RESIDENTIAL SPACE HEATING POLICY ALTERNATIVES IN MANITOBA

By

Grant D. McVicar

A Practicum Submitted
In Partial Fulfillment of the
Requirements for the Degree
Master of Natural Resource Management

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INTRODUCTORY NOTE

The following report is intended to serve a twofold purpose:

(a) to be of practical value to the Province of Manitoba, as a policy paper in the area of residential heating; and,

(b) to be used as a practicum (practical research report) in order to satisfy partial requirements for the author's attainment of the degree of Master of Natural Resource Management at the Natural Resource Institute, University of Manitoba.

It is to be emphasized that the views expressed herein are those of the author alone, and will not necessarily reflect the views of either the Natural Resource Institute, or the Province of Manitoba.

ABSTRACT

This practicum analyzes the current residential space heating market in Manitoba. Using this analysis as a base, the practicum projects economic and social consequences of retaining the current provincial government policies which influence heating fuel allocation and conservation in Manitoba, and discusses a number of feasible alternative policies.

ACKNOWLEDGEMENTS

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CHAPTER I

INTRODUCTION TO THE PROBLEM OF RESIDENTIAL SPACE HEATING IN MANITOBA

1.1 Why Residential Space Heating is a Concern in Manitoba

The relatively cold climate of Manitoba necessitates the need for some form of residential space heating, if people wish to live in the province on a year-round basis. From this point of view, the provision of energy resources to be used to heat a residence should be looked upon as an essential service, which, like the provision of food, is necessary for the survival of people dwelling in the province.

In the past, wood and coal were the primary energy resources used to provide heat within a residence. The nature of these fuels, combined with the technology available at the time, resulted in a situation in which people were physically involved in the process of heating their home. This close physical link kept people aware of heating fuel, and, as a result, people probably did not take fuel supplies for granted.

Today's primary space heating fuels are oil, natural gas, and electricity. These fuels owe a large part of their popularity to their convenience factor (ie. the ability to set a thermostat at a desired temperature, and then forget about it, knowing that air temperature within the home will stay at the desired level). This convenience factor has, until recently, resulted in a situation where residential heating has been taken for granted by the public. This attitude has been manifested by homeowners' apparent lack of concern about the types and efficiencies of the heating systems which have been installed, coupled with an ignorance of the energy conservation potential of various design features of their residences. Apparently, low initial capital cost has been a much more marketable feature of housing than low future energy bills.

Governments have also been slow to act in the area of residential space heating. In fact, it is still possible in some parts of Canada to build a home without any insulation at all. However, there are signs that both the public and the private sectors of the economy are changing their attitudes towards future energy consumption. This change has been brought about by the fact that heating fuels are part of the energy supply which has recently been given notoriety as part of the 'energy crisis'.

From World War II until the early 1970's, North America lived in an era of cheap, abundant energy. Then came the OPEC embargo. As a result of the OPEC embargo, there has been a much voiced concern over the continued supply of energy fuels and of the ability of consumers to afford future fuel prices. On the brighter side, however, as the price of energy continues to rise, the benefits of a successful energy conservation program also continues to rise. This accounts for the general increase of interest in energy conservation shown by the public and the private sectors over the past few years.

Although there have been across-the-board increases in all energy resources, this does not mean that consumers of each type of energy resource have been affected equally. Changes in relative market prices of energy resources, and in consumer demands have, and will continue to, cause social and environmental disruptions. Governments should logically concern themselves with allocating fuels so as to minimize such disruptions, while, at the same time, they should seek the optimum position where fuels are allocated to their most economically productive purposes.

Manitoba is not as fortunate as some of the other Canadian provinces, in that it does not have significant reserves of oil, natural gas, uranium or coal. In fact, most of the energy which Manitobans consume, other than hydro-electric energy, must be imported from outside the province. Clearly, important decisions will have to be made to insure that residential space heating does not become a serious social and economic problem in the future. Some of the points that the author feels Manitoba should consider in formulating a residential heating policy are:[1]

(a) the lack of fossil fuel type energy resources located within the province;

(b) low-cost energy reserves are diminishing and the incremental costs of importing new units of energy will, in all probability, be much higher than present costs of energy;

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[1] The author will elaborate upon these reasons in greater detail in later chapters.

(c) establishing new reserves of hydro-electric energy within the province will have incremental costs which are greatly in excess of the average costs of providing units from established sources;

(d) there should be consideration given to the 'best end use' of fossil fuels used in the province (ie. perhaps the province should reserve petroleum products for the farming and transportation industries);

(e) a high proportion of total dwellings constructed in Manitoba have tended to be single detached buildings which require more heating fuel than do multiple unit dwellings with the same livable area;

(f) Manitoba's dispersed rural population required elaborate and expensive energy delivery systems; and,

(g) at the present time, sufficient energy conservation measures do not appear to be taken, even though these measures are economically justified.

1.2 Objective, Scope, and Methodology of this Report

The major objective of this report is to present an analysis of the many factors which should be taken into account by the Government of Manitoba, so that a reasonable set of policy alternatives dealing with the area of residential space heating may be established. Two crucial policy issues---allocation and conservation (concepts which shall be defined in detail later in this chapter)---will form the basis for the discussion of residential space heating policy. Following an analysis of the market allocation of heating fuels and the potential for conservation, the author will consider future market allocations and fuel consumption based on the assumption that there are no significant policy changes in the area of residential space heating. The aforementioned analysis sets the stage for a discussion of allocation and conservation policies which are feasible alternatives and which would have different economic and social consequences.

An attempt is made throughout this report to analyse previously unassembled data and opinions available in literature, universities, government offices, and private enterprises; in order to provide the basis for a number of options which are open to the government in the field of residential space heating.

The only topic considered in this report in any detail will be that of residential space heating. The fuels used in residential space heating are often the same as those used for lighting, cooking and air conditioning, but an in-depth discussion of these aspects is not deemed to be a part of this report. It should be stated, however, that many of the principles of allocation and conservation discussed in this report may also be applicable to these and other end uses of energy within a residence.

Many of the principles discussed in this report will also have some applicability in the commercial and industrial sectors of the provincial economy. A note of caution must be voiced if any attempt is made to apply these principles to the industrial or commercial sectors, due to the fact that heat loads usually have greater variations in industrial and commercial buildings than in residential units. The appropriate solutions in such cases may be considerably different, due to very heterogeneous heat loads in some industrial and commercial buildings, versus heat loads in residences, which are generally more evenly distributed.

The major types of residential heating fuels and systems now in operation in the province will be discussed in this report. A number of heating methods which are not in common use at the present time, but which show potential for making an impact in the residential space heating market by the turn of the century, will also be discussed as part of this report.

This report is intended to be interdisciplinary in its nature. The previous statement is meant to imply that any policies suggested by the author are implictly subject to the criteria of economic, technical, social, environmental, administrative and political feasibility.

1.3 Definitions of "Allocation" and "Energy Conservation"

The terms "allocation" and "energy conservation" are of such central importance to the subject matter discussed in this report, that their definitions must appear at the beginning of the report. These two key terms have a variety of definitions; thus, in order to forestall as much confusion as possible, they will be provided with operational definitions.

The term "allocation" may, in itself, be divided further into the concepts of short term and long term allocation. Short term allocation may be defined, in the case of heating fuels, as administrative rationing of a fuel for a short period of time, due to the event of an emergency shortage of the fuel. When dealing with such short term allocation problems, a government might recognise such policy parameters as the identification of users, where the disruption of a fuel supply causes the loss of an essential public service, the possibility of fuel substitution for large users, and fuel storage capabilities. This report will not concern itself with the subject of short term allocation.

The term "allocation", as used in this report, refers to long term allocation. The term is operationally defined as the proportionate consumption and the geographical distribution of the heating fuels used in Manitoba's residences.[2]

Fuel allocations existing in Manitoba at the present time, are the result of the interaction of two recognizable economic processes. In the first process, fuel allocations are the result of trading in an open marketplace. In this process, the long term equilibrium market share of each fuel is based upon its supply, demand, price, and the ease of substitution of other competitive fuels. As simple as it sounds, this process is actually quite complex, due to the fact that each element of the equilibrium model can be affected by any number of parameters, such as monopolies, cartels, limited distribution systems, or lack of perfect knowledge by both the producer and the consumer. The fact that there are problems associated with fuel allocation based solely on market allocation has resulted in a process of policy allocation or regulatory allocation by which the government can directly or indirectly correct the perceived inequities within the market allocation system. Governmental policy tools such as taxes, prices, subsidies, laws, rationing, or direct methods of distribution may be used to make adjustments in the market shares of various heating fuels.

Government's inate responsibility to the people whom they serve requires that certain areas need to be explored in order to assure that the formulation of a residential heating fuel allocation policy is in the best interests of the people. Some of the questions which need to be raised are:

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[2] The author confesses that many of the ideas expressed in this chapter are not entirely his own. The idea of using the operational definitions stated in this section occurred after reading a practicum byRalph F. Smith, Residential Space Heating Policy Alternatives In Saskatchewan, (Winnipeg, April, 1977). As a result, many of the ideas and definitions stated in this chapter are the same as, or only marginally different than, those of Mr. R. F. Smith.

(a) Should future residential heating fuel allocations treat different sectors of the heating fuel market separately (ie. should new houses be treated differently from existing houses; should multiple dwelling units be treated differently from single dwelling units; should urban residences be treated differently from rural residences)?

(b) What is the impact of space heating costs on the annual income of average, and lower than average, income consumers, given a particular type of heating fuel system?

(c) What are the opportunity costs, BTU efficiencies, environmental impacts, provincial economic impacts, security of supply characteristics, and administrative feasibilities, if a particular fuel or combination fuel and heating system is to retain a major share of the residential heating market over a long period of time?

The term "energy conservation" encompasses a wide variety of definitions. The following is a list covering a range of possible methods which could be used to conserve residential heating fuels.

