lake	Petersburg	3.0	—
	Blue Lake	Sitka	6.0	44
	Snettisham—Long L.	Juneau	46.7	211
		Subtotal	78.8	381
		Total Existing	123.8	611

Under Construction

Region	Name	Region Served	MW	GWh
Southcentral	Solomon Gulch	Valdez	12	65
Southeast	Green Lake	Sitka	16	64
		Total Under Construction	28	129

The topography of the Southcentral Region is not as steep as that in the Southeast, and is characterized with lighter runoffs and generally colder climatic conditions. The proven hydro sites are generally located mainly on large river systems. The two significant power potentials that stand out immediately are on the Copper River and the Susitna River. Development of the Susitna River is the largest hydroelectric facility presently under consideration by the State. The two dam project could total 1,392 MW. A $30 million feasibility study is under way by Acres American, as well as a $1.0 million Railbelt Alternatives study by Battelle Pacific Northwest Laboratories. While hydroelectric facilities provide power to the Anchorage-Cook Inlet area, natural gas fuels the major portion of the electric generation. Electric power in the Anchorage-Cook Inlet area is provided by five different utilities. This region contains about half of the state's population

The major river drainage areas of the Kvichak, Nushugak and Kuskokwim are in the Southwest Region. Very few hydroelectric facility sites exist within moderate transmission distances of population centers such as Bethel, Dillingham and Naknek. An estimated seven percent of the State's population resides in this region. The primary population centers as well as the scattered communities within this region are dependent primarily upon diesel generation to satisfy the electrical generation needs.

The National Hydro Study produced by the Corps of Engineers identified in excess of 150 possible hydroelectric sites in Alaska with 59 hydroelectric projects having a high degree of potential for economic feasibility. This inventory includes projects presently under construction, expansion of existing projects and projects in the planning phase. At the present time, Alaska's existing hydroelectric projects have a total capacity of 124 MW with an approximate 611 GWH annual energy capability. The Corps of Engineers is also studying small scale hydroelectric potential on a regional basis. It is evaluating sites selected in part because of community interest.

Recommendations

- The State should continue its extensive financial support of hydroelectric resource development. Although capital intensive, the further development of this major renewable energy resource capable of meeting the electrical energy needs of 95 percent of Alaska's population should be encouraged.
- A detailed evaluation of the extent of fuel substitution likely to occur from hydroelectric development in the space heating and transportation sectors should be completed and included in the 1982 plan.
- Stream flow measurements should be initiated for all potential hydro sites identified in reconnaissance studies and community energy assessments.
- An in-depth assessment of commercially available and developmental small and micro hydro technologies should be carried out.
- Large and small scale run-of-the-river hydro systems should be researched and evaluated to determine their applicability in the Alaskan environment.

TABLE IV-8
Proposed Hydroelectric Power Projects

Project	Agency*	Location	Market	Type	Output/ Purpose	Cost Estimate
Susitna	APA	Upper Susitna River NE of Talkeetna	Anchorage, Fairbanks, Mat-Su Valley, Kenai Pen.	810 foot rockwall dam at Watana, 635 foot concrete gravity dam at Devil Canyon 364 mile, 345 KW transmission line	700 MW installed capacity, 1,392 MW ultimate capacity	$2.5 Billion
Southeast Intertie	APA	Southeast Alaska	Juneau, Petersburg, Wrangell, Ketchikan, & intermediate communities	Interconnection of major hydroelectric facilities Snettisham-Tyee and Swan and adjacent load centers	Reliability and exchange of economy energy	
West Creek Hydro	APA	West in vicinity of Skagway	Skagway & Haines	107 foot high concrete dam	5.4 MW installed capacity	$80 Million
Tazimina Hydro	APA	North of Lake Iliamna/West side of Cook Inlet	15 communities in Bristol Bay Region	38 foot earth fill/forebay dam, 45 foot earthfill/ storage dam, 181 miles of 138KW transmission line	18 MW installed capacity	$80 Million
Bradley Lake Hydro	APA	Kachemack Bay near Homer on Kenai Peninsula	Kenai Peninsula & Anchorage	100 foot concrete gravity dam, 10 miles of 115 KW transmission line	70 MW installed capacity	$200 Million
Black Lake Hydro	APA	Near Klawock on Prince of Wales Island	Klawock, Craig & Hydaburg Service Area	28 foot bill wall/rock fill dam, 51 miles of 23 KV transmission line	5 MW installed capacity	$30 Million
Port Hydro	KEA	Port Lions Bay, Kodiak Island	Port Lions	7 foot sheet pile forebay	180 Kw installed capacity	$1.5 Million

Scammon Bay Hydro	APA	Scammon Bay-Spring-fed stream	Scammon Bay	8 foot rock filled gabion dam	150 KW installed capacity	$2.1 Million
Power Creek Hydro	GOE	Northeast of Cordova	Cordova	80 foot concrete dam, 6 miles of transmission line	5 MW installed capacity	$5.1 Million
Snettisham Hydro	APAd	Southeast of Juneau/Speel Arm	Juneau and Douglas Service Area	Crater Lake Phase & 3rd Generator	27 MW installed capacity	$70 Million
Green Lake Hydro	SITKA	Sitka on Vodo River	Sitka Service Area	280 foot double-curvature concrete dam, 8 miles of 69 KW transmission line	16.5 MW installed capacity	$62 Million
Tyee Lake Hydro	APA	Southeast of Wrangell near Bradfield Canal	Petersburg & Wrangell	Lake Tap-1,370 foot/Lake Tyee, 83 miles of 115 KV transmission line	30 MW installed capacity	$60 Million
Swan Lake Hydro	KPU	Northeast of Ketchikan near Carroll Inlet	Ketchikan Service Area	190 foot thin arch concrete dam, 31 miles of 115 KV transmission line	22 MW installed capacity	$110 Million
Terror Lake	KEA	Kodiak Island	Kodiak Island and	Rockfill dam-Terror Lake	20 MW installed	$110 Million
Solomon Gulch Hydro	CVEA	Near Alyeska Pipeline terminal at Valdez	Valdez & Glennallen	Rockfill dam-Solomon Lake 104 miles of 115 KV transmission line	12 MW installed capacity	$20 Million
National Hydro Power	COE	59 sites			Hydro-project report final-Sept., 1981	
S.E. Hydro Power	COE	Mahoney Lakes			Final Report & EIS-Sept., 1984	
Valdez	COE	Allison Lake			Final Report-April, 1981	
Cordova Hydro power	COE	Power Creek Crater Lake Humpack Creek			Final Report with recommendation April, 1982	
Small Hydro power	COE	Reconnaissance Studies for Aleutian Islands, Kodiak & Alaska Peninsula - 36 communities Reconnaissance Studies for Southwest Alaska - 84 communities Reconnaissance Studies for Northwest Alaska - 50 communities Feasibility studies including design are underway for Northeast and Southcentral Alaska. . .Tenakee Springs (S.E.), Scammon Bay (S.W.).				

*APA: Alaska Power Authority
APAd: Alaska Power Administration
COE: Army Corps of Engineers
LVEA: Copper Valley Electric Association
KEA: Kodiak Electric Association
KPU: Ketchikan Public Utility

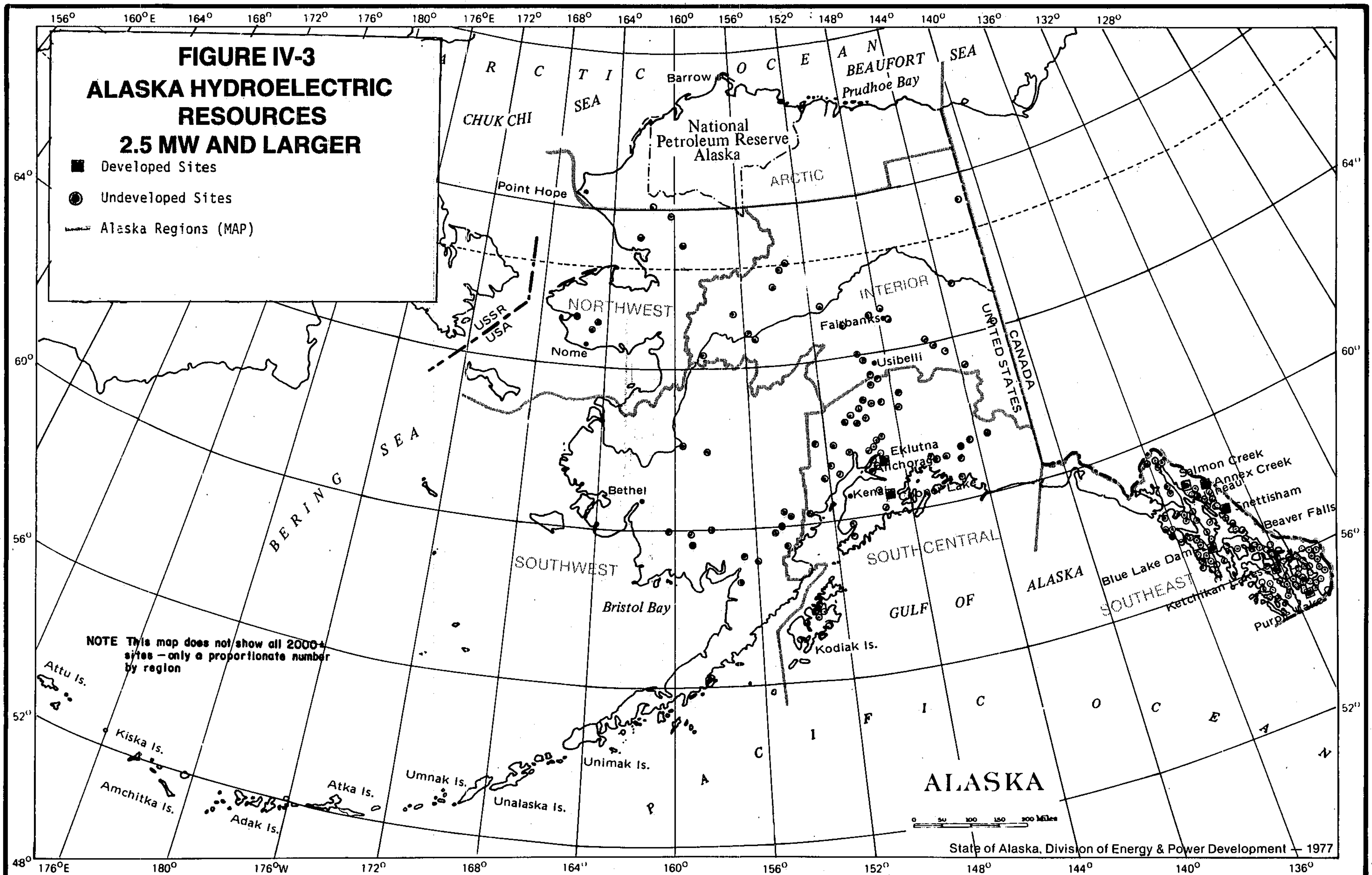


FIGURE IV-3
ALASKA HYDROELECTRIC RESOURCES
2.5 MW AND LARGER

Expanding Energy Options

According to a report from the Swedish Secretariat of Future Studies, "There really is not a shortage of energy. Energy usage . . . is a mere fraction of the total natural flow around us. The scarce factor is sufficient energy of high quality available at the right time at the right place."

Since 1973, crude oil prices have quadrupled, and then doubled again. Even after discounting inflation, the present international price of crude oil is six to seven times higher than it was in the early seventies. The oil price rise occurred for three basic reasons. First, OPEC successfully cartelized the market. Second, demand growth had been running at seven percent and over for decades. And, finally, the period of 1970 to 1975 was the first five year period in which world oil discoveries were less than world consumption.

If oil discoveries continue to lag behind consumption, further oil price rises are inevitable. And, this is the driving force behind energy transition. Just as cheap kerosine from the first Rockefeller Refinery replaced expensive whale oil for lighting in the last century, less expensive energy options will begin to replace oil in the coming decades.

It is Alaska's energy policy to encourage the transition from expensive oil to potentially cheaper and more abundant alternative energy resources. The purpose of the policy is to expand the State's energy options and to find new ways to convert, transform and use energy.

According to a report by the National Conference of State Legislatures, Alaska is in the forefront of alternative energy development in the United States. But, Alaskans are unaware of their position. This lack of knowledge is largely attributable to the shortage of hard data on renewable energy potential and the dispersed nature of appropriate technologies in the field.

Interest in renewables is growing rapidly in the State. Conferences such as those held by the Alaska Center for the Environment have been well attended, sometimes attracting over five hundred participants. From 1979 to 1980, inquiries to the Arctic Environmental Data Center for solar radiation information, wind speeds, and other climatological data increased by 79 percent.

Alaska's diverse energy resources present a variety of options unavailable to other states and nations. Making choices that will benefit the State in a lasting manner is the challenge before State decision makers. It is important that in making these choices Alaska continue to increase its diversity of options to permit better matching of the differing site specific considerations of communities throughout the State.

Many new technologies are being developed, permitting the replacement or more efficient use of fossil fuels. The only criteria for early elimination of a technology in the State should be the lack of resources of sufficient size and quality to benefit the State. The development of technologies that can survive the Alaskan environment and meet the energy needs of the State will occur as the result of research, demand, and commercial development. The timing and availability of the technology will vary with each resource. The State can influence the use of its resources and develop the means to use them.

Some of the renewable resources of interest are geothermal, biomass, wind, peat, solar, and tidal energy. Current information indicates that Alaska possesses sufficient quantities of each resource to justify support of their development and use. In addition, a set of energy technologies that can use a variety of energy resources is reviewed: hydrogen, fuel cells, waste heat from diesel generators, heat pumps and energy storage. Thoughtful application of these technologies will allow more efficient use of the resource and also the resource which may be replaced.

For each of the resources and technologies, a description of the resource size and location is presented within the constraints of information availability. Technologies that can be used to convert the resource into useful energy and the status of those technologies are discussed. The projected developments in each technology is presented. A chart showing the State actions underway in the resource is shown and recommendations for additional State action are made.

Figure IV-4 provides a summary of the status and uses of each of the resources and technologies. In any energy decision, it is important to match the energy provided to the current and projected energy use patterns of the consumers. An awareness is needed that use patterns will probably change over time as prices, availability and values evolve.

The core policy for the development of the action recommendations in the long term is that Alaska should stress the development and utilization of in-state renewable resources. It is the policy of the State to insure that the current revenues from the extraction of oil and natural gas provide the basis for achieving viable energy systems within the State. The importance of non-renewable resources cannot be underestimated. The long-term energy goal is the attainment of Alaskan self-sufficiency with growth in energy demand supplied by in-state energy resources. To achieve this goal, the State should commit itself to the in-state demonstration of renewables energy technology.

Resources should be selected on the basis of:

A) Resource assessment or reliable estimate that establishes the existence of the resource within the state.

B) Technical evaluation of the means of resource extraction conversion and use.

C) Economic evaluation of the potential for cost-effective utilization.

Technologies should be selected on the basis of:

A) Improved efficiency in the use of current non-renewables resources..

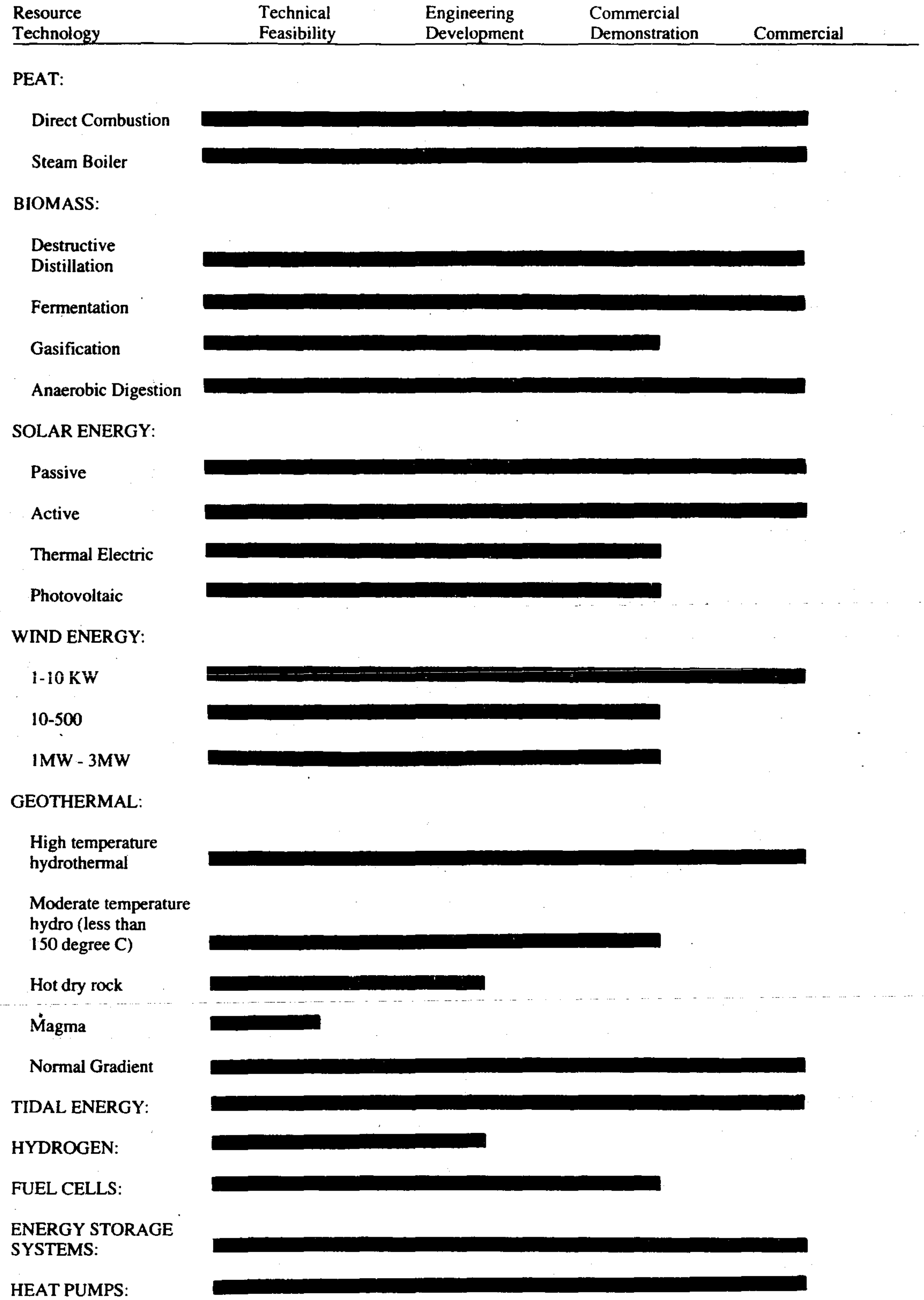
B) Application to the Alaskan economy, environment and regional culture.

C) Employment and other social benefits.

The action recommendations made in each section of the document are intended to achieve this policy goal.

FIGURE IV-4

ENERGY STATUS OF TECHNOLOGIES



*Photovoltaic cells are commercially available, but the development of cells competitive with other forms of electrical production is in the engineering demonstration stage.
**When used for space heating assistance.

- Technical Feasibility — Does the technology work (theory)
- Engineering Development — Pilot plant stage (practice)
- Commercial Demonstration — Demonstration at commercial or near commercial size
- Commercial — There are commercially operating types (does not mean economically competitive in all applications).

Peat

Resource Description

Peat is associated with shamrocks, drinking songs, and a warm hearth. Less romantically, it is organic matter which is partially decomposed under anaerobic conditions due to saturation with water. It could be an important energy resource in Alaska because it exists in many locations where other resources are very limited; it could prove reliable and immediately useful. Types of peat are:

- Sphagnum moss peat (peat moss)
- Hypnum moss peat
- Reed-sedge peat
- Peat humus
- Other peat

The general distribution of peat resource in Alaska is described in the accompanying map.

It is estimated that Alaska has 27 million acres of peat resource excluding permafrost areas. This is over 51 percent of the estimated peat resources in the United States. Of this amount, 5.5 million acres is estimated to be of fuel quality. Variations in the amount are due to estimation definitions of peat. Only two inventories of peat in Alaska have been conducted. In a report prepared by NORTEC in 1980 detailed identification and sampling was undertaken by 1) ground penetrating radar and then followed by samples taken from sites along the radar paths in the Susitna Valley, and 2) in remote regions, cores were taken at representative sites in several areas of the state.

This data and background report were prepared to present the results of initial efforts to inventory the occurrences of fuel grade peat in Alaska. Due to the immense size of the state, over 365 million acres, and the magnitude of the area covered by potentially useful peat, in excess of 100 million acres, this first effort was necessarily less refined in terms of detailed site specific analyses. However, the information gathered, and presented herein, is sufficient to indicate that Alaska does indeed contain a considerable fuel peat resource. Additionally, much of the currently available technology is directly applicable to the utilization of fuel grade peat in Alaska. The economic realty of fuel peat utilization in Alaska will, however, depend heavily on the results of subsequent study efforts.

Several options are available for examination relative to the continued exploration of Alaskan fuel peat utilization. Some of these options are:

1. Refine the statewide predictive model through more detailed site specific analyses.
2. Preselect only the highest potential occurrence and utilization areas as indicated in the results of this inventory for very detailed on-site analyses.
3. Bring current technology to bear on peat utilization wherever possible in bush Alaska using the existing data base.
4. Bring current technology to bear on the problem of peat utilization in Alaska's urban areas using the existing data base.

A combination of two or more of these options would enhance the development of the Alaskan resource. Further refinement of the data presented herein would be required to assess the associated technological, economic, and environmental factors to ensure the soundness of such development.

Resource Uses

Peat has long been an energy resource in Finland and Ireland. In these two countries, the resource has been farmed and used in the production of electricity and for space heating. Peat has an energy value about one-half that of high quality coal, but about equal to lignite. The energy content of peat on a dry basis is 7,200-10,000 Btu/lb. (Lignite is 6,000-7,000 Btu/lb.)

There are two main methods of harvesting peat; they are milled peat and sod peat. In both cases, the resource is piled or windrowed for in-field drying prior to removal from the site. Currently, equipment exists for the removal of the peat.

Peat can be made into briquettes and used in individual homes for home heating, or can be used in centralized district heating projects. Peat can also be used in multi-fuel facilities that could use coal, wood, municipal solid waste, biomass. In the case of electric production, the peat is introduced as a fuel into a boiler to produce steam or is gasified and used in the same manner as other thermal facilities. The attached table is reproduced from Volume II of *Peat Resource Estimation in Alaska*.

