MINNESOTA ENERGY PROJECT

Minnesota: Energy Used By Selected Public Services

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REPORTS OF THE MINNESOTA ENERGY PROJECT

FINAL REPORTS: These reports are available from the State Planning Agency.

MEP-74-15 Minnesota: Energy Requirements for Crop Production (Dec. 74)

MEP-74-16 Minnesota: Energy Used by Selected Public Services (Dec. 74)

MEP-74-17 Energy Demand Forecasting (Dec. 74)

MEP-74-18 Minnesota: Historical Data on Fuels and Electricity (Dec. 74)

MEP-74-19 Minnesota: A Primer on Energy Policy (Dec. 74)

DRAFT REPORTS: These reports are not generally available as they were printed only in limited quantity (for further information contact the State Planning Agency).

MEP-74-1 Minnesota: Historical Data on Fuels and Electricity (Jan. 74)

MEP-74-2 Minnesota: Energy Use in Schools (Feb. 74)

MEP-74-3 Minnesota: Energy Use Totals and Conversion Factors (Feb. 74)

MEP-74-4 Minnesota: Energy Requirements for Crop Production -- The Example of Field Corn (April 1974)

MEP-74-5 Minnesota: A Primer on Energy Options and Implications (April 1974)

MEP-74-6 Minnesota: Energy Requirements for Correctional Institutions (April 1974)

MEP-74-7 Minnesota: Energy Use in Colleges and Universities (May 1974)

MEP-74-8 Minnesota: Energy Use in Hospitals (May 1974)

MEP-74-9 Minnesota: Energy Use in Nursing Homes (May 1974)

MEP-74-10 Minnesota: Energy Use in State-Operated Health Facilities (May 1974)

MEP-74-11 Minnesota: Energy Use for Municipal Wastewater Treatment (July 1974)

MEP-74-12 Minnesota: Energy Use in Public Water Works (July 1974)

MEP-74-13 Minnesota: Energy Use for Fire Protection (June 1974)

MEP-74-14 Minnesota: Energy Requirements for Crop Production (Six Major Crops) (June 1974)

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FOREWORD

The purpose of this report is to provide data on the use of energy by certain selected public services. The report treats four areas of public service: educational, health, public safety and municipal services. The objective was to determine just what percentage of our state energy consumption is devoted to these important services.

The Minnesota Energy Project (MEP) was conducted by the All-University Council on Environmental Quality under contract with the Minnesota State Planning Agency. Included in the tasks undertaken by MEP were: a compilation of past energy supply data for Minnesota; a "primer" setting forth some general energy policy considerations with emphasis on Minnesota; a study of agricultural uses of energy in Minnesota; a study on projecting future energy demand; and this report on the energy used by various public institutions in Minnesota (schools, universities, correctional institutions, hospitals, ...). A complete listing of MEP reports, both preliminary drafts and final reports, is found on the inside front cover. All are reports of the Minnesota Energy Project to the Minnesota State Planning Agency.

The work and enthusiasm of the MEP staff must be acknowledged. Without their dedication, the project could not have been done. They were: Research staff -- Mr. Sam Rankin, Mr. Steve Emmings, Mr. John Gostovich and Mr. Chuck Sobiek; and Support staff: Ms. Clara Hurd and Ms. Linda Bick. Also, without the support of our contract officer, Edward Hunter, Deputy Director of the Minnesota State Planning Agency, there would have been no MEP.

Dean E. Abrahamson
Director, Minnesota Energy Project

FOREWORD

In the early summer of 1973, the State Planning Agency, after consultation with the Governor of Minnesota and the Minnesota Legislature, agreed to add the energy issue to its work program for fiscal year 1974. As a major part of this endeavor, the Agency requested the assistance of the All-University Council on Environmental Quality at the University of Minnesota. The reports in this series are the result of the work of the All-University Council, under contract to the State Planning Agency.

These reports, and the information and data contained therein, are intended as tools for planners and decision-makers, particularly in state and local government. It is also intended that they serve as a stimulus to further work in assessing the outlook for energy demand and supply and the design of appropriate state policies.

The opinions expressed in the reports are those of the investigators and do not necessarily reflect the position of the State Planning Agency.

A. Edward Hunter
Deputy State Planning Director

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INTRODUCTION

In the highly interdependent lifestyle of 20th century America, a change in character or function of any one sector of the economy has an impact upon all other sectors. One of the most vivid recent examples of widespread concern resulting from the disruption of one component of economic balance has come to be known as the "energy crisis." Many people have expressed a legitimate concern about the effects of energy shortages on the functional ability of activities serving important public needs. Of course, concern is also expressed for such other aspects of contemporary economic life as levels of unemployment, corporate and business profits, the financial impact on households (especially those with relatively fixed incomes), and possible changes in traditional patterns of mobility.

One task of the Minnesota Energy Project was to select certain services of importance to the public and determine the types and quantities of energy they have consumed in recent years. Such services fell into the broad categories of education, health, public safety, and other municipal services.

Table 1 contains a summary of the amounts of electricity and total energy used by the selected services in 1971, 1972, and 1973. The fraction of electricity sales and total state energy use accounted for by each of the selected public services is also found on Table 1. A more detailed breakdown of energy use by each public service is offered in the text that follows.