(a) decreasing the amount of energy inputs consumed in the production of energy used for space heating purposes;

(b) improving the efficiency of transmission and distribution networks;

(c) improving the efficiency of heating systems;

(d) improving the heat-retaining quality of the residence (ie. by using more insulation, weatherstripping, better architectural design features, orientation, wind breaks, etc.);

(e) ceasing to use heat in the residence where or when it is not required (ie. heated garages, the decision not to heat certain rooms if they are not used frequently); and,

(f) lessening the amount of heat energy required to heat a residence by turning down the thermostat a few degrees.[3]

It should be noted that, of the above list of energy conservation measures, only (c), (d), (e), and (f) are directly relevant to this report. Missing from the afore-mentioned list of energy conservation measures is the concept of substituting abundant or renewable forms of energy for scarce fossil fuels. From the author's viewpoint, the argument against including this concept in the list of energy conservation measures is best stated by Mr. Ralph F. Smith. He says:

> "The assumption that is taken... is that if energy demand for a particular job (in BTU's) is the same for one fuel as for another, then energy conservation cannot be said to be the result when substitution takes place, regardless of the fuels in question."[4]

This concurs with the view taken by the National Energy Board, which argued in 1975 that "decreases in the demand for petroleum products due to the substitution of other forms of energy could not be classified as conservation."[5]

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[3] Definitions similiar to these are found in a research paper produced for the Government of Saskatchewan. See Ralph F. Smith, Residential Space Heating Policy Alternatives In Saskatchewan, (Winnipeg, April, 1977), p. 9 - 10.

The special care, taken by these two authorities, in defining the nature of what is, and of what is not energy conservation, stems from a close relationship between the concepts of fuel allocation and energy conservation. Allocation of energy fuels should not necessarily be made solely on the basis of energy supplies and demands from various sectors of the economy. One reason for this is that the economic value of a fuel in one sector of the economy is not necessarily equal to the economic value of the same fuel in a different sector of the economy. In Manitoba, for example, the allocation of one unit of oil away from residential space heating applications for use in agricultural production may result in a greater dollar value per unit of oil being realized in the provincial economy. A second reason why fuel allocations should not necessarily depend upon supply is that different fuels have different efficiencies which are technically attainable at each level from primary production through to the end use product---heat within the residence. For example, it may require up to four BTU's of heat energy from coal to provide one BTU of usable heat energy in a residence, if the residence is heated with electric resistance heaters powered by electricity generated at coal burning power stations. On the other hand, it may require

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[4] Ralph F. Smith, Residential Space Heating Policy Alternatives in Saskatchewan, (Winnipeg, April, 1977), p. 10.

[5] National Energy Board, Canadian Oil: Supply and Requirements, (Ottawa, September, 1975), p. 35.

less than two BTU's of natural gas to provide the same one BTU of usable heat energy within a residence. Based upon the above information and the principle of efficiency, it would be a wise energy conservation decision to allocate natural gas for the use of residential space heating rather than coal, because fewer reserves (of BTU's) are required to deliver the same amount of usable heat energy.

Governments may also improve efficiencies of energy usage within individual residences. Methods of achieving improved efficiencies vary from regulatory measures, such as legislation or building code restrictions, to more subtle measures such as energy information booklets and low interest loans for insulation. Pricing of fuels is, in itself, a potent method for providing incentive towards energy conservation. The higher the price of energy, the more it pays users to invest in methods of conserving energy. The optimum investment in conservation methods for the consumer is when the cost of the investment is equal to the present worth value of future savings on energy bills.

In conclusion, conservation and allocation are integral parts of any residential space heating policy. Allocation of fuels is not only dependent upon market demands and the availability of supplies, but it is also dependent upon the technical efficiencies which can be achieved by each energy resource between its production and its final use as residential heat. Energy conservation, to a large degree, is influenced by the price of energy fuels; thus, the pricing of energy fuels is recognized as a tool for energy conservation, as well as an inducement for finding more energy reserves and the development of new sources of energy.

CHAPTER II

HEATING FUEL SUPPLIES FOR MANITOBA: AN OVERVIEW

2.1 Location of Energy Supplies for Residential Space Heating

This chapter of the report deals with the energy supplies which are either available or show potential for fulfilling Manitoba's demand for energy for residential space heating purposes. The energy resources to be considered in this chapter are coal, oil, natural gas, nuclear energy (uranium), electricity, and wood. These six energy resources have been singled out for discussion in this chapter, due to the author's belief that they are currently the most widely used energy resources for residential heating purposes. The author does not wish to imply that he does not consider such alternative energy resources as direct use of solar energy, wind energy, and biomass energy as unworthy of consideration for Manitobans. These alternative sources of energy will be discussed in a later chapter of this report.

(a) Fuels Located in Manitoba

Coal: At the present time, there are no operating coal mines in Manitoba. Coal was last mined in Manitoba in the years between 1931 - 1943, during which 30,877 short tons of lignite were mined.[1] Manitoba's known deposits of coal exist in the southwestern area of the province,

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[1] Bannatyne, B.B., "Summary of Available Data on Lignite Deposits, Turtle Mountain, Manitoba", unpublished report, Manitoba Department of Energy, Resources and Environmental Management, 1978.

near the town of Deloraine. The major concentration of lignite is in township 1, range 24 west, sections 13 and 24. "An estimated 5.3 million tons of lignite is present. More than 170 million tons of overburden would have to be removed to recover it."[2] Indications from widely scattered drill holes in the Deloraine - Turtle Mountain area show a bed of lignite having an estimated thickness of greater than one foot, but less than three feet. It can be postulated from the test hole results that between 200 and 400 million tons of lignite lie in this two hundred square mile area. However, the overburden in this area is from 150 to 500 feet thick.[3] It is the opinion of the author that this coal will not be mined during the next twenty-five years, if it can ever be economically mined at all.

Oil: At the present time, Manitoba has one small oil producing area near the town of Virden, in the south-west corner of the province. As of January 1, 1976, Manitoba's oil supply position stood as follows:[4]

	Initial Reserves MMStb*	Cumulative Production to 1/1/76, MMStb	Remaining Reserves MMStb
Manitoba	157.6	110.4	47.2
Canada	13895.2	7420.9	6474.2

[2] Ibid.

[3] Ibid.

[4] National Energy Board, Canadian Oil : Supply and Requirements, Ottawa, Queens Printer, February, 1977, p. 109.

* MMStb = millions of stock tank barrels.

Two facts are ascertainable from the above data. First, Manitoba is not one of Canada's major oil producing areas, and second, approximately seventy percent of the known crude oil reserves located in Manitoba have already been produced.

There is another component of supply which is not shown by the above data. This is the effective supply, or the rate of production of crude oil at the oil field. Table 1 shows estimates of Manitoba's requirements for petroleum products used for heating purposes. It should be noted that the refining of one barrel of crude oil results in the production of only a fraction of a barrel of heating fuel.

TABLE 1[5]

ESTIMATES OF CRUDE OIL PRODUCTION AND HEATING FUEL DEMANDS FOR MANITOBA (1000, barrels**/day)

Year	1975*	1976	1977	1978	1979	1980	1985	1990	1995
Crude Oil Production	11.21	10.31	10.48	8.72	8.02	7.38	5.31	3.37	2.08
Demand for Light Fuel Oil	6.5	7.4	7.3	7.2	7.0	6.9	6.7	6.6	6.5
Demand for Kerosene and Stove Oil	11.4	12.5	12.9	13.2	13.5	13.8	15.8	18.0	20.6

*Actual Figures.
**Barrels means barrels of 35 Canadian gallons.

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[5] Ibid.

It is apparent from the information contained in Table 1, that Manitoba can not meet its demand for petroleum based heating fuels from supplies of crude oil located within its boundaries, assuming that no new supplies of crude oil are found. It should be noted, however, that recent discoveries of oil in the United States, just a few miles south of the Manitoba - U.S. border have caused a considerable flurry of oil exploration in the southwest corner of the province. Only time will tell if these explorations will result in the discovery of new oil supplies in Manitoba.

Natural Gas: At the present time, Manitoba does not produce any natural gas. There has never been enough natural gas found in the province to warrant production. Unless natural gas is discovered, it appears that Manitoba will have to rely on imports.

Nuclear Energy (Uranium): Nuclear energy is not used directly to provide heat for residences. Nuclear reactors provide the power to produce electricity which can be used for residential space heating purposes. Right now, Manitoba has no nuclear generating stations, but this may not be the case in the future. The nuclear fuel used in a nuclear reactor is U-235, a fissable isotope of uranium. At the present time, Manitoba does not have any uranium mines in operation. However, recent exploration has resulted in the discovery of promising indications of uranium deposits in northwestern Manitoba. A report in "The Northern Miner" reads:

> "In northwestern Manitoba the most significant activities were reported by United Cisco Mines... strong anomolous areas with boulders containing massive pitchblend with unusually high uranium oxide (U_3O_8)

> values in underlying till... 5 out of 8 test holes ... Hasbla Lake, 13 of 16 holes." [6]

It appears that Manitoba may contain supplies of uranium. Whether or not these resources are developed will depend upon many things such as the price of uranium, the demand for uranium, and the competition from other uranium producing areas.

Electricity: In Manitoba, the majority of electricity is generated hydraulically. Manitoba's position with respect to supplies of hydro - electricity is summed up well in the Manitoba Hydro-Electric Board's 26th Annual Report. It states:

> "Water power has been the main source of electrical generation in Manitoba since 1906. As of March 31, 1977, the province's developed hydraulic capacity amounted to 2,538 megawatts. Present construction commitments will increase the capacity to 3,644MW by 1980.
>
> Beyond 1980, further hydraulic development is possible at a number of Manitoba sites---the Nelson, Burntwood, Rat, and Churchill Rivers promising 5,945 MW of additional generating capacity."[7]

As indicated in the report, Manitoba has a large supply of, as yet, untapped hydro-electric resources. Before these resources are developed, however, careful consideration needs to be given to the costs of development, particularly with respect to the cost of capital.