Cost of Power Generation from Peat

The economics of scale are very steep in power generation, as can be seen in the following table. It is obvious, that the smallest plants are not yet feasible, unless specific reasons raise the price of competing energy forms.

Environmental Impacts from Peat

The major impact is in the harvesting system and its impact upon the peatlands. Harvesting in permafrost areas is likely to have more severe impacts, but this has not been confirmed by study. However, harvested peat lands in the Carolinas have been reclaimed for agricultural purposes, making the land more productive than before. In home heating or electrical generation, the resource has less potential pollutants than the current coal or oil systems.

The harvesting will be the major safety consideration. Farming operations have historically tended to be more dangerous in terms of injury and accident than mining or oil extraction. New technology has helped in this regard.

Like the biomass option, peat development tends to favor local production and use; thereby, increasing the number of local jobs and stabilizing a portion of the economy. The development effort is toward hydraulic harvesting that would not dry the peat in the fields, but would move it by slurry to the power or conversion facility where it is mechanically dewatered. This would provide for a more stable resource and would lower the labor intensiveness of collection.

Recommendations

- The peat resource inventory and assessment program initiated with federal funds should be continued. Included should be a determination of the large scale development potential of the resource.
- A low technology peat harvesting and direct-use demonstration project should be initiated in areas of possible small-scale development.
- An identification and evaluation of specific institutional barriers such as the Matanuska Valley should be made. This should include the effect of Coastal Zone Management and federal wetlands policies.

FIGURE IV-5

PEAT RESOURCES OF ALASKA

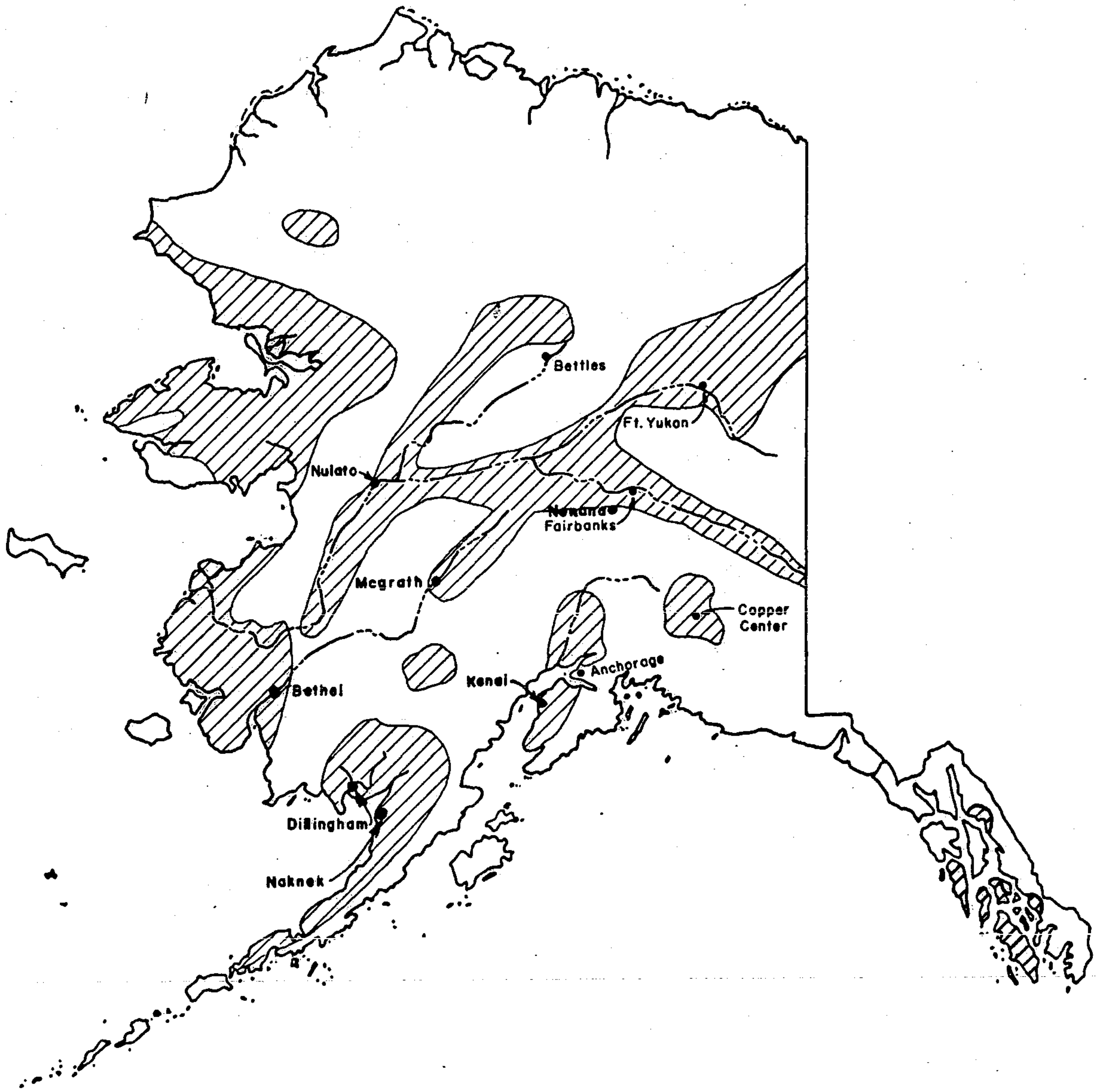


TABLE IV-11

Heat Generation Costs From Peat in 1980
($/Million Btu)

Individual House Heating	
- Sod peat fired	5.70 - 7.00
- Pellet fired	6.70 - 9.50
- Briquette fired	7.00 - 8.70
Centralized Heating	
- 1 MW plant, sod peat fired	6.60 - 9.30
- 10 MWt plant, milled peat fired	4.00 - 4.70

Power Generation Costs From Peat in 1980

250 kW cogenerating steam engine plant, sod peat fired	0.18 - 0.26
1 MW cogenerating steam turbine plant, milled peat fired	0.12 - 0.18
30 MW cogenerating steam turbine plant, milled peat fired	0.03 - 0.07
60 MW cogenerating steam turbine plant, milled peat fired	0.02 - 0.04

SOURCE: EKONO, inc.; Peat Resource Estimation in Alaska Final Report volume II; November 1980; p. 28.

Biomass

Resource Description

The energy source for most life on earth is ultimately traceable to the sun. Every plant and animal continuously stores this solar energy in its cells and tissues throughout its life. Biomass, the complete aggregate of living or recently living organisms, contains a tremendous amount of energy, much of which can be made available for use by humans.

Biomass waste products such as wood chips, solid organic refuse, or crop residues represent a significant energy resource. The increasing energy demands in the Lower Forty-Eight have made biomass energy conversion an attractive alternative to the waste disposal problems which vex most major cities even though the dispersed nature of this biomass may prohibit extensive development of this resource.

The Diamond Walnut Company provides one small-scale example of efficient waste conversion. By using gasifiers, they convert walnut shells to a combustible gas which in turn is used to dry the walnut meats.

On a larger scale, energy may be obtained from lumber and crops. The by-products of wood or crop processing may be converted to energy, as may lumbering and harvesting residues left in the field. Since 33 percent of Alaska's land is wooded, we can assume an abundant reserve of biomass waste in the event of harvesting these lands. Timber and crops could, of course, be specifically grown for their energy potential. This is referred to as energy farming.

Home use of wood in stoves and fireplaces is not treated in this study. We feel that with established patterns of individual wood use, the State should limit its concern to protection of public lands and human health and safety.

Biomass Availability

Despite Alaska's obviously large wood resource, the availability of this biomass for energy conversion is limited by land ownership and government land use policies. Also, sustainable yields are low in many parts of the State due to slow rates of forest growth.

Although the inventory of Alaska's biomass reserves is presently incomplete, several studies are underway. The Hoonah Wood-Fired Project, to determine electrical conversion potential for wood, will also provide wood resource data. The Battelle Pacific Northwest Laboratories has recently completed an *Assessment of Biomass Conversion to Energy for Delta Agricultural Project* from which data are available. The Division of Energy and Power Development has recently announced an eighteen-week project, *Interior Alaska Wood Assessment,* to identify the characteristics and extent of Alaskan wood reserves from existing sources.

TABLE IV-12

Summary of the Potential Energy Annually Available From Biomass Sources in Alaska

Source	10^{12} Btu/Year Other Estimates	10^{12} Btu/Year Likely Potential
Forests		
Present growth rate	161.	--
Minimal management	--	197.0
Non-intensive management	357.	--
Kelp		33.
Agriculture		
Crop		.664
Animal		.087
Solid Waste		4.063
		235.1

Another important potential source of wood fuel is driftwood found near many rivers and coastal communities. Below is a summary of the potential energy annually available from biomass sources in Alaska. This estimate is low in that many biomass resources were not included. It is high in the practical sense that it is not economically socially, or enviromentally desirable to collect all available biomass for energy conversion. All of the above resources have non-energy applications and costs which must be considered.

Conversion Technologies and Descriptions

The three primary biomass energy conversion technologies are combustion and gasification, alcohol fuels and anaerobic digestion.

Combustion is simply the burning of biomass waste to produce heat which may then be converted to electricity or used directly for space heating. Wood wastes are effectively used for cogeneration of steam-generated electricity and process heat in pulp mills in southeast Alaska. Boise Cascade Corporation's plant in Emmett, Idaho has used wood waste as a fuel resource in conjunction with plywood processing. In drying the plywood, the facility uses a fluidized-bed burner that blows input wood chips and particles onto a hot bed of sand held aloft by air. This process enhances conversion efficiency by increasing the total surface area of the burning material. Other biomass waste may also provide fuel for steam-generated electricity.

Gasification is a process for creating energy rich gas from solid biomass. This gas is created by the incomplete combustion of the biomass material. The Alaska Village Electric Cooperative (AVEC) Wood Gasification Demonstration Project utilizes this process with the resulting gas diesel engine.

Relatively dry biomass can be converted to methanol (wood alcohol) for use as a stand-alone fuel or in combination with other fuels. Ethanol (grain alcohol) can be produced from dry biomass and from sugar crops, grains and other fermentable wastes. As with methanol, it can be used alone or in mixtures.

Anaerobic digestion is a bacterial process in which hydrogen released from the breakdown of sugars and other organic materials is combined with inorganic compounds such as carbon dioxide from methane gas. Animal or human wastes are usually consumed in this process, although crop residues and wood could be used with less efficiency. Bacteria consume biomass and release what has been termed "biogas", a mixture of about 40 percent carbon dioxide and 60 percent methane. This biogas has an energy content of about 500 Btu/ft^3 compared with the 1032 Btu/ft^3 energy content of current pipeline gas.

In 1980 the Office of Technology Assessment ranked the following methods as having the highest potential for use during the next 20 years:

- Wood for gasification, alcohol production and direct combustion;
- Grain and sugar crops for alcohol production;
- Grass and legume herbage for combustion or alcohol production;
- Animal manure for biogas production.

Current Status

Wood is currently used within the timber industry for production of both heat and electricity. In the Pacific Northwest (including western Montana), 424 megawatts electricity (MWe) generation is presently used by industry, and an additional 871 MWe identified for potential use. Applications within the forest products industry account for approximately 80 percent of the current energy cogeneration potential in the Northwest. With Alaska's wood resources, a similar potential is available.

Grasses and crop residues are not yet being systematically converted but, as with wood, they offer great potential for methanol production. Additionally, these crops may be used to produce an intermediate-stage gas via gasifiers. Such gasifiers would be applicable in many commercial and industrial settings.

Municipal solid wastes offer some promise for methane production. Although anaerobic digestion has been applied in many solid waste facilities, and technical feasibility has been demonstrated with animal wastes, commercial application has not been developed. Direct combustion, however, has been unsuccessful in some non-Alaskan cities. Anchorage has examined the feasibility of converting electrical generation boilers to burn municipal solid waste.

Costs of Biomass Resources

The following table shows current costs for various biomass resources:

Costs of Various Biomass Resources

RESOURCE	1980 DOLLARS/MILLION Btu
Btu	
WOOD (@ $30.00/dry ton)	
Direct combustion or gasification with combustion	$2.25-$7.00
Methanol delivered to the service station	$13.40-22.00
CORN (@ $2.50/bu.)	
Ethanol delivered to the service station	$12.50-17.60
GRASS & CROP RESIDUES (@ $45.00/dry ton)	
Methanol delivered to the service station	$16.50-25.00
MANURE	
Biogas from 100,000 turkeys	$2.00-4.00
from 500 swine	$12.00-24.00

For comparison, the following figures from the Delta project have been included: (Battelle Pacific Northwest Laboratories, 1979): In 1979, Battelle Pacific Northwest Laboratories provided the following figures:

RESOURCE	1980 DOLLARS/MILLION Btu
WOOD	
Small scale direct combustion	$1.47-2.27
Direct combustion for existing power plants	$ .50-1.00
Methanol	$9.50 approx.
Fermentation for Ethanol Production	$19.27-26.78

Fermentation for Ethanol Production

Biomass fuel costs are highly variable. Alaska does not have great numbers of confined animals, so anaerobic production of biogas from animal wastes does not appear to be a viable large scale option.

Wood from the state's forests is the greatest biomass resource. Both wood and municipal solid wastes could be developed as mix fuels. Future coal facilities should be designed to allow the addition of multi-fuel use. Tacoma, Washington is now considering such a facility. The facility should be designed to operate on wastes, municipal solid wastes, and coal. The coal will be considered the back-up fuel supplying the energy needed to keep the facility operating at required levels.

Major Environmental Impacts from Biomass Energy

Biomass energy production will have both positive and negative effects upon the environment — positive in the sense of utilizing waste products such as those from Alaska's seafood industry and negative in that hydrocarbon fuel and land use may increase just to produce biomass energy sources.

Without careful planning, some of the following could result:

Wood

- Possible decrease in ground cover with consequent soil erosion.
- Increased commercial use of forests with consequent changes in land use patterns.

Grains

- Increased total fuel use if primary fuels are not replaced by biomass fuels
- Increased land use for energy production
- Use of new crops not suited to the Alaskan environment

The amount of energy required to plant, cultivate and harvest these crops is approximately the amount derived from the ethanol. This net energy balance should be calculated before proceeding with such a project.

Health and Safety Concerns

Except for municipal and industrial waste, biomass resources tend to be dispersed so transportation becomes a limiting factor in the size of biomass facilities. Its use, then is more applicable to rural communities where total energy demand would be less and biomass availability would be greater. Biomass energy systems would affect local economies by increasing jobs since biomass is a more labor intensive economy. Greater manpower is needed for crop harvest and collection.

The food we eat and the wood with which we build our homes also comes from our biomass reserves. Competition for biomass as fuel could increase the prices of food and shelter. Sugar and grain crops will be most susceptible to competition between food and fuel users. Additionally, biomass fuel users will need an advance guarantee of fuel supplies. The need for secure fuel stocks will lead to pressures for increased harvests and storage facilities.

Social and operation characteristics of biomass use have been reviewed nationally but not locally. Although biomass use in Alaska is promising, the lack of a market for biomass in the Lower Forty-Eight will limit technological growth. It is likely that technology for biomass use will continue to develop more slowly than that for other energy resources.

Development Potential for Biomass Energy

Wood harvest products will be particularly significant for Alaska due to technological improvements in commercial cogeneration facilities. Increased ethanol production is expected from similar technological improvement of distilling processes. Federal and state incentives should bring about construction of large scale facilities of both types.

Commercial processing improvements can be expected in small scale gasifiers and in methanol production from legume herbage, grass and crop residues. Commercial and governmental research will determine economic feasibility of these processes by investigating a variety of production facilities and methods.

Recommendations

- An in-depth assessment of the use of beach and river driftwood for residential and commercial space heating and community power production should be undertaken.
- The mid- and long-term potential and problems associated with expanded residential and community use of wood resources in Alaska's communities should be determined.
- The utilization of biomass derived fuels in Alaska should continue to be encouraged.

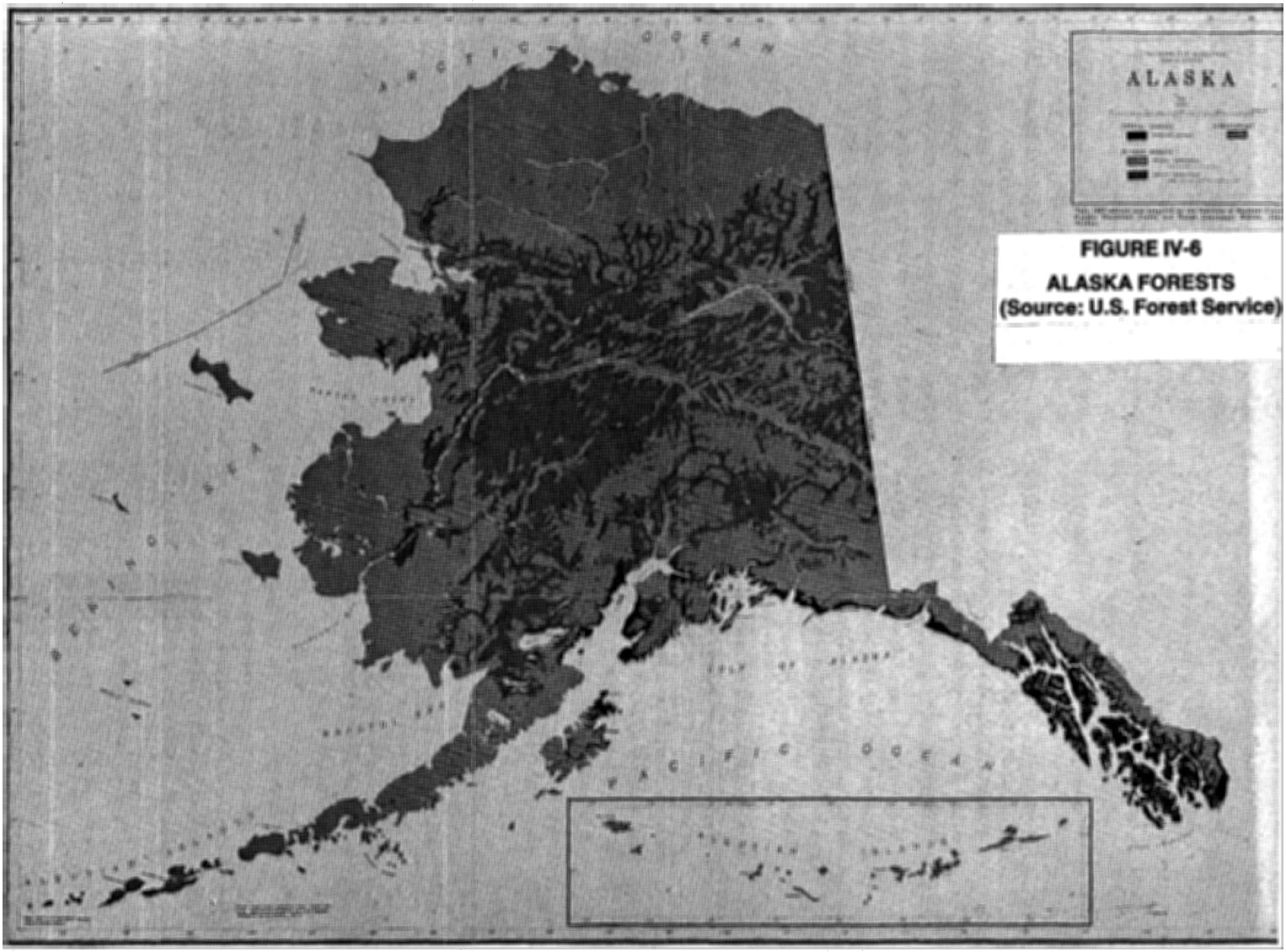


FIGURE IV-6

ALASKA FORESTS
(Source: U.S. Forest Service)

Solar Energy

Resource Description

Solar energy is received in the form of radiation from the sun. Sunlight may be used directly, giving us suntans and healthy gardens or indirectly, providing wind to propel our sailboats or wood for our stoves. Although most energy is traceable to the sun, our discussion in this section will be limited to direct solar energy technologies. Indirect forms such as wind and biomass are treated elsewhere.

Resource Availability

Contrary to popular belief, the sun does shine in Alaska. In fact, the State receives more hours of sunlight annually than some areas at lower latitudes. The greater number of sunlight hours between the vernal and autumnal equinoxes (about March 21 through September 23) more than balance the long nights of winter. Latitudinal, geographical, and climate characteristics, however, have considerable effect upon the amount of sunlight and solar potential for any specific area. Table IV-12A indicates insolation (solar radiation) at five Alaska locations of varying climates and latitudes.

TABLE IV-12A

Vertical South-Facing Surface
Average Mönthly Radiation Data
Btu Day/Ft²

	Annette	Barrow	Bethel	Fairbanks	Matanuska
January	719	0	832	864	753
February	837	98	1224	1149	1034
March	1126	467	1882	1808	—
April	1119	995	1689	1679	1307
May	1001	1367	1176	1323	1126
June	901	1479	1021	1271	1052
July	936	1204	886	1158	980
August	915	618	715	1094	945
September	992	331	874	912	859
October	627	79.5	823	723	696
November	397	0	518	513	446
December	470	0	502	263	316

The insolation data in this table were from a Natural Bureau of Standards report computed byı Kusuda and Ishii. The monthly values vary significantly when computed by others using different computational methods, especially for the months sNovember, December and January.

This points out the need for purchase and installation of solar energy measuring equipment for various regions of the state so that actual, measured data will be available to correlate with the current computed values.

Solar consultants and designers should be cautioned regarding the descrepancies in methods when using any one set of values in their design considerations.

Notice the greater variations in insolation as one travels further north. The lands above the Arctic Circle receive near total sunlight during those summer months when the Earth's northern axis is tipped toward the sun. Alaska's sun does, however, present a unique problem. Maximum solar absorption occurs when the sun's rays strike a surface, that of a solar collector for instance, at a 90° angle. While the sun's path maintains a relatively consistent curve across the sky of the Lower Forty Eight states, its path in northern Alaska tends to circle around the sky. Total solar collection in the far north would probably have to incorporate some fairly sophisticated and expensive tracking devices.

As shown below, solar data collection — an essential for solar energy assessment — has a varied history.