A few services that could logically have been included in the study were omitted -- some at the planning stage and others after the study was well under way. Local law enforcement agency energy use and energy use in doctors' offices and clinics were omissions necessitated at the design stage by complications in gathering satisfactory data. Ambulance service energy use was one area where attempts were made to gather information, yet the returns were so spotty as to be entirely unreliable. The entire areas of public transportation, street lighting, and traffic control were omitted from the MEP study. For these reasons it must be understood that the present report is not a comprehensive analysis of all energy consumed for public benefit.

FRACTION OF MINNESOTA ELECTRICITY SALES AND TOTAL ENERGY GOING TO SELECTED PUBLIC SERVICES

(in per cent)

	1971		1972		1973	
	Elec Sales	Btu Total	Elec Sales	Btu Total	Elec Sales	Btu Total
Educational Services						
Schools, Public & Private (K-12)	2.56	2.30[a]	2.80	2.53[a]	2.80	2.46[a]
Colleges and Universities	1.77	1.09	1.77	1.12	1.73	1.07
Total Education	4.33	3.39	4.57	3.65	4.53	3.53
Health Services						
Hospitals	1.38	0.95	1.35	0.96	1.42	0.99
Nursing Homes	0.42	0.32	0.43	0.34	0.46	0.35
State Operated Health Facilities	0.21	0.25	0.20	0.24	0.19	0.22
Total Health	2.01	1.52	1.98	1.54	2.07	1.56
Public Safety Services						
Fire Departments	0.04	0.05	0.04	0.05	0.04	0.05
Minnesota Highway Patrol	na	0.02	na	0.02	na	0.02
State Correctional Institutions	0.07	0.13	0.06	0.13	0.06	0.13
Total Safety	0.11	0.20	0.10	0.20	0.10	0.20
Municipal Services						
Water Departments	1.53	0.47	1.45	0.46	1.39	0.44
Wastewater Treatment	0.35	0.15	0.39	0.18	0.47	0.22
Total Municipal	1.88	0.62	1.84	0.64	1.86	0.66
Grand Total All Services	8.33	5.73	8.49	6.03	8.56	5.95
KWH x 10^9 used by selected services	1.83		1.95		2.08	
Btu x 10^{12} used by selected services		60.04		65.42		66.64

[a]Includes an estimated 0.30% for transportation.

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It should be noted that the annual consumption of energy by Minnesota's public services is not the only relevant information for making informed energy policy decisions. Of almost equal importance for some services are the seasonality of demand and the availability of energy at the times and places needed. Examples from two public services having different types of demand show that these considerations can be important. The Minnesota Highway Patrol's energy use consists almost entirely of gasoline -- the fuel for aircraft and highway patrol vehicles. Gasoline is widely available in all parts of Minnesota and the distribution system is fairly well understood and reasonably dependable. Also, the demand for gasoline by the Highway Patrol is quite constant throughout the year, having no distinct seasonality. Given these circumstances, plus the relatively minor total energy requirement, (0.076 per cent of the state's 1972 gasoline use) it can be seen that supplying the Highway Patrol with historic or even growing quantities of energy poses little difficulty. On the other hand, educational institutions of all types have distinctly seasonal energy use characteristics. Almost no oil, natural gas, or coal is used during the summer months. The annual use of these fuels is concentrated into the winter heating season. Electricity usage by schools, while still seasonal, fluctuates less than heating fuel use.

The type of heating fuel used by public services varies considerably from one place to another in the state. The fuel with the greatest variation is natural gas. In those parts of the state where natural gas is available, it is almost universally the heating fuel of choice, but in those places where it is unavailable -- particularly in the north-central counties and in some small, rural communities -- oil is the predominant fuel. To the extent that either oil or natural gas is in short supply, while the other major fuel is readily available, the impact on public services will vary regionally. That is, if the flow of natural gas into Minnesota is curtailed or interrupted but adequate supplies of heating oil are to be found, public services in those areas of the state that have placed heavy dependence on natural gas will probably suffer severely while their oil-dependent neighbors will be unaffected. In such circumstances it is clear that all parts of the state may not be disadvantaged equally by an "energy shortage," and local conditions and alternatives must be considered in plans to meet emergencies.

The remainder of this report consists of an analysis of the types and quantities of energy used by each of several important public services. Not all services are dealt with in equal detail -- largely because some are of much greater significance as energy users than others. By far the largest single user of energy for public services in Minnesota is the education sector. In this area -- schools, colleges and universities -- greater detail is included than for most other public services.

EDUCATIONAL SERVICES

Public and Private Schools (K-12)

Almost one-third of the people living in Minnesota are directly involved in education at the kindergarten through high school level -- most as students, but also many as teachers, administrators, and support personnel. Perhaps because schools are a part of the lives of such a large share of the population, and because the physical facilities of schools are so readily recognizable and so numerous, it is widely believed that schools consume enormous quantities of energy. As will be seen, the fraction is actually quite small.