Manitoba also has some capacity to produce electricity by thermal generation. Manitoba's total thermal generation capacity as

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6 The Northern Miner, March 2, 1968.

7 Manitoba Hydro-Electric Board, 26th Annual Report for the year ended March 31, 1977, p. 15.

of March 31, 1977 stood at 421,988 kilowatts.[8] Thus, thermal capacity is used during times of short term peak power demand, and in isolated areas of the province. It is not meant (except in isolated communities) to provide year-round power generation.

Wood: Manitoba does not keep statistics which deal with the amounts of wood used for residential heating purposes. There is little doubt, however, that wood is being used (at least partially) to heat many residences. The Canada-West Foundation states that Manitoba contains 60,109 square miles of forested area, of which 59,147 square miles are suitable for regular harvest.[9] Whether or not Manitobans will use this supply of wood for heating purposes, will depend upon the costs of using it, the costs of other fuels, and the competitive end uses for wood.

(b) Fuel Located Outside Manitoba (which is imported)

Coal: Manitoba imports very little coal for residential space heating purposes. What little coal is imported comes from Saskatchewan. Both Saskatchewan and Alberta have extensive reserves of coal, and it appears likely that these two provinces will be the major sources of the coal supply for Manitoba in the forseeable future.[10]

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[8] Ibid., p. 32.

[9] Canada-West Foundation, Location of Primary Wood Using Industries, Calgary, Alberta, March, 1975, p. 8.

[10] This discussion is based upon a discussion which the author had with Mr. A.A. Bannatyne, a geologist employed by the Manitoba Department of Energy, Resources and Environmental Management.

Oil: Manitoba imports crude oil from Western Canada via pipeline. The main collection centre for this pipeline is Edmonton, Alberta. Only areas with a surplus of oil can become a source of imports for the Province of Manitoba. Table 2 shows the positions of areas in Canada which produce oil by conventional methods (ie. from oil fields, as opposed to synthetic oil production).

TABLE 2[11]

CANADIAN CRUDE OIL PRODUCTION AND REMAINING RESERVES OF CONVENTIONAL PRODUCING AREAS MMStb

Area	Initial Recoverable Reserves	Cumulative Production 1/1/76	Remaining Reserves
Ontario	60.9	57.4	7.5
Manitoba	157.6	110.4	47.2
Saskatchewan	2142.5	1436.8	705.7
Alberta	11073.6	5539.0	5534.6
British Columbia	400.6	262.5	138.1
North West Territories	60.0	18.8	41.2
Canadian Total	13,895.2	7,420.9	6,474.3

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[11] National Energy Board, Canadian Oil: Supply and Requirements, Ottawa, Queens Printer, February, 1977, p.p. 100-109.

Table 2 shows that Alberta is the area of Canada which has the largest remaining reserves of crude oil. Due to this fact, it seems likely that Alberta will remain the main source of Manitoba's oil imports, until such a time as their oil reserves dwindle to such an extent, that they no longer have oil for sale outside of their area.

Natural Gas: Manitoba imports all of the natural gas which it uses from western Canada by pipeline. Table 3 shows the ultimate potential estimates of Canada's conventional natural gas producing areas. As can be seen from Table 3, each estimator indicates that Alberta has the greatest potential reserves of natural gas. It should be noted that these estimates were made before the recent discoveries of natural gas in the foothills area of Alberta. Before these new discoveries were made, the National nergy Board was predicting a shortage of natural gas in Canada by 1984 - 85.[12] These new discoveries in Alberta push the spectre of shortage of supply of natural gas from conventional producing areas into the late 1980's.

There are areas other than the aforementioned, which show potential for natural gas production. These areas are known as the Frontier Areas. Table 4 lists estimates of the ultimate potential reserves of these Frontier Areas. These areas are also a potential source of natural gas supply for Manitobans.

Nuclear Energy (Uranium): Most of the current known uranium reserves in Canada are associated with the uranium mines discovered

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[12] National Energy Board, Natural Gas: Supply and Requirements, Ottawa, Queens Printer, April 1975, p. 72.

TABLE 3

ULTIMATE POTENTIAL ESTIMATES, CONVENTIONAL PRODUCING AREAS (Trillion cubic feet),

April 1975

Area	Canadian Petroleum Gas Association*	Foothills Pipe-lines Ltd.	Gulf Oil Canada Ltd.	National Energy Board
British Columbia	32-17-24	17.0	20**	15
Alberta	125-79-86	99.5	111	92
Saskatchewan	3 - 2 - 3	3.3	4***	3
Southern Territories	18-10-14	7.1	--	4
Western Canada Total	178-108-139	126.9	--	114
Ontario & Eastern Can.	--	3.3	--	1
Canada Total	--	130.2	135	115

*Note: *high-low-average estimates
**includes Southern Territories
***includes all conventional producing areas, except Alberta, British Columbia, and Southern Territories.

TABLE 4[14]

ULTIMATE POTENTIAL ESTIMATES - FRONTIER AREAS

April, 1975 (Trillions of cubic feet)

Area	Canadian Petroleum Association *	Foothills Pipeline Ltd.	Gulf Oil Canada Ltd.
Beaufort-Mackenzie Basin	110-41-78	38.0	65
Arctic Islands	240-86-168	113.0	100-200
East Coast Offshore	200-60-110	142.0	130
Other Frontier Areas	23 - 6 - 14	6.5	7
Total	573-193-370	299.5	302-402

*

Note: *high-low-average estimates.

in the late 1940's and early 1950's. These uranium producing areas are in northern Saskatchewan, and the Elliot Lake and Bancroft areas in Ontario. New areas have already been discovered in British Columbia, northern Saskatchewan and Labrador.[15]

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[13] Ibid., p. 41.

[14] Ibid., p. 44.

[15] S.R. Hatcher, "Nuclear Fuel Supplies", (presented to the Nuclear Symposium for Manitoba Government), February 3, 1976, p. 2.

"The Northern Miner" reports that deposits have been discovered at Beaverhill, British Columbia, and Wolleston Lake in Saskatchewan.[16]

It seems likely that if Manitoba does wish to import uranium, it will import it from one of these areas.

Hydro-Electricity: Manitoba Hydro has interconnections with the power grids of Saskatchewan, Ontario, and the United States of America. Normally, due to a surplus of hydro-electric power, Manitoba is a net exporter of electrical power to all three of these areas. In the event of a shortage of electrical power in Manitoba, these areas would probably sell Manitoba electrical power, assuming that they have an available surplus at that time.

Wood: Manitoba is a well wooded area in a well wooded country. Table 5 shows Canada's forested area by province. It appears that Manitoba should be able to import wood, if it runs short of its own supply. The major consideration as to which area Manitoba would buy wood from, would probably be the price of the wood delivered to Manitoba.

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[16] The Northern Miner, April 27, 1978.

TABLE 5[17]

CANADA'S FORESTED LAND, BY PROVINCE (sq. mi.)

Area	Total Forest Area	Area Suitable for Regular Harvest
Newfoundland	47,576	34,359
P. E. I.	976	965
New Brunswick	15,515	15,024
Nova Scotia	24,464	24,220
Quebec	268,480	190,383
Ontario	188,335	180,424
MANITOBA	60,109	59,147
Saskatchewan	40,500	33,792
Alberta	106,754	93,948
British Columbia	215,743	210,684
Yukon	81,200	42,268
N. W. T.	194,600	33,977
CANADA	1,244,292	919,209

[17] Canada-West Foundation, Location of Primary Wood Using Industries, Calgary, Alberta, 1975, p. 8.

2.2 Summary of Manitoba's Fuel Supply Position

With respect to coal, Manitoba finds itself in a position where it does have some indigenous coal supplies, but they are of poor quality, and it is questionable if they can be mined economically. Manitoba's neighbouring province to the west, Saskatchewan and Alberta, have large supplies of coal. Bulk transportation of coal from these areas would be very expensive. If Manitoba does import coal from these areas, it will probably be through a pipeline as a coal-slurry or coal gas.

Manitoba does produce some crude oil, but the amounts produced and the projected reserves fall far short of current and projected demands. Manitoba relies on imports of oil from Alberta, at the present time, to meet its demands, and will probably do so until such a time as these supplies are no longer available. Recent discoveries of oil just a few miles south of the Manitoba - United States border, has resulted in speculation that Manitoba may also contain as yet, unknown supplies of crude oil.

Manitoba has no natural gas supplies of its own and relies on imports from Alberta. Recent discoveries in the foothills area of Alberta, combined with the potential reserves in the frontier areas, result in a situation in which Manitoba can be quite sure of continued supplies of natural gas with no cut backs, at least until the late 1980's.

Manitoba is in a favourable position with respect to supplies of electrical energy. The province contains the potential for generating between two and three times the amount of hydro-electricity as is being generated currently. Interconnections with the electrical grids of

Ontario, Saskatchewan, and the United States make it possible for Manitoba to sell surplus electrical energy and, if the need arises, to buy supplies of electrical energy. These interconnections also allow for the better management of Manitoba's hydro resources through good use of storage and seasonal power interchanges.

Recent exploration indicates that there is a strong possibility that Manitoba has significant uranium deposits, although, at the present time, there are no producing mine sites. Significant deposits of uranium have been discovered in Saskatchewan, British Columbia, and Ontario, and it seems likely that Manitoba could, if need be, import uranium from these areas. The whole question of whether or not Manitoba will need uranium supplies hinges upon whether or not Manitoba decides to have a nuclear generation station.

Manitoba, like the rest of Canada, is well forested. Whether or not this wood is used as a source of energy will depend upon the cost to the consumer of using wood versus the cost to the consumer of using a different energy resource.

With respect to Manitoba's supply of energy resources suitable for the purpose of residential space heating, the author concludes that Manitoba has sufficient resources of hydro-electricity and wood for its own use, but it will continue to rely on imports of coal, oil, and natural gas for its future needs. To date, Manitoba's uranium supply is an unknown factor, but exploration is still continuing to occur.