Historical Background and Information

According to the study, *Solar Energy Resource Potential in Alaska,* by Richard D. Seifert and John P. Zarling:

> The solar radiation data acquisition sites in Alaska have varied histories. The Annette Island station was established in July 1949, at approximately the same time data acquisition began at Fairbanks and at the Palmer Agricultural Experiment Station in the Matanuska Valley. The station at Barrow was added in April 1955, and the Bethel station began recording data in October, 1958 (USWS, personal communication). These three stations have since terminated data acquisition, mostly because of outdated faulty equipment and lack of financial support. The Barrow site ceased acquiring data in 1974, and Annette Island and Bethel stations terminated recording solar insolation in 1975. Matanuska still acquires hourly data using a strip chart recorder. Fairbanks is the only site supported by the National Weather Service which is still acquiring data. A new system was recently installed in Fairbanks in which solar radiation data is recorded directly onto cassette tapes. This new system provides for easier copying and dissemination of the data and is also a more accurate system.
>
> Presently, and for the last few years, data acquisition at Barrow has been supported by the Smithsonian Institution, and the data are available through their operations.

Detailed information to seasonal changes and time variations of insolation does not presently exist — either for major regions or specific areas of the State. Further, detailed information cannot be expected to accurately describe actual local weather. Since weather is so variable, insolation data are aggregated to indicate trends and probabilities rather than show actual weather conditions.

The initiation of an expanded solar data collection program should be done in conjunction with a similar wind data program. The State, with its many airports and small communities, has an adequate variety of locations available for data gathering. Such a study would be useful for gathering detailed insolation data and for enhancing the statistical reliability of our solar resource data. This last objective becomes increasingly important as solar energy potential becomes more significant in the peak energy demand load of electric or natural gas utilization or the community purchase of oil products.

Solar Technologies

There are four main types of solar technology in varying stages of use or development: passive solar design, active solar energy, solar thermal-electric and photovoltaic.

Passive Solar Design. This application uses solar energy through design and non-mechanical means. A passively designed building might incorporate features of geography, orientation to the sun and energy efficient construction to maximize the solar heating or cooling advantage. The lack of mechanical features refers only to the solar portion. The building itself could have any number of mechanical devices.

Active Solar Energy. Active solar energy systems use collection, storage, and distribution devices which include mechanical components — flat plate collectors, valves, fans, pumps, and controls. Active and passive solar designs are used primarily for indoor temperature control and domestic water heating.

Solar Thermal-Electric. One may use solar energy to generate electricity in much the same way one would use oil, coal or other non-renewable resources. In solar thermal-electric system, the energy source is used to heat water, or another fluid, to the vaporization point. The pressurized vapor — gas, steam, etc. — drives the turbine and generator which produces electricity. Since simple flat plate collectors cannot produce the necessary 500° - 1000° F temperatures, the sun's rays are concentrated by using an array of mirrors which focus their heat at a single point — the boiler.

Photovoltaic. Some semi-conductor materials such as silicon are capable of releasing electrons excited when struck by sunlight. The current of energized electrons from these photovoltaic cells increases proportionally with the amount of sunlight. Though photovoltaics have been used by the Alaska Railroad, for Anchorage municipal fire alarm boxes, in the Skylab program and in remote station communications, they are not yet cost competitive for many common uses.

Current applications of solar energy are:

Passive solar design

- New single-family residences
- New multi-family residences
- Retrofit single- and multi-family residences
- Commercial buildings
- Agricultural

Active solar energy

- Water and space heating
  - —new and retrofit residences
  - —commercial buildings
- Process heat
  - —industrial
  - —agricultural

Solar Thermal-Electric

- Electricity generation
- Process heat

Photovoltaic

- Electricity generation

Active solar water and space heating and passive solar design and orientation are generally recognized as being economically viable technologies. Other categories of solar energy — photovoltaics (residential); irrigation, large-scale, solar-electric or photovoltaic; energy cogeneration; large-scale production of process heat for industry; are not yet economically competitive.

Current Costs

Passive Solar. Passive solar designs are fuel conservation oriented and should be considered with fuel savings in mind since they incorporate energy efficient construction. Passive solar designs have been shown to be cost effective in almost all cases. The figures below represent levelized costs over a 20 year period for passive designs vs. conventionally designed homes in Albuquerque, New Mexico and Madison, Wisconsin (Carasso, 1980). Comparable figures are not available for Alaska.

	Albuquerque	**Madison**
Passive Solar	$12.21/MMBtu	$10.52/MMBut
Conventional	$10.50/MMBtu	$11.08/MMBtu

The conventionally designed homes in Albuquerque had electric heat and the Madison homes used natural gas. The figures for passive solar would indicate the economic competitiveness of this design. Passive solar designs are especially applicable with new homes since construction costs for solar are not appreciably higher than are construction costs generally.

Active Solar. A recent Oregon study estimated installed solar water-heating costs of $1,250-$2,500, with a range of $16-$33/MMBtu (Solar/Conservation Task Force, 1980). In Madison, studies indicated levelized solar water-heating costs of $12.48/MMBtu for retrofit installations and $12.13/MMBtu for new homes. Conventional water-heating systems in comparable homes cost $16.21/MMBtu.

Basing its conclusions on 1978 energy prices, *Solar Energy Resource Potential in Alaska* states, "Results indicate that solar energy cannot compete economically with oil-heated domestic hot water at any of the five study locations in Alaska, but that it may be economical in comparison with electrically heated hot water if solar collector systems can be purchased and installed for $20 or $25 per square foot." (Seifert, 1978)

The previously mentioned Oregon study indicated that solar space-heating combined with solar water-heating proved to be significantly more expensive than conventional heating. Active space heating in Alaska is not presently felt to be economically feasible.

Solar Thermal-Electric. According to the Electric Power Research Institute, solar thermal-electric technology is in the engineering development stage. A solar power tower for electric generation is being constructed in southern California.

Photovoltaic. Photovoltaic cells may be used for homes or by utilities in electric generation systems, but they have some definite drawbacks. At present, capital costs per installed kilowatt are high, and they are not productive in the absence of sunlight. They may, however, be of value for small commercial or remote applications or perhaps for communities where traditional fuel prices are extremely high.

Major Environmental Effects

Active and Passive Design. It is generally agreed that environmental impacts from solar space or water-heating will be negligible, but the manufacture of materials sometimes required for these technologies may have some ill effects. Decisions for massive solar use might lead to greater land use, or perhaps land sprawl to assure adequate sunlight exposure, but these effects would only become apparent if a large part of the population began using the technologies.

Solar Thermal-Electric. Major environmental effects might result from:

- Handling and disposal of system fluids and wastes (boiler blowdown) leading to contaminated water
- Heliostat reflections
- Microclimatic alternations
- Increased land use (670 acres would be needed for a 10^{22} Btu/year solar thermal-electric facility)

Photovoltaic. Negative effects from photovoltaics might include:

- Residential Applications
  — Toxic gas release during operation or malfunction
  — Solid waste disposal
- Commercial or Community Applications
  — Toxic gas release
  — Solid waste disposal
  — Glare from solar array
  — Local weather changes and thermal parameter changes over large areas
  — Increased land use (about 230 acres for a 10 Btu/year facility)

Major Social and Operational Concerns

As seen in Appendix F, Alaska will benefit directly from increased sales and use of passive solar designs, and will have some benefits from active solar water-heating designs.

Solar Development Potential

Passive and Active Design. For water and space heating, the technology is developed and ready for application, subject to case by case economic evaluation. The consumer can expect to see increasing numbers of new solar products on the market. Changes in public incentives, lending policies and legal stipulations will have more effect than technological improvements per se.

Solar Thermal-Electric. The heliostat (concentrating collectors) determines a solar-electric system's price. Current estimated costs are $\$100/M^2$ for orders of 25,000 or more units. The Electric Power Research Institute estimates a construction of a 2,000 MWe capacity on line by the year 2000 if price features can be met.

Photovoltaic. Photovoltaics represent a high technology area subject to major breakthroughs and price reductions.

The U.S. Department of Energy (DOE) estimated cost reductions from \$10.00/peak watt to \$.70/peak watt (or \$10,000/peak kW to \$700/peak kW), leading to total systems costs of \$1,000 to \$1,300 per peak kW by 1990 (Electric Power Research Institute, 1980). Photovoltaics, when considered as fuel savers, could become economically attractive in Alaska before the dates given by the DOE.

Recommendations

- A solar resource assessment program should be initiated in conjunction with the wind resource inventory which has also been recommended.
- Using existing data an in-depth technical and economic evaluation of passive and active solar systems and applications should be completed during FY82. It should be refined annually as additional solar resource and technology information becomes available.
- An active and passive solar heating demonstration program should be initiated to determine actual performance, operating characteristics and economics of solar systems in Alaska.
- An in-depth assessment of the application of photovoltaic cell technology in Alaska should be carried out. The cost of electrical power in the Alaskan Bush today may justify a serious State commitment to solar photovoltaic development.
- The potential for thermal electric production in Alaska appears limited. Technological developments in this area should be monitored.

Wind Energy

Resource Description

Wind has been a source of energy for centuries. It has drawn water for irrigation, separated chaff from grains, moved immense wheels to grind flour, held many a child's kite aloft and transported people and equipment to distant continents.

One can, of course, extract energy whenever the wind is blowing, but the wind must meet minimum requirements of speed and duration for practical energy capture. Fortunately, the winds along Alaska's 30,000-mile coastline have the strength and frequency to provide energy in both the near and long term. As Figure IV-7 and the chart below indicate, a variety of Alaskan locations possess the minimum 12 mph average annual wind speed generally considered necessary for practical wind energy capture.

Annual Average Wind Speed for Several Alaskan Sites

Location	At height = 10m (33 ft) Annual Miles per Hour
Cape Thompson	22.6
Cold Bay	19.0
Gambell	17.9
Cape Romanzof	16.0
Nunivak Island	15.9
Port Heiden	15.2
Adak Island	14.4
Kotzebue	12.9
Cape Newenham	12.5
Bethel	12.4
Barrow	12.0
Wainright	12.0
King Salmon	11.1
Unalakleet	10.7
Skagway	10.3

These National Weather Services figures were obtained by measuring wind speeds at a height of 10m (33 feet) — the approximate height of a wind generator — above the site's ground level. Unfortunately, the data were not collected with thoughts of wind energy in mind. The sites were selected because of their proximity to airports in some cases, and mere convenience and accessibility in others. Consequently, these figures only suggest sites of first opportunity and should not preclude investigation of other locations. But these figures do indicate promising wind energy potential for may areas of the State. Appendix G, Alaska wind Summary, contains a more extensive listing of average wind speeds by community.

Description of Wind Energy Technologies

Though mechanical applications are also possible, wind will most likely be used to generate electricity. In most wind energy conversion systems (WECS), the wind rotates the propeller-like blades, converting the air's kinetic energy of motion to rotational energy. The blades rotate a shaft which is connected to a generator or perhaps a mechanical device such as a water pump. Wind-driven generators produce direct current (DC) electricity which is sometimes used to drive DC motors or provided lighting. More often, the direct current will need to be converted to phased alternating current (AC) before it is usable by utilities or AC motors and appliances. DC-AC convertors or synchronous inverters are used for this task.

Unfortunately, the wind does not always blow as the user would have it. Some days it's too fast, other days too slow and sometimes it doesn't blow at all. Storage devices (tanks for water pumps, or batteries for electrical systems) must be incorporated if the user wishes to realize consistent benefit.

Wind system output ratings usually represent peak output under optimum conditions. Overall output potential must be estimated from the system's performance characteristics under conditions similar to those at the proposed site.

Also, one must remember that available wind power output varies as the cube of the wind velocity. In other words, if the wind speed doubles, the potential output is eight times the initial value. If the wind speed triples, the theoretical potential output is twenty-seven times the initial output. These theoretical values are never actually realized because of losses to friction, system inefficiency and structural limitations.

In stand-alone systems, storage devices are primarily used to offset times of low wind. They are used where the power output exceeds the immediate demands of the user. The excess energy can be stored for later use. The ability to increase the reliable capacity of the system by the addition of storage devices could offset the initial purchase price.

Wind system designs should also provide protection against excessive wind velocities which could damage the unit. The blades, for example, turn out of the wind when wind speeds are above a specific maximum.

Current Status of Wind Energy Technology

Small wind energy conversion systems are currently operating throughout the United States and are included in resource development plans of other nations. The potential user's questions will pertain to resource availability, economic feasibility and reliability in the Alaskan environment. The technology already exists for the very small machines. Systems of greater than 10kW rated peak output are in various stages of development. Recently, a 115 MW wind generator, owned by Bonneville Power Administration, began producing electricity in the state of Washington. This particular system was designed to determine the potential for wind energy in the Northwest Power Grid, rather than produce economically justifiable electricity.

Costs

Current estimated costs of wind systems are as follows:

Initial Costs	Small Scale (1-25kWe)	Medium Scale (25-500We)	Large Scale (Over 1MWe)
Costs by peak output rating	$3,000-5,000/kW	$1,000-3,000/kW	$456-922/kW
Costs per kilowatt hour produced	$.245/kWh	$.049/kWh	$.033-.044/kWh
Costs per million Btu	$24.50*	$4.90*	$3.30-4.40*

**Assuming a heat rate of 10,000 Btu/kWh and equivalent operating and maintenance costs, these figures can be compared to diesel fuel costs.*

Costs for a representative Alaskan utility system are given below (Robert W. Retherford Associates, 1980):

1.5kW windplant with induction generator 1.5kW control (Enertech 1500)	$ 3,900
Tower, including 60′, 3″-pole, pole top adapter guy wires and anchors (4)	900
Control anemometer wire (400 feet)	65
Freight, 4,000 lbs. @ $19/100 lbs.	760
Installation, 100 manhours @ $50/hr.	5,000
TOTAL	$10,625

Environmental deficits from wind energy are minimal. Mechanical stress associated with the blades and rotational system present some potential for accidents. Electricity-generating systems pose the usual problems of electromagnetic interference; and associated machinery could produce unacceptable noise levels. Wind energy systems are not considered aesthetically appealing, but to some, this is a problem for design architects. Early solar apparatuses for home and offices were not attractive either until architects began incorporating them into their designs.

Mechanical failures of either wind system blades or their supporting structures could cause human injury. Mechanical failure is, of course, possible wherever machinery of any kind is in operation, but conscientious design for maximum safety significantly reduces this risk.

The wind system should be built with two considerations in mind: 1) The generators of current electricity producing systems cannot be housed indoors, hence the apparatus must be accessible for inspections and repair under all weather conditions. 2) The blades will be subjected the most to weather damage. The system should be designed to facilitate local repair to the blades, shaft or generator.

Potential Wind Energy Developments

Major wind energy conversion system advances will occur in the design and development of storage systems. With these advances, users will have the ability to sustain supply during times of low output from the wind system. We anticipate that intermediate systems (25-150kWe) will receive developmental emphasis.

Wind system components are "turnkey" items; consequently, major costs will continue to be incurred from transportation of components, alterations to the site and construction of the site's tower. Prior to construction, a site-specific study should be conducted, the costs of which should be included.

Thus far, only small stand-alone systems (on the order the lkWe) have provided detailed information on operating exeriences. Some intermediate systems have been constructed and the federal government has developed large prototypes, but little operating information is presently available for either.

Alaskan Activities

In May of 1981, the Arctic Environmental Information Data Center expects to complete its *Wind Energy Resource Atlas* which will help potential users to determine their wind resource. The Division of Energy and Power Development has published a guide to the use of wind power in Alaska entitled *Introduction to Small Wind Energy Systems in Alaska*. Addressing the resource, technology, and problems which may be encountered, the Alaska Department of Transportation and Public Facilities is currently preparing the *Alaska Wind Power User's Manual* for designers and users.

Rockwell International, Inc., under contract to the U.S. Department of Energy, placed a 2.2-kilowatt SWECS at Kotzebue in August 1979, and interconnected with the City of Kotzebue Electric Utility. The project will provide data for future feasibility projects as well as electricity for the city. Similar study projects are occurring at Nelson Lagoon, Newhalen, Unalakeet, Chevak, Sheldon Point, and Skagway. Other wind activities in the state include a recently designed wind-powered freezer, and the use of wind-generated electricity on remote farms and homesteads.

Recommendations

- A statewide site specific long-term wind monitoring program should be developed as a means of determining the wind resource development potential. This should be coordinated with ongoing reconnaissance studies and community energy assessments.
- An Alaska based field test program for intermediate (25kW-150kW) wind energy conversion systems should be initiated.
- A general examination should be made of the potential and economic and technical feasibility of installing and operating large (150kW-3mW) and medium (25kW-150kW) systems in Alaskan communities.
- A joint wind systems testing program with Canada should be explored because of the many economic, social and environmental conditions the two areas have in common.
- Operating data and development information gathered from existing systems should be collected and made available to potential users.

FIGURE IV-7

ANNUAL AVERAGE WIND POWER
(Source: Wind Energy Resource Atlas)

Classes of Wind Power Density at 10 m and 50 m[a]

Wind Power Class	10 m (33 ft) Wind Power Density, watts/m2	10 m (33 ft) Speed,[b] m/s (mph)	50 m (164 ft) Wind Power Density, watts/m2	50 m (164 ft) Speed,[b] m/s (mph)
	0	0	0	0
1	100	4.4 (9.8)	200	5.6 (12.5)
2	150	5.1 (11.5)	300	6.4 (14.3)
3	200	5.6 (12.5)	400	7.0 (15.7)
4	250	6.0 (13.4)	500	7.5 (16.8)
5	300	6.4 (14.3)	600	8.0 (17.9)
6	400	7.0 (15.7)	800	8.8 (19.7)
7	1000	9.4 (21.1)	2000	11.9 (26.6)

(a) Vertical extrapolation of wind speed based on the 1/7 power law.

(b) Mean wind speed is based on Rayleigh speed distribution of equivalent mean wind power density. Wind speed is for standard sea-level conditions. To maintain the same power density, speed increases 5%/5000 ft (3%/1000 m) of elevation.

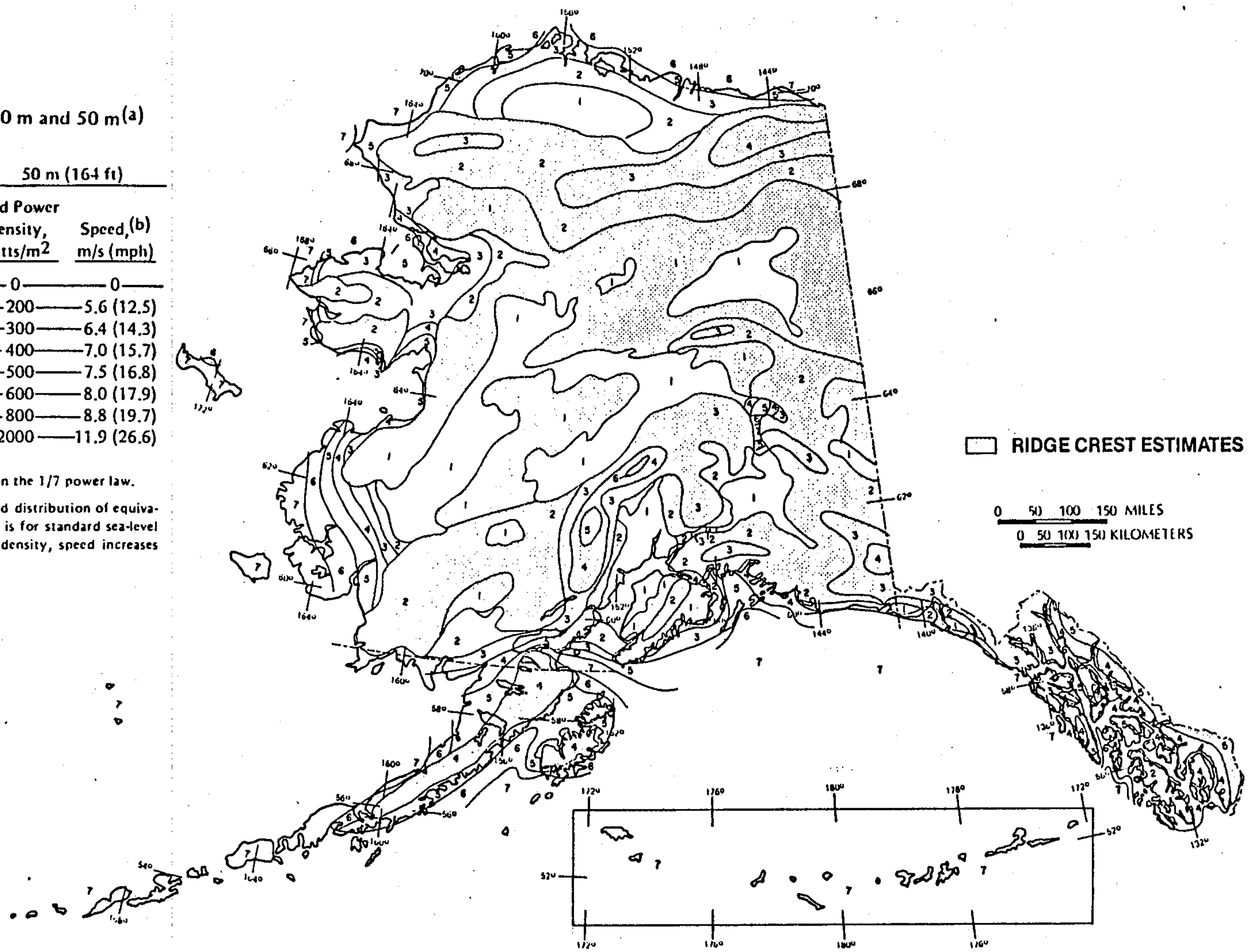
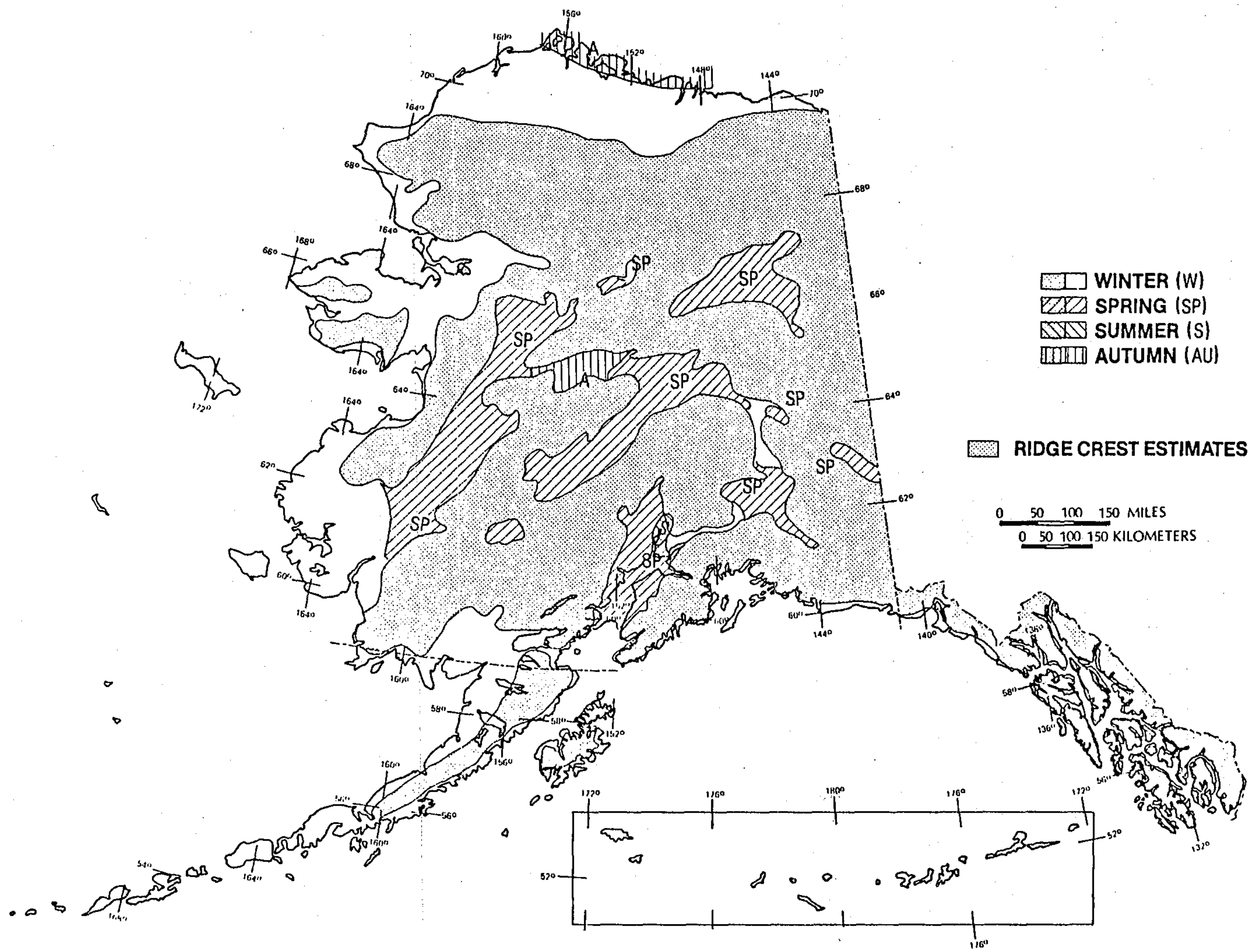


FIGURE IV-8

SEASONAL MAXIMUM WIND POWER IN ALASKA
(Source: Wind Energy Resource Atlas)



Geothermal

Resource Description

The recent eruption of Mt. St. Helens provides an excellent example of the potential of geothermal energy. Literally translated, the word "geothermal" means earth heat. This heat within the earth finds its way to the surface as radiant energy or in such forms as hot springs, geysers, fumaroles and volcanoes. Useable geothermal energy can be categorized under three basic headings: petrochemical, geopressure, and hydrothermal.

