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MINNESOTA ENERGY PROJECT

Minnesota: a Primer on Energy Options and Implications

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MINNESOTA: A PRIMER

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Dean E. Abrahamson

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FOREWORD

In September 1973, the Minnesota Energy Project (MEP) was commissioned by the Minnesota State Planning Agency to undertake a series of studies leading to a better understanding of energy flows in Minnesota. This is the fifth in a series of reports by the MEP. The other reports are listed on the inside cover of this report.

This report attempts to set forth some of the energy policy issues confronting the nation and Minnesota. This is a preliminary draft, circulated for comment. A final version of this report will be issued in September 1974.

Many individuals have helped prepare this report. I must particularly acknowledge the aid and counsel of Steve Emmings, Mary Trigg, Donald Geesaman and William Walton. Lorna McKeen suffered through the pains of typing and retyping, and Raymond Sobieck prepared the graphs and other figures.

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INTRODUCTION

This is a report about energy policy with emphasis on issues of particular importance to Minnesotans. Energy policy cannot be considered to be a single statement, but is a framework within which individual and corporate decision must be made. It is a topic for all; none can escape the responsibility of considering the energy implications of his decisions. The individual in deciding whether to buy beverages in returnable glass containers or throw-away aluminum cans is deciding energy policy. When the family makes a decision as to the level of insulation in their home or when they decide to live in a single family house or an apartment in the city or in the suburbs, energy policy is being enacted.

The Ford Foundation Energy Policy Project, in their preliminary report* notes:

> "Objectives for energy policy tell us where we want to go and provide a benchmark for policy successes and failure. Individuals may differ in picking out objectives, but these five would be high on most lists:
>
> (1) Assuring reliability of energy supply;
>
> (2) Achieving the lowest cost to society for energy;
>
> (3) Avoiding economic and regional inequities;
>
> (4) Safeguarding the quality of the environment; and
>
> (5) Minimizing international problems due to energy.
>
> "Unfortunately, in the real world these very desirable objectives are often in conflict and must be compromised. They must also be harmonized with other social goals in areas like transportation and overall fiscal and welfare policy...."

The Federal government obviously has a major role in the formulation

---

*Energy Policy Project of the Ford Foundation, Exploring Energy Choices: A preliminary report, March 1974 (Available, prepaid at $0.75 per copy from: The Energy Policy Project, P.O. Box 23212, Washington, D.C. 20024).

and execution of energy policy. What should be our national foreign policy goals, and how do they influence the flow of fuels in international commerce? What is our relationship to the developing nations, and to what extent do we consider the impact upon them of our energy policies? To what extent should agricultural production be expanded with an eye toward exports offsetting fuel imports? What role should be taken in imposing land-use decisions upon states and local governments? These are but a sample of policy actions which will be taken at the federal level.

But what of the states, and in particular Minnesota? Are there elements of the energy dilemma that fall directly into the domain of state responsibilities? This is an area which has not been explored in any detail. Even in Minnesota, where the Legislature has been involving itself in energy matters for at least two sessions, there is little indication that the State's role has been identified.

This report begins with a brief summary of some of the energy issues facing the nation with a bit more space given to those facets which have particular interest to Minnesota and the Upper Great Plains States. Both energy supply and energy demand are discussed. On the demand side the conventional, business-as-usual, projection for the immediate future -- the next twenty or thirty years -- is considered, but so are alternatives. The business-as-usual view, perhaps best characterized by continuation of past trends of growth in consumption, foresees energy use by the year 2000 about two-and-a-half or three times present consumption. This energy can be supplied, but at great cost. Were the choice but made, energy consumption could be dramatically reduced without disruption of present life-styles. Examination of potential energy use reductions by technical improvements in efficiency alone shows that without sacrificing personal choices there could be at least a 40% reduction from the business-as-usual projection by the year 2000.

The potentials for energy supply are also reviewed. Supply situations having particular emphasis for Minnesota are stressed, and suggestions are made for Minnesota's support of the development of alternative energy sources.

The final parts of this report focus specifically on Minnesota and adjacent states. The mix of energy sources differs significantly between regions of the United States, between states within a region, and between regions of a given state. Some of these differences for Minnesota and the adjacent states are noted. Although there is good data on energy supply to Minnesota, there is relatively little known about how energy is used in Minnesota.

The report closes with some speculations on what the future holds for Minnesota regarding the energy systems and some suggestions as to what energy related tasks are before the State.

The report does not purport to be a detailed and definitive statement of energy policy issues, but it does provide a framework for consideration of the State's role in energy policy formulation and management. It does give some indication of the range of concerns that Minnesota should be addressing. We can be sure that many energy decisions will be made in the near future which will affect Minnesota. To the extent that it does not act, the State may well see her interests poorly served by pre-emption of its responsibilities by Federal government or by having decisions made without public participation.

"Although adequate energy is essential to a high quality of life, increase in the use of energy will not necessarily lead to improvement in the quality of life. Improvement may depend largely on having a range of choices available, and on the ability to make choices with a balanced perspective of immediate and long-term consequences. Our energy policies play an important role in enabling Canadians to have adequate energy for their needs, and in directing its use towards attainment of the objective of a satisfactory and improving quality of life."

------<u>An Energy Policy for Canada, Phase I, Volume I - Analysis</u>
The Minister of Energy, Mines and Resources, Ottowa, Canada, 1973.

"Probably no other single change aided the farmer as much as the improvement from candlelight to electric light. Many pioneers lived through four or five phases of household lighting. Artificial lighting in any form was expensive in the early days in terms of money and labor involved. The tallow candle provided the first light in those tiny pioneer homes. Tallow candles, a by-product of home butchering, were commonly made by tying twisted cotton rags between two legs of a chair and slowly pouring warm tallow over the rags. After the first layer of tallow hardened another layer was poured and allowed to harden. The process was repeated until the candle attained its desired size. For those who could afford them, candle molds were available. The mold was placed upside down with only a hole large enough for the string wick to stick through. A little of the wick was left sticking out of the mold on the open end to pull the hardened candle out of the mold. Making candles was a slow task and, therefore, they were used as sparingly as possible. They gave a dim yellow light, smoked, and smelled bad while burning.

"The second form of lighting used in the homes was the kerosene lamp that used a wick and was no less smoky and smelly than the tallow candles. It was, however, much cheaper because kerosene, or 'car oil,' was relatively inexpensive. A United States Department of Agriculture survey in 1920 revealed that eight out of ten farmers' wives were spending at least one-half hour each day to clean and refill the lamps used in their households. Their common complaint - 'Oh, washing those chimneys every day.' The earliest pioneers who had experienced using and making tallow candles did not complain quite as much about the job of cleaning the kerosene lamps. Much later, improved refining processes of kerosene reduced the smoke problem and a brighter light was secured through the use of a mantle. The most popular of these mantle lamps was the Aladdin lamp.

"After the periods of the homemade tallow candles and the kerosene lamps came the calcium carbide gas light. The carbide came in ten-gallon drums with a water dripper attached. As the water dripped into the drum, the carbide released gas that burned to supply light. Galvanized tubes were used to run the gas to the various rooms of the house. Some of the out-buildings had gas light too, but this was an extreme fire hazard. The light instrument itself looked much like the Bunsen burner used in science laboratories. The cost of such light was advertised at $1.60 per thousand cubic feet, or about one-half cent per hour.

"The next step in lighting was the gas lamp that produced the first virtually smokeless 'white light.' Gas lamps used mantles and were much simpler in construction and required only fuel and a match to light them. One brand, made by Coleman of Kansas, proudly bore its trademark on the bottom: 'The sunshine of the night.'

"Around the turn of the century some of the more progressive farmers quickly adopted the Delco system that provided electricity through the use of storage batteries kept charged by wind operated generators. The Delco system 'could even pump water and elevate grain' but most farmers used lanterns for lights and gasoline engines for portable power until the advent of rural electrification in the later 1930's. The advent of REA at that time possibly marked the most decisive change in American agricultural progress, and also marked the beginning of the second agricultural revolution."

------Hiram M. Drache, The Challenge of the Prairie, North Dakota Institute for Regional Studies, Fargo, 1970, pp. 50-51.

THE IMPORTANCE OF ENERGY

The significance played by energy in the life of every Minnesotan cannot be understated. Just as the flow of energy through an ecological system serves to characterize it, so it is in an industrial system. The availability, and use, of energy in virtually every human activity is essential. The history of energy use in Minnesota from pioneer days to the present is a fascinating story. Those who have participated in the growth in energy consumption during recent years associated with such things as the conversion from black-and-white TV to color, or from "ordinary" refrigerators to "frost-free" refrigerators, may have difficulty in understanding the profound differences in life-style associated with the growth in energy consumption over the first decades of this century. We are now confronting what is sometimes called an energy "crisis" which can be characterized as shortages of modest dimensions in the short run and the inability to maintain historic growth rates in the longer term.

What follows attempts to define some of the considerations involved in energy policy decisions that are facing Minnesota in the mid-1970's. Energy use is an intimate part of all that we do, and virtually every decision has energy implications. During the past several decades Minnesotans have come to take energy availability for granted. We were told, and had little reason to question until recently, that energy was plentiful - "penny cheap." Those days are over. Perhaps we must begin to entertain the notion of substituting the idea that "enough is best" for "more is better."

How 25 U.S. oil firms fared in 1973

Company	Annual — Net profit* (Thousands of dollars)	Annual — % change from 1972	Annual — % change 1972 vs. 1971	4th quarter — Net profit*	4th quarter — % change from 1972	4th quarter — % change 1972 vs. 1971
Exxon	2,440,000	+ 59.3	+ 0.9	784,000	+ 59.0	+ 13.2
Texaco	1,292,403	+ 45.4	− 1.6	453,486	+ 70.1	+ 8.7
California Standard	843,600	+ 54.2	+ 7.0	283,100	+ 94.2	+ 12.8
Mobil	842,800	+ 46.8	+ 6.2	271,600	+ 68.2	+ 7.9
Gulf	800,000	+ 79.1	− 15.9	230,000	+ 98.3	+ 8.4
Subtotal	**6,218,803**	**+ 55.0**	**− 0.5**	**2,022,186**	**+ 71.3**	**+ 10.9**
Indiana Standard	511,200	+ 36.4	+ 10.0	121,400	+ 52.7	+ 14.0
Shell	332,694	+ 27.7	+ 6.5	79,394	− 1.5	− 9.3
Atlantic Richfield	270,185	+ 40.3	− 8.6	91,697	+ 47.4	+ 11.2
Continental	242,700	+ 42.6	+ 21.5	89,300	+ 91.6	+ 63.5
Phillips	230,400	+ 55.3	+ 12.2	86,700	+127.6	+ 5.2
Tenneco	230,212	+ 13.4	+ 9.9	80,920	+ 14.4	0
Sun	230,000	+ 48.4	+ 2.0	75,000	+ 59.6	+ 14.6
Amerada Hess	218,364	+177.3	− 65.3	104,490	+471.9	− 19.4
Union	180,200	+ 47.8	+ 6.3	51,000	+ 55.5	+ 7.5
Cities Service	135,600	+ 36.8	− 5.2	42,100	+ 49.8	+ 23.2
Getty†	135,032	+ 77.4	− 36.6	52,612	+115.0	− 13.6
Marathon	129,405	+ 62.2	− 10.1	46,946	+ 92.8	+ 17.8
Ashland§	85,219	+ 25.7	+ 64.5	34,400	+ 52.2	+ 15.3
Pennzoil	80,412	+ 37.1	+ 24.3	24,103	+ 68.4	+ 20.6
Ohio Standard	74,100	+ 24.1	+ 1.4	11,600	− 39.9	+ 4.9
Murphy	48,533	+239.9	+ 28.9	13,935	+181.0	+ 48.3
Skelly	43,983	+ 17.0	− 1.8	16,812	+ 31.3	+ 18.5
American Petrofina‡	36,951	+104.6	+ 38.0	16,729	+218.2	+ 44.1
Clark	30,500	+265.6	+132.6	8,087	+140.8	+183.6
Tesoro§	19,874	+ 52.3	+ 70.1	12,580	+183.5	+ 37.3
Subtotal	**3,265,564**	**+ 47.9**	**+ 0.4**	**1,059,805**	**+ 65.1**	**+ 12.9**
TOTAL	**9,484,367**	**+ 52.7**	**− 0.2**	**3,081,991**	**+ 69.9**	**+ 11.5**

*Excludes nonrecurring gains and losses. †Includes Getty's share of Mission Corp. and Skelly Oil Co. ‡Includes revenue of Standard (Ohio) assets acquired July 1, 1973. §Fiscal year and first quarter.

--- THE OIL AND GAS JOURNAL, Feb. 18, 1974, p.33

WHAT IS THE ENERGY PROBLEM?

Even the most casual observer of current events could not avoid notice of concern with energy in the year 1974. Is it a crisis? Is there a blatant conspiracy afoot? Is it simply a smokescreen to cover other current events? If it is a crisis, what is to be done and who is to do it? Is it short term or is it something with which we will have to contend for years to come? These questions, and others, are before all of us. Were the answers obvious there would be little need for Congressional investigations; for the flurry of activity in state legislatures; and for the mass of paper and ink being consumed discussing means to avert, to abort, or to live with the "energy crisis." Governmental, industrial, and consumer decisions impact on energy supply or demand -- are part of energy policy. These decisions range from the passage of new national laws protecting the environment or providing tax advantages to homeowners and oil companies, to personal decisions to buy large air conditioned cars or to live far from work, to state decisions on land-use. They have collectively contributed to the leveling off of domestic energy production and a simultaneous steady rise in consumption.

"Another factor that will create additional demands for power is the growth in our standard of living. In general, the living standard of any given family in the United States can roughly be measured by the number of appliances it has and by the amount of electricity it consumes, just as total power consumption is a good indicator of the standard of living of a nation."

------John W. Simpson, President, Westinghouse Power Systems Co., in a speech to the St. Louis, MO. Electrical Board of Trade, February 9, 1971, reprinted in the Congressional Record, March 8, 1971, pp. E1564-1565.

BUSINESS-AS-USUAL

Without knowing the framework in which energy policy options have been considered in the past, it is impossible to understand the nature of the current energy problem and the options being discussed. For many decades energy use has been promoted. This promotion has taken many forms, including:

- rate structures for natural gas and electricity have promoted more consumption by offering large-volume users a lower price per unit energy than small users
- promotional advertising has encouraged the use of energy-consuming goods such as autos, air conditioners, appliances, electric heating systems, and goods which use large amounts of energy in their manufacture, such as plastics and other petrochemicals
- the interstate highway system with billions of dollars from the highway trust fund has created a rapid increase in inter-city, high-speed auto travel
- subsidies to truck and air transport has encouraged a shift in freight away from more efficient rail transport
- investment tax incentives and steadily rising wage rates has encouraged industry to expand with energy intensive capital equipment
- the growth in suburbia, encouraged by freeways, federal income tax breaks and federally guaranteed loans for homeowners, has resulted in the soaring use of gasoline for commuting and of other energy for the single-family homes that were built.

"Oh where does economics tend,

when end is means and means is end?"

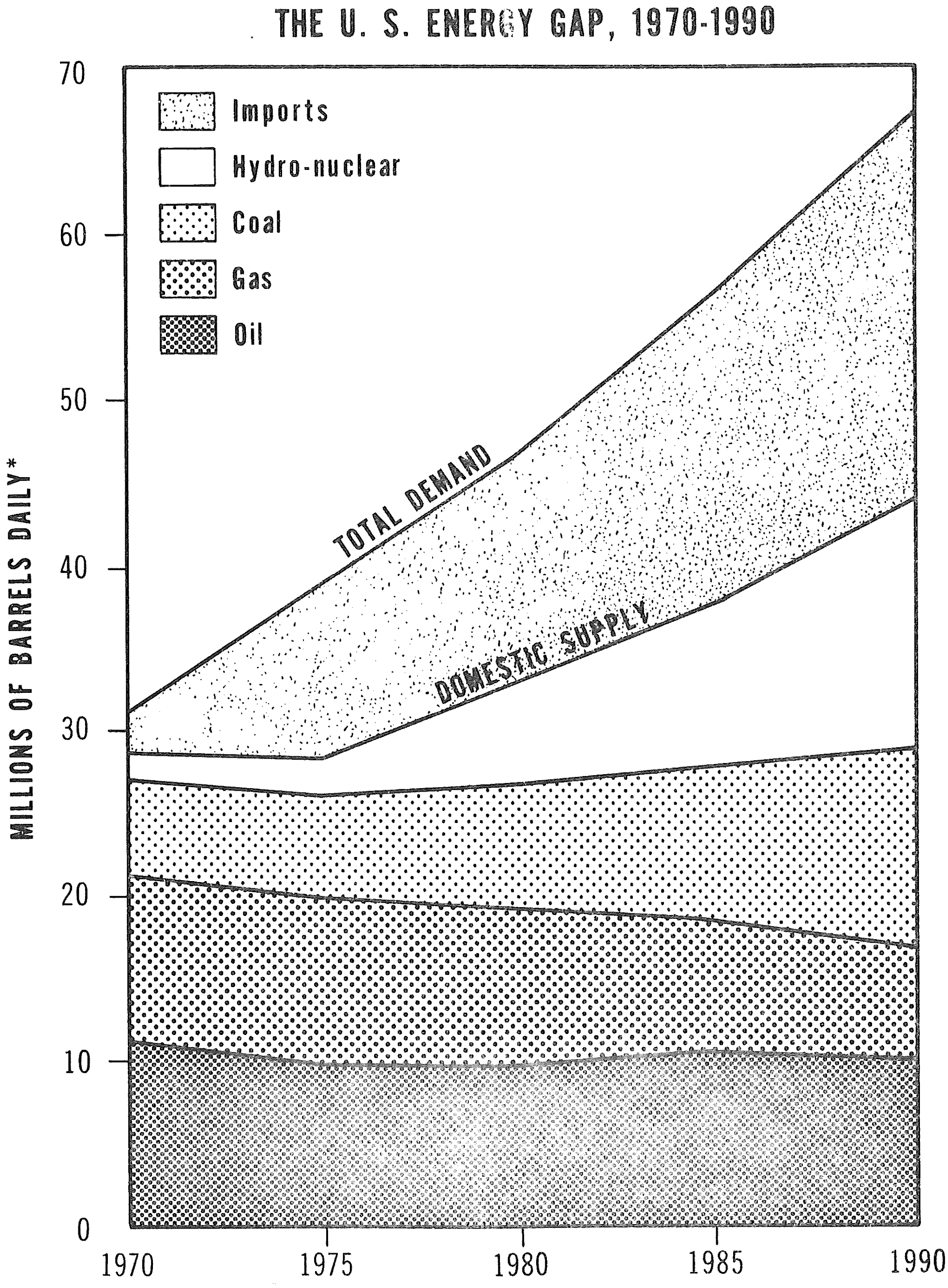
-- Kenneth Boulding, Economist

Energy use has been considered to be a good thing, and somehow increasing energy use has been taken to be an index of all things regarded as desirable. It is not uncommon to find energy use equated with standard of living. Others equate standard of living with per capita gross national product. Intertwined in all of this reasoning is the assumption, sometimes explicitly stated and sometimes not, that economic growth and standard of living are tightly coupled and that both are inexorably tied to growth in energy consumption. It is doubtful that these assumptions will withstand objective examination. The result has been that per capita energy use has increased, and it has been assumed that it would continue to increase at more or less the rates of the past.

Over the years many studies have been done estimating energy use in the near future. Except in rare instances, the method for the projections has been to determine what the growth rates have been in the recent past, and to assume that these rates would prevail for the period of the projection. All energy policy questions have been reduced to how to meet the demand resulting from these projections, and virtually all projections have assumed that a large fraction of the increased energy use would be supplied from imported oil. There are many such projections, that made by the Shell Oil Company in 1973, Figure 1, is representative.

Although there is a range of estimates for our energy demand for any given year in the future (at least to the year 2000), a typical value is that energy consumption will increase from its 1973 level of 36.6 million barrels

FIGURE 1



*Crude oil equivalent

Source: THE NATIONAL ENERGY OUTLOOK, Shell Oil Co., March 1973, p. 4

of oil per day equivalent,* to about two-and-a-half or three times that value by the end of the century.

There are other features of the business-as-usual view of the energy future that are important to an understanding of the general energy debate. The production of electricity presently consumes about a quarter of all fuels used in the United States. Electrical use is growing significantly faster than total energy use, and it has been an accepted prediction that by the year 2000 between fifty and sixty percent of all fuels will be used for the production of electricity. In addition, it has been projected by the Atomic Energy Commission that about half of all electricity would be produced by nuclear fission by the year 2000.

How will all of the energy required by the business-as-usual view of the energy future be produced? To answer this question we must first review briefly the forms of energy currently being utilized, and compare them with a representative estimate of the fuel mix for some future year, say 1990, Table I. Over three-quarters of all energy is derived from petroleum and natural gas. Coal, the fossil fuel in greatest abundance, provides less than 17% of current energy use, and it declined by 36% between 1947 and 1962. All fuels must be produced somewhere, the United States or abroad. Domestic

---

* In expressing energy data as "barrels of oil equivalent," or in other "equivalents," the heat content of the energy, from whatever primary fuel, is converted to its equivalent Btu value for oil. A Btu is the amount of energy needed to raise one pound of water one degree fahrenheit. Because energy from all fuels can be converted to Btu's, it can be the standard term of measurement. Conversion rates used in this report are:

1 barrel of crude oil (42 gallons)	= 5.8 million Btu's
1 cubic foot of natural gas	= 1,032 Btu's
1 kilowatt-hour of electricity	= 3,413 Btu's
1 ton of coal	= 22 million Btu's

A more complete listing of conversion factors is available in, "Minnesota: Energy Use Totals and Conversion Factors," staff report of the Minnesota Energy Project, Report MEP-74-3, February 18, 1974.

TABLE I

UNITED STATES ENERGY SOURCES 1973 AND PROJECTION FOR 1990

FUEL	Million Bbl/day Oil Equiv. 1973	1990	Percentage, total energy 1973	1990
Oil				
Domestic	11.0	10.5	29.0	15.0
Imported	6.3	18.0	16.9	25.7
Shale	-0-	0.8	-0-	1.1
Natural Gas				
Domestic	11.2	8.0	29.8	11.4
Imported	0.5	4.0	1.4	5.7
Coal	6.7	14.0	17.9	20.0
Hydroelectric	1.5	2.4	3.9	3.4
Nuclear	0.4	12.0	1.1	17.1
Geothermal	-0-	0.4	-0-	0.6
TOTAL	37.6	70.1	100.0	100.0

NOTE: The sources of data for the tables are listed in Appendix B.

production of petroleum and natural gas has limited potential. Imports have supplied our growth needs since 1970. The conventional view of the energy future has an increasing amount of oil and natural gas being imported. The fraction of our fuels to be derived from imports varies from estimate to estimate, but that of the U.S. Congress' Joint Committee on Atomic Energy, Table II, is representative.

So the stage has been set: rapidly increasing consumption, decreasing or fixed domestic production rates for oil and natural gas, increasing imports, rapid expansion of nuclear power, coal recognized as a necessary fuel of the future but not given particular emphasis because of its ugly health and environmental side effects, and rapid increase in electricity as a use form tied to nuclear fuels or coal. Other energy sources -- solar, geothermal, solid wastes, winds -- have been regarded as interesting possibilities, not to be taken seriously in planning future energy supplies.

Even before the Middle Eastern embargoes of oil in late 1973, there were signs that supplies were not keeping up with demand. In addition, there was evidence that energy growth rates might increase substantially. Energy consumption grew at an average annual rate of about 3.5% from 1950 to 1965 and then increased to about 4.5% thereafter. At about the same time it was noted that the amount of energy required to produce a dollar of gross national product increased sharply, Table III. If this deviation from the historic trend of decreasing energy use per dollar GNP is other than a short-term fluctuation, and if one of our primary goals is to maintain a steadily increasing real GNP, then energy consumption will have to grow even more rapidly than in the past.

The implications of maintaining the 4.5% annual increase in energy

TABLE II

DEPENDENCE ON IMPORTED FUELS

Year	Imports, Millions Barrels of Oil per Day, Equivalent	Percentage of Total U.S. Energy Consumption
1950	0.9	5.6%
1960	2.0	9.5
1970	3.9	12.0
1973	6.8	18.3
1980	11.9	25
1990	22.0	32

NOTE: Imports include oil and natural gas, converted to the heat equivalent of oil.

TABLE III

CHANGING RELATIONSHIP BETWEEN GROSS NATIONAL PRODUCT AND CONSUMPTION OF ELECTRICITY AND TOTAL ENERGY

Year	Thousand BTU / $1 of GNP	Kilowatt-hour / $1 of GNP
1920	141.3	0.41
1930	121.5	0.63
1940	105.2	0.80
1950	96.1	1.10
1960	92.2	1.74
1965	87.1	1.87
1970	95.0	2.28

consumption has been graphically portrayed by the Chase Manhattan Bank in their report Outlook for Energy in the United States to 1985. Their sector by sector analysis of growth between 1970 and 1985, Table IIIa, reveals that "the nation's over-all requirements for primary energy are likely to be almost twice as large in 1985 as in 1970. The average annual rate of growth for the 15 year period will be 4.5 percent. And the accumulated consumption will be nearly twice as great as in the preceding 15 years."

For these and other reasons, it was anticipated that energy consumption would rise even more rapidly than in the past. But we are beginning to see symptoms that energy supplies can no longer meet energy demands: brownouts, natural gas interruptions, shortages of fuel oil in winter and gasoline in summer, and insufficient residual oil are prominent examples.

There were also factors at work which were acting in a way expected to lead to a reduction in energy consumption growth rates below those of the business-as-usual forecasts. Any such forecasts, which are simply extensions of past trends carried into the future, carry with them a host of assumptions, including:

(1) that there is no constraint on the availability of fuels; if we want a barrel of oil from Saudi Arabia or wherever, it is there to be bought;

(2) that the trend in fuel prices will be those of the past, which in the present example means continuing decline in the real price of fuels or that should fuel prices increase that there is no corresponding decline in the quantities used; and

(3) that all other factors, such as restraints imposed by environmental or other considerations, will not change.

TABLE III-A

CHASE MANHATTAN BANK PREDICTED ENERGY NEEDS BY 1985

SECTOR	Million Barrels per day 1970	1985	Change Million B/D	Percent
Transportation	8.013	13.715	+ 5.702	+ 71.1
Industrial	10.557	16.645	+ 6.088	+ 57.7
Commercial	1.689	2.930	+ 1.241	+ 73.5
Residential	4.567	6.845	+ 2.278	+ 49.9
Electric Utilities	8.154	23.580	+15.426	+189.2
TOTAL	32.980	63.715	+30.735	+ 93.2

"For the regulated electric utilities, growth and profitability are closely related. The regulated 'fair rate of return on capital' has been interpreted by the courts to be based on three criteria. The rate of return must be (1) commensurate with returns on investments in other enterprises having commensurate risks, (2) sufficient to insure the financial integrity of the enterprise, (3) able to maintain the credit of the enterprise and attract capital. For those of us who study growth the criterion most relevant is the last. In order to attract the capital needed to finance the rapid expansion of capacity, the rate of return must be higher than in other investments of equal risk. The need for rapid growth, if established to the satisfaction of regulatory agencies, leads to requests for a higher allowable rate of return, and it is notable that higher rates have already been granted to some utilities and that many petitions for other rate increases are now pending. Furthermore, even if the regulated rate of return is held constant, the utilities have abundant incentive to expand productive capacity in order to increase the base to which the regulated rate is applied, and thus to increase total profits. If the rate of return must be raised to attract capital, so much the better. But in order to expand and to raise the rate, utilities must convince the regulatory commission of the need for expansion. To do this, the utilities must be able to point to a 'shortage,' which they can by showing that demand is increasing faster than supply. To increase demand it is necessary to advertise and to give lower rates for use in large quantities. Perhaps this explains the curious fact that the electric utilities, a public monopoly, spent eight dollars on advertising for every one dollar spent on research and development. Another incentive to growth beyond the optimum is that a large part of the cost of increased electric power is the social cost of environmental deterioration, which is paid by society in general, rather than by the parties directly responsible for the costs. Although one is not accustomed to thinking of electric utilities as a 'growth stock,' Standard and Poor now inform the investor that 'electric power is not only the backbone of the American economy(!), it is also a vigorous growth industry.'

"Electric power is now used to illuminate advertising signs during daylight hours, to run electric toothbrushes, and to convey shoppers through parking lots on movable sidewalks. With so many trivial uses of electricity in present vogue, one wonders just what we will possibly do with twice as much electricity in 1980, four times as much in 1990, etc. It is not my intention to belittle the tremendous importance of electrical energy or of production in general. The French economist de Jouvenel has put the issue very well:

> 'But if I do not at all object to the much enhanced status of production, I may point out that production has come to embrace so much that it would be foolish to grant any and every productive activity the moral benefit of an earnestness not to be found in so-called 'nonproductive activities.' When popular newspapers propose to bring out their comic strips in color, I find it hard to regard such 'progress in production' as something more earnest than planting flowering shrubs along the highways. I am quite willing to regard poetry as a frivolous occupation as against the tilling of the soil but not as against the composing of advertisements.
>
> 'When organizers of production have to relieve a situation of hunger, efficiency is the one and only virtue. But when this virtue has been thoroughly developed and comes to be applied to less and less vital objects, the question surely arises of the right choice of objects."

-------Herman Daly, <u>Toward A Steady-State Economy</u>, Freeman, 1973, pp. 253-254.

It is now obvious that all of these assumptions may have been acceptable in the past, but are not valid today. Although the details are still a matter of dispute, it is clear that demand is a factor of energy prices, and that energy prices -- for all energy forms -- have risen sharply and are expected to increase still further. Likewise other factors, which may express themselves through regulation rather than through the price mechanism, will influence energy consumption. Air quality is in large part determined by energy use patterns, and measures to maintain or enhance air quality will impose constraints on the growth of energy consumption, as will other environmental considerations.

So there are factors at work which, by themselves, could lead to the expectation that energy consumption in the future could be greater than, or less than, the consumption projected in the business-as-usual forecasts.

Many individuals are now questioning the desirability of maintaining the growth rates of the business-as-usual view of the future. In challenging this continued growth environmental and other social costs are stressed and the internal considerations of electric utilities and other energy companies are examined. Likewise, those with vested interests in maintaining or increasing energy consumption growth rates are heard whenever it is suggested that we cannot, or should not, maintain historic patterns.

Energy policy decisions of the past have been made by Congress, the energy industries, and the Federal Executive Branch. There has been little direct citizen participation.

Project Independence, the administration's program to make the United States self-sufficient in energy by 1980, is supply oriented. It is based on the premise that the task before us is to supply as much energy as

"Without an adequate clean supply of electrical energy: First, we cannot maintain our present level of consumer goods production; second, we cannot increase the quantity of consumer goods to supply the inevitable increase in population between today and the year 2000 A.D. Third, last but not least, we cannot produce the devices which will give us the deterrent military strength to prevent nuclear war, and establish by credible negotiation a universal peace.

"The challenge posed by the impending energy deficit is stark and clear; we must double our present generating capacity by 1980.

"We must double the 1980 generating capacity by 1990.

"We must increase the 1990 generating capacity by a minimum factor of 50 percent, or by a possible factor of 100 percent by the year 2000.

"These are sober, reasonable estimates of increased power requirements based on the best calculations of the most credible and best informed professionals available. In my opinion these projections are as accurate as can be made.

"What does this mean in terms of national interest? It means that it is urgent and important to our people and the people of the world.

"It is important to our people because it involves the viability of our society. First, the doubling factor every decade for the next 30 years is basic to our standard of living, now and in the future. Second, 70% of our electricity is used in industrial operations which provide employment for our present workers and must continue to be used for our increasing population of workers. Third, I list this third, perhaps it should be first, we cannot provide the solution for pollution without this tremendous doubling of electrical energy every decade. Why? Because without abundant, cheap, clean electricity, we cannot clean the contaminants from our air. We cannot clean the contaminants from our water. We cannot treat sewage or industrial effluents. We cannot compress solid waste -- old automobile bodies, bottles, cans, and so forth -- into smaller cubical space for transportation, recycling, or disposal. We cannot recycle recoverable metals, glass, paper, and so forth. Where can we get this increased amount of electricity? The answer is clear to those of us who have spent years in the study of this problem.