Until the fall of 1973, little interest had been expressed in data on energy use. No central governmental authority or professional association keeps records of the quantities of energy used by schools in Minnesota, and many school districts, while aware of the cost of fuels used during recent years, have little knowledge about actual quantities of each energy form consumed.

Methodology: A survey questionnaire was sent to each of the 442 public school districts and 471 private schools in Minnesota. The questionnaire asked for information on the quantities of each type of energy the district or school had used during recent years. Responses to the survey ran slightly over fifty per cent, and from the information returned, per-student consumption totals were calculated for electricity and heating fuel Btu's. The data were extrapolated to arrive at an estimate of total statewide energy use in schools.

Findings: In the most recent year for which information was available -- the 1972-73 school year -- an average of 613 KWH of electricity was used for each student attending school in Minnesota (Table 2). This amount was six per cent more than in the previous year and 24 per cent more than in the 1970-71 school year. Heating fuel (natural gas, oil, coal and LP gas) consumption increased much slower than electricity consumption, averaging about 14.5 million Btu's per student in 1970-71 and 16 million Btu's in 1972-73. The sharp rise in heating fuel use between 1970-71 and 1971-72, followed by a slight decrease in 1972-73, can probably be accounted for by the unusually cold early months of 1972. Weather Service statistics indicate that temperatures for the year 1972 resulted in nine per cent more heating degree days than the 1965 to 1973 average.

TABLE 2

ENERGY USED BY PUBLIC SCHOOLS* IN MINNESOTA

Electricity	1972-73	1971-72	1970-71
Per Student Average KWH	613	577	493
Total Public Schools KWH	581 mm	547 mm	467 mm
Change in Public School Use of Electricity	+6.2%	+17.0%	
Fraction of Total Minnesota Electricity Sales Used by Public School	2.52%	2.54%	2.30%
Heating Fuels			
Per-student Average Btu	15.8 mm	16.0 mm	14.6 mm
Total Public Schools Btu ($x10^{12}$)	15.0	15.2	13.8
Mix of Public Schools Heating Fuels			
#1,2,3 Oil	34%	32%	32%
#4,5,6 Oil	8%	6%	9%
Natural Gas	54%	57%	54%
L.P. Gas	1%	1%	1%
Coal	3%	4%	5%
Change in Public School Use of Heating Fuels	-1.2%	+9.5%	
Total Energy			
Total Public School Btu for Heat and Electricity ($x10^{12}$)	21.4	21.2	19.0
Change in Total Public School Energy Use	+.9%	+11.6%	
Fraction of Total Minnesota Energy Used by Public Schools (excluding transportation fuels)	1.94%	2.01%	1.84%

*Almost 90 per cent of Minnesota students at the kindergarten through high school level attend public schools, therefore figures for consumption of electricity and heating fuels by all students were calculated by dividing public school consumption figures by 0.90. (See text and Table 1.)

All electricity used in Minnesota's schools from 1971 through 1973 amounted to no more than 2.80 per cent of the electricity sold in the state in those years. Of Minnesota's total energy use in each of the years studies, schools accounted for a consumption of only about 2.50 per cent.

Public school districts of different size were found to use differing amounts of energy. School districts having between 251 and 500 students used the least electricity per student (441 KWH) whereas districts in the 2501 to 10,000 student size range used the most (725 KWH per year). Heating fuel consumption, on the other hand, was least in the largest districts -- those having 20,000 or more students -- (14.4 million Btu's per student) and greatest in the smallest districts -- those with fewer than 250 students -- (22.8 million Btu's per student).

Statewide, the most popular heating fuel for public schools in 1972-73 was natural gas (supplying 54 per cent of the Btu's) with oil second at 42 per cent and coal supplying only three per cent. In recent years the importance of coal as a heating fuel has decreased steadily. As may be expected, different regions of the state reported wide deviations from the average statewide mix of heating fuels.

Transportation energy usage by schools, as with most other public services, was difficult to assess. One of the difficulties peculiar to school transporation results from the practice in many districts of contracting with commercial transportation companies for some or all of their transportation needs. Under these conditions, the schools keep no record of their transportation fuel usage. The limited data which were collected suggest that per-student energy used for transportation is relatively small when compared to the energy used for heating, lighting, and operating school facilities.

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Colleges and Universities

Colleges and universities in Minnesota enroll the equivalent of approximately 125,000 full-time students. The number has declined somewhat in recent years, but it is frequently predicted that the decline will level off and enrollments will stabilize not far from the present number. Four distinct types of higher educational institutions are found in Minnesota,

each serving a somewhat specialized clientele. The largest group of students attends the University of Minnesota, including its several branch campuses. State colleges and private colleges and universities each serve somewhat fewer students than the University. The smallest group of students consists of those attending community colleges. See Table 3 for the number of students attending each type of institution of higher education during the fall term of the years 1971, 1972, and 1973.

TABLE 3

STUDENTS ATTENDING MINNESOTA COLLEGES AND UNIVERSITIES
1971 to 1973

	University of Minnesota	State Colleges	Community Colleges	Private Colleges	Total
1973	43,459	32,096	18,339	29,500	123,394
1972	44,488	34,143	18,228	31,746	128,605
1971	45,354	36,486	18,734	30,251	130,825

Methodology: A survey questionnaire was sent to each college and university in Minnesota. Institutions enrolling over 85 per cent of Minnesota's college students responded. For each type of institution, total energy consumption was calculated by extrapolating reported per-student quantities of electricity and heating fuel to the number of students attending that type of institution in each of the years studied.