Petrochemical energy comes from magma — molten igneous materials — which are close to the earth's surface. Volcanic activity and faulting are indicators of this magmatic process. Near surface earth heat can also be found concentrated in the crystallized hot dry rock which forms from cooling magma. The primary heat source for all magmatic activities is radiogenic decay. Insulated from the earth's surface, these atomic processes heat the earth's core to over 6000 degrees C.

Geopressured energy is found in geologic zones where mud, silt and organic materials have been buried quickly and trapped at great depths within permeable sands located below an impermeable insulating layer of rock.

The trapped water actually fills the space between individual particles so they do not touch. This "floating" of the earth above the geopressure zone give rise to considerable pressure. The water, heated by radiogenic decay, produces methane from the biomass in the section. The heat, extreme pressure, and methane are all attractive resources, but technically difficult to reach and control.

Hydrothermal energy comes from water heated by contact with hot materials in the earth's crust. Geysers and hot springs represent surface manifestations of this form of geothermal energy. Largely because of the technical difficulties in using petrochemical or geopressure resources, hydrothermal is the most widely used geothermal resource. In the natural system, water is heated as it circulates near magma or other heat concentrations in the earth. The water acts as a heat transfer agent as it is forced to the surface by its own expansion upon heating. The technologies for steam and hot water utilization in electricity generation and space heating are well developed.

Availability of Geothermal Energy

Petrothermal sites are categorized as either igneous-related or conduction-dominated: Igneous-related sites are those having direct contact with magma. Eighty-five percent of the nation's geothermal sites are igneous-related. In Alaska, there are 85 identified active or dormant volcanoes and volcanic fields. The thermal energy remaining in these identified sites has been estimated at approximately 9.0 × 1018 Btu. At an electrical conversion efficiency of 15 percent, this energy would provide 4.5×10^7 MW years.

Conduction-dominated or hot dry rock systems — restricted by definition to the outer 10 Km of the earth's crust — refer to energy trapped in dehydrated rock, through which heat from magma has been conducted: In the United States, hot dry rock systems are estimated to contain the equivalent of 3.34×10^{23} Btu. The Alaskan resources have not been inventoried.

Geopressured energy refers to water trapped at great depths under high temperature and extreme pressures of 10,000-15,000 psi. This water, containing natural gas, might be brought to the surface through manipulation of the high pressures. It is felt that geopressured water may be found in conjunction with many of the world's oil and natural gas fields. Our knowledge, however, is limited to fields in the Gulf Coast region of the United States. No such resources have been identifield in Alaska to date.

Geysers, hot springs and fumaroles are indicators of near surface hydrothermal resources. This energy comes to use in two forms: vapor-dominated at temperatures greater than 150 degrees C and liquid-dominated at temperatures below 150 degrees C. Low temperature sites may be utilized in some instances. Alaska's hydrothermal resources have been estimated to contain sufficient energy to produce 5.4×10^6 MW years, or 1.085×101^8 Btu annual (U.S. Geological Survey, 1978).

The development of geothermal energy is limited by lack of investment capital, lack of demand and lack of knowledge about the resource. Most of our geothermal knowledge has been acquired through general observation of hot springs or other geothermal activity rather than through resource confirmation programs.

The United States Geological Survey has periodically assessed resources in the U.S., including Alaska, but did so using procedures more appropriate for petroleum identification. Most Alaskan geothermal sites, then, must be considered "potential". A recent list of thermal springs in the U.S. includes 113 Alaskan sites with temperature ranges of 20° to 154° C (68° to 310° F).3 Though some of the sites have been tapped for energy, Alaskan site applications have been limited to the space-heating or recreation. No electricity has been geothermally produced in Alaska to date.

Geothermal energy development will occur when the economic, resource, technological and socio-political considerations combine to make it the best option. Sites identified as having potential for new or expanded development include:

- Pilgrim Hot Springs
- Kotzebue
- West side of Mount Drum (Klawasi)
- Willow
- Chena Hot Springs
- Circle Hot Springs
- Manley Hot Springs
- Horner Hot Springs
- Clear Creek Hot Springs
- Central Baranof Island (Sitka Hot Springs)
- Tenakee Hot Springs
- Northern part of Unalaska Island
- Umnak Island
- Emmons Caldera
- Northeastern Atka Island
- Adak Island
- Akutan Island

Current Status

Technology to extract energy from hydrothermal resources for electrical generation with temperatures above 150° C is well developed and currently in use. Dry steam from geyser fields in northern California generate three-fourths of the electricity demanded in the San Francisco area. Geothermal has also been developed in Japan, New Zealand, Italy, Iceland, Russia and other parts of the world. Technology for electrical production from sites below 150° C are in the development stage. Until recently, these less efficient systems have not been competitive.

The binary fluid cycle used to raise efficiency is a method of transferring heat to a fluid which possesses better vaporization characterisitics at a given temperature than does water. Vapor or gas from this second fluid will then drive turbines which would otherwise be driven by steam. Plants in Idaho and California are currently testing this technology with the hope of extending geothermal potential.

Hydrothermal energy at lower temperatures may be used, and may be preferred, for non-electrical applications. Resorts and homes in Alaska have been geothermally heated since the days of the Gold Rush. Alaskan commercial process heat applications have been diverse, including forest product processing, fish processing, aquaculture enhancement, agricultural processing and mineral processing.

Costs of Geothermal Energy

Expenses and charges for the geothermal fluids used may constitute a major portion of geothermal costs. In some instances, the geothermal fluid cost has been tied to costs of competing fuels such as oil, in which case the price of the geothermal energy escalates with the price of oil. In Alaska, however, state law treats all geothermal resources below 120 degrees C as a water resource. If the cost is figured by amortizing well development costs over time, the fuel cost is fixed. Expenses for the resource and system operation and maintenance can be considered part of the overall geothermal system costs.

Estimated Costs of Geothermal Energy Systems

SPACE HEATING:		1980 DOLLARS
Capital Mall, Boise, Idaho*		$1.64-7.97/MMBtu
Space heating (residential and commercial)**		$3.00-29.00/MMBtu
ELECTRICAL PRODUCTION:		
High temperature source (greater than 150 degrees C)***		
	Capital Costs	Cost/kWh
	$740.00/kW	$0.071#
	(70% capacity factor)	$0.057##

*McClain, 1979.
**Northwest Energy Policy Project, 1977.
***Hughes, 1980.
Cost if geothermal fluid is priced with cost of oil
##Cost if geothermal fluid is owned by operator of the facility

In Alaska, the cost of direct use of geothermal energy may just be the cost of the delivery system. With a total cost of just a few hundred dollars, Chuck Dart of Manley Hot Springs uses pipes from a penstock to heat his greenhouses and home. However, the Navy estimates the cost to provided 25 MW electrical 10 MW space heating capacity to Adak to be $65 million in 1978 dollars. The largest single cost would be for production drilling.

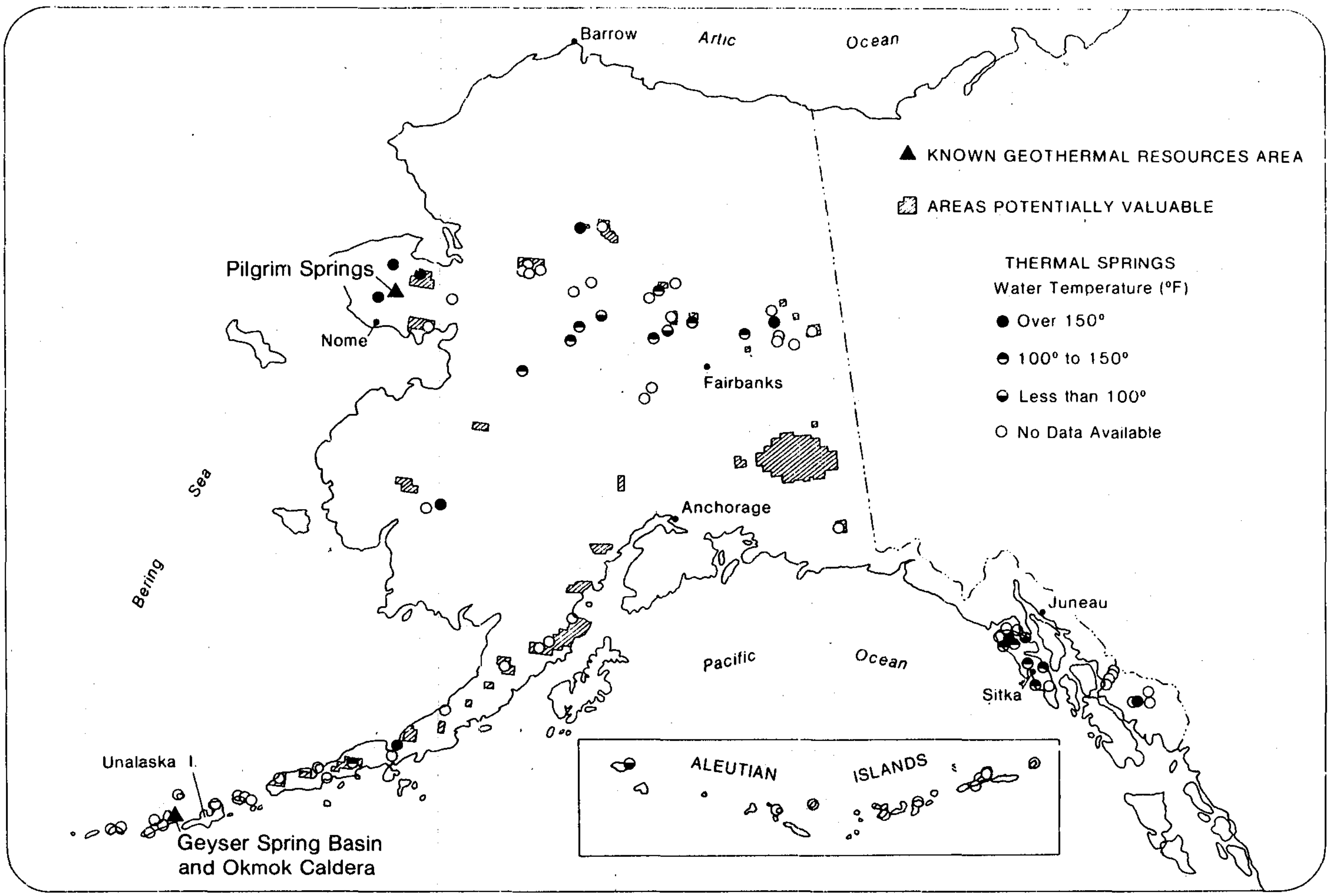
Major Environmental Concerns

Steams or vapor-dominated systems present several environmental considerations which include high noise levels, excess steam disposal problems and hydrogen sulfide emissions, carbon dioxide emissions, heavy metals and other precipitates which are highly site, reservoir and time dependent. Users of liquid-dominated systems must contend with fluid disposal problems.

Recommendations

- The development of the priority sites identified in the Alaska Geothermal Implementation Plan should continue.
- The geothermal resources investigations included in the Division of Geological and Geophysical Surveys Capital Improvements Projects (CIP) five year plan should be supported.
- A five year exploratory drilling confirmation drilling program to compliment the CIP plan should be initiated.
- The State should discuss with the petroleum industry the development of information from drilling data that can be used to evaluate geothermal resource potential in areas of the State which have been subject to oil and gas exploration.

FIGURE IV-9
GEOTHERMAL RESOURCES OF ALASKA



Source: Selkregg, L.L., and others, ALASKA REGIONAL PROFILES, prepared for Federal-State Land Use Planning Commission, published by Artic Environmental Information Data Center, University of Alaska, 1976

Tidal Energy

Tidal Energy Description

In several of the coastal areas of Alaska, the tidal variations are of sufficient size to consider the construction and operation of energy facilities that use this variation to create a hydraulic head that can be used to produce electrical or mechanical power. The areas most discussed and considered in Alaska are the Turnagain and Knik Arm of the Cook Inlet, which have some of the largest tidal ranges in the world. It has been estimated that the power potential of the Cook Inlet is over 8,000 MWe. In addition, the tidal zones near Angoon in Southeast Alaska are also of sufficient variation to consider as a potential resource. Other areas have received little consideration as potential tidal energy sites.

Conversion Technology and Description

A tidal power system applies the same principal as a hydroelectric facility. The water is routed through a turbine to produce electricity. In a tidal power system, the dam is intended to block the flow of water generated by a change in tides. In the case of an increasing tide, the water is restricted from flowing into the land side until the difference in water height is sufficient to power the turbines as it is allowed to flow through to the lower side. As the tide recedes, the water stored on the inland side of the dam is held until the head once again reaches a height sufficient to produce power. In this case, the energy system can produce power from both directions of the tide. In addition, facilities utilizing two dam structures have been proposed to avoid the absence of power generation when the water levels are the same. The ability to use this resource efficiently and economically is dependent upon the height of the tide and the geographical conditions of the area.

Major Environmental Impacts From Tidal Energy

A tidal system will have impacts similar to those of a hydroelectric dam. The location of the dam on an open body of water will cause changes in the tidal conditions and sedimentation of a portion of that body and will impact the environment of the tidal zone.

State Actions

An electrical power study conducted for Angoon in 1980 found that tidal power was not competitive with other energy sources. Small scale tidal development appears to be expensive and limited in potential. However, the possibility of using the energy of tides is very site specific. The State is currently undertaking studies of tial power potential in Cook Inlet.

Other Ocean Energies

Ocean thermal or wave energy may someday be used by Alaska's coastal communities. Both technologies are in the development phase and are not likely to realize near-term application. It is in the best interest of the State to monitor developments in these energy options at present.

Recommendations

- No specific recommendations are made at this time pending completion of the ongoing Cook Inlet Tidal Power Study.

Hydrogen

Hydrogen, as fuel, has an advantage in energy development in that it can be produced from renewable resources and is flexible in its uses. Renewable resources, such as solar, wind or hydro which will not be depleted, can be used to produce hydrogen. Hydrogen production can also use non-renewable resources such as coal, gas and oil, which will eventually be depleted. Hydrogen, like oil, is flexible. It can be trucked, shipped, barged or piped to virtually any destination and stored indefinitely prior to use. Electricity is less flexible in that it is tied to the fixed distribution of the electrical system and is not readily stored in large quantities. Hydrogen gas could be piped to buildings in a manner similar to that of natural gas. Hydrogen in a hydride storage medium could be stored in cars and airplanes for use enroute.

Presently, there are four principal ways to produce hydrogen, two of which require non-renewable feedstocks such as oil, coal or natural gas, and two which involve electrolysis or water-splitting but no non-renewable feedstocks. If electricity or a high temperature heat source is available from a renewable resource, such as hydro, it is possible to produce hydrogen indefinitely. The hydrogen itself can be obtained from water. The end product from its combustion is water, which is environmentally acceptable in most circumstances.

The shift to a hydrogen fuel economy is thought to be a last step in a centuries-old energy transition: wood to coal, coal to oil and gas, oil and gas back to coal and other solid hydrocarbons, and finally to complete dependence on renewable energy sources. This is, a world-wide energy transition; Alaska may play but a small part in the technological development. However, Alaska may provide conventional hydrocarbons and hydropower used in the evolution of the hydrogen fuel economy.

Of particular interest in Alaska is the possibility of hydrogen-based rural communities in which windpower and even seasonal hydropower are the locally available renewable energy sources utilized. Optimistically and in the long term, each community could be energy self-sufficient by using hydrogen for heating, cooking, power generation and transportation.

As part of the tidal power study of Cook Inlet being conducted by Acres American, the generation and storage of hydrogen will be addressed. The Alaskan Division of Energy and Power Development recently initiated a hydrogen study. The next annual report of the Long-Term Energy Plan will include the results and recommendations of this effort.

Description of Hydrogen Technology

Hydrogen fuel can power automobiles, heat homes, run appliances and produce electricity. Since hydrogen usually occurs in chemical combination with other elements, it must be derived from these sources.

The following hydrogen production methods have been identified:

- Partial oxidation of relatively unreactive feedstocks such as residual fuel or coal, followed by a shift reaction with steam
- Steam recombination of light hydrocarbons such as natural gas or naphtha
- Electrolysis of water to produce oxygen and hydrogen.

Current State Actions

The current study by Alaska's Division of Energy and Power Development will comprise the following tasks: review state-of-the-art hydrogen use and research; evaluate Alaska's potential as a large hydrogen fuel producer and exporter; develop a community development plan; and estimate a demonstration project's design and costs.

Recommendations

- No specific recommendations will be made at this time pending completion of the hydrogen studies now underway.

Fuel Cells

Technical Description

A fuel cell resembles a battery in that chemical energy is converted into electrical energy. The fuel cell functions using an external fuel supply rather than energy stored internally. In a two-step chemical process, electrons are separated from fuel molecules and then recombined with the resulting molecules and oxygen to complete the circuit. The products of the simple hydrogen fuel cell are electricity, water and heat.

One advantage of the fuel cell is its ability to convert chemical energy to electrical energy in one step as compared to the multi-step (chemical to thermal to mechanical to electrical) process of thermal conversions. The fuel cell produces direct current, however, which must be converted to alternating current before use by utility systems or many electrical appliances.

The total fuel cell system comprises a fuel processor, the fuel cell itself and a power conditioner. The fuel processor converts hydrogen-rich fuel to a gas stream which the fuel cell then converts to electrical DC output. The power conditioner converts the output to alternating current.

The electrochemical reaction is independent of size. Consequently, the efficiency of conversion is independent of the system's total size (a one kW fuel cell is no less efficient than a one MW fuel cell). In fact, the systems will allow modular building of total output by linking a series of smaller cells. Also, the efficiency of conversion curve is nearly level over the rated load, meaning that the system can be cycled in its electrical output without affecting the conversion efficiency. If the heat generated by the fuel cell can also be utilized, the total fuel conversion efficiency can rach 80-90 percent.

Current Status

Fuel cells have been operated in the most demanding environments. In the National Aeronautics and Space Administration space program, they provided electricity and sometimes drinking water for the Gemini, Apollo and Space Shuttle projects. Since reliability was paramount in these projects, the systems were designed to run directly from hydrogen and oxygen and were consequently expensive for the energy produced. Since the mid-1960's, fuel cell development has emphasized commercial applications. Programs have been initiated by private industry, the gas and electric utilities and their research institutions, and the Federal government to demonstrate the commercial viability of various types and sizes of fuel cell. The work has centered on two fuel cell sizes — 40 kW and 4.5 MW.

A one MW pilot facility was constructed and tested in 1976-1977 by United Technologies Corporation. The follow-up to this project is the construction and operation of a 4.8 MW facility by Con Edison in urban New York City. An additional like facility has been ordered by a Tokyo electrical utility.

A series of 12.5 kW fuel cells were tested in conjunction with gas utilities in Canada, Japan and the United States. They were operated in home, apartments, offices, stores, restaurants and industrial settings.

Major Environmental Impacts

One advantage of the fuel cell is its minimal impact on the environment at the point of operation. Fuel cells are low in emissions; the potential pollutants are from the fuel processors or spillage from damaged fuel cells. The systems cause little noise, allowing their installation at sites where electrical power plants are presently unacceptable.

Potential Fuel Cell Development

The present design goals of Federal and commercial fuel cell programs are reduction of capital costs to $350/kW with a guaranteed stock cell endurance of 40,000 hours. A commercial lifetime of 20 years is anticipated for the system.