"We must have every kilowatt of electricity that we can produce from every fuel source available."

-------Representative Chet Holifield, Congressional Record, June 4, 1971, p. H4722 possible from domestic sources and to reduce consumption only as necessary to eliminate imports by 1980. There is abundant evidence that maintaining the historic high growth rates in energy consumption carries with it sacrifices in environmental quality and increasing centralization both of energy supply systems and of governmental controls.

Are there no alternatives? Must we look forward to either candlelight and cold houses or a future with deteriorating environmental quality, increased mortality and morbidity, deteriorating personal freedoms, and a steady erosion of authority vested in state and local governments?

OTHER OPTIONS

Continuation of the business-as-usual trends in energy supply and consumption carries with it grave implications for environmental quality, international relations, economic stability, and balance between federal and local controls. Perhaps there are other options which can and should be considered. As we shall see there are other options, but there is no free lunch. Should we continue the trends of the past there will be enormous supply problems; should we elect to pursue policies geared to lowering the energy consumption growth rate there will be a quite different set of issues -- but the supply problems, while greatly reduced, will not go away.

At the outset, it must be made clear that only options open to the United States will be considered here, although a few other nations (e.g., Canada, Norway, the Soviet Union) are in situations very similar to that of the U.S. The energy options confronting industrialized countries with scant domestic energy resources (e.g., Japan, Sweden), developing countries with large fuel reserves (e.g., Saudi Arabia, Nigeria), and developing countries with only modest domestic resources of fuel (e.g., India) are vastly different. In addition, although it will not be discussed in this report, there are international implications to whatever energy policy is followed by the United States.

The place to begin a consideration of the alternative energy futures, through reduction of consumption, is with the current end uses of energy. Just as it is impossible to consider the potential for increasing supply without examination of each individual supply option, so it is impossible to discuss energy conservation in the abstract. Different uses present different potentials for conservation, and different policy tools to encourage more efficient use are called for in the various categories of end use.

Few data are available for the end uses of energy for Minnesota, but quite a lot is now known about national averages. The most striking observation is that only five categories of end use -- transportation fuels, production of electricity, residential and commercial space heating, and industrial process steam production -- account for nearly 85% of total energy use. Energy use data, with electricity allocated to its specific end use and not carried as an individual entry, can be presented in many ways: by category of end use, Table IV; by sector of the economy, Table V; by the fuel mix for each sector, Table VI; or by individual specific end use, Table VII. Also of interest is a more detailed breakdown of residential uses, Table VIII. These data are all for 1968, the last year for which the end use analysis has been carried out in detail.

When considering the potential for reducing energy consumption, it is reasonable to focus first on individual large end uses. These are the places where increased efficiency in end use will have the greatest impact.

The business-as-usual view of our energy future is based on a forward extrapolation of the trends of the recent past. If one accepts the proposition that we can influence our future, that future should be to some measure under our control. To illuminate the range of choices which appear to be accessible, three plausible, but very different views of our energy future are presented. These three views -- business-as-usual, a technical fix scenario, and a scenario which approaches zero energy growth by about the year 2000 -- follow the analysis of the Ford Foundation Energy Policy Project. The interim report of the Energy Policy Project, released in March 1974, contains detailed descriptions of the analysis which is only summarized here.

The business-as-usual view assumes that the use of energy will con-

TABLE IV

ENERGY USE PATTERNS BY MAJOR CATEGORY OF END USE
ELECTRICITY ALLOCATED TO INDIVIDUAL END USE - 1968

	Percent of Total
Transportation (fuel; excludes lubes and greases)	24.9%
Space heating (residential, commercial)	17.9
Process steam (industrial)	16.7
Direct heat (industrial)	11.5
Electric drive (industrial)	7.9
Feedstocks, raw materials (commercial, industrial, transportation)	5.5
Water heating (residential, commercial)	4.0
Air conditioning (residential, commercial)	2.5
Refrigeration (residential, commercial)	2.2
Lighting (residential, commercial)	1.5
Cooking (residential, commercial)	1.3
Electrolytic processes (industrial)	1.2
Total	97.1%

TABLE V

ENERGY USE PATTERNS BY SECTOR OF THE ECONOMY
ELECTRICITY ALLOCATED TO EACH SECTOR

	Consumption (quadrillion Btu) 1960	1968	Growth Rate (Percent)	Percent of Total 1960	1968
Residential	8.0	11.6	4.8%	18.6%	19.2%
Commercial	5.7	8.8	5.4	13.2	14.4
Industrial	18.3	25.0	3.9	42.7	41.2
Transportation	11.0	15.2	4.1	25.5	25.2
Total	43.1	60.5	4.3%	100.0%	100.0%

TABLE VI

FUEL USE BY ECONOMIC SECTOR -- 1968

	Percentage of Sector Requirements				
	Coal	Gas	Petroleum	Electricity	Total
Residential	- %	50.1%	34.8%	15.1%	100.0%
Commercial	8.3	26.8	49.2	15.7	100.0
Industrial	26.2	43.3	20.9	9.6	100.0
Transportation	0.1	4.0	95.8	-	100.0
	Coal	Gas	Petroleum	Nuc & Hydro	Total
Electrical Generation	57.3	26.1	9.5	7.1	100.0

TABLE VII

ENERGY CONSUMPTION IN THE UNITED STATES BY END USE
1960-1968
(Trillions of Btu and Percent per Year)

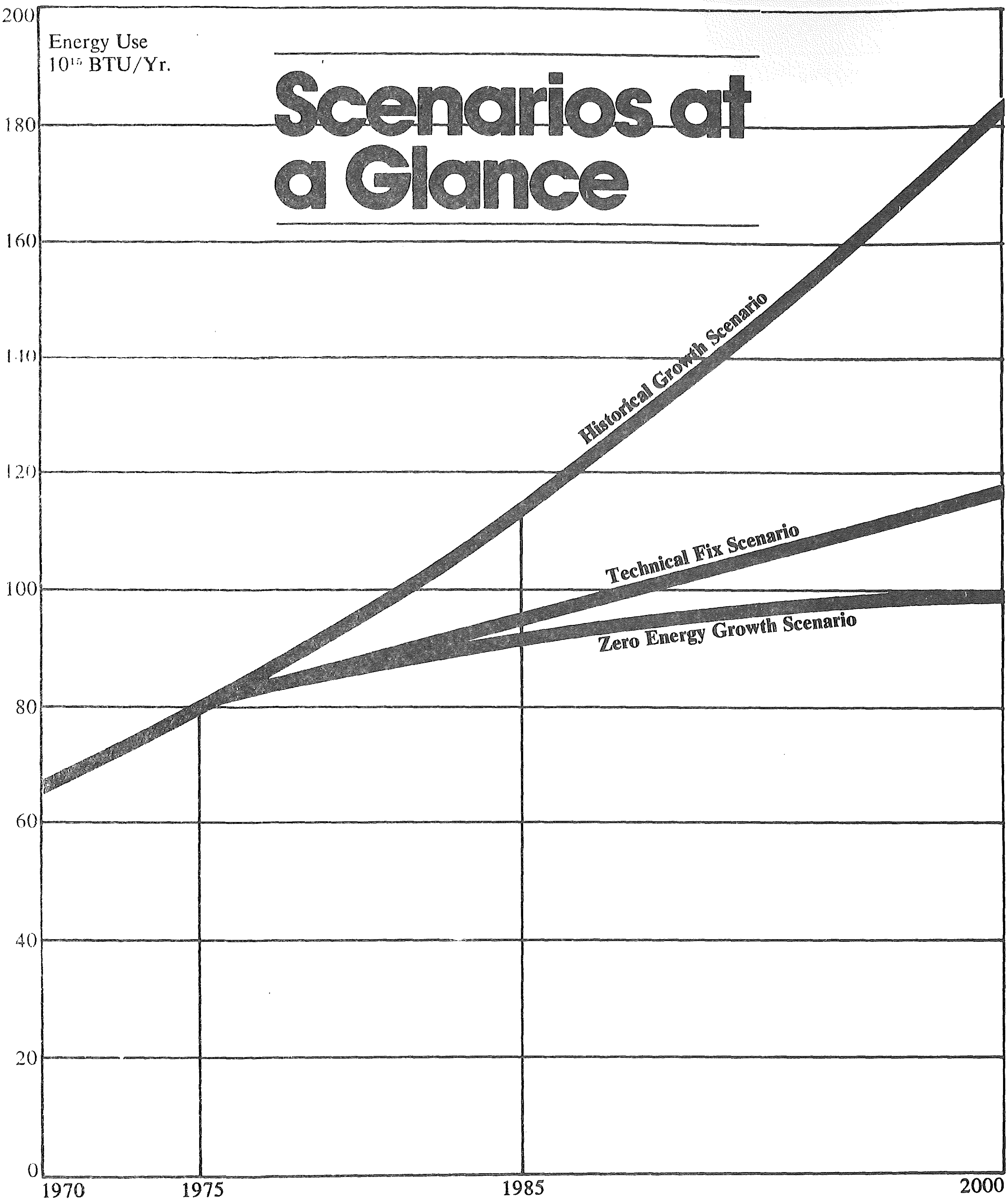
Sector and End Use	Consumption 1960	Consumption 1968	Annual Rate of Growth	Percent of National Total 1960	Percent of National Total 1968
Residential					
Space heating	4,848	6,675	4.1%	11.3%	11.0%
Water heating	1,159	1,736	5.2	2.7	2.9
Cooking	556	637	1.7	1.3	1.1
Clothes drying	93	208	10.6	0.2	0.3
Refrigeration	369	692	8.2	0.9	1.1
Air conditioning	134	427	15.6	0.3	0.7
Other	809	1,241	5.5	1.9	2.1
Total	7,968	11,616	4.8	18.6	19.2
Commercial					
Space heating	3,111	4,182	3.8	7.2	6.9
Water heating	544	653	2.3	1.3	1.1
Cooking	98	139	4.5	0.2	0.2
Refrigeration	534	670	2.9	1.2	1.1
Air conditioning	576	1,113	8.6	1.3	1.8
Feedstock	734	984	3.7	1.7	1.6
Other	145	1,025	28.0	0.3	1.7
Total	5,742	8,766	5.4	13.2	14.4
Industrial					
Process steam	7,646	10,132	3.6	17.8	16.7
Electric drive	3,170	4,794	5.3	7.4	7.9
Electrolytic Processes	486	705	4.8	1.1	1.2
Direct heat	5,550	6,929	2.8	12.9	11.5
Feed stock	1,370	2,202	6.1	3.2	3.6
Other	118	198	6.7	0.3	0.3
Total	18,340	24,960	3.9	42.7	41.2
Transportation					
Fuel	10,873	15,038	4.1	25.2	24.9
Raw materials	141	146	0.4	0.3	0.3
Total	11,014	15,184	4.1	25.5	25.2
National Total	43,064	60,526	4.3	100.0%	100.0%

NOTE: Electric utility consumption has been allocated to each end use.

TABLE VIII

Residential uses of energy in 1968 given as total energy consumed (in trillions of BTU), percentage of total United States Energy use and the percentage of the residential use accounted for by each specific use.

	(trillion BTU)	%total energy use	% resid
Space heating	6,675	11.0	57.50
Water heating	1,736	2.9	14.95
Refrigeration	692	1.1	5.95
Cooking	637	1.1	5.50
Air conditioning	427	0.7	3.69
Lighting	412	0.68	3.55
T.V.	352	0.59	3.03
Food freezers	220	0.36	1.90
Clothes drying	208	0.3	1.79
Small appliances	180	0.3	1.55
Washing machines	41	0.08	.35
Dish washing	36	0.06	.31
	11,616	19.17	100.07



Energy consumption associated with the three scenarios analyzed by the Ford Foundation Energy Policy Project. This graph is Figure 5, page 40 of:

------<u>Exploring Energy Choices</u>, Energy Policy Project of the Ford Foundation, March 1974. (Energy Policy Project, P.O. Box 23212, Washington, D.C. 20024, ¢75/copy) tinue to grow much as it has in the past. It assumes that the nation will not deliberately impose any policies that might affect our ingrained habits of energy use, but will make a strong effort to develop supplies at a rapid pace to match rising demand. As will be shown in the following section of this report, this energy future is possible, perhaps with domestic resources alone, through the year 2000. It would, however, require recognition of the long energy system leadtimes and very aggressive development of all possible supplies. The political, economic, and environmental problems of getting that much energy out of the earth would be formidable.

The technical fix scenario shares with the business-as-usual view a similar level and mix of goods and services. But it reflects a determined, conscious effort to reduce demand for energy through the application of energy-saving technologies. It has been shown that through these energy-saving means, which do not involve changes in life-style and each of which meets the test of economic efficiency, the energy consumption could be reduced to little more than half of that of the business-as-usual future. There would then be more flexibility of energy supply, while providing a quality of life at home, travel convenience, and economic growth that differs little, if at all, from the business-as-usual view.

The zero energy growth view is different, representing a real break with our accustomed ways of doing things. Yet it does not represent austerity. It would give everyone in the U.S. at least ten percent more energy on the average than he enjoys today -- even enough to allow the less privileged to catch up to the comforts of the American Way of life. It does not preclude economic growth. Why might we consider zero energy growth? It is eventually necessary, given the finite limits of the planet, and may come about quite soon as society becomes more concerned about the social and environmental costs of energy growth. Further, it would reflect broader social concerns like uneasiness about the dehumanizing influence of immense centralized institutions.

To illustrate the changes which make up the technical fix and the zero energy growth views of the future, a few examples will be considered. They have been selected because significant quantities of energy are involved, major improvement in energy efficiency is possible, and they involve the household. Similar examples could be cited for commercial and industrial energy uses.

A large part of our energy is used for residential and small commercial space heating -- 11% for residential heating and 18% for the total category. Estimates of future consumption based on extrapolation of past and current practice carries with it some assumptions about how we will heat our homes, namely that it will be "business-as-usual." The energy required to heat our homes could be reduced by at least half, and at the same time meet the test of economic efficiency -- that is, without resulting in additional net expenditure for homeowners.

There are several ways that residential space heating energy requirements could be reduced. Among other available options heat loss could be reduced by upgrading insulation, windows, and other factors which determine heat loss; homes could be smaller; or homes could be cooler. Only the first one, reducing heat loss, satisfies the requirements imposed in defining the "technical fix" energy future. Were the quantity of insulation, the quality of windows, and other factors which influence heat loss upgraded, it would result in higher first costs. Houses would be more expensive, down payments higher, and taxes and interest payments more. On the other hand, because of the lower heat losses, less fuel would be required to heat the home, resulting in lower fuel bills. When the costs associated with lowering heat loss are compared with the savings associated with lower heating costs over the expected lifetime of a home, and the houses insulated at the point of net savings to the homeowner, it is found that the energy used for residential space heating could be reduced by half. The business-as-usual projection assumes that present practices, inefficient both technically and economically, will continue indefinitely. The technical fix projection assumes the same number of houses, of the same size, heated to the same temperature as does business-as-usual, but the houses would be insulated to the point of net economic advantage to the homeowner.

These and other similar changes involving, for example, more efficient transportation, more efficient furnaces, the use of heat pumps and total energy systems, more efficient industrial steam production, and metal recycling, result in the conclusion that through technical changes alone energy consumption could be reduced by between 40 and 50% of the business-as-usual forecast.

It is difficult to argue that changes of this kind should not take place. Indeed, it is difficult to understand why they have not already occurred, unless the compelling forces which are so reverently described in textbooks of economics operate imperfectly. In considering policy changes which might be made to permit, or encourage, these improvements in technical efficiency, it will be necessary to examine the factors which act to prevent actions which, as in the case of the home heating example, are clearly in the interest of the consumer. For example, perhaps the interests of the home builder or developer do not coincide with those of the family that lives in the house and must pay the heating bills.

What then might be involved in the changes which could lead to a

future of zero energy growth? Present-day society is geared to a relatively heedless use of energy. To develop a society that husbands its resources, including energy, would require a different kind of economic emphasis. Redesign of cities and transportation systems would be a must as would increased durability of goods. Growth in energy-intensive industries, such as making plastics from petrochemicals, would be de-emphasized. Instead there would be more vigorous growth in the service sector
and in industries which use less energy. Indeed, there may even be a relationship between the present lack of some goods -- education, health care, public services in general -- and a seemingly inexhaustible supply of other goods -- military hardware, deodorants, intoxicants, plastic bags -- and the forces which have lead us into more and more energy-intensive activities. These relationships must be examined when choosing between policies to permit the development of lower energy futures.

Transportation and housing are tightly linked. The technical fix view only requires more efficient home heating or automobiles which get more miles per gallon. To approach zero energy growth it will be necessary to take another step and eliminate some of the need for transportation and reduce home heating needs by other than improved insulation in single family homes. These changes would result in living closer to where we work and closer to schools and shopping centers. This could be done by bringing people back to the central cities, by designing new communities where homes are closer to jobs and commerce, or by decentralization and expansion of "cottage industry."

Instead of simply requiring construction with lower heat loss, zero energy growth would include such things as greater use of multifamily housing.

"The notion of 'needs' is totally undefined until the purpose is specified, i.e., need for what? Let us define 'energy requirements' as the energy resource flows necessary to maintain or achieve a population of a certain size, living at a certain standard of per capita consumption, during a certain period of time, using certain kinds of technology. It makes no sense at all to speak of energy needs without having specified, at least in general terms, these four elements of purpose. Alternatively, if one speaks of energy needs he must be making some assumptions, explicitly or tacitly, about each of these four elements.

"What are the most common assumptions made, and what are the most prudent assumptions to make about each element?

"Probably the most common assumption is to extrapolate recent growth rates in population and per capita consumption, assuming some arbitrary, round-numbered time period, and assuming constant technology, or a constant direction of technical change (i.e. that technology will change in the future in ways similar to how it has changed in the past.) The result is that total requirements grow as the product of population and per capita consumption growth, usually exponentially, and energy requirements for maintaining such growth become overwhelming within the time period chosen. The conclusion is that such requirements in all likelihood cannot be met. This means that the four assumptions of purpose are inconsistent and one or more must be modified.

"One way out is to shorten the time period, usually with arguments about the futility of looking very far ahead, and perhaps arguing that at a 7% rate of discount what happens more than 15 years from now will and should carry little weight in current decisions. Another way out is to assume new, qualitatively different kinds of technical progress that will reduce per capita, and per dollar, energy needs as fast as growth increases population and per capita GNP. Another way out is to assume reduced, eventually zero, rates of growth of population, and per capita consumption.

"Finally there are the peacemakers and middle-of-the-roaders who argue that we ought to do a little of each: don't try to look too far ahead, have more faith in technology, and take comfort in the lessening rate of population growth and the likely slowdown in economic growth.

".....the four elements of purpose in relation to which energy needs must be defined are each subject to limits. Population cannot grow forever, per capita consumption cannot grow forever, the 'relevant time period' cannot be shortened forever, and technology cannot reduce material intensity forever. Nevertheless there are short and middle run trade-offs among the four elements.

"What combination of values of the four 'variables' is optimum? This is fundamentally an ethical question. Even if we could precisely and objectively specify the terms of the trade-offs, the choice of the optimum combination within the feasible set would still be an ethical choice. But unless we have made this choice we cannot answer the question 'energy needs for what?,' and thus cannot give any empirical content to the concept of energy needs."

------Herman E. Daly, Economist

Household energy consumption is much lower in multi-family, than in single-family, dwellings. In addition, the more multi-family units there are, the greater the potential would be for the employment of total energy systems, which generate electricity and use the waste heat for space conditioning.

Using means such as this, which are desirable for many other than simply energy saving reasons, it can be shown to be quite feasible to stabilize our total energy use at a level less than 50% higher than present annual consumption.

All three of these options -- business-as-usual, the technical fix, and zero energy growth -- share certain characteristics. They all assume household comforts and conveniences greater than today; no one must live in a lightless shack or a sweltering tenement because of energy scarcity. Every American could have a warm home in winter, air conditioning in hot climates, and a kitchen complete with appliances. He would still drive a car and have a job although he may drive less or have a different job depending on the option the nation follows.

The choice is ours. Both of the lower energy consumption futures considered imply that the choice will be made on the basis of the general public preference and not on the basis of the short-term advantages to be gained by vested interests in the energy related industries. It would be an unprecedented change. The Minnesota Legislature has already had before it bills specifically addressing the kinds of energy efficiences implicit in the technical fix future view. A first step has been made through the recognition that market forces cannot be relied upon to permit decisions that are in the consumer's, and society's, interest. The invisible hand has become truly invisible.

Whatever course is followed regarding our energy future, it will involve

"'To accomplish our goals [achievement of energy self-sufficiency for the U.S. by 1980], we will use a variety of tools -- the regulatory process, financial incentives, and the allocation of scarce materials and resources for energy plant construction.' Both Schatz and McWinney [of the Federal Energy Office] admitted that -- although they hoped it could be avoided -- the end result of their plans could be a vastly expanded federal management of the economy with a heavy coercive potential over private enterprise. McWinney said: 'When I stop and think of the implications of what we're planning, it's a little frightening. But the fact is that we may have to accept a massively controlled economy in order to achieve Project Independence.'"

------Interview with Robert Schatz, a staff member of the Hudson Institute currently directing the organization of the Federal Energy Office's Energy Resources Development Office, and Robert T. McWhinney, Schatz' executive assistant. Quoted in National Journal Reports, February 16, 1974, pp. 230-231.

"A primary goal then of energy policy for the United States is likely to be the achivement of energy self-sufficiency at the earliest possible time. Individual choices and corporate policies must aid that goal in whatever way possible.....However, there exists the possibility that formulation of energy policy may simply bring another significant entry of the federal government into society's economic and political fiber, under the premise that 'man must be protected against himself and the President and the Congress know best what is in the national interest.....Ironically, the very magnitude of possible federal energy research programs raises for some the fear it will result in operation of commercial-sized facilities and the federal camel will once more have its nose in the private enterprise tent. For some, TVA and Bonneville are vividly recalled history lessons."

------Northern States Power Company, Energy: An Assessment of Supply/ Demand Factors Through the Year 2000, January 1974, pp. 24, 62,75.

policies that intrude into what has been regarded as the private sector. If we should opt for business-as-usual, then increasing centralization, increasing federal control, and increasing entry of the federal government into energy supply activities are inevitable. On the other hand, effective policies to reduce energy growth will remove some of the choices that we have come to take for granted in our every-day personal or corporate decision-making. One can wish it were otherwise, but wishing rarely changes reality.

"...our growing requirements for oil and gas imports will provide a large and growing deficit in the U.S. balance of trade in fuels. By the early 1980's, this deficit could be in the $20 billion to $30 billion range (note: this was written in 1972 when the 'old' oil prices prevailed) as compared to a current deficit of less than $3 billion. The magnitude of this projection becomes clear when you consider that our total exports of goods and services are only about $66 billion. To pay for our imports of fuel, we will, of course, need to seek additional exports of other goods and services. But $20 billion to $30 billion of additional exports is a very large item. Consider, for example, the travail that lay behind President Nixon's recent negotiations to increase our exports to Japan by a mere $1 billion to $2 billion.

"What do we sell and to whom? We cannot look to our usual trading partners, the industrialized countries of Western Europe and Japan, because most of them will be struggling to increase their own net exports to pay for growing fuel imports. Ultimately, the situation can come to equilibrium on a worldwide basis only when the oil exporting countries are able to absorb greatly increased imports from us and the other oil importing countries. But, the major oil exporting countries are few in number, and in the very early stages of industrial development. They do not have the populations, mass consuming markets, and economic infrastructures to permit the ready absorption of large imports from us. Much thought needs to be given to what they can reasonably buy from us and the time schedules on which they will be prepared to do it."

------John G. McLean, Chairman and Chief Executive Officer,
Continental Oil Company, September 21, 1972

MEETING THE DEMAND

Whatever expectations we have, it will not be possible for us to use more energy than is available. It would be pointless to consider the business-as-usual projection for the future if it were manifestly obvious that the fuels to produce that amount of energy were not available. Just what is the fuel supply outlook?

Previously it has been mentioned that our present energy demands are met largely through the use of oil and natural gas, with coal supplying somewhat less than 18%, hydroelectric about 4%, and nuclear fission barely one percent. It is almost axiomatic that these fuel mixes cannot be drastically changed over a short period of time. Just as the changes in demand in response to increasing prices take several years to be expressed, and the changes in conversion to more efficient end uses of energy depend on the time required to implement the desired techniques or to change the institutions, so must the transition to a different mix of fuels be accomplished over a period of years or even decades.

As when demand projections were presented, conventional studies of future energy supply are presented along with various supply options related to a lower energy use than that inherent in business-as-usual consumption. Virtually all projections made prior to the onset of the current Middle East disturbances assumed continued availability of petroleum and natural gas for import to the United States. In recent months the availability of these imports has been called into question. The balance of payments issue is also intimately involved with the decision of continuing to import fuels. Even at the old price projections of \$4 to \$5 per barrel of imported oil, vast amounts of money would have to be generated to pay for fuel imports. At the new prices, which might stabilize at nearly \$10 per barrel, these economic

"You are furious about mounting food prices and perplexed about Nixon's new farm policy, but the answer is very simple -- oil. How do oil and food mix? The U.S. has lost, probably forever, its edge over Western Europe and Japan in manufacturing efficiency and technology. At the same time, it is burning imported oil at an ever-mounting rate. Question: How do you pay for the oil if you can't export enough manufactured goods?.....That's where farming comes in.....the U.S. has the acreage, the climate and the potential surplus over its own needs to become the granary of the world -- a world where both population and ability to pay are rising fast.....It (the U.S.) must keep the price of its grains competitive to hold the market and to lessen the attraction for Japanese investment in growing soybeans and feed grains in Australian and Brazilian soil.....The new policy (in international distribution of U.S. foods) is more realistic: It is based on selling for cash to those who have the money. Russia and China are in. India is out.

"But an even more basic change is involved. This time we would not be so much selling grain as meat -- in the sense that the grain would be converted into meat -- for countries with a rising standard of living. For those who can't yet afford meat but need protein, there are soybeans.....

"What about the American consumer?.....Perhaps the rise in prices will level off, but if the Nixon gamble works, the American people will never again know food as cheap as they have had in recent decades. Again, because the Government will have to see to it that prices stay reasonably steady. Consumers may be angry at high food prices, until they get used to them. But farmers would never forgive a party that encouraged them to expand and then let their market collapse."

-------"Can Agriculture Save the Dollar?," Forbes, 3.15.73, pp.32 ff.

problems are compounded. What can the United States export to generate these funds? That question has tended to focus attention on agricultural products. United States agriculture is to "save the dollar" by providing the exports which would generate the funds to provide the payment for imported oil and natural gas (part of which would be plowed back into agriculture to produce the crops, to...). As Minnesota is a major agricultural state, this aspect of the energy dilemma has major implications for Minnesota.

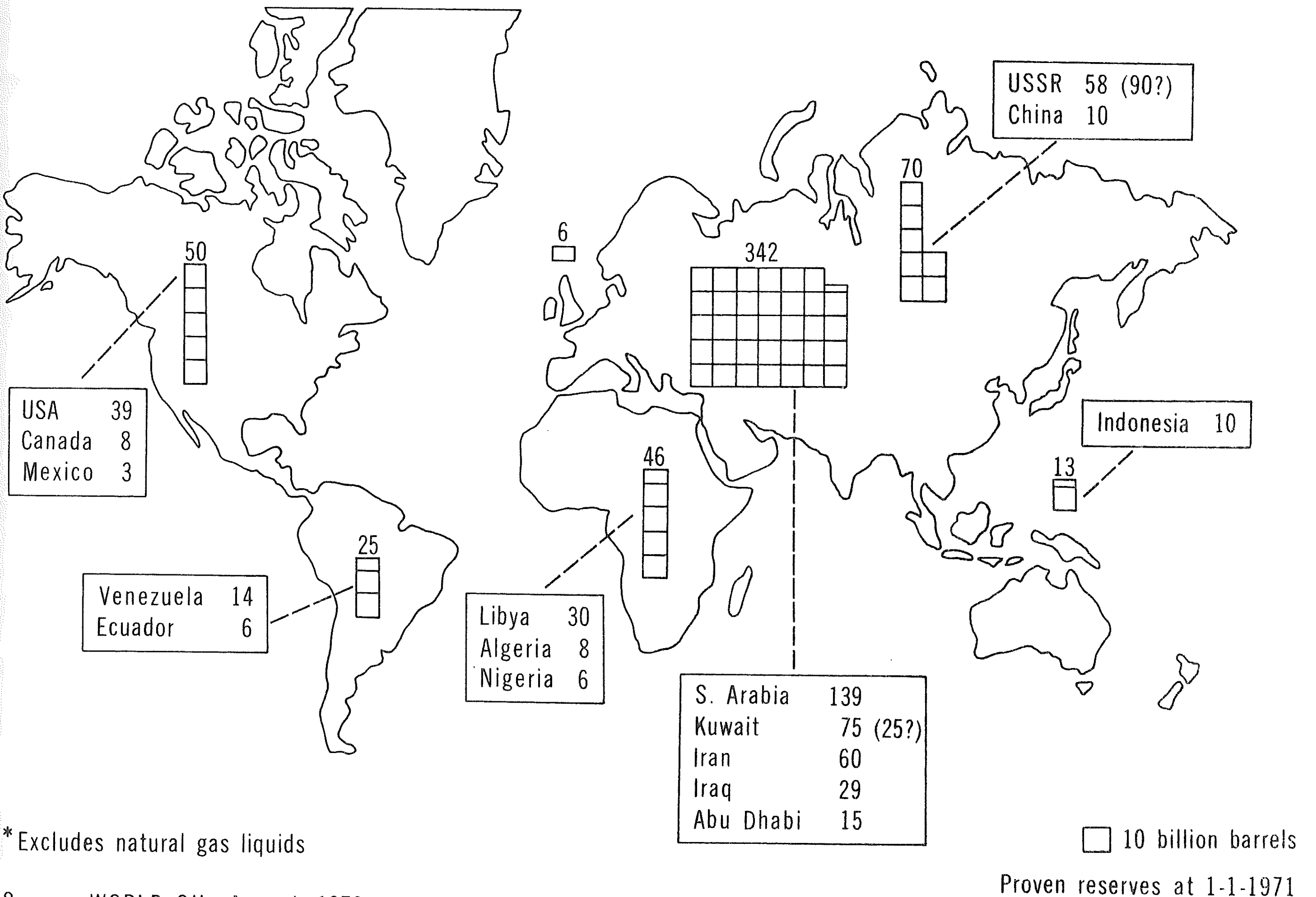
Before turning to domestic energy sources, world reserves of oil and natural gas should be reviewed. Even at current growth rates in energy consumption, there are sufficient recoverable reserves of oil and natural gas to supply the anticipated world demand for a few decades, Figure 2. The question is not one of existence of resources, it is whether political and economic reality will allow access to the resources.

To date the United States has imported its oil primarily from Latin America and Canada although within the past two years the Middle East has become increasingly important with 30% of our oil imports coming from these countries in 1973. Imports from Canada are of particular importance to the Midwest. As will be considered in more detail later, Minnesota's oil refineries get nearly 90% of their crude oil from Canada.

