COMPREHENSIVE ENERGY RESOURCES PLAN

submitted to Governor Joseph E. Brennan
and the 110th Maine Legislature

Maine
Office of
Energy
Resources

1981

Joseph E. Brennan
Governor

State of Maine
Executive Department
OFFICE OF ENERGY RESOURCES
State House Station 53
Augusta, Maine 04333
(207) 289-3811

Gordon L. Weil
Director

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Submitted to Governor Joseph E. Brennan and
the 110th Maine Legislature
by
The Office of Energy Resources

This report was prepared under the supervision of Constance Irland, Deputy Director for Planning and Resource Development, with the assistance of Richard Darling, Supervisor of the Conservation Division, Joel Davis, Resource Planner, Jamie Firth, Assistant to the Director, and staff of the Planning and Resource Development Division.

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I. INTRODUCTION

I. INTRODUCTION

The Maine Comprehensive Energy Resources Plan - 1981 is a description of existing energy sources, existing and projected energy demands and uses, and an analysis of existing and potential energy resources to meet the needs between the present and the year 2000. The Plan is designed to assist the Governor, the Legislature and the People of the State of Maine to work together to determine our energy policy and to shape our energy future.

The purpose of this Plan is to provide the information needed to devise an energy strategy for Maine. In this sense, the report is descriptive rather than prescriptive. It makes no recommendations concerning the amount of each resource we should expect to use to meet our expected needs. Before we decide where to go and which paths to follow, we must have an understanding of where we have been, where present trends could take us, and what options are available to us in charting our future course.

The Legislature deliberately chose this descriptive approach. During the First Regular Session of the 109th Legislature, the mandate of the Office of Energy Resources was clarified to require a two-stage process in the development of energy policy. The first part consists of a Comprehensive Energy Resources Plan to consist of two elements:

"1. A description and quantification of the present supply rates of use and energy needs of the State; a cost analysis of providing energy to meet the State's future needs; a description of the assumptions upon which the predictions and costs are based and the probability of error in the projections in the plan. These tasks shall be completed on an annual basis and submitted to the Governor and Legislature by January 15th of each year; and

2. A description and quantification of the availability of various energy resources for the State. This assessment shall utilize the most current available data and include all resources that can potentially help meet Maine's energy needs. This task shall be accomplished on a biennial basis and public input shall be sought through a public hearing process determined by the director in accordance with provisions of Title 5, chapter 375. After public hearings have been held, the final copy of the Plan shall be submitted to the Governor and Legislature by January 15th to serve as a basis for legislative initiative..."

This document is intended to respond to both requirements. Section II corresponds to the annual report and Sections III-VI correspond to the biennial report. A separate document is mandated to recommend Maine energy policy:

> "The Office of Energy Resources is directed to prepare a state energy policy to include the following: The direction or directions most feasible for Maine to pursue in the field of energy resource use and development, feasible alternatives to implement the state energy plan and long range as well as short range energy programs."

This two-stage approach is not only required, it is preferable. It will allow a thorough public review and debate on the various resources described in this Plan prior to making the important decisions and recommendations which must be made in the State Energy Policy.

With the submission of this Plan, we embark on an extensive public discussion concerning energy policy with a view to the preparation of the energy policy document. The Office of Energy Resources will seek out the views and expertise of the Legislature, the executive agencies, interest groups and oranizations, energy specialists and, above all, Maine people. In fact, in the preparation of the present document, this process has already begun. We intend to complete this process and prepare the State Energy Policy before the conclusion of the First Regular Session of the 110th Legislature.

The preparation of this Plan and, in particular, the comments received on the draft on which testimony was taken at public hearings, have indicated the ways in which this Plan should be improved in the future. To respond to this need, the Office of Energy Resources will reorient its efforts to provide more sophisticated information on the energy mix employed by each class of users and better projections on the impact of reduced or increased use of specific resources on the rise of that and other resources and the use of other forms of energy.

A word should be said about "the probability of error" in the projections contained in this Plan. Broad limits were adopted for the projections made and, as a result, it is relatively safe to state that actual developments will fall within the upper and lower limits selected. Because of the methodology used, it is highly likely that energy costs in the future will not be as high as those contained in the most pessimistic scenario included here. However, the very conservatism of the projections contained in this report must serve as a stimulus for the Office of Energy Resources to improve its methodology in order to refine its projections without sacrificing their reliability.

We expect that the state energy policy will be a blueprint for action extending years into the future. Because our information will inevitably change and improve over the years, the biennial element of the Comprehensive Energy Resources Plan can serve, in the future, as a way of updating the State Energy Policy. Of course, the Policy itself may be revised and updated from time to time.

In evaluating the various energy resources, we have used a uniform approach. We have examined the current use of each type. The resource availability in the State of Maine is also studied within the limits of currently available data. General considerations that those developing energy policy may wish to take into account are summarized. And, because state government has been pursuing a variety of programs and short-term energy policies in the past few years, they are outlined. We also look briefly at those user sectors where each resource is and can be used. In addition to evaluating energy resources, we also focus on conservation, which will be of utmost importance to any ultimate energy policy.

The public hearing conducted in connection with the preparation of this Plan and the oral and written comments received outside of those hearings have revealed a number of broad concerns to which the State Energy Policy might be expected to respond:

1. Maine people are vitally concerned about the cost of energy. In a state with a low per capita income, rising energy prices, almost totally determined outside of the state, exact a heavy and, for some, unbearable toll.

2. Maine, located at the end of the energy "pipeline" for the resources on which we are mostly heavily dependent at present, must improve the security of energy supplies.

3. The way of life and the environment of our state are highly prized, and energy development must take into account the need to preserve these assets which give Maine its special character.

4. Given the economic status of the state and projections that per capita income will continue to remain relatively low, we need to undertake policies and programs to promote economic development that will create jobs and increase income.

5. Local initiative in the development of energy resources should be recognized and encouraged.

6. Traditional energy sources will continue to be needed in the coming years because the transition to the newer resources may be difficult and will be incremental.

7. To the greatest extent possible, the State of Maine should come to rely on indigenous and renewable resources.

8. Energy conservation should be as vital an element of our policy as energy development.

9. Market forces will be perhaps the major determinant of energy resource utilization, and policy should be designed to channel these forces so as to respond to the other public concerns.

Obviously, various organizations and individuals may interpret these concerns differently. In the development of energy policy, compromises will have to be found among these differing interpretations and difficult choices will have to be made. But, to best serve Maine, energy policy should recognize them all, as well as others that may emerge in the public discussion in the next few months.

Of course, we cannot wait for the publication of the State Energy Policy to take action to respond to these concerns. Since the petroleum embargo of 1973-74, three governors and four legislatures have responded vigorously and imaginatively. Even as this Plan was being completed, Governor Joseph E. Brennan submitted to the 110th Legislature a package of proposals which, if adopted, will represent a broad response to concerns expressed above.

The programs of the past few years do not answer two important questions:

1. What combination of conservation and energy resource utilization will best serve the needs of Maine as it moves through a transitional period toward its ultimate energy mix?

2. What should be the long-term energy utilization pattern and what steps should we take in the next decade to insure its achievement?

These are the questions to which the State Energy Policy will respond. The Office of Energy Resources invites the involvement of all Maine people in the coming months in the preparation of the recommended responses to these questions in light of the broad concerns listed above. While we must recognize that developments in Maine will be strongly influenced by forces outside of the State, we can act affirmatively to affect our own destiny.

The contributions of those who testified at the public hearings and who submitted oral and written comments were influential in shaping this report and in pointing out areas for further work. Those who participated in the process included: Cheryl Ring, Maine Audubon Society, Dan Boxer, Paper Industry Information Office: Richard Leighton, Maine Hospital Association; Stephen Powers, Maine Oil Dealers Association: David Thodol, Congress for Safe Energy: Alwyn Waite, Congress for Safe Energy: James Friedlander, Greater Portland Council of Governments: Bill Butler, Maine Woodsman's Association: Michael McConnell: John Rensinbrink, Congress for Safe Energy: William Pynchon: Alan Philbrook: Anne Hammond, Brunswick Citizens for Safe Energy: Barbara Biggs, Maine Women for a Nuclear Free Future: Norman Temple, C.E. Monty, Seward Brewster, Central Maine Power: Nancy Doble, Greater Portland Nuclear Referendum Committee: Pat Garrett: William H. Beardsley, Bangor Hydroelectric Company: Christine LeGore, Maine Nuclear Referendum Committee: Judith M. Barrows: Denise Gravelle: Steven D. Webster, Maine Friends of the Earth, Congress for Safe Energy, Committee for Alternatives: Milton Huntington, Maine Petroleum Association: Paul Firlotte, Great Northern Paper Company: Peter Heimann, Natural Resources Council: John Baldacci: John Jerzbek: Frank Hochmoth: Stuart Silverstein: Richard R. Sevony, R.L. Petit Co.; Mal Corey, University of Maine at Farmington: Gordon E. Torrey, Portland Ocean Services: Stanley C. Moses, City of Bangor: Normand Laberge: Robert Faunce, City of Lewiston: Theodore S. Chadbourne, R.H. Chadhourne Co.: Dick Baker.

Overview

The purpose of the Maine Comprehensive Energy Resources Plan is to provide a basis for making the policy decisions that will shape Maine's energy future. This will be accomplished by providing the most current information available concerning the State's existing energy supplies and demand, outlining high and low forecasts of energy use during the next two decades, and by discussing the renewable and non-renewable energy sources available to meet those needs. Using this information, the assessment of various policy options will be more easily made. 1978 is the latest year for which complete, consistent data on Maine's energy supply and demand exist. For this reason, 1978 was used as a base year to develop assessments of current energy use and forecasts of future demand. Wherever OER has been able to compile accurate data regarding a particular fuel source for 1979 and 1980, this information has been included.

Total energy use in Maine grew fairly steadily between 1960 and 1978. Except for the period during the Arab oil embargo of 1973-1974, total energy consumption increased at an average rate of just over 3% per year. In 1978, total consumption of energy in the state was 336.1 trillion BTUs.

The future demand for energy in Maine will depend heavily on fuel costs, fuel availability and the rate at which conservation and other energy efficiency measures are implemented in each end-use sector. The OER low demand estimate, which assumes a high level of conservation efforts, projects a total energy demand of 270.4 BTUs by the year 2000. This would be a decrease of 9.6% over total consumption, not including electrical generation losses, in 1978. The high demand forecast, which assumes high economic growth and no conservation measures beyond current levels, projects a total energy demand in 2000 of 345.0 trillion BTUs. This would be an increase of 15.3% over 1978.

As a group, petroleum fuels presently comprise the major source of energy for Maine, accounting for 68% of the total energy used in 1978. Three types of petroleum products made up the bulk of this amount. Motor gasoline supplied 19.4% of Maine's total energy supply, residual fuel oils (used primarily by utilities and industry) supplied 16.7%. Home heating oil and related distillates accounted for 18.6% of Maine's total energy consumption. Other types of petroleum products such as kerosene and aviation fuels were responsible for the remaining percentage amount. The only other type of non-renewable energy source that currently makes a major contribution to Maine's energy supply is nuclear power. In 1978, natural gas and coal both provided less than 1% of the State's energy supply.

Currently, Maine's most used renewable energy resource is hydro power, which provided 7.9% of the 1978 energy supply. Wood provided 5%, while other native renewable resources (solar, wind, tidal, biomass, peat, and solid waste) provided either much smaller unquantified amounts or no contribution in 1978.

Electricity is not defined as a primary energy source in terms of total energy supply in this plan since electrical generation actually uses primary energy sources. Of course, electricity does provide a substantial amount of power to residential, commercial, and industrial end users. In

1978, electricity, as a secondary power source, provided 15.3% of the end-use energy consumed by those three sectors. The primary energy sources used to generate electricty used in Maine are nuclear, hydro power and oil.

To provide a better understanding of Maine's energy situation, this Plan describes current energy consumption and forecasts of future demand by residential, commercial, industrial and transportation end-users. In 1978, 22.2% of Maine's total energy supply was used in the residential sector; 18.1% in the commercial sector; 30.0% in the industrial sector and 29.7% was used for transportation. In the OER low growth forecasts to the year 2000, each sector's share of total energy consumption would not be expected to change substantially.

Under the high demand scenarios, the industrial sector would show the greatest increase in energy use. The high demand forecast for the year 2000 suggests that the industrial sector's share of the state's total energy consumption would increase to about 42%.

One of the most important factors in Maine's energy future will be conservation, defined here as "an improvement in energy efficiency." OER forecasts estimate a potential for a 9.6% decrease in overall energy demand by the year 2000 through increased conservation measures. The ultimate potential may be far greater than this.

Most of our energy conservation opportunities are well known. They include:

- Energy efficient weatherization of existing buildings;
- Energy efficient construction of new buildings;
- Energy efficient operation of commercial and industrial buildings and processes;
- Installation of energy-efficient appliances and industrial equipment; and
- Increased implementation of energy-efficient transportation methods, including ridesharing and public transportation where appropriate, and the use of higher mileage vehicles.

Another attractive method of increasing energy efficiency is cogeneration, the use of waste heat to generate electricity or supply space heating needs. The Office of Energy Resources estimates that there is a potential for a significant increase in cogeneration in Maine. Much of this potential is within the forest products industry.

A preliminary study done for the OER indicated that "an additional 265 MW of steam turbine generating systems could be installed at Maine paper mill sites and produce electricity at costs competitive with current utility production costs, while meeting the mill's process steam requirements."

Maine has a relatively large renewable energy resource potential and substantial quantities of peat resources, which are theoretically, but not practically, renewable. Of these, three major renewable resources hold the greatest promise for increased energy potential: hydro power, wood, and solar. Other renewable resources, such as solid waste, wind, tidal and biomass, can also make significant contributions to local and regional energy demands.

Maine's renewable energy resources offer many important opportunities to diversify the state's energy mix. Along with strong conservation efforts, their increased development can substantially reduce the state's dependence on imported fuels and the drain those fuels impose on the state's economy. In addition, the development of these alternative resources have many potential indirect economic benefits for the state through business and job development.

Progress in developing these resources and the extent of their contribution to our energy needs in the future will depend on many factors. These factors include market conditions, available technology, private and public policy choices that must try to balance economic and environmental concerns, and the availability of affordable capital.

Currently, there are 85 hydro power facilities operating within the state. Current developed capacity is more than 600 MW, equal to approximately 8% of Maine's current total energy consumption (down from about 17% in 1950 when energy demands were smaller). At present, hydro power provides roughly a third of the electricity used in Maine. New efforts to use Maine's untapped hydro potential were being actively pursued at over 50 existing dam sites in the state during the past year.

The potential may exist to approximately triple the amount of energy produced by hydro power in Maine. However, conflicts with other beneficial water uses, environmental impacts and economic constraints are such that only part of this potential can reasonably be expected to be developed.

If environmental and economic constraints allow only half of the currently estimated hydro power potential in Maine to be developed over the long term, about 1030 MW of capacity would be gained and the contribution of hydro power to state energy needs would double. Hydro power would then contribute the equivalent of about 20% of Maine's total current annual energy consumption, or about 40% to 50% of the state's total current annual electrical use.

Use of solar power is limited at present, but a great potential for increased use exists. Solar energy technology is being used in about 1400 Maine homes and commercial buildings, primarily for space heating or domestic hot water heating. The most common and inexpensive method of using solar power is through passive solar building designs. Retrofitting buildings with simple low cost solar air heating devices which simply transfer heat into the adjacent interior space is also gaining in popularity.

Solar hot water heaters are another widely available, increasingly popular solar alternative. Thus far, about 400 solar water heaters have been installed in Maine. These heaters can supply up to 60% of the heat required for a domestic hot water supply. It is estimated that 60% of all existing buildings in the state have adequate "solar access". With proper planning, about 90% of all new buildings could use solar power for some degree of space or water heating at little or no additional cost. Most existing solar space heating installations in Maine provide an average of 20% to 30% of a building's yearly space heating needs: current solar water heaters supply about 40% to 60% of the domestic hot water needs in buildings where they are used. Simple passive solar systems will probably be used most extensively in the next two decades. Active solar systems use will increase as well, but more slowly.

A major result of the past decade's rising oil prices has been a dramatic increase in the use of wood for space heating. In 1970, Maine homeowners burned about 324,000 cords of fuelwood. During the 1978-79 heating season, the figure had risen to 575,000 cords.

The New England Fuelwood Survey found that during the 1978-79 heating season 46% of all Maine households burned wood as a primary or supplementary heating fuel. An OER Resurvey found that approximately 55% of Maine households burned wood during the 1979-80 heating season.

Maine's pulp and paper companies have also increased their use of wood residues, such as sawdust, shavings and bark, for space and process heating needs.

The exact amount of oil saved by this trend is unknown: but it is believed to be a substantial amount. For example, the new bark-fired boiler used in one of Great Northern Paper Company mills allows a savings of over 400,000 barrels of oil a year.

About 90% of Maine is forested. Considering the size of our forest resources and the fact that trees are renewable, wood could be used as a major fuel in the state in the future. The limits to the contribution wood can make as an energy resource depend on a number of factors including: how well our forests are managed, how efficiently wood fuel is used, and the extent of the demands for wood as a resource for manufactured products and other uses.

Municipal waste-to-energy systems could supplement Maine's energy supply and at the same time help to solve solid waste disposal problems. The city of Auburn has become the first community in Maine to build a solid waste resource recovery project. When this facility begins operation early in 1981, it will generate steam for use by industry.

There are 12 urban areas in Maine where waste-to-energy projects are considered feasible. Towns in eight of the areas are actively investigating refuse to energy options. If built, these projects, plus Auburn's would save the equivalent of 400,000 - 600,000 barrels of oil each year.

Wind power can make substantial contributions to the electrical needs of individual homeowners. However, more efficient, less expensive technology must be developed and made available before the use of wind power will be widespread and its potential contribution to Maine's overall energy needs can be realized.

The most favorable sites for tidal power development in Maine are generally considered to be in Cobscook and Passamaquoddy Bays. These areas have both the right coastline configuration and the 15-20 foot tidal ranges common east of Machias.

Since 1976, the Passamaquoddy Indians at the Pleasant Point Reservation at Perry have been studying the feasibility of building a small-scale tidal powered electric generating facility at Half Moon Cove in Cobscook Bay. It would cost $21 million to $35 million to construct and have a capacity of 10 to 12 MW, enough to serve the electric needs of an estimated 5,000 to 10,000 people. They are expected to apply for a license to build and operate the facility during 1981. Construction could be finished and the plant could go on line as early as 1985.

Preliminary OER studies indicate there are approximately 100 sites along the Maine coast where small-scale tidal facilities may be practical. Fifteen to twenty of these sites with potential ranging from 40-1000 KWH of capacity are now being actively studied.

The Army Corps of Engineers, which has been studying the potential for building a large scale tidal plan in Passamaquoddy and Cobscook Bays, concludes that a large scale tidal project is not economically feasible at this time.

Biomass is any plant or organic matter, including agricultural crops, crop residues, other plants, animal wastes, wood and wood residues, garbage and solid waste material containing cellulose. Biomass can be burned directly, pelletized, gasified and made into alcohol. Although there are many potential sources of biomass energy, wood and wood residues are the only sources being used extensively in Maine at this time.

Maine produces a number of agricultural crops that could be used for ethanol production, an alcohol fuel that could be used to make gasohol. For example, if all of Maine's cull potatoes were used for alcohol production, about 4 million gallons of alcohol or about 1.5% of Maine's unleaded gasoline consumption for 1979 would be produced. There are presently 3 moderate to large scale ethanol projects that are in various stages of planning or construction in Maine. Two of the plants would use potatoes. One of the plants would use imported grains from the Midwest.

Although peat can be used as a fuel and Maine has considerable peat reserves, they are not currently used to supply any portion of the state's energy demands. The energy potential of Maine's peat deposits may be great, and a number of local and national firms are studying the feasibility of peat energy facilities in Maine. However, there are many major areas of concern with respect to the potential environmental effects of peat mining. This may severely limit the possible use of peat as a fuel.

Maine is extremely dependent on non-renewable fuels for its current energy needs. As a group, non-renewable fuels provided about four-fifths of the energy used in Maine during 1978. Hydro power, wood and other renewable energy resources supplied about one-fifth. In the next few decades, non-renewables will likely remain the dominant factor in our energy situation, though changes are expected to occur in the availability and levels of use of the various non-renewable fuels.

The most problematical non-renewable energy sources are petroleum products, which make up 68% of Maine's total current energy supply. Our supplies of gasoline, home heating oil and other distillate oil fuels are critically tied to foreign reserves and production rates. Political events abroad have led to shortages of these fuels in the past decade and may create others in the future.

It is also possible that world reserves of crude oil will become tighter and tighter as the turn of the century approaches and it is certain that prices of petroleum products will continue to rise. The importation of petroleum fuels already leads to a heavy drain on Maine's economy (about $1 billion annually) and shortages or increasingly unaffordable prices could lead to severe economic and social crises in the state unless dependence on these fuels is reduced.

Natural gas has been available in Maine for 13 years. During that time it has made a relatively small contribution to Maine's total energy needs. However, the potential exists for natural gas to have a larger role in the future, especially in the Portland and Lewiston/Auburn areas.

Though only about 1% of Maine's population currently uses natural gas, an estimated 12%, or 130,000 people, live within 100 feet of an active gas main. This includes roughly two-thirds of the population of Portland, South Portland, Westbrook and Cape Elizabeth and nearly the entire population of Lewiston/Auburn. The major barrier keeping natural gas from expanding to meet this potential is the lack of existing piping from gas mains to buildings.

Two things are remarkable about the use of coal as an energy resource in Maine. One is the decrease in coal use over the past 30 years. The other is the promise it holds for supplying energy to Maine in the future. From more than 21% of total energy supplied in 1950, coal use dropped to virtually nothing in 1978.

The use of coal has not yet rebounded from it's recent low point to major levels. However, the prospect for increasing coal use in Maine over the next two decades is evident. Several recent developments indicate likely future trends. For example, the Martin Marietta cement plant at Thomaston has converted to coal for its space and process heat uses. Central Maine Power is considering constructing a major coal fired-electric generating plant on Sears Island, possibly using new innovative coal burning technology. CMP will soon convert 67% of its present generating capacity at the currently oil-fired Mason Station in Wiscasset to coal burning. And, while exact figures are not yet available, there has been a strong expansion of the home heating market for coal over the past two years. These events are undoubtedly signs of the upward direction of coal utilization in Maine. Coal-fired electric generation, as well as industrial and domestic use, are expected to expand over the next decade.

Maine's single existing nuclear power plant, Maine Yankee, has a rated generating capacity of 829 MW. Maine utilities own and distribute half of Maine Yankee's output. The rest of the electricity it produces is exported out-of-state through the New England power grid. Thus, Maine Yankee supplied 27% of the electricity used in Maine during 1979, although it produced 60% of the total electricity generated in the state.

Maine utilities also own a combined total of 70 MW of capacity in nuclear plants located elsewhere in New England. In 1979, these out-of-state plants contributed approximately 6.2% of the electricity sold to Maine consumers. At this time it appears unlikely that any new nuclear power plants will be built in Maine, and Maine Yankee is only licensed until 2008. Imports of power from nuclear power plants located elsewhere in New England or in Canada may temporarily increase the contribution of nuclear power to Maine's total energy supply by up to 50%. It's contribution is expected to substantially decline after the turn of the century.

There is an increased potential for importing electricity from Canada in the next five to ten years. Quebec has shown interest in exporting hydro power from its large James Bay project and additional power may be available from the Churchill River area in Labrador. New Brunswick's new nuclear power plant, Point LePreau, is also expected to have at least a short-term surplus capacity. Central Maine Power Company is presently negotiating for 30 MW. If an agreement is reached, this power will be available between 1981 and 1989. Presently, the State of Maine does not receive any natural gas directly from Canada. However, one immediate and two longer range Canadian sources for natural gas imports may exist.

As this overview demonstrates, there is a vast amount of information which must be assimilated and digested before appropriate policy choices are made regarding our energy future. This Plan is an attempt to do this. It is hoped that using this Plan as a basis, the development of a reasonable State energy policy will soon occur.

II. SOURCES AND USES OF ENERGY IN MAINE: TRENDS, CURRENT STATUS AND PROJECTIONS

II. SOURCES AND USES OF ENERGY IN MAINE: TRENDS, CURRENT STATUS AND PROJECTIONS

Introduction

In order to develop a comprehensive plan of any sort, it is necessary to examine historical trends, understand the current situation, and make the best possible forecasts regarding the future. Such a process is undertaken in this section. By completing this analysis, we will have established a frame of reference against which it will be possible to measure the relative value of particular policy options as they become apparent.

"Sources and Uses of Energy in Maine" is divided into four sections which follow the line of thought described above. Part 1, "Historic Use, 1960-1978", describes the history of Maine's energy demands and supplies, Part 2, "1978 Energy Supply and Demand Status", describes Maine's energy supply and demand status as of 1978. 1978 is the most recent year for which complete, consistent data are available in terms of energy supply and demand. Federal sources, from which this information is derived, experience about a two-year "lagtime" in the production of federal data bases. Wherever the OER has been able to compile accurate data regarding a particular fuel source which include 1979 and 1980, this information has been used and noted. Part 3 forecasts possible supply and demand scenarios in the future.

In each part of this section, energy consumption trends are described from an "end-use" viewpoint. Throughout this plan, "end-use" refers to the actual purpose, or end, for which energy is required. In dealing with energy demand, four major end-use sectors have been identified: residential, commercial, industrial, and transportation. In dealing with energy supply, each part describes various energy supply resources which have been used in the past, are currently utilized, or may be used in the future.

The data represented in the graphs in this section are derived from several sources. Much information was taken from the State Energy Data Report DOE/EIA-0214 (78), April 1980, produced by the Energy Information Administration of the U.S. Department of Energy. Other sources include the Maine Department of Finance and Administration Bureau of Taxation, the New England Fuel Wood Survey, the Maine Public Utilities Commission (PUC), the Electric Council of New England (ECNE), the Federal Energy Regulatory Commission (FERC), the 1975 and 1979 Fuel Distribution Surveys compiled by the OER, and data provided by the major petroleum suppliers to the OER which, because of confidentiality, are not reproduced in this report but which were used to validate data from other sources.

Because the sources of information in this report are so diverse, there are many variations in data on individual fuel types. Where such variations occur, the particular variation and the reason for its occurrence are noted. The OER is continually collecting and assessing energy supply and demand data from various sources. The information presented in this report represents the best collection of data available. This information provides a sufficiently accurate basis for projecting future energy needs and resources. As the process of energy planning matures, the accuracy and reliability of this data will constantly be reviewed and improved where possible.

1. Historic Use, 1960-1978

This section describes the manner in which energy has been used in Maine and the types of energy resources which have been consumed to meet the needs of the State. This analysis will provide the reader with an accurate perspective as to the history of energy supply and demand in the State. The following analysis is presented by a series of graphs and charts which illustrate certain key trends. The long term historical data, presented in Figures 1 and 2, are shown in terms of trillions of BTUs. While BTUs are a good basis for comparison, most people are more familiar with units of measure such as gallons of oil, cords of wood and kilowatt hours of electricity. One trillion BTUs are equivalent to 8 million gallons of gasoline, fifty thousand cords of hardwood or 300 million kilowatt hours. Although the average citizen will not normally buy this amount of energy at one time, these figures will give the reader a point of comparison.

A. Demand

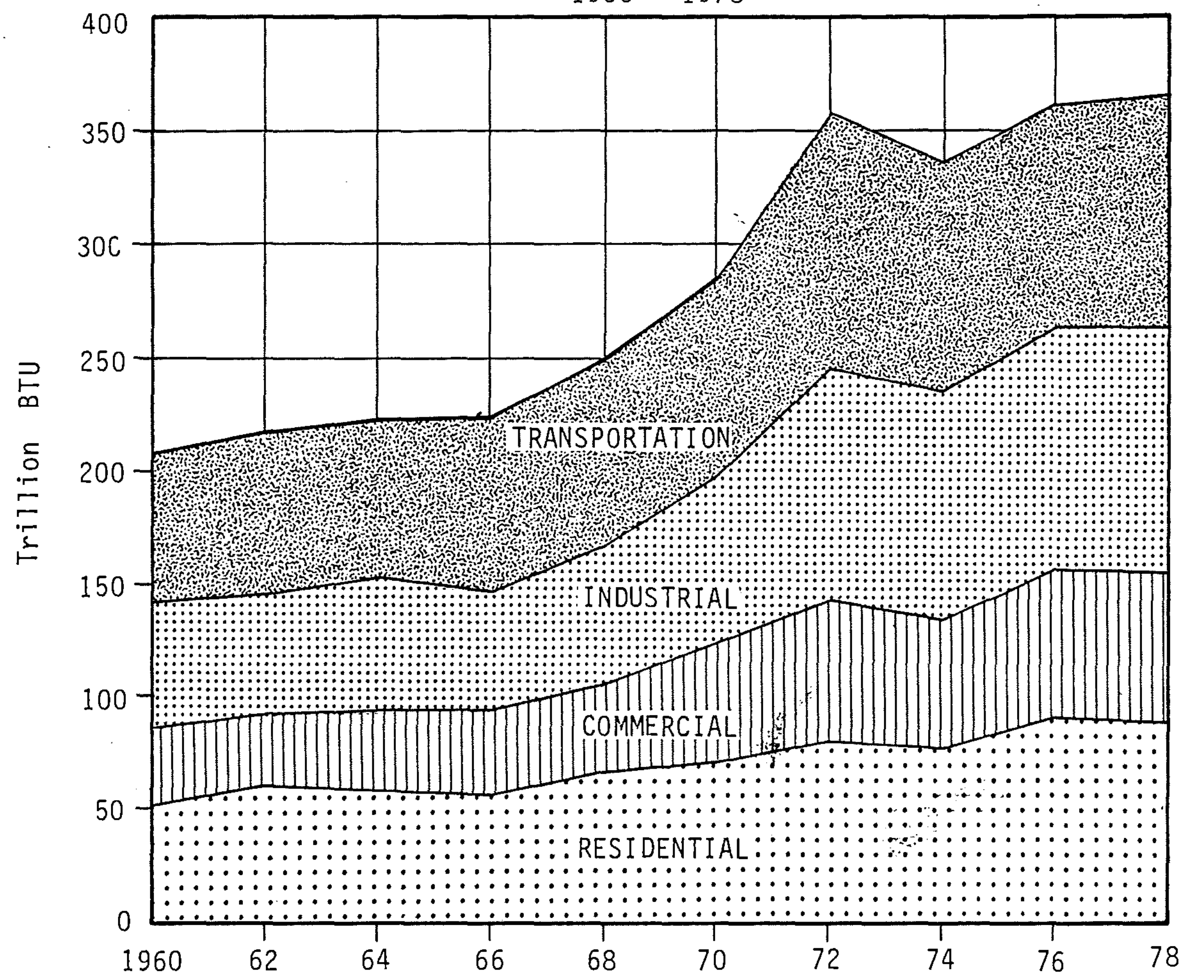
1. Total Demand

Figure 1 describes energy consumption in Maine from 1960-78 in terms of the total energy consumed by end use. Four end-use sectors are described: residential, commercial, industrial and transportation. The residential sector includes energy consumed for space heating, cooling, water heating, lighting, refrigeration and other uses in homes, apartments and other types of residential units. Commercial energy users include wholesale and retail stores, office buildings, hospitality establishments, government buildings, institutional buildings and the construction trades. The construction industry is included in the commercial sector primarily because it is considered a service rather than a primary production industry.

The industrial sector includes all primary goods production facilities in the State. Energy consumed in agriculture is also included in the industrial sector since agriculture involves the primary production of goods. Transportation uses include all private and commercial vehicles involved in on-road use. It excludes fuel used for construction, agriculture or other off-road purposes.

FIGURE 1

MAINE ENERGY CONSUMPTION BY END USE SECTOR
1960 - 1978



Source: U.S. DOE/EIA 1978: State Energy Data Report

2. Demand by End-Use Sector

The demands for the various fuels are created by consumption of these fuels to meet end-use demands in the four energy consuming sectors of the economy: residential, commercial, industrial and transportation.

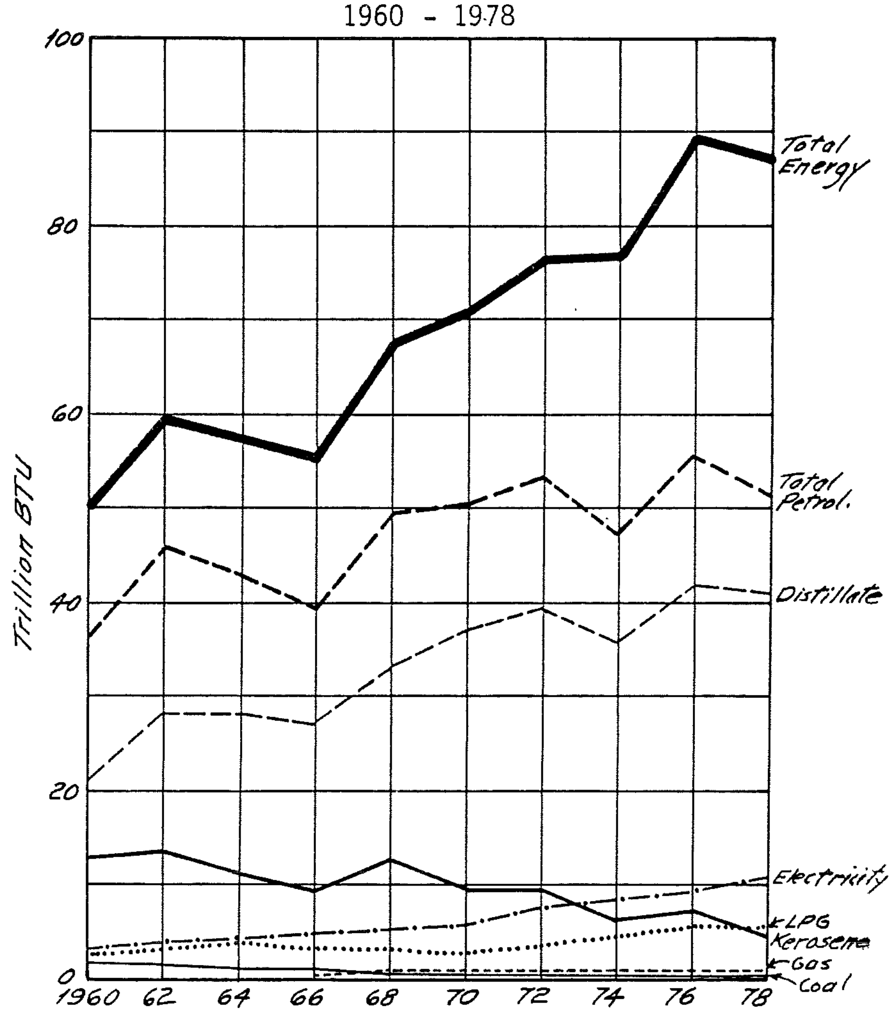
Figures 2 through 5 illustrate the trends in energy consumption by each sector of the economy from 1960 through 1978. These figures reveal that the most rapid growth has been in the industrial sector. This sector grew most rapidly between 1966 and 1972, prior to the OPEC oil embargo.

Residential Energy Consumption

Figure 2, "Residential Consumption of Energy in Maine", details the trends in energy consumption in the residential sector between 1960 and 1978. Petroleum, particularly distillate fuel oil (home heating oil), is by far the primary energy source for this sector. This fuel is used mainly for space heating during Maine's winter months. The relatively rapid increase in the consumption of electricity reflects the rising popularity of that energy form for space heating. The graph is also marked by a significant decline in the demand for kerosene, and the virtual disappearance of coal as a fuel in the residential sector.

FIGURE 2

RESIDENTIAL CONSUMPTION OF ENERGY IN MAINE
1960 - 1978



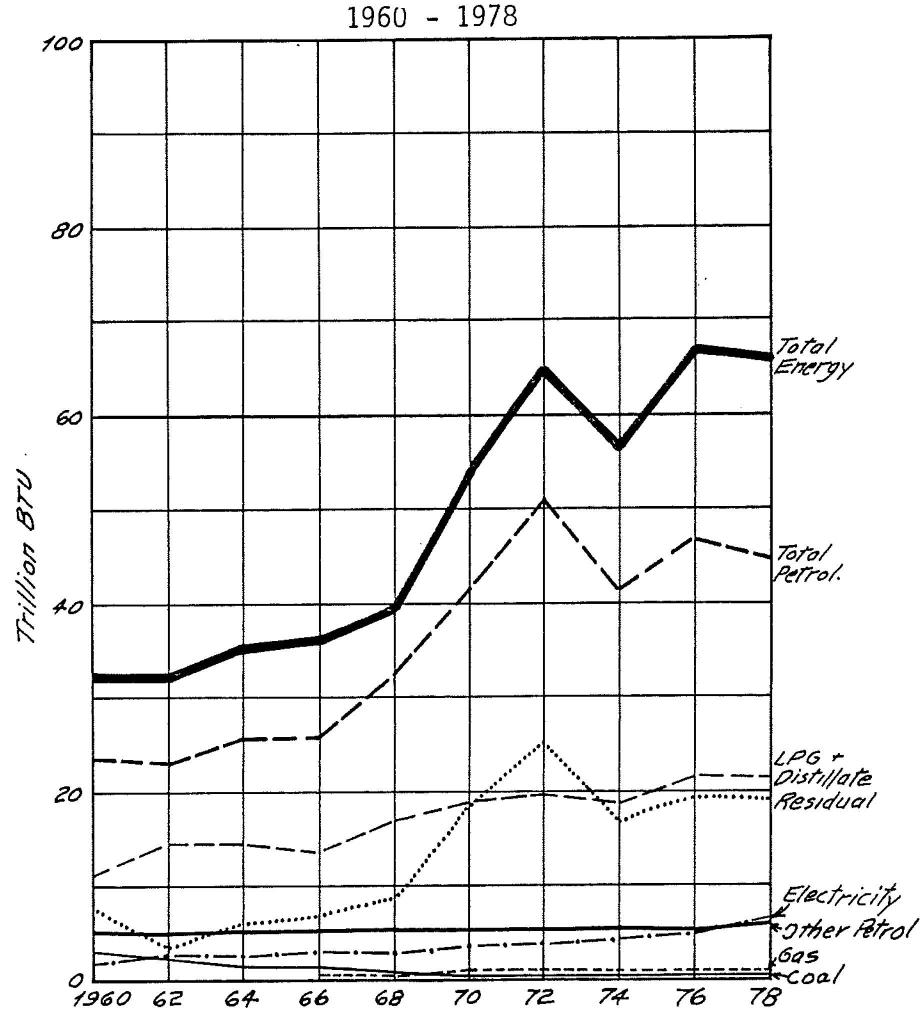
Source: U.S. DOE/EIA 1978: State Energy Data Report

Commercial Energy Consumption

The most striking feature about Figure 3, "Commercial Consumption of Energy in Maine, 1960-1978", is that this sector, too, is dominated by the use of petroleum products as the major energy source. Distillate fuels, along with liquified petroleum gas (LPG, or "propane") and residual fuel oil make up the majority of the petroleum used. Electrical use has grown quite rapidly. Coal has declined to relatively insignificant amounts and natural gas also constitutes a minor component of the energy mix on a statewide basis.