Technical feasibility has been demonstrated. Current operations of the 40 kW and 4.5 MW systems are intended to demonstrate commercial feasibility. Costs of initial production models will be above the $350/kW goal, but the goal should be met before introduction of 1500 MW units. This feature poses a developmental dilemna: The first models will not be cost competitive in themselves, but their purchase is necessary for the industry to get off the ground. An additional problem is created by the current requirement to use fossil fuels, as the fuel source.

Current research focuses upon fuel cells with high operating efficiencies and expansion of fuel types that can be used by the system itself. Fuel input depends upon the fuel processor, and as processors capable of producing hydrogen-rich gas streams from various fuels are developed, the flexibility of the fuel cell will be enhanced.

Fuel cells hold great promise for the Alaskan Bush, including better conformance to load demands, reduction of noise levels, increased fuel efficiency, and potential use of local energy resources. However, their commercial viability has not yet been demonstrated and testing in remote communities will be necessary.

Current State Actions

The Department of Transportation and Public Facilities (DOT/PF) is sponsoring a fuel cell demonstration. The unit is being used for electrical generation and space heating in a prototype modular school building. Also, DOT/PF is monitoring federal and industry programs underway elsewhere to determine Alaskan fuel cell applications. Particular emphasis is on the U.S. Department of Energy's 40 kW fuel cell demonstration program.

Recommendations

- Pending results of the DOT/PF fuel cell demonstration program, no Alaska specific recommendations will be made. Federal and private fuel cell developments should continue to be monitored.

Heat Pumps

Resource Description

Basically, a heat pump is a device that pumps heat from a relatively cool area to a relatively warmer area (which is against the natural flow of energy). A heat pump absorbs heat from the air outdoors and transfers it indoors.

Even cold air contains heat — cold simply means the absence of some of the heat available. For example, at 0°F, air contains about 90% of the heat available at 100°F. Heat is totally absent from air only at absolute zero (-460°F).

The heat pump works against the natural energy flow by using a refrigerant fluid phase change to move heat from a cooler area to a warmer one. To do this, the heat pump uses an outdoor coil containing a low pressure liquid refrigerant that is even cooler than the air. When a fan blows outdoor air across the coil the cooler refrigerant absorbs some heat from the air, boils, and turns to a vapor. The vapor is then pumped through a compressor where it becomes "superheated" due to the pressure.

Once superheated, the vapor is pumped through an indoor coil. Because the vapor temperature is now higher than room temperature it condenses and turns to a liquid. This change from vapor to liquid releases heat which is then used to heat the house.

The cycle is completed as the condensed liquid is pumped back outside to the coil. Enroute, it passes through an expansion valve which lowers the liquid's pressure so that it can boil more easily in the outdoor coil.

Heat pumps can cool as well as heat simply by reversing the operation.

Heat Pump Efficiency

The efficiency of a home heating system is measured by the number of units of heat energy output obtained for each unit of energy input. This is termed the Coefficient of Performance (COP).

$$\text{COP} = \frac{\text{Energy Delivered}}{\text{Electrical Energy Consumed}}$$

Heat pumps are quite efficient where the temperature difference between the source and the end use is low. Since heat pump performance drops with ambient temperature and heating demand increases as ambient temperature decreases, there is a "balance point" below which the heat pump capacity is not adequate to meet the heating demand. This is usually approximately 25°F to 35°F. At this point auxiliary heat must be supplied (usually electric resistance). To avoid using the more expensive resistive heat the balance point is kept as low as possible. Since the heat pump is sized to give a low balance point it has excess capacity much of the time. There becomes a mismatch between capacity and demand much of the time. This is especially critical in Alaska when considering the economics of a heat pump as an alternative heating source.

Energy and dollar savings with a heat pump depand on such factors as climate, price of local energy, and capital costs of the installed unit.

Factors Determining Whether a Heat Pump is an Economical Alternative

- Heat pumps are most economical when used year around for both heating and cooling.
- The efficiency of a heat pump varies significantly with the outdoor temperature.
- The initial cost of installing a heat pump system can be 15 to 30 percent higher than the cost of installing a conventional system.

Types of Electric Heat Pumps Available

"Air-to-air" which transfer heat from outside air to house air.

"Water-to-air" which exchanges heat with ground water, surface water or waste water and interior air.

"Ground-to-air" which uses heat stored in the ground and transfers it to the interior air.

In warmer climates than Alaska's, a heat pump can normally produce about two or more units of energy in the form of heat for every unit of electrical energy required in its operation. However, to be more accurate the efficiency of the source where the electricity is generated should also be considered and overall efficiency can then be expressed. This overall efficiency approach should also be used when referring to "100 percent efficient" electric heat (Hilpert, 1981). (This does not necessarily apply to hydroelectric based energy.)

Alaskan Application

The Alaska Power Administration, in cooperation with Alaska Light and Power and Glacier Highway Electric Association, has funded a heat pump demonstration study in the Juneau area. (Alaska Power Administration, 1980) Initial reports indicate that heat pumps could be economically viable in Juneau when using the hydroelectric energy sources available in that region as compared to electric resistance heat and oil.

By November 1980, eight heat pumps had been installed in Juneau as part of the program and were being monitored. Average installation costs were reported to be $7,000 in existing homes and $5,600 in new homes. The average system operating cost for all systems was $1.74, $1.65 and $2.63 per day for January, February and March, 1980. (Alaska Power Administration, 1980).

In Fairbanks the Federal Building uses a heat pump and provides both heating and cooling of the office area. After some fine tuning it appears to be operating satisfactorily although no energy savings data is available.

Mike Crawford of Ellerbe Engineering has suggested that heat pump application in Alaska is probably limited to structures with high internal heat loads that require both heating and cooling such as office buildings and hospitals, shopping areas, and computer rooms.

Recommendations

- An assessment of the potential use of heat pumps in Alaska should be initiated. Included should be a determination of fuel savings and cost-benefit analysis of the heat pump versus traditional heating sources projected to the year 2000.
- Progress of existing heat pump demonstration projects in Juneau and Ketchikan should be monitored.

Waste Heat Recovery from Small Diesel Generators

This section is applicable to the existing diesel generators which range in size up to 500 kW single units and higher capacity where multiple units are located. The subsection "Waste Heat in Alaska" relates this generic description to application in the Alaskan Bush.

The amount of heat that is recoverable from existing units is dependent upon size, manufacture, age, operating mode, outside air temperature and fuel used. All of the factors can be readily evaluated for each specific location. For purposes of this report, a conservative waste heat available factor will be used which can be applied to almost all existing diesel generating plants.

At 100 percent of rated load, it will be assumed that 30 percent of the heat content of the input fuel is exhausted at temperatures in the 600°F to 900°F range and another 30 percent is extracted in the cooling water at 180°F to 200°F. Data from representative installations shows the actual waste heat to be 3 to 10 percent greater than these numbers.

Amount of Waste Heat Available

A village with 300 kW diesel generator may have a $100,000 annual fuel bill. Approximately 30 percent of this is available as low temperature (180°F to 200°F) heat from the cooling water. Up to $30,000 worth of waste is available to be utilized for space heating. Another $30,000 worth of energy is available at 600°F to 900°F from the exhaust. Generally, 50 to 60 percent of this energy is easy and economical to capture. The remaining energy requires much more equipment and engineering analysis to be assured of satisfactory utilization. Existing technology is available for this use, however it is very site specific.

Technical Description of Use Technologies

Low-Mass Non-Metallic Heat Exchangers for Diesel Exhausts. An example of recent developments is a non-metallic heat exchanger material which has been used in high temperature turbines and other high temperature speciality applications. In 1978, the U.S. Department of Energy contracted with a number of firms to develop high temperature heat exchangers for manufacturing firms which had waste heat between 1000°F and 1500°F. One result was a non-metallic modular heat exchanger which was less costly than existing units for temperatures as low as 600°F. Being non-metallic, rust and corrosion is not a problem. These units are now in commercial production and could be applied to exhausts on diesels at much less capital cost than metal units. Life expectancy for this application is over 10 years and probably as much as 20 years.

All of the surfaces exposed to hot temperatures on these units are made of ceramic materials. They are so resistant to thermal shock, that a blast of cold air may be used to blow dust off of the surfaces. Hundreds of these units are in industrial service. Many installations have exhaust temperatures over 1000°F. This technology is well-proven and can be adapted to diesel exhaust without further development.

Large-Mass Non-Metallic Heat Exchangers for Diesel Exhausts. This is a non-metallic unit which was designed for incineration and heat recovery of solvent type materials diluted in large amounts of hot gases (air). It has a higher capital cost. This higher cost may be offset by its large thermal mass, simplicity of operation, long life and ability to handle both the cooling water and exhaust gas waste heat. This unit should be able to extract exhaust gas heat down to about 200°F. Its large thermal mass would help keep a more uniform source of heat during low duty cycles of the diesel engine. This unit also would act as a very efficient noise suppressor which would allow the engine to be located much closer to occupied buildings.

Like the low-mass units, all exposed surfaces of these units are made of easily fabricated ceramics materials. Many large-size units have been in industrial operation for a number of years. The first units were installed prior to 1974. In these applications, they are recovering waste heat from temperatures in excess of 1000°F. The only parameter that needs additional evaluation is pressure drop through the units. Existing data shows a pressure drop that is acceptable for diesel exhausts.

Heat Pipe Diesel Exhaust Heat Recovery. For locations where the exhaust waste heat can be utilized within a few hundred feet, the heat pipe or frost tubes may be the most economical. Again, earlier reports have assumed a premanufactured unit built to aerospace specifications. In 1978, an economic analysis was made comparing "build your own" type heat pipes to other methods of utilizing waste heat from ovens with 450°F exhaust temperatures. At that time, for up to 500 feet, the heat pipe was the most economical. This analysis was based on a discussion with one of the major suppliers of the Alaska frost tubes.

For specific applications such as the Trans Alaska Pipeline, heat pipes are well proven. A number of firms make short, coupled (a few feet) heat pipe heat exchangers for temperature up to 1000°F. Some of these have been in industrial use since 1974.

Further engineering analysis of specific site requirements are necessary to verify the usefulness of heat pipes for this application. The internal operational charactistics would be the same as existing installations. Therefore, no additional development is required.

Conventional Steam or Hot Water Recovery. Where larger amounts of waste heat are available and steam can be economically utilized, waste heat boilers along with some of the other low temperature, heat recovery devices, may be the most economical approach. Recent developments have significantly reduced the cost and size of heat recovery boilers, some of which are designed specifically for diesel engines. These improvements and new designs have also greatly increased their reliability and ease of operation.

Modern design waste heat boilers have been utilized on large diesel and combustion turbines for many years. They are very reliable and require no more maintenance and operational attention than low pressure hot water boilers. Site specific engineering analysis is required to determine the economics of such installations.

Increased Electrical Generation by Waste Heat Recovery. Organic fluid Rankine Cycle (ORC) systems are now available as package systems. They require more maintenance due to the required controls than diesel generators. They are reliable enough for any applications. These systems would be used where existing waste heat is available or in conjunction with diesel, combustion turbine or steam boilers. An ORC unit will add about 10 percent additional energy electrical output to each of these prime energy converters.

ORC units are available as skid-mounted complete packages. They have been installed in many locations, including some on diesel exhausts. However, all of these installations have been where skilled maintenance personnel are available if required. One manufacturer claims to have units in operation at remote communication sites. Information from such installation would verify ease of operation for diesel exhaust heat recovery at remote Alaskan villages.

Costs

All six of the above-described technologies are site specific. Installation, operating and maintenance costs can only be determined by a site specific design. After a design was completed for one or two sites, it would be easy to estimate within 20 percent the cost for most other sites.

Major Environmental Impact

Each of the evaluated technologies reduce waste heat now being exhausted to the environment. None of them add any particulate or other chemicals to the environment under normal operating conditions. The heat pipes, waste heat boilers and ORC all are closed loop-type where none of the working fluids are intended to be released. All of the fluids are in common use. As far as is known, they all readily meet or can be easily contained to meet existing environmental requirements.

In all of the above cases, improvements in reduced noise levels would be experienced.

Major Health and Safety Considerations

None of the described technologies should add any safety or health problems which would be as significant as those associated with the operation of the existing diesels.

Major Social or Operational Considerations

Only the waste heat boiler and ORC technologies would add significantly to the amount or type of existing operational and maintenance requirements. Anyone who can perform the day-to-day operations on a diesel can easily be trained to perform the same functions on a waste-heat boiler. More analysis is required to determine if ORC units can be operated by local personnel.

Efficient use of waste heat for space heating requires proximity to the heat source. Its utilization is therefore dependent, in part, on attitudes about the location of housing units and other buildings.

Waste Heat in Alaska

Because of small size, remote location, limited transportation, and lack of viable alternatives, many communities in Alaska are dependent on diesel engines as the prime mover for their electrical generation. For essentially these same reasons, petroleum fuel prices in these communities far exceed the national average. Consequently, it has been recognized for some time that in Alaska, waste heat capture and use offers the most immediate, practical and, in many cases, only response to the escalating cost and forecast shortage of petroleum fuel.

In June 1978, a document, *Waste Heat Capture Study,* was prepared by R. W. Retherford Associates, for the Division of Energy and Power Development. The study examined the "state-of-the-art," the hardware, the engineering considerations and the economics of waste heat.

For economic reasons, most of the smaller diesel electric power plants in the State are unmanned. An operator usually makes only short inspection visits on a daily basis. Generally, he is qualified and paid to perform only minor maintenance chores. This means that waste heat capture equipment must be simple enough to conform to the operating mode of the existing facility. For these reasons, and because exhaust heat exchangers must be cleaned frequently, and also because most engine manufacturers recommend rather narrow limitations on exhaust temperatures and pressures, most applications in Alaska are limited to capturing waste heat only from the jacket water system. Indeed, most Alaskan dealers offer a diesel generator package with heat exchanger and valving factory installed in the cooling system for a very modest cost increase over a conventional unit. However, few fuel exhaust heat exchangers are installed.

The temperature of the heat from a diesel engine's cooling system and, to a lesser degree, from the exhaust system, is of relatively low temperature. Within practical economic considerations, this fact limits the heat transfer efficiency as well as uses for the heat from a waste heat application. Some process preheating is sometimes practical, but mostly the heat is used for space heating for human comfort. The low temperatures also mean that large amounts of transporting medium must be used to effect much heat transfer. Since the usual transporting medium is water, or a glycol solution, large piping and pumping systems must be employed. Therefore, economics usually dictates that the heat load be fairly close to the source.

Because of the noise, power plants were normally relegated to the outskirts of the community. This meant that the power plant was also remote from most potential users of waste heat. Consequently, the economics of retrofitting existing power plants for waste heat capture and use is seldom attractive. In some instances, it appears cheaper to move the power plant. In most cases where proximity to a heat load makes it appear attractive, it is either accomplished, under construction or under study.

In the planning of new facilities, along with the stimuli of improved exhaust silencers and the higher cost of fuel, consideration is given to concentrating industrial or commercial facilities to improve the feasibility of waste heat capture and use. Fire safety, usage and ownership considerations often dictate separate buildings. But locating them close together when such options exist is done frequently. Waste heat from whatever source, is still considered a resource in Alaska and its capture and use is and will continue to be promoted.

Recommendations

- Where economically justified, the inclusion of the evaluation of waste heat use potential in facility siting criteria and procedures for State-financed building projects should be mandated.

- Inclusion of a waste heat recovery retrofit capability for State-financed thermal power projects (including village scale diesel generators) should be considered.

- An education program for village and community leaders relating to the opportunities and problems associated with waste heat recovery for new and existing diesel electric plants should be instituted.
- Research and demonstration of waste heat recovery systems, such as the Organic Rankine Cycle System (ORCS) should be continued.

Energy Storage Systems

An energy storage system is a means to store energy produced by a conversion process for use at a later date. In a broad sense, oil is an energy storage system, storing the energy from living systems in underground reservoirs until tapped by man. A battery is the most common form of energy storage. The energy is stored chemically and when used is converted into electrical energy.

In the development of intermittent energy resources such as those from the sun or the wind, the use of energy storage has taken on a greater meaning. Since the energy resource may not be available when it is needed, or may not be of the right quantity to be useful to the community or industry, an energy storage system allows one to reduce variations and to use the energy as it is demanded rather than as it is produced.

In the case of wind energy systems, many of the current models utilize batteries to store excess energy in times of heavy winds and then pull the energy directly from the batteries when the wind is insufficient to meet the demands of the user.

Energy availability fluctuates not only hourly and daily, but also on a seasonal basis. The improvement of seasonal storage will be especially important in Alaska, where both climatic conditions and consumption patterns vary widely over the year. TRW is currently studying the feasibility of storing waste heat in an aquifer below Bethel.

Other forms of energy storage includes flywheels, where the energy is stored by the spinning of wheels with a high velocity and the energy can be extracted by the use of the wheel to spin and electrical generator or mechanical device. Pumped water is another type, where excess electricity from a hydroelectric facility is used to pump water to a storage site where it is run through turbines when required. Eutectic salts are a salt/fluid combination that can store excess thermal energy that can then be used to run thermal engines or heat home or buildings.

The following energy storage systems are in use or under consideration today:

- Pumped hydro storage
- Production and storage of hydrogen
- Rocks and other high thermal mass systems
- Flywheels
- Electric batteries
- Compressed air in containers or subsurface geologic formations
- Thermal heating of subsurface water systems
- Thermal heating of oils or salt mixtures

Because of the limitations on this first energy plan, a detailed review of energy storage systems was not conducted. This will be an element of the next energy plan. As the state moves to deploy wind and photovoltaic systems and expand its hydroelectric systems, the use of energy storage to guarantee the usefulness of the energy and the development and operation of energy storage systems that will complement energy production become more important.

Recommendations

- A detailed status report on energy storage systems now available and under development should be prepared. Included should be analyses and recommendations pertaining to which technologies and applications should be emphasized in Alaska. Special attention should be given to seasonal storage.

FIGURE IV-8
ENERGY PROJECTS UNDERWAY

Peat

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
Rural Alaska Peat Farm	The demonstration of the harvesting and use of peat as a fuel resource for space heating in rural areas	Statewide	DEPD	Peat

Biomass

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
AVEC Wood Gasification Demonstration Project	Phase I has developed a wood and coal gasifier that can be used with diesel generators. Phase II will conduct testing in Anchorage area (Nulato will be site of rural testing).	Statewide	DEPD/AVEC	Gas to power diesel generators
Delta Agriculture Project Biomass Assessment Study	Assessment identified potential energy uses of biomass from land clearance.	Interior	DEPD	87-100 tons per year processed fuel pellets 13.2-15.8 MW electrical potential. 10-12 million gallons/year methanol
Interior Wood Assessment Study	Contract has been awarded	Interior	DEPD	Unknown
Hoonah Wood-Fueled Generation Project	Feasibility assessment	Southeast	APA	2.7MW
Noatak School Wood-fired Boiler Project	System design underway	Northwest	APA	Space Heating
Feasibility of using Gasohol and Alcohol Fuels in Alaska	Determine potential use problems by field testing in DOTPF vehicles	Statewide	DOT/PF	Transportation

Solar Energy

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
State Solar Planning	Continuing solar planning activities and State participating in Western Sun.	Statewide	DEPD	N/A
Prototype of Passive Solar Alaskan School Design Manual Development	Design of a modular school building that will incorporate solar heating and the preparation of a manual for use in new design and retrofit of school buildings.	Statewide	DOT/PF	Space Heating
Solar Heated Fire Station Demonstration Project	The design and construction of solar assisted buildings that will serve as garages for fire fighting equipment.	Interior	DOT/PF, Chena Goldstream Volunteer Fire Department.	Space Heating

Wind

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
Rockwell Wind Energy Program	Demonstration of two small wind energy systems in Alaska	Northwest/ Southcentral	DEPD/USDOE	2.2kW:Kotzebue. 18kW: Homer
Kotzebue Wind Project	Wind system intertied into community college	Northwest	DEPD/Chukchi Community College	2kW
Alaska Wind Demonstration Wind Monitoring and Supplemental Budget	This project is proposed to support the current wind energy demonstration projects in the state by providing data on results and information on equipment operation.	Statewide	DEPD	N/A
Homer Wind Project	Move the current wind machine in Homer to a permanent site.	Southcentral	Alaska Energy Center	Electricity
Line Village: Wind Regime Analysis	Wind insufficient for use. Photovoltaic cell use for refrigeration is under construction (Lime Village Region?)	Southwest	DEPD	Electricity
Nelson Lagoon Wind Demonstration Project	Feasibility of grid demonstrated. System encountered difficulties.	Southwest	DEPD/USDOE	18kW
Wind Anemometer Loan Program	Provides 30 anemometers on loan to citizens of the state.	Statewide	DEPD	N/A
Newhalen Wind Demonstration Project	Wind generator was constructed for use in providing use for community laundry (facility is down for repair).	Southwest	DEPD/USPHS	8kW
Sheldons Point Wind Demonstration Project	Prototype to be tested 12/80. If successful, wind farm to be erected spring '81 with a max of 13 systems.	Southwest	DEPD	1.8kW/each
Wind Power Demonstration (Skagway)	Find and install vertical axis machine, intertie into existing electrical system.	Southeast	APA/DEPD/ City of Skagway	N/A
Unalakleet Wind Demonstration Project	Install Wind Machine Summer of 1981.	Northwest	APA/DEPD/ Unalakleet Valley Electric	20-40kW

Geothermal

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
Alaska Geothermal Development Plan-1979	Determined 15 sites with greatest geothermal potential.	Statewide	DEPD/OIT/ U.S.D.E.	N/A
Geothermal Commercialization Grant	Three sites will be selected by the contractor for commercial analysis	Statewide	DEPD	Geothermal heat
Kotzebue Geothermal Study	Heat resource determined to be insufficient for direct use, may be used as a pre-heater for other district heating techniques.	Northwest	DEPD/APA	Geothermal Water
Tenakee Springs Geothermal Study	Core drilling to confirm geothermal resource will take place.	Southeast	DEPD	Geothermal Water
Pilgrim Hot Springs Geothermal Study	1979 drilling results indicate potential for direct use.	Northwest	DEPD	Hot Water 300kW
Dutch Harbor-Unalaska Geothermal Project	Determine extent of geothermal resource on the island.	Southwest	APA/DEPD	Hot water Steam

Tidal

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
Angoon Tidal Power Alternative Study	Tidal resource determined not to be commpetitive with other resources.	Southeast	APA	Unknown
Cook Inlet Tidal Study	To determine the technical and economic feasibility of the construction and operation of tidal energy facilities in the Cook Inlet.	Southcentral	Office of the Governor/APA/ DEPD/DPDP	Unknown

Waste Heat

Resource/ Project	Purpose/ Comments	Region	Responsible Agency	Capacity or Fuel Type
Waste Heat Organic Rankine Cycle (ORC) Electrical Generator Demonstration Project	To demonstrate use of low temperature fluids to increase efficiency of electrical generation by diesel from waste heat, or geothermal. A demonstration is underway at Manley Hot Springs.	Interior	DEPD/ University of Alaska	2.5kW, (300kW proposed Pilgrim Hot Springs)
Waste Heat for Agriculture Feasibility Study (proposed)	To develop demonstration projects to establish the feasibility of economic waste heat capture systems for agricultural uses.	Northwest/ Interior	DEPD	N/A
Golden Valley Waste Heat Recovery Project	Use of waste heat from the Trans-Alaska Pipeline to produce electricity	Interior	DEPD/ Golden Valley Electrical Cooperative/ Alyeska	to be determined
Nushagak Waste Heat Recovery Project	The Nushagak Electric Cooperative will construct and operate waste heat recovery equipment on diesel generators (Dillingham).	Southwest	APA/Nushagak Electric Cooperative	N/A
Rural Waste Heat Demonstration Project	Design for several waste heat demonstration projects is underway.	Statewide	APA	to be determined
Fairbanks District Heat Study	Feasibility study underway	Interior	APA/Fairbanks	Space Heating

CHAPTER V

Energy Conservation

Introduction

Energy conservation, as defined in *Energy: The Next Twenty Years,* means "those energy-saving investments, operating decisions, and changes in the goods and services that we buy and use that save money over the life of energy-consuming products. Money can be saved by substituting intelligence, prudence, maintenance, better equipment, or different equipment for purchased energy; the substitution should be made up to the point where the cost of not using the energy is equal to the cost of the energy saved.''