Canada has recently re-examined its fuels policies with conclusions which, while of some importance to the United States as a whole, are potentially of great concern to Minnesota and the Upper Midwest. While Canada is a net exporter of oil, it has also been a major importer. The exports have been from the Western Provinces; the imports have been into the Eastern seaboard. Present Canadian policy is to construct pipeline facilities so that it will have the capability of moving its own oil to its demand centers and,

FIGURE 2

WORLD PUBLISHED PROVEN CRUDE OIL RESERVES*



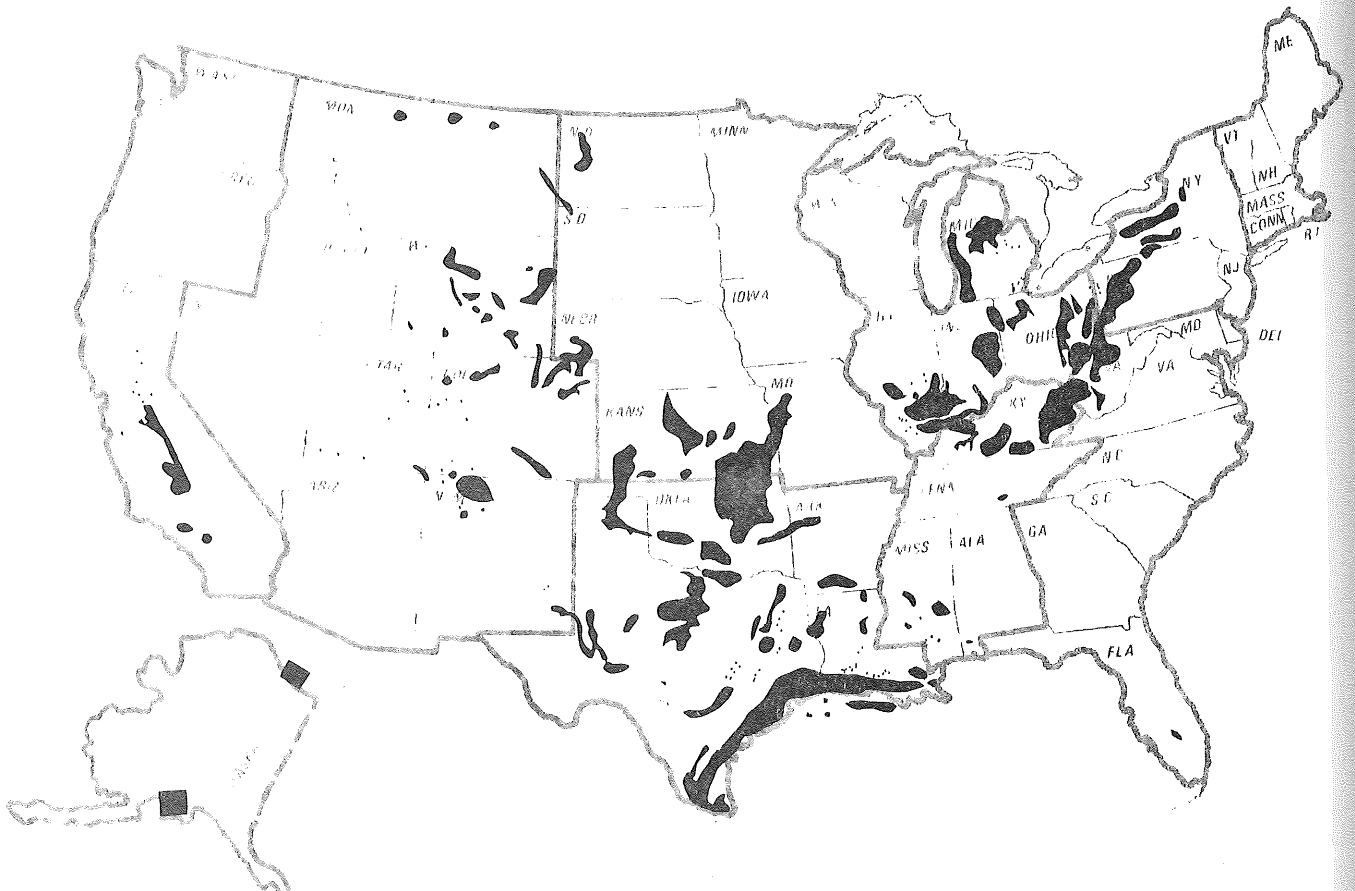
*Excludes natural gas liquids

Source: WORLD OIL, August, 1972
from: THE NATIONAL ENERGY OUTLOOK, Shell Oil Co., March, 1973

in so doing, to curtail its exports and its imports. It is reasonable to expect that the availability of Canadian crude oil to the Upper Midwest will be limited to a very few years. Whether new supplies come from Alaska (via a new pipeline down the Mackenzie River valley), the outercontinental shelf, or from imports, Minnesota's refineries will be a long way from the sources of crude oil.

President Nixon has recently announced "Project Independence," the goal of which is to become capable of domestic self-sufficiency in energy by 1980. While it is generally agreed that such a goal, if one assumes continuation of present energy consumption trends, is wishful thinking, it is important to explore the extent to which we could provide future energy needs from domestic sources.

It is not possible to give a definitive estimate of the availability of domestic oil and natural gas. Domestic oil production peaked in 1970; natural gas production is near its peak now. There is little question but that the major remaining reserves are offshore and in Alaska. Estimates as to the potentially available oil from these sources vary widely. The extent to which we can increase domestic production of oil and natural gas, and the nedessary or desirable size of the synthetic fuel industry described below, depends critically on how one believes the recent doubling of oil prices will affect supplies of oil from conventional sources in the United States. Some experts doubt that we can significantly increase current production rates. On the opposite end of the spectrum are a number of reputable economists whose chief concern is not a depressed and oil-starved economy but rather, "the coming (in about ten years) glut of energy." For example, Hendrick S. Houthakker, a former member of President Nixon's Council of Economic Advisers,



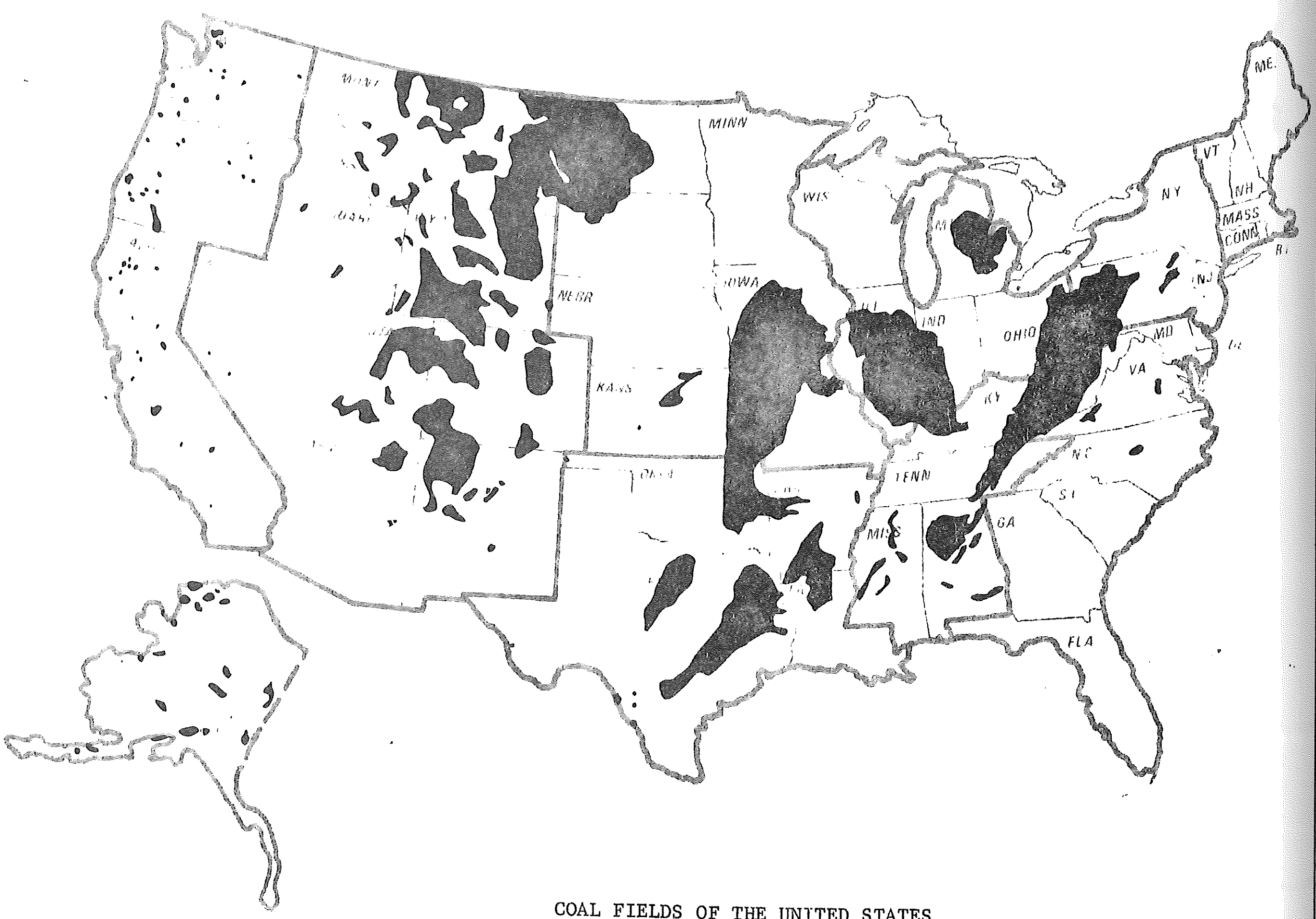
OIL AND GAS FIELDS OF THE UNITED STATES

believes that the now-doubled price of oil could lead to a doubling of North American production without any help from synthetic fuels. According to Houthakker, the United States could become an oil exporter by the early 1980's.

Economists are not of one mind on this subject. Some are highly skeptical of projections such as Houthakkers, arguing that they are much too optimistic, but some industry economists believe doubled prices could triple production. Many of the current flurry of energy investigations now underway are directed at examination of this question.

In the very short term, at least the next three or four years, in large part because of the long energy system lead times, it is safe to assume that there cannot be significant expansion of domestic production beyond stripper wells (a well which produces less than 10 barrels per day). Beyond that time the picture is not clear, but there are many who feel it is imprudent to base energy policy decisions on the assumption that the United States could ever again supply its needs for oil and natural gas without developing our large reserves of oil shale and technology for deriving synthetic oil and gas from coal.

Minnesota is now faced with a very serious situation regarding these fuels. Its transportation sector is almost exclusively fueled by petroleum. There is no reason to expect that Minnesota will be any better, or any worse, off than are other states in this regard. Contrary to the situation elsewhere, electricity in Minnesota is produced almost exclusively from coal and nuclear fission. Hence, the unavailability of oil should not have significant impact on our local electric utilities. Curtailment of natural gas supplies, however, will have a major impact on the industrial and large commercial sector and will further exacerbate shortages of oil. Northern Natural Gas Company, which supplies about 95% of our natural gas, recently announced that



COAL FIELDS OF THE UNITED STATES

by 1978 no gas will be available for large users. While that announcement made clear that until 1978 there will be sufficient gas to supply present residential and small commercial/industrial users of gas, an extension of the data provided by Northern Natural Gas makes it clear that following 1978 there may well be curtailment of service to those consumers as well.

What of other fuels? The U.S. has over half of the world's reserves of coal, sufficient to supply our needs for hundreds of years at present use rates, but perhaps only several decades if energy consumption growth continues and the supply shifts primarily to coal. Just as when considering the world picture for oil and natural gas, there is no fundamental resource constraint on the use of coal for the period of immediate concern, the next several decades. Coal has, however, two fundamental problems: we can't mine it and we can't burn it, without paying the large social costs associated with coal miner health and safety and the environmental insults associated with coal production and use.

Coal could be used in several ways. One way is to mine it and then transport it to the point of use. This is typical of coal use today, for example, in the generation of electricity in Northern States Power Company's Allen King Generating Plant. Coal can also be burned near the coal mine to produce electricity and the electricity transported to the load center. This option, which is called "mine-mouth generation of electricity," is currently being used to a limited extent. A truly enormous mine-mouth complex of electric generating facilities is being developed in the four corners area of New Mexico, Arizona, Utah and Colorado. Similar facilities are being considered near the coal fields of North Dakota, Wyoming and Montana -- including plants recently announced to supply Minnesota utilities. Electricity

MANSFIELD SAYS HE IS AGAINST TURNING MONTANA INTO STATE-WIDE STRIP MINE

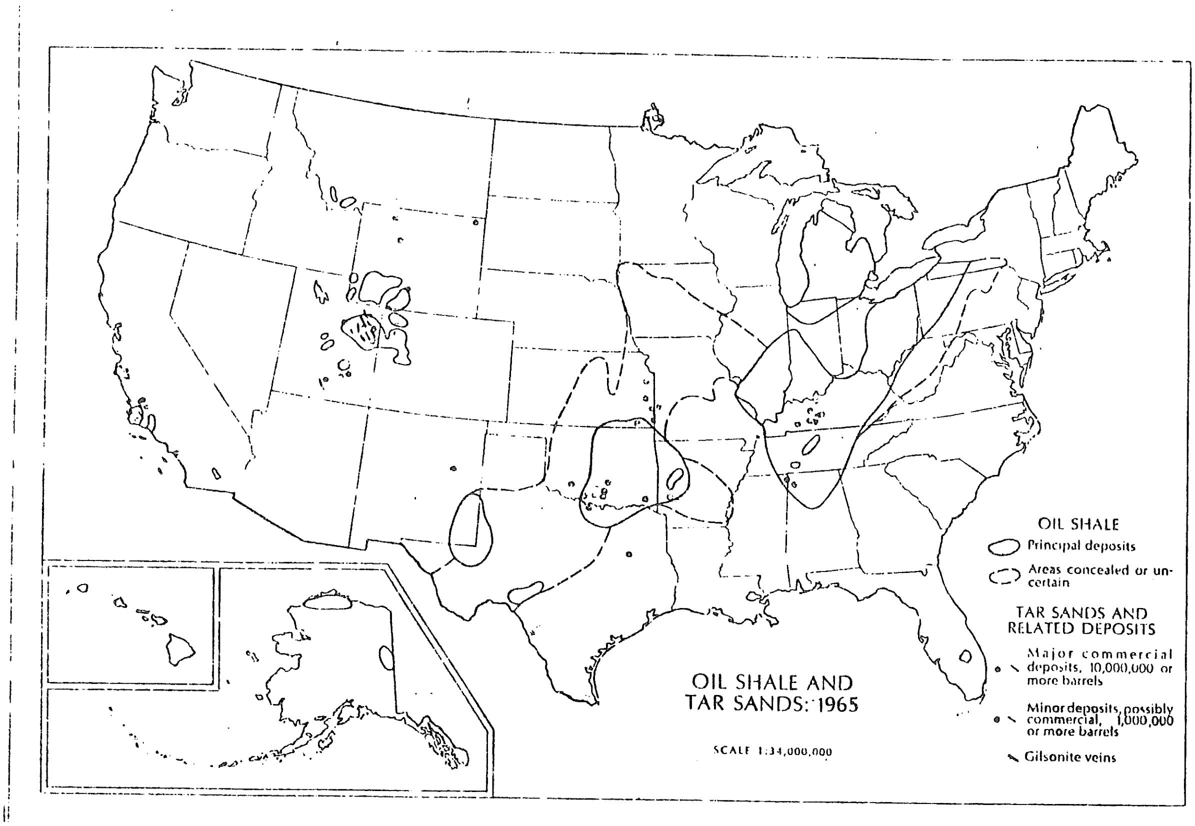
"Senate majority leader Mike Mansfield served notice on the floor of the Senate last week that he will not retreat from the position expressed in his amendment to S. 425, the strip mining bill passed by the Senate four months ago. The Mansfield provision would prohibit strip mining in areas where the federal government controls the mineral rights but not the surface rights. It drew howls of protest from coal producers. Stating that 'the West need not become the utility backyard for the rest of the nation,' Mansfield admitted that his amendment would 'create a checkerboard pattern in many areas proposed for surface development. But the enforcement of this amendment,' he added, 'would give all parties, especially the people of Montana, time to consider fully the consequences of poorly-regulated and expansive development of coal in the West -- the success or failure of reclamation, demands on water, and the socio-economic problems associated with the impact of coal gasification plants.'"

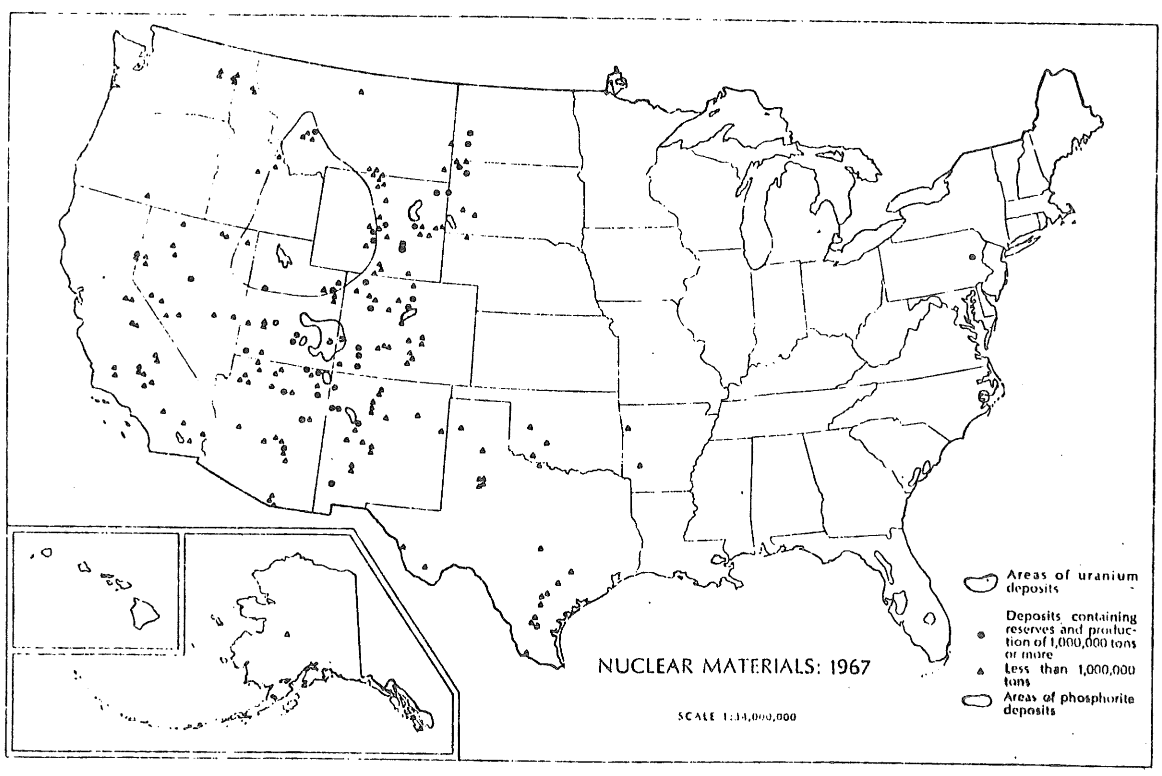
-------from Weekly Energy Report, February 11, 1974, p. 10

is a clean fuel at the point of end use, but serious pollution results at the generating plant -- where the coal or other fuel is converted into electricity. In addition, large quantities of water are required by the power plants, and the areas of the U.S. most richly endowed with low sulfur coal reserves are only modestly supplied with water.

A third option for the utilization of coal is to convert the coal into either synthetic oil or synthetic natural gas. The basic characteristics of these processes are not unlike the mine-mouth generation of electricity. An energy form, synthetic natural gas (SNG), is produced which is clean at point of end use. The pollutants are then associated with the gasification plant. Also, this process, like the generation of electricity, is intensive in its use of water. The production of SNG from coal is some years in the future because of purely technical considerations. The processes are known; there have been pilot plants. The first full-sized commercial plant is, however, yet to be built or operated. There is little reason to expect that SNG will be available in significant quantities before the mid-1980's at the earliest. The Joint Committee on Atomic Energy projections conclude that only 1.3% of our energy could come from SNG by the year 1990; other projections are consistent. In the long run, synthetic fuels from coal will be of paramount importance, but they cannot be expected to replace a significant amount of oil and natural gas for some years to come.

Conclusions vary as to the availability of coal for use in more conventional ways. There are several considerations: how much could coal utilization increase were there no environmental constraints, and how much


OIL SHALE
Principal deposits
Areas concealed or uncertain
TAR SANDS AND RELATED DEPOSITS
Major commercial deposits, 10,000,000 or more barrels
Minor deposits, possibly commercial, 1,000,000 or more barrels
Gilsonite veins
OIL SHALE AND TAR SANDS: 1965
SCALE 1:34,000,000

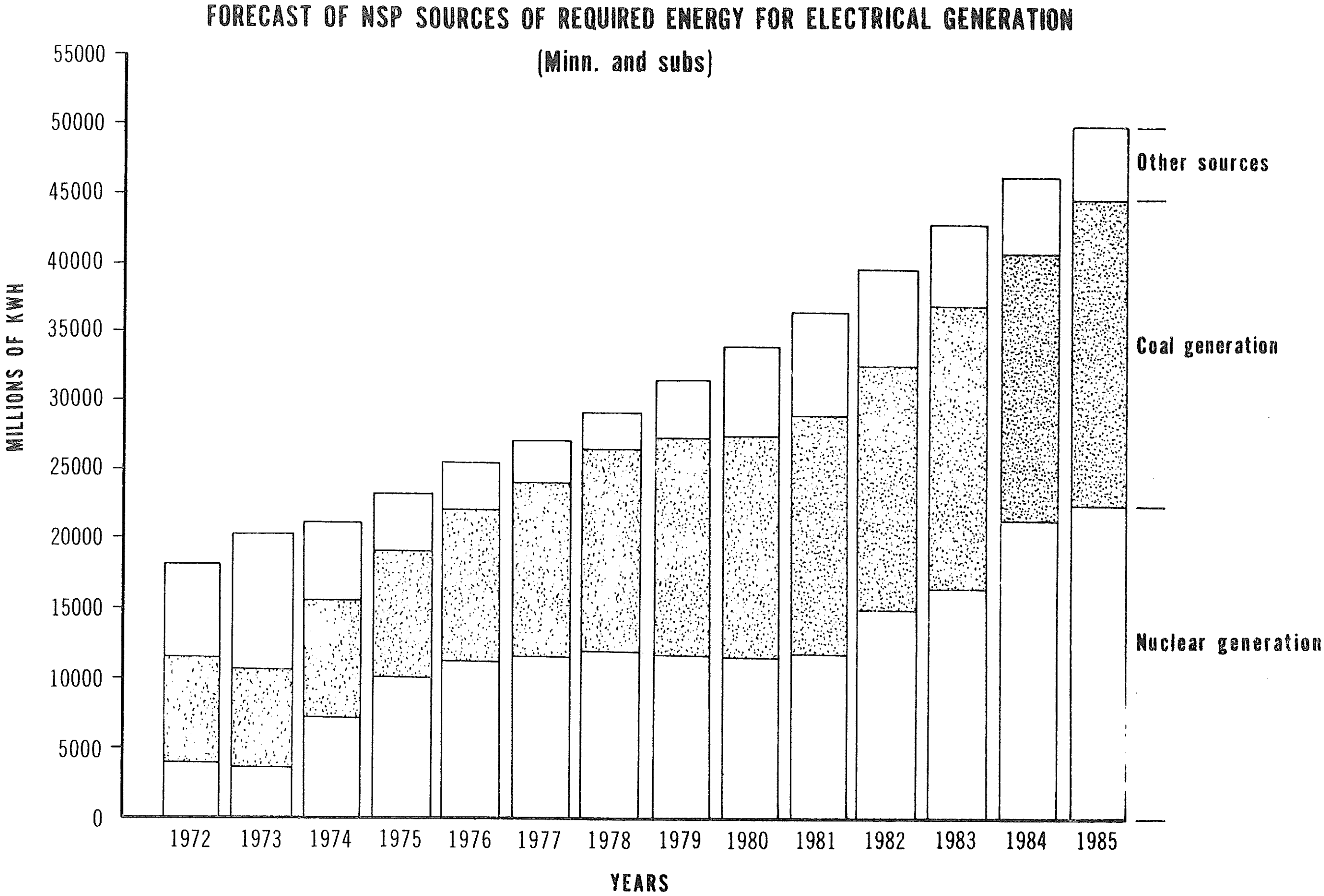

Areas of uranium deposits
Deposits containing reserves and production of 1,000,000 tons or more
Less than 1,000,000 tons
Areas of phosphorite deposits
NUCLEAR MATERIALS: 1967
SCALE 1:34,000,000

can it increase given the environmental quality goals which have been enunciated by Congress? It is clear that in the past inadequate attention has been given to mechanization of coal mines, to coal miner health and safety, to reclamation of surface mined land, and to pollution control associated with the combustion of coal. Because of this neglect we cannot rapidly expand the production and utilization of coal without paying very severe penalties in environmental damage and in human death and disease. How will these trade-offs be made? It will not be an easy decision.

The other resource from which synthetic oil can be produced is oil shale. Oil shale is present in very large quantities, and is primarily located in the Rocky Mountain States. The potential for this energy source is substantial -- estimates range from hundreds to thousands of billions of barrels, depending on the grade of the deposits considered -- but the first commercial plant has yet to be built. In addition, there are severe environmental problems associated with mining and processing shale. Although development is beginning, there is no reason to expect it to contribute significantly to our energy supply before the mid-1980's.

Nuclear fission also figures heavily in the current energy debates. Minnesota's electrical utilities are rapidly committing to nuclear power. For example, Northern States Power Company anticipates that nuclear power will produce 48% of its total electrical output by 1983, Figure 3. This is not typical of the nation as a whole, which is committing to nuclear somewhat less rapidly; but as has been discussed previously, nuclear power has been projected to supply upwards of 25% of the nation's total energy, and

FIGURE 3



Year	Hydro	Coal	Gas	Oil	Nuclear	Purchases
1973*	4%	46%	11%	5%	17%	17%
1974	4%	40%	8%	2%	34%	12%
1975	4%	39%	4%	3%	42%	8%
1976	3%	45%	1%	2%	43%	6%
1977	3%	48%	1%	2%	41%	5%
1978	3%	51%	1%	2%	39%	4%
1979	3%	56%		2%	36%	3%
1980	3%	59%		2%	33%	3%
1981	2%	62%		2%	31%	3%
1982	2%	55%		2%	38%	3%
1983	2%	46%		2%	48%	2%

* 1973 Budget

Source: NSP Power Supply Planning Dept.

"Let me now turn to the question of nuclear safety. I do not have to labor before this audience the proposition that every nuclear power plant has a tremendous destructive potential. It is difficult to imagine any other kind of man-made, non-military, device or facility which has the inherent capacity to cause as much personal injury and property damage as a nuclear power plant. The fact that this is so is vividly demonstrated by the existence of the Price-Anderson Act, which singles out nuclear facilities, alone among our technologies, for special government indemnity and limitations on liability. The question of the enormity of the risk of nuclear power is not debatable so long as the Price-Anderson Act remains on the books.....

".....They [the public] cannot believe that nuclear power plants are as safe as they are advertised to be so long as the Price-Anderson Act shows that the Joint Committee on Atomic Energy, the Atomic Energy Commission, and industry regard the risk of a catastrophic accident as real. Indeed, there seems to me to be something fundamentally wrong with a system which subjects the public to the risk -- however remote -- of a catastrophic accident when industry itself is not prepared to assume this very same risk without the protective umbrella of Price-Anderson."

------Harold P. Green, address given February 1972, Oak Ridge National Laboratory Safety Information Conference, published in <u>Nuclear News</u>, September 1972, pp. 75-78.

upwards of 50% of its electricity, by the year 2000. At the same time as the utilities, and the rest of the "Atomic Establishment," is committing heavily to nuclear fission, there is growing concern with the safety of nuclear power. At the time of this writing, there are nuclear moratorium bills pending in nine states, including Minnesota, and the moratorium arguments are gaining strength in other countries as well. It is clear that a growing number of individuals and organizations are concluding that nuclear fission is simply an unacceptable or highly suspect means of producing energy. It is entirely possible that nuclear power will be deemed unacceptable, and it is clear that a national commitment to nuclear fission cannot be assumed. This issue is of sufficient importance so that the arguments should be briefly reviewed in this discussion.

Nuclear fission has two intrinsic and very important advantages over the fossil fuels, but creates serious hazards of its own. In the first place, nuclear fission avoids the environmental insults characteristic of the fossil fuels, for example, oil spills, releases of combustion products, and strip mining of coal. The political problems created by the world distribution of remaining reserves of fossil fuels could likewise be reduced through the use of fission. Secondly, the nuclear fuels are present in large quantities and hence the long-term resource constraint on the fossil fuels is not present. Nuclear fuels could clearly supply any conceivable energy requirements for hundreds if not thousands of years. In addition, it is argued that nuclear fission represents a known technology, one that can be rapidly expanded and which is capable of supplying a major fraction of our energy needs in the immediate future.

Those who argue that nuclear fission is not acceptable base their

"We nuclear people have made a Faustian bargain with society. On the one hand we offer -- in the catalytic nuclear burner -- an inexhaustible source of energy.....This source of energy, when properly handled, is almost non-polluting. But the price that we demand of society for this magical energy source is both a vigilance and a longevity of our social institutions that we are quite unaccustomed to. We make two demands. The first, which I think is the easier to manage, is that we exercise in nuclear technology the very best techniques and that we use people of high expertise and purpose. Quality assurance is the phrase that permeates much of the nuclear community these days. It connotes using the highest standards of engineering design and execution; of maintaining proper discipline in the operation of nuclear plants in the face of the natural tendency to relax as a plant becomes older and more familiar;.....in short, of creating a continuing tradition of meticulous attention to detail.

"The second demand is less clear, and I hope it may prove to be unnecessary. This is the demand for longevity in human institutions. We have relatively little problem dealing with wastes if we can assume always that there will be intelligent people around to cope with eventualities we have not thought of."

-------Alvin Weinberg (former director of the AEC's Oak Ridge National Laboratory), "Social Institutions and Nuclear Energy," <u>Science</u>, 7.7.72, pp. 27-34.

"CONSUMERS POWER CHARGED WITH WILLFULLY HOLDING INFORMATION FROM AEC

'We are in deep trouble and the sooner engineering and Bechtel admit it we can find a solution.' So runs a memorandum allegedly written by a top executive of Consumers Power in connection with a matter now being investigated by AEC regulatory operations inspectorate staffers -- the alleged willful avoidance of reporting to AEC the fact that the Palisades [nuclear power plant] offgass holdup system was in 1972 leaking small amounts of radioactive gas into the atmosphere. The memos were given to AEC by a Michigan investigative reporter, Patrick Clawson, who sources say obtained them from an engineer working within the plant.....The memo, written by one executive to another within the utility, said, 'You must be aware of the fact that although our license states that we will hold up radgas for seven days we have not been able to meet this to date.' It noted that there would be a minimum 'slap on the wrist' citation from AEC. A source said another document, a letter written by a Consumers employee to the utility management, urged that something be done about reporting the tech specs violation. 'He was told to mind his own business,' said the source......"

------from <u>Nucleonics Week</u>, February 21, 1974, p.1

concern on three considerations. First, there is potential for catastrophic accidents at the nuclear power plant itself, during transport of the radioactive wastes produced in the reactor, and elsewhere in the nuclear fuel cycle. These accidents are potentially very serious and could conceivably result in thousands or tens of thousands of deaths and serious injuries, and damages measured in the billions of dollars. On the other hand the probability of such accidents is conjectured to be very low. How low is a matter of dispute. Not unrelated to the question is the insurability of nuclear power installations. At present, full liability insurance is not commercially available and that insurance which does exist is provided, in major degree, by Congressional intervention through the Price-Anderson Act.

The second problem also involves the highly radioactive waste products produced by all nuclear power plants. These wastes are small in volume, but highly radioactive and also biologically active. The toxic nature of the wastes is such that they must be absolutely isolated for thousands, or hundreds of thousands, of years. Although this problem has been recognized since the inception of the atomic age, no politically and technically acceptable means has been found for this storage in perpetuity.

The wisdom of a commitment to nuclear power ultimately rests on the capability of our technology and institutions to manage, perhaps indefinitely, a very hazardous enterprise. Many individuals feel that society can meet these challenges and that the benefits of nuclear power are well worth the necessary commitment. Others are much more pessimistic about the capabilities of our human institutions. Reasonable men differ substantially on these judgments.