CHAPTER III

HEATING FUEL USAGE IN MANITOBA: AN OVERVIEW

3.1 Method of Giving an Overview of Manitoba's Heating Fuel Use

This chapter of the report attempts to give as complete a picture as possible (within the time available for the production of this report), of the present day pattern of space heating fuel use in the Province of Manitoba. A presentation of this material is a necessary prerequisite to any discussion of future trends of heating fuel use and/or any discussion of feasible alternatives which would form the basis for a government residential space heating policy.

The following is a list of the components of the overview:

(a) historical growth comparisons between the consumption of various heating fuels and the total energy consumption;

(b) comparitive consumption of heating fuels among the provinces, and Canada as a whole;

(c) energy features of the Manitoba housing stock;

(d) household breakdown of heating fuel by type;

(e) new space heating installations for various fuels;

(f) heating equipment used;

(g) seasonal demand for space heating fuel; and,

(h) geography of heating fuel use.

3.2 History of Heating Fuel Use in Manitoba

A considerable proportion of the total amount of energy consumed in Manitoba (approximately 22.5% in 1975) was accounted for by the residential sector.[1] Nevertheless, energy consumed in residences is a major end-use factor, and probably 80% (see Chapter IV for a justification of this figure) of this energy is used for the purpose of residential space heating.

The proportion of residential space heating fuels consumed relative to the total energy consumption, and the mix of fuels used to meet Manitoba's space heating requirements have changed over time. Figure 1 compares the consumption growth in BTU of heating fuels to total energy consumption in Manitoba between the years 1963 and 1975.[2] Curves A, C, D, E, & F were plotted by making the 1963 consumption level equal to 100 for each fuel and calculating the relative annual consumption levels to 1974. Due to the very low consumption levels of liquified petroleum gases (LPG) in Manitoba prior to 1966, curve B was plotted by making the 1966 consumption level equal to 100 and by calculating the relative annual consumption levels to 1974. As a result, curve B is not properly indexed, as are the remainder of the curves. Curve B is included in this figure so that the growth of LPG consumption could be noted.

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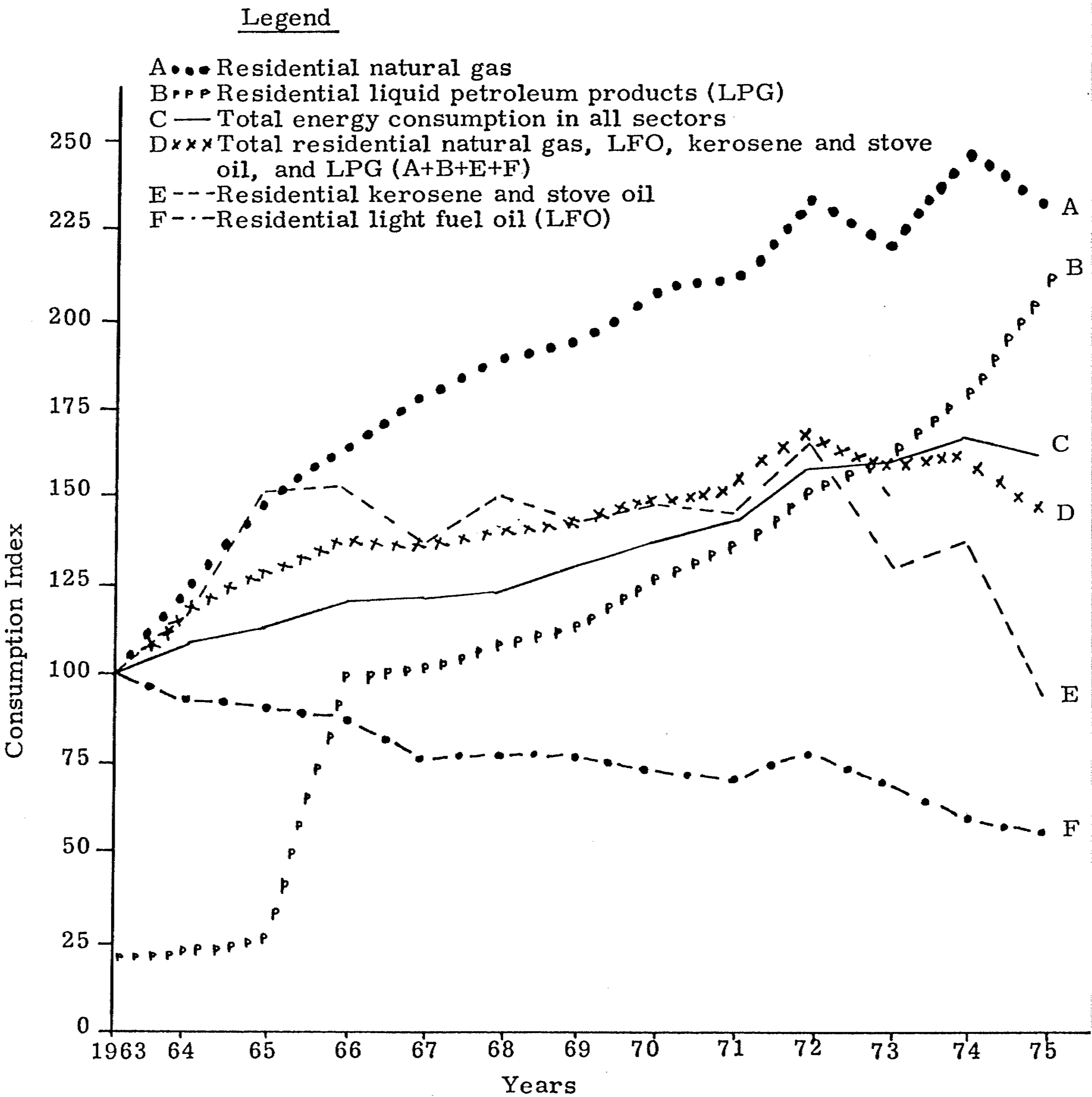
[1] This figure was arrived at by summing the 1975 Manitoba residential consumption in BTU of coal, LPG, kerosene and stove oil, light fuel oil, natural gas, and electricity, and dividing it by Manitoba's total energy consumption for 1975. Source: Statistics Canada 57 - 207, Detailed Energy Supply and Demand in Canada, 1975.

[2] The total consumption curve for Manitoba includes the fuels coal, coke, LPG, crude oil, still gas, motor gas, kerosene, diesel fuel oil, light fuel, heavy fuel oil, petroleum coke, aviation gas, aviation turbo fuel, natural gas, and electricity. The fuels, petroleum oven gas and coke oven gas were excluded, due to the fact that there are no figures available during the study period on their usage. It seems likely that these fuels have a significant impact on Manitoba's total fuel consumption curve. Consequently, curve C in figure 1 should be a fairly accurate description of the relative increases in Manitoba's total energy consumption.

FIGURE 1[3]

Comparative Residential and Total Consumption in Manitoba 1963 - 1975



[3] Sources: Statistics Canada 57 - 207, Detailed Energy Supply and Demand, 55 - 202, Gas Utilities, and 45 - 208, Refined Petroleum Products, Manitoba Energy Council.

Figure 1 shows two interesting trends which are commented upon. The first concerns total energy consumption in all sectors as compared to space heating fuel consumption in residences. The second concerns changes in the relative shares of different types of heating fuels within a residential sector.

The residential heating fuel consumption index increased at a similiar although slightly lower rate than the total energy consumption index between the years 1963 and 1975. Only substantial changes in the number of dwellings, or in the efficiencies of heating fuel use can expect to significantly affect the residential heating fuel use. Therefore, one is forced to conclude that one of these factors, or a combination of these factors, resulted in a situation where the residential sector consumption index increased at only a slightly lesser rate than the indexes of the industrial, commercial, transportation, and agricultural sectors of Manitoba's economy. This indicates the importance of energy used for residential heating purposes and underlines Manitoba's need for a residential space heating policy.

The relative market shares of the different types of heating fuels used by the residential sector did not remain constant between the years 1963 and 1975. Although total residential energy consumption increased, each type of fuel used did not enjoy the same rate of increase; in fact, some types of fuel decreased their share of the market during the study period. The amount of light fuel oil used for residential heating purposes declined almost constantly throughout the years 1963 and 1975. Use of the fuels, kerosene and stove oil increased rapidly in the years from 1963 to 1966, and then remained more or less constant until the early 1970's, when it decreased dramatically. This dramatic decrease coincides with the public revelation of the so-called "energy crisis", and higher fuel prices associated with the OPEC embargo. These two factors probably account for the shift away from kerosene and stove oil as fuels used for residential heating purposes.

Both natural gas and propane have increased their consumption curves during the years 1963 to 1975. The very rapid increase in propane is probably attributable to the rapid increase in the number of mobile homes within the province, as well as the fact that propane heating equipment is readily convertible to natural gas, if a connection to a natural gas line is a future possibility.[4] The rapid increase in consumption has many reasons; the increase in housing stock, the spreading of the natural gas system to new communities and subdivisions, the population shift from the rural to the urban areas, and the prices of other fuels used for residential space heating.

Electricity is another energy source used for residential heating purposes, which has increased its share of the market rapidly during the years 1963 to 1975, but not discussed in this section. It was not included as a separate 'fuel' in Figure 1 because exact statistics which separate electricity used for residential heating purposes from electricity used for other residential end-use purposes have not been kept in

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[4] These reasons for propane's increase were brought to the author's attention by the Mechanical and Engineering Department of the Manitoba Department of Labour.

Manitoba for the years in question. The Manitoba Energy Council has recently attempted to produce such a set of statistics. These are contained in Appendix B of this report.