Conservation of energy does not require curtailment of activities or degradation of the quality of lifestyle. Although in the past conservation has been negatively associated with "belt tightening," the evolving view of energy conservation as a "source" of energy is more positive. This view can be characterized as "leak plugging" and does not require individual sacrifice or degradation of lifestyle. Although energy conservation is often less expensive to implement than conventional and alternative energy sources, it sometimes still requires a significant initial investment in order to bring economic returns.

Energy conservation, then, means doing better with what we have by increasing the efficiency of energy and use. Even with Alaska's vast renewable energy development potential, conservation, particularly of petroleum derived products, could prove economically effective.

Alaska's Energy Conservation Potential

The potential to conserve energy in Alaska is great. Projected energy demand in the State, including the Railbelt, in the year 2005 is 522.5×10^{22} Btus. In Oregon, solar and conservation programs have the capability to produce an estimated 31 percent reduction in the residential energy use and a 37 percent reduction in industrial energy use by the year 2000. A preliminary analysis by the Alaska Power Administration indicates that an estimated 27 percent reduction in heating fuel consumption could be achieved for five of the largest communities in the Southeast through a building thermal efficiency upgrading program and conversion to electric heating systems. The increased electrical load requirements resulting from that conversion would be met through existing and proposed near-term hydro projects in the Southeast.

Energy in Transition, 1985-2010, recently published by the National Research Council, suggests that it may be possible to halve the energy requirement per passenger or ton-mile in the United States over the next 25-35 years. In Alaska, energy conservation activities in the transportation sector are almost non-existent. Yet, transportation represents almost 40 percent of the total energy consumed.

Energy end-use consumption figures for Alaska as a whole show that transportation, industry, and manufacturing account for 69 percent of the total energy consumed in the State. Residential use was the next largest category, while commercial and marine operations and national defense consumed the remainder. Significant differences also exist between the Railbelt and Alaska as a whole. In non-Railbelt Alaska, nearly one-half of all end-use energy is consumed in transportation and less than 10 percent is used for industry and manufacturing.

Railbelt and non-Railbelt Alaska also consume different kinds of fuels and exhibit different end-use consumption patterns. In Alaska as a whole, petroleum products represent just over one-half of total consumption, followed by natural gas which accounts for over a third. In non-Railbelt Alaska, petroleum products account for 87 percent of the end-use consumption and natural gas only 2 percent. The unavailability of natural gas in non-Railbelt Alaska is a major reason for these stark differences. In addition, much of the electricity consumed in much of Alaska is generated from petroleum products, giving more evidence that liquid petroleum dominates the energy economy of non-Railbelt Alaska.

Observations drawn from this end-use energy profile of Alaska and non-Railbelt Alaska can provide direction for the development of energy conservation programs. The first and most important observation is that non-Railbelt Alaska is almost totally dependent on liquid petroleum fuels. Transporting the fuels into these remote areas adds expense to the already high initial purchase price. A second observation is that relatively large amounts of these fuels are used for transportation and relatively small amounts are used by industry and manufacturing in non-Railbelt Alaska. The information on end-use energy consumption suggests that in order to obtain significant savings, State energy conservation programs in non-Railbelt Alaska should be directed at liquid petroleum use — primarily in transportation, residential and commercial buildings. Since each of the remaining sectors uses 10 percent or less of total end-use energy consumed, conservation programs are not likely to result in large relative savings.

Alaska can look to the Lower Forty-Eight to find examples of ways to reduce petroleum consumption in transportation, residential and commercial energy use.

Energy Conservation Initiatives

Generally, energy conservation programs throughout the nation have concentrated on energy education through public schools, conferences, seminars, workshops, demonstration workshops, public media and speechmaking activities, and public meetings and hearings. The expectation has been that increased knowledge would lead to voluntary conservation. The few mandates initiated have been limited to thermal and lighting efficiency standards for new construction, energy audits for State owned and operated buildings, energy efficient purchasing requirements for state agencies, and other primarily federally imposed actions. Legislatures and state executives have encouraged the passage of incentives such as tax credits, grants, utility sponsored energy audits and no-interest loans for weatherization, but have been less interested in coupling incentive with disincentives. Disincentives might include higher automobile registration fees for energy inefficient automobiles and trucks, higher parking fees for one-person parking in state-owned garages and in municipal and city parking areas, and higher mortgage rates or property taxes for energy inefficient homes and commercial buildings.

As an example of such a coupling, the setting of lighting and thermal efficiency standards is a most important energy conservation measure. When combined with builder, realtor, banker and consumer education, and penalties for non-compliance, the standards are realistically achievable.

In the regulatory arena, few utility commissions had initiated conservation rates and/or programs prior to the passage of the Public Utilities Regulatory Policy Act of 1978. Even now, as the commissions review the applicability of conservation actions for their regulated utility companies, traditional rate-making strategies, rewarding consumption rather than conservation, are the norm.

Increased energy efficiency is in large part a result of economic pressure. If an individual, business, or government agency finds it less expensive to save energy and complete the same task, energy conservation becomes a clear winner. Opportunities for energy conservation are many, but significant savings will primarily be made when the impacts are financial.

With this in mind, it is useful to briefly examine some effective energy conservation programs which have been directed at the financial side of consumption. Rather than list all possible programs which have been initiated throughout the country, a few are described and the reader is encouraged to refer to the bibliography for additional sources of information.

As stated, short-term opportunities for significant energy savings rest in financially motivated programs. For example, the Oregon Alternative Energy Development Commission estimates saving of 50 percent in space and water heating use in new homes built between now and the year 2000 through passage and implementation of residential efficiency standards in Oregon. Such savings estimates have been duplicated in many states, although passage of such standards has only been accomplished in 13 states. A recent *Wall Street Journal* article states that in a survey of 5,000 home buyers, almost 80 percent of the respondents cited energy efficiency as the most important consideration in choosing a new home. Customers are also apparently willing to pay more for that energy efficiency. More than 93 percent of the buyers said they'd be "very willing" or "somewhat willing" to pay $500 for extra insulation, and 84.5 percent said they'd be very, or somewhat willing, to pay between $1,200 and $1,500 for storm or thermal-pane windows.

A small number of financial institutions in the nation provide lower-interest financing for energy efficient homes. This incentive helps the institution to attract new customers and is also an incentive for new home purchasers to consider energy efficiency.

The State of Massachusetts early in 1977 established thermal efficiency standards for new residential and commercial buildings. These standards have been a model for developing the national building energy performance standards. The State of Idaho created a local option thermal efficiency code and focused attention on statewide training for mandatory implementation in communities opting for compliance. Some states have created gubernatorial boards for the development of standards and then offered continuing education credits in evening courses for building inspectors and others who needed to learn the mechanics of compliance.

Reform of the nation's utility pricing practices has been a subject of hot debate for a number of years. Until the passage of PURPA (Public Utilities Regulatory Policies Act of 1978), public utility regulatory commissions were able to literally control energy consumption through the rate design and charges developed for their regulated utilities. Few commissions realized the economic realities of scarce resources and consumption/prices impacts. PURPA and gradual change in current thinking among regulatory commissioners and staff have begun to reform outdated policies. States such as Idaho have followed the lead of states such as New York, California, Oregon and Illinois in flattening energy rates, utilizing marginal cost pricing, time of use rates, and competitive rates for cogenerated or small power production. There is no question that the long-held interest in keeping prices down for consumers has only served to make more harsh the real world when it has come time for reform. In the long-term, higher costs, in cooperation with conservation-related rate design, will serve to reduce energy consumption on a per capita basis, although obviously total energy costs will surely increase.

Incentives and, less frequently, disincentives, have been used to combat energy consumption in nearly every state of the nation. Most states have enacted tax credits, rebates, loans, grants, subsidies and other financial incentives to encourage energy conserving practices in homes, businesses and industries. The State of Oregon led the way in the Pacific Northwest with state weatherization loans by regulated utilities for single family dwellings. Other states have quickly followed suit.

In 1980, the State of Alaska developed and legislatively approved the passage of one of this country's more ambitious energy conservation acts. Among the provisions of Senate Bill 438 are:

- Establishment of thermal and lighting efficiency standards for both residential and commercial buildings, as well as for State owned and operated buildings.
- Establishment of a tax credit available to businesses who purchase and install energy conserving equipment or materials.
- Establishment of a statewide energy audit program, including auditor training and testing, provision of subsidized energy audits and informational materials for participants, and grants and loans for energy conservation improvements in audited homes
- Provision of matching grants for the federally-funded Appropriate Technology Small Grants program.
- Provision of financial assistance for rural educational facilities for energy conservation planning, and matching grants for federally funded energy conservation technical assistance and retrofit action by schools, hospitals and units of local government.
- Funding for educational programs, directed at interested citizens as well as enrolled students in classrooms throughout the state.

There are numerous other programs provided for in this legislation which all add up to a significant State commitment to energy efficiency.

Long-term understanding of energy resource development, conservation, and economics will come by way of education. Many states have worked almost exclusively with education, prefering to inform, persuade, and otherwise alter the thinking of citizens in regard to energy conservation. Every such State has been able to point to successes and failures. Every such State has examined the opportunities for educating children from pre-school to post-graduate age; for educating adults in the policy and technical aspects of conservation; and for educating lawmakers and policy-makers at all levels in the policy changes which must be made to pave the way for conservation action.

Innovative programs have been developed from coast to coast. They include workshops for county and city officials in Massachusetts on energy efficient street lighting and other government actions for conservation; questionnaires and resulting education seminars for state legislators in Oregon and Idaho; boiler efficiency and maintenance workshops for industrial consumers in California; tractor efficiency workshops for farmers in Idaho; library information packets, puppet shows, magic shows, reading programs and community resource materials for libraries in Idaho.

Actual energy saving estimates from these educational efforts are scanty. They are very difficult to project and therefore the usefulness of energy education has been called questionable at best. However, if education and information programs are utilized in conjunction with strong state policies and legislative and regulatory action, the educational programs have more impact and can be justified in terms of actual Btus saved.

Barriers to Energy Conservation

Barriers to energy conservation exist in the form of

- A lack of incentives for the efficient use of energy.
- High initial capital costs for certain conservation improvements.
- Limited access to information and technical assistance.
- Lack of consumer and lender confidence in energy conservation products.
- Bias of educators, engineers and others toward conventional energy supplies, and prejudice against conservation.

These barriers to energy conservation are not technical but political and institutional. Therefore, they are sometimes difficult to correct. In Alaska, as in many other states, problems of weather, distance, transportation and incorrect price signals serve to make conservation a difficult energy resource to tap. Nevertheless, difficulties in implementing conservation programs have rested on political and institutional inertia and traditional attitudes, lack of local resources, bureaucratic disincentives for energy efficient purchasing, utility pricing policies, and laws prohibiting cogeneration and small power production sales at equitable rates to utilities and other consumers.

One major barrier to effective energy conservation in Anchorage and its environs is the cost of natural gas. Since electricity and natural gas are relatively cheap, the incentive to be more energy efficient is not as high as in other regions. In the Bush, diesel fuel costs are so high that State policy reflects a desire to keep prices as low as possible. Two examples of this are the Power Production Assistance and the Bulk Storage Grant Programs. Although not verified, it has been argued that these actions may serve as disincentives to energy conservation. Energy conservation is an energy policy which may not by itself keep prices low, but which makes each Btu go farther, cutting total fuel needs and total fuel bills. Energy conservation is one of the near and mid-term actions which would help the State achieve its long-term goal of energy self-sufficiency.

A second, and perhaps more significant, problem facing energy conservation in Alaska is the lack of realistic dollar resources and levels of staffing committed by the State for adequate planning, implementation, monitoring and evaluation of conservation programs. Too much is expected too quickly from the small amounts of staff and financial resources to do a job competently. An example is the disappointing results from the federally-funded State Energy Conservation Program.

Energy Conservation in Alaska

Energy Conservation Technology

New and developing technologies for energy efficiency are among the fastest growing in the United States today. Home insulation materials, heating and air conditioning systems, appliance efficiency improvements, new building materials and lighting technology, recycling and cogeneration and waste heat opportunities, automobile efficiency improvements, industrial process modifications and agricultural efficiency improvements are all examples of ways that increasing prices have caused the evolution of energy conservation technology. Much of the research and development on these technologies, as well as their demonstration in "pilot" situations, is being conducted by federal agencies in nationally selected research programs. Others are being tried by private individuals and organizations who are putting their ingenuity to work.

Opportunities for using new energy conservation technologies in buildings, transportation and energy producing industries exist in Alaska.

Energy consumption in the residential and commercial sectors with significant energy use in buildings was 34,877 $\times$ 10^9 Btus or 20.2 percent of the total consumed in 1979. Energy use in the transportation sector was 38.2 percent or 80,605 $\times$ 10^9 Btus. In the industrial and energy-producing sector, it was 65,052 $\times$ 10^9 Btus or 30.8 percent. The technology to improve efficiency and reduce energy costs is available today.

For instance, in the residential sector, energy conscious building standards have been developed by the U.S. Department of Housing and Urban Development (HUD), and by numerous state and local governments. Requirements for improved insulation, greater use of double and triple paned windows, caulking and weatherstripping, 2 $\times$ 6 stud construction, passive solar site selection, water conserving showers and kitchen appliances, and downsized heating plants, have all been studied and in many communities incorporated into building requirements.

The State of Oregon has concluded that improved building standards, using these and other technologies, could create a 50 percent savings in space heating energy use and a 50 percent savings in water heating use for all new homes in Oregon built between 1980 and the year 2000. The result would save enough energy to heat 295,000 Oregon homes in the year 2000. These savings estimates have been similarly reported throughout the United States. Further, a report issued in 1975 by the A. D. Little Company found that improved use of energy conservation technology in residential buildings would not increase housing costs.

Energy Conservation Strategies

The manner in which public and private organizations encourage and assist the application of energy conservation remains a subject of disagreement among many. Classic struggles still exist between those who advocate complete removal of all price controls as a method of achieving conservation and those who advocate keeping a lid on prices while providing incentives and supply restrictions to encourage conservation. The current "anti-government" tenor throughout the United States today creates a challenge among policy makers at all levels as to the most equitable and judicious way to encourage conservation actions.

Nearly all energy conservation strategies may be classed as one of five broad strategies. Each strategy is distinctive in its conception and in many of its specific impacts. The strategies are:

- **Price Strategies.** These strategies cut energy consumption by relying on consumer reaction to higher prices, either for petroleum products or for all forms of energy. The benefits of price strategies are obvious — higher prices normally reduce consumption. Residential consumers may not be able to just ''stop buying'' energy when they need to keep warm. Commercial and industrial customers may continue buying energy at the higher price, but pass on these costs to their customers.

- **Supply Restriction/Allocation Strategies.** These strategies involve restricting energy supply to a fixed level, then using some non-market allocation or rationing scheme to distribute this limited supply among competing uses and users. Examples include import quotas for foreign oil, with the shortfall allocated by gasoline rationing.
- **Regulatory Strategies.** These strategies place constraints on how energy can be used, outlawing those uses or technologies thought by lawmakers to be most wasteful. Examples in Alaska include the thermal efficiency standards for new buildings included in SB 438, as well as the requirements for energy efficient buildings as a precondition for State-backed home and commercial building loans. Regulatory strategies are often seen as negative, although they can be viewed as minimal standards of policy for the State — a positive action. Regulatory strategies involve monitoring and penalties for noncompliance, which is difficult in Alaska, not only because of travel and communications difficulties but also because of the natural resistance to regulatory constraints. Impacts on the economy, society, and energy use must be carefully evaluated when considering regulatory strategies, for they have the potential to be inflationary (requiring consumers to buy more well-insulated homes), difficult to revoke (container deposit laws); and/or inconvenient or uncomfortable (limits on automobile size). size).
- **Incentive Strategies.** These strategies give incentives, usually monetary, for energy saving forms of production or consumption. Alternatively, disincentives (taxes) are used to discourage specific kinds of energy waste. Examples of incentives include tax rebates for purchasing and installing home insulation, special discounts on products that are energy efficient, and subsidization of energy conservation improvements in commercial and residential buildings. Examples of disincentives include taxes or higher prices on urban parking spaces, and higher interest rates on energy inefficient homes. Incentives and disincentives have been found to be most effective when coordinated with price strategies to impact consumer consumption habits.
- **Information Strategies.** These strategies attempt to change consumer habits of energy use either by exhorting them to change their lifestyles or by pointing out economic and other advantages of particular energy saving practices and furnishing "how to" information. Government can urge, warn, and admonish consumers to save energy. Government and private industry can set examples for the public by adopting energy saving programs for their own operations. Information programs are relatively inexpensive to administer and easily reversible. They provide direct service to recipients and enhance the operation of other strategies. Problems often associated with information strategies include generalized goals and objectives and difficulties in measuring results.

Each of these strategies have their proponents and each can play a role in Alaska's energy conservation policy. The conservation programs currently in place in Alaska all fit into one of these categories, as do the programs recommended in this Long Term Energy Plan. The State must apply selective criteria to determine which of these strategies is appropriate.

- **Program Selection Criteria.** The manner in which energy conservation programs are selected by federal, state, local and private organizations has been traditionally flawed. Rather than applying sound mechanical, economic, social, environmental and other principles to selection, politicians and decision-makers have relied on gut-level instincts, constituent interest, and success stories from other places. In part, this lack of attention to selection of conservation programs has resulted in a lack of credibility for them and those charged with program implementation.

The five mandatory programs of the Federal Energy Policy and Conservation Act (EPCA), show the lack of attention to the above criteria. One of these, a requirement for "Right Turn on

Red," was included in the legislation because of a Congressman's irritation with waiting at a red light in Washington D.C. Another one, a requirement for lighting efficiency in all public non-residential buildings, was included with little thought to the difficulty in legislatively mandating the re-lighting of thousands of square feet of commercial office space. Had some attention been paid to selection criteria, review of the success of many of these programs might not now prove so disappointing.

Prior to 1980 state energy conservation programs in Alaska were initiated primarily because of mandates placed upon the State by the federal government. Federal energy conservation funds have been accepted along with the "attached strings" of specific programs not necessarily in step with Alaska's geography, climate, politics, or administrative structure. Acceptance of those federal funds was a necessity, however. Until 1980, minimal State funds had been made available for conservation programs.

In 1980, SB 438, which mandated a very extensive group of conservation programs and authorized the expenditure of State funds for implementation, was enacted. An examination of SB 438's development indicates that a combination of good ideas, political interests, constituent demands, and replication of laws passed in other states formed the basis for this bill. Many of its requirements are well-proven conservation measures. Others such as the audit, grant and loan program may fail to attain their objectives immediately because implementation may prove more complex than anticipated.

Ideal energy conservation programs that result in large, immediate energy savings are acceptable to the public and easy to administer. They are technically feasible, cheap, and produce positive environmental, social and economic impacts. Unfortunately, few, if any, programs with all of these attributes are available. It is therefore necessary to lay out criteria to evaluate alternative programs. The following set of criteria is designed to highlight the essential issues that should be considered when evaluating any proposed energy conservation program. It is not an exhaustive list of everything that should be considered in every case, but rather an abbreviated hierarchy of the essential considerations necessary for prudent decision-making.

- **Potential Energy Savings.** The first step in the selection of an energy conservation program is to determine the potential for energy savings. The amount of potential reduced energy use and the type of energy fuel saved are essential pieces of information necessary to assess the desirability of any program within prevailing energy consumption patterns. In addition to the energy savings at the end-use level, the additional savings resulting from reduced generation and transmission in the case of electricity, and reduced extraction, refinery losses, and transport in the case of fossil fuels, must be included. Finally, the time frame over which the energy will be saved must be considered. Some programs will produce more immediate results than others, while in many cases initial capital investments will lead to continued savings over long periods of time.

  Numerous organizations, including the U.S. Department of Energy, have developed methodologies for projecting energy savings of conservation initiatives. The Division of Energy and Power Development should use these methodologies or develop its own for all of its programs, and should be prepared to assist other organizations in utilizing energy savings methodologies as they develop their programs.

  It is important to highlight the need for examination of fuel availability as a criterion somewhat apart from the costs of energy savings. This should include availability regionally as well as to Alaska as a whole. The intent here is to determine whether or not the resource being saved is in critical or abundant supply.

- **Economic Feasibility.** In order for an energy conservation measure to be economically feasible, the value of the sum of energy saved plus the environmental and social costs avoided must at least equal or exceed the sum of the conventional and social costs of the conservation measure. In other words, the total benefits accruing to society at large must equal or exceed the total costs accruing to society at large. It is important to recognize that the appropriate benefits and costs to consider are the totals accruing to society at large rather than those accruing to an individual homeowner or entrepreneur since many social costs and benefits are not reflected in the price of energy facing the individual decision-maker. The selection of the most economically desirable program involves comparing programs on the basis of the benefit per dollar of cost to the extent that costs and benefits are measurable. Costs and benefits which cannot be quantified in terms of dollars must be considered on a judgmental basis by the appropriate energy policy makers.