Findings: In 1972, Minnesota colleges and universities used some 407 million KWH of electricity and 12,142 billion Btu's of energy in all forms. To put these figures in perspective, colleges and universities bought 1.77 per cent of the electricity sold in Minnesota in 1972 and used 1.12 per cent of all energy supplied to the state in that year. Table 4 contains a listing of the types and quantities of energy consumed and breaks totals down into per-student average consumption in each of the years.

Overall per-student consumption of electricity showed an increase from 2902 KWH in 1971 to 3408 KWH in 1973. This increase was relatively uniform for all types of colleges except private colleges where the increase was

TABLE 4

ENERGY USED BY MINNESOTA COLLEGES AND UNIVERSITIES

	University[a] Of Minnesota	State Colleges	Community Colleges	Private Colleges	Total
Electricity ($KWH \times 10^6$)					
1973	160.2	136.5	30.8	93.1	420.6
1972	149.5	131.3	29.4	97.2	407.4
1971	137.1	129.6	21.9	91.0	379.6
Heating Fuels ($BTU \times 10^9$)					
1973	3177.5	1570.9	365.2	2207.5	7321.1
1972	3024.5	1678.1	430.1	2366.8	7599.5
1971	2803.5	1723.5	296.4	2363.3	7186.7
Electricity and Heating Fuel Total ($BTU \times 10^9$)					
1973	4963.3	2092.9	708.3	3245.6	12010.1
1972	4691.8	3141.6	757.5	3550.9	12141.8
1971	4332.5	3168.4	541.1	3377.9	11419.9
Average Btu Per Student ($\times 10^6$)					
1973	114.2	96.4	38.6	110.0	97.3
1972	105.5	92.0	41.6	111.9	94.4
1971	95.5	86.8	28.9	111.7	87.3

[a]Note that some of the heat and electricity used by the University went to the University Hospitals and to the State Department Of Health Building.

TABLE 5

AVERAGE PER-STUDENT USE OF HEATING FUEL BTU'S, 1971 TO 1973
(In Millions Of Btu's)

	University	State Colleges	Community Colleges	Private Colleges	Statewide Average
1973	73.1	48.9	19.9	74.8	59.3
1972	68.0	49.1	23.6	77.7	59.1
1971	61.8	47.2	15.8	78.1	54.9

very slight. Community colleges required the least electricity per student, largely because these institutions supply no residential facilities.

Natural gas is by far the most important heating fuel for colleges and universities in Minnesota. In each year, approximately sixty per cent of the heating fuel Btu's were derived from natural gas. The remainder of heating fuel Btu's were split about evenly between coal and oil. Coal is an especially important fuel at the University of Minnesota were 40, 36, and 26 per cent of the heat used came from that source in 1971, '72, and '73 respectively. As with electricity, community colleges used by far the least heating fuel per student (Table 5).

It will be noted that whereas per-student heating fuel consumption decreased in private colleges, it increased steadily at the University of Minnesota and remained relatively constant in state colleges. Heating fuel consumption in community colleges fluctuated too much for the identification of a trend.

HEALTH SERVICES

One of the important factors contributing to Minnesota's commendable standard of living is the ready availability of high quality medical care. In this report, the health facilities in the state are divided into three groups -- hospitals, nursing homes, and state-operated health facilities (Table 6). The first group, hospitals, consists of approximately 190

TABLE 6

HEALTH CARE BEDS IN MINNESOTA, 1971 - 1973

	Hospitals	Nursing Homes	State Facilities	Total
1973	25,013	34,972	10,809	70,794
1972	24,347	31,621	10,720	66,688
1971	24,515	29,930	10,806	65,251

institutions that are licensed to provide service to about 25,000 patients at any one time. Some 3450 of the patient beds herein designated as hospital beds are actually contained within convalescent and nursing care units attached to hospitals. The second group consists of a growing number (355 in 1973) of freestanding nursing homes having a licensed bed capacity in 1973 of nearly 35,000. The third group is made up of the 13 major state institutions devoted to physical and mental health care for state residents. These insitutions have a bed capacity for just under 11,000 patients.

While it is true that some overlap between the types of health facilities does exist -- nursing care units in hospitals, state-operated institutions providing nursing care service -- the general structure and function of the three groups is sufficiently different to greatly affect energy consumption patterns. That is, there is much greater uniformity in consumption within each group than between groups.

Energy use data on all health services was obtained by a survey questionnaire asking for quantities of each energy type used by each facility

during recent years. Response rates ranged from only 45 per cent for nursing homes to 65 per cent for hospitals and 75 per cent for state-operated health facilities.

Hospitals

General hospitals are readily accessible to persons living in all parts of the state even though some 45 per cent of all hospitals are located in the seven counties of the Twin Cities Metropolitan Area.