The third hazard involves not the radioactive waste products, but the

"I state categorically that, given the required amounts of nuclear materials, nuclear explosives sufficiently effective to quality as weapons of mass destruction could be designed and built by any nation in the world, by non-governmental organizations consisting of only a dozen people or less, or conceivably, even by one person working alone. In all cases, the information, non-nuclear materials, and facilities that would be required are readily available throughout the world.

"The technical skills and resources required would depend on the desired efficiency, predictability, total weight, and yield of the explosives; nevertheless, the physics and engineering information that is publicly available is sufficiently extensive to be of direct use to design teams having a wide variety of levels of technical expertise."

-------Theodore B. Taylor, "Diversion of Nuclear Materials: Prospects and Possible Countermeasures", talk to Scientific Research Society of America, March 14, 1974

"It is understandable that we should be hypnotized by the vision of such ghastly possibilities. The risk, however, is that our concentration on this aspect of the consequences of nuclear warfare will lead us to overlook another result of the new technique of war. Essentially it resides in the fact that many small or relatively poor nations, even though they possess no fully developed industrial base or highly skilled labor force, can gain possession of nuclear weapons. As the example of China has shown, a nation with only a limited amount of industrial capacity can manufacture nuclear warheads by itself, although probably not missile delivery systems. The warheads can nonetheless be launched by bombers, smuggled into enemy harbors by ship, etc. In addition, poor nations can obtain nuclear weapons as a by-product of the atomic power plants that many of them are now building or contemplating (or that will be built for them in the coming years by the developed countries).

"Thus there seems little doubt that some nuclear capability will be in the hands of the major underdeveloped nations, certainly within the next few decades and perhaps much sooner. The difficult question that must then be faced is to what use these nations might be tempted to put this weaponry. I will suggest that it may be used as an instrument of blackmail to force the developed world to transfer large amounts of wealth to the poverty stricken world.

"I do not raise the specter of nuclear blackmail to indulge in the dubious sport of shocking the reader. It must be evident that competition for resources may also lead to aggression in the other, 'normal' direction -- that is, aggression by the rich nations against the poor. Yet two considerations give a new credibility to nuclear terrorism: Modern weaponry for the first time makes such action possible; and 'wars of redistribution' may be the only way by which the poor nations can hope to remedy their condition."

-------Robert L. Heilbroner, "The Human Prospect", <u>The New York Review</u>, January 24, 1974 nuclear fuels themselves. These fuels, primarily plutonium, are themselves highly toxic and are the stuff of which atomic bombs are made. For many years the mythology associated with atomic power included the belief that the construction of nuclear weapons was extremely difficult, and that it would require an effort comparable to the program mounted by the U.S. during World War II. That myth has now been demolished and it is generally recognized that the construction of crude, but effective, atomic explosives is not a technically difficult task once the nuclear fuels are available. The concern arises because the civilian nuclear power industry provides the potential to get these materials. There is no question but that any nation employing the nuclear fuel cycle can, should it so decide, divert nuclear fuels from the reactor program into a national weapons program.

Further, the potential exists for terrorist and other sub-national organizations to steal nuclear fuels and to use them for highly disruptive activities.

The nuclear controversy is a reality; it will not be wished away. The nature of the controversy has been put in sharp focus by Alan Kneese, a respected resource economist, who wrote:*

> It is my belief that benefit-cost analysis cannot answer the most important policy questions associated with the desirability of developing a large-scale, fission-based economy. To expect it to do so is to ask it to bear a burden it cannot sustain. This is so because these questions are of a deep ethical character. Benefit-cost analyses certainly cannot solve such questions and may well obscure them.

What of alternative energy sources? We hear a great deal about the potential for power from the wind, from urban or agricultural waste, from

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*Allen V. Kneese, "The Faustian Bargain," Resources, Dec. 1973, pp. 1-5.

geothermal heat, from the tides, from nuclear fusion, and from advanced forms of nuclear fission reactors such as the breeder reactor. These new energy sources are discussed at length in several readily available reports, and space considerations limit discussion of them here. Except as one is considering a research and development policy -- and some state responsibilities in energy R & D are discussed later -- it is sufficient to indicate that these sources are potentially important, but that over the next decade they cannot be depended on for supplying much of our energy.

Before dismissing entirely the near term potential for solar energy, windmills, and other "small" sources, one might reflect a bit on their development. When one thinks of energy sources one thinks of large power plants, large refineries, or other massive installations characteristic of the highly centralized energy supply system that now exists in this country. There are other alternatives. The technology has long been known for small solar heaters suitable for heating, cooling, and supplying hot water for individual buildings or a few contiguous buildings. A convincing demonstration house, largely if not entirely self-sufficient in energy through the use of wind and solar power, has been built in Rosemount, Minnesota by students and faculty of the University of Minnesota.

The development of these small scale energy sources has been impeded by two considerations. First, because natural gas, and to a lesser extent oil, was thought to be available in unlimited quantities, and at very low prices, there has been little incentive to develop alternatives. A solar or wind driven system for supplying residential needs, for example, has a relatively high initial cost (compared with the initial cost of a system using natural gas or electricity) but low operating costs. With readily available and cheap natural gas or oil, solar energy could not meet the test of economic efficiency. That situation is rapidly changing, and even at current prices it is highly likely that individual solar or wind-powered units are now economic. Why then are they not being more rapidly developed? Most of the solar energy research and development effort, modest as it is, is directed toward large, central station utilization of solar energy. To explain this one needs to look at the structure of the economy and the influence of the highly developed major industrial groups that comprise the energy industry. The interests of these major firms in no small part dictate the allocations of research and development resources, whether at the universities or through federal and state funding programs. Is it of interest to near monopolies to develop energy systems that are not dependent on high technology; systems that can be manufactured, sold, and maintained by small establishments or conceivably by the homeowner himself? It is well known that the small firms which could develop simple technologies have little access to the vast research and development funds of the Federal government.

It is these very technologies which are now needed to supply a portion of our energy consumption, and it is these very technologies which could provide industries for regional development in Minnesota. It could also be argued that a cold state without a fuel base should consider noncentralized, redundant systems such as solar or wind power.

Perhaps Minnesota should consider those incentives which could encourage these developments -- incentives that might include state supported research and development, or creation of a tax climate for resource-saving industry that is as favorable as that provided for resource-depleting industries.

Returning to considerations of national energy supply options, it seems possible to meet the demands of even the business-as-usual energy future, although over the next several years there will be serious supply problems. There is growing evidence, however, that to do so implies some very serious consequences. To meet this high-energy future, to the year 2000, it would probably be necessary to push every energy resource to the limit. Nuclear power would have to be expanded at a rate limited only by the ability of equipment manufacturers to supply the nuclear hardware and the utility industry to generate the capital to absorb them into their systems. Coal production would have to be greatly expanded, especially production from the western coal fields. All sources of domestic oil would have to be pushed to the limit, including rapid exploitation of the Alaskan oil fields, greatly expanded offshore oil production, and the opening of the Naval petroleum reserves. Increased production of natural gas would more or less parallel oil production irrespective of natural gas prices so long as they reflected costs plus a reasonable rate of return. Most of the available remaining hydroelectric sites, including the Grand Canyon, would have to be developed. Oil shale would have to be brought into production as rapidly as possible, and so also with other potential supplies such as geothermal and synthetic fuels from coal. Even so we would have the uncertainties and economic costs of importing large quantities of petroleum and natural gas. Just as a diverse ecological system is more stable than a simple ecological system, so is an industrial system having redundancies more stable than one that does not. An industrial system that is utterly dependent on pushing all of its energy supplies to the limit is much more vulnerable to disruption than an industrial system that is dependent on a multiplicity of different energy sources, each of which is operating at considerably less than its maximum capacity.

The environmental implications of this hypothetical future are considerable. Vast areas of the West and Midwest would be subject to surface mining. Air quality would be further reduced both in our cities and in the regions adjacent to refineries or coal facilities. The hazards of nuclear fission would be compounded by the furious growth. Exploitation of oil shale and other new energy forms might be initiated with insufficient attention to potential environmental consequences. Unwise land use decisions might be made.

Land-use considerations illustrate another politically alarming consequence of a continuation of high growth rates in energy consumption -- the increasing centralization of decision-making. Within the past few weeks, the Nixon administration has proposed legislation that would remove from state or local control any land-use decisions involving large energy facilities: deep-water ports, refineries, power plants, coal mines, transmission lines, and so on. This shift to federal control represents an unprecedented erosion of state and local authority, but it is inevitably associated with land use and environmental considerations in meeting the rapidly increasing energy demands of the business-as-usual future.

If we should opt for a less energy-intensive future, even through only maximal use of energy conserving technologies without changes in life-style, there will be considerably more latitude in energy supply options. All energy use carries with it some environmental insult, but there will be

"This paper lays out a program for energy self-sufficiency for the United States by 1980. It shows that by stepping up the growth rate of energy production in the U.S. to 4.7% per year, and by cutting back the consumption growth rate from a projected 3.6% to 2%, the U.S. energy supply and demand can be in balance by 1980. Moreover, the U.S. can become a net exporter of energy during the 1980's.

"The principal elements of supply increase are an expansion of coal production from 600 to 960 million tons per year; expansion of oil production from 10.9 to 14.0 million barrels per day; and expansion of natural gas production from 23 to 27 trillion cubic feet per year. The principal conservation savings will take place in household and industrial use of energy and in transportation.

"To accomplish these objectives, the U.S. must engage in a major national effort which includes:

1. The creation of a comprehensive Federal Energy Administration controlling all energy policy within the Government.
2. Complete decontrol of energy prices including prices of new oil, new gas, coal, and other energy forms in 1974.
3. A strong energy facility siting bill passed in 1974.
4. A major energy research and commercial development program financed in part by an energy trust fund.
5. A major expansion in the leasing of mineral rights in the Outer Continental Shelf with twenty-four million additional acres leased by the end of 1978 and construction of two oil pipelines and one gas line in Alaska.
6. A five-year relaxation of secondary sulfur emission standards applicable to electric utilities.
7. Concerted development of U.S. oil shale resources leading to 500,000 barrels per day output by 1980.
8. Conservation programs involving better insulation of buildings, energy labeling of appliances, increase in the average mpg of automobiles to 17 mpg by 1980, greater use of mass transit, an increase in industrial conservation, major recycling programs for aluminum, glass and steel, and production of energy from municipal trash and sewage.

"Utilities should cut consumption of electricity through peak load pricing and must use 29 percent more coal in 1980 than they do today."

-------Office of Policy Analysis and Evaluation, Federal Energy Office, PROJECT INDEPENDENCE: A Proposed Program for U.S. Energy Self-Sufficiency by 1980, February 8, 1974. Summary, pp. 2-3 more time to implement pollution abatement methods. In fact, with maximum use of energy conserving techniques, it would be possible to do without one of the major energy sources. We could ban nuclear plants; or we could delay the utilization of coal pending the development of "clean" technologies for using coal; or we could opt to forego the exploitation, and the attendant risks, of massive offshore oil development. We could not forego more than one of the three but there would be significant supply options -- there would be slack in the rope.

REGIONAL AND STATE DIFFERENCES IN ENERGY SUPPLY/DEMAND

Thus far the discussion has primarily focused on the nation as a whole. There are, however, significant regional differences in energy use patterns. Only a few data will be presented here to illustrate these differences.

In their analysis of energy to the year 1985, the Chase Manhattan Bank has broken out both variations in end uses of energy and variations in the type of fuel used by five major regions in the United States. Primarily because of the great variation in industrial use of energy, and in spite of compensating differences in regional transportation patterns and space heating needs, there is a difference of over 100% in per capita energy consumption between regions, Table IX. The North Central Region, which includes Minnesota, is almost exactly on the national average for total energy use.

There is also a dramatic variation in the primary source of the energy used in the several regions, Table X. For example, oil supplies 57% of the energy for the East Coast, but only 36% of the energy in the North Central regions. Natural gas has an even wider variation with the East Coast deriving only 17% of its energy from gas, and the Gulf Coast using gas for 55% of its total energy. It is obvious that although the entire nation will suffer dislocations due to the curtailment of any given source of energy, there will be regional differences in impact. The East Coast, with its high reliance on imported oil for electrical generation, has borne the brunt of the current shortages due to reduction in oil imports. On the other hand, the East will be relatively less affected by curtailment of natural gas supplies than are those regions, which include the Upper Midwest, that are more highly dependent on natural gas.

Turning now to the Upper Midwest, we again find significant variations,

TABLE IX

ENERGY USE - REGIONS OF UNITED STATES - 1971

Region	Population -Percent of	Energy Use Total U.S.-	Per Capita Use Barrels Per Year*
East Coast	39	31	47
North Central	33	34	61
Gulf Coast	12	20	101
Rocky Mountain	2	3	69
West Coast**	14	12	51
Total U.S.	100	100	59

*Oil Equivalent

**Includes Alaska & Hawaii

TABLE X

ENERGY SOURCES — REGIONS OF UNITED STATES - 1971

	East Coast	North Central	Gulf Coast	Rocky Mountain	West Coast
	-------- Percent of Total Energy Used ----------				
Oil	57	36	37	40	48
Natural Gas	17	31	55	34	33
Coal	23	31	7	16	1
Water Power	2	1	1	10	18
Nuclear	1	1	-	-	-
Total	100	100	100	100	100

both in energy supply and in patterns of end use, Table XA , from state to state. Data are available for each of the fifty states, but only Minnesota, Iowa, the Dakotas, and Wisconsin data are summarized here to illustrate local differences.

The relative dependence upon the various fuels differs from state to state, Table XI. For example, the Dakotas produce a large fraction of their electricity from hydro plants, while Wisconsin gets almost three-fourths of its electricity from coal.

The end use allocation between economic sectors also shows significant variation, Table XII. Iowa depends on natural gas for over 60 percent of its residential energy, primarily space and water heating, while the other states in the region get well over half of their household needs from other fuels. The industrial fuel mixes also vary.

Turning to energy facilities, major differences are also found, Table XIII. Minnesota has no conventional fuels within its borders and hence has no coal mines, oil wells or gas wells. Iowa and North Dakota, on the other hand have significant coal production and North Dakota has over a thousand producing oil wells. There is no reason at present to think that the existence of energy producing or conversion facilities within a state's boundaries will in any way lessen the impact of shortages. The existence of such industries does mean, however, that the state will have certain regulatory responsibilities and will have to cope with the environmental and economic impacts generated.

Finally, within Minnesota there are major variations in energy use patterns between its economic development regions. These will be illustrated later with other energy issues of particular importance to Minnesota.

TABLE X-A

POPULATION AND GROSS PER CAPITA ENERGY USE

MINNESOTA AND ADJACENT STATES - 1971

State	Population in millions	Gross energy use Btu/capita
Minnesota	3.88	279×10^6
Iowa	2.85	298
North Dakota	0.625	457
South Dakota	0.670	312
Wisconsin	4.48	284
National Average		333

TABLE XI

ENERGY SOURCES IN MINNESOTA AND ADJACENT STATES - 1971

	Minnesota	Iowa	North Dakota	South Dakota	Wisconsin
Coal	18.1%	17.3	42.5*		28.9
Petroleum	46.4	39.7	33.8	46.4	38.4
Natural Gas	33.5	41.8	12.1	15.7	28.3
Nuclear & Hydro	2.0	1.1	11.6	37.9	4.4

NOTE: *Includes South Dakota

TABLE XII

ENERGY USE PATTERNS IN MINNESOTA AND ADJACENT STATES - 1971

	Minnesota	Iowa	No & So Dakota	Wisconsin
Household				
Coal	4%	1%	4%	9%
Petroleum	49	37	58	50
Natural Gas	47	62	38	41
Industrial				
Coal	18%	21%	25%	34%
Petroleum	16	14	21	7
Natural Gas	66	65	54	59
Electrical Production				
Coal	62%	56%	47%	72%
Petroleum	3	1	1	2
Natural Gas	26	38	2	9
Nuclear & Hydro	9	5	50	17

TABLE XIII

NUMBER OF ENERGY FACILITIES IN MINNESOTA AND ADJACENT STATES - 1971

	Minnesota	Iowa	North Dakota	South Dakota	Wisconsin
Coal mines	0	13	15	0	0
Crude oil wells	0	0	1,716	20	0
Natural gas wells	0	0	29	0	0
Uranium mines	0	0	0	0	0
Refineries	3	0	2	0	2
Electrical plants					
Fossil	138	169	35	51	78
Nuclear	1	0	0	0	2
Hydro	24	8	1	6	79

AND SO WHERE DO WE BEGIN?

What then can be accepted as givens, as facts upon which to begin our consideration of energy and its special implications for Minnesota? Although there might be some quibbling about details, the following should be acceptable to virtually all observers of the energy scene:

- Total energy use has been growing at between 4 and 5 percent per year, leading to doubling times of about 15 years.
- Electricity consumption has been growing at about 7 or 8 percent per year, leading to doubling times of about ten years.
- The conventional view of our energy future was that these growth rates would be maintained. It is assumed by many that growth in standard of living and that economic growth requires that there be vigorous growth in energy consumption.
- There are alternative patterns of energy growth. Major energy savings, through shifts to more efficient technologies of energy use, are possible. Further savings would be possible through other changes; for example, the development of our central cities or through conversion to other transportation systems.
- At present over 75% of our energy is derived from oil and natural gas. It would be difficult to shift to other fuels in a short time period.
- World reserves of oil and natural gas are sufficient to supply foreseeable demands for many decades. There are, however, serious problems, both political and economic, associated with importing large quantities of these fuels.

- Domestic production of oil and natural gas has peaked and is now decreasing. Estimates vary widely as to the extent that domestic production of oil and natural gas might increase. It is highly unlikely that increases in production could be realized in less than three to five years, if at all.

- The U.S. has large reserves of coal and oil shale, sufficient to supply our needs for hundreds of years. There are very serious environmental and occupational hazards associated with the use of these fuels, in addition to problems of land and water use.

- Nuclear power is at present providing only about one percent of our energy supply. The AEC and its associated industries are projecting that by the year 2000 nuclear power will provide about half of the electrical supply, or about a quarter of the total energy supply, for the U.S.

- Commitment to nuclear energy is an ethical decision. Nuclear energy carries with it hazards having an enormous potential for societal disruption (nuclear accidents, deliberate attempts at disruption, and proliferation of nuclear weapons). The nuclear establishment argues that these hazards, while real, have such a remote probability of occurring that they can be managed or tolerated. Nuclear critics argue that they are of sufficient gravity to justify a ban on the further use of nuclear power.

- There is great eventual potential for alternative energy supplies, particularly for solar energy. These energy sources are unlikely, however, to contribute a major fraction of our total supply in less than a decade; and at present levels of development support, and with the present structure of our institutions, it will be longer than that.

- There is little reason to expect that energy will be cheap again for many years, if ever. In the near term we can look forward to increasing scarcity and rising energy prices.
- Technical means are available to substantially reduce our energy consumption, without changing our basic way of life. There have been few attempts to create situations that would encourage employment of these energy-conserving technologies.
- There are significant differences in energy consumption and supply patterns between regions of the U.S. and between states within a region. These differences could result in differential impacts of scarcity and also suggest that there will be differences in the roles for states in the formulation and management of energy policy.

NOW TURNING TO MINNESOTA

When a state's role in energy management is considered, it is important to recognize the vast variations between states in their energy supply patterns, their energy use patterns, the energy facilities located within the states, and the degree to which the states may be affected by energy developments in other states. These factors will determine the extent to which a state must regulate its energy industry, be concerned with environmental problems, and include energy facilities in land use planning. There will be, in addition, responsibilities that fall more or less equally on all states. For example, should there be a national shortage of a given fuel such that some rationing or allocation program is necessary, all states will share in that task. Likewise, states have responsibility in shaping national policy through the example shown by decisions taken by the state, and in bringing to the attention of the Congress, the Executive Branch, and the industries involved, the issues which are of growing concern. As Minnesota has often led the nation in development of other policies, so it is possible that Minnesota will lead the nation in developing a response to the increasing scarcity of resources in general and energy in particular. This State also should not ignore its broader responsibilities when its energy utilization is the cause of environmental insults or occupational health and safety hazards occurring in other states. Minnesota must respect their third party interests if they are to respect hers.

PAST AND PRESENT ENERGY USE IN MINNESOTA

Minnesota's energy use, as that of the nation, has been steadily increasing, Figure 4. As has been noted, per capita energy use in Minnesota is only about 84% of the national average. In 1971, Minnesota's population was 1.88% of the nation's, but Minnesota's energy use was only 1.58% of the total national energy use. These may be significant differences in shaping Minnesota's response to energy scarcity. Although detailed studies would be necessary to support the conclusion, it appears that in spite of our large energy needs for heating, Minnesota's overall economy is less energy-intensive than that of the nation as a whole.

Although the fuel mix in Minnesota is known with reasonable accuracy, Table XIV, few data are available on end uses of energy. When, in the pages that follow, end uses are discussed, they will be based on national average data, except where noted otherwise.

Electricity

In 1970, 25% of the total fuels consumed in the U.S. went to the production of electricity; in Minnesota it was 21.6%. Only approximately 30% of that energy, however, appears as useful electricity at the wall-plug; the balance -- approximately 70% of the total fuel burned for the production of electricity -- appears as waste heat either at the power plant or in transmission. The thermal efficiency of the average steam-electric generating plant is about 34% (that of a new fossil fuel plant is about 38%), and losses in transmission and distribution are about 10% of the net output of the generating plants. Hence, as useful energy at point of end use, electricity supplies about 6.4% of Minnesota's energy use. In most applications, a very high fraction of this electricity is converted to useful work. Other fuels

FIGURE 4

MINNESOTA ENERGY TOTAL AND MIX, 1920-1971

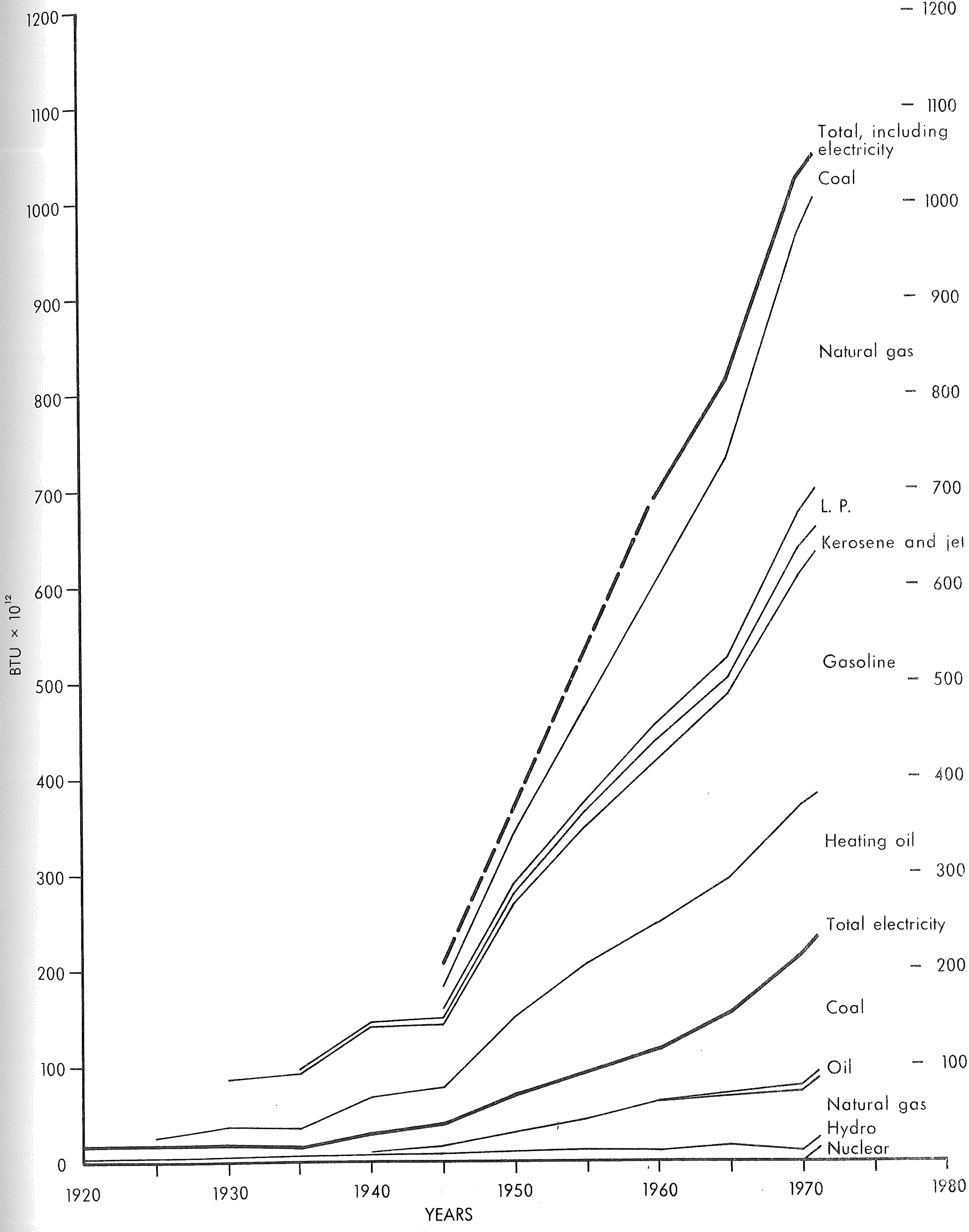

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TABLE XIV

ENERGY AND FUEL USE IN MINNESOTA -- COMPARED WITH NATIONAL AND REGIONAL AVERAGE - 1971

	Minnesota		National	Regional
Energy form	Btu (10^{12})	Percent	Ave. %	Ave. %
Gasoline	253.9	24.1		
Distillate oil	138.5	13.1		
Residual oil	17.5	2.4		
LPG	37.8	3.6		
Kerosine	7.9	0.7		
Jet Fuel	21.0	2.0		
Total petroleum	484.7	46.02	44.6	39.7
Coal	182.9	17.3	17.5	16.2
Natural Gas	362.7	34.4	33.3	40.9
Hydroelectric	10.9	1.0	4.0	3.0
Nuclear	13.3	1.3	0.6	0.2
TOTAL	1,046.4	100.0	100.0	100.0

NOTE: The Dept. of Interior includes Minnesota in its West North Central region. Together with Minnesota, this region includes Iowa, Missouri, the Dakotas, Nebraska and Kansas.

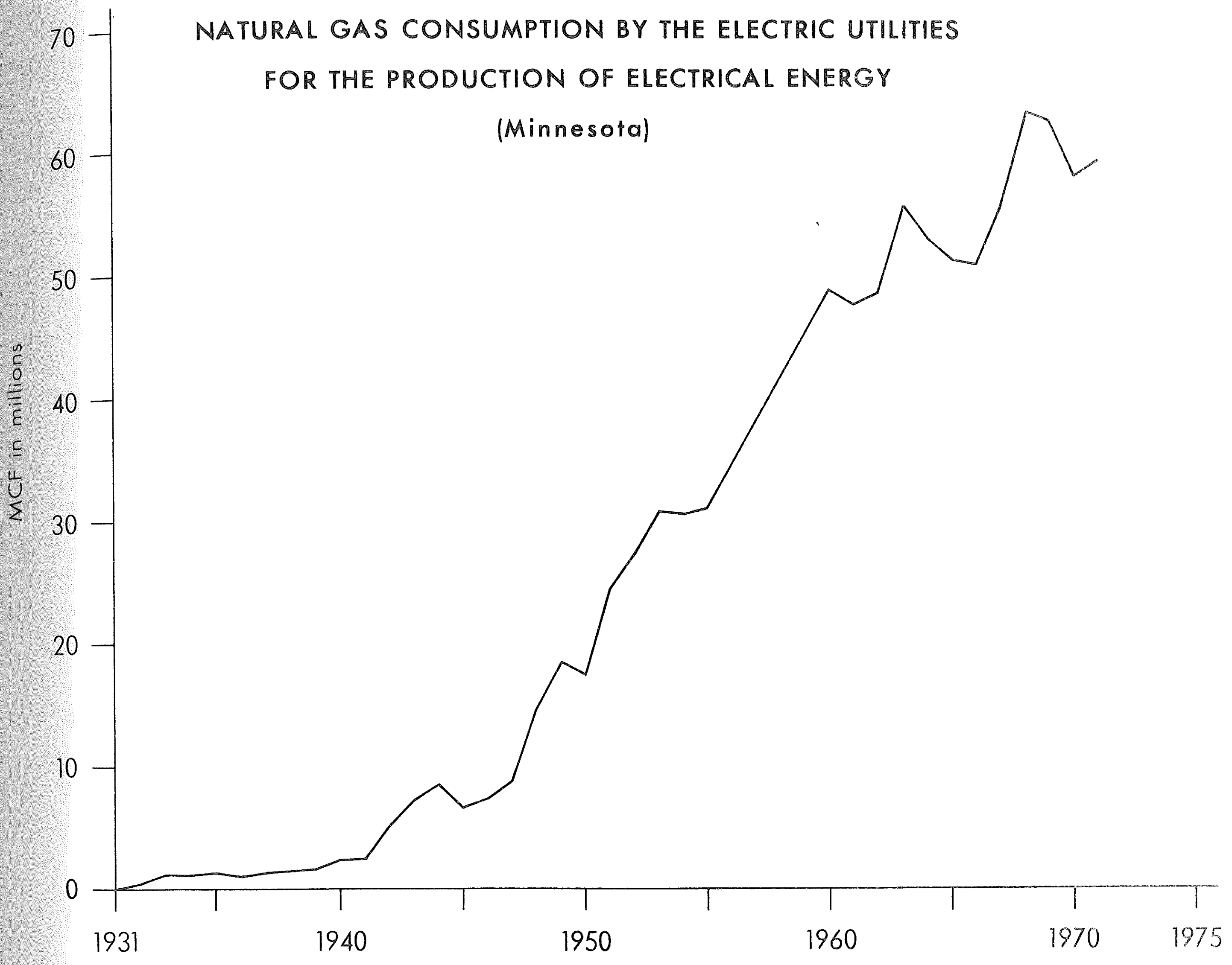
are used, often with low efficiency, but without the conversion process which characterizes the production of electricity.

The bulk of Minnesota's electricity is now produced from coal, Figure 4. It has previously been noted that Northern States Power Company's projections, Figure 3, foresee that nuclear power will grow considerably faster for their system than for the nation as a whole. Regardless of the nation's decision on the acceptability of nuclear power, it is projected that the production of electricity used in Minnesota will be based on some mix of nuclear fission and coal in the future. Although the use of natural gas for electricity production, Figure 5, has increased rapidly since about 1945, no natural gas is expected to be available for this use after 1978. Minnesota has the potential for increased hydroelectric generation, but it is in a large number of individually small sites,and heretofore,it has not been deemed economic to utilize them.

The seasonal variation in fuels used for the production of electricity, Figure 6, is due to a number of factors, including the availability of natural gas to electrical utilities, constraints imposed by air quality regulations, and need to use oil-fueled peaking plants at times of peak demand. Of these factors, natural gas availability has been the most important.