3.3 Comparative Heating Fuel Consumption Among the Provinces

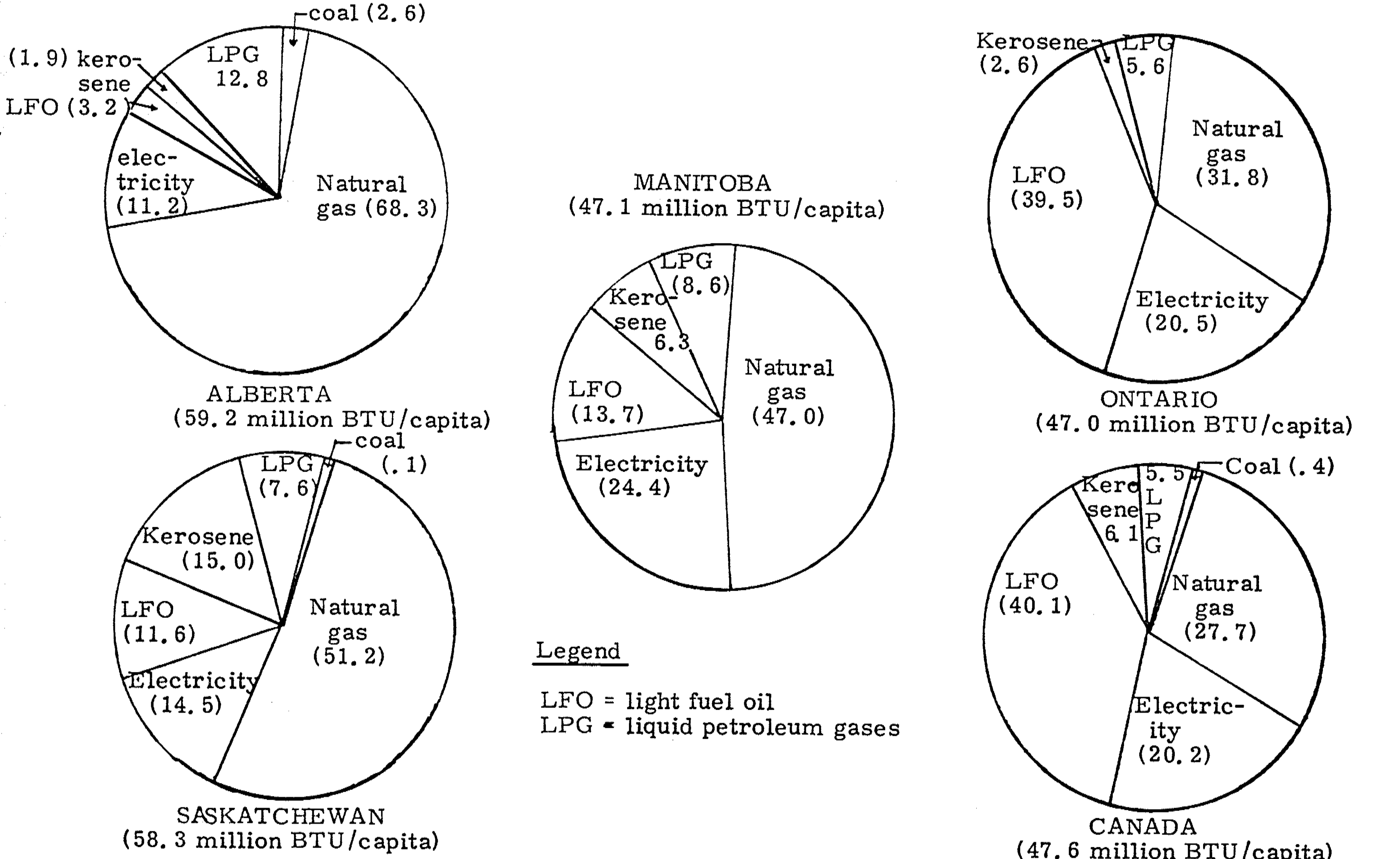
Each province relies on a different energy mix for meeting its residential space heating requirements. Figure 2 compares the proportions of coal, liquified petroleum gas, kerosene, light fuel oil, natural gas, and electricity used in the domestic and farm sectors of Manitoba, Saskatchewan, Alberta, Ontario, and Canada as a whole for 1975. The major portion of each of the listed fuels is normally used for space heating purposes. The exception to this generalization is electricity. Electricity is used normally in most residences to run appliances and for lighting purposes. Electricity is a source of residential space heat in the 23,197 electrically heated homes and 15,211 apartment suites which Manitoba had in 1975. A further bias is contained in the electrical consumption of this sector by the inclusion of electricity used in the farm yard. Given these limitations, the following points are notable with regard to the proportionate fuel consumption by the domestic and farm sector of the selected provinces and Canada in 1975:

(a) Manitoba and Ontario consumed virtually no coal for meeting its domestic and farm energy requirements. Saskatchewan and Alberta consumed some coal, but very little in relation to other fuels used for meeting domestic and farm energy requirements. This reflects the situation of Canada as a whole, where only 0.4% of the energy required for the domestic and farm sectors was derived from coal.

(b) Manitoba was second only to Alberta in its reliance on liquid

FIGURE 2[5]

Domestic And Farm Fuel Use in Canada And Selected Provinces, 1975 (by % of BTU consumed)



[5] Source: Statistics Canada 57 - 207, Detailed Energy Supply and Demand 1975, and 1971 and 1976 Census of Canada, from which populations of each area were estimated for 1975. Diesel fuel and heavy fuel are excluded from above.

petroleum gases for meeting its domestic and farm energy requirements. Although used primarily for space heating, L.P.G. is also used for water heating, cooking, clothes drying, and refridgerators, particularly in mobile homes.

(c) Manitoba consumed slightly more kerosene for its domestic and farm energy requirements, than Canada as a whole. Manitoba consumed a higher proportion of kerosene than Canada, Ontario and Alberta, but less than Saskatchewan.

(d) Manitoba consumed a considerably smaller proportion of light fuel oil than Canada or Ontario, but a higher proportion than Saskatchewan and Alberta.

(e) Manitoba relied heavily on natural gas for its domestic and farm energy demand, although to a lesser degree than Alberta and Saskatchewan. This fact assumes great importance upon consideration of the fact that Manitoba has no indigenous natural gas supplies. Although natural gas is used for water heating, cooking and drying clothes, it is primarily used for space heating.

(f) Manitoba consumed a higher proportion of electricity than any of the other areas, including Canada as a whole. Both Manitoba and Ontario have relied more on electricity for space heating than Saskatchewan or Alberta or Canada, because of the hydro-electric potential and the lack of natural gas supplies in the former two provinces.

(g) On a BTU/capita basis, domestic and farm total energy consumption in Manitoba was considerably below that of Saskatchewan and Alberta, but very close to the rates of Ontario and the national average of Canada.

Using 1975 as a point of comparison, one can attempt a brief characterization of space heating fuel use in the Manitoba domestic and farm sectors, based upon (a) to (g) above. Manitoba's level of domestic and farm fuel consumption on a per capita basis is very close to Canada's national average. Manitoba relies on natural gas and electricity for the majority of its domestic and farm energy requirements, with the proportions of both being greater than the average for Canada, and with the proportion of electricity greater than the other provinces and Canada. Manitoba's reliance on liquid petroleum gases for space heating requirements is second only to the reliance of Alberta for this purpose. Manitoba has a slightly greater than average reliance on kerosene, but uses a significantly lower portion of light fuel oil than average for Canada. Manitoba's use of coal in the residential and farm sector is not significant on an overall basis.

3.4 Energy Use Features of Manitoba Housing Stock

Heating fuel requirements in a residence are related to a large number of factors including the residence size, the design type (single or multiple dwelling unit), the thermal resistance of the building materials used, air infiltration rates, furnace efficiencies, conservation habits, etc.. Therefore, in an examination of residential heating fuel use in Manitoba, one should consider the qualities and locations of residences, in addition to the quantities of existing residences. The distance of residences to transmission lines and/or fuel distribution centres is also an important matter to consider, particularly if inter-fuel substitutions are contemplated.

Prior to 1945, many of the houses which were built in Manitoba were constructed without any wall insulation at all. Ceilings were commonly insulated with wood shavings, but there was no specified R value. Three to four inches of shavings resulted in insulation with an R value of approximately R 6.6 to R 8.8. This was probably the most common practice for insulating ceilings. During the latter half of the 1940's, walls began to be insulated to a much greater extent than previously. Wood shavings were still the primary insulating material, which resulted in walls using 2x4's for framing, having an insulation value of approximately R9 - R10 (includes R7 from shavings and approximately R1 - R2 from cover materials). Wood shavings provided adequate insulation levels at the time, but as an insulating material, it suffered from several faults, such as:

(a) unless treated chemically, wood shavings do not act as a fire deterrent, but rather they add a considerable amount of fuel to a fire.

(b) insects and vermin are able to live in wood shavings, unless they were treated chemically

(c) unless treated chemically, shavings are susceptible to mold and mildew

(d) wood chips tend to settle and sag inside a wall, leaving gaps near the top of studs, where heat could escape.

From the early 1950's, mineral wool and fibre-glass began to take over the insulation market. However, actual R value of the installed wall insulation did not change in the 1950's. The most common wall insulation became a two-inch fibre-glass batt, with an Rvalue of R6.5 to R7.

Prior to 1970, construction standards for financing houses under the National Housing Act specified insulation standards which were based upon the cost of heating oil in the Ottawa area of the country. In 1970, the standards for the resistance value of the insulation used in ceilings and walls, were, to some extent, made dependent upon the degree days of the area in which the residence would be located. In the Winnipeg area, for example, the thermal resistance values (including the building materials used in the construction of the ceilings, walls and basements) as of 1975 were --- walls, R13.7; ceilings, R14.1; and basements, R8.7, for non-electrically heated residences and R14.0, R16.8, and R10.1 respectively for electrically heated residences.[6] These standards have remained the same in the 1977 regulations.[7]

Keeping the preceeding historical sketch[8] in mind, it is now possible to turn to the existing housing stock in Manitoba. Table 6 is a profile of the Manitoba housing stock as it existed at the end of 1975.[9]

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[6] National Research Council of Canada, Residential Standards, Canada, 1975, p. 82 - 83.

[7] National Research Council of Canada, Residential Standards, Canada, 1977, p. 86 - 87.