FIGURE 3

COMMERCIAL CONSUMPTION OF ENERGY IN MAINE
1960 - 1978



Source: U.S. DOE/EIA 1978: State Energy Data Report

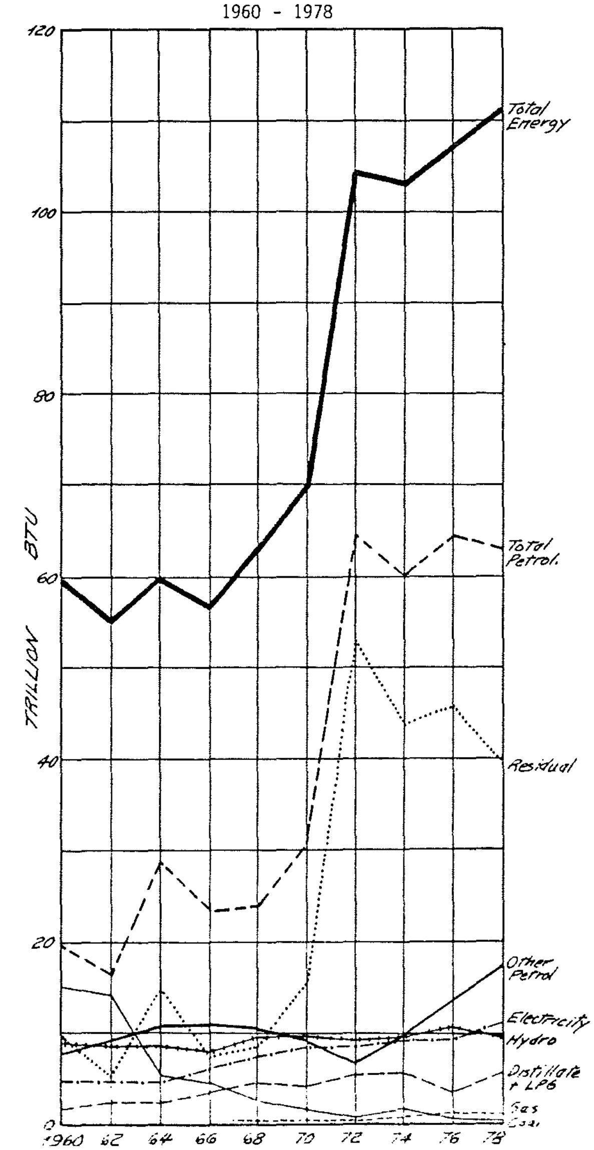
Industrial Energy Consumption

Figure 4 depicts the fact that Maine's industrial base is fueled primarily by petroleum products, with residual fuel oil being the principal constituent. Smaller amounts of distillate fuel oils, LPG, and other petroleum products make up a comparitively smaller portion of the fuel mix. Purchased electricity surpassed self-generated hydro power for the first time between 1976 and 1978, as total electrical consumption grew and self-generated hydro power by Maine's industrial establishments remained relatively stable.

Two distinctive features dominate this figure. The first is the decline in coal use and increase in residual fuel oil use through the 1960's as industry undertook a fuel-switching effort due primarily to environmental constraints. The second distinctive feature is the sharp rise in total industrial energy use in the early 1970's, again dominated by increased residual fuel oil consumption, which marks a major expansion of Maine's pulp and paper industry, with several new mills, new paper machines and accompanying oil-fired boilers.

FIGURE 4

INDUSTRIAL CONSUMPTION OF ENERGY IN MAINE
1960 - 1978



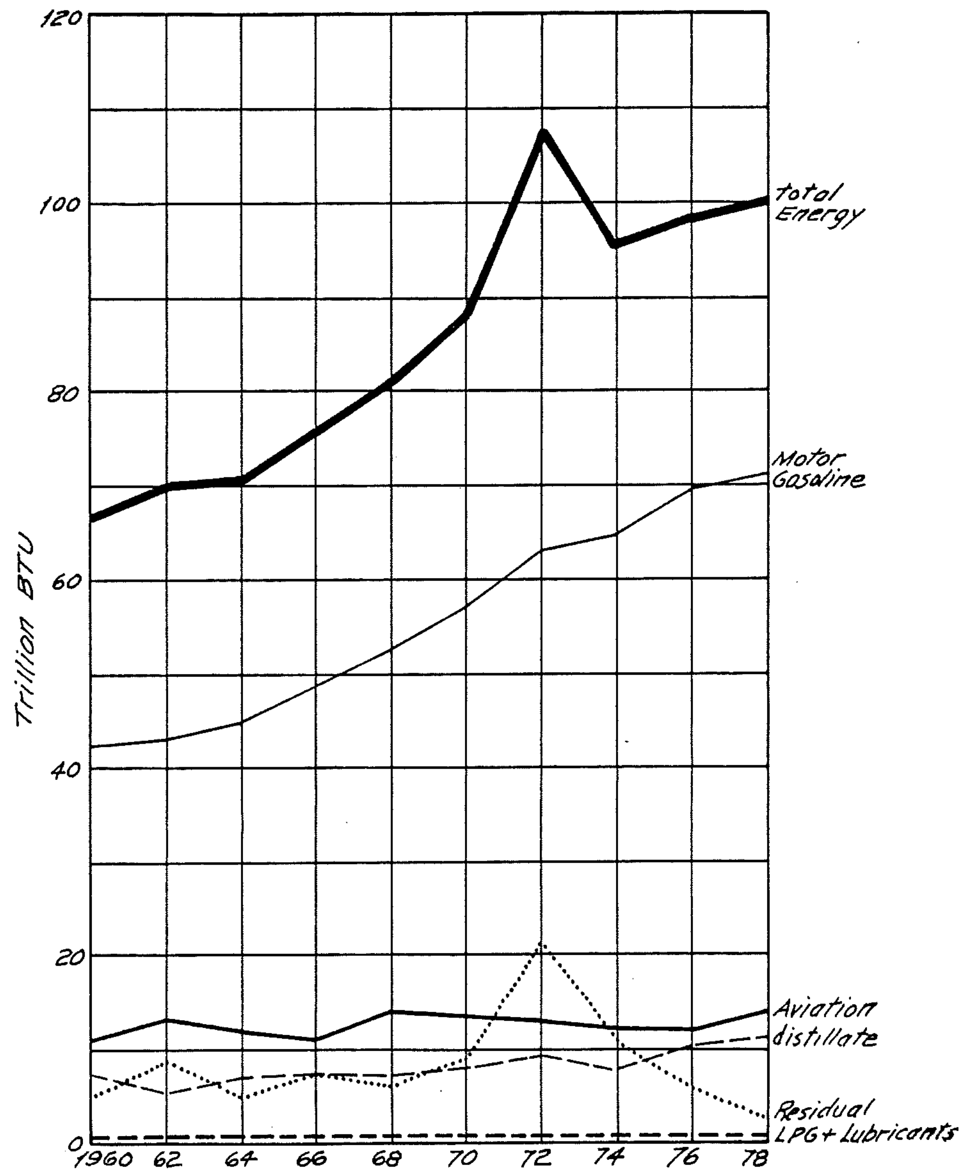
Source: U.S. DOE/EIA
1978: State Energy
Data Report

Transportation Energy Consumption

Maine's transportation system is virtually 100% dependent upon petroleum fuels as an energy source. The contributions from non-petroleum sources are insignificant and cannot be accurately depicted on the trend charts (Figure 5). The principal constituent in the transportation energy supply mix is motor gasoline, used primarily in private automobiles and light duty trucks. The other major motor fuel used in Maine is diesel oil with aviation fuel and residual oils having a small use for specific modes of transit.

FIGURE 5

CONSUMPTION OF ENERGY BY
TRANSPORTATION SECTOR IN MAINE 1960 - 1978



Source: U.S. DOE/EIA 1978: State Energy Data Report

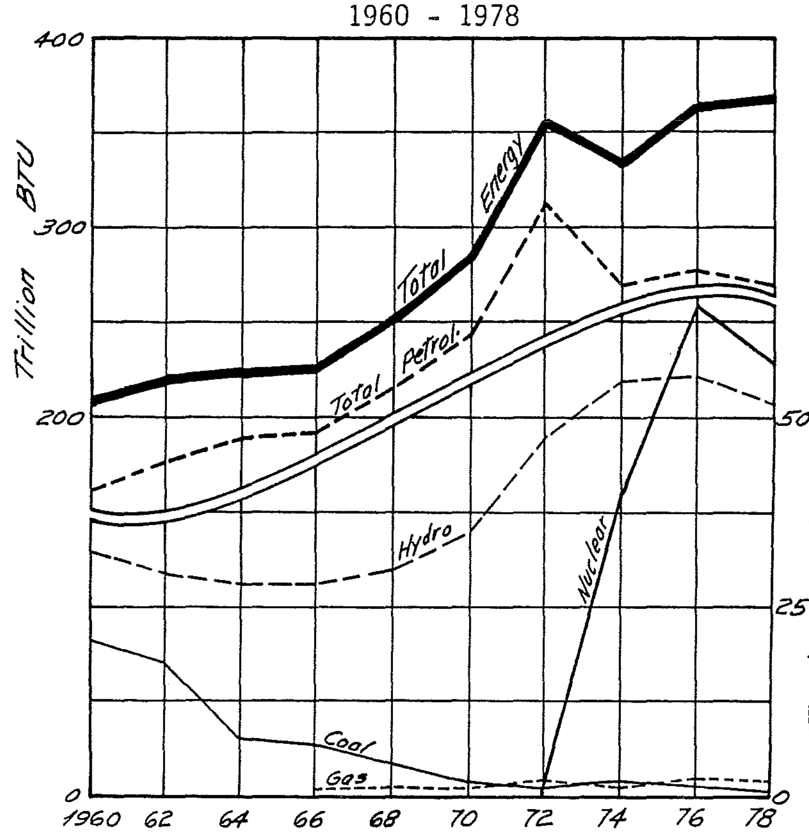
B. Energy Supply

1. Total Consumption by Fuel Type

Figure 6 presents the historical supply of energy to Maine, 1960-78, by fuel type. This energy supply picture divides energy supply into five segments: petroleum, hydro, nuclear, natural gas and solid fuel (wood and coal). It should be noted that the cumulative energy supply and demand figures described in Figures 1 and 6, if superimposed, do not always coincide. This is because the State has alternated between being a net importer or exporter of electricity during different years. When these imports and exports are accounted for, the supply and demand figures balance.

FIGURE 6

CONSUMPTION OF ENERGY BY FUEL TYPE IN MAINE
1960 - 1978



Source: U.S. DOE/EIA 1978: State Energy Data Report

Figure 6 shows that individual fuel types have varied dramatically in terms of their contribution to Maine's energy supply. Coal, for example, supplied almost 10% of Maine's total energy consumption in 1960, but less than one percent in 1978. Petroleum declined to about 72% of use in 1978[1] after peaking at more than 80% of total energy earlier in the decade. Nuclear power use was non-existent in 1960, but accounted for almost 16%[2] of the energy used in Maine in 1978. Hydroelectric power use has also remained relatively constant, contributing about 8% of total energy supply in 1978. Finally, use of natural gas, which was introducted in 1966, has grown slightly from 0.23% in that year to almost 0.6% in 1978.

2. Consumption by Resource

Petroleum Supply and Demand Trends

Petroleum in many forms is Maine's major energy resource. Of course, it has occupied this prime position for decades, as oil pushed aside other forms of energy which were most costly, less efficient and more cumbersome to transport. However, since the 1973-74 oil embargo, consumption patterns have changed significantly as has the mix of petroleum products used in Maine.

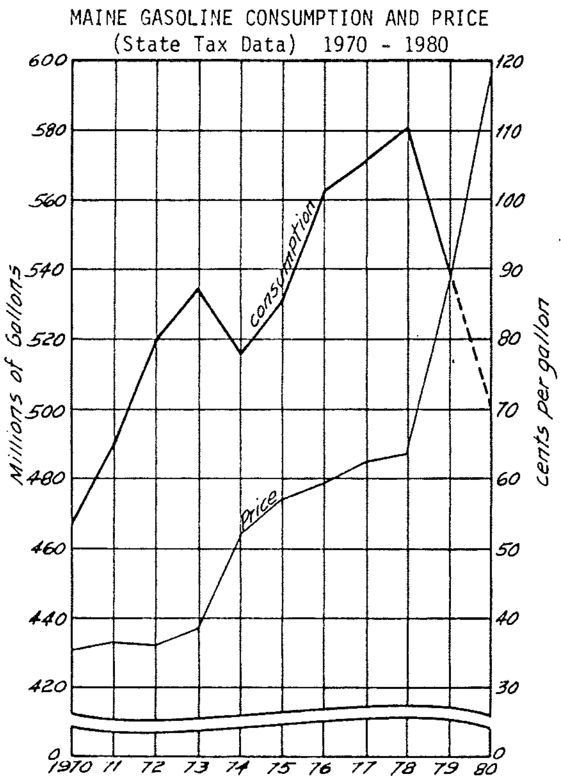
a. Gasoline

Between 1960 and 1978 gasoline consumption increased steadily, reflecting its availability and reasonable price, both of which served to promote widespread use of automobiles with little regard for economy of operation. In 1978, however, the consumption trend turned downward as the combined effect of sharply higher gasoline prices and general inflation caused motorists to choose more fuel-efficient vehicles and to reduce their driving. As prices have continued to climb, consumption has continued to fall. This trend indicates considerable demand elasticity, especially as compared with previous expectations. Figure 7 indicates the 14% decrease in gasoline consumption in Maine between 1978 and 1980.

[1] This figure is calculated using the U.S. DOE figures as presented in the State Energy Data Report. These figures are adjusted slightly in the analysis of 1978 energy consumption, and the percentages shown there are somewhat different than the numbers shown here.

[2] The hydro and nuclear figures include energy losses attributed to the electrical generation process.

FIGURE 7



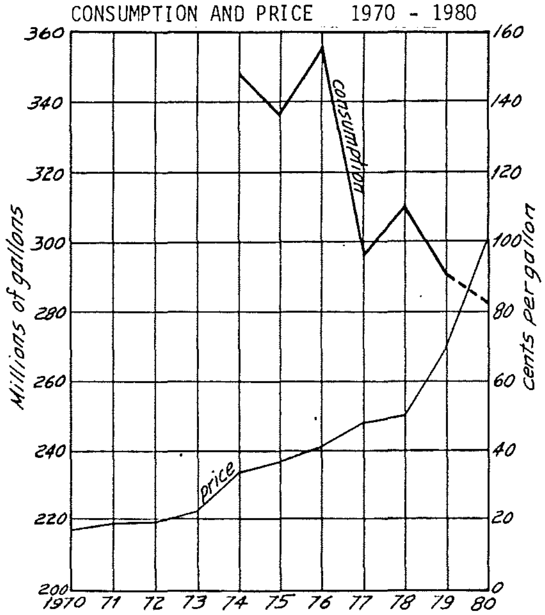
Source: State Tax Data, Department of Finance and Administration

b. Middle Distillates - Domestic Heating Oil

Home heating oil or No. 2 heating oil constitutes the largest share of all distillates used in Maine. Between 1974 and 1980, consumption of No. 2 oil decreased by 17%. The shift in consumption resulted from the pressures exerted by rising prices, parallelling the situation with respect to gasoline. However, the downturn began earlier than it did in the case of gasoline, suggesting that doubts about security of supply, resulting from the embargo, stimulated conservation efforts and the selection of alternative fuel types. Consequently, demand flexibility is evident with respect to No. 2 oil. Figure 8 indicates the trends in price and consumption.

FIGURE 8

MAINE #2 HEATING OIL
CONSUMPTION AND PRICE 1970 - 1980



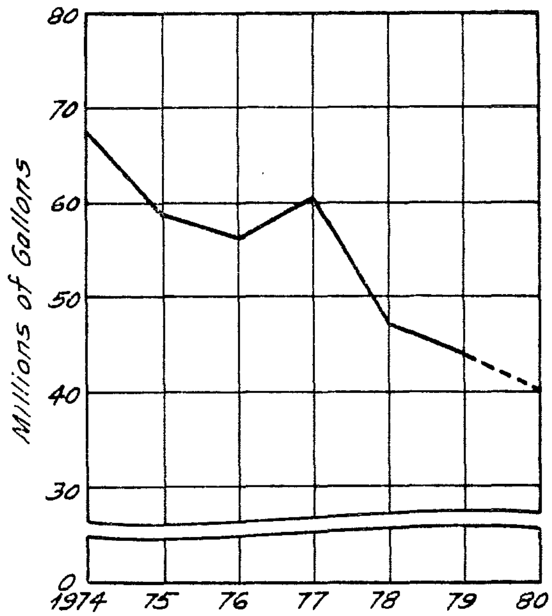
Source: Maine Office of Energy Resources: Fuel Distribution Surveys

c. Middle Distillates - Kerosene

Over the years, kerosene has been a significant heating fuel in Maine. In the last five years, however, kerosene has become sharply limited in availability on the Maine market, and No. 1 or range oil has been substituted for it. The decline in availability of kerosene results from its use as a base for jet airplane fuel. Kerosene or No. 1 oil has been widely used to blend with No. 2 heating to reduce "pour point" of the more readily available distillate and thus to eliminate the tendency for No. 2 oil to congeal at low temperatures, a major problem for residential users who store their fuel in outdoor tanks. Recently, other methods of reducing the "pour point" have become available, reducing some of the demand pressure on No. 1 oil and kerosene. Kerosene has also been used in residential space heaters in homes without central heating systems. The majority of kerosene users have been low-income families. Figure 9 illustrates the decline in kerosene consumption in Maine in the 1970's, a trend that is expected to continue until virtually no kerosene is available at the end of the decade.

FIGURE 9

MAINE KEROSENE USE 1974 - 1980



Source: Maine Office of Energy Resource: Fuel Distribution Survey

d. Middle Distillates - Diesel Fuel

The use of diesel fuel increased during the last decade and, notably, during the last two years of the period when gasoline use declined. Almost all over-the-highway trucks and many short-haul vehicles are diesel fueled. In recent years, a growing number of light trucks and automobiles powered by diesel fuel have been put in service in Maine. The incentives to increased diesel utilization are higher efficiency than gasoline and a somewhat more favorable price. At least one manufacturer has suggested that one-quarter of all light trucks and automobiles manufactured in 1990 will be diesel powered. It is expected that diesel use in Maine will continue to increase during this decade.

e. Residual Fuel

Residual fuel oils are used principally for industrial boilers and electric utility generating plants. No clear trend emerges as to the utilization of residual fuel. Users often have relatively large storage facilities which somewhat obscures demand trends. In fact, the use of residual oil may vary greatly over a specific period, if consumers shift to other energy resources. Because of rising oil prices, reflected in utility bills, and uncertain supply, residual fuel may show a decline in use due to conservation and shifts to other types of fuel. Still, this trend is expected to be gradual, with residual fuel continuing to be a major energy resource in this decade.

f. Liquid Petroleum Gas (LPG)

Very little LPG is used in Maine and demand has risen only slightly in the last decade. LPG or propane costs less than other petroleum fuels and it is more readily available throughout the world. As a result, consumption in Maine may increase from the 1978 level of 84.9 million gallons. One potential use of propane may be as a replacement for kerosene in homes lacking central heating systems.

g. Aviation Fuel

Because the majority of aviation fuel is kerosene-based, and in light of dwindling supplies of that fuel, aviation fuel use has been falling in recent years as supplies have tightened. Consumption has fallen by 40% between the 1979-1980 period, and without federal government intervention, it could almost totally disappear from the Maine market.

h. Other Petroleum Products

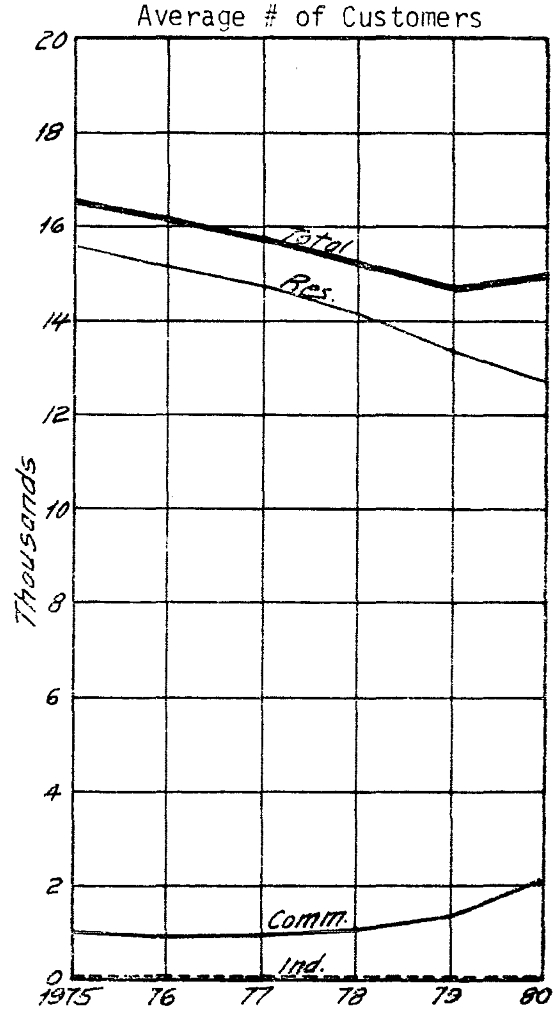
Asphalt, lubricants and other non-fuel petroleum products account for about 6% of petroleum use in Maine and are expected to continue at this level of usage in this decade. Waste lubricating oil is being used on a small scale as a fuel, when mixed with other fuel oils. This usage may have a minor impact on total petroleum consumption.

Natural Gas

This fuel was introduced in Maine in 1966, replacing manufactured gas first in Portland and later in Lewiston-Auburn. It is used in the residential, commercial and industrial sectors, and its total usage has increased in recent years. Maine's only gas utility, Northern Utilities, expects that usage will continue to increase and estimates that 12% of Maine's population have potential access to the existing natural gas distribution system. A considerable potential also exists in the commercial and industrial buildings located along the supply pipeline. Federal controls, scheduled for removal by 1985, have kept the price of natural gas lower than competitive fuels and this price advantage should persist for several more years, an encouragement to continued steady growth in this decade. Natural gas has been supplied from domestic sources, providing for security of supply. Additional supplies from Canada may become available which could improve availability in the existing market areas and in areas, such as Bangor, which would be situated along the supply pipeline. Outside of the existing market areas, usage would be expected to be principally in the industrial sector. Figure 10 shows consumption patterns.

FIGURE 10

CONSUMPTION OF NATURAL GAS IN MAINE
1975 - 1980
Average # of Customers



Source: Federal Energy Regulatory Commission Power Systems Statements (Form 12)

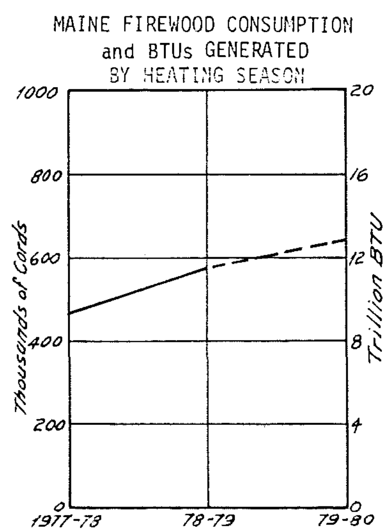
Coal

As has been noted earlier (see Figure 6), use of this fuel declined steadily from 1970 to 1977. Because of its potential as an alternative to No. 2 and wood, and because of its possible industrial uses, it has begun to increase its share of the Maine market since 1978. Coal use in Maine in 1980 was approximately 20,000 tons, and demand outstripped supply. Most of the coal used in the residential sector in Maine is anthracite, while commercial and industrial users rely principally on bituminous.

Wood

This fuel was once the backbone of energy supply in Maine, supplying an estimated 1.2 million cords for home heating and cooking in 1880. Throughout this century, wood has given way to coal, oil, gas and nuclear energy. Rapid price increases for petroleum, especially No. 2, and concern about security of supply, led in recent years to increased utilization, almost all from Maine sources. Wood has been most popular among residential users, but also has been used in industrial and commercial applications. Although there have been some recent signs that many residential users may eventually prefer coal or some other affordable alternative to wood fuel, due to the inconvenience associated with wood use, and despite the growing recognition of the limitations on total wood availability, it is expected that steady growth will continue in coming years. Figure 11 shows the recent upswing in residential fuelwood consumption.

FIGURE 11



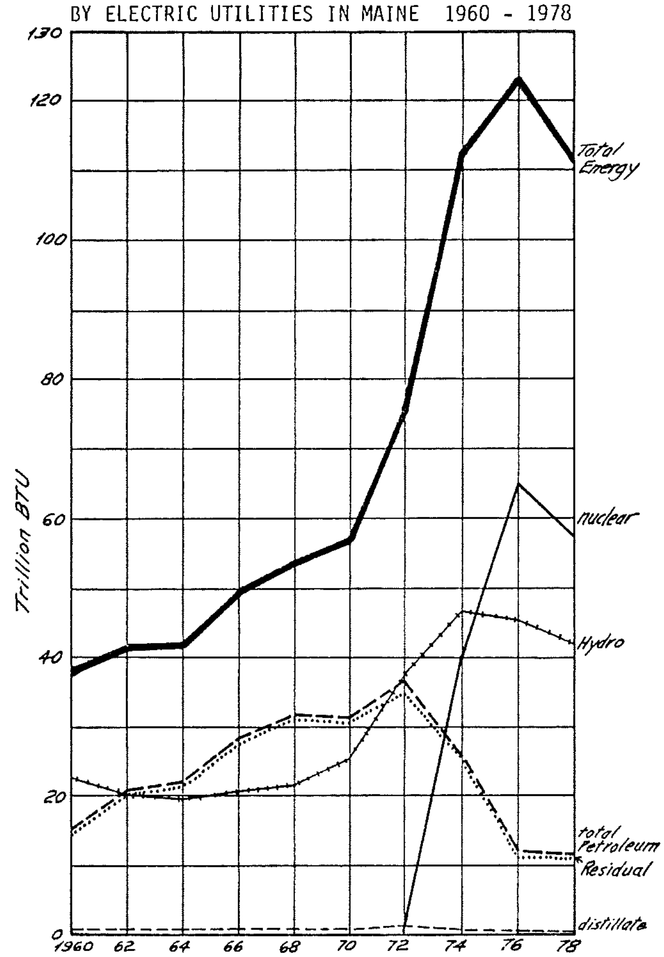
Source: Maine Office of Energy Resources: New England Fuelwood Surveys

C. Electricity

Unlike other sources of energy, electricity plays a dual role in the supply of energy. On one hand, electricity is a primary user of energy: oil, nuclear, and hydro power. These primary energy sources are consumed in the production of electricity and in that process a certain amount of energy is lost. Electricity then becomes a secondary source of supply and it is that amount of energy that is consumed directly by the residential, commercial and industrial sectors.

Figure 12 shows the consumption of primary energy sources by electric utilities in Maine between 1960 and 1978. Electricity use in Maine has risen steadily over the last 10 years at a rate of about 5.6% per year. In the last 5 years the rate of growth decreased to about 4.9% and in 1979 (not shown on the graph) the growth rate was 1.9%. The decreases in the rate of growth are considered to be due to conservation and the increasing use of alternative energy sources, measures motivated by the steadily increasing cost of electricity.

FIGURE 12
CONSUMPTION OF ENERGY
BY ELECTRIC UTILITIES IN MAINE 1960 - 1978



Source: U.S. DOE/EIA 1978: State Energy Report

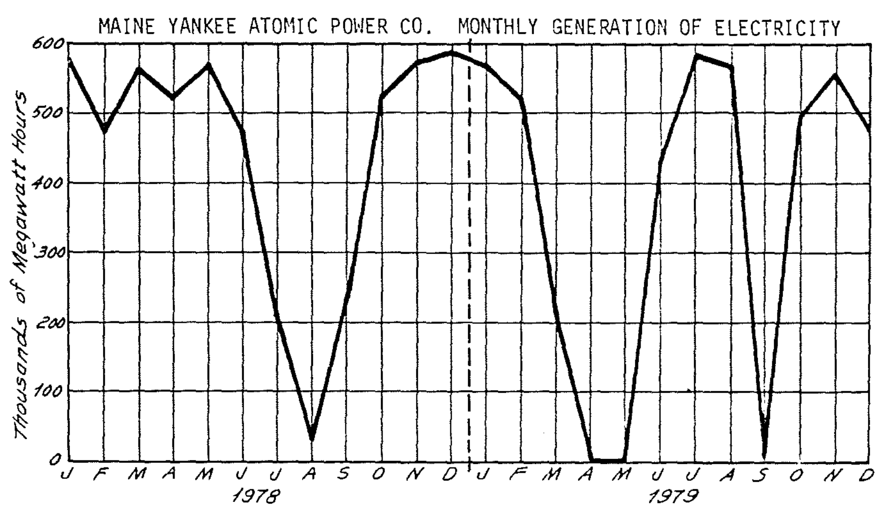
Hydro electric generation accounts for between 1/4 and 1/3 of the electricity generated by electric utilities in Maine. Dependence on hydro electric generation increased to an all time high in 1974 but, due to low water flows, declined somewhat in the last four years. In 1979, 15% of the utility-owned electric generation capacity in Maine was hydro. In addition, Maine industries own about 300 megawatts (MW) of hydro power capacity (not shown) for both electric power generation and direct mechanical drive. The industrial hydro electric generation capacity contributes about 1 billion kilowatt-hours (KWH) annually, nearly all of which is used by the industries.

Dependence on petroleum fuels for electric power generation in Maine has been reduced considerably since 1970. Oil contributed about 60% (over 4 million barrels) of Maine's electricial generation mix in 1972, but fell to 9% (less than 1.5 million barrels) of the mix in 1977, before increasing slightly again in 1978. Maine now relies on fossil fuels for about 16% of the electrical generation, nearly all of which is residual oil.

In 1972 the energy mix changed dramatically when Maine Yankee Atomic Power plant began commercial operation. Maine Yankee has a rated net plant capacity of 829 MW and has produced since it has come on line an average of 4.6 billion kwh of electricity per year. During the last 5 years it has produced an average of about 6 billion kwh. Maine utilities own 50% of Maine Yankee's capacity. Therefore, only 27% of the electricity sold in Maine in 1979 was produced by nuclear generation, although nuclear generation produced nearly 60% of the total electricity generated in the state. Maine utilities also own a combined total of 70 MW of capacity in other nuclear power plants in New England.

Figure 13 details the monthly megawatt-hour generation by Maine Yankee for 1978 and 1979. The sales of electricity by end-use

FIGURE 13



Source: Federal Energy Regulation Commission (FERC) Power Systems Statement (Form 12), 1978, 1979 sector are shown in Figure 14. As discussed earlier, the rate of growth of demand has slowed in recent years and as shown in this graph, has actually declined in the residential and commercial sectors. Prior to 1972 when Maine Yankee went on line, Maine imported more electricity from out of state than it exported. Between 1972 and 1978 Maine exported a substantial amount of electricity (see Figure 15). In 1979 we became a net importer again mainly because of the Maine Yankee shutdown in April and May.

FIGURE 14

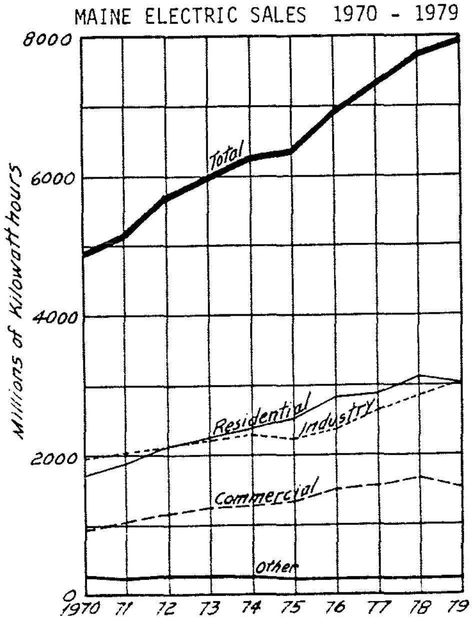
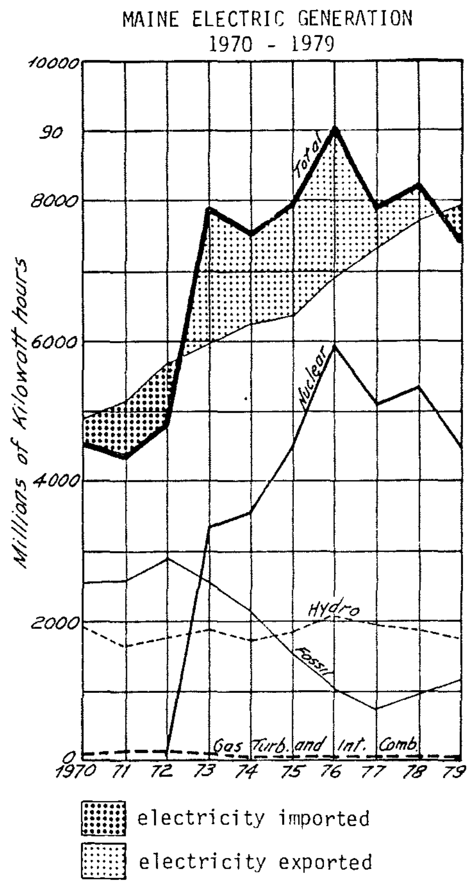


FIGURE 15



Source: Electric Council of New England: 1980 Statistical Report

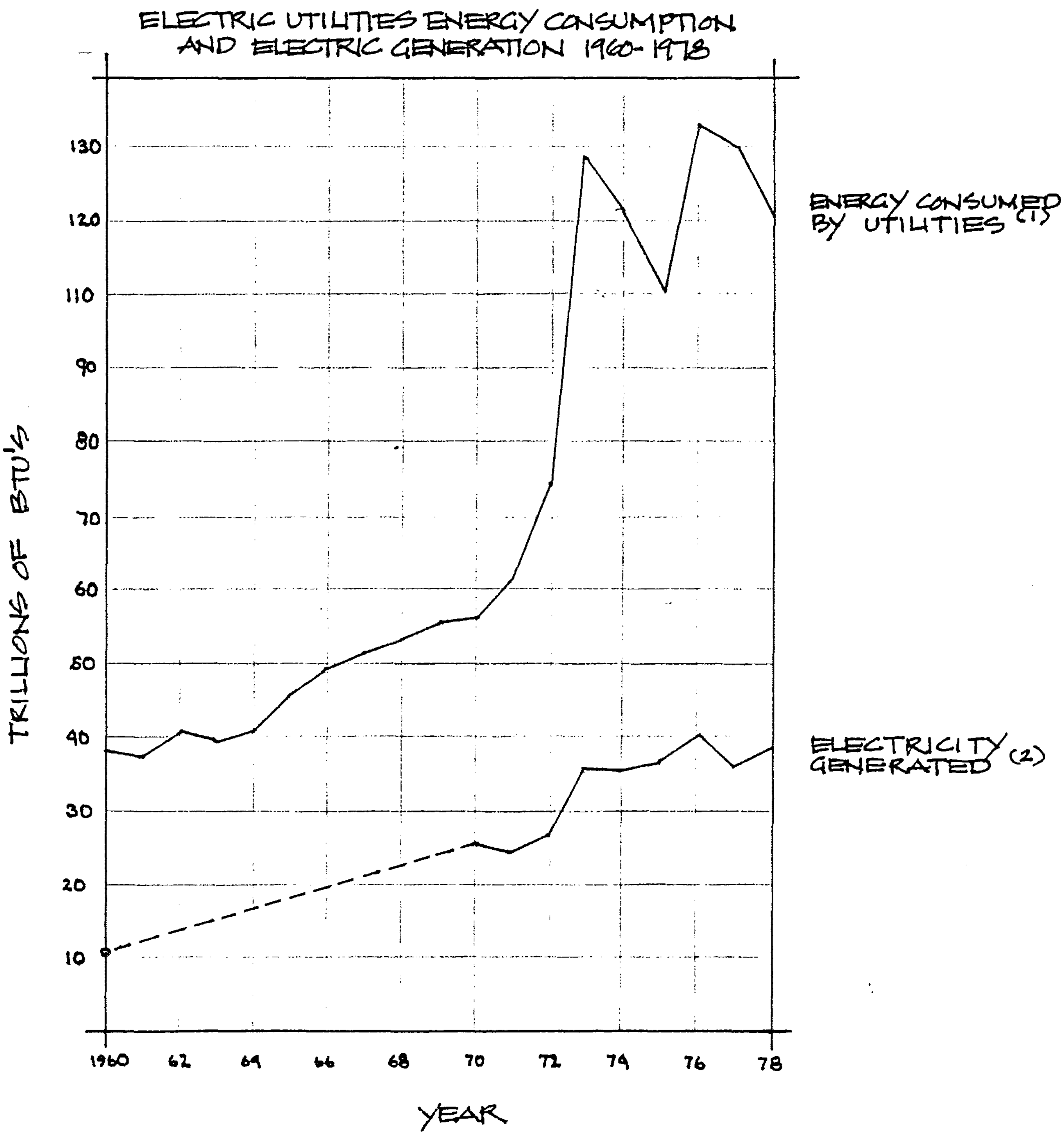
As noted at the beginning of this section, electricity is a secondary source of energy. It is an intermediate conversion and not an end-use. In nearly all conversions of a primary energy source to power there is a loss of energy. The degree to which the conversion process makes use of the full potential of an energy source is the "efficiency" of that process. For example, when oil is burned to heat a home about 70-85% of the potential energy in the oil is put to use and the rest is lost "up the chimney". Therefore, the use of oil in home heating is considered to be approximately 75% efficient.