Natural gas is presently burned for production of electricity during the period when space heating needs are relatively modest. For example, in 1971, 91% of the natural gas consumed for electricity production was burned between April and October. All natural gas is delivered to Minnesota by pipeline. The natural gas pipelines operate at constant capacity throughout the year because natural gas production is more or less constant over

FIGURE 5



Source: Federal Power Commission, *Electric Power Statistics*

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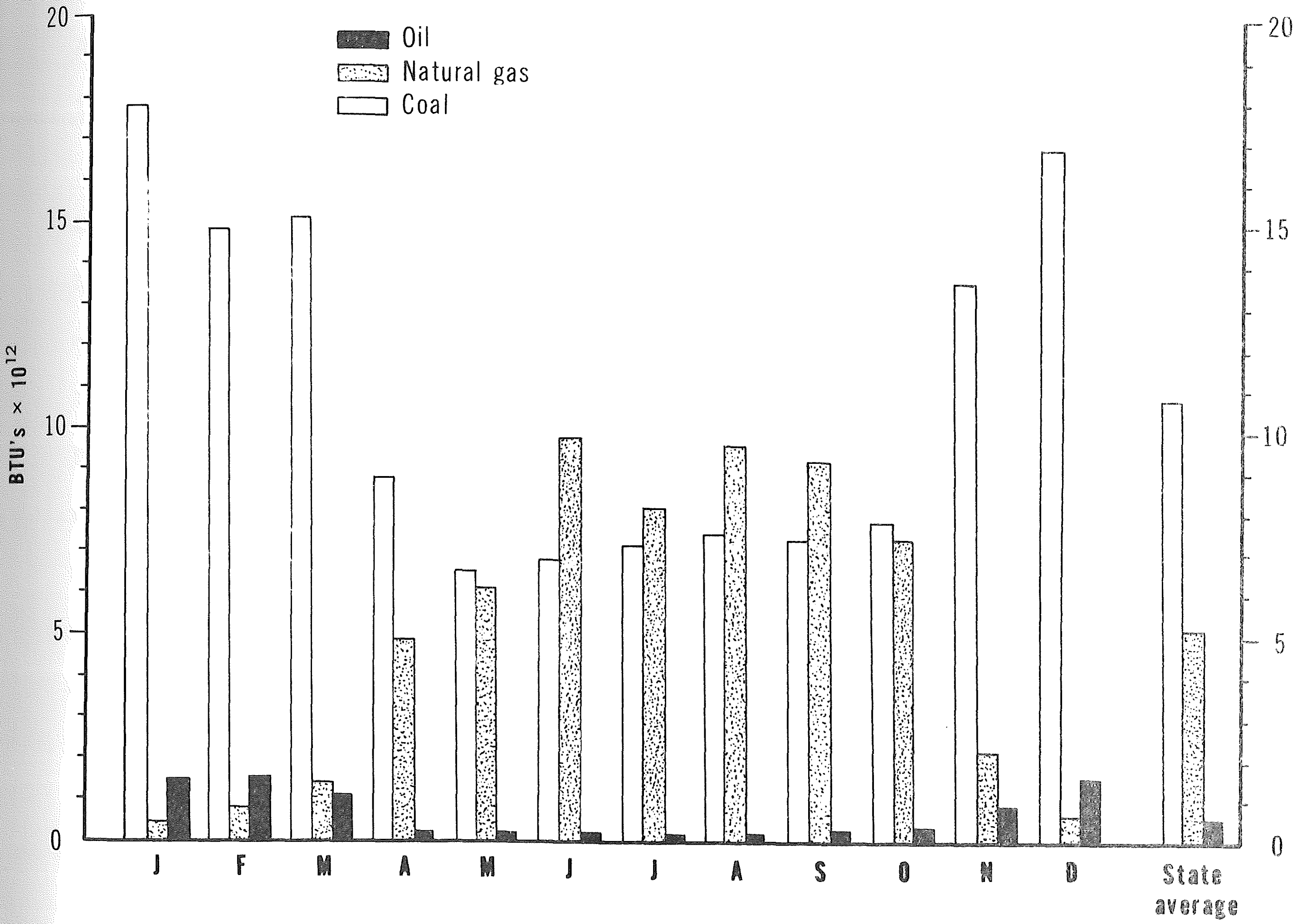
FIGURE 6

MONTHLY CONSUMPTION OF COAL, NATURAL GAS, AND OIL BY ELECTRIC UTILITIES IN MINNESOTA, 1971



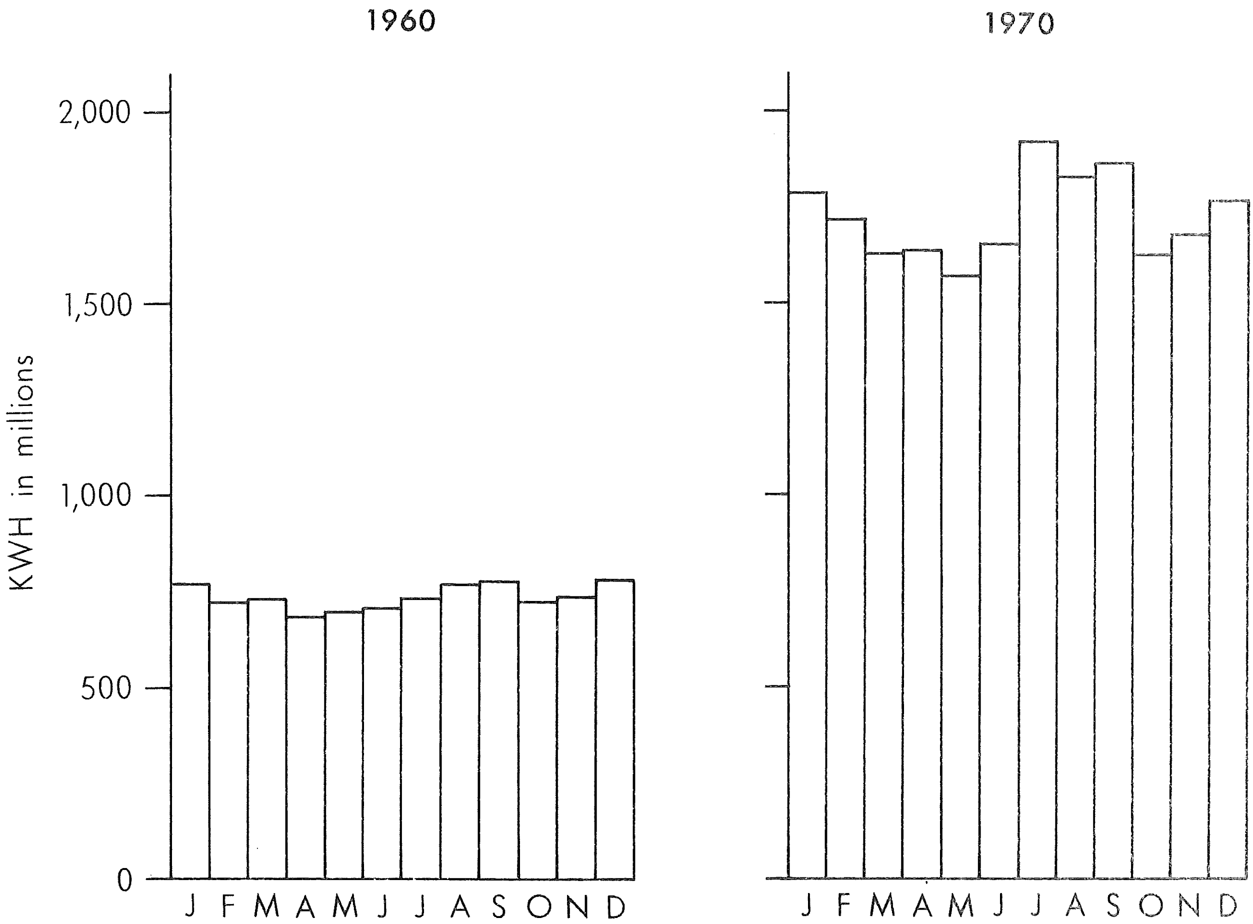
Source: Federal Power Commission, ELECTRIC POWER STATISTICS the year. During those periods when the residential and other relatively small individual users have had low demand, large quantities of gas were made available to the electrical utilities and other large users at low cost. The alternative would have been to build large natural gas storage capacity so that a large fraction of the gas transported to Minnesota during the non-heating season could be stored until it was needed during the winter. As we shall see in the next section, this storage will be developed within the next few years, but until now it has been economic to do it otherwise.

The variation in electricity sales over the year has changed significantly over the past decade. In 1960, electrical sales in Minnesota varied by only about 12% from the seasonal low to the peak, and the summer and winter peaks were virtually identicial, Figure 7. By 1970, the total seasonal variation was in excess of 18% and the summer peak exceeded the winter peak by more than 7%. Although few data are available on end uses of electricity in Minnesota, this shift probably is a reflection of a shift to building practices which fail to take full advantage of natural cooling and ventilation opportunities and instead require the substitution of air conditioning and mechanical ventilation at all seasons. This shift must be recognized as a deficiency in the coordination between two of Minnesota's major industrial activities -- the utilities on the one hand and building design on the other. As a consequence building operation may be acutely affected by energy scarcities and the operation of the electric utilities will operate in less than an optimal manner. An uneven demand, whether over a given day or over the year, means, since electricity cannot be stored, that there will be unused generating and distribution capacity during those times when demand is less than peak capacity. Different

FIGURE 7

MONTHLY SALES OF ELECTRICAL ENERGY TO ULTIMATE CONSUMERS, 1970 AND 1960

(Minnesota)



Source: Federal Power Commission, *Electric Power Statistics* interests will propose different remedies to this imbalance in electricity demand. It stands, however, as indisputable evidence that Minnesota is in need of coordinated planning -- in this case between building design and operation practices and utility planning.

Natural Gas

Natural gas supplies 47% of residential energy, 66% of industrial, and 26% of electrical production in Minnesota (1971). About 59% of Minnesota's net receipts of natural gas are from domestic sources, the balance being from Canada. Natural gas use in Minnesota, as in other regions far removed from production fields, has grown rapidly since the development of pipelines in the late 1940's, Figure 8. Along with the growth in natural gas use, there has been a comparable increase in pipelines in Minnesota, Table XV.

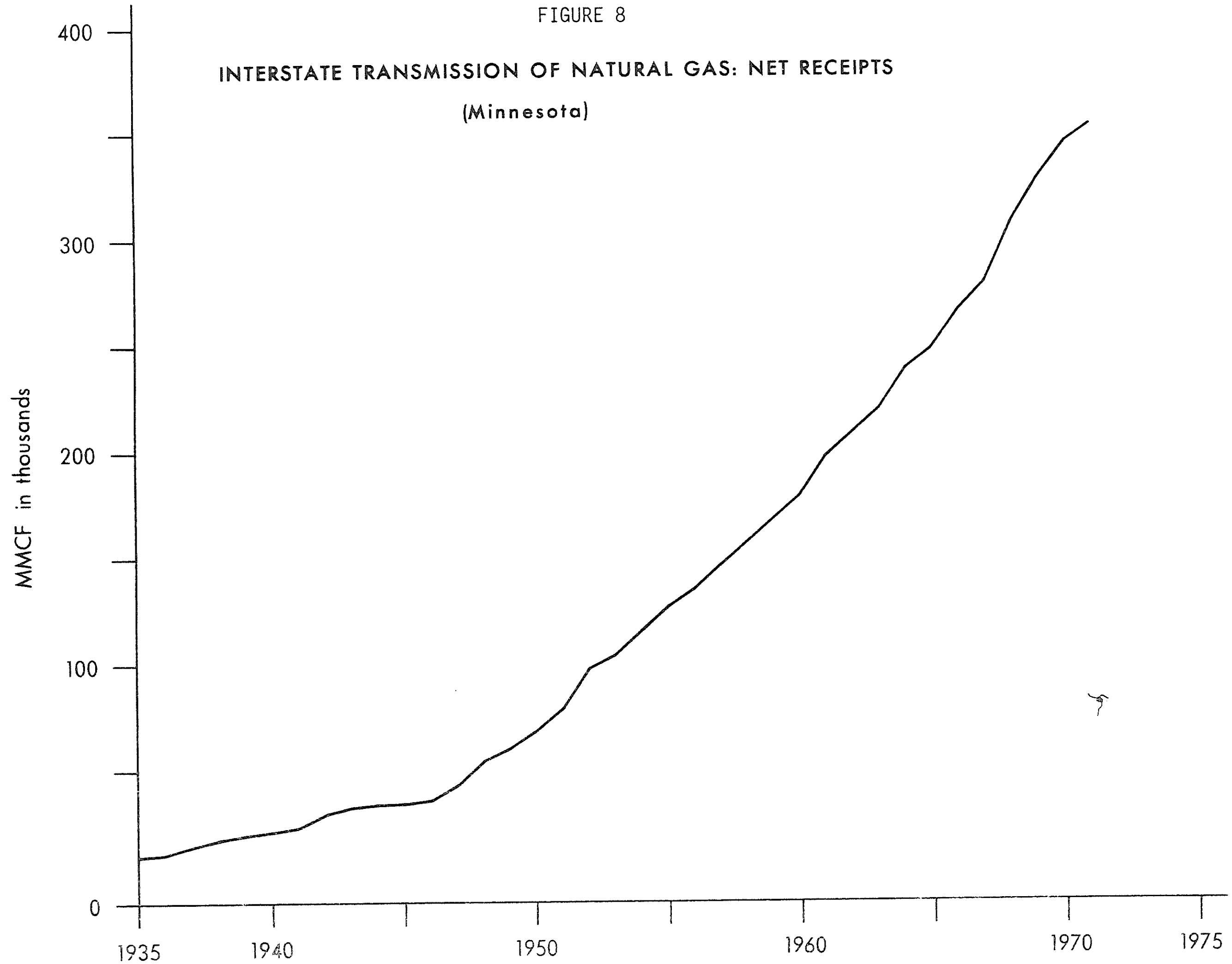
Natural gas moves from the producing wells, most of which are in the southern U.S. and Canada, via transmission pipelines into Minnesota. It then passes into distribution systems and directly to the user, except for the small fraction which is stored. Minnesota has only one large storage facility for natural gas. This storage is in underground formations; gas can be pumped in during periods when pipeline deliveries exceed demand and recovered when needed. The estimated ultimate capacity of this storage reservoir is 3.7 billion cubic feet, which is about 1% of 1971 total sales, or 6.3% of sales for the generation of electricity.

Natural gas is used primarily as a heating fuel in Minnesota, and is sold to residential, commercial, and industrial users. The residential users are about 91% of the total number of customers, but consume only about

FIGURE 8

INTERSTATE TRANSMISSION OF NATURAL GAS: NET RECEIPTS

(Minnesota)



Sources: American Gas Association, *Historical Statistics of the Gas Industry* and *Gas Facts;*
U. S. Bureau of Mines, *Mineral Industry Surveys*

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49% of the gas sold, Table XVI.

Natural gas receipts in Minnesota have grown rapidly since the late 1940's, but are expected to decrease beginning in 1974. Northern Natural Gas Company, which provides 95% of the natural gas burned in Minnesota, plans to reduce its sales in Minnesota beginning with the large-volume users. According to reports in the Minneapolis Tribune, Northern Natural will reduce its system-wide output in seven states, including Minnesota, by about 10% in 1974-1975, and further cut by 21% in 1977, 26% in 1979. These reductions result from decreasing production from U.S. gas wells, coupled with an anticipated reduction in supply available to Northern Natural via its Canadian subsidiary, Consolidated Natural Gas Co.

First to be affected will be large-volume users, which in Minnesota include: the taconite plants; Twin Cities breweries, Hoerner-Waldorf Corp. in St. Paul; large apartment, office, bank and department store buildings; the State Capitol; the University of Minnesota; a number of colleges and hospitals; and some high schools. Each year, from now to 1979, supplies to these large users will be reduced. Should the reduction continue, residential and small commercial-industrial users will be affected after 1979.

This shift will cause a massive shift to oil, to the extent that it is available, and to coal. As will be considered in more detail later, this drastic reduction in natural gas supply for Minnesota has the potential for considerable disruption.

TABLE XV

NATURAL GAS PIPELINE TRANSMISSION IN MINNESOTA

Year	Miles
1951	720
1961	2,470
1971	3,944

TABLE XVI

BREAKDOWN OF MIX OF CUSTOMERS FOR NATURAL GAS
IN MINNESOTA -- BY NUMBER AND BY SALES -- 1971

Class of Customer	Percentage of Total Customers	Percentage of Total Sales
Residential	91	33
Commercial	8	15
Industrial	1	49
TOTAL	100	97

NOTE: 100% of the residential customers were "firm," 86.8% of the commercial gas sold was on "firm" contract, and 44% of the industrial gas was on "firm" contract.

Only 97% of natural gas sales are included in the above table, the original source for these data are publications of the American Gas Association and the other 3% of the sales are identified as "other".

Coal

In 1971 Minnesota derived 18.1% of its total energy from coal, with 4% of residential energy demand supplied, 18% of industrial, and 62% of electrical generation (Tables XI and XII). In terms of coal use, 77% goes to electrical utilities, 6% to coke and gas plants, and the balance to other small users, Table XVII. Coal is moved into Minnesota via Lake Superior, by river barge, and by railroad. In the past, the largest fraction of coal used in Minnesota has come from the coal fields of the Midwest, primarily Illinois, and has arrived in Minnesota by river barge. With the expansion of coal supplies from the Rocky Mountain states and the Dakotas there has been a dramatic shift to rail transport for the coal, Figure 9.

Much of the energy production from the developing Western coal fields may move through Minnesota either in the form of coal, as electricity via transmission lines, or through new natural gas pipelines from coal gasification plants. The anticipated shift from industrial use of gas, and perhaps oil, to coal will also result in more coal being burned in Minnesota, with resultant implications for air quality. The use of coal for the production of electricity has increased by more than ten times over the last 30 years, Figure 10. Future coal use will be primarily for electricity production and other large industrial, commercial, or institutional uses.

Petroleum Products

During the past two years there has been a good deal of attention focused on petroleum, both crude oil and refined petroleum products. Minnesota has contributed its share to the increased demand for these fuels, Figure 11. Sales of both distillate fuel oil (used for individual homes,

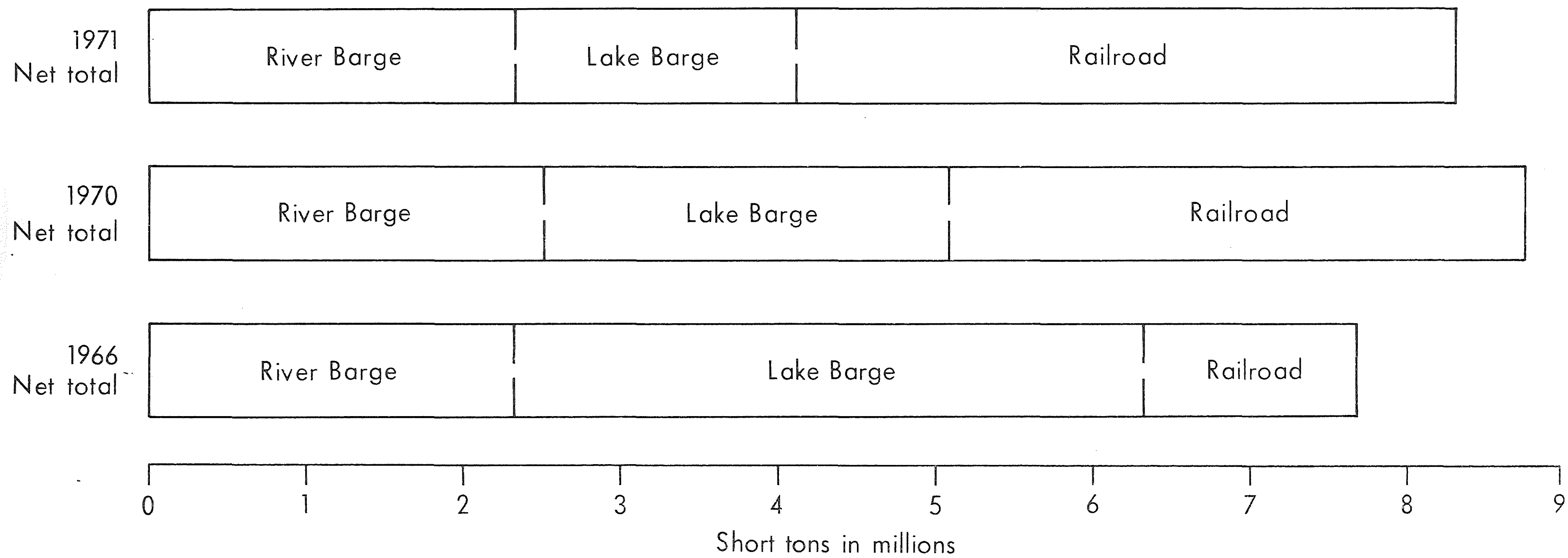
TABLE XVII

END USES OF COAL IN MINNESOTA -- 1971

End Use	Millions Short Tons	Percentage of Total
Electric Utilities	6.403	77
Coke and Gas Plants	0.509	6
Retail Dealers	0.500	6
Other	0.901	11
TOTAL	8.313	100

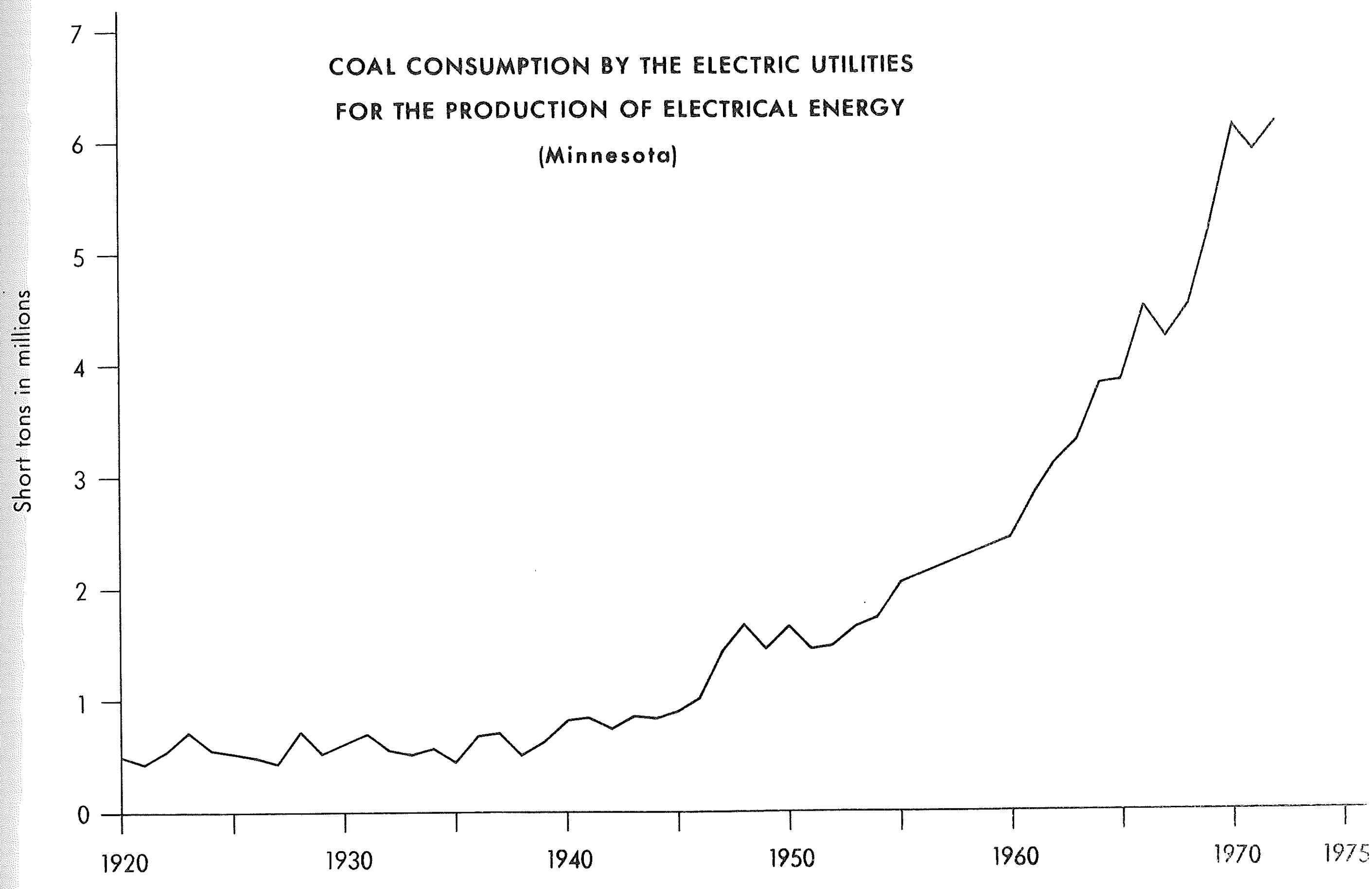
FIGURE 9

COAL SHIPMENTS TO MINNESOTA, 1971, 1970, AND 1966



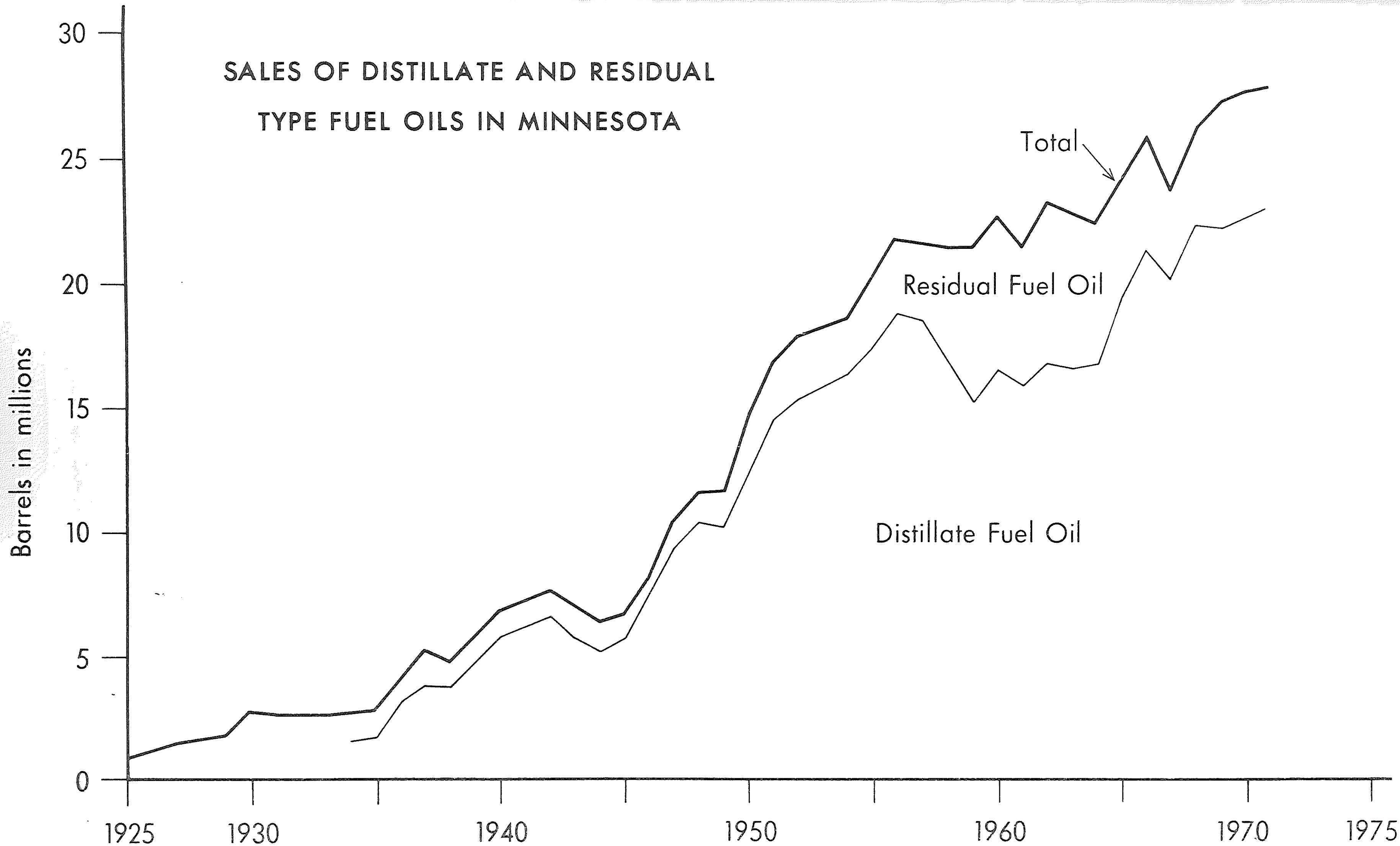
Sources: National Coal Association, *Coal Traffic Annual* 1971
U. S. Bureau of Mines, Mineral Industry Surveys, *Distribution of Bituminous and Lignite Coal*
U. S. Army Corps of Engineers, *Waterborne Commerce of the U. S.*

FIGURE 10



Source: Federal Power Commission, *Electric Power Statistics*

FIGURE 11



Sources: American Petroleum Institute, *Petroleum Facts and Figures*
U. S. Bureau of Mines, *Mineral Industry Surveys*

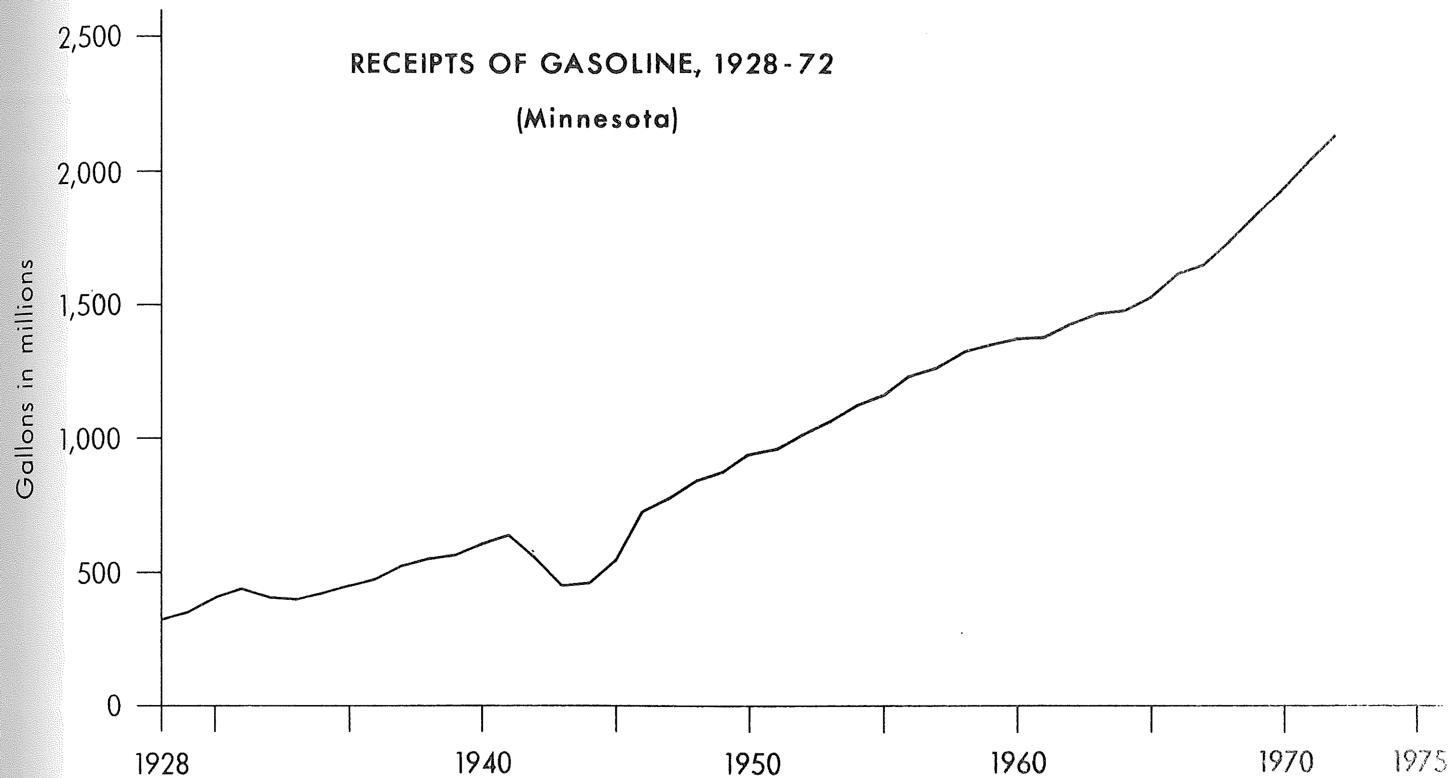
schools, other small users, and for electrical "peaking plants") and for residual fuel oil (the heavy oil used only by large installations) increased dramatically between 1940 and about 1955, and have increased somewhat more slowly since that time. The reduced growth of these heating oils since the early 1950's is a reflection of the increased availability of natural gas following the construction of interstate pipelines in the years following World War II. The other principal fuel derived from crude oil, gasoline, has shown a steady increase in Minnesota, Figure 12, as a result of growth in the demand associated with motor vehicles.