- **Program Acceptability.** In order to be effectively developed, initiated, and implemented, conservation programs must be acceptable not only to the policymakers who put them in place but also to the implementing agencies, concerned interest groups, and the affected public. Psychological, socio-cultural, political, institutional, and positive or negative attitudinal factors must be identified. The ability of education and dissemination of information to inform all concerned and later preconceived attitudes and opinions must be assessed.

  A major flaw in the Energy Policy and Conservation Act conservation requirements, as well as in many other nationally developed programs, is the inattention to program acceptability at the state and local level. As a result, states have often failed to accomplish program objectives established by the federal government and have had to receive continuing "dispensations" for their efforts, while continuing to receive federal monies.

  An example of this situation is the federal requirement for energy efficient building codes, which were accepted by state legislatures as of January 1, 1978. In October 1979, only 13 states were in compliance with these federal regulations. Although the number of states in compliance has risen slightly since that time, implementation of the standards and codes, with effective local enforcement, remains inadequate, rendering the standards almost meaningless.

  The same problem with local acceptability holds true for legislation passed at the state level and expected to be implemented in local communities throughout Alaska. Attention to political, geographical, social, and economic programs is imperative.

- **Technical Feasibility.** Determining the technical feasibility of energy conservation measures involves the assessment of the likelihood that the identified level of desired energy savings is achievable and will be realized. Some conservation measures, particularly those designed to reduce heat loss in heated structures, have proven records and are reliable if properly installed. Others, such as changes in industrial processes, involve unproven technological changes and exhibit more risk of not attaining desired savings. Another consideration is the time frame over which new technology for saving energy will be developed, perfected, and proven commercially feasible.

- **Environmental, Social and Secondary Economic Impacts.** State energy conservation programs will inevitably produce various side effects, including environmental, social, and secondary economic impacts. Environmental impacts refer to the increase or decrease in environmental residuals expected from the implementation of state energy conservation programs. For the most part extraction, production, and transport or transmission of energy produced adverse environmental impacts and, therefore, reduced consumption reduces these adverse impacts and produces an environmental benefit. Social impacts in the case of energy conservation programs are primarily the differential effects which various programs have on different socio-economic or income groups. Since lower income groups spend a higher percentage of their income on energy than higher income groups, programs which produce energy cost savings for lower income (as opposed to higher income groups) are generally deemed more socially desirable. Secondary economic impacts are the effects which various energy conservation programs have on levels of employment and income. Labor intensive incentive programs will have different secondary impacts than capital intensive programs. Programs which rely heavily on local labor will have different local impacts than those that rely on imported products with high levels of embedded labor from other areas.

- **Monitoring and Evaluating Energy Conservation Programs.** If energy conservation is ever to realize its potential and to become an important, effective component of Alaska's energy policy, the efforts currently underway must be carefully monitored and evaluated for both energy savings and societal impact. Additionally, **all** new programs must include a monitoring and evaluation component when they are planned. Only by proving that energy conservation is an energy resource, that it is economically, environmentally, socially, and politically a way to produce energy will its benefits be realized.

Many energy conservation programs initiated and proposed in Alaska and elsewhere rely on estimates of likely achievable savings, since no historical data on actual measured savings are available. As more and more of these programs are implemented, it is crucial that data on measured effectiveness under actual conditions be carefully collected. Without such a monitoring and evaluation scheme, there will always exist some doubt as to program effectiveness.

Throughout the United States, questions exist as to the effectiveness of conservation. A recent U.S. Department of Energy Report on the effectiveness of state energy conservation programs from 1976 to 1978 indicates that the goals of the federally mandated Energy Policy and Conservation Act and the Energy Conservation and Production Act are not being met. The report points out that evaluation is rarely a part of the state's submitted plan and that there is a great need for baseline data from which to measure effectiveness. Low priority has been given by most states to collecting data and evaluating programs, resulting in "seat of the pants" analysis, unknown energy savings, and questionable rationale for expenditure of funds.

This kind of criticism has finally moved the U.S. government and many state energy departments to take a more careful look at monitoring and evaluation. In 1979, the Department of Energy hired Price Waterhouse and Co. to develop general guidelines for monitoring and evaluation and to work with each state in designing an evaluation program specific to that state's conservation programs and availability of data. Such specialized assistance is important and useful but has not been completed for all 50 states. Alaska will benefit from this assistance if provided the financial and personnel resources to carry out recommended evaluation activities.

Individually, certain states have begun to develop their own evaluation programs. Washington State hired a consultant to essentially finish what Price Waterhouse and Co. did not — to develop a program-by-program evaluation, with "how-to" instructions on conducting surveys and analyzing data. The State of Maine, with assistance from the Region I DOE office, developed a computerized system of tracking costs for each program and energy data. The State of Idaho hired an economist to work with each staff member and contractor working on state and local energy conservation programs to develop a monitoring and evaluation program **before** funds were allocated to the program itself.

It is important to recognize that the results of energy conservation efforts may not be direct, but may spring from a variety of impulses. Higher energy prices, opposition to additional energy generating capacity in a locale, unavailability of energy supplies, unexpected supply disruptions, changing lifestyles, all may result in reduced energy consumption. A particular program or effort may not cause efficiency in consumption by itself — other outside factors surely have a role to play. It is imperative that the organizations responsible for financing and implementing conservation programs make an effort to quantitatively and qualitatively analyze the impact of the program itself, and, additionally, with the outside factors.

Systematic monitoring and evaluation will produce the necessary information to establish the actual level of Btu and dollar savings obtained from various programs. For example, the Division of Energy and Power Development and Battelle are working together to develop a monitoring system for the Residential Energy Conservation Program. The division's interest is to evaluate program participation and effectiveness. As part of the Railbelt Alternative Study, Battelle will obtain residential energy end-use data which will also be valuable for the Plan. It can help to identify ways to increase the efficiency of such programs, especially in the area of determining effective ways to reach people and promote various programs. It can identify programs which are not producing anticipated energy savings and possibly provide information necessary to turn unsuccessful measures into successful energy-conserving programs. Finally, careful evaluation of the benefits in terms of documented savings and the actual cost in terms of funds and effort expended on programs can lead to a determination of which programs lead to the most energy saved per dollar of program cost. This information can then be used to guide additional expenditures into the more efficient energy conservation program areas and away from those less efficient.

- **Federal and State Energy Conservation Programs in Alaska.** Many state and local organizations, both public and private, are involved with energy conservation programs. Primary activities include information dissemination, educational programming, energy audits and weatherization services for residential buildings, and minimal research and demonstration projects. The impetus for this activity at the state government level is federal legislation, including such acts as the Energy Policy and Conservation Act (EPCA), the Energy Conservation and Production Act (ECPA), the National Energy Conservation Policies Act (NECPA), the Energy Extension Service Act (EESA) and the Institutional Buildings Grants Program. Locally, the initiation of conservation programs has been based on financial assistance from state or federal government, consumer demand (as in the case of utility programs), and federal mandate (as in the case of Rural Electrification Administration requirements for REA member utilities). Whatever the reason, energy conservation efforts are taking hold in Alaska as never before.

The impact of federal mandates on Alaska state programs has been both positive and negative. Financial incentives have been provided for almost all conservation efforts initiated by state agencies, but there have been myriad rules and regulations, and often conflicting requirements and impossible to meet deadlines, which have been more frustrating than successful. Most important has been the sometimes poor applicability of federal requirements to the particular Alaskan geography, climate, and political and institutional establishment. For example, a program such as the Weatherization Program for Low-Income Persons has survived funding cuts, delayed payments (which delay work during decent weatherization weather) and limitations on spending authority for administrative costs and home repairs.

Federally-funded programs which have been tied to energy savings, although laudable for their insistence upon energy savings, have brought delays while bureaucrats have quibbled over numbers. Certain federal programs have limited applicability in Alaska. One such example is the Residential Conservation Service Program which impacts only two of Alaska's largest utilities — Chugach Electric Association and Alaska Gas and Service Company.

Quantifiable energy savings from federally-mandated conservation programs have been minimal in Alaska. The Division of Energy and Power Development has been dissatisfied with federal mandates and energy consumption assumptions made by federal agencies. Savings projections made by federal agencies have not been adhered to. Both the DEPD and the U.S. Department of Energy admit the projections and assumptions for energy savings have been unrealistic.

The passage of SB 438 in the 1980 session of the Alaska State Legislature has brought both promise and frustration. Many existing needed energy conservation initiatives were included in the bill. Many of these were "known" energy savers, and the legislation included extensive financial assistance to those who would participate in conservation programs, as well as disincentives to those who did not.

Table V-1 details the energy conservation programs known to be currently in place in Alaska.

TABLE V-1
Alaska's Energy Conservation Programs and Projects

Project/ Program	Method of Implementation	Authority	Responsible Organization	Area of Impact	Energy Savings	Budget/ costs
			– Residential Sector –			
Alternate Energy Resource Center— in Anchorage	Library, workshops, conferences, Library ux 3,000 newsletter, solar	NA Center	AERC ACE	Statewide/Focus	None Computed. Workshop att. 1500 Newsletter 1,000 Book grants to 35 lib.	Alaska
Rural Alaska Program	Information/ Technical Asst.	ACTION	DEPD	Statewide	None Yet	
Energy Extension	Information/ Technical Asst.	EES Act	DEPD	Statewide/focus on Anchorage	None Known	
Cooperative Executive Service Program	Information/ Education		CES, U of Alaska	Fairbanks, Anchorage, Bush Villages	None Known None Known	
Utility Sponsored Energy Audits and Thermography	Technical Asst.	Rural Electrification Administration	Homer, Chugach, Matanuska, Golden Valley, Wrangell & Ketchikan Electric Assoc.	Applicable Communities	None Known None Known	
Classes for Urban Bush Energy Applications	Education/ Technical Asst.	NA	Alaska Center for Community Self Reliance	Rural Areas Fairbanks	None Measured	
Energy Design Clinics for the Public.	Education	NA	Alaska Chapter, Institute of Architects.	Anchorage	None Known 8 clinics	
Fairbanks North Star Borough Conservation Tips	Information	NA	Fairbanks North Star Borough	Fairbanks & Borough	None Known 5-10 calls/week	
Appropriate Technology Small Grants Program	Incentives	DOE	DEPD	Statewide	None Known	
Weatherization Program for Low Income Persons	Incentives	DOE	DEPD & Contractors	Statewide	Estimate: 6 trillion Btus, 1980	
Weatherization Grants & Refunds	Incentives	SB 438	DEPD	Statewide	None Known	

Project/ Program	Method of Implementation	Authority	Responsible Organization	Area of Impact	Energy Savings	Budget/ costs
Weatherization Loans	Incentives	SB 438	Division of Business Loans	Statewide	None Known Yet.	
Emergency Fuel Assistance Loans and Grants; Fuel Seminars	Incentives/ Education	CSA	RURAL CAP DEPD	Bush, Villages, Bethel, Fairbanks, Kotebue		Manage-ment
Housing Rehabilitation Program for Weatherization	Incentives	HUD	Local HUD Offices	Juneau	27 homes/1980 No Computed Savings.	
	Assistance for Community Business.	Incentives	NA Community Development Corporation.	Anchorage	Anchorage	Unknown.
Energy Auditor Training & Certification.	Legislative Mandate	SB 438	DEPD	Railbelt & Selected other Communities.	None Yet	
State Financing of New Residences after 12/31/80 Tied to Building Code.	Legislative Mandate	SB 438	None	Statewide	Unknown	
Energy Conservation Considerations by Financial Institutions after 12/31/80.	Legislative Mandate	SB 438	None	Statewide	Unknown	
Provision of Energy Info Prior to State Loans for New Construction.	Legislative Mandate	SB 438	None	Statewide	Unknown	
Exceptions to Building Codes in the Interest of Energy Conservation.	Legislative Mandate	SB 438	Borough Planning	Statewide	Unknown	
Authorization for 2nd Class Boroughs to Participate in Conservation REHAB Program	Legislative Mandate	SB 438	NA	Second Class Boroughs	Unknown	
Energy Education at Institutions of Higher Learning	Legislative Mandate	SB 438	Senior/ Community Colleges	One or more college campuses (Anchorage Community College)	None Projected.	

– Commercial Sector –

Requests for Information	Information	Energy Extension Service	DEPD	Statewide	Unknown	
Super-Insulated Demonstration Building	Information/ Research & Demonstration		DEPD	Fairbanks	Unknown	
Power Project Loan Fund	Incentives	SB 438	APA	Statewide	No Funds Yet Provided For Energy Conservation Project	
Bethel Waste Heat Project	Research/ Demonstration	NA	Community of Bethel Utilities Co.	Bethel	Unknown	
Business Energy Conservation Tax Credit	Incentives	SB 438	Dept. of Commerce	Statewide	Unknown	

Project/ Program	Method of Implementation	Authority	Responsible Organization	Area of Impact	Energy Savings	Budget/ costs
Small Business Energy Loans	Incentives		Small Business Administration	Statewide/ Urban Areas	Unknown. Two Loans for $65,000 each	$138,000
Energy Conservation Building Standards	Legislative Mandate	SB 438	DEPD	Statewide	Unknown	$84,000
State Financing Tied to Building Standards	Legislative Mandate	SB 438	Department of Revenue	Statewide	Unknown	
			– Transportation/Land Use Sector –			
Carpool, Bus Programs. Emission/Efficiency Tests.	Information/ Technical Assistance	State Energy Conservation Plan (EPCA)	DEPD & State & local Governments	Juneau, Anchorage, Fairbanks, Barrow	Unknown	
Borough Zoning Regulations & Energy Efficiency	Legislative Mandate	SB 438	DEPD & Boroughs	Statewide	Unknown	
			– Government Sector –			
Seminars, Information, Staffing for Energy Conserving State Purchasing	Education/ Technical Asst.	State Energy Conservation Plan (EPCA)	DEPD	Statewide	Estimated 12 Trillion Btus (vehicles only)	
Intergovernmental Coordination/ Programming	Education	State Energy Conservation Plan (EPCA)	DEPD & Alaska Municipal	Statewide	Unknown	
Ft. Richardson Energy Conservation Program - Heat Recovery; Weatherization; Public Awareness	Information/ Education/ Tech. Asst.	U.S. Army	Ft. Richardson		25% Savings Since 1975. $323,000 bbls./1979	
Municipality of Anchorage Energy Program	Information/ Technical Asst.	Municipality of Anchorage	Municipality of Anchorage	Anchorage	Unknown	
Government Agency Recycling Program	Legislative Mandate	SB 438	Department of Environmental Conservation	Statewide	Unknown	$131,000
Anchorage Recycling Program	Information	State Appropriation	Anchorage	Anchorage	Unknown	$46,000
			– Public Building Sector –			
Institutional Buildings	Incentives	DOE	DEPD	Statewide	Projected, 3rd Qtr 1980 12 billion Btus	
School District Planning Grants	Incentives	SB 438	DEPD	Rural Areas	Unknown	$500,000
Energy Audits & Reports to Legislature	Legislative Mandate	SB 438	DOT/PF	Statewide Unknown		
Energy Conservation Standards for New Buildings	Legislative Mandate	SB 438	DOT/PF	Statewide	Unknown	
Energy Training for Public Building Maintenance Personnel	Legislative Mandate	SB 438	DOT/PF	Statewide	Unknown	

Project/ Program	Method of Implementation	Authority	Responsible Organization	Area of Impact	Energy Savings	Budget/ costs
			– Industrial Sector –			
Waste Heat and Information Dissemination	Information	State Energy Conservation Plan (EPCA)	DEPD	Statewide	None.	
Regulatory Exemption for Sale/Exchange of Waste Heat	Regulatory	SB 438	APUC	Statewide	Unknown	
Waste Heat Recovery Systems	Miscellaneous	N/A	ML&P, Chugach, Naknek, Kotzebue Electric Associations, Selected Spnthake Greenhouse, U. of Alaska, North Slope Borough, and North Pole.	Selected Areas	Unknown	
			– Petro-chemical Sector –			
			NO PROGRAMS			
			– Fishing/Agriculture Sectors –			
			NO PROGRAMS			

Recommendations

Energy conservation is still in its infancy in Alaska. As a policy issue, it has captured the interest of the Legislature, numerous government organizations and small and large communities faced with steadily rising gasoline and diesel prices. The State, in recognition of conservation as a critical part of its energy policy, has taken some major steps forward, which few other state governments have done. Nevertheless, the following recommendations recognize the work already begun in Alaska while suggesting possible improvements in direction:

- The development and implementation of energy conservation programs in Alaska must be addressed separately in order to account for the special needs and problems of rural villages.

- An adequate monitoring and evaluation system for existing and new conservation programs should be established immediately. A status report and cost/benefit analysis of these efforts should be included in the 1982 Long-Term Energy Plan.

- Specific goals and objectives for the State's energy conservation policies and programs should be defined and included in next year's plan. These should be developed by considering energy conservation as another energy supply option.

- Alaska should carefully evaluate further participation in Federal conservation programs. The state has many unique conditions not found elsewhere and its programs need to be suited to them. In addition, federal conservation funding will decline significantly in FY82.
- State sponsored energy conservation programs should be focused only on measures which show proven energy conservation opportunities and result in a positive benefit to cost ratio.
- A strong program of specific public information, education and technical assistance network should be established. Included should be the utilization of the State's telecommunications capabilities.
- Monitoring of the heat pump demonstration program now underway in Juneau and Ketchikan should be continued and evaluated.
- A demonstration of water heat pumps should be initiated.

CHAPTER VI

Energy Emergency Planning

Introduction

Given the nature of the Alaskan energy system, the primary emergency problems that can be addressed with a statewide planning program are in the petroleum sector. There are two broad categories of problems inherent to oil: an international problem and an unusual distribution problem within Alaska. Although the State government has more control over the internal distribution problem, there are also measures that can be implemented in the event of an international oil disruption that will help to moderate the problem.

More than any other factor, the risk of oil shortages stems from the inescapable fact that the U.S. is heavily dependent on imported oil, much of which is purchased in the turbulent Middle East. There are a variety of events that could evolve into an oil disruption in Alaska, along with the rest of the country: political instability or revolution in the oil exporting nations, sabotage of critical foreign or domestic oil installations, natural disasters, limited warfare between the producing countries and their neighboring nations, a blockade of shipping, and a politically-based witholding of oil. Given all of these potential problems, it is essential that state and local officials become aware of the risk of future disruptions along with their probable severity.

Closer to home, Alaska's unique geography and population distribution may give rise to isolated spot oil shortages within the State. Specifically, many Alaskan Bush communities could experience an oil shortage due to transportation or financial problems. These problems may not stem directly from an international oil supply problem, but they could have a tremendous disruptive effect on the community and are an important component of Alaska energy planning.

The International Problem

Although Alaska did not experience any significant problems during the 1973 or 1979 oil disruptions, this would not be the case if there is a major oil shortage in the future. As a result, Alaskan officials should be aware of the possible reasons behind an international oil problem. Over the next several decades, U.S. oil import vulnerability is unlikely to diminish. In the past, both the 1973 Arab oil embargo and the 1979 Iranian Revolution caught government officials unprepared. Although the conditions surrounding each of these disruptions were different, both of them point to the likelihood of future oil problems.

Before the Arab oil embargo of 1973, international oil markets had enjoyed steady undisturbed growth for nearly three decades. A major reason for this was the ability of U.S. oil producers to expand production whenever necessary, such as the period during the Suez Crisis. By 1973, however, the U.S. no longer had any excess production capacity and had itself become dependent on Arab oil sources.

Oil shipments from the Arab OPEC nations were cut nearly 25 percent in October, 1973. Additionally, a series of price increases began. By the time the Arab oil embargo was lifted in April 1974, there had been a quadrupling of prices — from $3.01 a barrel in the summer of 1973 to $11.65 a barrel early in 1974.

The key issue during this disruption was not the size of the supply cutbacks, but the expectations on the part of the oil importing Western nations over the future availability of crude oil. The Arab oil embargo not only proved to be the prophetic incident of the seventies, but it marked the beginning of a transition away from conventional hydrocarbons towards alternative energy supplies.

Five years after the Arab oil embargo, world oil markets were jolted by another tumultuous event: the fall of the Shah of Iran. Late in 1978, many government officials doubted that the Ayatollah Khomeini's rise to power would seriously influence world oil markets. Yet, by April, 1979 there was no indication that Iran — once the cartel's second leading exporting nation — would ever again be sending five million barrels a day or more to Western markets.

By May 1979, spot market prices of Middle East oil had increased from $23 to $34 per barrel. Official contract prices, which had been only $12 to $13, had increased to $23.50. By June of 1980, the official price had increased to $30 per barrel and more. Thus, in just over a year, oil prices had increased 120 percent, with the resulting economic impact being on a par with the price increase of 1973/74.

In early 1981, crude oil prices are edging to $40 per barrel, Iran and Iraq are at war, and many officials have cautioned that another oil shortage could be imminent. The present circumstances are in fact not that serious. But an oil shortage — possibly much more severe than already experienced — could occur again. And the odds are that it will, as long as the U.S. imports a significant portion of its oil.

Broadly speaking, the potential causes of oil disruptions can be grouped into five categories:

- **Production cutbacks for economic purposes.** The stated purpose of OPEC is to cartelize the oil market. To date, however, the cartel has not coordinated a production cutback for the sole purpose of raising prices. If this happened and the cutback was poorly managed by OPEC, shortages could occur.

- **Embargoes and production cuts for political purposes.** The most serious threat in this category is another Arab oil embargo. With the exception of Saudi Arabia, no oil exporter is sufficiently large to make a significant impact on the market unless there are other difficulties at the same time. Individual threats by Libya or Nigeria, for example, are not serious unless they are coordinated with other countries.

- **Civil wars and other internal disturbances.** The Iranian Revolution is, of course, the classic example of this type of disruption. It should be noted that the Iranian Revolution was an exception, not the rule. Governments have changed hands many times in the OPEC countries, primarily through coup d'etats, and there has rarely been a shutdown of crude oil exports. The Iranian Revolution was distinctly different because it was a broad-based social revolution.

The primary threat of an oil disruption from internal disturbances concerns the dominance of Saudi Arabia as an oil exporter. Saudi Arabia is the only oil exporting country large enough to create a serious disruption if its oil exports are shut down. The temporary loss of Nigerian or Indonesian oil, for example, would not be likely to cause widespread shortages unless it was combined with other events.

One additional observation is that many Shiite Moslems characterize the events in Iran as an Islamic Revolution — far more fundamental to Moslem society than a national revolution. In this view, similar Islamic uprisings and reorganizations could occur in any Moslem country. If this view is correct, the risk of major shifts in all of the Persian Gulf states is fairly high and the consequences extremely grave.