In the generation of electricity, fossil fuels are generally accepted to be 30-40% efficient and nuclear energy is 30-33% efficient; thus, 60-70% and 67-70% of the energy potential is lost in conversion. On the other hand, hydro electric generation is nearly 100% efficient since little energy is lost in converting the energy of falling water to electricity. In order to include hydro power in the data presented in this and other sections, a constant "heat rate" of 10,400 BTU/kwh is applied to all electricity generated by hydro power. In reality, however, the electricity from hyro facilities requires no external energy input.

Figure 16 shows the relationship between the total amount of energy used to generate electricity from 1960 to 1978 and the total amount of electricity actually produced. The top line includes the total potential number of BTU's available in the primary energy source (fossil fuels, hydro and nuclear). The line labelled Electricity Generated represents the resulting energy available after conversion. This is also the total number of Kwh produced. The ratio of the two lines is the average efficiency. The loss incurred in conversion and transmission is the difference between the two lines. The average efficiency varies with a change in the mix of primary energy sources and conversion technologies.

The line representing electricity generated also represents the demand for electricity in the residential, commercial and industrial sectors. If this demand is met through other energy sources directly rather than through the use of electricity, a secondary energy source, the overall demand for energy can be reduced. For example, if oil is used to heat a home, 15-30% of the energy potential of a gallon of oil is lost in converting oil to heat. If electricity is used to heat a home and oil is used to generate the electricity, 60-70% of the energy potential of the oil is lost. When hydro power is used to generate electricity, virtually no potential energy is lost. Thus, electricity used for space heating and hot water in particular is usually not as efficient as using a primary energy source.

FIGURE 16



(1) SOURCE : STATE ENERGY DATA BOOK

(2) SOURCE : ELECTRIC COUNCIL OF NEW ENGLAND – STATISTICAL TABLES
ELECTRIC UTILITY INDUSTRY IN NEW ENGLAND

2. 1978 Energy Supply and Demand Status

1978 is the latest year for which complete, consistent data on energy supply and demand are available. For this reason, 1978 was used as the base year for this plan, and, together with the supply and demand data in Part 1, was used to develop forecasts of future energy use as presented in Part 3.

In order to put Maine's energy supply and demand patterns into perspective it is necessary to compare them with the national situation. The pie charts presented in Figure 17 allow an easy comparison of Maine's supply and demand distributions with the nation as a whole. The detailed information on which the pie charts were based is provided in Tables 1 and 2.

In terms of overall supply, Maine uses somewhat more energy in the residential (1.3%), commercial (2.1%) and transportation (3.3%) sectors and less energy in the industrial sector (6.7%) than is used nationally. From an end use perspective Maine used a total of 336.1 trillion BTUs in 1978.

The pie charts entitled "Energy Supply by Fuel Type" show very significant differences between Maine's supply mix and the national mix. Maine depends on petroleum products for 68% of our total energy supply, while the United States, as a whole, depends on petroleum for only 47.4% of the total. Likewise, natural gas and coal are almost negligible portions (0.6% and .1% respectively) of Maine's total energy supply, but they contribute 25.6% and 17.8% to the national mix. Wood, hydro and nuclear contribute greater percentages of total supply in Maine as compared with the rest of the nation.

Total energy supply equals 369.1 trillion BTUs or approximately 32 trillion BTUs more than total energy demand. This 32 trillion BTUs was energy consumed to generate net exported electricity from the state. Petroleum supplied 68% of the total energy consumed in Maine in 1978. However, because out-of-state utilities own a large fraction of the Maine Yankee Atomic Power Plant and smaller fractions of other electric generation facilities in Maine, the actual amount of energy supplied to the end use sectors in the state accounts for only 95.5% of the total energy consumption. If this out of state utility ownership were omitted from consideration, Maine's dependence on petroleum products would increase to slightly above 71%.

According to studies by the New England Regional Commission of oil supplied to New England, over 80% of the petroleum coming into the region is imported. Thus, Maine consumers are dependent on foreign oil for nearly 57% of their total energy supply. At the current average price of $30 per barrel, this level of dependence on foreign oil represents a drain on Maine's economy of more than $1 billion annually in the outflow of petroleum dollars, and contributes to the Federal balance-of-payments problem. As a result, current state programs are designed to: 1) reduce Maine's dangerous overdependence on undependable and expensive foreign petroleum supplies and 2) mitigate the adverse effects on Maine's economy that are due to rapidly escalating petroleum prices.

Table 1

1978 Energy Supply by Fuel Type

	Maine TBTU	Maine %	Maine UNITS	United States TBTU	United States %	United States UNITS
Gasoline	71.788	19.4	573.972* (13.666)	14,210.988	18.2	113,623* (2,705)
Residual[1]	61.766	16.7	412.482* (9.821)	6,936.026	8.9	46,336* (1,103)
Distillate[1]	68.648	18.6	495.971* (11.809)	7,296.139	9.3	52,607* (1,253)
Av. Fuel	14.254	3.9	109.704* (2.612)	2,230.039	2.8	16,792* (400)
LPG	8.111	2.2	84.924* (2.022)	2,068.288	2.6	21,657* (516)
Kerosene	4.474	1.2	33.138* (.789)	363.118	0.5	2,680* (64)
Misc. Petrol	22.038	6.0	214.704* (5.112)	4,860.697	5.1	35,213* (838.41)
Petroleum Subtotal	251.079	68.	1,924.895* (45.83)	37,965.295	42.4	288,919* (6,879)

	Maine TBTU	Maine %	Maine UNITS	United States TBTU	United States %	United States UNITS
Coal	0.498	0.1	20,000 tons	13,943.887	17.8	623.5 M tons
Nat. Gas	2.149	0.6	2,115 B	19,998,907	25.6	19,627.5 T cu ft
Wood[2]	19.25	5.2	962,500 cords	1003.527[3]	1.3	50.1764 M cords
Hydro	29.244[4]	7.9	1,850,000 MWH	3,173.000	4.1	304.073 M KWH
Nuclear	57.661	15.6	5,354,000 MWH	2,976.585	3.8	276.402 M KWH
Imported Elec.	9.23[5]	2.5	2,700,000 MWH			
TOTAL	369.111	100%		79,259.924[3]	100%	

NOTE: All petroleum figures are shown in millions of gallons and the parentheses indicate millions of barrels.

TBTU = Trillion BTUs
B = Billion T = Trillion
M = Million MWH = Megawatt Hours KWH = Kilowatt Hours

FOOTNOTES on the following page.

[1]Distillate and Residual Figures adjusted for displacement by wood (9.25 trillion BTU in Residential and 10.00 trillion BTU in Industry)

[2]Wood figures from Dartmouth University and New England Fuel Wood Survey

[3]Includes 1 quadrillion BTUs from wood waste in the pulp and paper industry

[4]Hydro Electric Generation calculated at 10434 BTU/kwh
Hydro electric represents the sum of electricity generated at utility owned hydro facilities (taken from the Electric Council of New England Statistical Report) plus the electricity generated by private industrial hydro facilities (taken from the DOE/EIA State Energy Data Report).

[5]Imported electricity calculated at 3414 BTU/kwh
The Imported Electricity figure was calculated by summing the total electricity generated by utilities in the State, subtracting the amount of electricity sold out of State (based on out of state ownership of electric generating plants) and calculating the difference between that amount of electricity and the actual electricity demand for all sectors (from the DOE/EIA State Energy Data Report).

Table 2

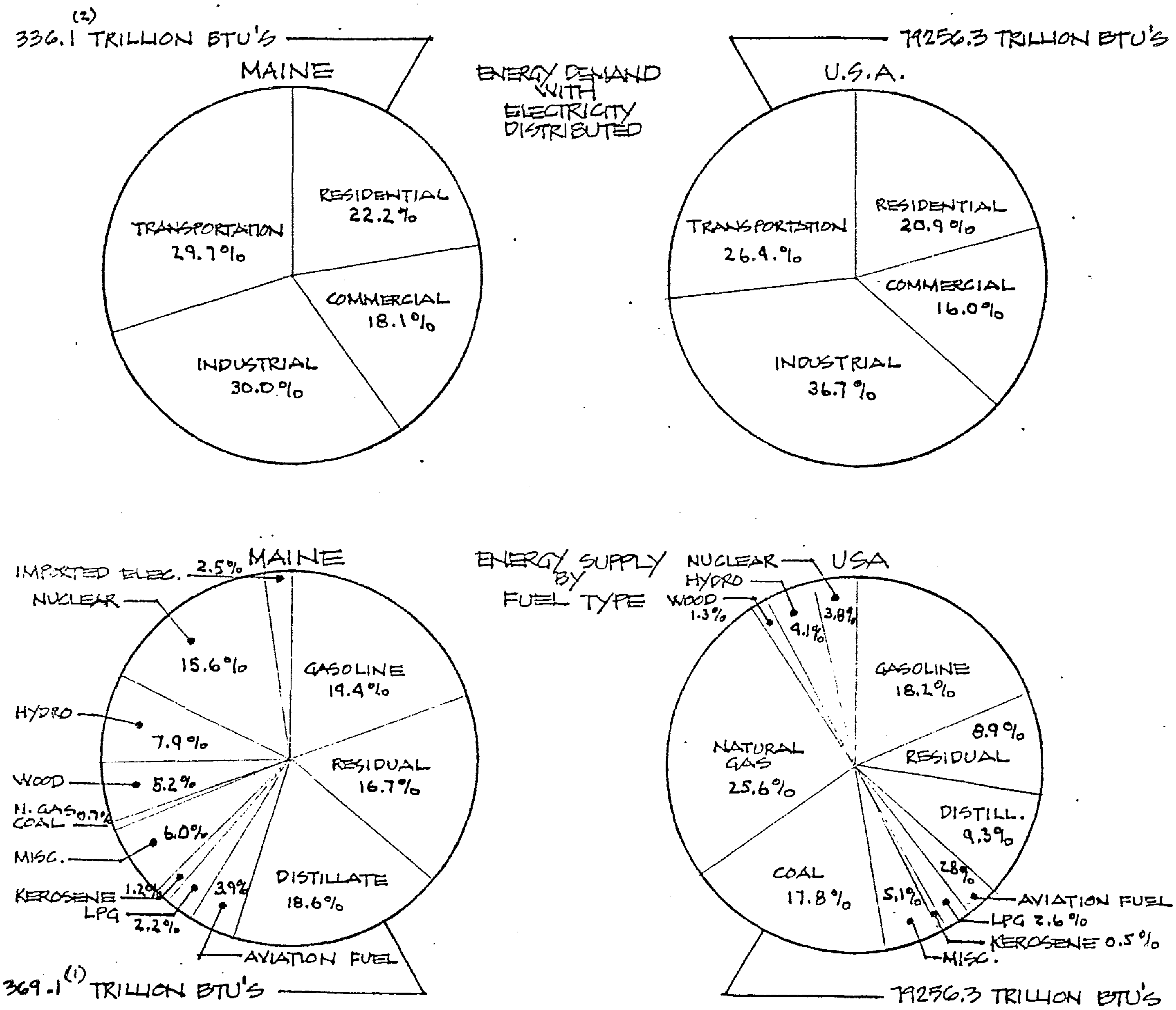
Energy Demand by Consuming Sector

	MAINE		UNITED STATES	
	Trillion BTU	Percent	Trillion BTU	Percent
Residential	74.6	22.2	16,334.8	20.9
Commercial	60.8	18.1	12,558.5	16.0
Industrial	100.9	30.0	29,739.1	36.7
Transportation	99.8	29.7	20,623.9	26.4
TOTAL	336.1	100.0	79,256.3	100.0

Note: The energy required to generate exports of electricity equals 32.2 trillion BTU

ENERGY SUPPLY AND DEMAND DISTRIBUTION
MAINE vs. U.S.A. 1978

FIGURE 17



NOTES:

(1) INCLUDES 2700 MILLION KWH IMPORTED ELECTRICITY AT 3413 BTU/KWH

(2) EXCLUDES 32.3 TRILLION BTU'S OF ENERGY REQUIRED FOR GENERATION OF ELECTRICITY EXPORTED

3. Forecast of Maine Energy Demand, Supply and Price Projections: 1985, 1990, and 2000

Introduction

The decisions that will determine Maine's energy future might well be divided into three types - individual decisions, policy decisions, and external decisions. Every day hundreds of Maine citizens make individual energy use decisions in their personal lives and businesses: whether or not to buy a new car which is more fuel efficient, whether or not to insulate their homes, whether or not to install more energy efficient equipment in their factories. These are the individual decisions. They are made within the context of fuel availability, price levels, personal incomes, and administrative regulations. Many of the factors in this equation are beyond their control. At the same time, although less frequently, the State's voters and government and the major energy producing businesses make energy use decisions with broad public consequences: whether or not to shut down Maine Yankee, whether or not to build the Sears Island plant, whether or not to subsidize home weatherization, whether or not to mandate energy efficiency standards for buildings. These are the policy decisions. They are by and large, decisions that can be made at the State level. These policy decisions affect the context within which individual decisions are made. Together they can have an important impact on Maine's energy future. Finally, there are decisions and events that are largely beyond the State's control: whether or not oil from the Mideast is interrupted by war, whether or not major new gas or oil reserves are discovered, whether or not Congress decontrols energy prices. These are external decisions. They affect the context within which individual and policy decisions are made and thus the ultimate character of Maine's energy future.

Given the uncertainty surrounding this hierarchy of energy use decisions and the interrelationships among them, an attempt to calculate a single forecast for energy supply and demand is nearly impossible. The purpose of projection is to improve decision making, to describe the alternate futures that are possible, to list the actions that will likely be required to realize each and to explain the implications of taking any particular course of action.

A. Forecast of Maine Energy Demand: 1985, 1990, 2000

The forecasts made in this section are developed from the demand viewpoint. Each major energy use in the four end-use sectors is examined and, based on historical trends and socio-economic factors, forecasts are made of energy demand in each sector. Given rapidly changing national and international events, the complex interrelationships around energy use decisions and the limited data available, an attempt to calculate a single forecast for energy demand would not be useful or valid. Therefore, the forecasts shown in this section establish a range of possibilities within which actual energy demand by end users will occur for the years 1985, 1990 and 2000. A "Low Demand" forecast for energy consumption is made assuming a combination of low growth rates in the end use sectors and a higher utilization of energy conservation measures than presently exists. This does not mean that low growth and conservation are necessarily related. This combination, however, yields a low boundary for probable energy demand. An assumption of high growth rates and adoption of conservation measures based on current practice is used to develop a "High Demand" forecast.

1. The Residential Sector

Energy consumption in the residential sector depends on the number of households, the thermal efficiency of the housing units, the number and electrical efficiency of lights and appliances used in each household, the cost of energy, and individual preferences. Future energy demand in the residential sector thus depends on a wide variety of factors. To provide a range of values within which future residential energy demand is likely to occur, high and low demand forecasts are made.

The residential forecasts are made using 1978 residential energy use and housing data as a point of departure. Energy consumption for each household is computed by dividing the adjusted total residential energy use (62.7 trillion BTUs) not including electrical generation losses by the number of households (370,000) to give an average consumption of 169.46 million BTUs per residential unit.

A study by A.D. Little for the Department of Energy shows that energy use in the residential sector breaks down as follows:

75% Space Conditioning
15% Water Heating
10% Lighting, cooking, appliance.

Applying these percentages to the overall residential consumption yields the following averages:

127.09 million BTU's for Space Conditioning
25.42 million BTU's for Water Heating
16.95 million BTU's for Lighting, cooking, appliance.

This breakdown can be used as a basis for assumptions about potential conservation measures. The greatest potential for energy conservation is in the area of space conditioning which represents 75% of the total residential energy use. To compute the energy demand forecasts for 1985, 1990 and 2000 we have focused first on conservation as it relates to space conditioning.

From surveys done for OER by the Social Science Research Institute at the University of Maine and statistical analysis of REAP questionnaires (see Section III, Conservation), estimates are made regarding the present level of energy efficiency in existing residential units (Table 3). The average home (one using 127.09 million BTU's) is assumed to be at Level 1: conservation measures including heating system maintenance, caulking and weather stripping, storm doors and windows have been adopted. Approximately 1/3 of all existing homes are at this level.

Table 3

Level	Adopted Conservation Measures	Households at Level: Percentage	Households at Level: Number	Energy Consumption Levels (MBTU)
0	None	37%	136,900	146.06
1	Heating, System Maintenance, Caulking and Weatherstripping Storm windows and Doors	33%	122,100	127.08
2	Level 1 plus R-38 ceiling insulation	20%	74,000	112.47
3	Level 1 plus floor and wall insulation	10%	37,000	86.18

Energy Consumption levels for new housing are calculated differently from those for existing housing. All new houses are assumed to meet the Maine Energy Efficiency Building Standards which allow a maximum heat loss of 38,000 BTU per square foot of floor area. This assumption is based on the agreements that have been reached by the OER with the Maine State Housing Authority and the Farmer's Home Administration for new construction to meet these standards. MSHA and FMHA account for 75% of all new housing construction in Maine. If, in addition to meeting the standards, these houses are properly designed and sited to take advantage of passive solar energy, the space heating energy consumption can be reduced even further. These two additional levels are represented as follows:

Level	Adopted Conservation Measure	Energy Consumption Levels (MBTU's)
4	Meets building standards	52.80
5	Level 4 plus passive solar	42.30

Table 4 shows the low and high growth forecast of housing units expected to exist in the State in the years 1985, 1990 and 2000. Two forecasts were made by the Maine State Planning Office for high and low growth scenarios.

Table 4

Number of Households in Maine

	Low Growth	High Growth
1985	407,000	423,000
1990	436,000	461,000
2000	494,000	527,000

Table 5

Distribution of Housing Units by Level of Conservation

Energy Consumption Level	0 146.06*	1 127.08*	2 112.47*	3 86.18*	4 57.80*	5 42.30*
1985 High	24,000 units	185,000 units	110,000 units	0	47,700	5,300
1985 Low	55,500 units	148,000 units	148,000 units	18,500	33,000	3,700
1990 High	66,000 units	148,000 units	129,500 units	18,500	81,900	9,100
1990 Low	0	110,000 units	220,000 units	37,000	59,400	6,600
2000 High	0	110,000 units	220,000 units	37,000	133,450	23,550
2000 Low	0	110,000	277,500	92,500	93,000	31,000

*MBTU

The high growth scenario assumes an annual growth in residential housing of 7% by 1985, 1990 and 2000. The low growth rate is based on present 5% growth in new housing. Using the household growth and conservation data presented, the distribution of housing units by level of conservation is calculated (Table 5).

The low demand forecast is calculated based on an assumption of low household growth, 5% per year, and extensive adoption of energy saving conservation methods through private efforts and public programs. By 1990 all new housing units in the State are assumed to have adopted at a minimum, level 4 conservation measures and the number of existing units achieving level 2 conservation is doubled. This forecast further assumes that by the year 2000 all homes will have achieved conservation levels 0 and 1 with the majority of existing homes at level 2. This forecast represents demand estimates for a low growth situation with maximum achievable levels of conservation.

The second demand forecast - the high demand scenario - assumes a residential growth rate of 7% and that conservation investments continue at current levels without further public intervention. The high demand scenario assumes conservation will take place at a slower pace than in the low demand scenario. Conservation levels achieved in the low demand forecast in 1990 are not achieved in the high demand forecast until the year 2000. In this forecast nearly 7% of homes in the year 1990 have not achieved level 1 conservation while in the low demand forecast all homes achieve this level.

To this point the focus of the analysis has been on forecasts as they relate to space conditioning demands. Current rates of conservation for water heating, lights and appliances are used in both the high and low demand scenarios. In calculating total demand for each scenario we have allocated the same proportion of energy necessary to meet these uses.

Table 6 and Figure 18 represent the high and low demand forecasts. In the total low demand scenario the forecast shows a decline in residential energy demand through 1990 followed by a slight increase in the year 2000. This forecast assumes that the greatest potential for conservation is achieved by the year 1990 and that demand from the growth in new homes marginally outweighs savings from conservation efforts by the year 2000.

In the high demand forecast there is a rapid increase in demand until 1985. The forecast then assumes that market forces will provide an increased incentive to conserve and that new buildings will be at level 4 or 5 of energy conservation efficiency. This results in a leveling off in total demand for the years 1990 and 2000. In the year 2000 the low demand forecast shows a decline in demand of 5.6% from 1978 and the high demand forecast an increase of 7.2%.

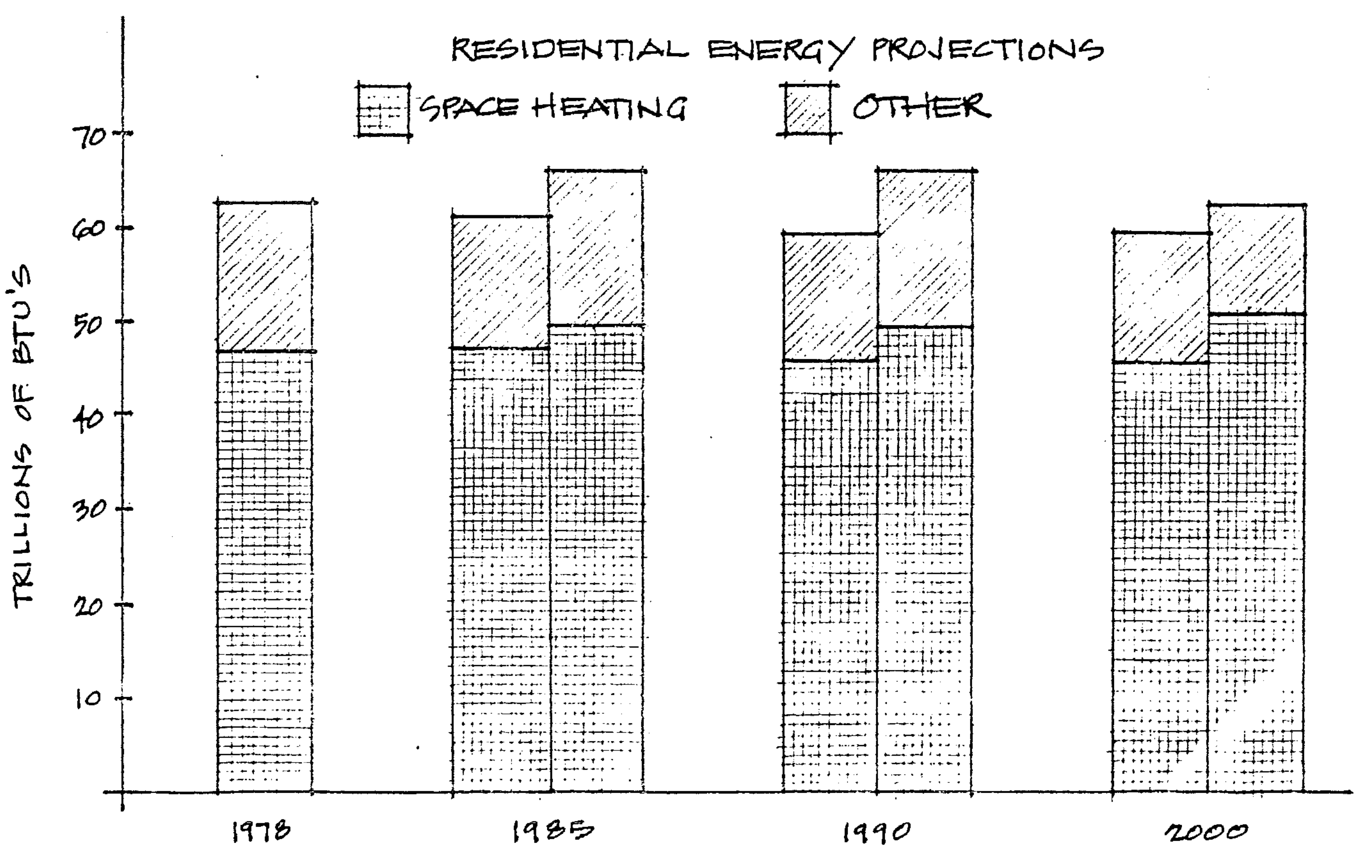
TABLE 6

Forecast of Total Residential Energy Use
1978-2000

All Data in Trillions of BTU's

Actual Energy Demand		
1978		
Space Heat	47.0	
Lights, Appliances	15.7	
	62.7	
	Low Demand	High Demand
1985		
Space Heat	47.2	49.7
Lights, Appliances	13.7	16.5
	60.9	66.2
1990		
Space Heat	45.6	49.5
Lights, Appliances	13.3	16.5
	58.9	66.0
2000		
Space Heat	45.9	50.6
Lights, Appliances	13.3	16.4
	59.2	67.5

FIGURE 18



2. The Commercial Sector

Energy consumption in the commercial sector, as in the residential sector, serves primarily to provide space heat (59.3%) and to run lighting (24.3%) and appliances (16.2%). In the commercial sector water heating accounts for only .3% of total demand, as contrasted with 15% in the residential sector.

Future energy demand in this sector will depend primarily on the growth of commercial activity in the State, on the thermal efficiency of commercial buildings, and on the electrical efficiency of the lights and appliances used in commercial establishments. High and low energy demand forecasts, therefore, are built upon alternative forecasts of commercial growth and estimates of the proportion of commercial establishments which adopt various energy saving technologies between now and the year 2000.

The total square footage of conditioned commercial space was estimated using employment figures. Future employment figures, as projected in the Energy Systems Research Group Study[1] for high and low economic growth scenarios for each of 14 categories of commercial employment were then used to project the total floor space occupied by each of those categories in 1985, 1990 and 2000. These figures were then multiplied by the average per square foot energy consumption for 1978 (673,550 Btu/sq.ft.) to determine the baseline energy consumption figure. As can be seen in Table 7, total commercial floor area is projected to increase by 32% in the year 2000 in the high demand scenario and 19% in the low demand scenario.

[1]Energy Systems Research Group, Inc., Long Range Forecast of Central Maine Power Company and New England Electric Energy Requirements and Peak Demands, October 1980. The high growth forecast was taken from the NEPOOL Forecast of New England Electric Energy and Peak Demand, 1980-1995. The low growth forecast was taken from U.S. Department of Labor Projections of Industrial Employment to 1985.

TABLE 7

Floor Area in Millions of Square Feet

Category	1978	1985 High	1985 Low	1990 High	1990 Low	2000 High	2000 Low
Office	14.23	16.50	17.53	17.70	19.41	20.13	23.12
F.I.R.E. Federal Govt. State & Local Government Professional Services							
Retail	25.75	32.16	27.76	34.11	28.22	39.20	30.07
Wholesale/ Retail Trade Lodging Repair							
Schools and Hospitals	25.66	23.78	25.82	24.99	23.93	27.46	26.00
Other	10.39	11.78	10.59	12.23	10.75	13.40	11.08
Truck & Warehousing Transport Communication Recreation Railroad							
TOTAL	76.03	84.23	78.22	89.03	82.32	99.97	90.28

The following table outlines the basic breakdown of energy consumption in existing buildings in the commercial sector. The conservation potential for each end is indicated for three levels. The percentages for each of the levels indicate the potential for savings. These percentages were obtained from case studies[1] of actual energy savings in existing commercial buildings. These figures are used to generate the projections and the relative level of conservation achievable for each use for existing buildings.

End Use	% of Total Demand	Conservation Potential Level 1	Conservation Potential Level 2	Conservation Potential Level 3
Space Heating	59.3	7%	15%	25%
Lighting	24.2	10%	18%	25%
Equipment	16.2	15%	25%	35%
Water Heating	0.3	5%	7%	10%

The levels delineated for each end use are explained below:

Space Heating:

Level 1 - Improvements in the operation and maintenance of heating, ventilating and air conditioning systems including adjustment of outside air vents, replacement or repair of worn valves and steam traps and/or readjustment of system controls.

Level 2 - Level 1 plus improvements to the building envelope including caulking and weatherstripping, door vestibules and/or storm windows.

Level 3 - Level 2 plus additional improvements to envelope including insulation.

Lighting:

Level 1 - Removal of unnecessary lamps, cleaning of fixtures and other routine maintenance.

[1]"How to Save Energy and Cut Costs in Commercial and Industrial Buildings, An Energy Conservation Manual", F. Dubin, L. Mendell and S. Bloome, FEA Conservation Papers, Number 20 and 21, 1975.

Level 2 - Level 1 plus replacement of flourescent 40 and 80 watt bulbs with 35 and 70 watt bulbs and replacement of incandescent bulbs with lower wattage bulbs.

Level 3 - Level 2 plus replacement of incandescent lighting fixtures with metal halide or flourescent fixtures.

Equipment:

Level 1 - Reduction of unnecessary equipment usage, replacement of inefficient equipment at the end of the useful equipment life.

Level 2 - Level 1 plus rewiring of controls to allow more efficient operation, rescheduling of processes to reduce equipment usage.

Level 3 - Level 2 plus replacement of inefficient equipment before the end of its useful life where energy savings potential shows a positive payback.

Hot Water Heating:

Level 1 - Reduction in hot water temperatures.

Level 2 - Level 1 plus reduction in hot water usage through installation of flow reducing devices.

Level 3 - Level 2 plus renovation of hot water heating system.

A study done by the Arthur D. Little Company for the Federal Energy Administration compared energy consumption in existing commercial buildings with that of similar buildings built to conform to ASHRAE Standard 90-75 for Energy Conservation in new buildings. Since Maine's Energy Efficiency Building Performance Standards are similar to ASHRAE 90-75 the potential savings identified in the A.D. Little study were used to determine the energy efficiency of new buildings in Maine. The table on the following page summarizes the savings achievable if buildings are built to that standard.

New Commercial Buildings

Commercial End Use	Potential Savings
Office Buildings	61.5%
Retail/Wholesale Trade	41.6%
Schools	45.6%
Other Commercial Buildings	39.1%

Table 8 indicates the percentage of commercial building types forecast in the three conservation levels to the year 2000. Thus, the percentages shown indicate the "penetration rate" for the various levels of conservation in each building type. For example, we project that 25% of office buildings will be brought to conservation level one by 1985 in the high conservation scenario. In the low conservation projection only 10% of the buildings will be brought to level 1 by 1985. The minimum conservation projection assumes that conservation is caused only by market forces and that the real or perceived advantages to conservation will be small. The maximum conservation projection assumes government incentives as well as market forces will affect conservation and raise the real or perceived conservation ethic.

Energy conservation opportunities were calculated for each category and applied to the high and low economic growth projections to arrive at final energy demand figures. The level of use of diesel fuel for construction was assumed to be constant for the low demand scenario and to increase at the rate of 1% per year in the high demand scenario. About 8% of the energy consumed in the commercial sector is diesel fuel used to power heavy equipment, mostly in the construction industry.

The forecast of total energy demand for the commercial sector to the year 2000 is shown in Table 9 and Figure 19. As can be seen in the low demand forecast, total energy demand is projected to decrease by nearly 5.0% by 2000. This decrease can be attributed to several factors including increased energy conservation through building standards, lighting and low economic growth. In contrast, the high growth forecast shows an increase in demand by 8%. This is a result of greater economic growth and maintenance of current levels of conservation.

TABLE 8

Commercial Energy Conservation
Penetration Rate

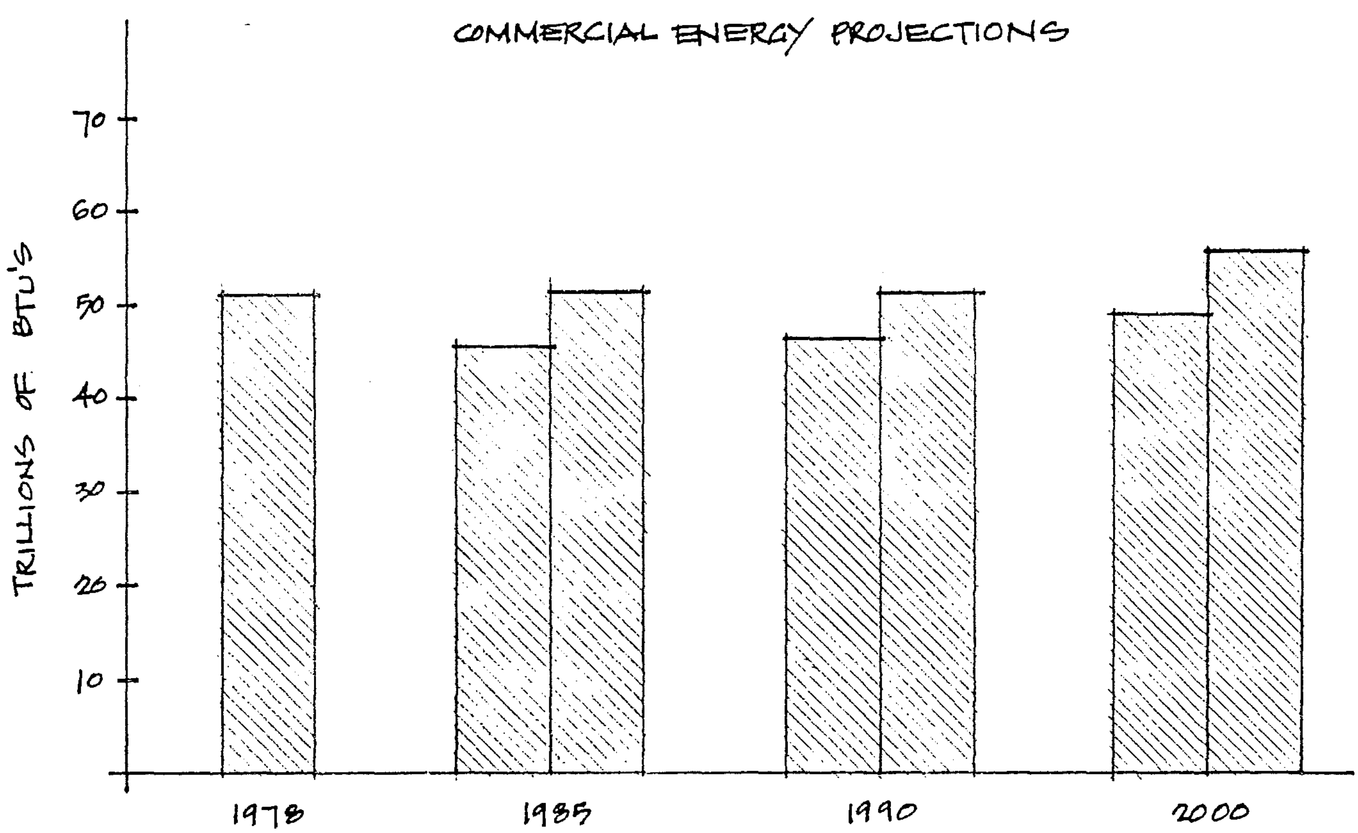
Building Type	High Conservation Level 1	High Conservation Level 2	High Conservation Level 3	Low Conservation Level 1	Low Conservation Level 2	Low Conservation Level 3
Office						
1985	25%	23%	12%	10%	07%	03%
1990	34%	25%	18%	14%	11%	08%
2000	42%	30%	25%	24%	19%	15%
Retail						
1985	28%	16%	06%	12%	06%	00%
1990	32%	18%	09%	21%	10%	04%
2000	47%	21%	12%	37%	20%	10%
Schools & Hospitals						
1985	45%	30%	25%	75%	15%	10%
1990	30%	35%	35%	65%	20%	15%
2000	15%	40%	45%	50%	30%	20%
Other						
1985	10%	05%	00%	05%	00%	00%
1990	15%	10%	05%	08%	02%	00%
2000	25%	20%	10%	15%	05%	00%

Table 9

Forecast of Total Energy Demand
By Building Type and Construction Trades
(Trillions of BTUs)

	1985		1990		2000	
	High	Low	High	Low	High	Low
Office	9.11	7.59	9.05	8.47	9.35	9.56
Retail	17.93	15.39	18.23	15.50	19.31	15.75
Schools and Hospitals	13.47	11.57	12.76	12.01	14.15	13.20
Construction	4.40	4.10	4.62	4.10	5.11	4.10
Other	6.92	6.52	7.06	6.15	7.43	6.16
TOTAL	51.83	45.17	51.72	46.24	55.35	48.77

FIGURE 19



3. The Industrial Sector

Energy in the industrial sector is used to power machinery to provide process and space heat. Future industrial energy demand, therefore, depends on growth in industrial activity and increases in the energy efficiency of industrial processes. In addition, the industrial sector has the capacity to generate much of its own energy through utilization of hydropower, burning of waste materials, and reclamation of lost heat. High and low forecasts of industrial energy demand result from different assumptions about these basic determinants of demand. The total energy demand projections for the industrial sector are based on an energy use per employee basis.

Based on data in the ESRG Study as previously documented, the following levels of economic growth were used as a basis for these projections:

High Growth	3.0% per year through 2000
Low Growth	1.5% per year through 2000

From data gathered by the OER for the Energy Conservation "C" Awards program and data available from the U.S. Department of Energy on conservation potentials and the level of conservation now underway in the industrial sector, the following conservation potentials were determined:

Year	High Conservation	Low Conservation
1985	5%	0%
1990	10%	5%
2000	20%	10%

The 5% conservation figure is considered to be a minimum level achievable through increased emphasis on operations and maintenance procedures such as the cleaning and periodic replacing of steam traps. The 10% and 20% levels of conservation involve capital investment to improve the efficiency of equipment, to upgrade boilers to allow for cogeneration of electricity and improved technologies for making basic products.

It should be noted that the conservation levels for industry are not broken down by end use as in the preceeding sectors, because it is difficult to trace a given BTU of energy through an industrial process and determine how it is used. Also, when the Federal Energy Administration (Now DOE) set voluntary industrial energy conservation targets in 1975, only total energy consumption was considered. Since the results of that program were used to form part of the data base for these projections, a projection of total conservation was made.

These projections represent various levels of conservation in different types of industrial processes. A detailed analysis of those processes and a determination of the absolute conservation potential and payback for each is unavailable, and therefore a more detailed estimate cannot be made. As OER meets with industrial energy users throughout the State, more of this type of definitive, quantifiable data will be collected and better estimates will then be possible.

Unlike the commercial sector, the 1978 consumption figure, not including electrical generation losses, is divided by the total number of employees in that sector in that year to determine a baseline energy consumption figure of 601.5 million BTU/employee. This number, along with the figures delineated previously, are used to generate the following table which indicates the energy use per employee for the high and low conservation scenarios.