[8] This historical sketch was written by the author after discussions with C.M.H.C. and Mr. Ernie Lomonaco of Winroc Gypsum Supplies, one of Winnipeg's largest insulation suppliers. (Table B - a in Appendix B lists insulation levels in residential construction standards financed under the National Housing Act in codes from 1954 to 1977).

TABLE 6*

MANITOBA HOUSING STOCK PROFILE

Dwelling type	Pre 1945	1946-50	1951-60	1961-75	Total	By Type
Single detached	90,355	27,850	46,550	64,545	229,300	69%
Semi-detached	1,965	480	995	4,985	8,425	3%
Row	2,430	500	1,575	5,125	9,630	3%
Duplex	5,720	1,035	1,700	2,030	10,485	3%
Apartment	19,670	2,525	8,015	42,745	72,955	22%
Total	120,140	32,390	58,835	119,430	330,795	100%
% by period	36%	10%	18%	36%	100%	
% by period single detached	75.2%	86%	79.1%	54%	69%	
% by period apartments	16.4%	7.8%	13.6%	35.8%	22%	

*Source: Central Mortgage and Housing Corporation, Thermal Efficiency In Existing Housing and the Potential for Conservation, 1976.

Table 6 indicates that roughly one-third of the Manitoba housing stock which existed in 1975 was built in 1945 or ealier, one-third was built between the years from 1946 - 1960, and one-third was constructed between the years 1961 and 1975. By considering the comments made previously in the historical sketch, it is possible to make the following rough approximations about the insulation features of the existing Manitoba housing stock:

(a) roughly one-third of the Manitoba housing stock has no insulation in their walls, and none or small amounts (up to R7) of insulation of dubious quality in their ceilings;

(b) roughly one-third of the Manitoba housing stock have walls containing insulation with a value of R7, which has lost at least part of its efficiency through aging and sagging, and R7 insulation of perhaps dubious quality in the ceiling;

(c) roughly one-third of the Manitoba housing stock have R7 to R10 of effective insulation in their walls and R7 to R14 in their ceilings.[10]

The period of construction (and, as a result, the insulation features) vary from one part of Manitoba to another. By considering the

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[9] The assumptions used in preparing this table are contained in Appendix B. Until the results of the 1981 Census of Canada are known, estimates such as these can only be regarded as being very approximate.

[10] These may, in fact, be rather optimistic estimates, since they assume that most of the residences have insulation levels equal to the N.H.A. standards.

census division data from the 1971 Census, it can be seen that the oldest dwellings (built prior to 1946) are in the southern and western parts of the province. Census divisions with large urban centres tend to have approximately 55% of their housing stock constructed after 1945. In the five most northerly divisions, 12, 15, 16, 18, and 19, more houses were constructed during the period 1946-1960, than in any other periods considered by Table 6.[11]

In addition, as can be expected with the growing urbanization of Manitoba during the past few decades, there is a considerable difference between the construction period of urban and rural dwellings. Rural farm and non-farm dwellings tend to be considerably older than the average urban dwelling.[12]

There are several different types of dwellings which make up the Manitoba housing stock. It will be demonstrated later on in this report that single detached dwellings require more BTU of heating fuel for the same livable area as compared to multiple housing units with similar thermal insulation features and air infiltration rates. In 1977, Manitoba was estimated to have 319,000 dwellings, of which 223,000 or 69.9% were single detached dwellings. In the same year, Canada was

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[11] Refer to Figure B - a in Appendix B for a map of construction periods of occupied dwellings in Manitoba by 1971 census division.

[12] Refer to Table B - b of Appendix B for the period of construction of urban and rural occupied dwellings in Manitoba in 1971.

[13] Statistics Canada 64 - 202, Household Facilities and Equipment, April 1977.

estimated at 7,022,000 dwellings of which 4,164,000 or 59.3%, were single detached dwellings.[13] In Manitoba, therefore, there is a considerable higher proportion of single detached dwellings than there is in Canada as a whole.[14]

Another factor which affects the amount of fuel consumed by a residence is its size. Unfortunately, information is not available at this time on the average sizes of Manitoba residences.

C.M.H.C. estimates that in recent years, 30 - 40% of the new residences in Winnipeg have been financed under the National Housing Act. The Research Branch of C.M.H.C. in Winnipeg also estimates that the size of Winnipeg houses follows very closely the size of N.H.A. financed houses throughout Canada. Keeping this in mind, Table 7 gives an indication of the relative areas of new houses financed under the N.H.A. in Canada from 1970 to 1977. A word of caution should be noted when using this table as being a representative of average new housing sizes, since N.H.A. financing tends to relate more to the smaller sized residence, rather than to the larger sized residences. Nevertheless, this table indicates that these N.H.A. financed houses have tended to decrease in size since 1970.

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[14] For a further illustration of Manitoba position in relation to design types, see Appendix B, Table B- c , and Table B - d .

TABLE 7*

SIZES OF NEW HOUSES FINANCED UNDER THE NATIONAL HOUSING ACT IN CANADA

Year	% Distribution of Square Feet				
	0 - 999	1,000 - 1,199	1,200 - 1,399	1,400 - 1,599	1,600 +
1970	23.5	44.2	16.9	7.4	8.0
1971	28.8	52.8	15.8	6.1	6.5
1972	31.6	42.3	14.9	6.3	4.9
1973	31.9	44.2	13.8	5.5	4.6
1974	37.0	43.7	11.5	3.5	3.3
1975	41.1	44.3	9.4	2.5	2.7
1976	40.4	44.9	9.6	2.8	2.3
1977	40.5	45.4	9.0	2.7	2.4

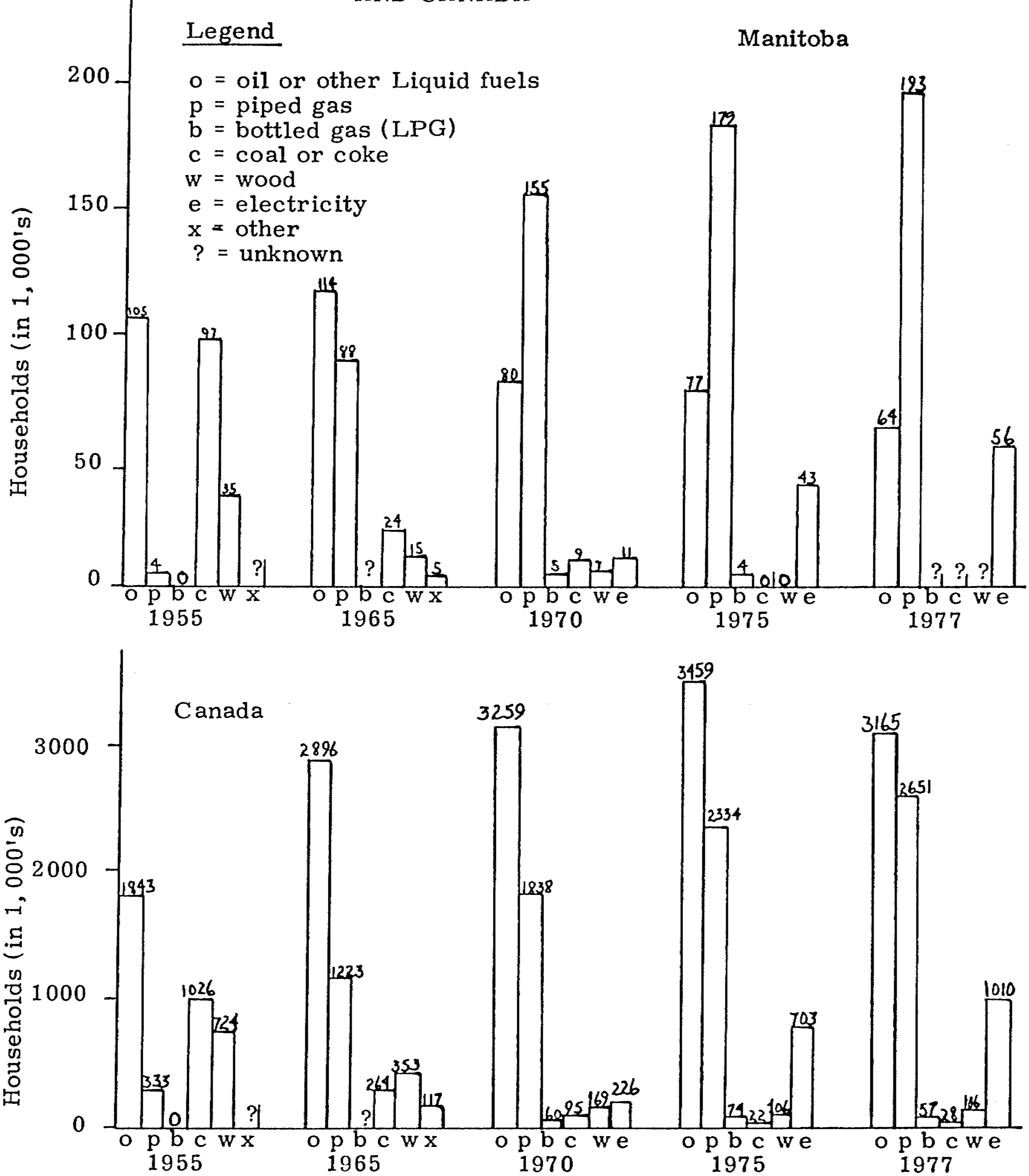
*Central Mortgage and Housing Corporation, Canadian Housing Statistics, 1971 - 1977.