Findings: Hospitals, like schools, use approximately one-third of their total energy in the form of electricity and the other two-thirds as heating fuel. The average amount of electricity used for each hospital bed increased considerably from 1971 to 1973 (Table 7).

TABLE 7

ENERGY USE BY HOSPITALS IN MINNESOTA, 1971 - 1973

	1973	1972	1971
Electricity			
Per-Bed Average KWH	13,768	12,783	12,113
Total Hospital KWH ($x10^6$)	344	311	297
Change in Hospital Use of Electricity	+7.7%	+5.5%	
Fraction of Total Minnesota Electricity Sales Used by Hospital	1.42%	1.35%	1.38%
Heating Fuels			
Per-Bed Average Btu ($x10^6$)	290	283	271
Total Hospital Btu ($x10^9$)	7,251	6,896	6,654
Mix of Hospital Heating Fuels			
#1, 2, 3 Oil	15%	17%	12%
#4, 5, 6 Oil	11%	14%	14%
Natural Gas	74%	68%	73%
Change in Hospital Use of Heating Fuels	+5.2%	+3.6%	
Total Energy			
Total Hospital Btu for Heat and Electricity ($x10^9$)	11,089	10,366	9,967
Change in Total Hospital Energy Use	+7.0%	+4.0%	
Fraction of Total Minnesota Energy Used by Hospitals	0.99%	0.96%	0.95%

This increase undoubtedly had many causes, an important one being more widespread acceptance of air conditioning in most or all patient areas of hospitals. Virtually all replacement facilities are constructed with air conditioning systems, and room or central units are increasingly common in older structures. The fraction of Minnesota's electricity sales used by hospitals has fluctuated somewhat but seems to be on the rise. That is, the quantity of electricity used by hospitals seems to be increasing somewhat more rapidly than the total used by all customers in the state.

The amount of heating fuel energy used per bed in Minnesota hospitals has increased also, from 271 million Btu's in 1971 to 290 million Btu's in 1973. This increase, multiplied by a large number of patient beds, has resulted in an overall rise in heating energy requirements. The mix of fuels used to heat Minnesota hospitals did not change significantly in the years studied. In each year, natural gas supplied about seventy per cent of the heat. Coal has been almost entirely phased out as source of heat for hospitals.

Hospitals have been using an increasing fraction of Minnesota's total energy budget (in 1973 the fraction was just under one per cent) and there is little reason to suspect that the upward trend will soon reverse itself. As more emphasis is placed on health care availability, it seems entirely reasonable to anticipate further increases in both the absolute and the relative amounts of energy allocated to hospitals in the years ahead.

Nursing Homes

Nursing homes serve primarily the elderly, but are also used by persons of all ages who are in need of more intensive health care than can be provided at home, yet do not need to be hospitalized. The importance of such facilities can be appreciated when one realizes that in 1970 some 10.7 per cent of Minnesota's residents were 65 years or older and 4.4 per cent were aged 75 years or more. The number of nursing homes has increased rapidly during recent years. In 1971, Minnesota had 328 licensed nursing homes. By 1973 the number had increased to 355, an eight per cent jump. During the same time period bed capacity increased 17 per cent.

Findings: The average per-bed use of electricity in Minnesota nursing homes increased gradually during the years 1971 through 1973, but with increasing numbers of nursing home beds involved, the total electricity used by nursing homes increased from 90 million to 111 million KWH -- 23 per cent in two years (Table 8). As with several other public services, the consumption of electricity by nursing homes increased more rapidly than total consumption in the state.

About seventy per cent of the heat for nursing homes is derived from natural gas. Oil makes up all but about two per cent of the remaining heat. Interestingly, number 5 oil (residual) has decreased in importance at about the rate that number 2 oil (distillate) has gained in popularity.

TABLE 8

ENERGY USED BY NURSING HOMES IN MINNESOTA, 1971-1973

Electricity	1973	1972	1971
Per-Bed Average KWH	3,177	3,145	3,012
Total Nursing Home (KWH ($x10^6$)	111	100	90
Change in Nursing Home Use of Electricity	+11.6%	+10.5%	
Fraction of Total Minnesota Electricity Sales Used by Nursing Homes	0.46%	0.43%	0.42%
Heating Fuels			
Per-Bed Average Btu ($x10^6$)	72	81	79
Total Nursing Home Btu ($x10^9$)	2,510	2,551	2,372
Mix of Nursing Home Heating Fuels			
#1, 2, 3 Oil	24%	24%	20%
#4, 5, 6 Oil	1%	4%	6%
Natural Gas	72%	70%	72%
LP Gas	2%	2%	2%
Change in Nursing Home Use of Heating Fuels	-1.6%	+7.6%	
Total Energy			
Total Nursing Home Btu for Heat and Electricity ($x10^9$)	3,747	3,661	3,376
Change in Total Nursing Home Energy Use	+2.4%	+8.4%	
Fraction of Total Minnesota Energy Used by Nursing Homes	0.35%	0.34%	0.32%

Consumption of heating fuels by nursing homes shows a drop from 1972 to 1973. The only apparent cause for this reduction was the particularly cold weather during the early months of 1972 compared with a relatively mild winter in 1973.