Energy Use Per Employee

Year	Low Conservation	High Conservation
1985	601.5 million BTU	581.5 million BTU
1990	571.5 million BTU	541.4 million BTU
2000	541.4 million BTU	481.2 million BTU

These numbers are then multipled by the high and low growth projections of employment to determine the total energy demand for the industrial sector. After determining demand, the share of demand met by self-generated hydro electric and purchase electricity are estimated using the industrial electric growth rates projected by OER in its testimony regarding the Sears Island Case and projected development of private hydro sites by industrial concerns. The resultant forecast is outlined in Table 10 and Figure 20.

Because industrial growth is assumed in either case, the forecasts show an increase in industrial energy demand in both the high and low demand scenarios. In the low demand scenario, the level of conservation assumes high capital investment in energy saving and production technologies. This forecast also includes an increase in self-generated electricity by hydro electric facilities. Self-generated electricity in itself conserves energy in two ways. First, it decreases industry's dependence on oil or other fossil fuels necessary to generate electricity in the plant. Second, it reduces the demand for utility generated electricity. Both of these result in savings because of the increased efficiencies inherent in hydro electric generation. Overall, demand in the low demand forecast increases by 10% in the year 2000.

In the high demand forecast, the combination of high economic growth and low investment in conservation results in a 42% increase in demand by 2000. In this scenario, self-generated electricity increases at a low rate with the balance made up by a large increase in purchased electricity.

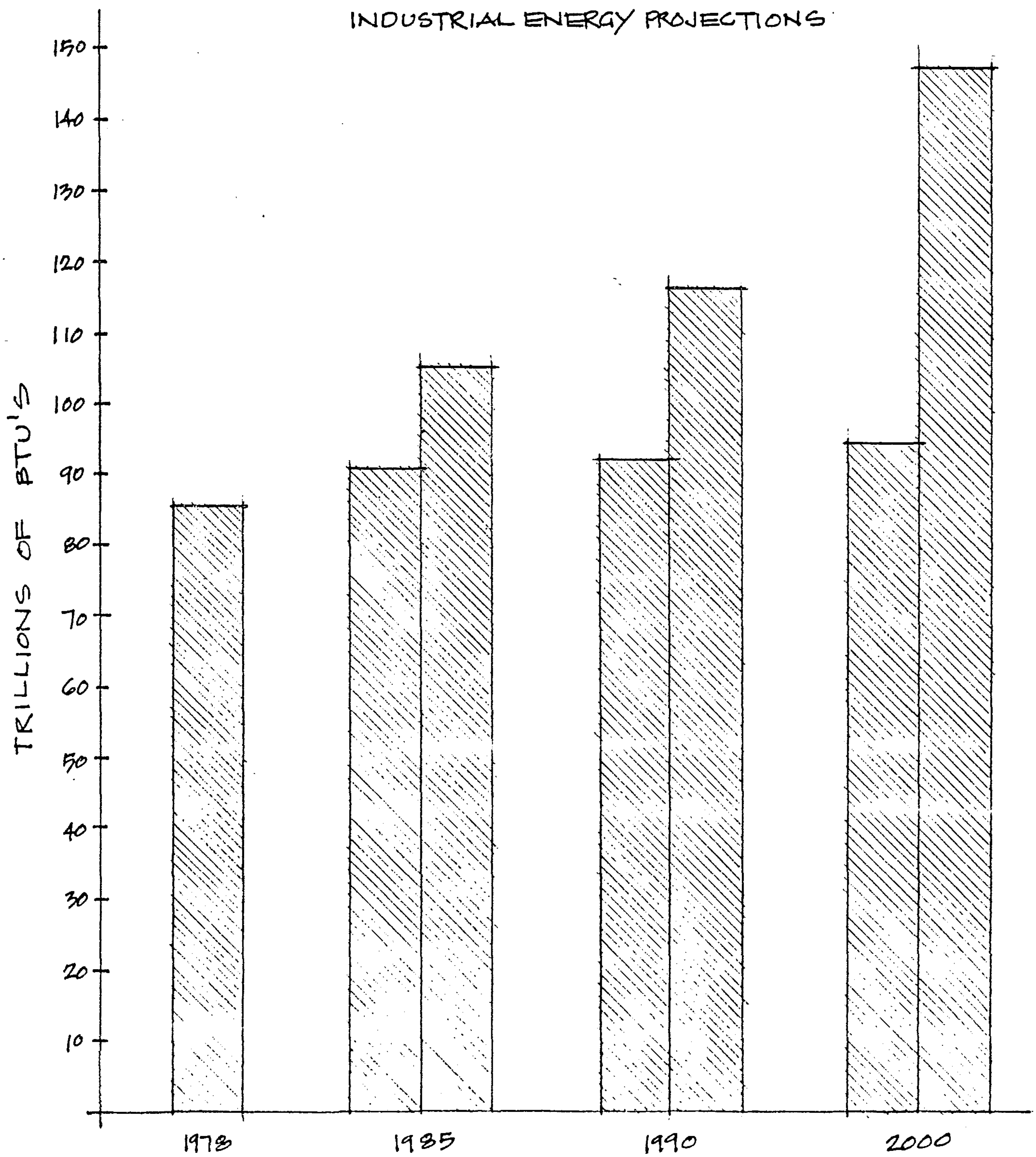
TABLE 10

Forecast of Industrial Energy Use, 1978-2000

1978 (Actual)	Trillions of BTU's
Electricity	
Self-Generated	10.8
Purchased	10.8
Other	64.62
TOTAL	85.42

	Low Demand	% Change from 1978	High demand	% Change from 1978
1985				
Electricity				
Self-Generated	10.9		10.4	
Purchased	11.0		15.2	
Other	68.2		79.5	
TOTAL	90.1	+ 5.48%	105.1	+23.04%
1990				
Electricity				
Self-Generated	11.4		10.9	
Purchased	11.0		17.3	
Other	68.2		87.5	
TOTAL	91.9	+ 7.49%	115.7	+35.45%
2000				
Electricity				
Self-Generated	12.0		11.4	
Purchased	10.9		24.5	
Other	71.3		111.4	
TOTAL	94.2	+10.28%	147.3	+42.32%

FIGURE 20



INDUSTRIAL ENERGY PROJECTIONS
TRILLIONS OF BTU'S
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
1978
1985
1990
2000

4. The Transportation Sector

All the energy used in the transportation sector comes from petroleum products. Gasoline and diesel fuel power land-based transportation such as cars, trucks, buses and trains. Airplanes burn both kerosene jet fuel and aviation gasoline and some ships use residual oil.

Land-based transportation consumes 82% of the energy in the transportation sector. As a result, this forecast focuses on gasoline and diesel usage. The major factors affecting transportation demand include the number of vehicles in the state and their fuel efficiency, the number of miles driven, transportation conservation programs, and the price which can have an impact on all of these.

A number of assumptions underlie the forecast. Linear projections based upon historical Maine data are considered to be adequate in predicting fuel consumption, the number of registered vehicles, and their average mileage per gallon. Diesel fuel demand is expected to increase at a rate based upon historical consumption patterns, but aviation fuel demand should be restrained by high prices and lack of availability and will level out at 40,000,000 gallons per year.

In making the forecasts for total fuel use it is assumed that the gasoline demand will decrease as vehicles become more fuel efficient. Table 11 shows historical and projected mile per gallon figure for vehicles in Maine. The forecast shows vehicle and truck efficiency will more than double from 1980 to 2000. In other words, the same miles can be driven for 1/2 the amount of gas. The average mileage figures presented in the forecast are based upon Maine vehicle registration data, fuel economy levels as measured by the Environmental Protection Agency, and statistics from the Regional Transportation Data book. Truck mileage per gallon is assumed to increase at the same rate as automobile mileage.

TABLE 11

Average Miles Per Gallon

Maine Vehicles

	Automobile	Truck
1975	13.61	11.83
1976	13.84	11.83
1977	14.44	11.83
1978	15.06	11.83
1979	15.85	11.83
PROJECTIONS		
1980	16.34	13.97
1985	19.85	16.97
1990	24.11	20.61
2000	35.58	30.41

Based upon Maine vehicle registration data, industry fuel economy levels as measured by EPA, and the Regional Transportation Data Book.

Table 12 illustrates the growth in vehicle registration on a historical and projected basis. In this forecast, the number of automobiles increases by 42% from 1980 to 2000; trucks increase 100%. An assumption is made that higher mileage automobiles will increase from approximately 21% of the total registered autos in 1980 to over 40% by the year 2000.

TABLE 12

Vehicle Registration in Maine by Type, 1970-1979

	Total Automobiles	Total Trucks	Higher Mileage Automobiles
1970	374,795	101,881	36,003
1971	388,612	109,811	42,307
1972	406,272	120,015	49,371
1973	421,400	131,719	57,196
1974	428,559	141,443	64,233
1975	440,826	149,895	71,836
1976	466,524	152,209	78,541
1977	492,594	164,866	89,861
1978	494,417	188,378	88,565
1979	496,374	192,831	96,404

Projected Vehicle Registration In Maine, 1979-2000

	Total Automobiles	Total Trucks	Higher Mileage Automobiles
1980	522,044	203,082	109,316
1985	595,464	254,801	157,024
1990	668,699	306,389	212,579
2000	741,934	409,178	303,877

In projecting fuel usage, the number of miles travelled per vehicle are expected to remain constant at 10,728. There have been reductions in miles travelled as a direct consequence of fuel price increases. The assumption that the average number of miles driven will remain constant is based on two considerations. First, greater fuel efficiency will enable motorists to drive the same distance as they now travel and still realize a savings in fuel consumption. Second, much of the driving done in the state is commuting to and from work so many people will need to drive as much in the future as they did in the past. Based on statistics compiled by the Office of Energy Resources, out-of-state tourists will use 10% of the state's gasoline consumption each year.

The high demand of gasoline consumption forecast to the year 2000 assumes conservation occurs as a result of market forces and carpool and vanpools remain at current levels. The forecast shown in Table 12-A and Figure 21 indicates that increased mileage efficiency of automobiles and trucks will reduce the demand for total fuel by more than 25% from 1978 to 2000.

The low demand forecast is based on assumptions in the growth in the use of vanpools and carpools as a result of private employer actions and government involvement above current levels. In this forecast vanpools increase at the rate of 200/year and carpools at the rate of 1350/year. This scenario shows a decrease in fuel consumption of 31.7% from 1978 figures.

The increase of additional conservation measures as reflected in the low demand scenario shows a savings of 8.8% over the high demand forecast in the year 2000. Overall, however, with increased conservation resulting from more fuel efficient vehicles both "high" and "low" demand forecasts show a significant decline in fuel consumption by 2000.

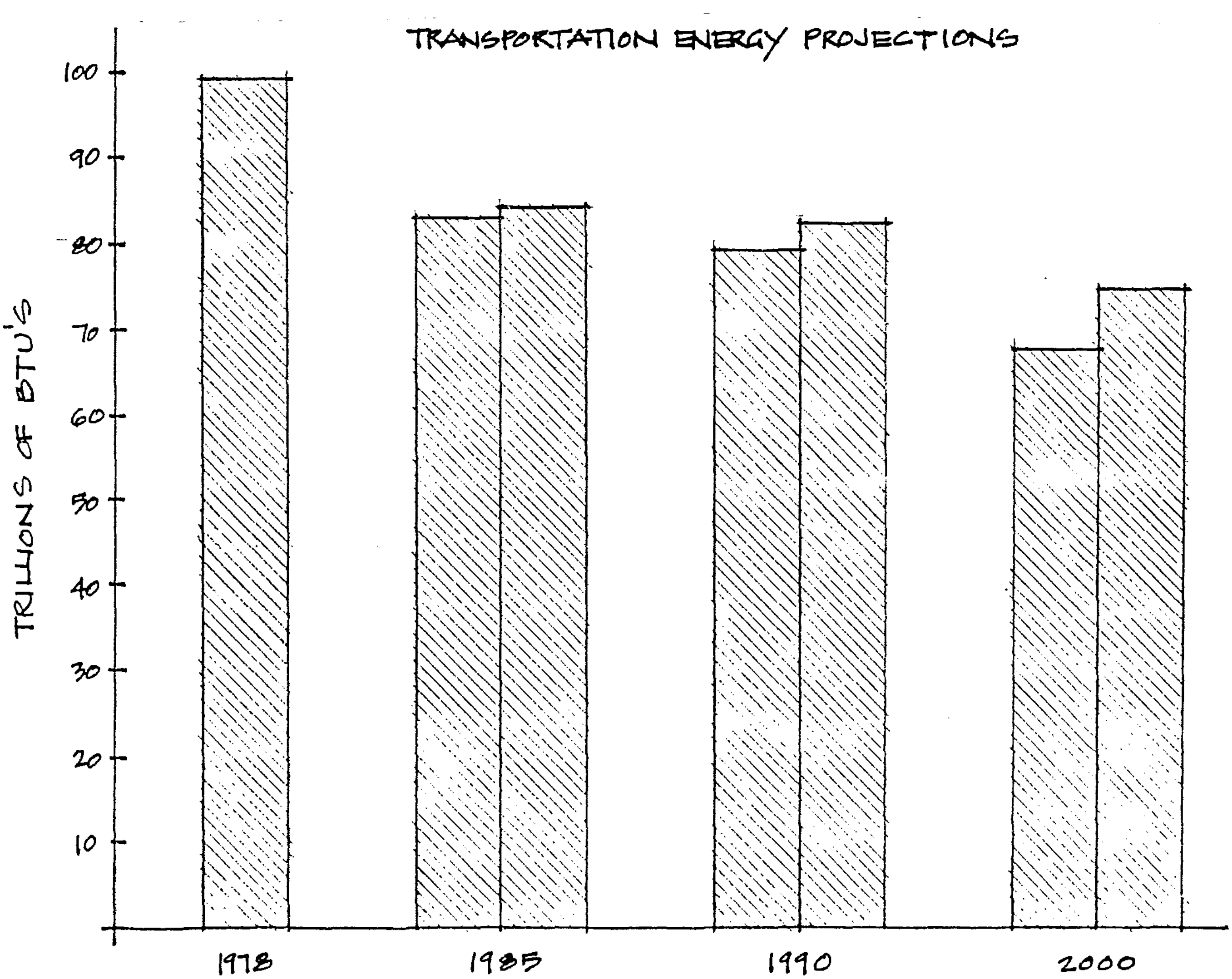
TABLE 12-A

Energy Demand Forecast for the Transportation Sector

1978 = 780,606,000 Gallons

	LOW			HIGH			
Year	Gallons	Btu's (in trillions)	% Change from 1978	Gallons	Btu's (in trillions)	% Change from 1978	% Dif. between Low and High
1985	652,768,744	82.73	-17.1	665,749,744	84.37	-15.5	1.3
1990	626,844,903	79.63	-20.2	652,816,902	82.89	-17.0	3.9
2000	493,888,031	68.21	-31.7	545,810,031	74.79	-25.0	8.8

FIGURE 21



5. Total Energy Demand in All Sectors

By adding the forecasts for each end-use sector, a forecast of Maine's total energy demand may be estimated (this is shown in Table 12-B and Figure 22). The high demand scenario - high growth and adoption of conservation levels based on current practice - shows an increase in total energy demand for each year of the projection and over a 15% increase by the year 2000. In contrast, the low demand scenario - low growth and a higher utilization of conservation measures than presently exists - shows a continual decline in total energy demand to nearly a 10% decrease in energy demand from 1978 to 2000. This 25% range of expected energy consumption values clearly indicates the variation which may be expected, partly due to the influence of economic activity, energy conservation measures, and changes in end use consumption patterns of energy in Maine.

The high and low forecasts offer a wide range for actual energy use. The actual demand will, in all likelihood, fall somewhere within this range and, hopefully, will be a figure representing high growth and high conservation.

TABLE 12-B

Total Energy Demand Forecast: 1978 - 2000

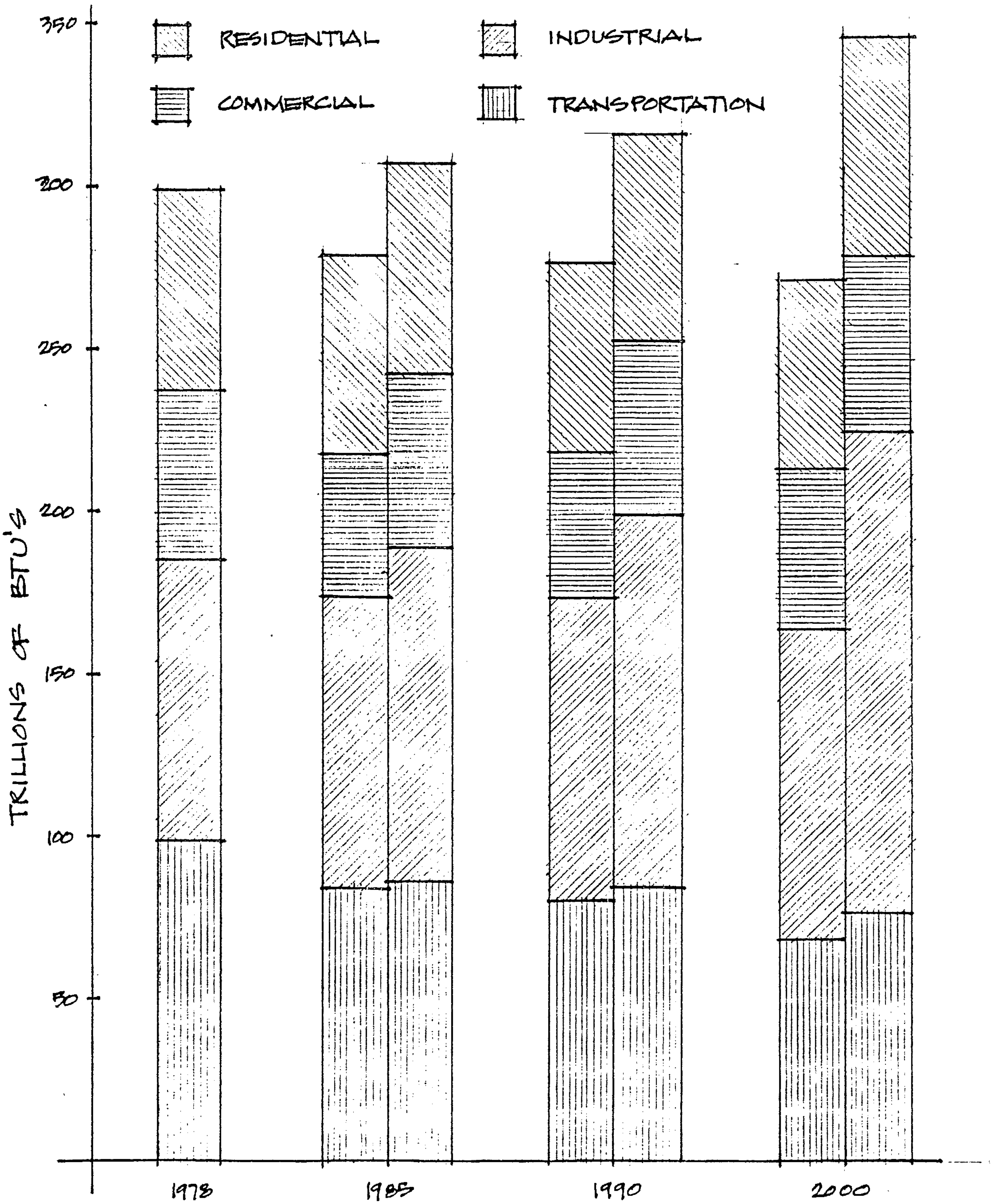
All Data in Trillions of BTU's

1978 Actual*	
Residential	62.71
Commercial	51.21
Industrial	85.42
Transportation	99.80
TOTAL	299.14

	High Demand	% Change since 1978	Low Demand	% Change since 1978
1985				
Residential	66.2		60.9	
Commercial	51.8		45.2	
Industrial	105.1		90.1	
Transportation	84.4		82.7	
TOTAL	307.5	+ 2.8%	278.9	-6.8%
1990				
Residential	66.0		58.99	
Commercial	51.7		46.2	
Industrial	115.7		91.9	
Transportation	82.9		79.6	
TOTAL	316.3	+ 5.7%	276.9	-7.4%
2000				
Residential	67.5		59.2	
Commercial	55.4		48.8	
Industrial	147.3		94.2	
Transportation	74.8		68.2	
TOTAL	345.0	+15.3%	270.4	-9.6%

*Does not include losses attributable to electrical generation.

FIGURE 22



TOTAL ENERGY DEMAND FORECAST

Other recent studies suggest that the forecast presented in this report is modest and represents only a portion of the total conservation potential available, specifically in end use of electricity consumption. For example, in a study submitted in December of 1980 to the Maine Public Utilities Commission by the Energy Systems Research Group (ESRG), it was found that the average annual rate of growth in electricity consumption could decline at a rate of -0.7% through 1989, in a conservation case scenario. This is in contrast to their earlier base case forecast of nearly 1.8% growth in electricity consumption. The conservation case scenario was based upon implementing additional institutional initiatives to further incorporate electricity conservation, thus going beyond the existing market forces and public policy. The base case includes only those conservation measures expected to be implemented given existing policies and trends.

Table 13 below summarizes the growth rates expected under these scenarios for the CMP service territory.

TABLE 13

Comparison of Growth Rates in Energy ESRG Base Case and Consumption Forecasts for the CMP Service Territory

Case	1979*	% Year 1979-89	1989*	% Year 1989-99	1999*
Base	6446	1.8	7680	1.1	8570
Conservation	6446	-0.7	6020	-0.3	6000

*Annual Energy (KWH)

Source: ESRG

There is little doubt that a sizable potential for increased conservation exists. The forecasts for conservation presented in this report may be seen as modest. These forecasts and others should be reviewed and re-evaluated periodically to take into account new and more accurate information, new events, and changing policies.

B. Forecast of Maine Energy Supply: 1985, 1990, and 2000

By statute, the Office of Energy Resources (OER) is required to prepare a State Energy Resource Plan, which contains a forecast and cost analysis for the State's future energy needs. In the preparation of this forecast the following factors have been taken into account:

- o Those aspects of economic growth and development trends, which may significantly affect energy consumption in the State (e.g. urban development, transportation, demographic shifts in population):
- o The introduction of new energy technologies and conservation measures which may change the State's energy requirements:
- o The potential contribution of the state's native resources, such as hydro, wood, etc., may play in decreasing the State's importation of fossil energy supplies: and
- o The impact of State and federal energy policies on Maine's energy needs and availability of traditional energy resources.

The supply forecast presented in the following tables are based upon energy demand projections for each end-use sector as determined in the previous section on demand forecast. In this manner, the total amount of a variety of energy resources needed to supply Maine's energy requirements through the year 2000 can be determined. The forecasts present individual fuel requirements based upon the most likely energy mix of conventional resources.

This forecast method reflects the most important aspects of current state and federal conservation programs and policies. In particular, two key elements which impinge on the energy forecast are the price projections for world oil prices and the level of economic activity projected for future growth. Specific revisions to this forecast will be required to adjust these figures if either of those two elements dramatically change from anticipated levels.

The supply forecast was constructed by building a modeling system based upon historical energy supply trends and incorporating expected shifts in fuel use. Thus, the method integrates all major fuel forms and permits an analysis of the potential for substitution among more competitive fuel types for various end use applications.

For example, oil and petroleum products are expected to be the most expensive primary energy source. Thus, oil will be perceived as the most vulnerable fuel source subject to supply interruptions. In the projections, oil is therefore expected to be replaced by other fuels where possible.

The OER forecast builds upon these concepts and recognizes that the State's economic activity will directly influence the demand for petroleum products. This forecast system can provide a framework for examining relationships and interactions among energy use, levels of economic activity, future price projections and certain aspects of public policy.

The energy supply forecast is based upon an interactive process and incorporates the specific end use requirements and substitutions as described below. For each energy source in the four demand sectors the 1978 energy consumption figures were used as the basis for the 1985, 1990, and 2000 forecasts. Electricity consumption for each sector was accomplished in an earlier process of evaluation. The OER staff analysis, as submitted to the Public Utilities Commission in regard to CMP's Sears Island pending application, was extended to include the total State and used to project total electric energy requirements. It was recognized, however, that although electricity will be the most expensive energy source for the end user, it will continue to be more heavily utilized across all sectors.

Wood use in the residential and industrial sectors were determined by OER staff projections, based upon current trends and substitution effects. While wood use is higher in the low projection than in the high, it was assumed that because there is a perceived price and availability advantage, wood use would be more widespread in this scenario.

The use of coal in the residential sector was projected to be 75,000 tons in 2000 in the high demand scenario and 10,000 tons in that year in the low demand scenario. This projection yielded a calculated annual growth rate of 20% for the high demand scenario and approximately 10% for the low demand scenario. These growth rates were applied to the Commercial Sector to calculate coal demand, in addition to projected coal conversions in the industrial sector.

As can be seen in the tables, kerosene use is projected to decrease to zero by 1990. Through 1985, the level of kerosene use is expected to be uniformly decreasing. The home heating demand now met by kerosene was projected to be met partially by distillate oil and partially by LPG. The LPG projections were based on half of the kerosene demand being supplied by this fuel. Since kerosene demand was historically fairly constant because of the small number of users, there is no difference between the high demand and low demand figures for LPG use.

The use of all other petroleum products, principally in the industrial sectors was determined as a function of the level of production. Therefore, these figures were projected according to the level of growth in that Sector.

In the residential sector the use of distillate oil was determined by subtracting the sum of projected uses of all other sources from the total demand projections. A similar technique was used in the Commercial and Industrial sectors with distillate and residual oils with the 1978 ratio of usage of the two products held constant.

The total requirement for gasoline, distillate and aviation fuel for the transportation sector was determined earlier in the demand scenario for the transportation sector. Residual oil use was assumed to remain constant in that sector and all other petroleum, used principally for lubrication, was projected as a constant percentage of total demand. THe energy supply forecast thus reflects these aspects of petroleum requirements.

Having projected the total requirement for each fuel in each sector, a total forecast was made for each fuel type. As previously noted, in determining sectoral demand, electricity was assigned its end use energy value of 3413 BTU/kwh. Thus, the total electrical requirement, for all sectors, was determined without regard to the source of electrical generation. From the historical data presented in Section II, the maximum electrical energy production for all generating plants now in operation in Maine was calculated. Since out of state utilities own capacity in certain generating plants in Maine, the out of state share of the total electric generation was subtracted from the total available electricity. The amount of electricity which would have to be imported to the state to satisfy projected electrical energy demand could then be determined.

To develop total BTU energy requirements, electrical energy forecasts were distributed to the various types of existing and proposed generating plants. The use of nuclear and residual oil for electrical generation are assumed to remain constant at their maximum historical demand levels. Hydro electric generation is projected to increase slightly and utility coal use, from the conversion of the Mason Station Plant, is also expected to increase.

As can be seen in Table 14, Maine's future energy requirements appears to lie within a relatively wide band of possibilities. Low economic growth coupled with increased emphasis on conservation can lead to decreased energy use at the rate of about 0.27% per year. With high economic growth and low emphasis on conservation, energy consumption may increase at a rate of 0.51% per year. These figures point out that the energy consumption levels in Maine may vary only slightly from their present levels. Even the highest projected growth rate appears much lower than the historical average.

TABLE 14

A. Forecast of Residential Energy Use Requirements by Fuel Type in Trillion BTU's

	1978	1985 High	1985 Low	1990 High	1990 Low	2000 High	2000 Low
Coal	0.032	0.42	0.11	1.1	.17	1.65	.22
Natural Gas	0.777	2.05	1.09	4.10	1.40	6.65	2.27
Distillate	32.56	31.5	23.8	26.08	19.58	17.15	11.12
Kerosene	4.173	1.74	1.74	0.0	0.0	0.0	0.0
L P G	5.691	6.91	6.91	7.78	7.78	7.78	7.78
Electricity	10.224	12.40	11.74	14.24	12.97	18.77	15.81
Wood	9.25	11.2	15.5	12.7	17.0	15.5	22.0
TOTAL	62.707	66.2	60.9	66.0	58.9	67.5	59.2

B. Forecast of Commercial Energy Use Requirements by Fuel Type in Trillion BTU's

	1978	1985 High	1985 Low	1990 High	1990 Low	2000 High	2000 Low
Coal	.022	.29	.08	0.76	.12	1.13	0.15
Natural Gas	.593	1.56	.83	2.54	1.07	5.08	1.73
Distillate	20.593	19.42	16.95	17.89	16.79	16.25	16.33
L P G	0.632	0.64	0.56	0.64	0.57	0.68	0.60
Residual	18.76	17.69	15.45	16.30	15.29	14.81	14.88
All Other Petroleum	4.43	4.48	3.91	4.47	4.00	4.79	4.22
Electricity	6.175	7.75	7.39	9.12	8.40	12.61	10.86
TOTAL	51.21	51.83	45.17	51.72	46.24	55.35	48.77

C. Forecast of Industrial Energy Use Requirements by Fuel Type in Trillion BTU's

	1978	1985 High	1985 Low	1990 High	1990 Low	2000 High	2000 Low
Coal	0.444	1.25	1.25	2.61	2.61	11.42	11.42
Natural Gas	0.788	.921	.921	1.028	1.028	1.29	1.29
Distillate	3.897	5.16	3.08	5.20	2.56	6.60	0.86
Kerosene	0.30	0.0	0.0	0.0	0.0	0.0	0.0
Residual	29.702	39.36	23.50	39.63	19.50	50.33	6.54
L P G	1.771	1.85	1.85	1.91	1.91	2.03	2.03
All Other Petroleum	17.335	21.33	18.28	23.48	18.65	29.89	19.12
Self Generated Hydro	9.953	10.9	10.9	10.9	11.4	11.4	12.0
Electricity	10.802	12.32	12.32	13.54	13.54	16.34	16.34
Wood	10.00	12.5	18.00	14.4	20.7	18.00	24.8
TOTAL		105.1	90.1	115.7	91.9	147.3	94.2

D. Forecast of Transportation Energy Use Requirements by Fuel Type in Trillion BTU's

	1978	1985 High	1985 Low	1990 High	1990 Low	2000 High	2000 Low
Gasoline	71.24	66.39	64.78	62.83	59.60	50.60	44.118
Distillate	11.22	10.08	10.08	12.18	12.18	16.38	16.337
Aviation Fuel	14.25	5.00	5.00	5.00	5.00	5.00	5.00
Residual	2.16	2.16	2.16	2.16	2.16	2.16	2.16
All Other Petroleum	0.86	0.73	0.71	0.71	0.69	0.64	.59
TOTAL	99.8	84.36	82.73	82.91	79.63	74.78	68.21

E. Total Energy Use Requirements in Maine by Fuel Type in Trillion BTU's

	1978	1985 High	1985 Low	1990 High	1990 Low	2000 High	2000 Low
Gasoline	71.79	66.39	64.78	62.83	59.60	50.60	44.12
Residual	61.77	71.90	53.80	70.78	49.64	79.99	40.23
Distillate	68.65	66.16	53.91	61.35	51.11	56.38	44.69
Aviation Fuel	14.25	5.00	5.00	5.00	5.00	5.00	5.00
L P G	8.11	9.4	9.32	10.33	10.26	10.49	10.41
Kerosene	4.74	1.74	1.70	0.0	0.0	0.0	0.0
Misc. Petroleum	22.04	26.54	22.90	28.66	23.34	35.32	23.93
Coal	0.50	1.96	1.44	4.47	2.90	14.20	11.79
Natural Gas	2.15	4.53	2.84	7.67	3.50	13.02	5.29
Wood	19.25	23.70	33.5	27.1	37.7	33.5	46.80
Hydro	29.44	30.09	30.59	30.59	31.09	31.09	31.69
Nuclear	57.66	57.66	57.66	57.66	57.66	57.66	57.66
Imported Electricity	9.23	14.02	13.00	18.45	16.46	29.27	24.56
TOTAL	369.58	379.09	350.44	384.89	348.26	416.52	346.17*

*Includes electrical generation losses

As stated in the introduction to the forecast, an attempt has been made to delineate a range of possibilities for future energy supply and demand. This will allow energy planners to define all possible energy resource alternatives, to examine the benefits and drawbacks of those alternatives, and to present informed and objective recommendations to the policy makers in the public and private sectors of the State.

Table 14 depicts the energy requirements of each individual sector by fuel source and summarizes them to show projected total energy requirements in Maine.

C. Forecast of Maine Energy Prices: 1985, 1990, 2000

The OER has prepared a forecast of energy price relationships for a wide range of fuel types in various sectors. This was produced in conjunction with the state energy requirement forecast, and thus reflects certain assumptions governing the supply and availability of fuels.

In all cases, the 1978 prices should reflect average prices paid for these sources during the year. The price forecasts in 1985, 1990 and 2000 of the energy sources rest on the following assumptions:

- The real world price for petroleum products, including crude oil, gasoline, residual, distillate, aviation, and kerosene will increase in real terms at an average annual rate of 3% per year through the year 2000.
- Natural gas will increase at an average rate of 5% per year in real terms through the year 2000.
- All other energy resources will escalate at an average rate of 3% per year in real terms over the next two decades.
- Inflation is assumed, for the basis of current cost forecasts, to average 7% per year to the year 2000.
- All price forecasts were made from actual 1980 prices, adjusted for inflation.

The OER staff reviewed price assumptions in a variety of reports including, the Energy Information Administration; U.S. Department of Energy Report, Energy Supply and Demand in the Midterm, 1985, 1990 and 1995, the American Gas Association; Data Resources, Inc., CONAES; the U.S. DOE Annual Report to Congress, and several State Energy Office price projections. The results presented in Table 15 reflect and support the conclusions drawn by this review. While it is recognized that prices will fluctuate, and inflation may not be constant, for the purposes of this study, all changes were held to be linear. Recent events, including the current Iranian stalemate, existing OPEC pricing policies, and the major changes in utility rate structure, emphasize the uncertainties associated with energy forecasting. Thus, it should be recognized that these forecasts represent a series of estimates for future prices, based upon the assumptions used to build the forecast model.

The previous historical prices suggest that the price increases follow a pattern of a series of incremental escalations, rather than a continuous smooth rise in price. OER's official forecast, however, integrates those aspects such as the rate of discoveries of crude oil, natural gas deregulation and pricing policy, and recent pricing patterns for wood use and other fuels. The resulting pattern of prices were then extended to the year 2000, and adjusted for inflation. Tables 15 and 16 present the price forecast for individual fuel types, both by a unit and BTU value.

TABLE 15

Price Forecasts by Fuel Type

Dollars per Unit

	1978	1985		1990		2000	
Fuel Type/ Unit	$/Unit	Constant 1978 $'s	Current $'s	Constant 1978$'s	Current $'s	Constant 1978 $'s	Current $'s
Crude Oil /bbl	12.46	34.77	55.83	40.30	90.76	54.17	239.94
Gasoline /Gal	.692	1.32	2.12	1.53	3.45	2.05	9.08
Residual Oil /bbl	12.75	37.10	59.57	43.00	96.84	57.80	256.08
Distillate /Gal	.51	1.20	1.93	1.37	3.08	1.84	8.15
Av. Fuel /Gal	.69	1.32	2.12	1.53	3.45	2.05	9.08
Kerosene /Gal	.50	.85	1.37	.98	2.20	1.31	5.80
Coal(Indus) /ton	50.00	75.35	121.00	87.35	196.75	117.40	520.15
Natural Gas /MCF	2.53	3.50	5.62	4.47	10.06	7.30	32.34
Wood /cord	40.00	60.28	96.80	69.89	157.40	93.92	416.10
Electricity /kwh	.043	.0655	.1052	.0759	.171	.1020	.452

TABLE 16

Price Forecasts by Fuel Type

$/MMBTU

Fuel Type	1978 $'s	1985 Constant 1978 $'s	1985 Current $'s	1990 Constant 1978$'s	1990 Current $'s	2000 Constant 1978 $'s	2000 Current $'s
Crude Oil	2.22	6.19	9.94	7.18	16.17	9.65	42.75
Gasoline	5.34	10.18	16.36	11.80	26.62	15.82	70.07
Residual	2.03	5.90	9.48	6.84	15.48	9.20	40.73
Distillate	3.68	8.65	13.92	9.88	22.20	13.27	58.77
Av. Fuel	5.34	10.18	16.36	11.80	26.62	15.82	70.07
Kerosene	3.70	6.29	10.14	7.25	16.28	9.70	42.92
Coal(Indus)	2.08	3.14	5.04	3.64	8.20	4.90	21.67
Natural Gas	2.44	3.41	5.48	4.36	9.82	7.13	31.5
Wood	2.00	3.01	4.84	3.49	7.87	4.70	20.80
Electricity	12.59	19.19	30.82	22.23	50.10	29.88	132.43

III. CONSERVATION

III. CONSERVATION

Introduction

One of the most important factors in Maine's energy future will be conservation. Wise conservation of energy sources does not imply reduced economic activity or lower standards of living. On the contrary, more efficient use of energy can help to stimulate Maine's economy as a result of financial savings from reduced fuel consumption and a reduced outflow of state dollars spent on imported fuels. Conservation can help stretch our supplies of non-renewable fuels as we begin to develop native renewable resources and postpone or eliminate the need for large new electric generating facilities that may have significant environmental and economic costs.

Conservation is defined as "an improvement in energy efficiency". This can be accomplished in many ways and great potential for conservation exists in every sector. The following section provides an overview of conservation opportunities and current programs in four broad categories: residential, commercial/institutional, industrial and transportation. These are followed by discussions of cogeneration and district heating, two technologies which can increase the efficiency of conventional fuel use.

Conservation has long been one of the top priorities in State energy programs. Maine's citizens, commercial firms, public institutions and industries have all made great strides toward conservation in recent years. The Federal Government has also begun to focus more attention on this area. Obviously, it is now being widely recognized that conservation offers many benefits and that it is cheaper to save energy through efficient use than it is to produce new energy.

1. Residential

There is tremendous potential for energy savings through conservation measures in Maine's residential buildings. For example, Section II, Part 3, projects almost a 6% decline in energy demand in the residential sector from 1978 to the year 2000 in the low demand scenario. Assumptions were made in this scenario that low-interest weatherization loans, largely financed with public money, would be available and that major efforts will be made to educate the public.