- **Sabotage by terrorists.** Nearly 40 percent of the Western nations' oil supply passes through the Straits of Hormuz. The supply infrastructure in the Persian Gulf — pipelines, shipping terminals, and storage tanks — are concentrated at key locations. This, of course, makes the infrastructure highly vulnerable to terrorist attack. The threat of terrorist activity is serious, however, only if the attacks are broad-based and prolonged. It would require a very substantial set of terrorist attacks to reduce production capacity by even 4 to 5 million barrels per day.

In the event of such an isolated terrorist attack, part of the production loss could be made up from excess capacity elsewhere. The rest could be made up from inventory drawdown. Unlike a revolution, in which the future course of events is highly uncertain, repair and replacement of damaged infrastructure can be more precisely managed. Even though the loss of crude oil might be as large as that of past experience, the psychology would be different. On the other hand, if there were successful repeated attacks, then the problem could become serious.

- **Limited war.** Without question, the threat of a Persian Gulf war that involves key nations is the most serious threat to Western oil supplies. Such a war would likely result in all of the combinations of problems cited above — destruction of the pipelines, storage tanks, loading terminals and tankers, possible coups or internal revolutions, and increasing hostility directed at one or more of the consuming nations. There is also great danger from a more limited war, such as the Iran-Iraq conflict. Not only is crude oil production disrupted in those countries, but also the general level of uncertainty is increased.

After reviewing all of the problems that might arise, it is all too painfully clear that any number of things could go wrong. In retrospect, it can be considered lucky that the world has experienced only two oil shortages since the early seventies.

What does this mattter to Alaska with all of its oil? First, the shortages experienced in the U.S. so far are, in relative terms, minor. Although it may not be likely, it is possible to imagine events that would result in a truly catastrophic loss of imported oil. For example, the outbreak of a war that involved all of the Persian Gulf states could result in a loss to the Western industrialized world of at lest 40 percent of its oil supplies. Given the U.S. commitment to an international oil sharing agreement, this would result in total loss of oil imports. Everyone in the United States would have to nearly halve petroleum usage. Alaska has a lot of crude oil, but it is still largely dependent on refineries located elsewhere. Almost 40 percent of the petroleum products used within the state are imported from California or Washington state.

Second, even if Alaska were to expand its own refinery capacity, federal regulations are unlikely to allow Alaskans to enjoy an oil surplus while industry in the Lower Forty-Eight is being brought to its knees. One way or the other, if the U.S. loses its oil imports, Alaskans will suffer like all Americans.

The Alaskan Distribution Problem

Regardless of the occurrence of international oil problems, the geography and population dispersion of Alaska presents special challenges for many outlying communities. These problems are primarily economic, but they are related to the transportation characteristics of the Bush and the timing of the shortage.

Economic problems arise from oil pricing or from untimely cash flow problems. Oil is typically priced higher in Bush communities than in the more populous regions of the state, due primarily to higher transportation costs.

A related economic problem in Bush communities is the uncertain income that many communities have. Due to the reliance on seasonal industries (such as fishing), the primary income to a community may not coincide with the time that payments must be made for fuel supplies. Related to this cash flow problem is the fact that many communities only order petroleum supplies once a year. Or, due to weather conditions, they can only receive their supplies once a year. As a result, the State provides financing in order to ensure that Bush villages receive their needed fuel supplies on time. Although this helps to prevent spot shortages, it would be of minimal assistance should a long-term supply disruption occur.

Preparing a Successful Contingency Plan

As was shown in Chapter III of this report,petroleum is the dominant fuel used in Alaska. Unfortunately, it is the energy source most susceptible to future problems. Problems can arise from the international arena or they can be related to specific Alaskan distribution circumstances. Consequently, there is a great deal of importance in preparing a broad-ranging, successful contingency plan for petroleum emergencies. Further, there are several criteria that must be considered if a contingency plan is to be successful.

The first key to creating a successful plan is to ensure that the Alaskan plan conforms to the responsibilities delegated to states by the federal government. Although Alaska is a major oil producing state, the federal government is committed to managing a major shortage such that no particular region of the country is better off than another. Thus, the virtue of being an oil producer does not necessarily ensure that the State will fare well through an emergency. Alaska's plan must meet federal expectations and standards.

A second component for a successful contingency plan is to ensure that the public has a good understanding of the plan. This will only occur if the public is involved in formulating the plan. A large part of any contingency plan is the determination of measures that will alter people's behavior. This can be accomplished easily if the public understands what the plan is to accomplish and why.

A third, and major, component of a successful plan is credibility. In the past both federal and state energy emergency plans have lacked credibility because government officials had been forced to deal with issues with which they were not familiar. The repeated announcement of policy shifts coupled with misleading and contradictory information helped to limit the effectiveness of the response. A key part of preparing a good contingency plan is to ensure that the State has its own experts familiar with the problems.

A fourth component is to ensure that the plan is clear about the State's goals and objectives during an emergency. The plan should develop criteria for establishing priority uses of fuel. For example, should all energy-using activities take the same cut? Should the availability of heating oil have priority over diesel for trucking?

A fifth point concerns hoarding. Any good contingency plan must deal with this phenomenon. This is essential because some emergency measures can have contradictory results. For example, closing service stations on weekends will cut driving, but it will also limit access to fuel and create panic buying. The contingency plan must make a distinction between measures that are aimed at managing a shortfall and those that are aimed at constraining demand and are, as a result, helping to prevent fuel shortages.

Finally, a successful contingency plan must be a flexible plan. Changes can occur rapidly in the international arena. Similarly, economic or physical circumstances of isolated Bush communities can also change. The contingency plan should be broad-ranging enough to account for these changes. In addition, procedures should be designed to allow a regular updating of the plan. In this context, a successful contingency plan is similar to a business plan, which is open to dynamic changes, rather than a land-use plan, which is often viewed as a static type of plan.

Federal Allocation Policy and Alaska's Royalty Oil

The gasoline shortages experienced by California and the East Coast were caused, in part, by the inflexibility of the federal allocation controls on gasoline and crude oil. This program has just been eliminated by President Reagan (it was originally due to be phased out in September). Despite the problems with allocation, these controls are likely to be implemented again in the event of emergency, because they do give state and federal governments some control over the distribution of petroleum products.

The theory of allocation is quite simple. Everyone is entitled to a set percentage of the petroleum products purchased last year. So if the shortfall is 10 percent, everyone is guaranteed 90 percent of supply. This program can be made to work on the production and wholesale distribution level. But at the retail level it becomes unmanageable because almost no one keeps such detailed records.

At the moment, the federal government has a standby allocation program under consideration. The form of this standby program should be of considerable concern to Alaskans. In the event of an energy emergency, it will determine the trading relationships between oil producers, refiners, wholesalers and retailers. That, in turn, will affect all Alaskans. It could also affect the contractual terms concerning the sale of the State's royalty oil.

Alaska is the only state to actually own a major share of crude oil being produced within its borders. Consequently, royalty oil could be used by the Governor to moderate or eliminate an oil shortage, which is a supply option no other state has. In order to use the oil during a shortage, any contractual sale should have a clause which mandates that the oil must be refined and sold in Alaska unless it is offset with product from elsewhere. Exceptions to this clause could be granted during normal market conditions.

If such a plan is to be successful, however, it will have to be made a part of the federal standby allocation regulations. Otherwise, purchasers of Alaskan royalty oil face the prospect of being in violation of either state or federal requirements.

The Size of the Disruption and the Type of Plan

Earlier in this chapter it was pointed out that a total loss of Persian Gulf oil (or Saudi Arabian oil) could result in a truly catastrophic loss of oil imports. Table VI-1 (from An Energy Emergency Contingency Plan for Alaska Phase One: The Management Plan) illustrates the probable size of an oil shortage given a variety of potential problems. Figure VI-1 illustrates how they can be grouped into two basic categories of disruption.

percent, is similar to the disruptions that the world experienced in 1973 and 1979. The second category, a serious shortage, could entail a loss of oil imports from 12 to 26 percent.

Of course, nearly any combination is possible. But, for the purposes of contingency planning, this analysis indicates two things. First, two types of plans need to be completed: one for a moderate shortage and one for a serious shortage. Second, it is possible to predict the expected size of the shortfall in U.S. imports on the basis of the event occuring in the OPEC countries. Thus, once officials know a shortage is coming they will also know its approximate size.

If the impending shortage is expected to be moderate, under 8 percent, a simple contingency plan is likely to resolve the problem. Experience in the past decade has shown that voluntary conservation and programs like odd-even rationing, when combined with higher prices, can prevent serious disruptions. And, any serious problems tend to resolve themselves in a few weeks or months.

On the other hand, a serious shortage is not likely to be resolved by simplistic programs. And the price increases necessary to reduce demand in the short-term may have unacceptable economic and social side effects. As a result, the contingency plan for dealing with a serious shortage will have to be very carefully prepared and implemented as soon officials are certain about the disruption.

It takes 60 to 90 days to ship oil from the Persian Gulf to U.S. ports. Consequently, there has been a two to three month period in which warnings were sounded, but the shortages had not yet arrived. In such circumstances it is possible to identify three distinct stages of disruptions; the preparatory period, actual fuel shortages, and the aftermath.

The contingency plan prepared for a moderate shortage should have three pases which parallel the states of the disruption. In the first phase there should be preparation and appeals to public for voluntary conservation. The second phase should be the implementation of the programs intended to deal with actual fuel shortages. Finally, there should be a third phase, in which the plan switches back to voluntary conservation and public information programs.

In a moderate shortage the "trigger point" to implement the first phase of the plan should be about 30 days after the first reduction in OPEC oil production. The trigger point for the second phase should be the occurrence of actual fuel shortages — particularly gasoline. The trigger point for the third phase is judgmental, but should follow indicators such as reduced gasoline lines.

Planning for a more serious shortage is much more difficult. So far, the only experience has been with moderate shortages. If there is a major loss of Persian Gulf oil it could precipitate serious hoarding in a few days. Crude oil in tankers may not be landed or not refined because the industry knows that a major shortfall is coming. Concurrently, the public may panic.

Thus, trigger points for the various phases are much harder to identify. The implementation of measures may be required immediately, or it may not. The process will have to be judgmental.

TABLE VI-1
Estimating the Size of an Oil Shortage

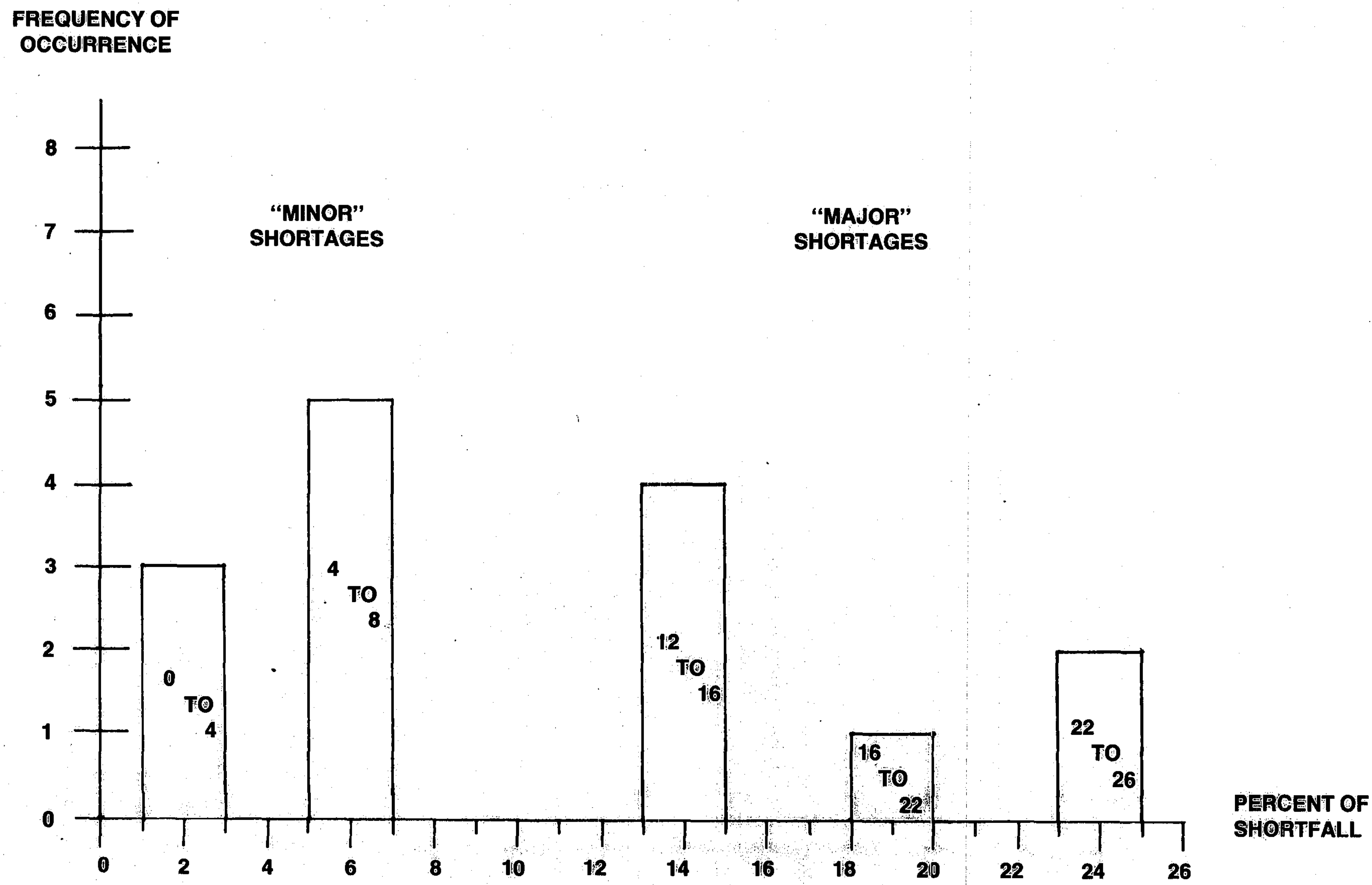
	Gross Reduction*	Impact on the IEA	Impact on the U.S.
I. Embargoes or Prduction Cuts			
Arab Oil Embargo over Conflict with Israel			
– 10 percent cut	2.0	3.4%	3.4%
– 20 percent cut	4.0	7.4%	7.4%
Iranian Sanctions against West	2.0	--	--
Nigerian Protest of Apartheid	2.0	--	--
Libyia Cuts U.S. Exports	.8	--	--
OPEC Price firming Cutback			
– Low	2.0	4.0%	4.0%
– Moderate	3.0	6.0%	6.0%
– High	4.0	8.0%	7.6%
II. Civil War and Political Disturbances			
New Regime in Iran	1.0	--	--
Coup in Iraq	2.2	1.0%	1.0%
Civil War in Indonesia	1.6	--	--
Civil War in Nigeria	2.2	--	--
Coup in Saudi Arabia			
– Cut back to 2.0 mmb/d	7.5	9.0%	8.2%
– Total devastation Saudi Fields	9.5	13.0%	11.8%
Saudi Revolution	9.5	13.0%	11.8%
III. Sabotage or Terrorist Activity			
Sabotage Saudi Shipping Facility	9.5	13.0%	11.8%
Partial Sabotage of Platforms	2.5	--	--
IV. Limited War			
Persian Gulf Blockade	19.0	38.0%	26.5%
Hostile Occupation Saudi Arabia	9.0	13.0%	11.8%
Hostile Occupation of Gulf States	14.0	28.0%	20.6%
Total Iran/Iraq War	5.0	5.0%	5.0%
Gulf War, Loss of Shipping	18.0	36.0%	25.3%

*Table IV-1 assumes the worst situations and is based on May, 1980 production rates and capacity. The estimate of the shortfall to the U.S. assumes that IEA sharing agreement is implemented, and all available capacity is utilized. Total seasonally adjusted IEA consumption was assumed at 35.0 mmb/d, with imports at 21.0 mmb/d. Total seasonally adjusted U.S. consumption was assumed at 17.0 mmb/d, with imports at 6.0 mmb/d. This table is speculative and meant only to illustrate the types of possible oil shortages.

Source: An Energy Emergency Contingency Plan for Alaska Phase One: The Management Plan.

FIGURE VI-1

ANALYZING THE RISK OF AN OIL SHORTAGE



The Governor's Emergency Authorities

Governor Hammond's direct authority for dealing with an energy emergency is based on the Alaska Disaster Act of 1977. This is a general act which considers all disasters, such as fire, earthquakes, floods, and shortages of food, water, clothing and fuel.

Under the Alaska Disaster Act, the Governor may issue any executive orders, proclamations or regulations required to protect the public health, safety and welfare. In order to take such action, a disaster must occur and the Governor must declare a condition of disaster emergency.

If the legislature is not in session following the declaration of a disaster emergency, a special session will be called. The legislative convention may be cancelled by the unanimous agreement of presiding legislative officers. If the session goes ahead, the gubernatorial actions must be ratified within 15 days. The proclamation expires in 30 days, if not renewed by the legislature. In addition, the legislature may terminate the proclamation by a concurrent resolution.

During the effective emergency period, the Governor may suspend state regulations, use the state government's available resources, transfer personnel, alter function, commandeer private property subject to just compensation, and allocate fuel.

The major difficulty with the present authority for dealing with energy emergencies is that, according to the Attorney General of Alaska, the Alaska Disaster Act may only be applicable in extreme circumstances and for short periods of time. The National Conference of State Legislatures has pointed out that such authorities may not be suitable for energy shortages, which require advance planning and information to minimize impacts, have the potential to be prolonged, and may require special managerial skills and techniques.

A federal act, the Emergency Energy Conservation Act of 1978 (EECA), provides basic energy emergency authorities for states. In the opinion of the Attorney General of Alaska, the Governor could implement emergency measures under this act provided that the following conditions are fulfilled:

- The President declares an energy emergency.
- Specific State authority is not available in the circumstances of the emergency.
- The measures adopted by the Governor do not violate any Alaskan laws or the authority of State personnel to implement them.
- The measures to be implemented have been agreed to with federal officials in an emergency energy plan to be submitted by the State of Alaska.

The last point is the subject of a plan development now under way by the Division of Energy and Power Development. The U.S. Department of Energy has recently approved grants to Alaska and other states to begin developing emergency energy plans. There are expected to be two phases to the planning process. In Phase I, Alaska will prepare a management plan detailing how the actual Emergency Energy Plan will be developed in Phase II. The Phase I plan will contain a preliminary description of emergency measures that might be implemented. The next section contains DEPD's list of measures which are being researched for the State's emergency plan. These will be presented in public hearings as part of the review of the Long-Term Energy Plan. The actual emergency plan will take into account public comments and be completed by 1 January 1982.

It is worth pointing out that some state energy emergencies may be local in nature and thus not covered by EECA. Furthermore, some of these emergencies do not meet the criteria of the Alaska Disaster Act.

Options Available to Manage an Oil Disruption

Following is an abbreviated list of those items that could be implemented by the State of Alaska in the event of a petroleum emergency. These actions assume that there has been a statewide oil disruption. In addition, there are varying degrees of severity within the measures. Public comment is solicited regarding these and other emergency responses which could be implemented in Alaska.

Measures to Constrain Demand

- Reduce highway speed limits to 50 mph or less.
- Prohibit travel by private autos on different days. This could be implemented by a sticker plan, which limits the use of each registered vehicle one or more days per week.
- Prohibit driving on Sundays, weekends, or at other times.
- Provide additional transit service by operating a larger portion of available vehicles and redeploying vehicles to carry more passengers per vehicle mile.
- Increase commercial passenger transport aircraft load factors by rescheduling flights.
- Mandate a tune-up of vehicles every six months.
- Prohibit space heating in commercial buildings above 65 degrees. This could also apply to residential buildings.
- Mandate efficiency tests on all oil-burning industrial boilers and larger commercial heating plants. Poor efficiency conditions must be corrected.
- Restrict hours for commercial and industrial operations.
- Reduce the work/school week to four days.
- Prohibit or limit the use of private planes for nonessential uses.
- Institute public information programs.

Measures to Manage Shortages

- Odd/Even license plate rationing with mandatory service station openings.
- Hot lines for distress or other emergencies.
- Credible, accurate public information.
- State set-aside for emergency oil allocations.

Measures to Provide Supplemental Supplies

- Prohibition of the sale of royalty crude oil outside Alaska, unless offset by the sale of refined products. The ratio between royalty crude and petroleum produce sales to be determined by market conditions at the Governor's discretion.
- Emergency burning of wood or coal wherever possible.
- A strategic petroleum reserve funded and controlled by the Alaska State Government.

Recommendations

- The Alaska Energy Contingency Plan should be completed and submitted to the Legislature for approval by February 1982.
- Effort should be initiated immediately to amend federal standby allocation regulations to allow an Alaskan Royalty Oil in-state use clause during national shortages.
- The proposed legislation developed by the National Council of State Legislatures (NCSL) to provide the Governor with additional authority to respond to energy emergencies should be approved.

Energy Units and Conversion Factors

British Thermal Unit (Btu): The amount of energy required to raise the temperature of one pound of water one degree Fahrenheit (1°F) at or near the point of maximum density (39.1°F). The Btu is equivalent to 0.252 kilogram-calorie.

Electricity

Kilowatt Hour (Kwh): The amount of energy used in one hour by a load of one kilowatt.

At the point of consumption	3,412.0 Btu/Kwh
At the point of generation (approximate)	10,500.0 Btu/Kwh

Coal

Short Ton (ST) = 2,000 lb.

Alaskan (domestic) coal	8220.0 Btu/lb.
or	16.44 million Btu/ST

Natural Gas

Dry	1031.0 Btu/cu. ft.
or	100,000.0 Btu/Therm

Petroleum Products

Barrel (bbl) = 42.0 U.S. gallons

Crude Oil Equivalent	5.800 million Btu/bbl
Asphalt (6.65 bbl/ton)	6.636 million Btu/bbl
Aviation Gasoline	5.048 million Btu/bbl
Diesel Fuel (No. 2)	5.825 million Btu/bbl
Distillate Fuel Oil	5.825 million Btu/bbl
Gasoline	5.248 million Btu/bbl
Jet Fuel	5.513 million Btu/bbl
Kerosene	5.670 million Btu/bbl
Liquified Petroleum Gas (LPG)	4.011 million Btu/bbl
Lubricants	5.522 million Btu/bbl
Residual Fuel Oil	6.287 million Btu/bbl

SOURCE: Applied Economics Associates, Inc.