Nursing homes use a small but increasing fraction of Minnesota's energy budget. The 0.32 per cent used in 1971 increased to 0.35 per cent in 1973. With nursing homes increasing in popularity and importance in the state, the trend is likely to continue into the years ahead.

State-Operated Health Facilities

The state-operated health facilities covered in this report include ten state hospitals, two nursing homes, and the Minnesota Veterans Home. All are relatively large institutions having from 350 to 1650 beds, the average being 830.

In many respects, the energy use patterns of state-operated health facilities are strikingly different from those of either hospitals or nursing homes. Perhaps the biggest difference is that total energy use is actually declining, rather than rising as is the other health service groups. Other peculiarities are to be found in the fuel mix and the very low percentage of total energy used in the form of electricity.

Findings: The number of licensed beds in state-operated health facilities has remained very constant from 1971 through 1973. This factor, along with the relatively old age of many of the buildings involved and the lack of significant change in methods of operation, may help explain the unusual pattern of energy use. Electricity use has increased only very slowly -- much slower than statewide electricity sales have climbed -- with the result that a decreasing fraction of Minnesota electricity goes to state-operated health facilities. The already small fraction of 0.21 per cent used in 1971 decreased to only 0.19 per cent in 1973 (Table 9).

The amount of heating fuels used in state-operated health facilities decreased from 1971 to 1973, both in per-bed averages and in total. Heat for such facilities was considerably different in origin from that of other health services in that no more than half, and in 1972 only 40 per cent, of

heating fuel energy was derived from natural gas. Also unusual was the very small amount of distillate (#2) oil used and the relatively large amount of residual (#5) oil used. Coal also was used in several facilities and contributed over 23 per cent of the heating fuel energy.

TABLE 9

ENERGY USED BY STATE-OPERATED HEALTH FACILITIES IN MINNESOTA 1971 - 1973

	1973	1972	1971
Electricity			
Per-Bed Average KWH	4,241	4,364	4,132
Total Facility KWH ($x10^6$)	46	47	45
Change in Facility Use of Electricity	-2.0%	+4.8%	
Fraction of Total Minnesota Electricity Sales Used by Facilities	0.19%	0.20%	0.21%
Heating Fuels			
Per-Bed Average Btu ($x10^6$)	182	191	193
Total Facility Btu ($x10^9$)	1,968	2,052	2,085
Mix of Facility Heating Fuels			
#1, 2, 3 Oil	-	-	-
#4, 5, 6 Oil	26%	37%	29%
Natural Gas	50%	40%	42%
Coal	23%	22%	29%
Change in Facility Use of Heating Fuels	-4.1%	-1.6%	
Total Energy			
Total Facility Btu for Heat and Electricity	2,479	2,574	2,583
Change in Total Facility Energy Use	-3.7%	-0.4%	
Fraction of Total Minnesota Energy Use by State-Operated Health Facilities	0.22%	0.24%	0.25%

Whereas most of the public services studies -- including schools, colleges, hospitals, and nursing homes -- use approximately one-third of their total energy in the form of electricity, state-operated health facilitie use only one-fifth as electricity. No cause has been identified for this peculiarity.

Little change can be expected in the pattern of energy use in state-operated health facilities unless some major restructuring occurs in either patient loads or building design. As long as the total amount of energy remains static, the fraction of Minnesota's energy budget devoted to these facilities will continue to drop.

PUBLIC SAFETY SERVICES

Of the many tax-supported services contributing to public safety, three were studied by the Minnesota Energy Project. These were fire departments, the Minnesota Highway Patrol, and Minnesota correctional institutions. These three are not the only safety services that benefit the public; local police forces, county jails, the National Guard, and several others might also have been included but were not. The amounts of energy used by the public safety services not studied are unknown, but in all probability their cumulative energy budget would be no larger than for the three services studied.

Fire Departments

Data for the fire department phase of the study was gathered by surveying all large (cities over 10,000 population) and selected small (cities under 10,000 population) fire departments for information on their consumption of electricity, heating fuels, and motor fuels. Returns were received from departments serving approximately 40 per cent of Minnesota's population and the results were assumed to be representative of the other 60 per cent as well. In some respects, the data for energy use by fire departments is perhaps less firm than those for educational and health services. Fire departments frequently share at least some office space and occasionally other facilities with other municipal agencies, and energy use for heating and lighting must be allocated by estimation. Even conceding the possibility of some error in totals, the fraction of electricity and total energy going to fire departments is very small.

Findings: In 1973, fire departments in Minnesota used approximately 8.8 million KWH of electricity, up from 8.1 in 1972 and 7.1 in 1971. While this increase was somewhat more rapid than the growth of electricity use statewide, it remained within the range of 0.04 per cent of electricity sales in each year. The use of motor fuels increased at a faster rate, jumping from the equivalent of 445 thousand gallons of gasoline in 1971 to 490 thousand in 1972 and 565 thousand in 1973. This increase is accounted for by more pieces of firefighting and rescue equipment, newer vehicles getting

fewer miles per gallon, and a slightly increased number of emergency runs. Heating fuels held relatively constant at about 350 billion Btu per year.