Gasoline consumption also shows seasonal variation, as would be expected in a state which supports a large tourist industry. In 1972 the sales for the peak month, August, were about 25% higher than in the spring months, Figure 13.

It has often been stated that Minnesota is "at the end of the pipeline." To the extent that we depend on petroleum products that are refined elsewhere and transported to Minnesota that is true. However, Minnesota's three refineries, which operate largely with Canadian crude oil produce annually a quantity of gasoline which is equal to over 57% of Minnesota's annual consumption of gasoline, Figure 14. But it must be kept in mind that we are on the end of the crude oil pipeline, too. Again, as in the case of natural gas, Canadian energy policy will impact Minnesota as it now appears that Canada will decrease its exports of crude oil to the U.S. by nearly half over the next three years.

As has been noted, reduced availability of natural gas will lead to increased demands for heating oils. Heating oil demand presently shows a marked seasonal variation in consumption, Table 15. Whether or not heating oil production can be expanded to compensate for the reduction in availability

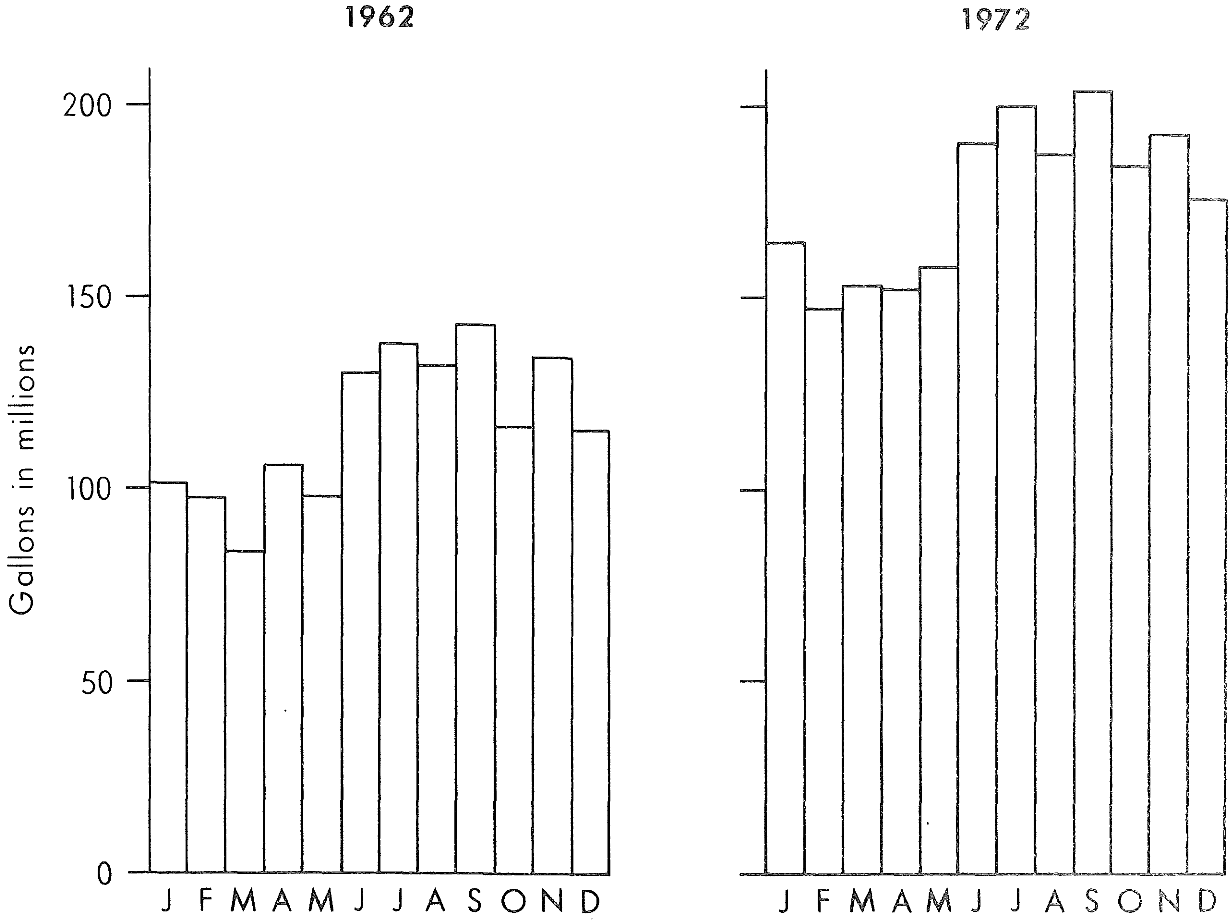
FIGURE 12



Source: Minnesota, Department of Taxation, Petroleum Division, *Annual Report*, 1972

FIGURE 13

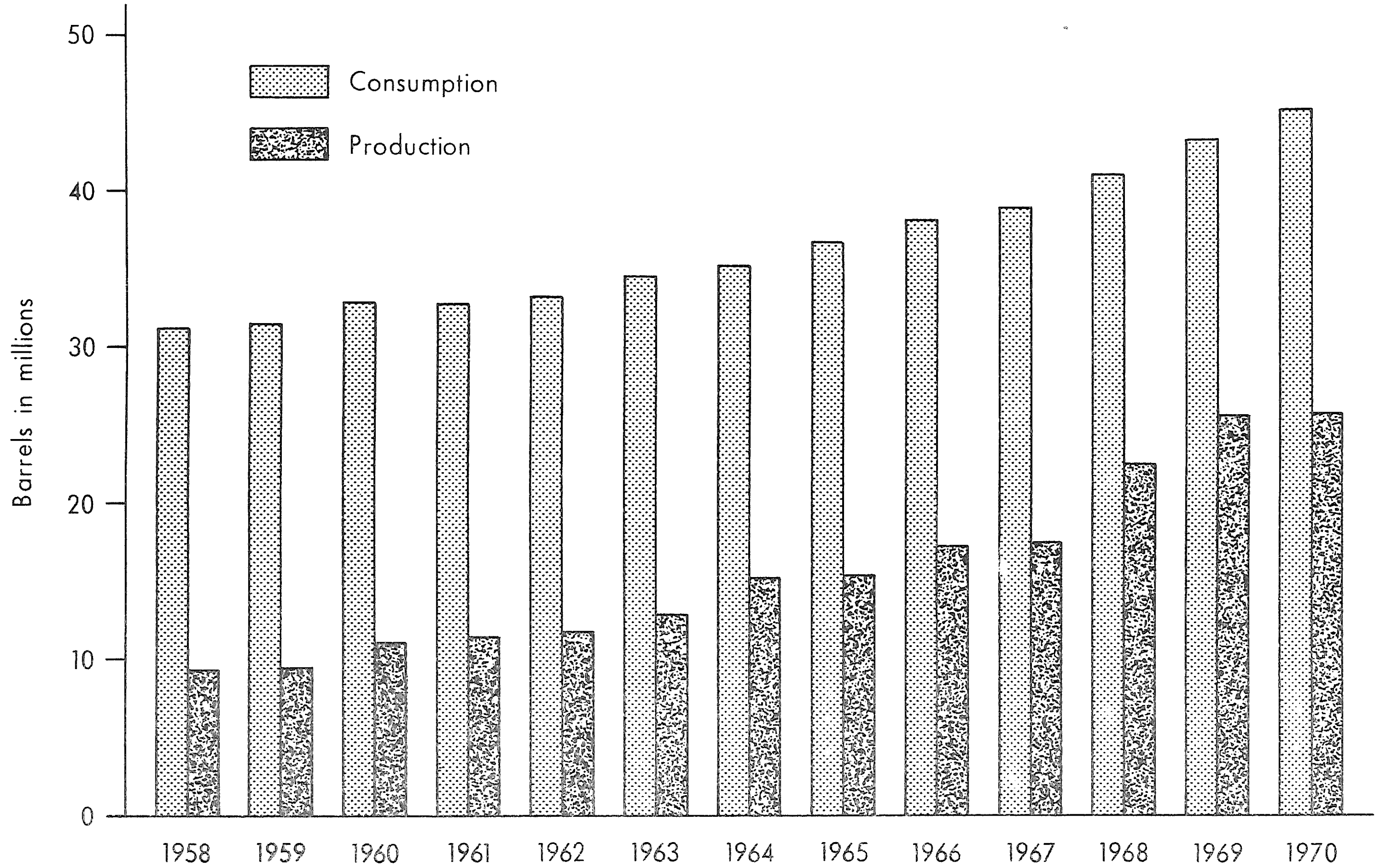
GASOLINE MONTHLY RECEIPTS, 1962 AND 1972
(Minnesota)



Source: Minnesota, Department of Taxation, Petroleum Division, *Annual Report*

FIGURE 14

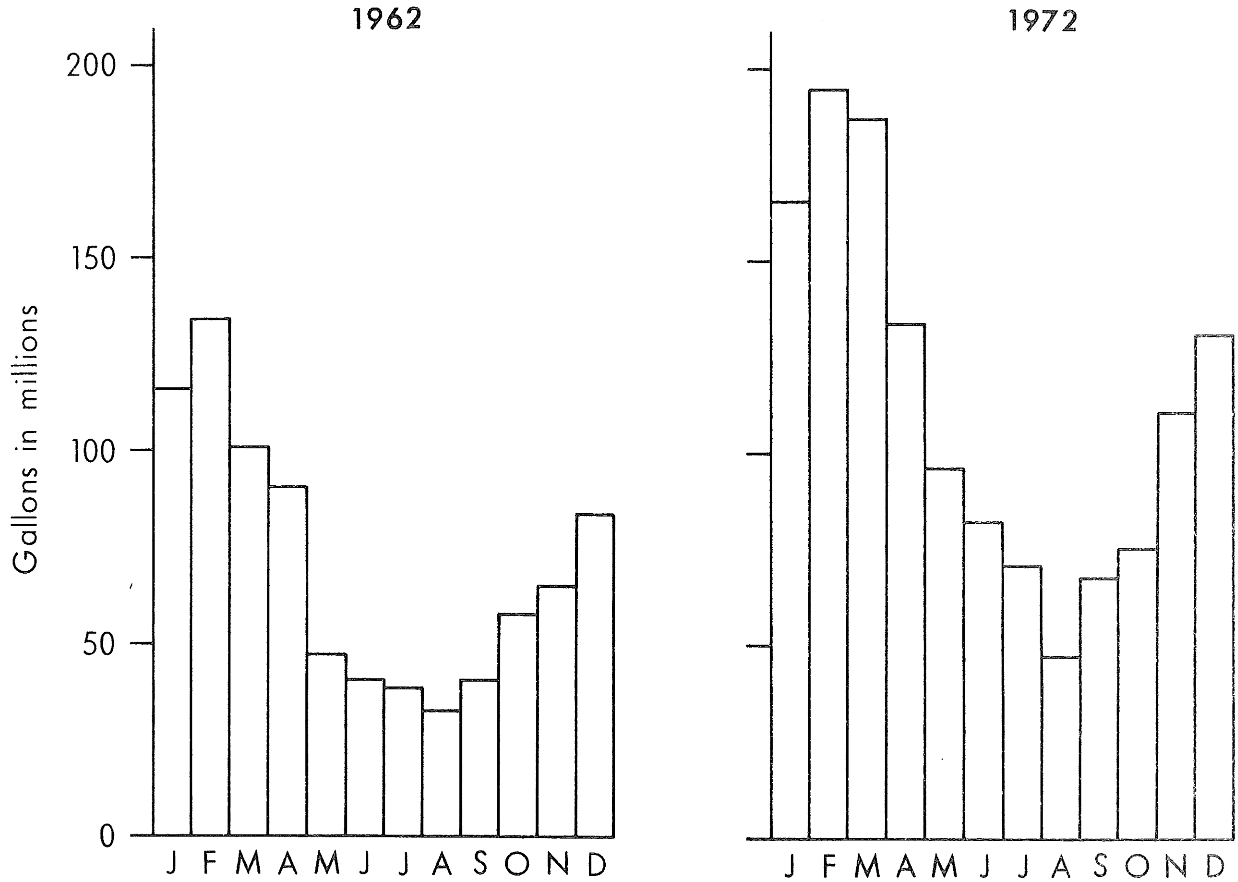
MINNESOTA PRODUCTION (REFINERY OUTPUT) AND CONSUMPTION OF GASOLINE



Source: U. S. Bureau of Mines, *Minerals Yearbook*

FIGURE 15

FUEL OIL MONTHLY RECEIPTS, 1962 AND 1972
(Minnesota)



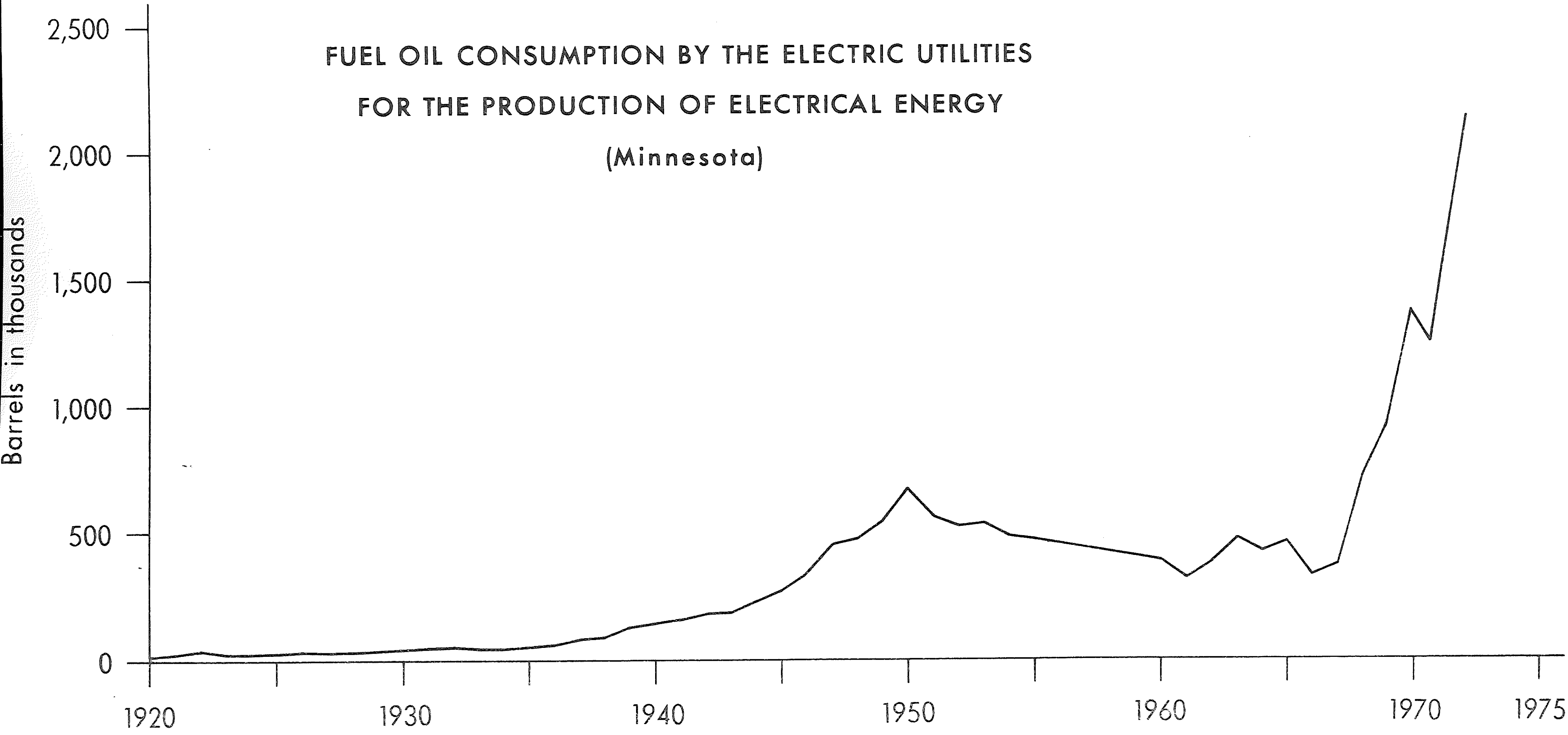
Source: Minnesota, Department of Taxation, Petroleum Division, *Annual Report* of natural gas, while maintaining the desired levels of gasoline production, must be seriously questioned. Should reduced exports of crude oil from Canada differentially impact Minnesota, as seems probable, the situation will be compounded. Further, if the path of providing fuels for industry -- and to date that has been interpreted to be unionized industry, not those such as the Minnesota tourist industry -- results in decreased production of gasoline, there might well be differentially heavy impact on those states for which gasoline demand is tightly coupled with general economic activity.

As is indicated on Figure 4, electrical utilities consume a small fraction of the heating oil used in Minnesota. This oil is used in two ways: (1) to power the small diesel engines used by small utility systems, and (2) to fuel the gas-turbine peaking units recently installed by the large utilities to enable them to provide the peak demands created by the breakdown in planning to which reference has earlier been made. As with so many other indices relating to energy use, the growth rates in fuel oil consumption for the production of electrical energy broke sharply with long-term trends in the mid- and late-1960's, Figure 16.

All crude oil is delivered to Minnesota in pipelines. Three companies operate crude oil pipelines in Minnesota, and these pipelines move crude oil both through and to the State. These pipelines vary from 16- to 48-inch; all have been installed since 1950. Of all petroleum pipelines in Minnesota, Figure 17, about 1,292 miles, or about half, were crude oil lines, the rest carrying refined petroleum products. In 1970, these pipelines had a capacity of about 2.4 million barrels per day.

Minnesota has three petroleum refineries, which in 1972 had listed capacities as follows: Continental Oil refinery at Wrenshall, 17,000

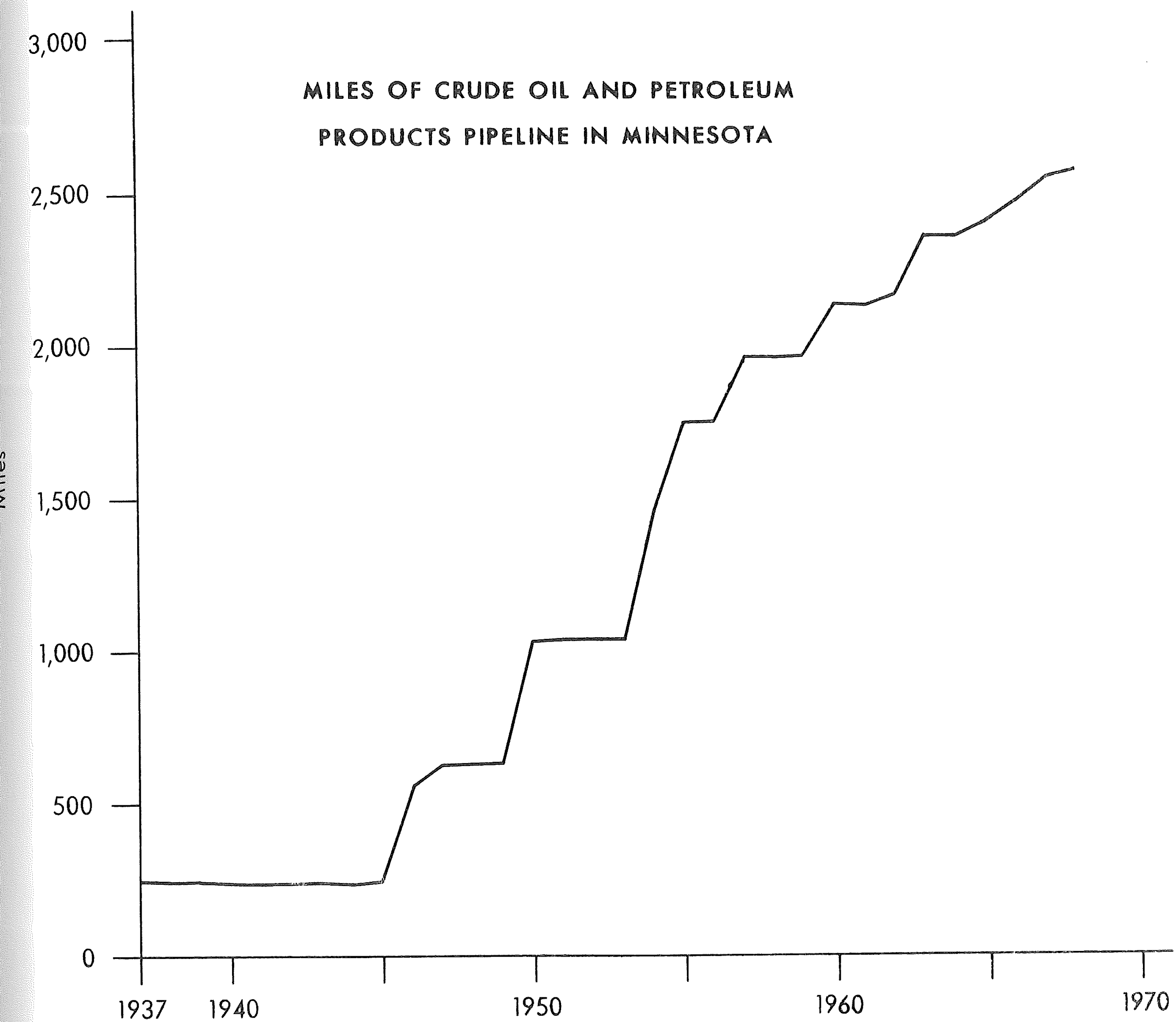
FIGURE 16



Source: Federal Power Commission, *Electric Power Statistics*

MINNESOTA ENERGY PROJECT
MEP-74-5 Mar. 1974

FIGURE 17



Source: American Petroleum Institute, *Petroleum Facts and Figures* and ICC, Transport Statistics, Part 6, "Oil Pipelines" barrels per day; Northwestern Refining Co. at St. Paul Park, 49,350 barrels per day; and Koch Refining Co. at Pine Bend, 87,900 barrels per day. Hence, the maximum amount of crude oil delivered to Minnesota refineries is only about 150,000 barrels per day. By far the largest quantity of crude oil carried in pipelines passing through Minnesota is for other than Minnesota's refineries.

Petroleum products are carried by pipeline, barge, railroad tank cars, and trucks. All of these means are used in Minnesota, but reliable summary data do not seem to be available as to the extent and regional distribution of each.

Liquified Petroleum Gas (LPG)

Propane and butane are important fuels in Minnesota. Although they account for only about 3.6% (1971) of total energy use, Table XIV, they are often used when other fuels are not available, for example for drying crops, for space heating in areas not served by natural gas pipelines, and as backup to natural gas for large commercial and industrial users who have interruptible gas contracts. It would be difficult to understand why there has been an apparent shortage of propane for crop drying if one were to consider only the total quantities of propane used for that purpose, Table XVIII. Of all propane used in Minnesota, less than 3% is used for crop drying, equivalent to less than 0.1% of total energy use in Minnesota. The efficiency of the farm lobby in voicing its concerns cannot be ignored, but the need for LPG for the drying of crops illustrates a case where, although small total quantities of fuel is involved, it is extremely important that it be available where and when it is needed.

TABLE XVIII

LIQUIFIED PETROLEUM GAS SALES IN MINNESOTA - 1971

Use	Millions Gallons	Percentage of total LPG	Percentage of total energy
Residential & Commercial	338.52	85.5	3.08
Industrial	35.26	8.9	0.32
Internal Combustion Fuel	10.59	2.7	0.10
Gas Utilities	3.17	0.8	0.03
Miscellaneous (Including crop drying)	8.52	2.1	0.10
Totals	396.06	100.0	3.62

Notes:

a. Of all LPG, 98.5% propane, 1.4% butane, 0.1% propane-butane mixture.

b. Residential/commercial is only propane.

c. Industrial includes all butane sold in Minnesota since 1967.

d. "Miscellaneous" is defined: "LPG sold or used for agricultural purposes such as flame cultivation, crop drying, tobacco drying, poultry breeding, and miscellaneous other farm uses are included in this category. Use of LPG for internal-combustion engines, such as farm tractors and irrigation pumps, are not included.

SOME DIFFERENCES BETWEEN MINNESOTA'S REGIONS

Just as there are major differences, both in energy supply and in patterns of end use, between regions of the United States, and between individual states within a region, there are differences between regions within a state such as Minnesota.

Very little attempt has been made to study the differences in energy use between Minnesota's eleven development regions but a few examples are known, and to a certain extent the nature of the differences can be deduced from the known mix of economic activity in the region, the extent to which it is served by gas pipelines, and similar information.

Some energy uses are virtually identical for the different regions. For example, virtually all intra- and inter-city transportation in Minnesota depends on petroleum products. For other uses, there are wide variations. The energy mix for residential space heating is one energy use showing this variation, Table XIX and Figure 18. Residential space heating is one of the single largest end uses of energy, and this variation between the State's regions must be given major consideration in the management of energy resources.

On the other hand, the energy use for public schools (grades K-12) is a very small energy use in the state, comprising but 2.5% of electrical use and less than 2% of heating fuel use in 1972. As would be expected, the form of energy used by schools shows much the same regional variation, Figure 19, as does residential space heating.

If only energy purchased as fuels or electricity by the farmer are considered, agriculture is not a highly energy consuming sector of Minnesota's economy. When all energy inputs into agriculture, for example the

TABLE XIX

OCCUPIED UNITS BY HOUSE HEATING FUEL

1970 - MINNESOTA

PERCENTAGE DISTRIBUTION BY REGION

Region	Util. Gas	Bottle/ LP Gas	Elect.	Oil/ Kero.	Coal/Coke	Wood	Other
1	17.5	10.0	2.4	67.6	1.1	1.3	.2
2	4.4	12.6	4.4	69.5	1.9	6.9	.4
3	16.9	6.9	1.8	63.3	4.2	1.4	5.5
4	19.7	9.6	2.4	65.6	1.3	1.2	.2
5	18.6	11.6	3.2	61.8	1.1	3.6	.1
6W	14.9	10.4	2.5	70.9	1.0	.2	.1
6E	21.8	10.4	3.8	62.3	.9	.1	.7
7W	24.4	11.1	3.2	59.7	.6	.6	.3
7E	27.1	20.7	1.9	47.2	1.3	1.6	.2
8	25.7	15.5	2.0	54.0	1.5	.4	.9
9	55.4	11.1	1.6	29.5	1.1	.5	.7
10	58.1	7.9	1.9	29.7	1.6	.4	.4
11	76.8	2.1	2.8	16.4	1.1	.0	.7
Total State	53.9	6.2	2.6	34.3	1.4	.6	1.0

NOTE: % may not add to 100.0 since some homes have no source of heat.

FIGURE 18

OCCUPIED UNITS BY HOUSE HEATING FUEL
MINNESOTA - 1970
(A Percentage Distribution by Region)

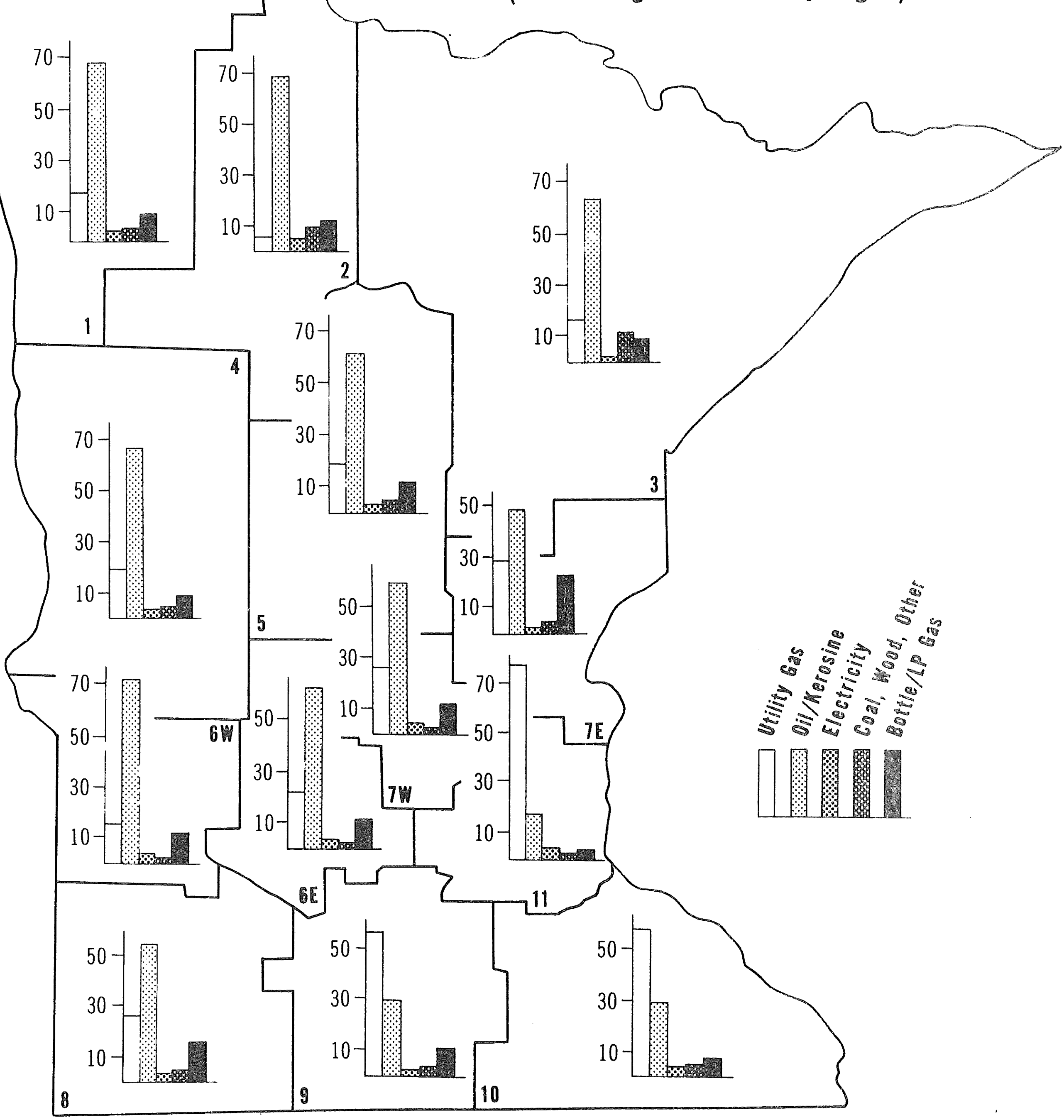
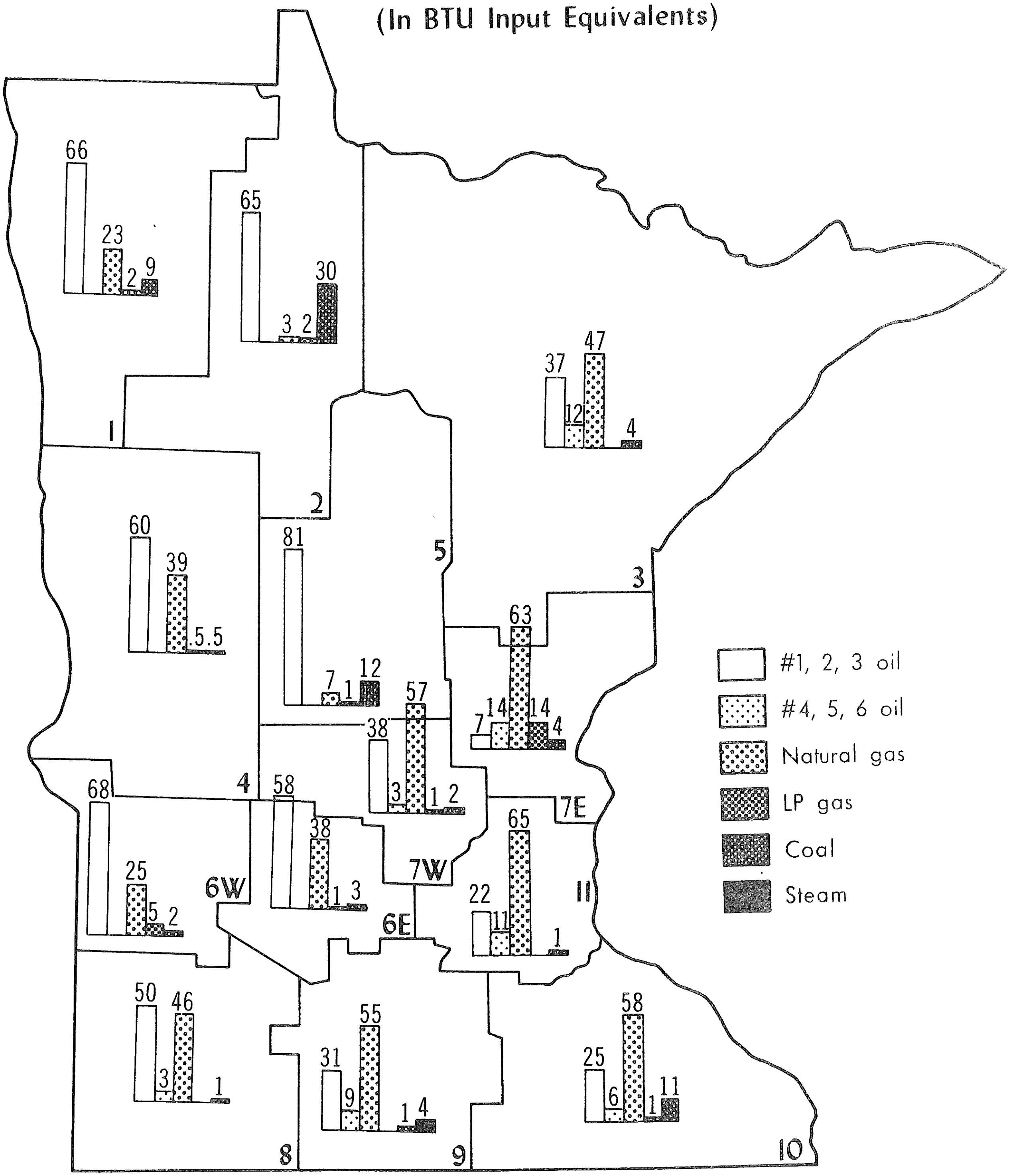