Improving the efficiency of home appliances could also result in substantial savings. This potential is suggested by a recent report to the Maine Public Utilities Commission by the Energy Systems Research Group (ESRG) of Boston. For example, the report includes data showing that certain improvements in the efficiency of refrigerators could reduce their energy use by up to 21% while adding only about $15 to the initial cost of the appliance. The report concludes that similar energy savings could result from improvements in other appliances. The setting of minimum efficiency standards for appliances could be a way of realizing this conservation potential.

Other measures that have been proposed and which could result in significant energy savings in the residential sector include the restructuring of electrical rates to discourage unnecessary or inefficient use of electricity, the adoption of time-of-day pricing strategies to help spread demand more evenly throughout the day and a reduction or ban of the use of electric resistance heating.

Some important conservation measures cost nothing to employ. As the ESRG report states, simply turning down the thermostat of a hot water heater 10 degrees (e.g. from 140 degrees to 130 degrees) can reduce the unit's energy use by 3% to 5%. Other conservation measures are low cost. Some, such as weatherization, can require relatively large initial investments. However, most conservation measures offer a very attractive pay-back period and virtually all result in substantial financial savings within a reasonable period of time through reduction of fuel costs.

To achieve the maximum potential of conservation in Maine's residential buildings education, training, technical and financial assistance and financial incentives will be fundamental.

There are many federal, state and local programs promoting residential energy conservation. A number have been in place for years; others for a shorter period of time. Still others are just being implemented. Of course, these programs are only a part of what is happening in this area. More and more people are taking conservation measures on their own, without assistance from government.

The Federal government is involved in most state energy conservation programs, usually through provision of financial assistance or through federal mandates that certain services be provided. Such programs include the low-income weatherization program, the Residential Conservation Service, the Energy Extension Service and the Residential Energy Analysis Program. In addition, the federal government offers homeowners an income tax credit of 15% on the first $2,000 spent for conservation measures.

Several state agencies are involved in residential energy conservation programs. A low income weatherization program conducted by the Maine Division of Community Services and financed by federal and state money has been ongoing since 1974. Through twelve community action agencies, the homes of over 18,000 low income and elderly families have been weatherized in this state. Community Services' goal is to complete weatherization of all eligible homes in Maine by 1985. This will require weatherization of approximately 1,000 homes per month over the next five years at a cost of approximately $50 to $60 million.

The National Energy Conservaton Policy Act, as amended by the Energy Security Act of 1980, requires major utilities to provide low cost, on site energy audits to their residential customers. OER was designated as the lead agency to prepare plans for implementation of a Residential Conservation Service by Maine utilities. The program is expected to begin in the spring of 1981 and OER will oversee the performance of energy audits and other services offered by the utilities.

The OER Energy Extension Service was initiated in the summer of 1980 to help small-scale energy users conserve energy. The Service currently has five energy associates headquartered in different areas of the state. They provide information and technical assistance to homeowners, small business owners, and commuters. Specific programs include wood burning safety education in coordination with the Maine Cooperative Extension Service, lighting workshops for small businesses coordinated with the Maine Merchants Association, "how-to" low/cost no/cost weatherization workshops, and promotion of the Residential Energy Analysis Program (REAP) coordinated with the Community Alternergy Corporation and promotion of ridesharing for commuters.

Since July, 1979, OER has offered a free, do-it-yourself energy audit to Maine homeowners. The Residential Energy Analysis Program (REAP) was publicized by virtually all Maine utilities and many members of the Maine Oil Dealer's Association. Thus far over 5,000 Maine homeowners have participated in the REAP project. Along with an analysis of energy use in the home and recommendations for weatherization measures, the REAP packages received by participating homeowners include a series of fact sheets on energy conservation techniques, insulation and tax credits and financial incentives. REAP is now being actively promoted by the OER Energy Extension Service Program and it is expected that another 5,000 REAP audits will be completed during the present heating season.

Related residential energy conservation programs initiated by state agencies or private and non-profit organizations include establishment of energy efficiency building standards, an energy conservation loan program, an oil burner efficiency program and the Neighbor-to-Neighbor Self-Help program.

The Maine Energy Efficiency Building Standard Act was passed in 1979 and the voluntary standards mandated by the law were developed and adopted by OER on July 1, 1980. The voluntary standard program establishes maximum heat loss levels for the building and performance standards for heating, ventilating and air conditioning equipment. OER has negotiated tentative agreements with the Maine State Housing Authority and the Farmers' Home Administration to adopt the OER standards for their construction projects. FMHA has also agreed to finance several passive solar single-family dwellings as demonstrations and to use wood or coal heating systems in two multi-family projects. OER is currently preparing a "manual of accepted practices" and conducting workshops and seminars in conjunction with the Homebuilders of Maine Association and lumber dealers throughout the state. A training program for local code enforcement officials will be developed by the University of Maine and presented in cooperation with the Maine Municipal Association.

The Maine State Housing Authority has used its authority to support home improvement loans for energy conservation and renewable resource energy systems. During the summer and fall of 1980, $4 million of existing funds have been made available to consumers at an attractive interest rate of 7%. Initial response to these "energy loans" has been very favorable and it is anticipated that additional funds may soon be needed to continue the program.

The OER and the Maine Oil Dealer's Association are currently conducting a joint project to promote conservation by improving the efficiency of oil heating equipment. The program trains service technicians in oil conservation techniques, servicing and installation of efficient burners, boilers and clock thermostats. Oil company marketing personnel have also been trained in effective marketing of these techniques and equipment. The program is scheduled to continue for two more years with the oil dealers gradually assuming complete planning and financial responsibility.

Under the sponsorship of Governor Brennan, various human services agencies, local public service groups and private organizations have formed a coalition to help low income and elderly citizens cope with energy-related problems during the winter. This Neighbor-to-Neighbor program has proven effective over the last two years in helping to coordinate public and private programs and provide maximum benefits to the poor and elderly.

2. Commercial/Institutional

Conservation measures in the commercial and institutional sector offer great potential for saving energy. About 60% of the energy used in this sector during 1978 was for space heating purposes. As with the residential sector, substantial savings could be gained by improving the energy efficiency of existing commercial or institutional buildings and ensuring that all new buildings meet minimum conservation standards. Other measures that can be taken include improving lighting in all commercial buildings to conform with state standards, and instituting energy management programs in Maine's commercial buildings.

Achieving a reduction in demand for energy in the commercial and institutional sector through conservation will require many of the same encouragements as in the residential area. Here too, education, training, technical assistance and financial incentives are fundamental.

The programs described here, which promote energy conservation in the commercial and institutional sectors, are presently underway. The first two include direct involvement from the federal government. Other programs, including establishment of building energy performance standards and the initiation of a State government management task force, are largely State efforts.

Under Title III of the National Energy Conservation Policy Act, the U.S. Department of Energy has provided Maine with approximately $500,000 to conduct energy audits and $2.2 million to complete energy conservation projects on schools, hospitals, local government buildings and public care institutions in Maine. A total of $1.6 million is expected to be forthcoming for additional conservation projects. In the fall of 1978, Maine voters approved a $2.5 million bond issue for energy conservation improvements on local government buildings. The money will be allocated on a 50%-50% matching basis using the results of energy audits completed by the staff of the Maine Municipal Association. Also, in November, 1980, Maine voters approved a $7 million dollar bond issue for energy conservation improvements to public schools and University of Maine buildings. These funds will augment $5 million already spent on conservation projects in schools from a bond issue authorized in 1977.

Since June 16, 1979, the Department of Energy has required virtually all non-residential buildings to be heated no warmer than 65 degrees in winter and mechanically cooled to no less than 78 degrees in summer. OER was designated by the DOE as the lead agency in Maine to insure implementation of these requirements. In the winter of 1979/1980, 500 non-residential buildings were inspected by a private contractor hired by OER. Over 95% of the buildings met the DOE requirements by the end of the initial inspection program. The inspectors also found that building owners are using many innovative approaches to energy conservation and alternate energy resource utilization.

Besides residential buildings, the State of Maine Voluntary Energy Efficiency Building Performance Standards also apply to commercial and industrial buildings. The standards contain lighting power standards for public buildings as well as maximum heat loss levels for the building and performance standards for heating, ventilating and air conditioning equipment.

Through the spring and summer of 1980, a State Government Management Task Force, appointed by Governor Brennan and headed by Commissioner Rodney Scribner of Finance & Administration, discussed various options for improving the efficiency of energy use by State Government. The Task Force report recommended continuing several ongoing State programs including the retrofit of State buildings, energy efficient procurement procedures, and the State vanpool program. The report also recommended the initiation of several additional efforts including the establishment of a uniform vehicle management system for State owned vehicles, the initiation of an energy consumption monitoring system and the creation of a permanent energy conservation assistance group within the Bureau of Public Improvements.

3. Industrial

Maine's industries used approximately 30% of all the energy consumed in the State in 1978. Leather, paper and wood products, textiles, chemical, electronics and other important Maine industries all require substantial amounts of power in their production processes, plus energy for space heating needs. Conservation measures, such as ensuring that all new industrial buildings are built to minimum energy conservation standards, and the use of strategies that allow more efficient use of the energy industries use, such as cogeneration (discussed in a following section), can lead to great energy savings in the industrial sector. OER projections estimate a range of increased demand in the industrial sector in the year 2000 from 10-42% over 1978 consumption.

The speed with which conservation measures are taken in the industrial sector will depend on many of the same factors as in other sectors, such as education, technical assistance and financial incentives. While Maine industries have large potential for energy conservation, the diversity of processes and needs will often require case-by-case study in order to obtain substantial savings in a cost effective manner.

Several current programs are directed towards energy conservation measures in the industrial sector. Over the past three years, OER has sponsored a number of workshops for industrial energy users, focusing on operations and maintenance procedures that can lead to energy conservation improvements. Over 250 representatives of firms throughout the State have attended these workshops.

Other programs directed at industry include Maine's Energy Efficiency Building Performance Standards, the Emergency Building Temperature regulations and efforts to promote cogeneration. The first two programs have been outlined under the commercial/institutional energy conservation section. Cogeneration is fully discussed in detail in the next section.

New state initiatives that could be undertaken might promote effective energy management programs in Maine's industries, the creation of new electrical generation capacity through industrial cogeneration and efforts to have all new industrial buildings built to at least minimum energy conservation standards. Another possibility that could reduce industrial energy consumption and encourage cogeneration would be restructuring utility rates for electricity to reduce the current price advantage of large consumers.

4. Transportation

Transportation accounted for 26% of all the energy consumed in the state in 1978. Maine is largely a rural and suburban state. Substantial distances often separate people, goods and destinations. As a result, we have become more dependent on the private automobile and the trucking industry than most other states.

Rising fuel costs have already lead to significant conservation efforts in the transportation sector. For example, more and more people are buying high-mileage cars, driving fewer unnecessary miles, and car or van pooling. Such measures have reduced gasoline consumption in Maine by 14% since 1978. Further reduced gasoline consumption is possible in the future. Projections made in Section II, Part 3, predict at least a 25% reduction in energy consumption in the transportation sector from 1978 to 2000.

Early State efforts to promote energy conservation in the transportation sector included lowering speed limits on all limited access highways and allowing "right-turn-on-red" at intersections. Other effective methods are now being pursued in the form of public transportation, rideshare programs, and renewed rail service.

Since 1977, OER has supported four area-wide metropolitan transit districts by providing funds for marketing the use of public transportation systems. OER has also encouraged these districts to address energy conservation in their ongoing planning and implementation programs. All of the public transit districts participating in this program have noted substantial increases in ridership during the past three years.

Since the summer of 1979, the OER has worked with major employers throughout the State to promote carpools and vanpools. Numerous publications promoting ridesharing have been distributed and a service to help employers identify potential carpoolers among their employees has been made available at no charge. Through statewide workshops and on-site visits, nearly 100 employers have learned of this service and agreed to participate. Thousands of potential carpools were identified and over 120 vanpools now operate throughout the State. Through contracts with the Portland and Bangor Chambers of Commerce, OER has initiated two areawide carpool matching services. The Portland service has been operating since September and the Bangor service is scheduled to start in December. Promotion has been coordinated by the local Chamber members with OER supplying technical and computer assistance. Area-wide task forces comprised of local business leaders have been established in order to promote these efforts. Over 1000 commuters have participated in the Portland program to date and the "match rate" for participants has been over 90%.

Since August 1979, the OER and the Department of Transportation (DOT) have jointly sponsored six state-owned vanpools for State workers. The program is currently operating between Augusta and the cities of Lewiston, Waterville, Winthrop, Readfield, Gardiner, Brunswick and

Jefferson. During the day, two of the vans are used to provide a shuttle service between state agencies in the Augusta area.

The New England Regional Commission, in cooperation with the Maine Department of Transportation, has recently completed two studies of the potential for increased use of trains in Maine. The first made an assessment of the future of freight transportation by rail in New England. It indicated that Maine may have the most promising future in the region for increasing the use of trains for hauling freight. The second study addressed the feasibility of reestablishing passenger rail service between Boston and Portland and concluded that such a service is not economically feasible at this time. Both studies point to a need to upgrade Maine's rail facilities, tracks, grade crossings, rolling stock and stations.

Future transportation initiatives may include placing more of Maine's commuters in some sort of rideshare arrangement (carpools or vanpools), increased use of existing public transportation systems or development of newer systems where appropriate, and assistance to Maine's trucking, rail and barge industries. "Piggy-backing" trailer trucks on railroad flatcars may also reduce fuel consumption and transportation costs. Efforts in regard to trucking, rail and barge will have to be undertaken in concert with the Maine transportation community.

Other methods of increasing energy conservation in transportation could involve developing package tours and group travel packages to destination resorts in Maine in cooperation with the Maine Publicity Bureau and the tourist industry. Such tourist services would allow travel in an energy saving manner and foster more complete use of the State's recreational facilities. Initiatives might involve further examination of rail service, intercoastal ferry systems, vanpooling, seasonal bus and trolley services and others. Working energy considerations into state and local land use planning efforts may also result in energy conservation by allowing better assessment of how zoning and other planning decisions can affect transportation.

Due to a lack of public transportation in most areas of the state, heavy dependence on automobiles will continue in the foreseeable future. Similarly, the trucking industry of Maine will continue to transport the majority of goods to and from markets. Thus, the need to carefully examine the feasibility of alternative and more efficient means of transporting people and goods is readily apparent. There are significant social, financial and institutional barriers to alternative transporation in rural states. As a result, transportation is probably the most difficult sector to deal with from an energy and program perspective and, as such, will require a very determined and innovative approach.

5. Cogeneration

a. Introduction

Cogeneration is an attractive method of improving fuel efficiency. In the broadest sense, cogeneration means putting waste heat to work. For example, most large energy producing facilities use relatively great amounts of fuel to provide adequate process steam for manufacturing, hot water for space heating, or electricity for distribution. A large percentage of the primary energy consumed is often lost in these processes, simply because methods of using the "excess" power potential are not employed. As a result, much useable energy disappears as waste heat. Cogeneration provides a way of using this excess energy to generate electricity or other useful forms of energy in process heat.

The term cogeneration applies to a number of different systems, all of which yield useable energy in more than one form. A cogeneration system can be fueled by oil, wood, coal, hydropower, waste, biomass, solar, geothermal, or wind. The generated energy can be in various forms: electricity, steam, heat, or mechanical energy. The uses of a cogeneration system depend upon the primary energy requirements of the user. For example, electricity is the primary requirement for a utility company. The heat or steam a power plant produces is thus cogenerated and could be used as a secondary product. The primary need for a paper mill may be process steam, with electricity cogenerated secondarily. When cogeneration systems produce heat or electricity in excess of the needs of a particular facility, that excess is potentially available to be sold to other users.

Cogeneration systems have been around since the 1880's. They were used extensively during the early part of this century when most industrial plants generated their own electricity with coal boilers and steam turbines, using the exhaust steam for industrial processes. Many factors, particularly increased electrical demand, the decreasing demand for process steam in industry, and the increasing availability of commercial electricity contributed to a decline of cogeneration. Utilities gradually became reluctant to purchase cogenerated power because it was produced erratically throughout the day and required a certain amount of utility backup equipment. And, up until the late 1960's, electricity prices from central utility plants became cheaper each year.

This decline in cogeneration of electricity by industrial facilities has been dramatic - from 22% of all electricity produced in this country in 1920, to less than 5% at present. Maine industries, particularly the pulp and paper industries, have continued to use cogeneration more than those in many other states. However, the potential is far greater than the current use. During the past few years, cogeneration has grown increasingly attractive as an alternative to conventional energy systems. As the energy costs and operating expenses steadily increase, the energy savings offered by cogeneration systems are being reevaluated - especially those systems capable of using native alternative fuels such as wood and biomass. In-plant electrical generation is also attractive to many industries because it is a secure source of electrical power not subject to price increases.

Increased use of cogeneration of electricity in Maine would benefit not only individual industries but also the state as a whole. Industries currently use about 40% of the utility-generated electricity in Maine. Utilities would have more electricity available for new industries and consumers if existing industries expanded their cogeneration efforts and reduced their demand for purchased electric power. This could lead to economically beneficial industrial expansion or help reduce the need for new utility generating plants. In addition, industries using cogeneration could sell power to the utilities when they had an excess, further increasing electricity available to other consumers.

b. Current Use

The forest products industry is the largest industrial energy consumer in Maine. Energy needs are met in a variety of ways including hydro power, burning of wood and wood wastes, and purchases of fuel oil and electricity. Many individual forest products companies have used cogeneration systems for some time. The pulp and paper industry group currently leads the state in cogeneration and has the greatest potential for increased efforts. A few large and small forest products enterprises now generate electricity in excess of their needs and sell this additional power to utility companies. A number of Maine's larger sawmills have cogeneration systems. Boilers which once provided only process steam to heat buildings and operate dry kilns are now powering steam turbines which generate electricity as well. These boilers are fired from wood residues which are either produced on the site or purchased from elsewhere. Cogeneration by other industry groups and utilities is not currently substantial.

c. Resource Availability

The Maine Office of Energy Resources estimates that there is a potential for a significant increase in cogeneration in Maine. Much of this potential is within the forest products industry.

A preliminary study done for the OER indicated that "an additional 265 megawatts of steam turbine generating systems could be installed at Maine paper mill sites and produce electricity at costs competitive with current utility production costs while meeting the mills process steam requirements."[1] This study focused on the potential for increasing electricity cogeneration in the Maine paper industry.

Central Maine Power Company (CMP) recently began studying the potential for additional cogeneration facilities in the CMP service area as part of their current analysis of new plant commitments. This study, completed by Charles M. Main, Inc., assumed that potential cogeneration facilities would only be oil-fired, and rated above a nominal capacity of 5000 kw. The conclusions of their analysis indicated a much more limited potential for increased cogeneration than the OER study.

A special study done by the New England Power Pool submitted to the Maine Public Utilities Commission by CMP also evaluated the potential for self-generated power in the Pulp and Paper Industry.[2] This study concluded that with existing technology, the Pulp and Paper Industry (SIC 36) could provide 585 kwh of electricity for every ton of paper produced, making it a net contributor to the amount of electricity available to other consumers.

Most major forest-related industries in Maine are now considering switching to coal or wood as a primary fuel source. Wood fuel can be in the form of chips, bark, or other residues. Cogeneration systems can be installed with both coal and wood-fueled systems (as well as with other fuel systems). The conversions which are now being contemplated provide good opportunities to install cogeneration systems. Major plant expansions and construction of new facilities also provide prime opportunities for installation of cogeneration systems.

The Public Utilities Regulatory Policy Act of 1978 (PURPA) has made the installation of cogeneration systems more attractive. PURPA mandates that every electric utility is required to purchase electricity made available to it by a qualifying facility. The effect of PURPA will be that excess electricity which might be produced by a cogeneration system can be sold to a guaranteed market. The Maine Public Utilities Commission will make the determination for sales rates during 1981.

In addition to PURPA, there are other incentives available to encourage the installation of cogeneration systems. An additional 10% tax credit from the Windfall Profits Tax is available for cogeneration equipment. And, as the cost of utility generated electricity increases, the return on investment in cogeneration systems becomes more attractive.

[1] Possibilities for Electricity-Steam Cogeneration Systems in Maine, Kenneth E. Johnson, Energy and Environmental Policy Center, Harvard University, 1977.

[2] Staff Report, (sic 26), Maine Public Utilities Commission Document: Staff Ex. 53.

A number of large forest products companies are currently evaluating cogeneration systems. For example, S.D. Warren's Westbrook mill is now buying some 6 MW of electricity from Central Maine Power Company. When S.D. Warren's new coal/biomass facility is completed, this picture will be reversed: CMP will buy nearly 13 MW of S.D. Warren's excess electricity. The difference between what is now purchased from CMP and what is planned to be sold to CMP will be roughly 20 MW, a considerable source of base load power for that utility company.

Several other paper mills are conducting evaluations of similar changes. Boise Cascade has recently applied to the Board of Environmental Protection for an air quality license to construct a new coal-burning facility. Boise Cascade is considering a range of electrical cogeneration possibilities, from being self-sufficient in electrical power to being a net contributor to the power grid. Madison Paper Company, St. Regis, Keyes Fiber, Pejepscot, and others are all considering the fueling of their boilers with coal or wood. These considerations afford the opportunity to install cogeneration systems. Even if cogeneration systems do not provide enough electricity to sell to others, the additional generation of electricity by industry displaces utility generated electricity which would have been purchased.

Cogeneration is by no means limited to the large paper and pulp mills. Woodtek, in North Anson, is considering a 5-7 1/2 MW power facility fueled with wood residued. Marine Colloids, a food processing facility in Rockland, and Hebron Academy are involved in plant facility changes which could produce electricity in amounts which exceed their needs and would be resold to others.

The Office of Energy Resources estimates that, in the next ten years, as much as 200 MW of new capacity could be realized by the combined development of new energy facilities in forest products industries, agricultural and fish processing industries, and other commercial, institutional, and municipal facilities.

d. Considerations

The use of cogeneration systems can reduce long term energy costs, and provide a more stable supply of both electricity and process steam. Thus, while at the same time as reducing the environmental impact of thermal pollution, these facilities can decrease total energy costs on a Btu basis. By using waste products such as bark, wood residues and chips, and domestic coal, cogeneration facilities can lessen Maine's dependence on traditional fossil fuels. Cogeneration systems require new equipment, increased manpower, and interconnected electrical distribution and relay systems and thus require substantial capital costs. However, the long-term economics of fuel savings tend to favor cogeneration in many cases, especially when attractive purchase rates are available for excess power. Assurances that excess electricity or heat from a cogeneration system can be sold at competitive prices to utilities or other users on a long term basis are thus an important factor in encouraging cogeneration.

There may be special siting problems involved in some cogeneration systems, particularly those where heat (rather than electricity) is to be sold to other users. In such cases, the facility must be located in very close proximity to the other users to avoid the loss of heat which results from a lengthy distribution system. In addition, both economic and environmental feasibility must be addressed before siting any cogeneration facility.

e. Current Programs and Policies

Recent changes in federal laws and regulations have been designed to encourage cogeneration. The Public Utility Regulatory Policies Act of 1978 (PURPA) removed three major obstacles which had discouraged both cogeneration and small-scale power producers (less than 80 MW). The first obstacle was that utility companies were not required to buy the electricity produced by cogeneration facilities or small power producers at reasonable rates. The second obstacle was that some utilities charged unfairly high rates for back-up electrical service to cogenerators and small power producers. The third obstacle was that a cogenerator or small power producer ran the risk of being considered an electric utility and thus being subject to State and Federal regulation as an electric utility.

PURPA requires that electric utilities purchase available electric energy from cogeneration and small power production facilities which qualify under the law. The utility is required to pay rates which are just and reasonable, are in the public interest, and do not discriminate against cogenerators or small power producers. Similarly, the law requires electric utilities to provide backup electric service to these facilities at reasonable rates. Finally, PURPA provides that qualifying cogeneration facilities and small power producers can be exempt from State regulation of utility rates and financing and from federal regulation as an electric utility.

In terms of OER programs, efforts to encourage cogeneration have been largely educational and informational. Some technical assistance has also been provided. These efforts include technology transfer, technical assistance regarding cogeneration for companies considering conversion to wood fuel, cogeneration workshops and seminars for business and industry, and assessment of the potential for industrial cogeneration in Maine.

6. District Heating

a. Introduction

District heating and cooling is achieved by distributing heat, either in the form of steam or hot water, produced from a central power source through a network of pipes to nearby buildings for space heating, cooling and hot water heating.

The use of steam district heating began in the U.S. in the late 1800's, but did not remain as common during this century as it has been elsewhere. By 1960, there were district heating systems of one size or another in about 50 major U.S. cities, several of them in New England. Originally, these systems were designed to run on coal, though many later converted to oil because of its relatively low cost during the late 1960's and early 1970's, and due to environmental considerations of coal-fired plants.

In European countries district heating came into its own during the 1920's, and never was reduced. Unlike American's, European's had always had limited supplies of oil and gas and felt that district heating was the most economical approach to meeting expanding domestic heating needs.

b. Current Use

Although no Maine communities have operating municipal district heating systems, a number of large building complexes in the State have steam heating systems that are essentially small scale applications of the concept. The Brunswick Naval Air Station, Loring Air Force Base, the Augusta Mental Health Institute, and the University of Maine at Orono all have "mini-district" heating systems. The City of Concord, New Hampshire, for example, has an existing wood fired central district heating facility that virtually heats the entire downtown core area.

The heat source for district heating can be either a heating plant built specifically to supply the system or an industrial or electrical power plant that gives off "waste" heat that can be cogenerated, or captured, for the system. The fuel to feed these plants varies. Existing systems in the U.S. and abroad are fueled by oil, coal, wood or peat, though other fuels could be used.

c. Resource Availability

Further study is needed to determine the extent to which district heating and cooling can be used in economically viable ways in Maine. The northern European experience does show that such systems are feasible in communities with compact populations, down to a size as small as 1200 persons. Thus a considerable portion of Maine's population might possibly be served by district heating systems.

The application of district heating through cogeneration may be possible where excess power plant heat or industrial process steam is available. Several Maine communities are now beginning to explore the resource potential of district heating with local utilities and industries.

d. Considerations

Waste heat from existing power stations or large industrial boilers could be used in many cases for heating the plant or nearby buildings, leading to potentially substantial savings of the current space heating fuel used. In addition, district heating could lead to conversions of conventional residential space heating to more efficient, inexpensive, and less polluting fuel sources.

Winter heating crisis problems of the poor and elderly might be alleviated in areas served by district heating more easily than is currently the case with individual heating systems.

While district heating systems are not common in the U.S., the necessary technology is fully developed in areas of Europe with a similar climate, geology and settlement patterns. Thus complete information on system design, costs, installation, and other important characteristics are readily available.

Another attractive aspect of district systems is that air quality improvements may be possible. Central, efficient and minimally polluting heating facilities could replace smaller, less efficient individual heating units. However, larger facilities come under more regulation and, depending on the fuel and technology used, could create air quality problems that didn't exist before.

To pursue Maine's district heating potential, new institutional arrangements would be necessary to establish and operate systems. Close cooperation would be required between the public agencies or utilities that establish and operate a district heating system and the power plants or industries that may be supplying heat energy to the system.

Installation of such systems within communities would often require extensive excavation that can be quite disruptive. Further, the pipes must be safely worked into the existing sub-surface systems (sewer, water, power, telephone, gas).

e. Current Programs

Past and current actions of the OER have focused on investigating the economic and technical feasibility of district heating systems in the most promising sites in Maine. Other aspects of OER district heating programs consist of providing information and technical assistance to communities interested in studying local district heating potential.

The Department of Energy, the Department of Housing and Urban Development, and other Federal agencies plan joint efforts to promote the use of district heating and cooling in hundreds of communities throughout the Nation. As currently envisioned HUD, will initially provide communities with funds and technical assistance for initial planning work. DOE is expected to assist communities which have already taken an initial look at district heating and want to take the next step towards developing these systems.

These joint efforts are part of a comprehensive Federal Action Plan for the implementation of a National District Heating Program. The long range National District Heating Program plans to study 300-450 communities for district heating possibilities and help establish working systems in 150-200 within five years.

7. Summary

There is an enormous untapped potential for energy conservation in Maine. Economical and technical opportunities exist that could reduce overall energy consumption in Maine in the next ten years while maintaining our current standards of living. OER forecasts conservatively estimates a potential for nearly a 10% decrease in overall energy demand by 2000. Most of our energy conservation opportunities are well known. They include:

- Energy efficient weatherization of existing buildings;
- Energy efficient construction of new buildings;
- Energy efficient operation of commercial and industrial buildings and processes;
- Installation of energy-efficient appliances and industrial equipment; and
- Increased implementation of energy-efficient transportation methods including ridesharing and public transportation where appropriate and the use of higher mileage vehicles.

Conservation cannot elimate our fuel needs. However, one of the most important aspects of conservation is that it can stretch depletable, conventional energy resources now in use over a longer period, perhaps long enough to bring renewable technologies and clean coal technologies on line to meet our needs with no transition period of fuel shortages. Conserving energy by using it more efficiently may also help improve the quality of the environment, by reducing fuel-related pollution and the need for new large power facilities.

Finally, conservation can stimulate economic growth by savings gained from lower fuel use and by keeping dollars from flowing out of state. The money we save and keep in-state will be available for local investment.

True conservation allows us to perform as much or more work while using less energy. Too often, conservation is equated with cold homes, closed factories and restricted travel during vacation; in general, doing without something we want or need. However, by taking the proper conservation steps, it will be possible to have warm homes, economic growth, and freedom of movement as well as lower energy use.

IV. RENEWABLE RESOURCES

IV. RENEWABLE RESOURCES

Maine's native renewable energy resources include hydro power, wood fuel, solar energy, wind, the tides, biomass, peat and solid waste. These resources offer many important opportunities to diversify the state's energy mix. Along with strong conservation efforts, cogeneration and district heating, their increased development can substantially reduce the state's dependence on imported fuels and the drain they impose on the state's economy.

Most of Maine's renewable energy resources are located in many or all parts of the state. This widespread availability presents attractive economic as well as energy opportunities that could play a key role in reviving Maine's rural economy. At present, our native energy resources are in widely varying stages of development and use. For example, much of the state's hydroelectric power potential has already been harnessed, while modern tidal power still remains in the planning stages. Wood fuel is used extensively by homeowners and forest products industries, but the state's peat reserves have yet to be tapped as a fuel source. However, whether currently used or not, the potential exists for increased use of all of our native energy sources to some degree. Progress in developing these resources and the extent of their contribution to our energy needs in the future will depend on many factors. These factors include market conditions, available technology and private and public policy choices that must try to balance economic and environmental concerns.

The following sections discuss the potentials and limits for the development of each of Maine's major renewable energy resources and some of the current government programs relating to them.

1. Hydroelectric

a. Introduction

Hydro power uses falling water to produce energy. It can be used directly as mechanical energy or, as has been more common in recent decades, it can be used to generate electricity for use at the site or elsewhere. Hydro power usually involves the building of a dam to raise the height of the water at a particular site and thus increase the energy potential. Other less common methods to increase the water height, or "head", include tunneling through the ground or building a large diameter pipe or "penstock" downhill from the water source. Water can also be pumped uphill to storage basins for later release. This is called "pumped storage" and can be used when enough excess low cost energy is available to allow a net energy gain.

Hydro power exerted a strong influence on the early development of the State. Before the early 1900's, methods of converting mechanical energy to electricity had not been discovered. Hence, most early mills and industrial plants were located at good hydro power sites and many of Maine's major cities and towns grew up around them. In the 1920's and 1930's after electricity came into broader use and the ability to build large dams developed, Maine's hydro power sites came under increased pressure for development.

During the period of cheap oil, from the late 1940's to the early 1970's, hydro power lost its economic advantages. As a result, interest in additional development of Maine's hydro power potential declined. More recently, the rising costs of oil and other non-renewable fuels has made hydro power economically attractive again and generated renewed interest in expanding use of this energy resource. At the same time, the use of Maine rivers for recreation has increased dramatically, as has concern for protecting the environment. This has, and will likely continue, to create conflicts of interest in some cases.

Nonetheless, on the whole, increased production of hydro power in Maine can make desirable and potentially large contributions to efforts to achieve more energy self-sufficiency.

b. Current Use

Currently, there are 85 hydro power facilities operating within the state. Since 1950, the total contribution of hydro power to Maine's energy needs has been relatively constant at 33 trillion Btu's (or 2.5-3 billion kw hours annually).[1] Current developed capacity is more than 600 megawatts, equal to approximately 7.9% of Maine's current total energy consumption (down from about 17% in 1950 when energy demands were smaller). At present, hydro power provides roughly a third of the electricity used in Maine. New efforts to use Maine's untapped hydro potential were being actively pursued at over 50 existing dam sites in the state during the past year.

c. Resource Availability

Two major studies of hydro power development potential in New England are currently being conducted by the U.S. Army Corps of Engineers[2] and the New England River Basins Commission[3]. These are taking into consideration the revitalization of existing dams and the building of new ones. While these studies have not fully addressed environmental and economic limits to this hydro development, the preliminary findings provide an approximation of the hydro power development potential remaining in Maine. (See Figure H-1)

[1]Maine Comprehensive Energy Plan, 1976 Edition, Maine Office of Energy Resources.

[2]"National Hydroelectric Power Study, Northeast Power Coordinating Council Regional Report, Volume XV", U.S. Army Corps of Engineers, New England Division, Waltham, Massachusetts

[3]Ongoing Hydropower Expansion Study, New England River Basins Commission, 141 Milk Street, Boston, Massachusetts.

Table H-1
Development Potential in Maine

	Capacity (KW)	Energy (MWH)
New power from		
Existing Dams[1]	370,055	2,260,825
New Dams[2]	1,643,000	3,688,290
TOTAL	2,013,055	5,949,114

Source: [1]New England River Basins Commission Hydropower Study. This estimate assumes a 70% plant factor.

[2]National Hydropower Study: Corps of Engineers, 1980. This estimate includes base, intermediate and peaking power.

The figures above are calculated assuming development of both the Dickey-Lincoln School Project and a large-scale Cobscook Bay Tidal Project - neither of which may be built due to economic and environmental concerns. (Tidal power is discussed in this Plan under Renewable Resources.) Even so, the estimates may be low since no studies to date have included estimates of the development potential for a number of possible hydro power activities, including:

- development of additional upper-basin or pumped water storage facilities,

- construction of new small, or "low head", hydro projects, and

- improvements in existing storage and power capabilities at sites in basins already developed.

The potential may exist to approximately triple the amount of energy produced by hydro power in Maine. However, conflicts with other beneficial water uses, environmental impacts and economic constraints are such that only part of this potential can reasonably be expected to be developed. Development of new dams is particularly sensitive to the interest rates on construction loans (due to the high initial costs of construction) and also to prices set for electricity they generate. As oil prices and other fuel costs continue to rise, hydro power development will become increasingly attractive in terms of these economic considerations. The number of feasible dams and the potential contribution of hydro power to the state's total energy mix will also increase if effective interest rates become lower and as regulations affecting small power producers are established.

If environmental and economic constraints allow only half of the currently estimated hydro power potential in Maine to be developed over the long term, about 1030 megawatts of capacity would be gained and the contribution of hydro power to state energy needs would double. Hydro power would then contribute the equivalent of about 20% of Maine's total current annual energy consumption, or about 40% to 50% of the state's total current annual electrical energy use.

o Dickey-Lincoln School Lakes Project

The only large-scale conventional hydro project currently proposed for Maine is the Dickey-Lincoln School Lakes Project. It would be built on the upper St. John River at a site that probably offers the only opportunity for a very large hydro facility in the state. In October 1965, Congress appropriated funds for preliminary planning and design work on the project, which is an offshoot of the earlier Passamaquoddy Bay - Rankin Rapids combined tidal and hydro power proposal. The project would consist of two dams - a 335 foot high dam at Dickey, impounding an area of 86,000 acres with a generating capacity of 760 megawatts, and a smaller dam at Lincoln School to smooth out stream flow fluctuation caused by the releases from the Dickey dam. The Lincoln School dam would be 90 feet high and have an installed capacity of 70,000 kilowatts. The Dickey powerhouse would be used primarily to meet peak power demands, generating 1.2 billion kilowatt hours annually. Regulation of stream flows in the St. John would also result in increased energy output at downstream Canadian hydroelectric plants by about 350 million kilowatt-hours annually, some of which might be returned to the United States, pending execution of a formal agreement with Canadian Officials.

Congress has allocated annual funds for planning and design of Dickey-Lincoln to the Corps of Engineers since the original 1965 authorization. The first draft Environmental Impact Statement was made public in August 1977. The draft EIS for the transmission lines was released by the Department of Energy in March 1978. A revised draft EIS for the dams and powerhouses was published in December 1978, and the final EIS for the project is due to be published in late 1980. At this point, Congress has not made a decision on whether to provide full construction funding for Dickey-Lincoln. If approved, construction of the project would take about 8 years, though some power production could begin about six years after construction begins.

Governor Brennan has been a strong and active proponent of the Dickey-Lincoln project throughout his administration. However, opposition by various public groups and recent political developments raise doubts as to whether construction of Dickey-Lincoln could occur in this decade, or at all.

A study of the feasibility of constructing the Lincoln School dam only for base and intermediate power generation is now being made by the Northern Maine Regional Planning Commission. No plans have yet been formed to pursue this alternative.

d. Considerations

In general, hydro power is a very desirable source of energy for Maine. It is a relatively large, native renewable resource that offers power with no cost for fuel. Once hydro facilities are built, operation and maintenance costs are low and dam construction keeps capital in Maine. Some hydro projects can reduce flood damages downstream and provide other downstream benefits, such as control of the flow for recreation, water supply or municipal wastewater assimilation. In addition, hydro generators can be turned on and off quickly to respond to the need for peaking power, and hydro power produces no environmentally harmful pollutants.

However, the feasibility of hydro power at a given site is heavily influenced by economic and environmental considerations. Some potential hydro sites would flood large areas of land valuable as timber land, as a wildlife and plant habitat or for some other purposes. Damming can interfere with the migration of anadramous fish if adequate fishways are not installed. Impoundment and changes in downstream water flow can adversely affect other fish species as well as create conflicts with sport fisheries. The development of some sites would eliminate popular stretches of whitewater used for canoeing, rafting and kayaking and "drown" significant natural features of the landscape. Impoundment can force longtime residents off their land and conflicts can arise between the needs of dam owners to regulate water flow and the desire of shoreland owners for stable water levels.

These and other potential impacts make it necessary to carefully consider each hydro development project on a case-by-case basis during regulatory permit procedures.

e. Current Programs

Maine's current laws tend to encourage development of hydro power while at the same time controlling it, to ensure that unreasonable adverse impacts on the environment and other water uses do not occur.