The combined effect of electricity and motor fuel use increasing while heating fuel remained essentially constant, and statewide energy use increased, was to keep fire department energy use at about 0.05 per cent of Minnesota's energy budget in 1971, 1972, and 1973.

Minnesota Highway Patrol

Energy use by the Minnesota Highway Patrol consists almost entirely of gasoline for aircraft and highway patrol vehicles. Office and hanger space for the Patrol is leased on a "utilities paid" basis and no record of heating fuel and electricity consumption is available; however, the quantities are thought to be rather small since they represent use for only 25,400 square feet of office space and 3,600 square feet of hanger space.

In 1973, the Minnesota Highway Patrol used 1.85 million gallons of gasoline. This amount was up 15 per cent from the 1972 usage of 1.62 million gallons and up more than 22 per cent from the 1971 consumption of 1.57 million gallons. While 1.6 million gallons may seem like a great quantity of gasoline, it represents only 0.074 per cent of the gasoline burned in Minnesota in 1972.

When the Btu content of the gasoline burned by the Patrol is compared to Minnesota's annual energy budget, this public service is seen to require somewhat less than 0.02 per cent of annual energy use. While the fraction has been rising in recent years, the Minnesota Highway Patrol is still far from the point of constituting a significant energy user.

State Correctional Institutions

Correctional institutions in Minnesota supply living quarters for approximately 2,000 residents. Energy use information was gathered for the years 1969 through 1973 -- a longer time period than for any other of the public services studied.

Findings: Minnesota correctional institutions have used an almost constant quantity of electricity during the past five years. This approximately 14 million KWH represents a declining portion of electricity sales in the

state -- down from 0.07 per cent in 1969 to 0.06 per cent in 1973. The relative stability in electricity consumption can be accounted for by slowly declining inmate populations combined with established, unchanging physical facilities.

Heating fuel consumption seems to have been relatively constant also, rising during particularly cold winters and decreasing in years having warmer winters. Natural gas and coal continue to supply the bulk of heat for correctional institutions, with residual (#5) heating oil increasing in importance during recent years (Table 10). In all, some 1,200 billion Btu's per year are used for these institutions. The total of all energy used by correctional institutions in recent years has remained relatively constant at about 1,375 billion Btu's per year. In 1973, this accounted for 0.13 per cent of Minnesota's energy budget, a lower fraction than in any of the other years studied. Only a little over ten per cent of the energy used by correctional institutions was in the form of electricity. This ten per cent was the lowest for any public service.

TABLE 10

HEATING FUEL MIX FOR MINNESOTA CORRECTIONAL INSTITUTIONS 1969-1973
(% Of Btu's From Each Fuel)

	1973	1972	1971	1970	1969
#1,2,3 Oil	2.1	1.0	1.0	1.0	0.7
#4,5,6 Oil	8.3	9.6	7.4	4.9	2.1
Coal	21.2	22.0	20.6	19.1	21.3
Natural Gas	68.3	66.4	71.0	74.9	75.8
L.P. Gas	n	0.1	0.1	0.1	n

[n] less than 0.05%

Since no major changes in physical facilities or inmate populations are expected, correctional institutions will probably continue to use a nearly constant amount of energy and an ever decreasing fraction of the state's energy.

MUNICIPAL SERVICES

Of the several municipal services that could have been selected for study by the Minnesota Energy Project, water departments and wastewater treatment were picked because they are licensed by state agencies and because they are almost always supplied to urban residents as government services (whereas garbage collection and some other services are frequently supplied by private operators). These conditions made data collection somewhat easier and more reliable.

With both water departments and municipal wastewater treatment systems, samplings of the cities were made rather than blanket surveys. Data for selected cities were assumed to be representative for the type and size of city from which they were drawn.

Municipal Water Departments

Water departments use by far the majority of their energy (75.5 per cent in 1973) in the form of electricity. This electricity is consumed in the pumping of water from wells or other sources, in the process of treatment and purification, and for distribution to residences and industries within the system. The electricity actually used amounted to 328.5 million KWH in 1971, 334.3 million KWH in 1972, and 336.5 million KWH in 1973. While this amount is increasing in absolute terms, it is decreasing as a percentage of electricity sales in Minnesota. In 19731, Minnesota water departments used 1.53 per cent of the state's electricity sales. In 1972 the fraction had dropped to 1.45 per cent, and in 1973, it amounted to only 1.39 per cent of statewide electricity sales. If present trends continue and the population of Minnesota continues to aggregate in a limited number of metropolitan areas, economies of scale may become more applicable and the energy cost of delivering a thousand gallons of water may further decrease. If such is the case, an even lower fraction of the state's energy budget will be required to procure and deliver water of high quality.

The per capita energy cost of delivered water is lowest for cities with populations over 10,000 and highest for cities with populations between 500 and 10,000 and having hospitals (See Table 11).