FIGURE 19

PUBLIC SCHOOLS HEATING FUEL MIX, 1972 BY PLANNING REGIONS (In BTU Input Equivalents)

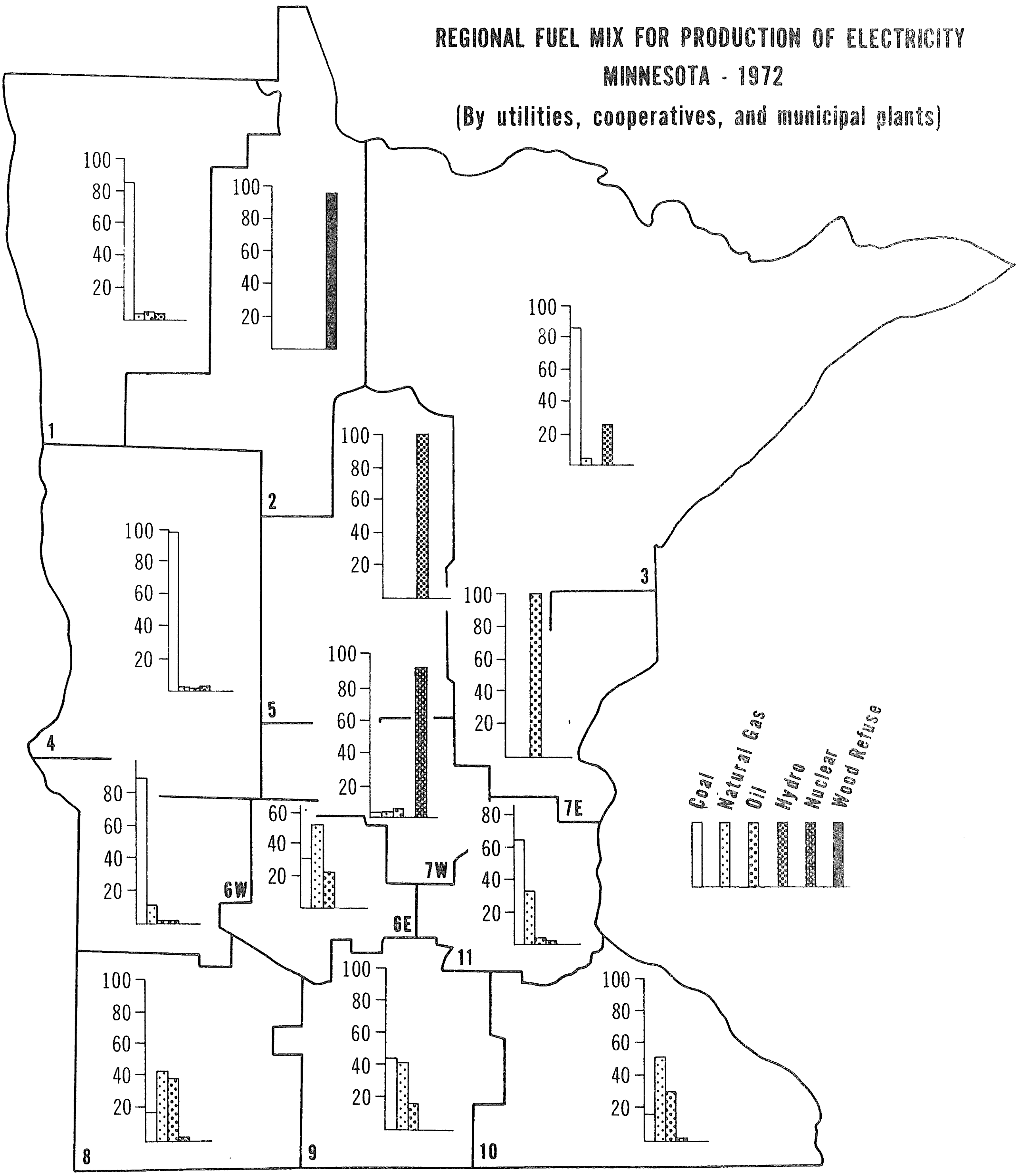


energy required to manufacture chemical fertilizers and other agrochemicals, agriculture is rather energy-intensive. Nonetheless, it would be expected that regions of Minnesota that are primarily agricultural will have rather modest per capita energy demands.

The mining industries and paper manufacturing are energy-intensive, and those regions of Minnesota where these activities are carried out will show large per capita energy consumption. Anything other than a highly speculative, and qualitative analysis, must, however, await detailed studies of end uses of energy in Minnesota. These studies must be done if Minnesota's energy flows are to be understood and if the impacts of energy scarcity are to be anticipated and corrective measures taken.

In summary, certain types of regional differences, for example for residential space heating, are very significant. In other cases, for example fuel used for production of electricity in Minnesota's regions, Figure 20 and Figure 21, differences between regions are more apparent than real. A detailed breakdown of Minnesota energy uses, including analysis by region, is badly needed but to date is unavailable.

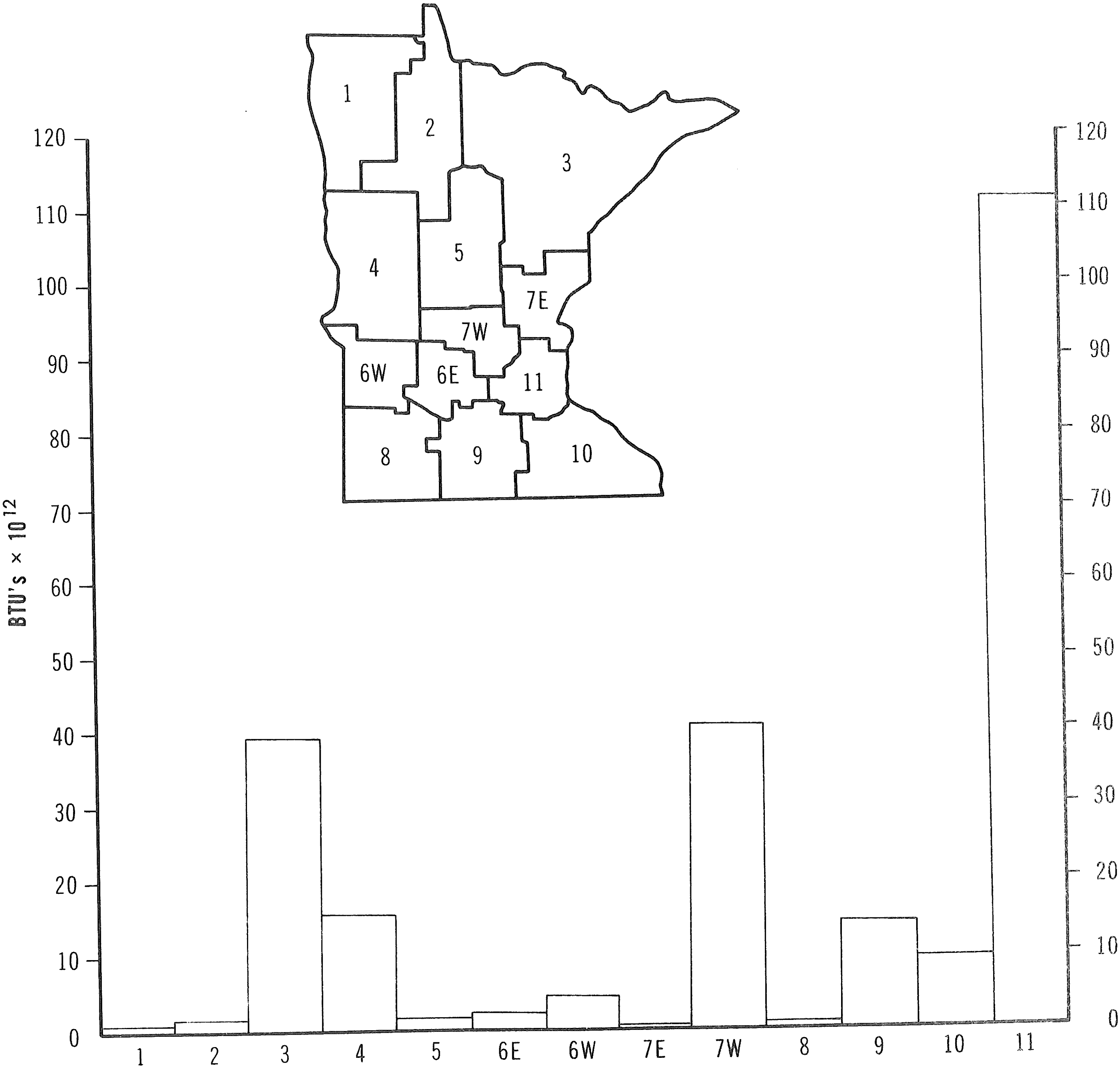
FIGURE 20



REGIONAL FUEL MIX FOR PRODUCTION OF ELECTRICITY
MINNESOTA - 1972
(By utilities, cooperatives, and municipal plants)
1
2
3
4
5
6W
6E
7E
7W
8
9
10
11
Coal
Natural Gas
Oil
Hydro
Nuclear
Wood Refuse

FIGURE 21

REGIONAL ENERGY CONSUMPTION FOR PRODUCTION OF ELECTRICITY BY UTILITIES, COOPERATIVES AND MUNICIPAL PLANTS IN MINNESOTA, 1972



Sources Keystone Coal Industry Manual, 1973
MEP-74-1 (Preliminary Draft)
Electric World Directory of Electric Utilities, 1972-73

WHAT OF MINNESOTA'S ENERGY FUTURE?

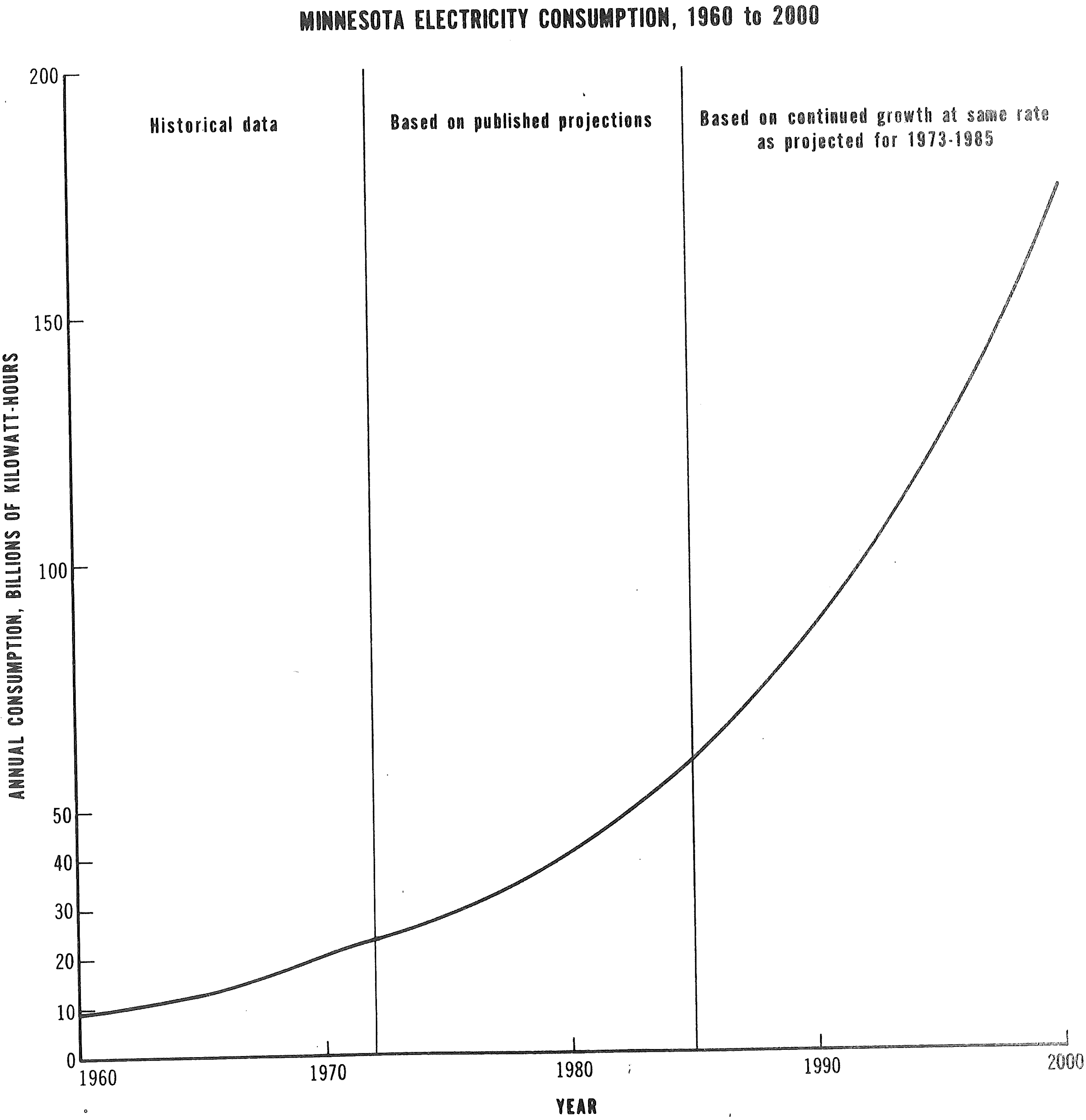
It is impossible to predict the future development of energy facilities or the course of energy consumption growth in Minnesota. If sufficient assumptions were made, it would be possible to roughly describe the future energy system in Minnesota, but insufficient work has been done to date to spell out in any detail the specific impacts of following any one of the alternative energy options. At this time it is possible only, with illustrative cases, to outline some of the implications and give some indication of the magnitude of the problems which could be facing Minnesota within the next few years.

Minnesota will be impacted both by energy-related activities which relate directly to her own energy production and consumption, and by activities which are associated with the production, conversion, transportation and use of energy in other states. Within Minnesota there will be expansion of all energy systems.

Electrical System

From published reports of Minnesota's utilities, and various federal agencies, it is possible to get some idea of the anticipated electrical power growth in Minnesota, Figure 22. The total sales of electricity is expected to increase from 23 billion kilowatt-hours in 1972 to something like 175 billion killowatt-hours by the year 2000. Because of energy conservation programs, possible fuel shortages, and the effects of increased energy prices, it is highly doubtful that this projection will be realized. Nonetheless it is instructive to examine the implications of this growth which, until recently, was the accepted view of the future.

FIGURE 22


MINNESOTA ELECTRICITY CONSUMPTION, 1960 to 2000
Historical data
Based on published projections
Based on continued growth at same rate as projected for 1973-1985
ANNUAL CONSUMPTION, BILLIONS OF KILOWATT-HOURS
200
150
100
50
40
30
20
10
0
1960
1970
1980
1990
2000
YEAR

"AEC HAS PROPOSED A 10-20,000 MWE CAPACITY NUCLEAR POWER PARK to the Federal Energy Office as one of eight potential demonstration projects to help achieve the U.S. goal of energy self-sufficiency by 1980....

"An AEC draft feasibility study envisions a demonstration nuclear energy center containing 10-20,000 Mwe electrical capacity and fuel reprocessing, fabrication, waste management, and storage and related facilities. Such a facility would cost $5-10 billion in in private funds and a like amount of government money, the report said. The project could be initiated as early as 1977 if a site were selected next year, and while such centers would not contribute directly to the goal of energy self-sufficiency by 1980, AEC said they 'have the potential for accelerating the rate of growth of nuclear electrical capacity.' The earliest the first reactors in an energy park could be brought on the line would be 1985-90, it added. From an environmental standpoint, the concentration of nuclear power plants and related facilities should have less adverse impact than conventional diverse siting practices, the study said, but the environmental effect of the discharge of 20-80,000 Mw of thermal energy at a single location and the socio-economic impact would have to be assessed...."

------Nucleonics Week, February 28, 1974, p. 7.

Some additional assumptions are necessary before anticipated consumption can be translated into things to which one can more easily relate, e.g., number of power plants, acres of land committed to power plants and transmission lines, or increased air pollution. The most basic assumption is that on average as much electricity will be produced in Minnesota as is consumed in Minnesota. It must be recognized that it could be otherwise.

Some present developments could ultimately lead to the situation in which Minnesota would consume more electricity than is generated here. Because of Minnesota's posture on nuclear power, it is conceivable that Minnesota's utilities will, as NSP has done with their proposed nuclear complex announced for Durand, Wisconsin, site atomic power plants outside of Minnesota to produce electricity for sale in Minnesota. Likewise, Minnesota's utilities may turn increasingly to mine-mouth electrical plants located in the Dakotas, Eastern Montana, or Wyoming. Two of Minnesota's generation cooperatives, the Cooperative Power Association and the United Power Association, have announced plans to build such a unit. In this case, a power plant located in North Dakota and burning strip-mined lignite will transmit its electricity to Minnesota using high-voltage transmission lines.

It is also possible that electricity production in Minnesota would exceed consumption. For example, production of electricity by mine-mouth plants could be limited by availability of water in the West. Minnesota has water, and there is an existing railroad system connecting Minnesota with the western coal fields. Or, should the nation find nuclear power acceptable and turn to the development of large nuclear parks, the location of these parks would be to a large extent fixed by the availability of large quantities of cooling water. The first such nuclear park has recently been proposed

"FLOATING NUCLEAR PLANTS: POWER FROM THE ASSEMBLY LINE

"The still somewhat obscure concept of producing floating nuclear plants (FNP's) by assembly line methods and putting them offshore received a boost on 11 February at the International Energy Conference held in Washington. Addressing the delegates, William E. Simon, administrator of the Federal Energy Office, referred to nuclear power and the breeder reactor as an essentially inexhaustible energy source and, for the long run, as the most important answer to the energy problem. Simon then spoke of the FNP concept as of major significance even for the near term ...there is probably a better than ever chance that the first FNP's will be produced by 1980. Since 1971, Offshore Power Systems (OPS), a joint venture of Westinghouse and Tenneco, has been preparing to build a FNP manufacturing facility on the St. Johns River at Jacksonville, Florida ....Normally, two or more FNP's would be moored together in water of from 40 to 70 feet deep. They would be protected by a massive breakwater from storms and from ships that might stray off course.... The FNP sites must, at present, be within the U.S. territorial limits, which extend 3 miles from shore. One reason for this is that the Price-Anderson Act, which in the case of a nuclear accident would limit the liability of private insurers and the government to a total of $560 million, generally applies only to accidents occurring within the United States.

"OPS is interested in eventually establishing manufacturing facilities to serve markets on the Pacific Coast, along the Great Lakes, and abroad...."

------Luther J. Carter, "Floating Nuclear Plants: Power from the Assembly Line," Science, 15 March 1974, pp. 1063-1065.

by the Atomic Energy Commission. These parks would include fuel fabrication, fuel reprocessing, radioactive waste management and storage, and related facilities in addition to several power reactors. The first proposal speaks of ten to twenty reactors but notes that the sites seem to have the capacity to support twenty to forty reactors. Lake Superior is an obvious reservoir of cooling water in the North Central region. Plans for floating nuclear power plants on the Great Lakes have also been discussed.

Hence, there is a basis for argument that electricity production might be significantly less than, or more than, consumption in Minnesota. But assuming that on average production and consumption will be equal, the consumption projections can be translated into installed generating capacity and number of power plants, Table XX.

Depending on the type of cooling water system employed, and the choice of fuel, a 1000 MW plant requires between 1,000 and 3,000 acres of land. A source of cooling water is necessary, as is rail or barge access, transmission lines from the plant, and additional support facilities. The land-use commitment and the environmental implications are massive. If projected electrical growth continues, Minnesota must soon decide whether it will require the development of a few large energy parks -- with many generating units on a single site -- or whether it will permit the present policy of a proliferation of many small sites. This will not be an easy decision for there are strong arguments favoring both options. In addition, alternative land-use considerations will become increasingly important as pressures continue for maintaining agricultural land for agricultural purposes and recreational land for recreational purposes. During the process by which the Henderson power plant site was selected, the alternative of siting

TABLE XX

MINNESOTA ELECTRICITY CONSUMPTION, INSTALLED GENERATING CAPACITY, AND NUMBER OF POWER PLANTS -- 1950-2000

YEAR	CONSUMPTION Billions, Kw-Hr	INSTALLED CAPACITY Megawatts	APPROXIMATE NUMBER OF POWER PLANTS IN ADDITION TO 1970 PLANTS IF EACH PLANT WERE OF SIZE		
			500 MW	800 MW	1000 MW
1950	4.06	1,151			
1960	9.03	2,434			
1970	20.35	4,006			
1980	41	7,900	8	5	4
1990	85	16,300	24	15	12
2000	175	33,700	60	37	30

NOTES:

a. Consumption and installed capacity for 1950-1970 from MEP-74-1.
b. Consumption projections for 1980-2000 based on same assumptions as used for Figure 22.
c. Installed capacity for 1980-2000 assumes approximately the same ratio of installed capacity to consumption as for 1970.
d. The Monticello, High Bridge, Allen King, Black Dog, and each unit at Prairie Island plants are approximately 500-600 MW.
e. Each unit of the new Sherburne County plant and the proposed new coal-fired plant at Henderson, Minnesota are about 800 MW.
f. The largest individual plants now under construction, and each unit of the proposed nuclear plant at Durand, Wisconsin, are about 1000-1100 MW.

power plants in areas of the state having relatively few alternative uses was introduced but not seriously pursued. It is imperative that these considerations be fully explored.

Electrical generating plants in Minnesota could burn fossil fuels or be powered by atomic fission. The acceptability of nuclear power is being vigorously questioned in Minnesota and there is little evidence that this situation will change. Natural gas and oil will become increasingly scarce fuels for generating electricity. But coal is available.

The limiting case would be to assume that all of these plants were to be fired with low-sulfur, western coal which would be moved into Minnesota by unit train, Table XXI.

These considerations cannot be taken to be a precise forecast for the future. But they lead to the realization that continuation of the growth rates of the past -- the conventional business-as-usual forecast for the future -- implies a massive impact. We need only remember the controversy which surrounded the siting of power plants and transmission lines in the recent past to appreciate the stresses which would be associated with the siting of tens of additional power plants within the next few years.

Oil

As has been previously mentioned, Minnesota's refineries produce a significant fraction of Minnesota's consumption of heating oils and gasoline. These refineries are almost totally dependent on crude oil from Canada. Canada is modifying its energy policy, and there is reason to expect that Canada's exports of crude oil will experience a "gradual reduction." Where will Minnesota's refineries obtain their crude oil, and should they

TABLE XXI

COAL CONSUMPTION 1980-2000 WERE ALL NEW

MINNESOTA POWER PLANTS COAL FIRED

YEAR	PROJECTED ELECTRICITY CONSUMPTION BILLIONS Kw-hr	COAL BURNED MILLION TONS	APPROXIMATE NUMBER OF UNIT-TRAINS PER DAY
1980	41	20.6	5 1/2
1990	85	42.2	11 1/2
2000	175	87.5	24

NOTES:

a. Assumes heat rate of 10,000 Btu per kilowatt-hour
b. Assumes coal with heat value of 10,000 Btu per pound
c. Assumes 100 cars per train and 100 tons of coal per car
d. Assumes that trains will run 365 days per year

"Project Independence will also serve to improve our energy relationship by eliminating by 1980 much of our reliance on Canadian oil. We presently import approximately 1 million barrels of oil per day from Canada. It is now Canadian policy to reduce over time her exports to the United States. Canada has informed us that these exports will decline by approximately 500,000 barrels per day by 1976 or 1977. This will occur when the Inter Provincial pipeline is completed. This pipeline will convey to Canadian consumers east of the Ottawa Valley 500,000 barrels of oil per day which previously were available for export to the U.S. Project Independence will enable the United States to meet these shortages created by the Canadian decision to curtail exports.

"The Canadian National Energy Board has licensed for export to the U.S. approximately 1 trillion cubic feet of gas over the next 4 to 5 years. Any increase in supply will have to await significant increases in Canada's proved gas reserves. Project Independence gradually eliminates our need for Canadian natural gas. However, it is highly desirable for both nations to seek a greater degree of cooperation in the development and delivery of Canadian and American Arctic petroleum reserves. We will actively pursue this goal. We will continue to import Canadian natural gas beyond 1980 at a level consistent with this goal and in a manner that will encourage interest in, and joint development of Arctic resources."

------Federal Energy Office, "Project Independence: A proposed program for U.S. energy self-sufficiency by 1980," a staff paper, February 8, 1974, pp. 104-105.

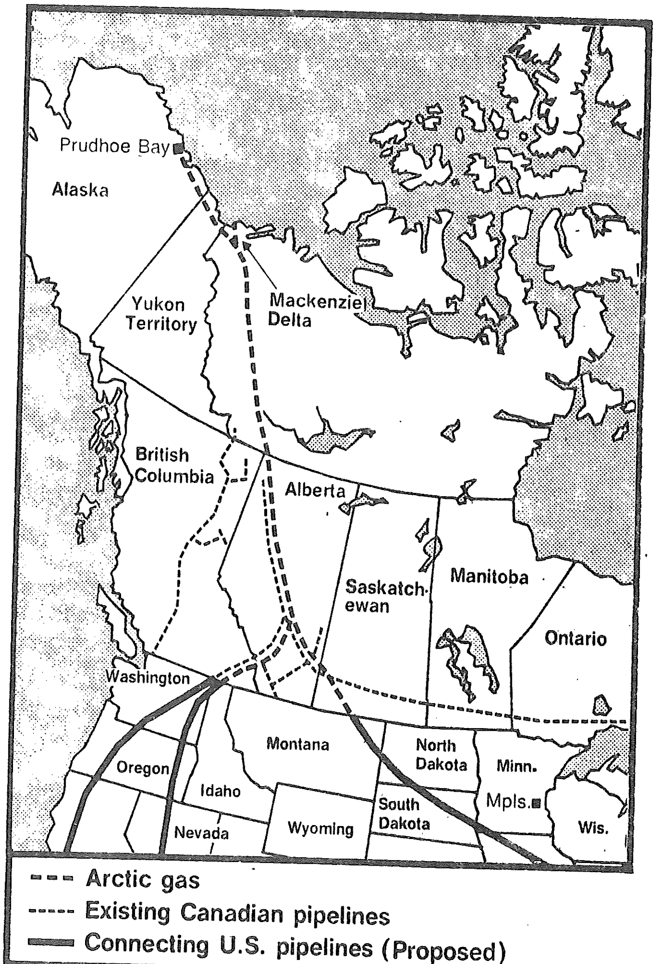
not find a source of supply, how might that affect petroleum availability in Minnesota and its neighboring states?

A related consideration is the location and operation of pipelines from Alaskan oil fields. It has been decided that the first pipeline from Alaska's North slope will pass through Alaska to the Pacific coast. It is clear, however, that there will be several more pipelines from Alaska to the lower forty-eight states. Where will these terminate? Will they pass through Minnesota, and if so when might they be expected and what are the implications for the expansion of oil refining in Minnesota?

Because of partial interchangeability of fuels, consideration of natural gas and synthetic natural gas are closely related to future oil availability.

Natural Gas

Northern Natural Gas Co., which supplies over 95% of Minnesota's natural gas, has recently announced that beginning with a ten percent reduction over the next two years all gas supplies to large-volume users will be terminated by 1979. This will mean an annual shift in Minnesota of 85 billion cubic feet of gas from the large-volume users -- enough to supply about 280,000 residential customers for twelve months. This is equivalent to the heating value of some 650 million gallons of home heating oil, or over 40% of the fuel oil consumed in Minnesota in 1973.
What fuel will compensate for this change in the natural gas market? To what extent will the demands of the affected large-volume users erode into the already tight supplies of distillates for the residential, or small commercial and industrial sectors? Finally, although the announcement from



Route of proposed gas pipeline

A consortium of 27 firms has asked government approval for a $5.7-billion pipeline, 2,600 miles long, to transport natural gas from Alaska's North Slope and the Mackenzie Delta in Canada. The pipeline would start moving gas from the Mackenzie Delta by 1978 if the U.S. and Canadian governments approve the route by 1975.

---<u>Minneapolis Tribune</u>
March 23, 1974, p. 12A

Northern Natural Gas does not address the point, it would appear that after 1979 there could be further curtailment of natural gas supplies which can only mean decreasing the availability of natural gas for new, and possibly existing, residential and small commercial users.

Searching for possible alternative sources of natural gas gives little encouragement in the near term. The three most promising prospects will not be available until about 1980 at best. It is thought that there is about as much natural gas in Alaska as there is oil, and the most promising route for the first natural gas pipeline from Alaska is across Canada passing through or near to Minnesota. But this pipeline has not yet been announced and construction would take several years after finalization of the plans. Should there be finds of natural gas and oil in as yet unexplored parts of the Outer Continental Shelf, this gas could be brought to Minnesota as to the rest of the nation. But this source too is several years away. The other alternative is synthetic natural gas (SNG) from coal. Although pilot plants are in operation, and the first commercial plants have been announced, there is little expectation that SNG will be available before the early 1980's.

There must be prompt and careful attention given to the implications of reduced supplies of natural gas considered in conjunction with the substantial uncertainties in the future availability of oil.

As has been noted, the curtailment of natural gas supplies to large users will achieve its desired goals only if storage facilities are constructed such that gas delivered to Minnesota in the summer is available to small users during the heating season. It has been reported that several tens of billions of cubic feet of gas might be involved. Minnesota

"NORTHERN NATURAL AUTHORIZED TO BUILD $16.4 MILLION LNG PEAK SHAVING PLANT

"The Federal Power Commission today authorized Northern Natural Gas Company, of Omaha, Nebraska, to build a $16,413,000 liquified natural gas peak shaving plant in Minnesota.