3.5 Household Breakdown of Space Heating By Fuel Type

Useful information on heating fuel use can be found in the Statistics Canada household data which Statistics Canada has derived from a survey where estimates of the number of households, which consume each type of fuel are, at best, approximations. With these limitations kept note of, Figure 3 demonstrates the relative significance of the various heating fuels for both Canadian and Manitoban households from 1955 to 1977. Canada had a regular increase in the number of households using heating oil for heating purposes between 1955 and 1975, but showed a decrease between 1975 and 1977, although heating oil still maintained its position as the predominant heating fuel in the country. Manitoba, on the other hand, has seen approximately a 35% drop in the use of heating oil for space heating purposes between 1955 and 1977. Both Manitoba and Canada have shown a dramatic increase in the numbers of households using natural gas as their principle heating fuel. However, approximately 60.5% of Manitoba's households were heated by natural gas in 1977, as compared to approximately 38% in all of Canada. The statistics available on bottled gas (propane) used in both Canadian and Manitoban households proved to be of dubious quality, due to the statistical techniques used to obtain them. As a result, the author finds himself unable to comment upon the use of bottled (LPG) gas among either Manitoban or Canadian households. The use of coal and wood have declined drastically in both Canada and Manitoba during the years 1955 to 1975, but showed a leveling-off trend from 1975 to 1977, according to the Statistics Canada data. Both Manitoba and Canada

FIGURE 3*

PRINCIPAL HEATING FUELS IN HOUSEHOLDS, MANITOBA AND CANADA



*Source: Statistics Canada 64 - 202, Household Facilities and Equipment. Figures include single and attached dwellings and apartments.

have experienced a rapid growth in the numbers of households using electricity as their principal heating fuel. Manitoba households exibited an increase in use of electricity as a heating fuel, of approximately 510% between the years 1970 and 1977, while Canada exibited an increase of approximately 447% during those same years.

3.6 Heating Equipment

Estimates of the numbers and types of heating equipment located in Manitoba are shown in Table 8. This table indicates that hot air furnaces have been, and continue to be, by far the largest segment of the market for heating equipment in Manitoba during the years between 1967 and 1977. The number of heating stoves and cook stoves used as household heating equipment has declined, while steam or hot water furnaces have increased their numbers slightly during the last ten years. The use of electric equipment for heating houses has increased on an almost continuous basis over the last ten years, up to the point where it is now second only to hot air furnaces as the principal type of heating equipment found in Manitoba households.

TABLE 8*

HEATING EQUIPMENT CONTAINED IN MANITOBA HOUSEHOLDS

(by 1,000's) 1967 - 1977

Year	Total House-Holds	Steam or Hot Water Furnace	Hot Air Furnace	Heating Stoves and Cook Stoves	Electricity and other
1967	246	36	178	27	---
1968	258	43	185	23	5
1969	263	36	194	24	5
1970	266	42	191	18	11
1971	270	48	189	21	11
1972	287	44	204	18	20
1973	292	44	209	12	25
1974	306	47	206	13	39
1975	311	42	214	10	43
1976	314	37	220	9	40
1977	319	46	203	10	52

*Source: Statistics Canada, 64 - 202, Household Facilities and Equipment, This table does not contain exact figures; but rather approximations based upon a statistical analysis of surveys conducted by Statistics Canada.

3.7 New Space Heating Installations

Table 9 is an estimate of new residential installations and conversions for various heating fuels in Manitoba for the years 1969 to 1977. This table can also be used as an indicator of the current popularity of the various fuels. Natural gas installations increased until 1972, and have shown a considerable decrease from 1973 to 1977. Heating oil installations have decreased substantially with the exceptions of the years, 1970, 1972, 1973 and 1975, during which there were increases in the installation numbers. Propane installations increased slowly during the period from 1971 to 1974, dropped dramatically during 1975, and have been increasing slowly to 1977. This drop in 1975 coincides with the 1975 drop in natural gas installations and the tremendous jump in the installations of electricity, which took place in that year. The use of electricity as a heating fuel has continued to gain in popularity almost throughout the period 1971 to 1977.

TABLE 9

NEW INSTALLATIONS AND CONVERSIONS OF RESIDENTIAL HEATING EQUIPMENT - BY FUEL TYPE 1969 - 1977

Year	Natural Gas [a]	Heating Oil [b]	Propane [c]	Electricity [d]
1969	5,957	150	Not Available	---
1970	4,500	291	Not Available	--- [e]
1971	5,961	126	343	2,105
1972	6,824	159	364	2,650
1973	5,648	187	366	2,796
1974	4,177	59	442	3,576
1975	2,334	101	368	6,634
1976	3,678	82	338	6,580
1977	3,548	52	418	6,920

(a) Source: Statistics Canada 55 - 002, Gas Utilities.

(b) Source: Manitoba Department of Labour, Annual Report: Mechanical and Engineering Department, 1969 - 1977.

(c) Source: Manitoba Department of Labour, Annual Report: Mechanical and Engineering Department, 1969 - 1977; Statistics Canada 55 - 002, Gas Utilities.
5% of the total number of residential gas burner permits (other than gas furnaces) was estimated as the number of residential propane installations per year.

(d) Source: Manitoba Hydro, Marketing Division, Historical Trend In Electrical Heating Growth.

(e) The total number of electrically heated residences from 1960 to 1970 was 7,706.

3.8 Seasonal Demand for Space Heating Fuel

Consumption of heating fuels varies on a seasonal basis, with peak demands occurring in December and January, due to the space heating needs during those months. Some fuels are not used as extensively or as exclusively for space heating as others are, and, as a result, they are not as responsive to seasonal variation. Figure 4 illustrates the seasonal variations in both Manitoba and Canada during 1976 for all consumer classes. As can be seen from the diagram, sales of both light fuel oil and stove oil follow the monthly degree pattern quite closely. Natural gas and electrical consumption are not quite as responsive to the monthly degree day pattern, however, due to other residential end uses for these fuels. Seasonal variation in space heating fuel demand has implications for both the fuel delivery systems and fuel storage capability.

Figure 4 also indicates the greater severity of the Manitoba[8] climate as compared to other areas of Canada. The total degree days of heating for Winnipeg, Manitoba in 1976 were 5,978.7 (these are degree days Celsius). Toronto was used to symbolize the rest of Canada because of the large population based in that area and because, until 1975, it was the area upon which the N.H.A. insulation standards were based. Toronto's total degree days (Celsius) in 1976 were 4,458.8. Thus, in 1976, Winnipeg had 1,519.9 more degree days (Celsius) than Toronto.

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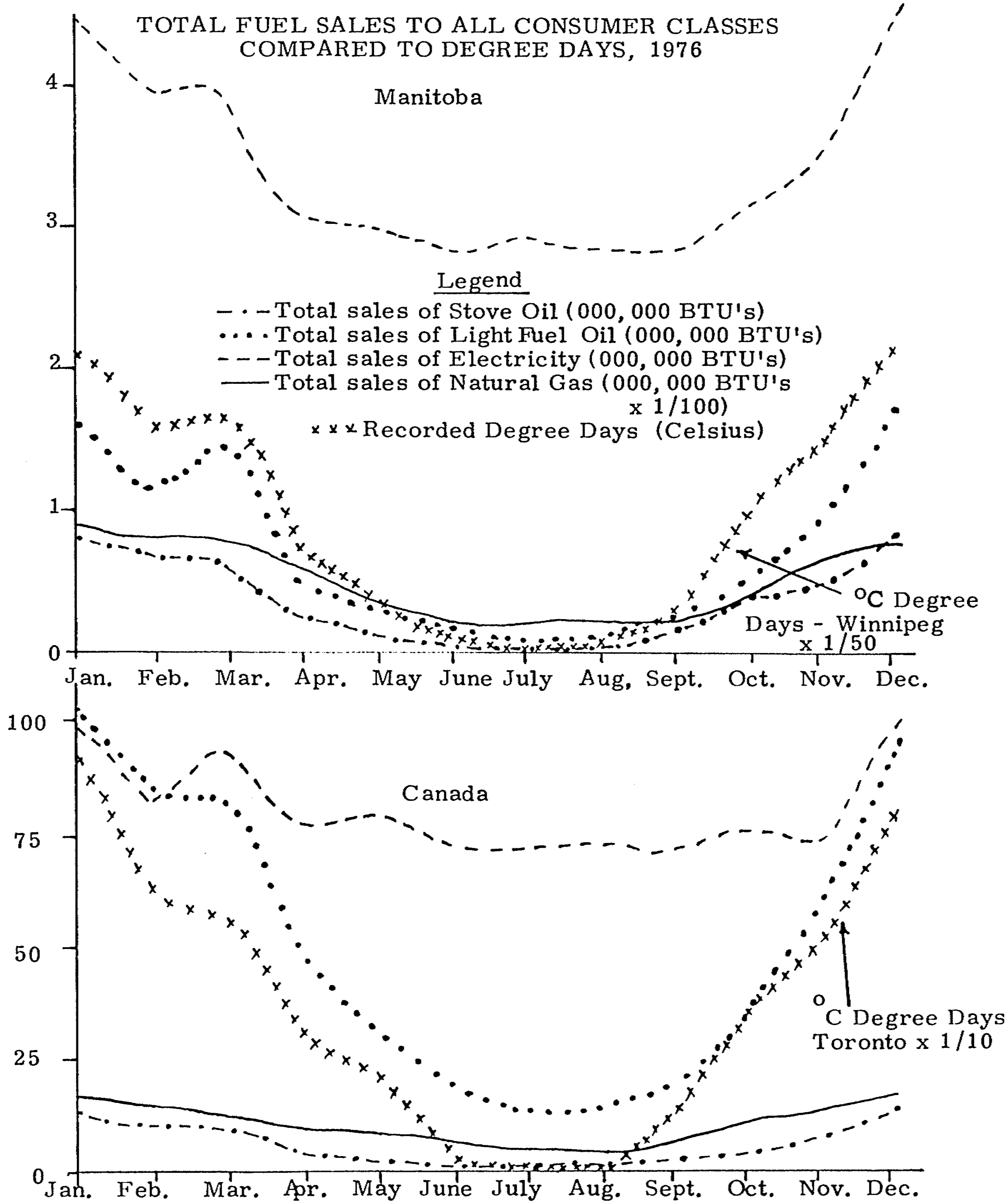
[8] Refer to Figure B - b, Appendix B, for a map of degree days (F.) of heating in Manitoba.