The Mill Dam Act allows a shoreland owner to flood the land of others as a result of building an approved dam. Flowage rights must be paid. The revitalization of existing dams is encouraged in the Abandoned Dams statute by allowing anyone to claim an abandoned dam if its owner can not be determined. The Small Power Production

Facilities Act defines the relationship between small power producers and the utilities in a way that encourages small scale power production. (For example, making it possible for small dam owners to sell excess power to utilities at a reasonable rate.)

Legislation was passed in 1979 that simplifies the regulatory procedures for installing power facilities at existing dams. This act allows the Board of Environmental Protection to act as a "clearinghouse" agency in the review of permit applications by several state agencies including Inland Fisheries and Wildlife, Marine Resources, Land Use Regulation Commission, Historic Preservation Commission, Transportation and Energy Resources.

At the same time that Maine law encourages hydro development, it also controls it. To protect the environment, Maine laws require permits and State review for activities associated with hydro development that may impact land, water and other resources. Public utilities are required to get a certificate of public necessity and convenience for large hydro facilities intended to produce electricity. Such regulation is meant to curb unwise or unnecessary hydro development.

In addition to its laws, Maine has several programs that address hydro power development. The Office of Energy Resources offers information, technical assistance, and encouragement to responsible hydro power developers, as well as working for the public's interest in hydro-related developments in legislation and administrative proceedings. The Office of Energy Resources has also helped to work out disputes over water levels between power producers and shoreland owners.

In January 1978, the OER began participation in the new England River Basins Commission's (NERBC) Hydropower Expansion Study. The first step in this study was to inventory existing dams in the region and to assess the technical and economic feasibility of hydropower development at these existing dams. Adandoned dams that do not currently produce hydropower were assessed in the first phase. The development potential at new sites are being evaluated in the second phase of the study, as are the socio-economic and environmental impact considerations.

The Maine Critical Areas Program is working to identify the scientific and natural values of Maine's water resources (for example, the most significant waterfalls and areas of whitewater. This information will help to avoid aesthetic and environmental conflicts and allow more informed decisions concerning which hydro sites to develop.

Financial assistance has been made available to small hydropower developers through the Maine Guarantee Authority and the Maine

Municipal Securities Approval Act. In addition, the federal government provides low interest loans through the Farmer's Home Administration and through the Department of Energy for feasibility studies. DOE Region I also provides free technical assistance to prospective hydropower developers through a contract with a consulting engineering firm.

Federal law also encourages and controls hydro power development. Federal tax laws provide an eleven percent tax credit for investments in hydro power facilities, in addition to the regular 10% investment tax credit normally allowed for business investments.

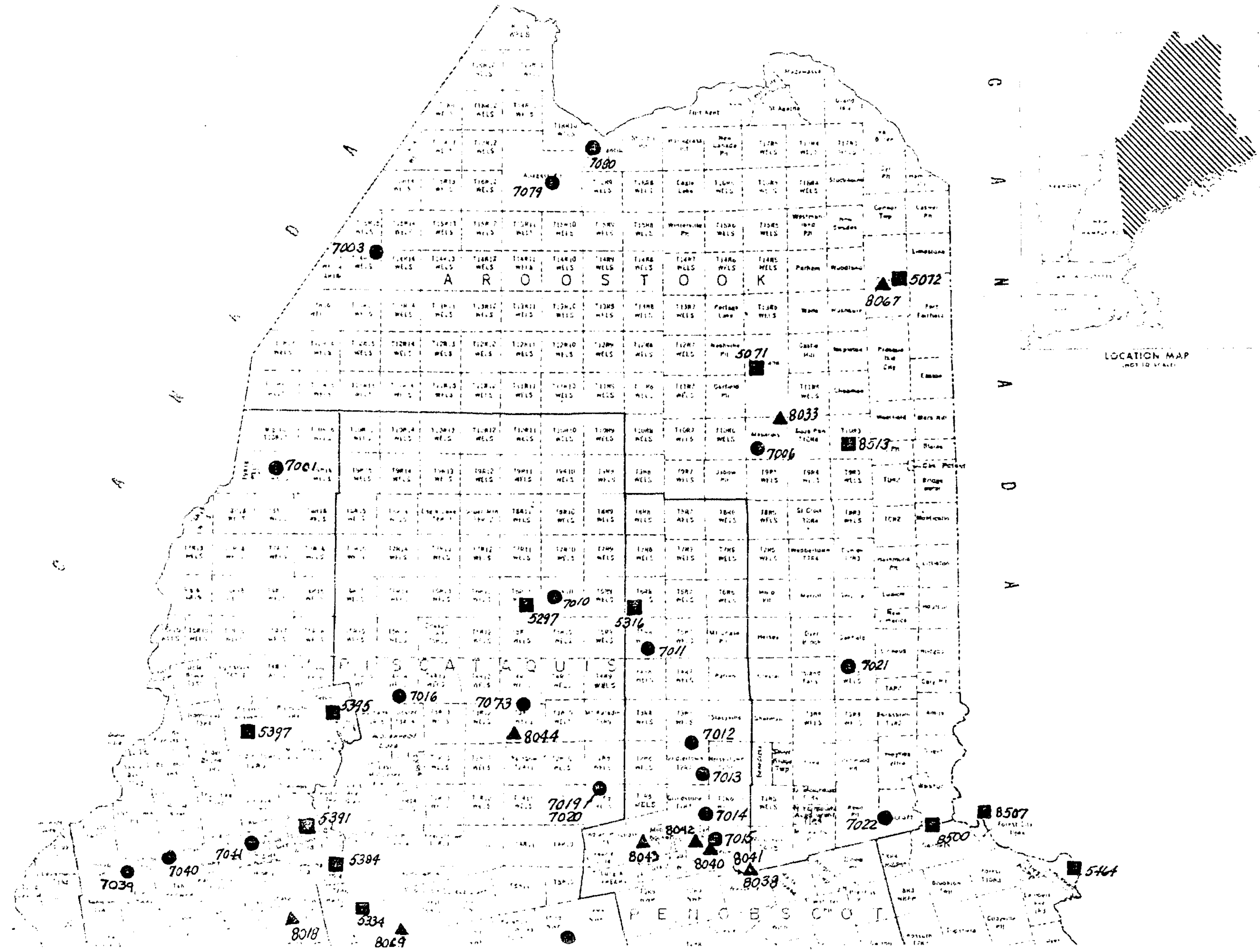
One of the five sections of the National Energy Act, the Public Utilities Regulatory Policies Act, requires that utilities must buy power produced by small hydro power facilities when it is offered for sale. In Maine, the price the utility must pay is the cost of producing the same power from oil fired plants. Since many hydro facilities can produce power for less than oil fired plants, this makes investment in hydro more attractive.

Development of hydro power facilities is also encouraged by the laws authorizing the Army Corps of Engineers to construct multiple purpose water development projects. For example, the Corps is authorized by Congress to work on the Dickey-Lincoln School Lakes project on the St. John River in Maine.

Like Maine laws, Federal laws also control hydro development. For proposed dams with greater than five megawatts of capacity, a license must be obtained from the Federal Energy Regulatory Commission (FERC). Projects at existing dams with less than five megawatts of capacity may be exempted from Federal licensing upon application from the owner.

The National Environmental Policy Act requires that an Environmental Impact Statement be prepared on all major federal projects affecting the environment (such as the Dickey-Lincoln dam project). The EIS must address environmental impacts of the proposal and alternatives to the proposed action.

Additional Federal laws such as the Endangered Species Act, the Acts establishing the National Natural Landmarks Program, the National Wild and Scenic Rivers Program and the Historical Preservation Act make it difficult for federal agencies to fund or participate in projects that would conflict with the goals of these Acts or their related programs.


CANADA
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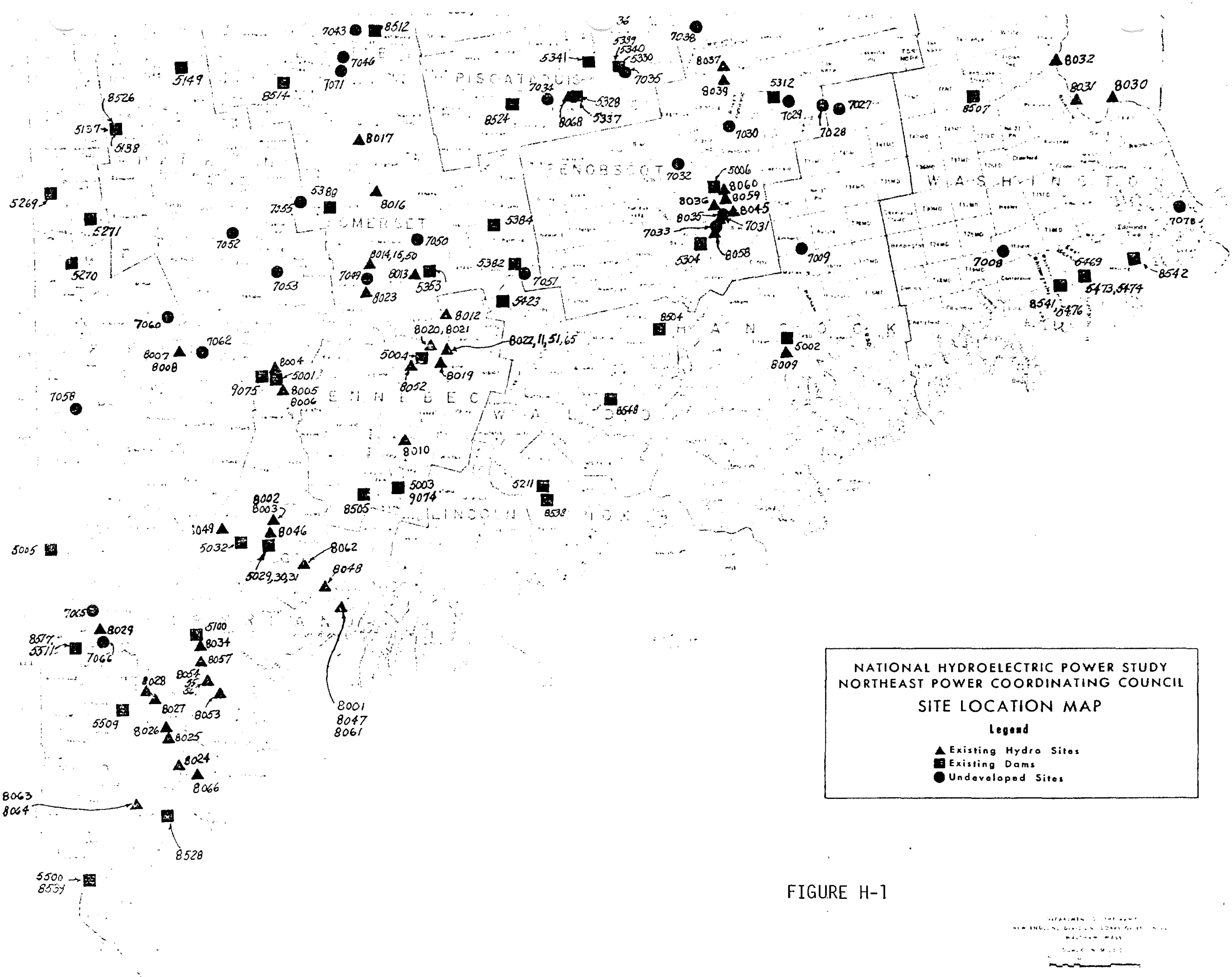
NATIONAL HYDROELECTRIC POWER STUDY
NORTHEAST POWER COORDINATING COUNCIL
SITE LOCATION MAP
Legend
Existing Hydro Sites
Existing Dams
Undeveloped Sites
PISCATAQUIS
PENOBSCOT
WASHINGTON
HANCOCK
LINCOLN

FIGURE H-1

2. Wood

a. Introduction

A major result of the past decade's rising oil prices has been a dramatic increase in the use of wood for space heating. In 1970, Maine homeowners burned about 324,000 cords of fuelwood. During the 1978-79 heating season, the figure had risen to 575,000 cords. Maine's pulp and paper companies and some other forest products industries have also increased their use of wood residues, such as sawdust, shavings and bark, for space and process heating needs.

b. Current Use

The New England Fuelwood Survey found that during the 1978-79 heating season 46% of all Maine households burned wood as a primary or supplementary heating fuel. An OER Resurvey found that approximately 55% of Maine households burned wood during the 1979-80 heating season.

Even before the 1973 Arab Oil Embargo, many pulp and paper mills used wood residues as a fuel to some extent. As oil prices rose, the paper industry's use of residues increased. Currently, most Maine pulp and paper mills have converted, either totally or partially, to burning their wood residues. The exact amount of oil saved by this trend is unknown; but it is believed to be a substantial amount. For example, the new bark-fired boiler used in one of Great Northern Paper Company mills allows a savings of over 400,000 barrels of oil a year.

Some other types of forest products industries, ranging from toothpick factories to furniture manufacturers, also use their wood wastes as fuel. Currently, about 50 forest products firms, not including the pulp and paper companies, are burning wood for their space or process heating needs. About 30 other firms are considering the possibility of converting to wood.

c. Resource Availability

About 90% of Maine is forested. Considering the size of our forest resources and the fact that trees are renewable, wood could be used as a major fuel in the state in the future. The limits to the contribution wood can make as an energy resource depend on a number of factors, including: how well our forests are managed, how efficiently wood fuel is used, and the extent of the demands for wood as a resource for manufactured products and other uses.

The 1970 U.S. Timber Resources Survey found that high-quality trees of several hardwood species were already being overcut in many parts of the state. As the recent firewood boom has developed, it is likely that instances of local overcutting have increased, especially in easily accessible areas. This may account for the fact that firewood supply problems have already developed in some parts of the state. On the other hand, there are hundreds of thousands of forested acres where hardwoods are unused or underutilized either because they aren't easily accessible, or because local demand is low, or, in some cases, because the owners require softwood species in their production process.

The 1970 Timber Survey also found that most of Maine's 100,000 small private woodlots are not managed efficiently for long-term, sustained yield. Some are overcut. Most of these woodlots are not under a forest management program and produce far less wood for manufactured products or fuel than they could if properly managed.

Another factor that will influence the future availability of wood for fuel is the competition for hardwoods for manufactured forest products. The demand for forest products is expected to double by the year 2000 and some concern exists that competition will develop between forest products industries and firewood users for forest resources. Forestry professionals believe that wood used for firewood should be limited mostly to low-grade and cull trees. A cord of high-quality hardwood that is cut and split, valued at about $100 as firewood, is worth several hundred dollars to the state's economy as a manufactured product.

The energy potential of wood could be expanded by advances in technology that allow more efficient burning or the increased use of low-grade wood and wood residues by homeowners. For example, OER and the Maine Forest Service predict that more and more people will turn to recently developed automatically-fed central heating systems. These systems may use wood chips or compressed wood pellets.

OER estimates that approximately 75% of all Maine households will be heating totally or partially with solid fuel by 1990. By the year 2000, this percentage will probably remain at or near 75%. Firewood, wood chips and wood pellets will make up a substantial portion of this total. However, wood is expected to be replaced gradually with coal in many households as coal becomes more available in Maine.

About 35% of Maine's households are apartments or mobile homes. The New England Fuelwood Survey and preliminary results from the Resurvey indicate that a large number of mobile home and apartment households have converted, or are considering converting, partially or fully to wood heat. It also appears from these surveys that the turn to woodburning has not yet peaked, but is still continuing to increase.

While the use of wood fuel by homeowners and non-forest products industries may eventually decline, the forest products industries will probably rely heavily on wood energy for a longer period of time. For these industries, wood residues are readily available at low or no cost and if their wood wastes are not used, they will create disposal problems. The potential of wood energy in forest products industries is more fully discussed in this report's section on cogeneration.

d. Considerations

Wood is a very attractive fuel for Maine. It is a readily available, renewable native resource requiring minimal transportation costs. Wood harvesting and processing provide local jobs. It is cheaper for home heating than heating oil, kerosene or electricity. Wood burning technology is relatively well developed and simple, and residential wood burning equipment is generally affordable. Wood residues can be burned to decrease waste disposal problems, and the use of all types of wood fuel decreases our dependence on foreign oil. Wood can also be used in the pulp and paper industry and the other forest products industries for cogeneration.

Of course, there are a number of potential problems that must be considered with regard to wood heat. It is estimated that several thousand wood-burning related house fires occur every year in Maine, generally as a result of unsafe installation of stoves or chimney fires caused by creosote buildup. Wood smoke contains rather high quantities of particulate pollutants. Thus, increasing pollution from residential wood-burning might conflict with the need for industrial expansion due to legal limits on the amount of pollutants that can be emitted in a given area. Particulates and other pollutants produced by wood-burning may also pose risks to human health if they exceed certain levels. On the other hand, in contrast to oil and coal, wood smoke is very low in sulfur dioxide and nitrogen oxide emissions, currently two of our most common and serious pollutants.

A drawback of traditional chunk firewood is its time-consuming, bulky nature. An alternative that makes wood more convenient is the use of central furnaces that use wood pellets or chips. At this time a supply system for consumer supplies of pellets and chips is not adequately developed for widespread use. However, it should steadily expand in the next few decades.

e. Current Programs

The increasing switch from oil to wood as an energy source has occurred without major government assistance. In fact, most federal programs have placed a higher priority on conservation and on other energy resources than on wood. The U.S. Department of Energy has funded feasibility studies on several wood-fired electrical generation projects. However, little attention has been given to home space heating. It was not until this year that the Internal Revenue Service decided to allow tax credits for the purchase of wood burning devices.

State government is encouraging wood burning in Maine. For example, Maine allows a tax credit on part of the cost of wood-fired central heating systems, and both the Maine Forest Service and the Office of Energy Resources have programs to promote wood as a residential and industrial energy source. OER has two distinct wood energy programs. One is aimed at the industrial/commercial sector, while the other is aimed at homeowners.

The New England Regional Commission and the New England state energy offices have a cooperative industrial wood energy assistance program that provides information and technical assistance to large firms and organizations that are thinking about converting to wood. The program is tailored to each client and can include: a preliminary cost assessment: a preliminary site visit to survey the potential space for conversion to a wood-fired system: help in deciding if the switch to wood is worthwhile: technical assistance in how to switch: and an assessment of cogeneration possibilities. This program has so far helped about 15 firms in the State look at the possibility of converting to wood. Some of the larger firms and organizations currently considering wood as an energy source are Madison Paper Company, Marine Colloids, Brunswick Naval Air Station and the University of Maine system.

The Maine Guarantee Authority, the Small Business Administration, the Economic Development Administration and the Housing and Urban Development Action Grants have the ability to provide financial assistance for industrial wood conversion projects through bonds, conventional loans and direct grants.

In the residential sector there are several State programs promoting the use of wood as an energy source for homeowners and providing information on safety. OER provides publications and other information on wood burning to interested persons, fuelwood dealers, organizations and other agencies and holds public workshops on a variety of woodburning issues.

OER also monitors fuelwood prices across the state and has several ongoing programs aimed at increasing fuelwood availability. For example, it provides the public with a yearly list of the fuelwood cutting permit programs offered by pulp and paper companies and has set up framework for an emergency fuelwood program in conjunction with several large companies. A list of known fuelwood dealers is made available plus information on the Fuelwood Program which is administered by the Agricultural Stabilization and Conservation Sevice and the Maine Forest Service.

OER, with the State Fire Marshall's Office, has developed a publication called Recommended Standards for the Installation of Woodstoves, which is used statewide by fire departments and stove installers as a voluntary woodstove installation standard. OER participates in community woodburning safety programs and workshops, and has recently contracted with the Cooperative Extension Service to conduct safe woodburning programs throughout the State.

The U.S. Forest Service, in cooperation with the Maine Forest Service, is now conducting the decennial survey of Maine timber resources which will provide valuable data about the current availability of wood for energy, manufacturing and other uses.

3. Solar

a. Introduction

Solar power is the direct use of sunlight for space heating, water heating and other energy needs. Though the current use of solar power in Maine is limited, the near term and future potential is great. Most energy planners believe that solar power will be one of our major energy sources in the United States within 25 to 35 years. Just how quickly the full potential of solar energy can be realized depends on economic factors, advancements in solar technology, increased public awareness and government policy.

Maine's Comprehensive Energy Plan of 1976 proposed the increased use of solar power and other native energy sources as a cornerstone goal. The transition to solar energy has accelerated since then due to the rising costs of traditional fuels, educational programs, State and Federal tax incentives, special loan programs and increasing public interest.

b. Current Use

At present, solar energy technology is being used in about 1400 Maine homes and commercial buildings, primarily for space heating or domestic hot water heating. The most common and inexpensive method of using solar power is through passive solar building designs that use the building orientation, configuration and materials to collect and store solar energy. This can be as simple as increasing the area of southfacing glass in a building and using sufficient insulation to keep the warmth gained inside. Basic passive solar features can often be incorporated into new buildings at little or no additional cost.

Retrofitting buildings with simple low cost solar air heating devices which simply transfer heat into the adjacent interior space is also gaining in popularity. Though they have no means of storing heat or distributing it throughout the building, these devices are less expensive initially than systems with storage and distribution capabilities. These simple solar devices and passive solar designs will probably be more and more widely used during the 1980's while more sophisticated solar technologies develop.

Solar hot water heaters are another widely available, increasingly popular solar alternative. Thus far, about 400 solar water heaters have been installed in Maine. They are relatively simple to install on the roof or southern side of a new or existing building and can supply up to 60% of the heat required for a domestic hot water supply. The initial costs for a solar hot water heater can be high. However, their long term cost advantage is very attractive compared to electricity and other traditional energy sources because there are no costs for the solar unit's fuel once it is installed.

The use of simple passive solar technology such as described above is expected to grow steadily during the 1980's. More complicated "active" solar systems are -- and, in the near future, will likely remain -- less widely used. These systems use collectors and a mechanized storage and distribution system. Initial capital costs range from $5,000 to $20,000. In most cases, the energy savings eventually more than offset the high initial investment. However, few building owners have the finances required to purchase such systems. Solar photovoltaic cells that turn sunlight into electricity are also commercially available. At this time they are more costly than the conventional alternatives, but mass production, technological refinements and rising fuel costs should make photovoltaic solar systems increasingly cost competitive in the future.

c. Resource Availability

Despite its northern location, Maine receives enough sunlight to use current solar technology to produce low and medium temperature heat for space and water heating on a year-round basis. The state gets a comparatively high amount of sunlight in winter, when heating demands are greatest. In fact, sunlight availability in January and February for most areas of Maine is as high as for any East coast state.

Approximately 32% of Maine's present energy demand is for building space and water heating. Potentially, a substantial portion of the energy needed for these purposes could be supplied by solar power. (Most existing solar space heating installations in Maine provide an average of 20% to 30% of a building's yearly space heating needs; current solar water heaters supply about 40% to 60% of the domestic hot water needs in buildings where they are used.) The rest of the energy needed for space and water heating in solar buildings can be supplied by other forms of energy such as wood, electricity, gas or oil.

It is estimated that 60% of all existing buildings in the state have adequate "solar access." For the purposes of this report, solar access is defined as the orientation of at least one major building facade within 30 degrees of true south, with minimal (less than 5%) shading on that surface between 9 AM. and 3 PM. Simply put, saying that a building has adequate solar access means that it receives enough sunlight to make the use of solar power worthwhile.

With proper planning, about 90% of all new buildings could use solar power for some degree of space or water heating at little or no additional cost. However, solar energy use tends to make sense only in well-insulated buildings. It can be used most effectively and make the greatest contributions in new or old buildings that have been weatherized to adequate levels. (New buildings should at least meet the State Energy Conservation Building Standards.)

Simple solar technologies - such as passive solar building design and solar water heaters - can make significant long term contributions to individual and statewide energy needs in Maine. Maine citizens can take advantage of these opportunities right now. Future technological developments in solar power can be integrated into existing solar buildings to further reduce consumption of non-renewable fuels and make the solar contribution even greater.

d. Considerations

Solar power is one of Maine's most attractive and most available energy alternatives. It is a native renewable energy source for which there are no "fuel" costs. Thus, solar installation costs are eventually paid back through the savings gained. The long term costs of using solar power for space and water heating are lower than for traditional fuels. Solar power is virtually pollution-free and poses no conflicts with other uses of sunlight. Most of the money spent on solar installations is kept within Maine and the expanded use of solar power will create jobs and utilize native building materials in products manufactured or assembled in Maine.

However, for the full potential of solar power to be realized, a number of considerations must be addressed. For example, the initial costs of tapping solar energy can be high. Affordable long term financing is difficult for many building owners to find. There is a lack of clear legal status of solar access rights (i.e. what happens when one building blocks another's sunlight). In terms of practicality and looks there are sometimes difficulties in retrofitting existing structures to use solar energy since they were not originally designed or oriented to use it. Much of the general public and most contractors are still unaware of the potential of solar technologies and some people are put off by the unfamiliar design of certain new passive solar homes. Finally, the majority of existing homes are not insulated and weatherized heavily enough to use solar energy for space heating effectively. Thus, energy efficiency measures would be required in these homes for use of solar power to be effective.

e. Current Programs

A wide variety of current OER activities are aimed at increasing the use of solar power in Maine. Funds for these activities come from the Department of Energy through the Northeast Solar Energy Center. The following is a brief overview of the major solar programs that have been underway during the past three years.

Technology Transfer/Vocational Workshop Program

This program is designed to assure the existence of knowledgeable providers of solar technology in private industry. Toward this end, over thirty solar workshops have been sponsored since 1978 for building contractors, solar installers and other industry groups that provide, or could provide, solar technologies to consumers.

Solar Publications

The OER has developed a variety of publications about the use of solar power in Maine to expand public awareness, answer typical questions asked by consumers and provide useful technical information. These include fourteen publications on solar topics ranging from relevant financial and legal considerations to inventories of solar use in Maine. Additional materials are developed as new generic technologies emerge.

General Education Program

Because personal contact is one of the most effective ways of tranferring solar information to consumers, this program offers seminar and conference speakers on solar power to the general public. Program topics are geared for both uninformed persons who desire an introduction to solar technology and more informed individuals trying to make decisions about solar use. The goal is to develop and transfer a consistent information base to the public through all appropriate channels including government, educational institutions, community energy organizations and private industry.

Capital Transfer Program

The objective of this program is to make affordable financing for solar technology more available to all Maine building owners. This has included efforts to educate private, State and Federal financing institutions about solar possiblities as well as the publicizing of available borrowing opportunities (these opportunities will expand as funds from the Federal Solar and Conservation Bank become available in 1981.) Also involved are the development and administration of tax breaks and other legislative solar incentives.

Technology Development and Demonstration

This program makes available information on the nature and performance of working solar projects and, in the case of some new solar technologies, assists in their development. A wide variety of activities are used to demonstrate Maine's solar potential, including exhibits and audio-visual materials, buiding and design competitions and grants for certain solar and appropriate technology projects.

Solar Consumer Assurance Program

As part of a national effort to increase consumer trust and acceptance of solar technology, the Maine OER is one of thirty-five state agencies participating in a National Consumer Assurance Program. In Maine, the planned focus will be on the expansion or creation of voluntary quality control installer certification and consumer protection programs.

Removal of Barriers to Solar Utilization

The purpose of this program is to help remove obstacles to solar development in Maine. Thus far, it has included work on minimum warranties for solar products, incentive-oriented solar legislation and licensing procedures for solar technology installers, solar access education, and encouraging the consideration of solar in community energy planning.

4. Solid Waste

a. Introduction

Municipal waste-to-energy systems could supplement Maine's energy supply and at the same time help to solve solid waste disposal problems. Resource recovery offers larger communities alternatives to landfill sites, which are often hard to find locations for and increasingly expensive to maintain. It may also provide a local source of energy in times of reduced energy supply. Communities with solid waste energy recovery facilities can hold down or reduce their waste disposal expenses while providing a reliable and financially attractive source of energy to a local industry or to other consumers. Incineration of waste to produce steam is the most common resource recovery system being considered; however, conversion of waste to methane is also a possibility.

b. Current Use

The city of Auburn has become the first community in Maine to build a solid waste resource recovery project. When this facility begins operation early in 1981, it will generate steam for use by Pioneer Plastics, one of Auburn's largest industries. Auburn's experiences and methods of implementing the concept of solid waste resource recovery will be of great value to other communities in Maine.

c. Resource Availability

Currently, there are about 300 solid waste disposal sites (mostly sanitary landfills) in Maine. Eight regional areas: Sanford, Biddeford-Saco, Greater Portland, Lewiston-Auburn, Norway-South Paris, Augusta, Waterville-Winslow, and Bangor/Brewer, produce about 60% of the 750,000 tons of solid waste generated in the State each year. For many communities, present methods of disposing of municipal refuse are outdated, inefficient or prohibited by state and federal regulations.

There are 12 specific areas in Maine where waste-to-energy projects are considered feasible. Towns in eight of the areas are actively investigating refuse to energy options. If built, these projects, plus Auburn's, would save the equivalent of 400,000 - 600,000 barrels of oil each year. Descriptions of the projects being considered are provided in Figures 4.1 and 4.2.

d. Considerations

Determining the feasibility of a regional resource recovery system is a difficult and complicated task. A broad range of understanding in many areas is required, including the quantity and characteristics of the waste stream, transportation constraints, the costs, available markets for recovered energy, and various technological and financial options. Towns will need help in assessing these and other aspects of waste-to-energy systems. Many independent businesses and commercial facilities may generate enough solid waste to allow building their own waste-to-energy facilities. To help them decide if this is a sound idea, technical assistance will also be required.

Especially for the 12 urban areas where waste-to-energy projects seem feasible, solid waste could become a minor, but significant energy source in the future, as well as a solution to current solid waste disposal problems. However, where incineration is used, potential effects on air quality will have to be carefully evaluated.

e. Current Programs and Policies

The OER is currently studying possible construction of as many of the 12 identified urban waste-to-energy systems as are economically feasible. Because of mutual concerns, the Office of Energy Resources and the Maine Department of Environmental Protection are cooperating in providing assistance to communities and firms interested in resource recovery systems. The two agencies are able to provide assistance concerning regulatory, engineering, technical and financial aspects of solid waste energy facilities for Maine communities.

The U.S. Environmental Protection Agency is also able to provide support in the form of technical assistance although on a limited scale. Both DEP and OER are working with interested communities to obtain any available Federal assistance in this area.

Under Title II of the Energy Security Act of 1980, Congress authorized a two-year program of financial assistance with expenditures from the Energy Security Reserve of $850 million and Department of Agriculture expenditures of $600 million for biomass alcohol fuels and urban waste. $500 million of the DOE allotment will be used for urban waste projects. Financial assistance may take the form of loans of up to 80%, or loan guarantees of up to 90% of construction costs, and of price supports or price-support loans for new and existing facilities.

An Office of Energy from Municipal Waste has been established in the Department of Energy. This office will administer a variety of programs to assist municipalities in evaluating resource recovery from solid waste.

Figure 4.1

Area	Size	Estimated Cost	Type
Waterville/ Winslow	100 tons/day	$5 million	Incineration to Steam
Brunswick	Up to 300 tons/ day	$5-8 million	Incineration to Steam
Bangor/ Brewer	150 to 300 tons/ day	$5-15 million	Modular Incineration/ Steam Refuse Derived Fuel (RDF)
Augusta	100 tons/day	$5-6 million	Incineration to Steam
Biddeford/Saco	100 tons/day	$3-5 million	Modular Incineration/ Steam
Portland	250 to 400 tons/ day	$8-30 million	Incineration/Steam Recovery or RDF
Sanford	75 to 125 tons/ day	$3-5 million	Modular Incineration/ Steam
Norway/South Paris	50 tons/day	$2.5 million	Modular Incineration/ Steam

Source: Maine Department of Environmental Protection, November, 1980.

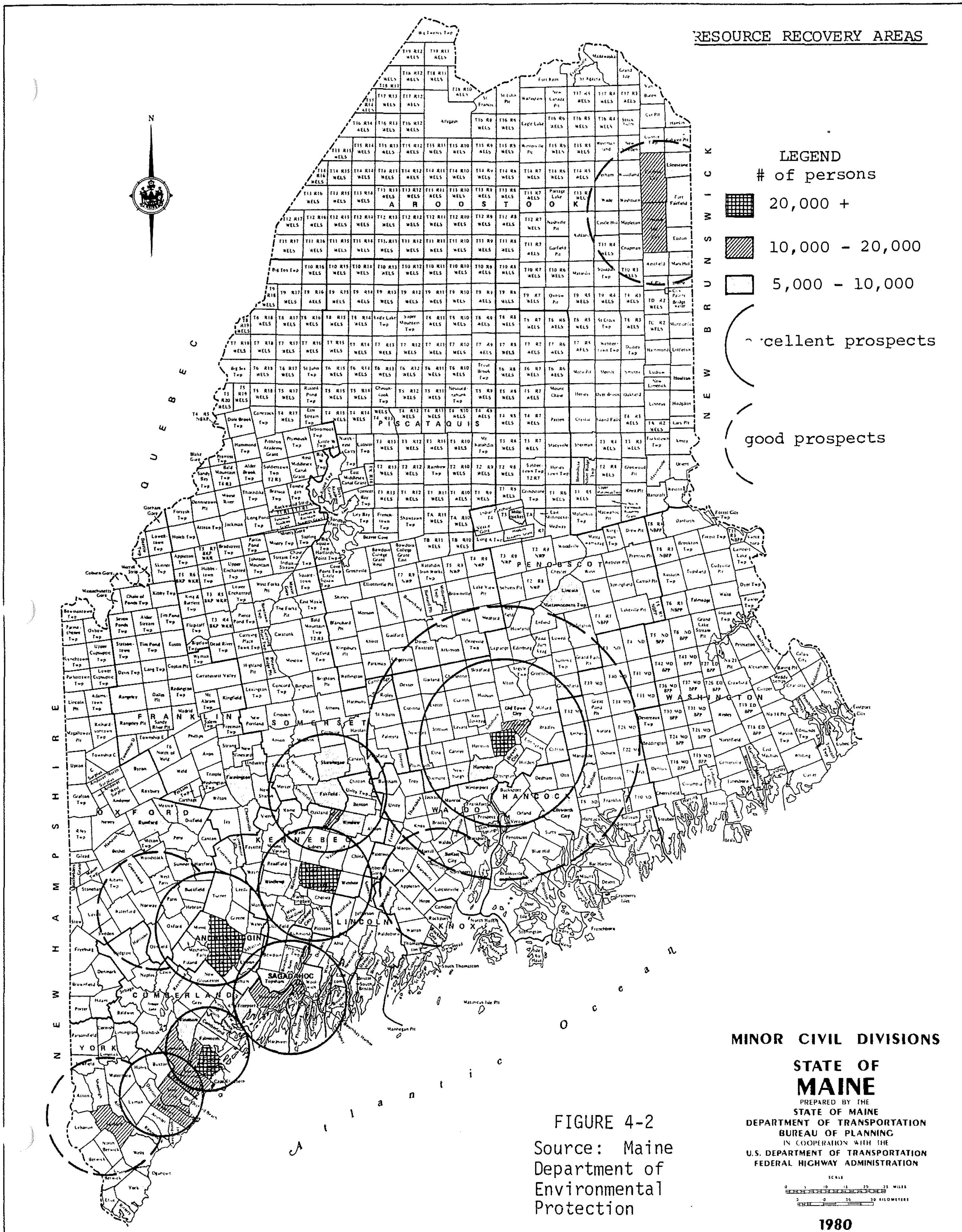

FIGURE 4-2
Source: Maine Department of Environmental Protection

5. Wind

a. Introduction

Wind power can make substantial contributions to the electrical needs of individual homeowners. However, more efficient, less expensive technology must be developed and available before the use of wind power will be widespread and its potential contribution to Maine's overall energy needs can actually be realized.

b. Current Use

Historically in Maine, windmills have long been used to pump water or perform other mechanical tasks, but the most promising use for wind power in the future is for electrical generation. About two dozen small scale wind generators are currently operating in the state, and several more will be operating soon. Each of these operating units can generate about 1 to 3 kilowatts of power, or up to 3000 kilowatt hours of power per year. Depending on individual needs, this is enough power to supply at least some and possibly all of the electricity required by a homeowner.

Though wind is an abundant resource, major problems have kept wind power from contributing greatly to Maine's total electrical supply. First, because of cost and the state of wind technology, it is not presently economically feasible to concentrate power into a few large generators. Small, relatively expensive generators are available to convert wind motion into useable power, but most can supply the needs of only one family. Finally, the wind does not blow constantly and expensive windmills may often stand idle or operate well below capacity if not properly sited.

Many of the wind systems in use today are the only source of electricity for a remote home or commercial operation. In such cases, expensive battery storage systems are usually required to provide power when the wind isn't blowing. Storage would not be a problem, however, if systems are part of the utility network, because other sources of power would always be available. Due to the high cost of the equipment needed, wind-generated electricity tends to be more expensive than power produced by hydro, nuclear fuel, coal or even oil at present. For example, the average cost of wind-generated power currently is 10¢ to 25¢ per kilowatt hour. By comparison, the hydroelectric generating facility being constructed on the Androscoggin River at Brunswick is expected to produce power at 4.5¢ per kilowatt hour. Oil fired generation costs between 3¢ and 6¢ per kilowatt hour for the fuel, plus additional fixed and variable costs of operation; however, these costs are continually rising.

c. Resource Availability

The potential of our wind resource is very large, though wind is currently used to produce only a tiny fraction of Maine's total energy supply. The relative inefficiency of current wind technology and the high costs of existing equipment currently prevent widespread use of this resource. Wind energy could become an attractive source for electricity if current engineering research produces wind-generation devices that convert a higher proportion of available wind to electricity, or if less expensive systems are developed or if the relative economic advantages of wind energy improves by some other means (such as the rising costs of other fuels).

Recent technical advances have made it easier to link individual home or business generators to electric utility systems, thus allowing owners to sell their excess power to utilities during periods of high wind. Legal obstacles once prevented this, but they have been largely resolved. Both Central Maine Power Company and Bangor Hydro-Electric Company will now purchase wind-generated power at 3 to 4¢ per kilowatt hour. Rates may be higher after the PURPA mandated rates are set.

d. Considerations

Wind power has many attractive features. Like solar power, there are no fuel costs and virtually no environmentally harmful side effects. Electricity generated by a small windmill can make a homeowner more "energy independent" or provide power where utility lines are not available. And, of course, any increasing use of wind can help to reduce the use of imported non-renewable fuels.