"Northern will build the plant in Carlton County, Minnesota, for the liquefaction, storage and vaporization of additional supplies of gas needed to meet the winter peak requirements of its utility customers.

"The new plant will be designed to liquefy natural gas at a rate of 10 million cubic feet daily for storage in a 630,000 barrel double-wall above-ground tank with a net capacity of 2 billion cubic feet equivalent of natural gas. The vaporization and send-out rate will be 200 million cubic feet daily.

"The facility will be built in a rural area of Carlton County with few nearby residences. As a result, the FPC said there is little danger that plant activities will affect the public.

"The FPC conditioned its approval to require that:

- After the plant becomes operational, Northern is to file semi-annual reports describing facility operations with the FPC within 45 days following each March 31 and September 30. The FPC is to be notified at once of any abnormality which might endanger the facility or operating personnel;
- Any significant changes in the facility are to be reported to the FPC promptly;
- Near the close of construction, a final inspection of the facility will be conducted by the Commission's staff, or by a designated consultant;
- Within six months, Northern is to file contingency plans for the rapid disposal of LNG contents of the tank when sensors indicate a threat of tank failure, and for notifying the public of a pending or existing threat to safety;
- Today's authorization will not become effective until all necessary Federal, State, and local authorizations, if any, have been secured; and
- Northern is to advise the Commission of all changes in design and construction techniques, and of any safety rules it may adopt which impose higher or different safety standards than are required by the regulations of the Department of Transportation's Office of Pipeline Safety."

------Federal Power Commission press release, February 5, 1974, Number 20036, Docket No. CP73-287, Northern Natural Gas Co.

at present has only one large natural gas storage facility, and it has a reported ultimate capacity of 3.7 billion cubic feet. Natural gas can be stored in two ways -- either as gas or after being liquefied. Our present storage facility is for gas which is pumped into underground rock formations. The Federal Power Commission has recently authorized Minnesota's primary supplier of natural gas, Northern Natural Gas Co., to construct the first large liquefied natural gas facility in Minnesota. This plant will be designed to liquefy gas at a rate of 10 million cubic feet per day for storage in an above-ground tank having a net capacity of 2 billion cubic feet equivalent of natural gas. These liquefied natural gas facilities must be sited with care for they pose certain safety problems.

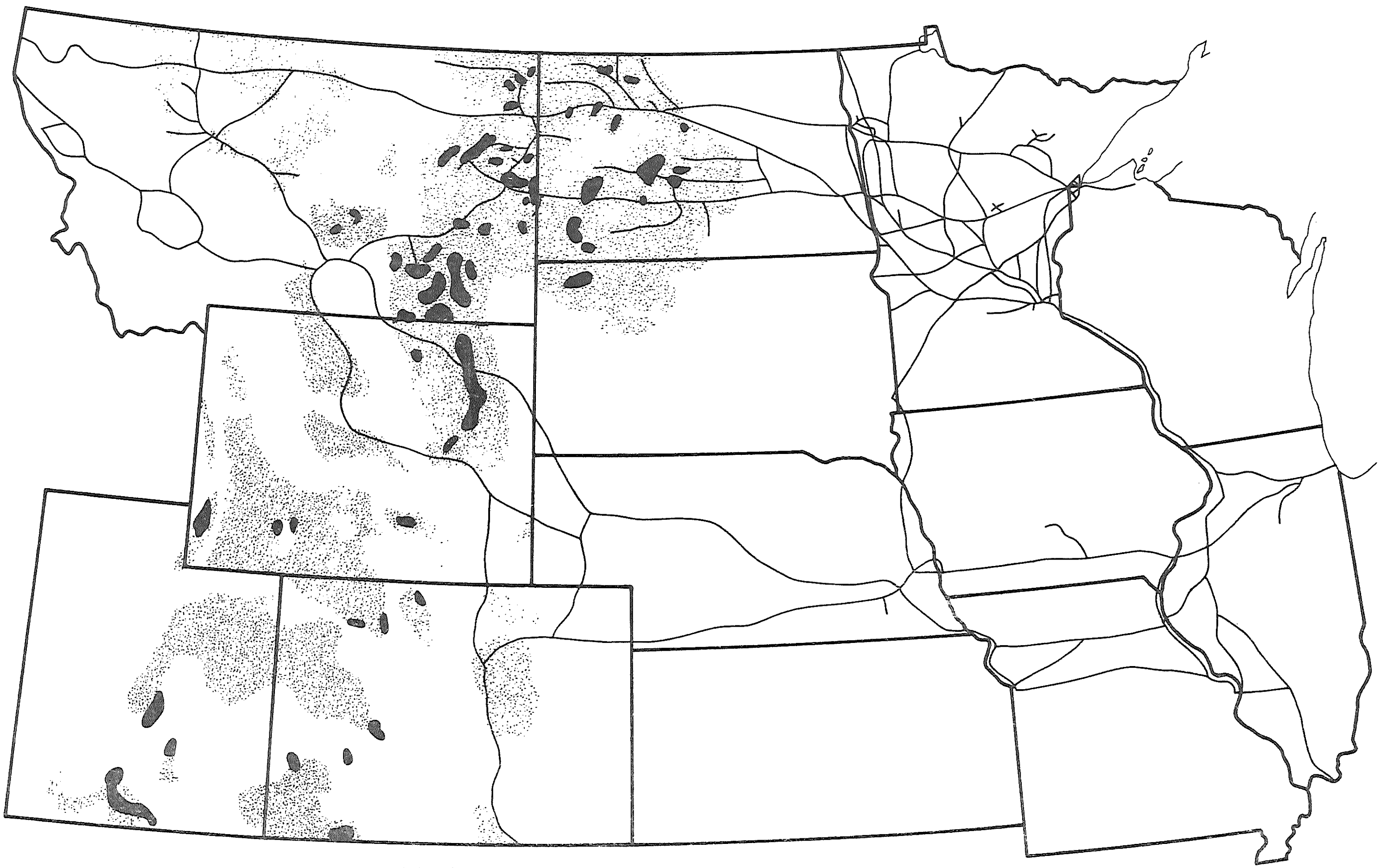
Coal

Coal is found in many states, but a large fraction of the low-sulfur coal is found in the West. Published data indicate that tens of billions of tons of low-sulfur coal is recoverable at current prices and with current technology. A glance at the location of the Burlington-Northern tracks in comparison with the locations of the strippable coal reserves of the Dakotas, Montana, and Wyoming, Figure 23, suggests that large quantities of strip-mined coal might move through Minnesota on its way not only to Minnesota's electric utilities and other industries, but also to coal users to the east. Burlington-Northern has already announced a ten million ton per year capacity dock facility in the Duluth-Superior harbor. There are plans for transfer facilities on the Mississippi River as well.

A recent study of the National Academy of Sciences has included a summary of the estimates of the coal that might be strip-mined in the

FIGURE 23

WESTERN STRIPPABLE COAL RESERVES AND BURLINGTON NORTHERN RAILROAD



Railroads

Generalized location of strippable reserves

Areas of coal reserves

Source: Burlington Northern
National Academy of Science, National Academy of Engineering Draft Report, 1973

"COAL AND THE TWIN PORTS

"...coal shipments into Duluth-Superior dropped from a peak of 12.6 million tons in 1923 to 894,140 tons in 1972.

"Now comes word that the country's rising demand for low-sulfur coal is soon to bring new life to the Twin Ports, but this time as an export -- to lower lake ports and overseas -- rather than the import it was in earlier decades. Sparking the turnaround will be a new $25-million dock facility to be built by Burlington Northern Railroad on the Superior side of the inner harbor. The project, which is being designed for an annual capacity of 10 million tons, will be started this spring, with completion planned for early 1976. A second company, Detroit Edison, Co., is planning construction in the Twin Ports of a huge coal-carrying freighter and the possible building of three or four more.

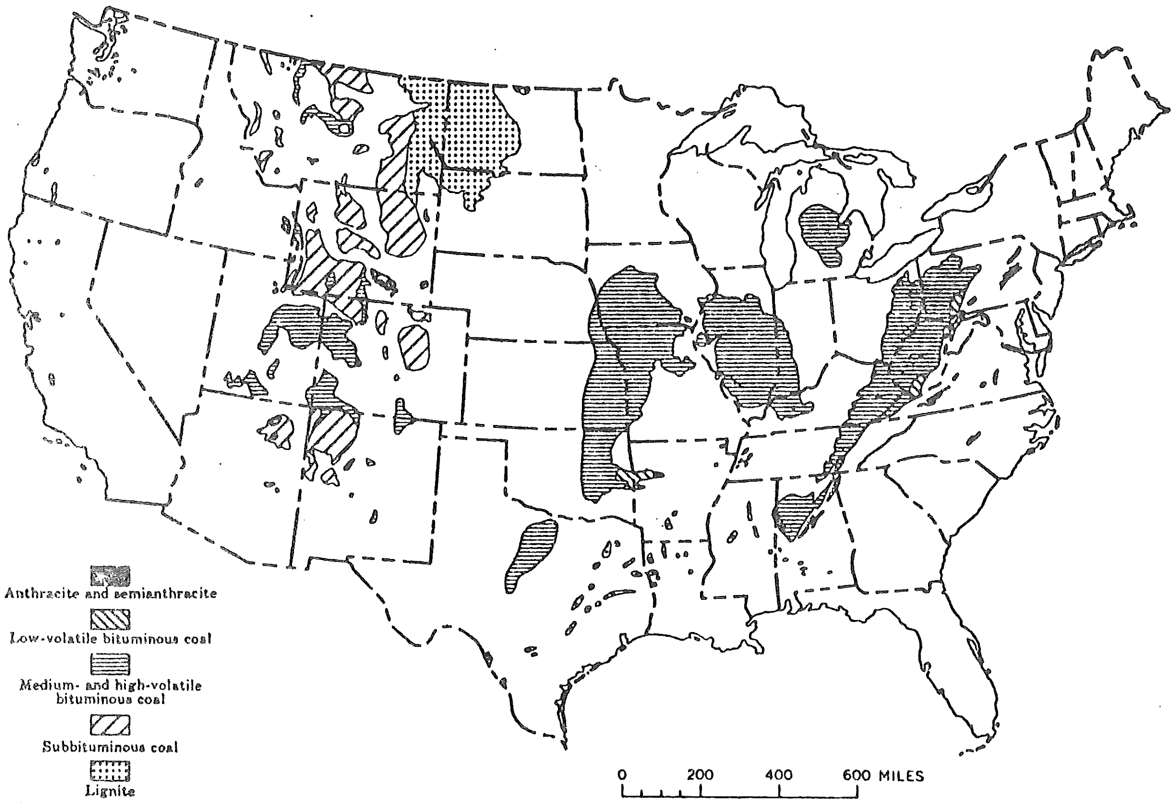
"Low-sulfur coal means energy for Minnesota. It looks now as it will bring other benefits to the State as well."

-------MINNEAPOLIS TRIBUNE, January 13, 1974, Editorial.

Dakotas, Montana and Wyoming through the year 2000, Table XXII. These estimates do not include coal that might be used for production of synthetic natural gas, nor do they reflect the increases in coal utilization that are part of Project Independence. The magnitude of the coal traffic which would result from the exploitation of these reserves of low-sulfur, strippable, western coal is impressive. Noticeable increases in train traffic, or in river barge traffic, in Minnesota could occur, Table XXIII.

Western coal will also be converted to either electricity or synthetic natural gas at facilities located in or near the coal fields. The electricity and synthetic natural gas would then be moved to load centers by high-voltage transmission lines and gas pipelines. If one looks at a map and begins to draw lines representing possible transmission line routes between the Montana and Dakota coal fields and the load centers to the east, a considerable number pass through Minnesota. The associated land commitment and visual impact is considerable and should not be taken lightly. Although pipelines do not leave the lasting scar of electrical transmission lines, their location and construction will be of interest to large numbers of Minnesotans.

There are other ways that these coal-related developments could impact Minnesota. Both electrical production and conversion to SNG require large amounts of water, and water is scarce where western coal is found. There are three possible solutions to this problem: (1) development of less water-intensive technologies, (2) transport of additional water to the coal sites, or (3) transport of coal to electrical plants or gasification facilities located on bodies of water. The first of these options is certainly a possibility, particularly in the case of the mine-mouth



"LIGNITE HAS ITS DRAWBACKS -- BUT IT'S CHEAP

"Besides open space, the one thing North Dakota has plenty of is lignite....

"...present plans for lignite-fire power plants will barely scratch the surface of lignite's potential. 'One-third of the recoverable lignite reserves can supply all the power needs from Winnepeg down to Omaha and from the Twin Cities out to Denver - for 40 years,' exclaims Andrew L. Freeman, general manager of Minnkota Power Cooperative, which recently opened a 235-Mw. plant in Stanton, N.D., next to a major lignite field...."

------Business Week, March 16, 1974, p. 102

"STRIP-MINING HANGOVER

"I have just returned from a wonderful trip through North Dakota, from the Red River Valley to the Little Missouri grasslands and the ranches beyond Theodore Roosevelt National Memorial Park.

"In West Virginia we have seen our precious soil ripped and ravaged by strip-mining and our people exploited and impoverished by coal interests taking huge profits out of the state without helping the people....

"Huge coal gasification plants consuming massive amounts of precious water, fed by lignite strip-mined from vast acreages, will bring a very temporary illusion of a boom followed by a bust. It is like taking several strong drinks in a row: 'You're riding high for a brief period, but the hangover comes when the coal is gone, the land is gone, the jobs are gone and the bitter truth of the morning after leaves you with a mouthful of ashes....'"

------A letter from Representative Ken Hechler (D-W.Va.) to the Grafton, N.D., RECORD, reprinted in MINNEAPOLIS TRIBUNE, March 18, 1974

TABLE XXII

PROJECTED SURFACE-MINED COAL PRODUCTION THROUGH 2000
(WYOMING, MONTANA, DAKOTAS)

(Does not include coal to be used for gasification or conversion into synthetic liquid fuels)

STATE	1972 (actual)	1975	1980	1985	1990	1995	2000
		(Million tons per year)					
Montana	8	10	20	30	40	48	58
N. Dakota	6.8	7.5	8	9	10	18	28
S. Dakota	0	0	0.5	1	1	1	1
Wyoming	9	18	28	36	40	48	58
TOTAL	23.8	35.5	56.5	76	91	115	145

TABLE XXIII

TRAINS PER DAY, AND RIVER BARGES PER YEAR AS A FUNCTION OF PERCENTAGE OF PERCENTAGE OF ANTICIPATED STRIP-MINED COAL FROM THE DAKOTAS, MONTANA, AND WYOMING

Year	Total production of strip-mined coal, million tons	Approximate number of 100-car unit trains per day, for following percentages of coal moved by train			Approximate number of river barges per year were 10% of the coal moved by barge
		100%	50%	10%	
1975	35.5	10	5	1	2,300
1980	56.6	16	8	1 1/2	3,700
1985	76	21	10	2	5,000
1990	91	25	12	2 1/2	6,000
1995	115	32	16	3 1/4	7,600
2000	145	40	20	4	9,600

NOTES:

a. Estimated coal production taken from Table XXIII.
b. Assumed 100-car trains, with each car containing 100 tons of coal.
c. Assumed each river barge contains 1500 tons of coal.

"The shortage of water is a major factor in planning for future development of coal reserves in the American West. Although we conclude that enough water is available for mining and rehabilitation at most sites, not enough water exists for large scale conversion of coal to other energy forms (e.g., gasification or steam electric power). The potential environmental and social impacts of the use of this water for large scale energy conversion projects would exceed by far the anticipated impact of mining alone. We recommend that alternate locations be considered for energy conversion facilities and that adequate evaluations be made of the options (including rehabilitation) for the various local uses of the available water."

------National Academy of Sciences/National Academy of Engineering, REHABILITATION POTENTIAL OF WESTERN COAL LANDS, recommendation No. 8, draft pp. 10-11, 1973.

electrical plants, but the other options are more probable. The option of moving water to the coal should not be generally discounted, but may prove to be impractical for a variety of reasons both technical and institutional. The option of moving coal to electrical plants or gasification facilities located on the Upper Mississippi River or Missouri drainage is a very real prospect. The land-use and environmental implications to Minnesota deserve serious attention.

Both mine-mouth electrical generation and coal gasification plants located to the west of Minnesota involve the atmospheric release of sulfur-oxides. To be sure, the coal is initially low-sulfur and sulfur removal techniques may be employed, but at least part of the impetus for locating such plants in the relatively sparsely populated western coal fields is that air quality requirements may be significantly less stringent than those applied to coal utilization near load centers. The situation is similar to that existing in northern Europe where large quantities of coal are burned in England and Germany with subsequent sulfur-oxide releases. The prevailing winds carry the sulfur compounds towards Scandinavia. This has resulted in steadily advancing fronts of acid rain which began in Southern Sweden and have steadily advanced northward. The acid rain has resulted in damage to land, forests, and lakes. This is a long-term, chronic effect and there is no obvious reason to think that a similar situation would not develop downwind of any major sulfur-oxide source. It should be remembered that the prime agricultural region of the Great Plains has a similar climatic orientation to the western coal fields. Whether or not similar sulfur-oxide releases in these areas should be of concern to Minnesota has not been established. However, the potential exists and should be explored before, rather than after, the fact.

Rising Energy Prices

Other than differences related to the transportation of the fuels themselves into Minnesota, there is no reason to expect that Minnesotans will be faced with higher energy prices than prevail elsewhere in the nation. There may be secondary, and disadvantageous, impact on Minnesota and other states similarly situated. The location of any industrial facility depends upon many factors, including the distance from the source of the raw materials and the distance to markets. Minnesota is not in an advantageous position with regard to these factors. Increasing energy prices, and the implied increase in transportation costs, could influence decisions to locate, or maintain, some types of industrial activities in Minnesota.

Another obvious differential impact of rising energy prices is associated with the need for space heating. Although it might provide comfort, air conditioning is in most cases not essential. Heating must be regarded as essential given the reality of Minnesota winters. To the extent that space heating is a factor in either commercial or industrial operations, fuel prices will become increasingly important in differential judgments.

Increasing scarcity of energy, and rising concern with the efficiency of energy use, could also have an impact on the mix of industrial activity in Minnesota simply because of shifts in demand for various products. Firms making insulation should expand as should the activities of those building trades associated with reducing heat loss from buildings. Firms making inefficient appliances or energy-intensive recreational vehicles may contract. Some effort should be given to an examination of the prospects for the various economic activities in Minnesota.

Increasing scarcity of energy will have a major impact on agriculture. Minnesota is an agricultural state and these impacts must be understood. The net impact is unclear. On the one hand the nation will rely more and more heavily on agricultural exports to pay for increased imports of fuels. To the extent that this causes increased prices for agricultural products, it will be a benefit to Minnesota agriculture. On the other hand, modern agriculture is energy-intensive requiring large energy inputs both directly as fuel and indirectly as fertilizers, chemicals, and heavy machinery. Increasing energy scarcity and rising prices of agricultural products may dramatically alter present agricultural practices and lead to major shifts in the production of various crops.

Development of Alternative Energy Supplies

State responsibility has not extended to supporting the development of energy supplies, except in rather unusual instances. Minnesota has no deposits of conventional fuels, but it has at least three heretofore untapped energy sources: solar, peat, and urban and agricultural wastes. The State should give serious consideration to supporting the development of these energy sources -- at least to the extent that federal or private resources are not made available.

There are several reasons why this sould be a desirable course for Minnesota. Any state without fuel resources will be dependent on supply lines which could, for a variety of reasons, be interrupted. Reliance on local fuel and energy supplies could provide a stable base of energy supply. The use of solid wastes for productive purposes has been recognized as desirable for reasons other than their energy content, but the energy content alone is of increasing importance. To the extent that wastes can be recycled in more desirable ways than by burning or conversion to fuels, they should, of course, be recycled. But in many cases, extraction of energy from these wastes is the most attractive means for recycling. The State should use the policy tools at its disposal to encourage these developments. The advantages of solar energy use have been considered earlier. But in summary: it is a known technology for space heating, water heating, and other local uses of energy; it is resource-conserving, and although capital-intensive in its installation, it will provide protection against the expected increase in fuel prices; and the production and service of solar heaters or solar air conditioning units could provide economic activity in Minnesota.

Finally, Minnesota's entry into energy supply activities could result in a protection of the State's interests through a demonstration of concern independent of the Federal government.

Regulatory Responsibilities

A number of regulatory responsibilities, in addition to land-use and environmental control, are becoming increasingly associated with energy supply. Although allocation of available natural gas supplies is currently in the hands of the Federal Power Commission, it is conceivable that the states will have responsibilities in this area similar to their responsibilities for petroleum.

A more traditional function, the regulation of the energy utilities, had been considered in Minnesota for many years but nothing was acted upon until this year. Although some argued that the absence of a state utility regulatory commission was further evidence of the enlightened condition of Minnesota politics, there are valid arguments for the establishment of such regulatory authority. This authority overlaps with energy conservation

"Before we begin the question and answer session, I want to pose to you some of the questions that we as a Nation are going to have to ask of ourselves and answer for ourselves.

"These are questions of values, political questions about some of the choices and trade-offs we will have to make, not only in our lifestyles, but in our styles of government:

- Do we strip-mine North Dakota to air-condition New York?
- And who decides that? Dakotans, whose land we might be destroying? Or all Americans, who might benefit from the energy?
- Do we put a ban on all housing and buildings that don't conform to certain housing standards for energy-saving insulation?
- And if it raises the cost of housing still further, where do the poor live? Even Abe Lincoln's cabin wouldn't pass modern housing standards.
- Do we put limits on the right to own a car that guzzles gas?
- Do we continue to allocate energy to those who can pay for it, and let what hardships may fall upon those who cannot?
- Or do we allocate energy based upon need? And what is need? Does a rich man with a 20-room house <u>need</u> more energy to stay warm than a poor man in a one-room apartment? If not, do we tell a man who has put his life's savings into a large home for his family that he won't be able to heat it?
- In general, where does the government get off, and where does the market take over in allocating scarce energy supplies?

"...the answers we choose will be answers for <u>all</u> the people. Some of those answers, like whether or not we strip-mine our farmland, will be with us for all time. We'd better start getting the people involved in the answering. It won't be any problem to get the special interests involved."

------Remarks by the Honorable John C. Sawhill, Deputy Administrator, Federal Energy Office, the Washington Journalism Center, March 6, 1974.

programs. Regardless of changes in the energy supply picutre, it is a certainty that increasing attention will be given to more efficient end uses of energy, and to the development and implementation of energy conservation programs. It is naive to expect that meaningful energy conservation measures will be adopted without regulations and the imposition of performance standards. Whether or not these regulations or standards originate from federal action, there will be a major role for the states. The energy conservation bills which have been introduced into the 1974 session of the Minnesota Legislature should be regarded as only the first in a series of such measures. Building codes can be modified, purchasing practices can be changed, some energy uses might be prohibited, but in every case the total energy costs of actions must be given consideration. A variety of policy tools will be needed to achieve the desired end of energy conservation, such as taxes, performance standards, and financial incentives.

Other Developments

These illustrations only scratch the surface of the potential energy related developments in Minnesota during the next few years. No attempt has yet been made to set forth in any detail the structure of the electrical industry, the location of the new pipelines or transmission lines, or the development of fuel storage facilities. In addition, there is a need to assure some measure of coordination between the several fuel systems.

The list of things which might influence, or be affected by, energy decisions is very long. A short list of examples might help to give a feeling for the kinds of things which need consideration. Population increases might affect energy demands, or high energy prices or prolonged shortages might increase out-migration. The attractiveness of the State as a place to locate or maintain an industry might be affected by increased transportation costs or fuel shortages. Recycling programs, too, might affect Minnesota's industries, especially forest products and mining. On the other hand, changes in energy supply could provide a base for the development of new local industries. The maintenance of high levels of agricultural production will be greatly affected by energy prices and supply. Any decision might affect the general quality of life in Minnesota, and in each specific case the specific associated impacts must be considered.

To be sure many of these questions are as real for other states as for Minnesota, but there is little indication that state or regional problems are being given any particular attention in energy related studies being conducted at the national level.

A Final Consideration

The State should consider the proposition that choices are often made for those who do not choose. Minnesota can influence its future, or it can be herded into the future on the basis of decisions by the federal government or the energy companies.

APPENDIX A

FOR FURTHER READING

There are now a very large number of books, reports, and articles dealing with energy technology and energy policy. Several of these reports have been used in the writing of this report. They are cited either as references to the tables and figures or as the source of the several quotes reproduced on the back sides of some of the pages of this report.

Three reports that should be of particular interest to the general reader who is interested in energy policy options are:

(1) Ford Foundation Energy Policy Project, EXPLORING ENERGY CHOICES, The Energy Policy Project, P.O. Box 23212, Washington, D.C. 20024 (paper, 75 cents a copy or 60 cents a copy for orders of 50 or more - all orders must be prepaid).

> This is by far the best discussion of energy policy choices that has yet been written. It is the preliminary report of the Energy Policy Project. A final, book-length, report will be issued in the fall of 1974 and about 18 technical reports will be issued by the project between April and October 1974. Detailed information about the other reports can be obtained by writing the project or its publisher: Ballinger Publishing Company, 17 Dunster St., Cambridge, Massachusetts, 02138.

(2) Chase Manhattan Bank, OUTLOOK FOR ENERGY IN THE UNITED STATES TO 1985, paper, 1973 (Available without charge from the bank).

> This report is short, very well written, and presents as lucid an account of the conventional view of the energy future as is available.

(3) Allen L. Hammond, William D. Metz, and Thomas H. Maugh, ENERGY AND THE FUTURE, American Association for the Advancement of Science, 1973.

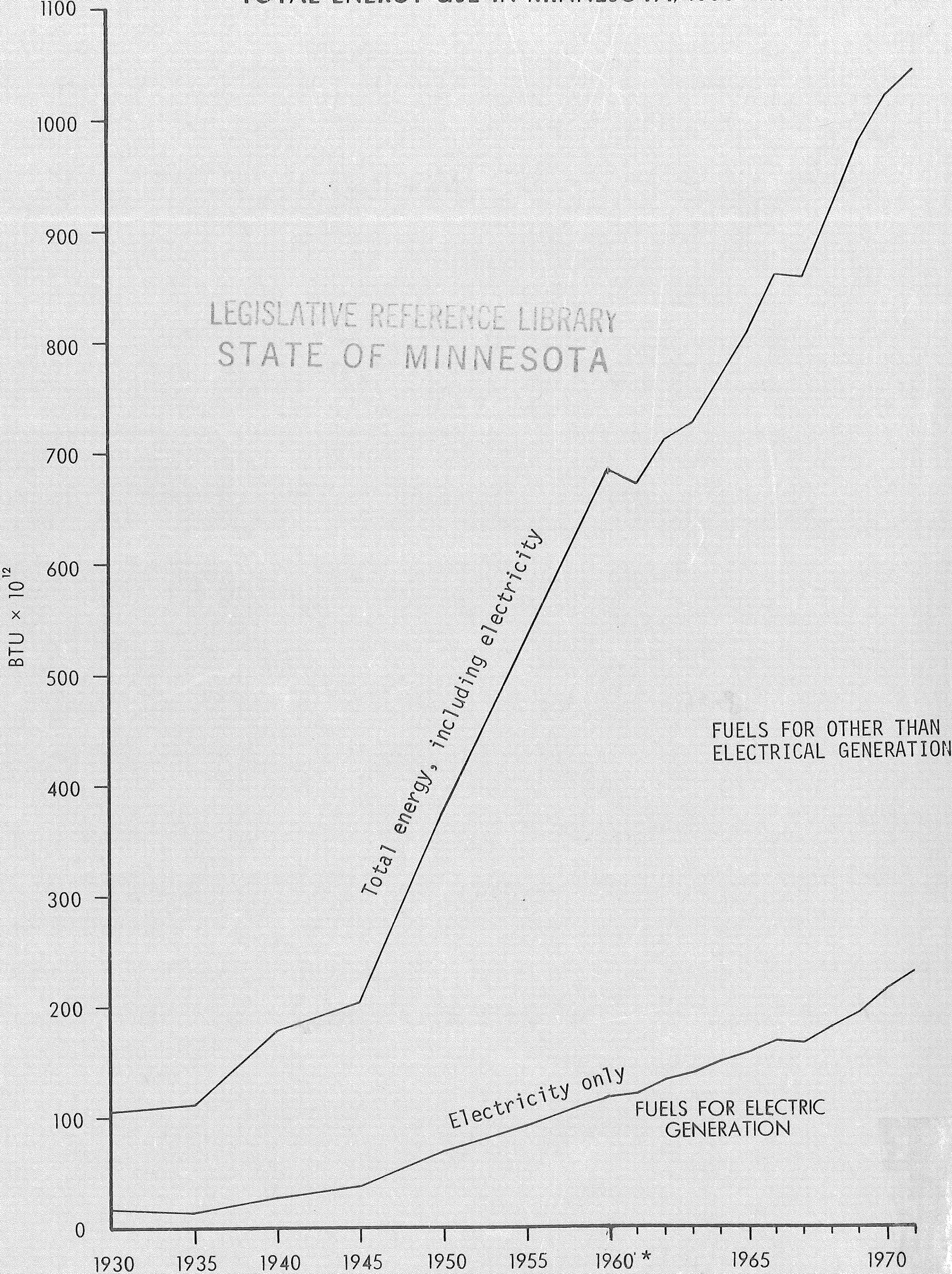
> This book concentrates on the more technical aspects of energy supply and demand. Essentially all alternative energy supply options, both those available now and those in various stages of research and development, are discussed. Although technical material is presented, it is done in a way to be readable by the general reader. It is an excellent book.

APPENDIX B

SOURCES AND REFERENCES FOR THE TABLES IN THIS REPORT

I	1973 preliminary data, U.S. Dept. of the Interior, Bureau of Mines (reported in Weekly Energy Report, March 11, 1974) 1990 estimates, U.S. Congress, Joint Committee on Atomic Energy, Understanding our Energy Dilemma, August 1973
II	1950, 1960, 1970 data and 1980 and 1990 estimates from Joint Committee on Atomic Energy report noted above. 1973 preliminary data from U.S. Dept. of the Interior, cited above.
III	Sam Schurr, editor, ENERGY, ECONOMIC GROWTH, AND THE ENVIRONMENT, Johns Hopkins Press, 1972, p. 158
III-A	Chase Manhattan Bank, OUTLOOK FOR ENERGY IN THE UNITED STATES TO 1985, June 1972, p. 27
IV, V, VI, VII & VIII	Stanford Research Institute, PATTERNS OF ENERGY CONSUMPTION IN THE UNITED STATES, Office of Science and Technology, Government Printing Office, Washington, D.C., January 1972
XI & X	Chase Manhattan Bank, report cited above
X-A, XI, XII & XIII	U.S. Department of the Interior, UNITED STATES ENERGY FACT SHEETS, February 1973
XIV, XV, XVI, XVII & XVIII	Steven Emmings, MINNESOTA: HISTORICAL DATA ON FUELS AND ELECTRICITY, Minnesota Energy Project report MEP-74-1 (preliminary draft), January 21, 1974 and U.S. Department of the Interior, report cited above
XIX	Minnesota State Planning Agency, MINNESOTA HOUSING CHARACTERISTICS, (from the 4th Count Summary Tape, 1970 Census), State Planning Agency and Minnesota Analysis and Planning System, St. Paul, 1973
XX & XXI	Derived as noted in text and in notes below the tables
XXII	National Academy of Sciences, REHABILITATION POTENTIAL OF WESTERN COAL LANDS, Washington, D.C., 1973, Table 3.6 (primary source documents cited in the NAS report)
XXIII	Derived, see notes below the table

TOTAL ENERGY USE IN MINNESOTA, 1930 - 1971



*Note that from 1930 to 1960, 5-year intervals are shown. From 1960 to 1971, the interval changes to one year.

MINNESOTA ENERGY PROJECT