TABLE 11

ENERGY USED BY MUNICIPAL WATER DEPARTMENTS IN MINNESOTA

Class[a]	Electricity MKWH[b]	Heating Fuels Btu x 10^9	Transportation Fuels Btu x 10^9	Total Energy Btu x 10^9	Average Energy Per Person Served[c] Btu x 10^6
Large					
1973	169,703	432.7	85.4	2410.3	1.213
1972	162,871	417.7	84.3	2318.0	1.166
1971	157,940	472.6	76.7	2310.3	1.162
"A"					
1973	8,363	71.1	5.2	169.5	2.716
1972	10,691	85.6	6.8	211.6	3.390
1971	10,553	78.8	4.0	200.4	3.211
"B"					
1973	68,570	445.5	83.1	1293.2	3.039
1972	68,678	497.9	83.8	1347.4	3.167
1971	69,245	438.4	84.9	1295.4	3.044
"C"					
1973	89,825	78.8	14.1	1094.5	3.739
1972	92,019	83.3	15.2	1124.5	3.842
1971	90,811	93.7	15.8	1122.1	3.834
TOTAL					
1973	336,461	1028.1	187.8	4967.5	1.795
1972	334,259	1084.5	190.1	5001.5	1.807
1971	328,549	1083.5	181.4	4928.2	1.780

[a]"Large" refers to municipalities with 1970 populations of 10,000 or more; "A" refers to municipalities with populations of under 500. "B" and "C" refer to municipalities with populations of 500 to 10,000 -- those having a hospital designated as "C" and those without a hospital designated as "B".

[b]Thousand kilowatt-hours.

[c]All populations are from 1970 census. No adjustment is made for variance in average per capita water consumption.

Of all energy used in Minnesota during recent years, water departments have used a declining fraction. In 1971, 0.47 per cent of Minnesota's total energy went to water departments. By 1973, the fraction had dropped to 0.44 per cent. It seems reasonable to expect that even though actual amounts of energy used by water departments will probably increase, the increase will be less rapid than for the state as a whole.

Municipal Wastewater Treatment

Wastewater treatment is a service that is all too frequently taken for granted by most people. Little thought is given to the intricate network of underground collector lines, sewer mains, lift stations, and treatment plants that urban people utilize each day. The continued operation of wastewater treatment facilities is essential for the health and well-being of our modern high-density society. Problems and costs of waste treatment and disposal increase at an accelerating rate as the population and population density of a municipal area and its surrounding countryside grow. The alternatives for effective sewage treatment and disposal are land, on one hand, and energy-intensive technology on the other hand. As land (for sewage lagoons and other "natural"methods of wastewater treatment) becomes more valuable and less available, central processing plants must be substituted. These central plants use much more energy per person served than land-consuming alternatives.

In Minnesota, approximately 68 per cent of the energy used by municipal wastewater treatment facilities is consumed at one plant -- officially known as the St. Paul Metropolitan Wastewater Treatment Facility, or more colorfully as "Pig's Eye." This one plant presently serves most of the population and industries in the seven-county Twin Cities Metropolitan Area. Detailed data on the energy use of the Pig's Eye plant are available and consituted the major source of information for the study of energy in Wastewater treatment.

Findings: Wastewater treatment in Minnesota has demanded greatly increased amounts of energy in recent years. Energy use for this purpose in 1973 was more than double the use in 1970. From 1970 through 1973 there was an average annual increase in energy demand of 26.6 per cent -- a much greater increase than in any other public service studied. Much of the increase can be attributed to governmentally imposed improvements in the quality of water discharge into the rivers, lakes, and streams of the state.

About half of the energy used for wastewater treatment in Minnesota is supplied in the form of electricity. In 1970, this amounted to 68 million KWH or 0.35 per cent of electricity sales in that year. By 1973 the electricity consumption had climbed to 114 million KWH or 0.47 per cent of sales. As water quality standards become more and more stringent in the years ahead, the use of electricity for wastewater treatment will probably continue to rise, but at a slower rate than in the four or five years just past.

All electricity and heating fuels (most of the latter used for sludge incineration) used by wastewater treatment facilities amounted to 2,512 billion Btu's in 1973, 1,949 billion Btu's in 1972, 1,611 billion in 1971, and 1,241 billion in 1970. During that time period, the fraction of Minnesota's total energy budget used by such facilities increased from 0.15 per cent in 1970 to 0.22 per cent in 1973. As with electricity, this energy demand may rise somewhat more in the years ahead, but at a slower rate.

Wastewater treatment is unique among the public services studied in that with the application of existing and evolving technology, the wastewater treatment service could become an energy producer rather than an energy consumer. All organic waste has the potential for conversion to energy, and wastewater treatment facilities are presently in the business of collecting at some central location huge quantities of organic waste. While no large-scale projects for converting waste to energy are presently in operation, several proposals have been made. It seems likely that a well-designed system would be able to create at least enough usable energy to power the wastewater disposal process, and under favorable conditions (steady supplies of homogenous sewage having a high organic matter content) could have the potential for energy to sell. The major holdup to projects for the conversion of waste to energy has been the large capital investment required for plant and equipment. To the extent that this problem is overcome, wastewater treatment facilities may, at some time in the future, be energy producers rather than energy consumers.

Minnesota Energy Project.

2. Minnesota: Energy Used by Selected Public Services.

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MINNESOTA ENERGY TOTAL AND MIX, 1920-1971