The greatest obstacle to increasing use of wind power is the current high cost for equipment that is relatively inefficient. However, there are other factors that can affect wind use, including wide variations in wind strength, potential aesthetic problems in scenic areas, and possible conflicts with zoning or land use regulations.

e. Current Programs

1. <u>Field Evaluation Program (FEP)</u>

Since November 1979, OER has been actively involved in this program, managed by Rockwell International's Wind Systems Program for the U.S. Department of Energy and designed to promote the use of small-scale wind generators (less than 100 kw).

Toward this goal, DOE is installing two windmills in each of the 50 states and some U.S. territories. The machines assigned to Maine have been sited through the cooperative efforts of the Office of Energy Resources, the electric utility industry in Maine, and the Northern Maine Regional Planning Commission, with technical assistance and review by engineers from Rockwell International.

The wind generators installed under this program in Maine are:

a) An Enertech 1800, a 1.8 kilowatt machine installed in October 1980 at the residence of James Buck in Trenton;
b) A Storm Master 18, an 18 kilowatt machine to be installed at radio station WDHP (FM)/WFST (AM) in Presque Isle.

2. New England Wind Project (NEWP)

In May 1980, the OER began participation in the New England Wind Project. The goals of this program are similar to those for the FEP, but the machines to be used will be experimental and are not yet commercially available. The systems planned under this program are:

a) 1-2 kilowatt DC output machines designed for independent applications where no electricity is available from utility systems.

b) 8-11 kilowatt AC output machines that can be linked with utility systems. Two sites have been chosen for these machines, one a residence on North Haven and the other a residence and ski lodge at Rangeley.

c) 100 kilowatt AC output Darrius (vertical axis) machines designed for commercial or small industrial applications.

3. Information Dissemination

More than 600 wind power information packages have been distributed to Maine's citizens by the OER to help them decide if wind energy is a good alternative for them. The package includes materials on site selection: unit sizing and load match: technical considerations: lists of available systems, manufacturers, dealers, and accessories: and descriptions of available tax credits and other incentives.

4. Technical Assistance

Dozens of Maine citizens have been assisted by OER with more specific, detailed consideration of wind energy systems for their use. Several communities, such as Rangeley, Monhegan, Matinicus, and North Haven/Vinalhaven have received help in assessing local wind energy development potential on a community scale. Further, OER has worked in cooperation with Public Utilities Commission staff to apply wind energy systems to specialized communication and electrical generation needs - particularly on the Maine coastal islands where remote locations, strong and steady wind, and high costs of hookup to utilities create ideal environments for wind power applications.

5. <u>Monitor Technological Developments</u>

Considerable research on wind power is occuring around the nation on wind energy systems of many sizes, from less than 1 kilowatt to about 3,000 kilowatts. Several test installations have been or are being erected around the country for large machines of up to 3,000 kilowatts capacity, DOE and NASA are the cooperating agencies for administering this large-scale Wind Energy Conversion Systems (WECS) program.

The Electric Power Research Institute (EPRI), on behalf of the country's investor-owned utilities, has installed a 3,000 kilowatt unit manufactured by the Bendix Corporation for Southern California Edison. Recently, the government of Price Edward Island has established a wind test facility as part of an initiative co-ordinated with the six New England Governors-Eastern Canadian Premiers' joint energy program under the direction of the Northeast International Committee on Energy (NICE). This facility will be dedicated to testing small scale wind machines in harsh coastal and marine environments and should yield technical data of special interest and use to Maine's coastal population.

6. Tidal

a. Introduction

Tidal power is a form of hydro power that uses the natural forces of daily tides to produce electricity. Most modern tidal schemes involve placing a dam and turbine at the entrance to a bay or inlet. As the tides fill and empty the bay water passes through the turbine and electrical energy is produced.

Of particular importance in selecting a tidal power site is the range between low and high tides. This tidal range, or "head", determines the energy potential of the site. A very large exchange in the volume of water is also crucial to tidal power development. The ideal site has a large tidal range and a narrow, shallow strait opening into a larger tidal basin area.

b. Current Use

In the past small tidal mills were fairly common along the Maine coast, including grist mills, saw mills and stone cutting operations. By the turn of the century most were gone, and currently there are no operating tidal power facilities in Maine.

c. Resource Availability

The most favorable sites for tidal power development in Maine are generally considered to be in Cobscook and Passamaquoddy Bays. These areas have both the right coastline configuration and the 15 to 20 foot tidal ranges common east of Machias, providing the best opportunity for tidal development. Tidal power is possible further down the coast, but with current technology the economics of using bays with tidal ranges of less than 15 feet become increasingly unfavorable.

Since 1976, the Passamaquoddy Indians at the Pleasant Point Reservation at Perry have been studying the feasibility of building a small-scale tidal powered electric generating facility at Half Moon Cove in Cobscook Bay. It would cost between $21 million and $35 million to construct and have a capacity of 10 to 12 megawatts, enough to serve the electric needs of an estimated 5,000 to 10,000 people. The power produced would replace the equivalent of 55,000 to 65,000 barrels of oil a year. Estimates as to the cost of the electricity produced by the proposed plant vary widely, but it would probably be somewhere between 5¢ to 7 1/2¢ per kilowatt-hour based on 1980 dollars. This would be less than the cost for power produced by most oil-fired plants and comparable to, or less expensive than, some other conventional fuels.

The Passamaquoddies received a preliminary permit from the Federal Energy Regulatory Commission in 1980 which gives them an option to use the site. They are expected to apply for a license to build and operate the facility during 1981. Construction could be finished and the plant could go on line as early as 1985.

A number of other sites in Cobscook Bay offer particularly favorable conditions for small-scale tidal power development and their potential has attracted increasing public interest. To study the opportunities, citizens from Eastport, Perry, Pembroke, Dennysville, Whiting, Lubec and the Pleasant Point Reservation recently organized the Cobscook Bay Tidal Power Committee. It is expected that this will soon lead to preliminary planning for Cobscook tidal projects other than Half Moon Cove.

Preliminary OER studies indicate there are approximately 100 sites along the Maine coast where small-scale tidal facilities may be practical. Fifteen to twenty of these sites with potential ranging from 40 to 1000 kilowatts of capacity are now being actively studied. The total energy potential for small-scale tidal power in Maine is not possible to estimate reliably at this time. It could make substantial contributions to the energy needs of some down east communities and could possibly supply a large portion of the electricity needed by Washington County if enough of the most promising sites in that region are developed.

The future contribution of tidal power could be significantly expanded, of course, by construction of a large-scale tidal facility. Maine's Passamaquoddy and Cobscook Bays are among the few sites in the United States where large tidal projects might be feasible. Since the 1930's, the U.S. Army Corps of Engineers has studied the possibility of constructing a large tidal power plant in the Passamaquoddy region. Early schemes envisioned a joint U.S. - Canadian Project, using both Passamaquoddy and Cobscook Bay, that would have an ultimate generating capacity of up to 1000 megawatts. The recent decision by Canada not to pursue this concept has apparently made it certain that the project won't be built. (The Canadian government has not abandoned the idea of tidal power. On the contrary, it is far into the planning stages for developing tidal sites that are wholly within Canadian waters and potentially much larger than the joint project would have been.)

The Army Corps of Engineers has also been studying the possibility of building small to large-scale tidal facilities that would use only Cobscook Bay. In their numerous reports, the Corps has identified about ninety tidal power alternatives for the area, including projects ranging from 5 to 500 megawatts, with possible annual power outputs of 16 to 790 million kilowatt hours a year. The conclusion of the Corps at this time is that none of these projects are economically feasible when the costs and benefits are weighed. Many Maine citizens do not agree with this conclusion. However, since construction of the large-scale projects probably depends on the Corps' interest and support, large-scale tidal facilities are unlikely in Maine for the foreseeable future.

d. Considerations

An oft-cited disadvantage of tidal power is that although it is predictable and steady over the long term, it is also intermittent. The power output rises and falls daily with the tides and the supply of peak tidal energy may not come at the same time as the peak demand. However, with interconnections to the overall electric power pool, this should not pose any great problem, since other sources could always fill the local needs.

On the whole, the potential availability of tidal power in Maine will be limited by the number of sites that are suitable for development. Such sites do not exist along the entire coast. And, like the damming of rivers for conventional hydro power, damming a bay for tidal power is not necessarily practical, economically or environmentally, even if the bay is physically suitable.

Most state laws cited in the section on riverine hydro power are applicable to tidal hydro power sites. In addition, tidal sites would require:

- A lease from the Bureau of Public Lands for use of the submerged lands at the dam site and beneath the power pool; and
- Federal permits from the Army Corps (Section 10) and the Coast Guard for dredging and filling and creating obstructions to navigation.

e. Current Programs and Policies

Maine currently has no State funding programs specifically available for tidal power development. There are, however, several federal funding programs for which the State has the authority to act as a clearinghouse. The State can also help to coordinate a developer's plans with the federal program.

The most significant federal tidal power program, both in terms of dollars and man-hours invested, is the work done by the Army Corps of Engineers on Cobscook and Passamaquoddy Bay tidal power studies. For the past 40 to 45 years the Army Corps has spent millions of dollars evaluating the tidal energy potential of these two bays. In the 1930's the Army Corps actually began initial construction but later suspended operations due to changing economic conditions.

One federal program that has assisted in the preparation of current tidal power plans in Maine is the Coastal Energy Impact Program, funded through the National Oceanic & Atmospheric Administration (NOAA). At the state level, the OER provides technical assistance to owners or proposed developers of small tidal power sites.

7. Biomass

a. Introduction

Biomass is any plant or organic matter, including agricultural crops, crop residues, other plants, animal wastes, wood and wood residues, garbage and solid waste material containing cellulose. Biomass can be burned directly, pelletized, gasified and made into alcohol.

b. Current Use

Although there are many potential sources of biomass energy, wood and wood residues are the only sources being used extensively in Maine at this time. Their use is discussed in more detail in the reports on wood and cogeneration.

A limited number of Maine service stations currently sell "gasohol", a mixture of 90% gasoline and 10% alcohol. Some of the alcohol used for these supplies is processed from corn and other agricultural crops, although none of the biomass used comes from Maine.

Ethanol and methanol are the two most common alcohol fuels presently being used in internal combustion engines. Both alcohols can be used straight or in a 90% gasoline and 10% alcohol gasohol blend. Most methanol is presently made from natural gas, although it can be made from coal or biomass containing cellulose. Methanol has been used for years to power race cars. Ethanol, which is made from any biomass material containing sugars or carbohydrates, is enjoying an upsurge in popularity. While alcohol stills have produced "moonshine" by fermentation illegally for years, farmers and entrepreneurs have recently begun to produce it legally.

Farm equipment or other vehicles that use an internal combustion engine can run on straight 160 proof or stronger alcohol by making minor adjustments to the engine carburetor. Engines can also run on blends of up to 20% alcohol and 80% unleaded gasoline with no modifications. However, because alcohol has a tendency to separate from gasoline and to collect water it is generally felt that a 90% gasoline, 10% alcohol (200 proof) blend is best.

Animal wastes and crop residues can be used to produce methane gas, which has fuel uses similar to natural or propane gas. A small number of Maine farmers currently use such biomass supplies to produce methane for their own use.

c. Resource Availability

Over 95 million cubic feet of wood residues (sawdust, shavings and bark) were produced by Maine forest products firms in 1979.

Much of this was used for energy. However, considerable amounts of useable logging slash are left in the forest. Dr. Harold Young, of the Complete Tree Institute at the University of Maine at Orono, estimates that for every 100 dry tons removed from the forest, 45 dry tons remain in the form of limbs, roots and other logging residues. Tree-chipping machines are used to change this biomass into chips useable for energy purposes. The chips are generally trucked to pulp and paper plants where they are used in boilers in the same way as other wood residues. In Vermont, such chips are used to fire a 30-megawatt electric generator. The large amounts of logging slash left in Maine's wood each year, as well as nonmerchantable trees, comprise a potentially great source of biomass that could be used as fuel.

Maine produces a number of agricultural crops that could be used for ethanol production. For example, if all of Maine's cull potatoes were used for alcohol production, it would produce about 4 million gallons of alcohol or about 1.5% of Maine's unleaded gasoline consumption for 1979. The following table gives the relative yield of alcohol per ton of various agricultural crops.

Relative Yield of 99.5% Alcohol Per Ton of Selected Crops

Material	Gallons
Wheat	85.0
Corn	84.0
Buckwheat	83.4
Grain Sorghum	79.5
Barley	79.2
Rye	78.8
Oats	63.6
Sweet Potatoes	22.9
Potatoes	22.1
Sugar Beets	22.1
Sugar Cane	15.2

Source: U.S. Department of Agriculture, Miscellaneous Publication 327, December 1938

Approximately 70% of solid waste material deposited in town landfills contains cellulose. This material could be used to make methanol, although the economics of methanol production favor large scale plants which would require large quantities of solid waste. Because of Maine's dispersed population areas, large enough quantities of solid waste would be hard to gather at one location. However, as discussed in the report on solid wastes, municipal trash could be burned in some towns as a way of providing an economically attractive waste-to-energy use for this source of biomass.

d. Considerations

Many native sources of biomass that could produce energy for Maine are available for this purpose. Cull potatoes and solid waste, for example, are unused or underutilized currently and their use as a fuel would have double advantages either economically or environmentally. As a whole, biomass is a flexible resource that could be used as a solid fuel or transformed into a liquid or gaseous fuel. In the case of alcohol fuels, biomass can be used to extend our supplies of an important conventional fuel. Gasohol blends not only help conserve gasoline, but also produce less pollution than straight gas and increase gas mileage by increasing the octane rating.

However, the initial costs involved in building biomass installations to produce a product like alcohol are high. Often, there may also be added costs for transporting biomass resources to such a facility.

The environmental effects of increased biomass use must also be addressed for each source. For example, the consequences of whole-tree harvesting on forest ecology are not clear, and the burning of wood residues can produce relatively large amounts of particulate pollution. Alcohol fuels can mix with and pollute water sources. Such considerations must be carefully explored if biomass is to become a substantial source of energy for the state.

Alcohols also have several undesirable characteristics as a fuel. They do not have as much energy output as gasoline, they burn with no visible flame, they are corrosive to engine parts, they often make starting in cold weather difficult, and they have a tendency to separate from gasoline in gasohol blends.

e. Programs

Federal Initiatives

Many Federal agencies including the Department of Energy, the Department of Agriculture, the Small Business Administration, and the Department of Housing and Urban Development have been given funds to boost biomass fuel production. Other agencies have been ordered to redirect part of their funding toward alternative fuels production.

Maine Alcohol Fuels Task Force

Maine has an Alcohol Fuels Task Force made up of 17 members representing both the public and private sectors of the economy. Their goal is to answer the broad question: "Should the State of Maine support an alcohol fuels industry?" Recently they have considered resource availability, various technologies, the economics of alcohol production, state and federal legislation and other aspects of alcohol fuels production. At the present time, the Task Force is studying the information collected in preparation for making their recommendations. A final report will be issued in March.

Maine Alcohol Fuel Projects

There are presently 3 moderate to large scale ethanol projects that are in various stages of planning or construction in Maine. Two of the plants would use potatoes. One of the plants would use imported grains from the Midwest. In addition, two small alcohol fuel projects were recently awarded DOE Appropriate Technology Feasibility Grants, and tax credits and other Federal incentives have helped to make alcohol fuels production more attractive.

Information/Technical Assistance

The Office of Energy Resources provides information and some technical assistance to persons interested in alcohol fuels production. OER is the state contact for the National Alcohol Fuels Commission, the Department of Energy's Alcohol Fuels Office and the Solar Research Institute's Alcohol Fuel Information Centers.

8. Peat

a. Introduction

Peat is made up of plant materials comprised of sphagnum moss, sedge and lesser amounts of other wetland plants that grow in peat bogs. Peat is the beginning stage in the geological process by which organic materials are turned into coal. Maine has relatively large peat reserves, though in the past they have been mined almost exclusively for use as an agricultural soil conditioner and for other agricultural uses.

In other parts of the world, peat has been used as a fuel for hundreds of years. A third of the electricity generated in Ireland is produced by burning peat fuel in power plants. The U.S.S.R., which accounts for about 95% of the world's current peat production, operates 76 peat-fired generating stations which produce about 3% of the country's total electrical output. Recent oil price increases have renewed the interest of government and industry in developing peat as an indigenous energy source.

b. Current Use

At present, peat is not used in Maine to supply any portion of the state's energy demands. Nearly 8,000 tons of peat are harvested each year in Maine, but used solely for agricultural and horticultural purposes. Most of the small number of existing peat mining sites in Maine are located in the eastern portions of the state, particularly Washington County.

c. Resource Availability

Recent estimates based on earlier soil and geologic surveys indicate that Maine may have approximately 770,000 acres of peat deposits, the largest reserves of any New England State. As of September, 1980, 285 field surveys on more than 78,000 acres have indicated an estimated commercial reserve of 117.5 million tons of peat.

As a fuel, peat has a somewhat greater heating value than an equal weight of wood, and about two-thirds as much as coal. Current peat mining practices usually involve draining a bog, then stripping off layer after layer of the deposits with large harvesting machines. Peat is used for fuel after it has dried thoroughly in its natural form or compressed into pellets or briquets. It can also be used to make synthetic natural gas. At this time, the use of compressed peat appears to have the best potential for providing energy for residential and industrial uses in Maine.

According to estimates by the Institute of Gas Technology, the energy equivalent of the U.S. peat reserves is 1443 quads (quadrillion Btu's), an amount equal to the energy of about 240 billion barrels of oil. IGT estimates that about 21 quads of this total is in Maine. This would amount to about 60 times the total number of Btu's used in Maine each year if it were all actually available as energy.

Realistically, economic and environmental concerns may limit the actual amount of energy that Maine could get from peat to only a portion of this potential. Even so, the energy potential of peat may still be substantial. A New England Energy Congress study estimated that a 10,000 acre peat bog averaging 15 feet thick might yield about 30 million tons of air-dried peat. This would equal the energy of about 15 million tons of coal, or 60 million barrels of oil.

d. Considerations

Peat is a potentially large native energy resource for Maine. Its development could make notable contributions to both local energy needs and the economy.

Theoretically, peat is renewable within a very long geologic time scale of thousands of years. Practically, on the scale of human lifetimes, it should be considered non-renewable. A peat bog that is mined will not renew itself for hundreds or thousands of years. However, it might be possible to reclaim some mining sites in an environmentally and aesthetically acceptable manner by turning them into lakes.

One of the major areas of concern with respect to peat mining is the potential for adverse environmental effects. Peat bogs are integral parts of many watersheds, particularly as ground water recharge and storage areas. Spongy peat deposits soak up and hold great quantities of water. Harvesting may significantly alter ground and surface water sources connected to a bog directly or indirectly through watershed links. In addition, peat bogs are unique landforms that provide important habitat for a variety of wildlife and plant species. Thus, in many cases, conflicts are likely to develop between peat mining advocates and those who want to preserve a bog in its natural state.

It is also necessary to consider that alteration of wetlands such as bogs are regulated by a number of government agencies. The restrictions and permits required for different areas of the state vary, but often permit procedures can be lengthy.

Development of many of Maine's more promising peat deposits may also be limited because of their remote locations and associated transportation problems. Processing of peat into a more compacted form at the site may reduce transportation costs and allow more economical use of some peat deposits.

At present, almost all peat harvested in Maine is used for valuable agricultural and horticultural purposes. Conflicts may arise about the best use for peat mined in the state, particularly given the potential benefits of using peat to improve Maine's farm land.

Finally, although peat has a relatively low sulfur content when burned, its high nitrogen content may cause air pollution problems if nitrogen oxide emissions exceed U.S. Environmental Protection Agency standards.

e. Current Programs and Policies

The Maine Geological Survey and the Maine Office of Energy Resources are currently conducting a cooperative program to assess the fuel potential of Maine's peat resources. The project is funded by the U.S. Department of Energy, and was designed to add to information from previous studies by the Maine and U.S. Geological Surveys. Under this program, peat deposits are mapped, their depth and size are determined, and the reserves for each deposit are calculated. Samples collected from the surveyed peat deposits are analyzed in U.S. Department of Energy laboratories for heating value, pH, ash content, and water content. Additional geochemical analysis is conducted at the U.S. Geological Survey laboratories.

Because of the importance of peat deposits to many watersheds, the Water Resources Division of the U.S. Geological Survey, in cooperation with the Maine Geological Survey and the OER, are investigating the hydrologic characteristics of selected peat deposits in the state. Surface water and ground water data and water quality information gathered in the field will be used to construct hydrologic models of the deposits' response to various stresses and changes. This information will be used, in part, to analyze the potential development impacts on peat deposits.

The Institute of Quaternary Studies at the University of Maine at Orono is analyzing peat samples taken from typical deposits for pollen and foraminifera content and radiometric dates. The Institute is also studying growth and regeneration rates for typical peatland vegetation.

With financial assistance from the U.S. Department of Energy, several national and Maine firms are currently studying the commercial feasibility of various types of peat energy facilities. A method of processing peat into pellets is being studied by a group of paper companies, utilities and private engineering firms. Another firm has proposed a process which could chemically and physically convert raw peat into an easily transportable and densified fuel source. One existing Maine horticultural peat operation is presently in the process of expanding its operation into energy production.

The Commissioner of the Maine Department of Agriculture has appointed a Task Force on Agriculture Uses of Peat in Maine. The Task Force has been asked to determine the potential value, quantity, and quality of peat utilized in agriculture, identify and support research or demonstration projects, and recommend policies regarding agricultural use of peat as a nonrenewable resource.

9. Summary

Maine has a relatively large renewable energy resource potential, and substantial quantities of peat resources, which are theoretically, but not practically, renewable. Of these, three major renewable resources hold the greatest promise for increased energy potential: hydro power, wood and solar. Other renewable resources, such as solid waste, wind, tidal and biomass can also make significant contributions to local and regional energy demands. In some cases, rising costs of non-renewable fuels and the availability of better technologies will speed up development of Maine's native energy resources.

Many of our alternative energy sources offer production costs which are comparable to conventional fuel costs. Hydro, wood and some others are either less costly than conventional sources or will be eventually as conventional fuel prices continue to rise. In addition to energy benefits, the development of these alternative resources have many potential indirect economic benefits for the state through business and job development. Energy resources that are developed and sold locally can stimulate the state's economy more than the use of conventional fuels that are imported.

The State's efforts to encourage the use of native energy resources have included resource assessment, providing a favorable financial climate, and demonstration and technical assistance for emerging technologies. In the past, many alternative resources were not adequately known to allow increased or initial development. Many new efforts now underway should change this. For example, new and existing hydro sites are being mapped, peat deposits analyzed and delineated, and tidal sites assessed.

Lack of access to capital has limited the development of many alternative resources. The availability of loans and financial incentives are needed to overcome some of the initial economic barriers to renewable resource development. This may require providing technical and economic information to banks, new legislation, and the removal of certain existing regulatory barriers.

Demonstration projects using alternate energy resources, such as wind systems and solar systems, can help to show their feasibility in Maine. In addition, performance data and cost information can be gathered. Transfer of information and technical assistance to the public and private businesses can further accelerate the development of Maine's alternative resources.

Increasing our use of the native energy resources described in this section, and decreasing our dependence on petroleum fuels, will strengthen Maine's economy, provide new jobs, help solve energy-related pollution problems, and reduce the potential harmful effects of oil supply shortages. In view of the rising costs and limited supplies of conventional non-renewable fuels, diversification of Maine's energy sources is crucial.

V. NON RENEWABLE RESOURCES

V. NON RENEWABLE RESOURCES

Introduction

As this plan is an attempt to describe Maine's various energy sources, a discussion of the current and potential future roles of non-renewable fuels is essential. These resources include petroleum, coal, nuclear energy and natural gas. Petroleum and nuclear energy have large roles in Maine's current energy situation and probably will in the next few decades. Coal and natural gas use is limited now but will likely become increasingly important. The purpose of this section is to describe some of the most significant factors and issues regarding use of non-renewable energy resources in Maine.

In the report's description of the role of each of these energy resources, a brief introduction defines the resource and provides basic background information. This is followed by a description of the current use of the resource in Maine. The availability of the resource and some of the most significant issues involved in terms of its future role are also discussed. This information is provided to establish a reference point by which policymakers can weigh the contribution and availability of each resource against the various merits and disadvantages of its use and, in turn, decide on an appropriate course of action. Even as these decisions are reached, however, it must be remembered that forces outside of Maine will have major effects on our supplies of petroleum, coal, nuclear energy and natural gas. Global and national economics and politics cannot be controlled by State Policy.

1. Oil

a. Introduction

Fuels made from oil, or petroleum, including gasoline, heating oil, kerosene, diesel, aviation fuel, and residual oil, have been the dominant source of energy in Maine for the past thirty years. Since 1978, oil consumption in Maine has been declining due to its high cost and concern over possible shortages. By the year 2000 oil supplies will become tighter as known reserves are depleted. There can be little doubt that the role of petroleum in the energy resource mix of Maine will be a dominant energy issue for the rest of the century.

b. Current Use

Petroleum had many advantages over other fuels during the period from the end of World War II to the Arab oil embargo in 1973-1974. Oil is easily transported by water, rail, and truck, making it an ideal fuel for a rural state like Maine. It is generally clean burning, easy to use, and for most of the period prior to 1973 it was a relatively cheap fuel source. For decades its price in real terms was either declining or holding steady. Moreover, oil products can be used to heat homes and offices, to run cars, trucks, and trains, and to generate electricity. It is little wonder that petroleum came to totally dominate the energy resource picture in Maine. As illustrated in Section II, oil accounted for 88% of all energy used in Maine in 1973, but dropped to 60% in 1978. Section II also shows what happened to oil consumption over the years since 1973. In recent years the trend for oil consumption in Maine has reversed entirely, and is now declining in all sectors from previous record high levels. The reasons for these declines are well known. The price of crude oil has gone up 800% on world markets since 1973, and the price of oil products that Maine people use have more than quadrupled (the differences in the rise in crude and product prices reflect in part the lower costs for domestic crude oil, which have been federally controlled.) In addition, the link between political stability in the Middle East and the supply and price of oil has led to two significant oil shortages on world markets during the past seven years. One in 1973 during the Arab Oil Embargo and one in 1979 as a result of the revolution in Iran. Each had serious consequences for Maine because of its dependence on petroleum products.

c. Resource Availability

Worldwide, the supply of oil is expected to be adequate to meet demand, at least through the mid-1990's. However, as the demand for oil increases with the economic and population growth of developing countries, and increased demand in some industrialized countries, the probability that oil supplies will become seriously tighter during the 1995-2000 period increases. Although the oil will not run out by the turn of the century, it will become increasingly scarce and increasingly expensive.

Of course, the higher price for oil provides economic incentive to explore for and produce more oil domestically. However, a large portion of the oil reserves that remain in this country are located in places where production costs are very high, such as the Arctic, under the continental shelf off Alaska, and in the deep water under the Atlantic continental shelf. Because production from existing domestic wells is expected to decline throughout the next 20 years and demand may increase because of population and economic growth, new supplies of oil will have to be found just to keep us more or less even. The following table compares estimated domestic production and imports in current and future years.

U.S. Oil Supply (MM bbl./day)

	1980	1985	1990	2000
Domestic	8.23 (53%)	8.23 (53%)	9.72 (60%)	10.54 (59.7%)
Imported	7.29 (47%)	6.48 (47%)	6.48 (40%)	7.10 (40.3%)

Source: Data Resources, Inc.

In addition to the status of overall national supplies, Maine's access to petroleum products may be affected greatly by the pending decontrol of crude oil and gasoline. In the past, major oil companies expanded their markets to include much of the U.S. Now, as transportation and product costs have increased dramatically, a number of companies are deciding to consolidate their markets and sell product only in areas near refineries and major distribution points. Maine not only lacks refinery facilities, but is located at the end of the petroleum distribution system in the Northeast. To date, one major oil company, Shell, has announced its intention of withdrawing from the Maine market after decontrol. Other refiners may well decide to pull out too.

d. Considerations

Reducing Maine's vulnerability to oil price hikes and supply disruptions presents the State with one of its greatest challenges. OPEC will continue to be able to exercise monopoly-like powers over both the supply and price of oil on world markets; there will continue to be a constant threat of political disruptions in the Middle East which might shut down shipments from that region entirely for unknown lengths of time; and there is no question whatsoever that the price of oil will be going up, making heating homes and driving cars an increasingly expensive proposition for Mainers. It is also certain that over the long run the world supply of petroleum will gradually decline. There is a finite supply of oil in the world, and though we have not yet reached the end of that supply, it lies somewhere in the future. Finally, uncertainty surrounds the availability of petroleum products in Maine after decontrol of the oil industry.

A more detailed examination of petroleum's future supply and price gives even greater weight to the necessity of reducing our overall levels of petroleum use through conservation and the development of alternative fuels. For example, while it is not possible to predict with any certainty what the future price of oil will be, OER forecasts for crude oil price (see Section II) estimates that a barrel of oil that costs $12.46 in 1978 will cost $34.77 in 1985 and $54.17 in 2000, in constant 1978 dollars. Prices in current dollars for 1985 will be $55.83 and for 2000, $239.94.

The rapidly escalating price of oil and other fuels has and will continue to create an economic crisis for consumers. Maine has approximately 70,000 low income households. These families, who are already suffering from the effects of inflation, find they must dedicate a larger and larger share of their dwindling income to home energy. Their inability to meet energy costs create serious economic hardship and threatens their health and well-being. The State of Maine administers two federally-funded programs designed to provide energy-related assistance to low income households: the Home Energy Assistance Program (HEAP) program, which provides financial assistance for home energy costs, and the Weatherization Program, which furnishes materials and labor to insulate homes. Priority for these programs is given to the elderly, the handicapped and those with the lowest incomes.

It is obvious that conservation of petroleum products must be a focal point of any energy strategy for Maine. If we still rely on oil for 71% of our energy in 1990 (as we did in 1978), and if that oil costs twice as much in real terms, and if we still get 40% of our oil from OPEC, we will still be in grave risk of economic catastrophe and Maine will be a significantly poorer state.

It should be possible to substantially reduce oil consumption in Maine between now and 1990. For example, at least a 25% reduction in energy consumption, nearly all of which is petroleum, is possible in the transportation sector between 1978 and 2000. Increased use of vanpools and carpools could increase savings up to 31%. Savings can also be made in the other end use sectors.

However, even with strong conservation efforts and conversions to alternate energy sources, Maine will probably still rely on petroleum for as much as half of its total energy needs by the year 2000. Because alternatives are currently limited, it is likely that nearly all of our fuel needs for the crucial transportation sector will continue to be met by petroleum products. Thus, in addition to conservation and increased use of native energy sources, it will also be necessary to continue and expand emergency oil-shortage contingency planning.

The Maine Office of Energy Resources has, as one of its responsibilities, the development of emergency plans for fuel shortages. Both the oil embargo of 1973-1974 and the gasoline shortage of 1979 underscore the need for such planning. By monitoring the supply of petroleum products in the State, the OER can now predict a potential shortage. Should a shortage appear imminent, the OER would immediately notify the Governor of the situation. He may then exercise his powers under the Civil Emergency Preparedness Act of 1974 and declare an energy emergency. If a call for voluntary compliance with publicized conservation measures proves ineffective, the Governor may choose to enact mandatory measures to conserve or allocate fuel.

At the present time, the Office of Energy Resources is developing a State Emergency Energy Plan which will meet the requirements of the Emergency Energy Conservation Act (P.L. 96-102, as amended). This plan will include measures to reduce the impact of both a gasoline and a fuel oil shortage. The OER recognizes the need to be prepared for future energy crises and will continue to develop and update its emergency plans.

A. Residual Fuel

a. Introduction

Residual fuel includes No. 4, No. 5 and No. 6 oils, Navy Special and Bunker C. Like other petroleum products, residual fuel has greatly increased in price and many major users are considering switching to solid fuels.

b. Current Use

Residual fuel oils are used mostly in industrial boilers and for electrical power generation. Past use shows no clear upward or downward trend in recent years. This is probably because users of residual fuel tend to have fairly large storage facilities and because the use of oil to generate electricity often varies greatly. Although residual oil will continue to be a major fuel in the next 20 years, use in Maine should decline steadily as a result of conservation and the trend to use less expensive, solid fuels.

c. Resource Availability

Although it would be affected by a shortage or cut-off of foreign crude oil, residual fuel has one advantage over other petroleum products. It can be refined from very heavy oils, such as those being produced more and more in this country. Thus, it is not as vulnerable as some other petroleum products that are made primarily from foreign oil. During the 1979 oil shortage, residual fuel supplies remained abundant and the same situation could reoccur during a future crisis. However, residual fuel is not immune to supply disruptions. Much of the oil produced by Iran and Iraq is heavy oil utilized to refine residual fuel. The cutoff in supplies from these countries has tightened supplies and pushed up prices. The northeastern U.S. as a region lacks substantial storage space for residual fuel and must depend on regular imports from out-of-state sources. If the region's current supply sources dried up, storage might not be adequate to keep industrial and utility users going until other residual fuel supplies were located.

d. Considerations

As a result of concern about residual fuel storage, the State of Maine, along with other northeastern states, has supported a proposal which would establish a Regional Petroleum Reserve of 20 million barrels of residual fuel oil. Such a reserve would help maintain normal industrial production and electrical generation during a temporary shortage and reduce financial hardship. However, in the spring of 1979, Congress refused to appropriate the necessary funds for the project. Recently, the State of Maine agreed to join with the other New England states in an attempt to persuade the federal government to include funding for the regional reserve in the 1981 budget.

Another potential problem associated with certain residual fuel oils is their relatively high sulfur content. The amount of sulfur dioxide pollution produced by burning some kinds of residual fuel is significantly greater than when light, low sulfur oils or some other type of low sulfur fuel is used. Sulphur dioxide pollution from oil-fired power plants and factories is a major cause of this country's mounting acid rain problems. It can also cause or aggravate a variety of human lung diseases. This has lead to increasing public concern over the use of high sulfur fuels.

State laws now require that low sulphur fuel be used in Maine to keep locally-produced sulphur dioxide emissions at acceptable levels. However, low sulphur oil is more expensive and a large portion of U.S. oil reserves are of the heavy, high sulphur variety. Rising costs of foreign oil have lead to pressure to increase production and use of high sulphur fuel reserves and related pressure to relax state or federal laws that might prevent their expanded use. The installation of effective pollution control equipment could provide an alternative solution. As opposed to relaxing air quality standards, better pollution control could keep emissions at acceptable levels and yet allow the use of less expensive, higher sulphur fuels.

B. Aviation Fuel

a. Introduction

Aviation fuel includes both aviation gasoline, used in small planes, and kerosene or naptha jet fuel, used in turbine engines. Recent developments in the marketing and distribution of these products have restricted the availability of aviation fuel in Maine. Due to the important role air service plays in economic development, assuring a continued supply of aviation fuel is of vital concern to the state.

b. Current Use

At the present time, at least 50% of the flying in the state is business-oriented. Many firms and corporations operate planes as a part of their business. The airport in Bangor serves a number of international flights and competes with airports in Boston and New York for business.

During the 1970's there was a steady increase in aviation fuel consumption in Maine, but use dropped nearly 40% in 1980 due to high prices and limited supplies. Demand for aviation fuel would be expected to continue growing as airports expand their services and the number of small private planes increase. However, high prices and tight supplies may continue to keep demand down.

c. Resource Availability

A number of factors combine to limit aviation fuel supplies in Maine. First, the distribution of aviation fuel to users depends largely on truck deliveries. To avoid transportation costs, the oil companies find it more profitable to sell full transport loads to large users located close to refineries, major distribution centers, or pipelines. Secondly, there are quality control considerations. If water develops in the fuel through improper handling, liability for any accidents occuring as a result of the contaminated product can be traced back to the refiner, who may be held liable. The major suppliers therefore want to limit the number of resellers handling their fuel and the distance it travels without their supervision. Maine's many small airports and distributors, who are spread out in a large geographical area, do not comprise the kind of market oil companies prefer.

Another problem is the trend for major refiners to sell more and more aviation fuel on the "spot market" and less through the regular contracts. Lack of fuel for increased contract volumes means that Maine users must turn to the more expensive, less reliable spot market to meet new demand.

This can be both a problem in planning and prohibitively expensive. An airport wishing to increase service cannot be sure of spot market costs or supplies. The high cost associated with purchasing, transporting, storing and insuring spot fuel makes it virtually impossible for Maine airports to compete in the regional market. Spot fuel provides no solution to the supply problem in the State. Its high price alone restrains demand and aviation-related development.

Finally, aviation gasoline and kerosene jet fuel are not subject to federal price and allocation controls. No regulatory mechanisms exist which insure that Maine users will be able to get a supply of either product. Instead, they are dependent upon the willingness of the major refiners to increase deliveries to the State. So far, none of the suppliers have shown interest in expanding their Maine market. In the process of decontrolling the airline industry, Congress mandated certain levels of service which must be maintained in each state, however, they made no provision to guarantee a supply of fuel for those required services. The lack of legislation requiring suppliers to continue supplying specific areas encourages major oil companies to pull out of relatively small, unprofitable markets and leads to an uncertain supply outlook for users of aviation fuel in Maine.

d. Considerations

The lack of flexibility in the aviation fuel supply system creates many problems, none of which have easy answers. Some mechanism for obtaining or increasing an allocation must be found. This may be very hard to achieve since the industry is now moving towards total decontrol. Several steps might reduce some of the problems. One solution that would create some flexibility and help resolve short-term emergency situations would be the establishment of a State set-aside for aviation gasoline and kerosene jet fuel. This could work the same way as the set-aside program for gasoline and middle distillates. The EIA 25 reporting forms currently received by the State already list the amounts of aviation gasoline and kerosene jet fuel coming into the State each month. Under a set-aside system, 4% of that could be reserved by the State to allocate in response to emergency hardship requests. Set-aside releases would be directed through the regular supplier.

Another possible solution is for Congress to amend its act which provides basic levels of air service under decontrol of the airline industry. Such an amendment might guarantee a supply of fuel for required flights and provide a way for base operators or airlines to obtain reasonably-priced fuel.

Finally, the State could explore the possibility of assisting in the development of a co-operative distribution and storage system for the marketers and users of aviation fuel in Maine. Under such a co-op plan, a number of dealers acting together could purchase spot fuel supplies making the product more affordable and more available then if they acted individually.

C. Diesel Fuel

a. Introduction

Diesel fuel, a middle distillate similar to heating oil, is used in many types of motor vehicles. Diesel use is expected to increase during the next two decades.

b. Current Use

Diesel is primarily used to fuel trucks and automobiles, farming and logging machinery, fishing boats, construction equipment and buses. Highway diesel consumption has increased significantly since 1974 and is expected to continue climbing. Diesel vehicles are becoming more available, their efficiency is greater than gasoline-powered vehicles, and diesel fuel costs less than gasoline. These advantages are attracting more and more people in Maine to buy diesel vehicles. One manufacturer estimates that 25% of the new automobiles and light trucks produced in 1990 will have diesel engines.

c. Resource Availability

Like all petroleum products, the supply of diesel fuel is tied to the flow of crude oil. But even without crude oil shortages, the demand from the agricultural sector during the planting and harvesting seasons may sometimes create temporary regional shortages. In general, though, diesel should continue to be adequately available to Maine consumers. In fact, the growth in diesel sales may partially cancel out the decline in heating oil consumption.

d. Considerations

Some concern has developed about the increased use of diesel because of the impact diesel emissions may have upon the environment. Studies are being conducted into the hazards of these emissions to determine what, if any, emission control standards should apply to diesel-powered vehicles. Although diesel emissions have received little public attention so far, they may become more controversial in the next decade.

D. Domestic Heating Oil

a. Introduction

Domestic heating oil, commonly called fuel oil or #2 heating oil, is the most widely used middle distillate in the state. Although the majority of homes in Maine still rely upon fuel oil for heat, consumption is declining .

b. Current Use

Most fuel oil is used for space and water heating. (However, heating oil may also be substituted for diesel fuel and used for both transportation and agriculture.) The consumption of heating oil has declined 17% since 1974 as prices have more than doubled. This downward trend should continue as prices rise even further and more people switch to other fuels or weatherize their homes to conserve oil.

c. Resource Availability

Unless a large number of major oil suppliers decide to withdraw from the Maine market once oil is decontrolled, sufficient heating oil should continue to be available to Maine consumers in the near future. However, availability also depends on the availabilty of crude oil. Any disruption in our supply of foreign oil will tighten heating oil supplies.

d. Considerations

The state of Maine faces two different kinds of heating oil problems: supply and price. As part of its efforts to deal with these problems, the State participates in the federal fuel assistance program to help low income households cope with energy costs. It is also developing an emergency plan to reduce the effects of a potential fuel shortage.

Reducing dependence upon fuel oil as a source of home heat can also help avert winter emergencies. The Office of Energy Resources and the Division of Community Services sponsor a number of programs to weatherize buildings and increase the efficiency of existing heating oil equipment. These programs are outlined in the section on Conservation. OER also provides assistance on other conservation techniques and promotes the development of renewable resources.

E. Motor Gasoline

a. Introduction

Motor gasoline, a petroleum product processed from crude oil, is used primarily for transportation. As a largely rural or suburban state with few mass transit systems, Maine is highly dependent upon gasoline-powered vehicles. However, in response to price increases, gasoline consumption in the state is declining.

b. Current Use

As detailed in Section II, gasoline consumption in Maine has dropped nearly 14% since 1978, after rising steadily for years. Rising gasoline prices have motivated consumers to buy more fuel efficient cars and to reduce the number of miles they drive. The downturn in gasoline use should continue as automobile gas mileage efficiency increases and more commuters join car or van pools.

c. Resource Availabilty

Though the price is constantly increasing, there are currently adequate gasoline supplies to meet demand in Maine. Two factors could reduce future availability: decontrol of the oil industry and any decline in or disruption of the crude oil supply. Shell Oil has already announced that it will pull out of the Maine gasoline market once federal regulations governing the allocation of the product are lifted. Whether or not other major refiners will decide to stop supplying Maine distributors or dealers is unknown at this time. However, the potential for reduced gasoline supplies as a result of decontrol does exist.

Maine, like the rest of the nation, had temporary gasoline shortages in 1973 due to the Arab Oil Embargo, and 1979 as a result of the Iranian revolution. Similar events, an expansion of the Iran-Iraq war, or any other developments that reduced the nation's crude oil supplies, would reduce gasoline inventories and create another shortage.

d. Considerations

Ample gasoline supplies are crucial to Maine. Ours is largely a rural and suburban state lacking in public transit systems, and most people rely almost exclusively upon cars or some other private gasoline-powered vehicle for transportation. Developing extensive mass transportation systems is not a practical alternative for most areas of the state. The tourist industry, which contributes greatly to Maine's economy, also depends upon gasoline to bring visitors to the state. Obviously, any shortage of gas creates a serious hardship for Maine citizens.

For this reason, the Office of Energy Resources has developed a Gasoline Contingency Plan which can be implemented during a gas shortage. This plan provides measures to manage gasoline lines and to reduce gasoline consumption and identifies priority users. The emphasis is on voluntary compliance, although mandatory measures could be used if necessary. OER also sponsors a program to encourage car and van pooling that could be greatly expanded during a shortage.

F. Kerosene

a. Introduction

Kerosene is a clear, light middle distillate used for a variety of purposes. Kerosene has become less and less available to Maine consumers and may soon be unavailable as a home heating fuel in the state. It has been replaced to a large extent by No. 1 heating oil, which has the same uses but does not burn as cleanly.

b. Current Use

Kerosene provides about 1.2% of Maine's current energy needs. It serves as the basis for jet fuel, it is burned as a home heating fuel, and it is blended with other oil distillates as a thinner to reduce their "pour point". Unlike diesel and domestic heating oil, kerosene does not thicken in cold weather and will continue flowing through fuel lines even in very low temperatures. Thus kerosene is often blended with diesel or heating oil to keep trucks running in the winter and to preserve fuel stored in outside tanks.

In the past, kerosene has been a fairly important home heating fuel in Maine. However, as shown in Section II, kerosene use has dropped greatly since 1974. Due to justifiable concerns about kerosene supply, the declining quality of the product and the fact that many kerosene appliances are old and inefficient, consumers have been using less and less kerosene.

c. Resource Availability

Supplies of true kerosene have become increasingly less available to Maine consumers in the past five years. No. 1 fuel oil has largely replaced kerosene for use in kitchen ranges or for blending with diesel or heating oil. Although No. 1 also reduces the pour point, it has a higher sulphur content than kerosene and does not burn as cleanly. Thus, using No. 1 in appliances with wick-type burners requires constant cleaning and adequate ventilation. No. 1 does not vaporize as quickly as kerosene and when a stove is turned off, a residue of the fuel remains on the wick. Re-lighting the stove can cause smoke and fumes.

Kerosene has virtually disappeared from the home heating oil market because increasing amounts have been diverted to the more profitable aviation market for jet fuel. Even No. 1 fuel may soon become scarce for this reason. One major oil company, Texaco, has already announced that after the

1980-1981 heating season it will no longer refine and market kerosene or No. 1 fuel oil for home heating use. Other refiners may make the same decision. Only about 20% of the kerosene refined in this country ends up as home heating fuel, and the market is limited to a few regional areas such as the Northeast. It is possible that during the next decade, kerosene will become unavailable as a home heating fuel in Maine.

As long as kerosene is available to Maine consumers, it will be subject to supply disruptions created by any crude oil shortages. Because the major oil companies appear to be phasing out production of kerosene as a home heating fuel, it may be even less available during an energy crisis than other petroleum products.

d. Considerations

Since 1979, the Office of Energy Resources has promoted the replacement of kerosene by other fuels in Maine, both because the future supply of the product is uncertain and because its quality has declined seriously. Recently, many homeowners who use kerosene have complained that the kerosene they purchased did not burn well, that it smoked and smelled of sulphur. Also, many kerosene ranges continuously radiate heat and are an inefficient and expensive ways of heating a home. (Kerosene can cost up to ten cents a gallon more than heating oil.) For these reasons, OER believes that it is in the best interest of Maine consumers who currently use kerosene to switch to another fuel.

One roadblock to switching is the fact that many kerosene users have low or fixed incomes and cannot afford to purchase new heating equipment. At the present time there is no financial assistance available for kerosene conversions. Dealers or consumers who use kerosene or No. 1 fuel to reduce the pour point of distillate oils can switch to new chemical additives known as pour point depressants. The OER has compiled information listing the various properties of a number of these additives. Although pour point depressants cannot alter fuel which has already thickened, they can prevent it from thickening in the first place. A number of companies in the state have tested these additives and have found them to be an adequate and much cheaper alternative to kerosene.

2. Natural Gas

a. Introduction

Natural gas has been available in Maine for 13 years. During that time it has made a relatively small contribution to Maine's total energy needs. However, the potential exists for natural gas to have a larger role in the future, especially in the Portland and Lewiston/Auburn areas.

b. Current Use

The use of natural gas in Maine has been limited largely by the lack of major supply pipelines and local piping systems. Presently, natural gas is only available in the Portland and Lewiston-Auburn areas, and even in these areas it is not widely used. Both areas are serviced by Northern Utilities Company, a division of Bay State Gas. During 1980 Northern Utilities served about 15,000 residential, commercial and industrial customers. These customers consumed over 2 billion cubic feet of natural gas in gas stoves and water heaters and for space and process heating. The number of residential natural gas customers served from 1975 to 1980 decreased by about 18% (2749 customers), while commercial customers increased 116% (2114 customers) and industrial customers remained the same (29 customers). The average number of customers from 1975 to 1980 decreased 10% (1615 customers), while the amount of gas consumed in thousands of cubic feet (MCF) has increased about 13% (244,591 MCF) from 1975 to 1980. (One thousand cubic feet equals 1,000,000 Btu's.)

c. Resource Availability

Natural gas provides 25% of the nation's energy, 9% of the region's energy but less than 1% of Maine's energy. The supply of gas coming into Maine usually meets existing needs, although shortages are possible during periods of heavy demand due to limits on pipeline capacity. Nationwide supplies of natural gas are expected to increase in the next few decades as the higher gas prices allowed under decontrol of the industry lead to new exploration and expanded use of known reserves.

Northern Utilities and its parent company Bay State Gas are exploring the possibilities of expanding their supply of natural gas through domestic sources and purchases from several proposed pipelines that would cross the Northeastern states from Canada. (The prospect of importing natural gas from Canada is discussed in greater detail in the section on Canadian Energy Exchange Potential.)

Northern Utilities estimates that natural gas use will increase in Maine by 300,000 to 450,000 thousand cubic feet (MCF) annually through 1985, and by considerable volumes after that. This equals a displacement of about 2.3 to 3.5 million gallons of #2 heating oil annually during the next five years. By 1985, Northern Utilities estimates that its yearly gas sales will have increased by between 69% and 101%, when compared with its 1980 sales. The 1985 total gas use in Maine may range from between 3.6 to 4.3 million MCF.

Thus it appears that natural gas will contribute an increasing share to Maine's energy supply mix throughout the 1980's, at least in the Portland and Lewiston-Auburn areas. Though only about 1% of Maine's population currently uses natural gas, Northern Utilities estimates that about 12%, or 130,000 people, live within 100 feet of an active gas main. This includes roughly two-thirds of the population of Portland, South Portland, Westbrook and Cape Elizabeth and nearly the entire population of Lewiston/Auburn.

The potential in the commercial and industrial sectors is also believed to be large and the availability of natural gas could be a factor in drawing new industries to the State. (Some industries presently served by natural gas are Maremont, Portland Whitney, Rockwood Industries, Data General and Bates Fabrics.)

The major barrier keeping natural gas from expanding to meet this potential is the lack of existing piping from gas mains to buildings. Providing service to new customers involves considerable expense and time. Due to one or both of these factors, Northern Utilities currently has a demand in excess of the company's ability to provide service. As of December 1980, a backlog of about 1000 Maine residential customers and apartment buildings owners were awaiting hookup, and the company has been forced to turn down requests for service from about 150 customers in the commercial and industrial sectors during 1980. Obviously the demand for natural gas in Northern Utilities' current service areas is strong.

A number of other towns near Portland and Lewiston/Auburn have old gas mains that are not in use. It might be possible to revitalize some of these, although that determination would have to be made on a case by case basis. If a proposed gas pipeline passes through Maine from Canada, the Bangor area may also have access to natural gas in the future.

d. Considerations

Gas is a very attractive non-renewable fuel. It currently has a price advantage over oil and electricity for most uses. And though the cost will almost surely rise as decontrol is phased in, gas is expected to remain economically favorable, compared to oil or electricity, at least in the short term.

Beyond this, there are relatively large reserves of natural gas in the United States as well as large volumes in Canada that may be imported. Thus, natural gas supplies are not particularly threatened by foreign politics and crises or by shortages of crude oil. Gas is a very efficient fuel that produces little pollution and it requires minimal equipment maintenance. It can generally be delivered to users with an efficiency comparable to oil and somewhat greater (in terms of lost, unused energy) than electricity.

Increased use of gas in Maine would help diversify the state's energy mix and reduce dependence on oil and electricity. Northern Utilities suggests that some 130,000 people and many commercial and industrial firms could be hooked up to existing gas mains. This would lead to a tremendous increase in the demand for natural gas in Maine. The company seems confident that supplies could meet increasing demands.

However, Northern Utilities apparently lacks the capital to fund major expansion of its gas servicing potential. Thus, growth in natural gas use will be slower than its potential unless the company finds affordable financing for an accelerated expansion program. Northern Utilities says it has not yet found a feasible source of financing and has suggested that the State may want to consider helping the company find affordable funds if increased use of natural gas is consistent with State policy.

3. Coal

a. Introduction

Two things are remarkable about the use of coal as an energy resource in Maine. One is the decrease in coal use over the past 30 years. The other is the promise it holds for supplying energy to Maine in the future. From more than 21% of total energy supplied in 1950, coal use dropped to virtually nothing in 1978. Oil was both cheaper and more available than coal during the 1950s, 1960s and early 1970s. So, during this period, most homeowners and commercial and industrial users switched to oil or electricity for space and process heat. And the last of the coal-fired steam locomotives were removed from service, to be replaced with diesels.

b. Current Use

The use of coal has not yet rebounded from its recent low point to major levels. However, the prospect for increasing coal use in Maine over the next two decades is evident. Several recent developments indicate likely future trends. For example, the Martin Marietta cement plant at Thomaston has converted to coal for its space and process heat uses. Central Maine Power is considering constructing a major coal fired-electric generating plant for Sears Island, possibly using new innovative coal burning technology. CMP will soon convert 67% of its present generating capacity at the currently oil-fired Mason Station in Wiscasset to coal burning. And, while exact figures are not yet available, there has been a strong expansion of the home heating market for coal over the past two years. These events are undoubtedly signs of the upward direction of coal utilization in Maine. Coal-fired electric generation, as well as industrial and domestic use are expected to expand over the next decade.

c. Resource Availability

Coal is by far America's most abundant fossil fuel resource. There are enough proven reserves to last for several hundred years at current consumption rates. However, several factors must be considered which will determine whether coal again becomes a major energy resource in Maine over the next ten to twenty years.

While it is not possible at the moment to predict the precise extent of future coal use in Maine, the trend is obviously up. Based just on existing and planned projects, it is probable that coal will account for between .8% and 1.2% of Maine's total projected energy needs by 1990. As more industrial, commercial, and residential users switch to coal and new coal-fired generating capacity is developed, this percentage will undoubtedly increase. In addition, between 1990 and 2000 it is likely that synthetic liquid fuels made from coal will begin to become available as substitutes for liquid petroleum fuels.

d. Considerations

The size of America's coal reserves alone make them an attractive energy resource and a potentially major alternative to expensive, unreliable supplies of foreign oil. In general, coal can be used to produce electricity at a lower cost than oil. It is also less expensive for home heating.

However, certain potential problems must be addressed if large increases in coal burning occur in the state, particularly potential environmental problems. Conventional coal burning, especially if high-sulfur eastern coal is used, can create large quantities of sulfur dioxide, a human health hazard and a suspected contributor to the acid rain problem. In addition, relatively great amounts of particulates and nitrous oxide pollutants are produced. This may severely limit the use of large scale coal burning facilities in Maine, particularly in or near "Class I" clean air regions (such as Acadia Park) where air quality laws impose stricter-than-average limits on emissions.

New combustion technologies are now available which hold promise for reducing pollution. CMP has already begun to investigate the feasibility of constructing a coal-fired Integrated-Gasification Combined Cycle generating plant. This technology can convert high sulfur coal to a medium BTU gas, which is burned in a gas-turbine and then further energy is extracted from the exhaust gas to produce steam to drive a steam turbine. This process removes a great deal of the sulfur and suspended particulates from coal emissions. Another promising technology is fluidized bed combustion which injects coal into a superheated bed of inert material. The superheating allows for more complete combustion of the coal and reduced consumption. Fluidized bed combustion is widely used abroad, and several major installations exist in this country.

The energy produced by such plants, or from conventional coal burning plants, can be further increased by using cogeneration facilities where the heat produced in the electric generating process is used in addition to the electricity. The alternate combustion technologies, particularly fluidized bed, are well suited to relatively small applications such as cogeneration stations. Although proven in other areas, the use of these technologies in Maine will require examination of potential environmental problems which may occur. This will be accomplished through the regulatory siting process.

Specific attention must be given not only to air quality, but also to the disposal of waste products, particularly coal ash and sludge, which result from coal combustion. Planning for suitable disposal sites, probably on a regional level, must occur along with additional research into the possible re-use of coal ash as a road bed material.

Availability of coal could also be a problem as demand grows. Presently, Maine's rail and cargo port facilities are limited in their ability to bring large quantities of coal into the state. To accommodate increased coal shipments, consideration must be given to the improvement of rail and port facilities.

Finally, there is the question of price. On a per BTU basis, coal most likely will continue to cost less than oil does. But as demand increases, it is likely that the price of coal will rise over the next twenty years at rates roughly comparable to the projected rise in oil prices. A projection of a 3% rise in the real price of coal above a 7% rate of inflation (or 10% annual price rise) would lead to coal prices as shown in the price forecasts in Section II.

e. Current Programs and Policies

In cooperation with the Department of Energy, the Office of Energy Resources is working to determine which industries and institutions in the state have the greatest potential for conversion to coal or coal-oil mixtures and what regulatory constraints would apply at those sites.

The Office will also assist the efforts of the State Development Office, the Maine Development Foundation, the State Planning Office, and private industry to promote rail and port development that can accommodate coal shipment. Various financing mechanisms, including bond issues, are being explored for the construction of such facilities.

Governor Brennan's Conference on Coal Utilization (held during May of 1980) was one of a series of workshops jointly sponsored by Maine's Office of Energy Resources and the Department of Energy as a service to industrial and commercial energy users. The purpose was to assist industrial and commercial firms in their decisions in considering coal as an alternative energy source.

The Office, regional planning agencies, the DEP, and SPO are working together in planning suitable sites for industrial coal ash disposal. Research, in conjunction with SPO and DOT, is also being conducted to determine the possibility of using coal ash as a road bed material.

4. Nuclear Energy

a. Introduction

Maine's single existing nuclear power plant, Maine Yankee in Wiscasset, began operating in 1972. The plant uses enriched uranium fuel pellets in a controlled fission reactor system. The heat produced is used to make steam. The steam turns turbines, thereby generating electricity. The United States Nuclear Regulatory Commission (NRC) regulates operation of the plant and the shipment of fuel pellets through the state. The Maine Public Utilities Commission regulates the price state utilities may charge their customers for electricity produced by Maine Yankee.

Because the cost of generating electricity with nuclear power is currently lower than by using oil, the worldwide oil crisis that developed in the 1970's has heightened interest in expanding the use of nuclear power in this country. At the same time, growing concern over health and safety issues has created increasing public opposition to nuclear power and drastically slowed the expected rate of new nuclear plant construction. Locally, for example, there was a recent, highly publicized effort to close down the Maine Yankee plant by referendum. The effort was not successful but it was a sign of mounting public concern. During the debate over the referendum, spokesmen for Central Maine Power Company (largest shareholder in Maine Yankee and Maine's largest utility) said the company has no plans to build any new nuclear plants in Maine.

b. Current Use

The Maine Yankee nuclear power plant has a rated generating capacity of 829 MW. It produces an average of 4.6 billion killowatt-hours of electricity annually. During its last five years of operation it produced an average of 6 billion KWH. Maine utilities own and distribute half of Maine Yankee's output. The rest of the electricity it produces is exported out-of-state through the New England power grid. Thus, Maine Yankee supplied 27% of the electricity used in Maine during 1979, although it produced 60% of the total electricity generated in the state.

Maine utilities also own a combined total of 70 MW of capacity in nuclear plants located elsewhere in New England. In 1979, these out-of-state plants contributed approximately 6.2% of the electricity sold to Maine consumers.

c. Resource Availability

The future of nuclear power is uncertain, both in Maine and the rest of the nation. For one thing, uranium ore (which is mined and then processed into uranium fuel) is a limited, non-renewable resource. Estimates as to the size of the recoverable supply and how long it will last vary widely. A National Academy of Science Study concluded there may be serious uranium supply problems by the mid-1980's. Using the same basic facts, a Ford Foundation report determined that U.S. uranium supplies will probably be adequate well into the next century. The Department of Energy is currently conducting studies to develop a dependable evaluation of uranium reserves.

The contribution of nuclear power to national energy needs could potentially be extended beyond the time when uranium reserves run out through fuel reprocessing and breeder reactor technologies. In different ways, both of these currently experimental technologies could produce substantially more energy from existing uranium supplies. However, fuel reprocessing involves the extraction of relatively large amounts of plutonium from used or "spent" nuclear fuel. The most highly developed breeder reactor technology, the Liquid Metal Fast Breeder Reactor (LMFB), also involves the conversion of non-fissionable uranium into plutonium, which is used as fuel for the reactor. (Other breeder reactor technologies are being pursued that use thorium rather than plutonium, though this technology is not as extensively developed as the LMFB reactor technology.) Plutonium is a highly toxic radioactive material that can be used to make atomic bombs. Thus, the hazards of producing, shipping and storing plutonium, and the possiblity that plutonium could be stolen by terrorists or used by other nations to make nuclear weapons, has raised serious safety questions relating to reprocessing and current breeder reactor technology. As a result, government policy and public opposition have worked to slow down research in these technologies. Neither is expected to be widely available during this century, if at all.

The Maine Yankee atomic plant is licensed to operate until the year 2008. Uranium supplies for the plant are expected to be available up to that point, though as nationwide reserves decrease their cost may rise. Maine utilities plan to buy a total of 253 MW from the Seabrook (New Hampshire) and Millstone (Connecticut) nuclear power plants now under construction. In addition, CMP is entitled to 32.8 MW from Pilgrim Unit #2 which is currently awaiting a construction permit from the Nuclear Regulatory Commission. Maine utilities may also purchase 130 MW of capacity from the new Point Lepreau nuclear plant in New Brunswick, Canada. Under the proposed contracts, Central Maine Power would buy 100 megawatts for a period extending from 1983 to 1989. Bangor Hydro would buy 30 MW of capacity from 1981 to 1990.

The prospects for construction of new nuclear power plants within the state of Maine are questionable. The nuclear industry has been heavily subsidized by the federal government in the past. Without similar subsidies, the construction of new nuclear plants might not be economically feasible. Also, the costs of nuclear waste disposal and shutting down, or "decommissioning", plants at the end of their operating cycle may be too high to make new plant construction practical. State legislation passed in 1977 prohibits the construction of any new nuclear power plants in Maine unless the Public Utilities Commission finds that a satisfactory solution exists to the as yet unsolved problem of nuclear waste disposal. However, this law may conflict with the authority of the federal Nuclear Regulatory Commission. A similar California law is being appealed to the U.S. Supreme Court. Governor Brennan, while supporting the continued operation of Maine Yankee, opposes construction of any new nuclear plants until problems of nuclear waste disposal and decommissioning are resolved. The recent referendum effort to close Maine Yankee served as an indication that many Maine citizens are also concerned about the use of nuclear power in Maine, and that strong public opposition to the construction of a new nuclear plant could be expected. Finally, Maine utilities say they have no plans to build a new nuclear plant. For these and other reasons, any new nuclear capacity for the State of Maine in the near future will likely be limited to purchases from plants located out-of-state.

The final fate of the Maine Yankee plant is unclear. As stated, it is licensed to operate until the year 2008. At that time, its owners may seek government permission to upgrade certain of the plant's components and continue to use it to generate electricity for another temporary span of years. As yet, the utilities have not indicated that they plan to pursue this possibility. In fact, during hearings on its most recent rate increase request before the PUC, CMP requested that it be allowed to set aside funds annually toward the cost of decommissioning Maine Yankee.

Another option was suggested in a 1980 U.S. Department of Energy study conducted by the Oak Ridge Associated Universities. It suggests turning Maine Yankee into a breeder reactor park. As envisioned, the park would accept and store spent fuel from New England reactors and those in other countries. The spent fuel would be reprocessed and the plutonium produced by the procedure would be used to fuel the breeder reactor. It would be up to the utilities that own Maine Yankee to request permission to pursue such a plan. They have expressed no intention of doing so at this time. In view of this, and considering the problems with breeder reactor technology already discussed, the breeder reactor suggestion appears unlikely at present.

In the absence of other plans, Maine Yankee will have to be decommissioned, or shut down permanently, after 2008. The exact costs, safety risks and technical procedures that will be involved in this decommissioning process are not yet clear. To date, about 65 experimental and demonstration nuclear power plants have been decommissioned, but no commercial plant as large as Maine Yankee has ever been decommissioned. However, two plants elsewhere in the United States are scheduled to close down in the 1980s. This should lead to much useful information. A 1978 study done by Pacific Northwest Laboratories for the NRC estimated decommissioning costs for a plant the size of Maine Yankee at $42 million (in 1978 dollars). Other studies have predicted decommissioning costs of up to $100 million. Under current laws, Maine consumers will bear at least half the decommissioning costs for Maine Yankee, based on Maine utilities 50% ownership of the plant. (Maine consumers will also share in the costs of decommissioning nuclear plants located out-of-state in which Maine utilities own shares.)

d. Considerations

Nuclear power raises numerous controversial and complicated issues. Currently, several of those issues are receiving considerable attention from state government. For example, recent NRC regulations require the State to develop emergency safety and evacuation plans that could be used in case of a nuclear accident at Maine Yankee. One plan must be prepared for an emergency planning zone covering a ten-mile radius around the plant, another for a planning zone within a 50-mile radius. The Maine Office of Civil Emergency Preparedness has now completed a draft of the State plan for the 10-mile zone and received preliminary reviews from the NRC and the Federal Emergency Management Agency. Final review and readiness of this plan will be completed by July 1, 1981. The 50-mile plan is scheduled to be ready in 1982.

The disposal of radioactive waste produced by Maine Yankee has become a particularly serious dilemma that has received increasing attention from the public and State. When nuclear power was introduced in this country over twenty years ago, it was generally believed that the federal government would have fuel reprocessing plants and permanent nuclear waste disposal sites ready by the 1980's. Spent fuel was to be stored at the power plants for only a few years, until it became less radioactive. Then it was supposed to be shipped to a reprocessing plant where the remaining useable uranium and plutonium would be separated from the unuseable wastes. Under this plan, the uranium and plutonium would be used to make fresh fuel and the waste would be shipped to supposedly safe nuclear waste disposal sites.

However, the development of safe reprocessing and waste disposal technologies turned out to be far more complicated and controversial than was expected. At this time, neither reprocessing facilities nor permanent nuclear waste disposal sites are available. Nuclear fuel reprocessing efforts have essentially been halted by President Carter, due to concerns that the plutonium produced could lead to nuclear proliferation or terrorism. The federal government is investigating potential waste disposal methods and sites, but it is not clear when either permanent disposal or reprocessing facilities will be available in this country.

As a result of these unforeseen delays, nuclear waste is steadily building up at Maine Yankee in what was originally meant to be a temporary spent fuel storage area. The plant's nuclear reactor core functions with 217 enriched uranium fuel bundles, each made up of 176 fuel rods. About 70 spent, or worn out, bundles are removed from the core each year and replaced with new ones. The spent bundles are stored in a specially constructed pool within the plant site.

Maine Yankee was originally licensed to store 318 fuel bundles. In 1975, when it became apparent that alternatives weren't available, it was allowed to reduce its rack spacing between spent bundles so that a total of 953 bundles could be stored in the pool. In September of 1980, the plant's owners applied for permission to use even closer rack spacing which would allow storage of 2,400 of the radioactive bundles. This would make it possible for Maine Yankee to operate normally until the year 2000, while storing all of its spent fuel at the plant. If the Nuclear Regulatory Commission denies the request, the plant would either have to ship its spent fuel wastes to some other plant's storage pool or to a federally designated "away-from-reactor" storage site (neither of which are available at present). Otherwise, when the plant reaches its current allowed storage maximum of 953 bundles in the near future, it will have to be shut down.

The State has also been closely monitoring federal studies aimed at determining if Maine has a suitable location for a permanent nuclear waste disposal site. The U.S. DOE is currently responsible for investigating this possibility. A study commissioned by DOE has indicated that 3 types of geologic formations - salt domes, basalt deposits and granite formations - are most suitable for nuclear waste disposal. Maine is among sixteen states that have been chosen for further study due to the existence of large areas of crystalline granite.

Finally, the State is monitoring the plans being made for decommissioning Maine Yankee when the useful life of the plant has ended and it must be permanently shut down.

5. Summary

Maine is extremely dependent on non-renewable fuels for its current energy needs. As a group, non-renewable fuels provided about four-fifths of the energy used in Maine during 1978. Hydro power, wood and other renewable energy resources supplied about one-fifth. In the next few decades, non-renewables will likely remain the dominant factor in our energy situation, though changes are expected to occur in the availability and levels of use of the various non-renewable fuels. Some of these changes will be purposeful, such as increased conservation of petroleum fuels and increased use of coal. Some -- such as potential national or worldwide supply shortages or disruptions -- will be beyond the control of Maine citizens.

The most problematical non-renewable energy sources are petroleum products, which make up about 71% of Maine's total current energy supply. Our supplies of gasoline, home heating oil and other distillate oil fuels are critically tied to foreign reserves and production rates. Political events abroad have lead to shortages of these fuels in the past decade and may lead to others in the future.

It is also possible that work reserves of crude oil will become tighter and tighter as the turn of the century approaches and it is certain that prices of petroleum products will continue to rise. The importing of petroleum fuels already leads to a heavy drain on Maine's economy and shortages or increasingly unaffordable prices could lead to severe economic and social crises in the state unless dependence on these fuels is reduced.

Most observers believe that expanded use of native renewable energy sources offer the most promising energy future. However, renewables may not be able to displace petroleum fuels fast enough to prevent crises. Thus, besides increasing our use of renewable fuels and conservation measures, planning must continue for possible energy emergencies.

Not all non-renewable fuels are as subject to supply and price fluctuations as heating oil and gasoline. And, though there are only limited supplies of any non-renewable fuel, some may become more available to Maine in the next few decades.

For example, the supply and use of coal from domestic reserves is expected to increase. Natural gas may also be more available in Maine in the near future. The contribution of nuclear power to Maine's energy supply may increase temporarily due to the importation of power from out-of-state nuclear plants. At present, the costs of these fuels is generally favorable compared to petroleum products.

Equally significant is the fact that the United States has enough coal, natural gas and uranium ore reserves to keep supply levels from being greatly affected by foreign events.

However, it should be considered that despite such attractive factors, coal, gas and nuclear power are all non-renewable fuels subject to depletion and that all must be imported from out-of-state. In addition, potential environmental and human health effects must be carefully examined, particularly in the case of coal and nuclear fuel.

VI. CANADIAN ENERGY EXCHANGE POTENTIAL

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Introduction

The prospects for an exchange of energy between Canada and New England have recently drawn the attention of officials in both countries. Possible surpluses in hydropower and nuclear power from Quebec and New Brunswick and natural gas from Alberta and Eastern Canada have stirred the interest of the New England governors, public officials and the state utilities.

The New England Governors and the Eastern Canadian Premiers established the Northeast International Committee on Energy (N.I.C.E.) in June 1978, in order to promote New England - Eastern Canadian joint energy projects. An information exchange program is presently underway and N.I.C.E. has sponsored several innovative joint programs highlighting alternative energy. These have included a solar design competition, the establishment of a wind energy test facility on Prince Edward Island and the recently completed "International Conservation Days" competition involving towns from all six New England states and all five eastern Canadian provinces.

1. <u>Electricity</u>

a. Current Use

Presently, Maine has six major interconnections (69 KV or above) with New Brunswick and several minor interconnections. The largest interconnection is the 600 megawatt capacity MEPCO line from New Brunswick. Maine utility companies buy a total of approximately 54 megawatts of capacity from the Coleson Cove oil-fired generating facility in New Brunswick. On November 1, 1985 this will drop to one-half that amount and on November 1, 1986 the contract expires completely. In 1979, Bangor Hydro Electric Company purchased about 60 million kilowatt hours of electricity from Canadian sources, CMP purchased 322 million kwh, Maine Public Service purchased 19 million kwh and Eastern Maine Electric Cooperative purchased 38 million kwh. These power deliveries included the Coleson Cove entitlements as well as other purchases from New Brunswick delivered over the MEPCO line. This amounts to about 4.4% of the total electricity used in the state.

b. Resource Availability

There is an increased potential for importing electricity from Canada in the next five to ten years. Quebec has shown interest in exporting hydropower from its large James Bay project and additional power may be available from the Churchill River area in Labrador. New Brunswick's new nuclear power plant, Point LePreau, is also expected to have at least a short-term surplus capacity. Central Maine Power Company is presently negotiating for 100 megawatts of capacity in that plant and Bangor Hydro is negotiating for 30 megawatts. If an agreement is reached, this power will be available between 1981 and 1989.

c. Current Issues

There are several barriers to increasing power exchanges with Canada. One is the current uncertainty over the amount of Canadian power that will be available to New England and how dependable it would be as a future source. A joint preliminary report prepared by the Hydro-Quebec and the New England Power Pool (NEPOOL) on potential New England/Quebec power interchanges indicates that importing of power from Hydro-Quebec to New England before 1987 is not likely because adequate transmission lines could not be completed before that time. The report also concludes that after 1987 Hydro-Quebec will have no surplus energy for sale. On the other hand, forecasts by Quebec planners of growth rates for provincial electric demands are quite high (6.5 to 7.5%). By comparison, recent New England forecasts average 2.0 to 3.5%. If the Quebec forecasts are high by even 2 or 3% the province may have a very large amount of surplus capacity, between 2,000 to 5,000 megawatts, that could be exported between 1985 and 1995.

Many utilities are hesitant to purchase power from facilities not located in the United States. Quebec, which may have the greatest export potentials, seems to prefer dealing with a single large entity such as the New York Power Authority than with individual utilities. Presently, there is no organization authorized to represent all Maine utilities or all of the New England states in bargaining for power. A NEPOOL team is negotiating for 2000 MW of power; however, individual utilities are not bound by the results of the negotiations. Finally, transmission lines between Canada and the United States will need to be upgraded or new ones constructed to allow increased imports. Studies by NEPOOL indicate economic advantages of long term energy exchanges and energy banking. One NEPOOL report recommends that construction of a new 600 MW tie be started immediately. The MEPCO line could probably be upgraded to assume greater capacity sooner than new transmission lines can be constructed since environmental permits would not be necessary.

2. Natural Gas

a. Current Use/Resource Availability

Presently, the State of Maine does not receive any natural gas directly from Canada. However, one immediate and two longer range Canadian sources for natural gas imports may exist. Currently, a proposal to transfer a surplus of Alberta natural gas across an existing pipeline interconnection at Niagara Falls, New York, is pending before the U.S. and Canadian governments. While this flow would primarily benefit New York, New Jersey and southern New England, a small amount would enter Maine by way of the Bay State Gas-Northern Utilities pipeline. This line serves the Portland and Lewiston-Auburn areas.

The potential for further gas exports from Canada may come with the proposed two stage extension of the trans-Canada pipeline, referred to as the Quebec and Maritime Pipeline Project. The first stage, extending the present pipeline to the Quebec area, has been approved by the National Energy Board and will be under construction soon (pending resolution of some environmental and right-of-way questions). The second stage, which extends the pipeline to the Maritimes, has been announced as a policy goal of the Canadian government. This portion of the pipeline may involve an export segment called the New England States Pipeline Project. This project is a joint venture between Algonquin Gas Transmission Company of Boston and Transcontinental Gas Pipeline Corporation of Houston. It involves the construction of a gas pipeline from the Canadian Border, through Maine, to Algonquin's pipeline in Rhode Island. It would bring 91.25 billion cubic feet per year of Canadian gas to New England and the New York area. Some of this large amount of gas could be available to Maine.

Future supplies that may add to the surplus of Alberta gas may come from offshore drilling on the Canadian Outer Continental Shelf or the Canadian Arctic/U.S. Alaskan Reserve. Recent discoveries of natural gas on Sable Island and in Hybernia off Newfoundland could yield more than Canada needs and, thus may be made available to New England markets.

b. Current Issues

Maine is not assured of access to the gas in the proposed New England pipeline project since allocations must be approved by the Federal Energy Regulatory Commission. However, Maine has been told by the companies involved that they would support distribution of gas from the pipeline in Maine. A report by E.J. Curtis Associates on behalf of the Massachusetts Office of Energy Resources, entitled "Prospects for Natural Gas Exchange between New England and Eastern Canada," states that the existence of the New England states pipeline would have implications that go beyond the immediate project:

> "Such a tie-in would constitute a "backdoor" interconnection with the entire U.S. gas pipeline system. To the extent that gas is delivered into the end of the U.S. gas pipeline, it creates some additional capacity in the system and, therefore, improves New England's access to supplies which may be developed to the south and west of the region. This is so because of the displacement principle. For example, if a Texas-based pipeline contracts to buy Canadian gas from the Sable Island Reserve, it could be delivered via New England to markets all the way down the line to Texas. Since gas is already flowing into the northeast from Texas, however, the Canadian gas would not have to be physically transported to Texas. Instead New England would use Canadian gas. The net result is a decrease in the actual flow of gas into the New England area from the southwest, thereby increasing the capacity of the existing system to bring new gas into the region. This would clearly be desirable to the New England gas industry in that it would significantly expand supply options."

These possibilities are in the future. However, if they do occur, Maine may well become an energy corridor supporting a pipeline to southern New England to deliver this gas and the available supplies of gas in the state could increase substantially. The use of natural gas in Maine is further discussed in this plan's section on that fuel.