FIGURE 4*



*Source: Statistics Canada 57 - 001, Electric Power Statistics, 57 - 002, Service Bulletin - Energy Statistics, 55 - 002, Gas Utilities, and the Meteorological Division, Canada Department of Transport.

3.9 Geography of Heating Fuel Use

An indication of the geographical variations of heating fuel use can be achieved through the use of the census division data dealing with the principal heating fuels in occupied Manitoban dwellings at the time of the 1971 Census. The following comments are based upon Figure B - c, located in Appendix B. Appendix B also discusses the reliability of these census estimates.

(a) Heating oil and other liquid fuels (kerosene) were used in more than 50% of the dwellings in fifteen of the twenty census divisions, and were dominant fuels in two other divisions in 1971. This situation probably overstates heating oils' and liquid fuels' position as it was in 1977, due to the expansion of the natural gas distribution system, the rural to urban population trend, the increase in electric heating, and the increased cost of heating oil and kerosene.

(b) Natural gas was used in more than 50% of the dwellings in two out of twenty census divisions in 1971. However, these two census divisions contain almost 64% of the dwellings located in Manitoba. The use of natural gas was second only to oil in ten other census divisions. As can be expected, the geographical pattern of natural gas use closely follows the more dense urban population within the province. It is also likely that natural gas has increased its number of users in many of the census divisions since 1971.

(c) Wood was of considerable importance to the more northern divisions, particularly division 18, which had 31.7% of its heating fuel requirements met primarily by wood. Wood was the second most important heating fuel (after oil in all cases) in six out of eighteen census divisions. It is likely that wood, as an energy fuel, has declined somewhat since 1971, but there are indications that it may regain its position as a major heating fuel in areas where it is easily available.

(d) Coal was used by more than ten percent of Manitoban dwellings in three of the census divisions. These were in the southwest corner of the province. It is likely that the proportion of coal used as a heating fuel will have decreased since 1971.

(e) Electricity was used by more than ten percent of the Manitoban dwellings in nine out of the twenty census divisions. The main consumption areas were northern, north western, and southwestern Manitoba. It seems likely that electricity will have increased in its proportion of the market, particularly in rural areas which are not on the natural gas distribution system.

There is a considerable difference between the mix of heating fuels used in the farm and rural areas, as compared with the urban centres.[9] According to the 1971 Census, 148,145 or 70.5% of urban dwellings had natural gas as their principal heating fuel, as compared to 10.3% for rural non-farm dwellings, and to 1.4% of the farm dwellings. While only 21.2% of urban dwellings were heated by oil or other liquid fuels, 59.8% of rural non-farm dwellings, and 43.7% of farm dwellings

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[9] Table B - e of Appendix B provides the basis for these comments.

were heated with such fuels. Coal was used only by 0.7% of urban dwellings, 3.2% of non-farm dwellings and 9.8% of farm dwellings; wood was used in .2% of urban dwellings, 14.1% of rural non-farm dwellings, and 13.1% of farm dwellings. The use of electricity as a primary heating fuel was much more evenly spread with 5.8% of urban dwellings, 9.8% of rural non-farm dwellings, and 8% of farm dwellings relying on it. As has been mentioned previously, the proportions of residential heating requirements met by each fuel will probably have changed somewhat since 1971.

3.10 Summary of Chapter III

(a) Heating Fuel Allocation

According to Statistics Canada, approximately 60.5% of Manitoba's households were heated by natural gas in 1977, as compared to the Canadian average of approximately 38%. An examination of Manitoba's domestic and farm energy consumption in 1975 shows that almost half of these requirements were met by natural gas, while electricity met approximately another 25%. The growing use of natural gas and electricity has been a relatively recent phenomenon because it was not until the latter half of the 1950's that distribution of natural gas for residential heating purposes was begun, while rural electrification did not take place until 1948.

Examination of the Manitoba data in the relative levels of annual consumption of fuels from 1963 to 1975, reveals that natural gas consumption grew more rapidly than the total energy demand of all sectors and the total consumption of the common heating fuels (excluding electricity) in the residential sector. During the same period of time, residential consumption of light fuel oil declined relative to the 1963 consumption levels.

In recent years, the number of new heating installations have demonstrated the continued popularity of natural gas and electricity as compared to heating oil and propane. New natural gas installations were down by almost half from the previous year in 1975, while new installations of electricity nearly doubled that year, allowing electricity to assume the position of greatest number of new installations from 1975 to 1977. New installations of heating oil equipment have dropped considerably over the years from 1969 to 1977, while propane installations have remained relatively constant.

Although heating oil and kerosene do not have the significance they once had (as recently as 1965) in filling the majority of Manitoba's residential space heating fuel requirements, they are still very important in certain regions of Manitoba today. As can be expected, the natural gas system follows the more dense distribution of population in the province. As a result, Manitoba's widely distributed rural farm and rural non-farm dwellings cannot expect to be connected to the natural gas system, due to the cost consideration of laying long lengths of pipe which would serve few customers. This accounts for 1971 Census data, which shows that 70.5% of Manitoba's urban dwellings used natural gas as their primary heating fuel, compared to 10.3% of rural non-farm and 1.4% of farm dwellings. It is in these rural non-farm and farm dwellings where heating oil and kerosene play a major role in space heating. Electricity shows much promise as a substitute heating fuel for heating oil and kerosene in dwellings which use these refined petroleum products for space heating purposes.

Heating Manitoba dwellings by wood has become almost insignificant today, as compared to 1955, when more than half of Manitoba's dwellings were heated by these fuels. Wood was still of considerable importance as a principal heating fuel in northern Manitoba in 1971. Some small amounts of coal were also being used in 1971, primarily in the south-west corner of the province.

(b) Total Residential Heating Fuel Consumption

Approximately 22.5% of the total energy consumed in Manitoba during 1975 was accounted for by residential uses. During 1975 (according to Statistics Canada), Manitoba's domestic and farm sector consumed 47.1 million BTU/capita (excluding diesel fuel), which was slightly more than Ontario, slightly less than the Canadian average, and considerably less than Saskatchewan or Alberta. Between the years 1963 and 1975, consumption of fuels commonly used for residential heating purposes increased at a rate only slightly less than total energy consumption for all sectors of Manitoba's economy.

The major type of heating equipment used in Manitoba households is the hot air furnace. Nevertheless, it was estimated that in 1977, approximately 15% of the total Manitoba households were heated with steam or hot water furnaces, approximately 3% with heating stoves or cook stoves, and approximately 16% were heated by electrical equipment (a large portion of which are hot air furnaces). If the installation trends of the various types of heating equipment continues as it has from 1969 to 1977, it seems likely that an even greater proportion of hot air furnaces can be expected.

By relating Manitoba's historical insulation practices to a C. M. H. C. Manitoba housing profile for 1975, the author was able to make the following (albeit somewhat optimistic) rough estimate of the insulation features of the existing Manitoba housing stock:

(i) approximately one third of the Manitoba stock has no insulation in their walls and none or small amounts (approximately R7) of insulation of dubious quality in their ceiling.

(ii) approximately one third of the Manitoba housing stock have walls containing insulation with a value of R7 that has lost much of its efficiency through aging and sagging, and R7 insulation of perhaps dubious quality in the ceiling.

(iii) approximately one third of the Manitoba housing stock have R7 to R10 effective insulation in their walls and R10 to R14 in their ceilings.

Since the rural dwellings tend to be much older than the urban dwellings in Manitoba, it can be expected that they have lower levels of insulation.

It was estimated as of 1977, that almost 70% of all dwellings in Manitoba were single detached dwellings, as compared to the national average of 59%. All other things being equal, these types of dwellings use more energy for heating purposes than do multiple unit dwellings.

No provincial estimates of dwellings' sizes or estimates in trends in dwelling sizes existed, which could be consulted for use in this report. However, the area of houses financed under the National Housing Act decreased during the years between 1970 to 1977. C.M.H.C. assured the author that the size of Winnipeg's houses follows the national average for N.H.A. financed houses very closely. It should be noted however, that N.H.A. mortgages tend to favour small housing size, and that only 30 - 40% of Winnipeg's housing (not all Manitoba houses) are financed under the National Housing Act.

CHAPTER IV

COST TO THE CONSUMER OF HEATING AND THE POTENTIAL FOR CONSERVATION OF HEATING FUEL WITHIN THE RESIDENCE

4.1 Consumer Decisions About Heating

Consumer choices of the type of heating fuel used within their dwelling differ in the case where the consumer is in the process of having a new house constructed, as opposed to the case where the consumer is already the owner of an existing home. From both a technological and an economic perspective, fuel choices are greater when a house is being designed than when it is already built. Until recently, the situation often existed wherein the consumer was very limited in his choice because, in the majority of cases, the decision about the type of heating fuel used in the house had already been made, by either the builder or the developer. Media response to the so-called "energy crisis" has made people more aware of energy usage, resulting in a situation where the communication links between the prospective house owner and the builder have strengthened, and consumers are able to exercise a greater influence on fuel installation decisions in new residences. Along with fuel choice, decisions have to be made about the type of heating system which is to be installed (ie. forced air, radiant, hydronic) in the residence. Providing that the builder has not already made the decision, there are also decisions to be made concerning the amounts of weatherstripping, ventilation, and insulation to be installed. Different architectural design features such as the orientation of the residence, the amount of and location of window space, and building envelope area, will also effect the amount of energy required for heating a residence. All of the aforementioned decisions will have an impact on the costs of heating a residence.

The owner of an existing house also has a considerable number of options available to reduce his space heating costs, using his existing fuel type. If these costs are very high, he might decide to use a different heating fuel, if alternative fuels exist which have considerable cost advantage. The decision to use an alternative fuel should be based upon the expectation that the cumulative present value of future fuel cost savings (using an appropriate discount rate) exceeds the costs of installation of the alternative fuel and the appropriate equipment.[1] The decision to change the heating system in a residence, even though it uses the same fuel (eg. changing from electric resistance heating to heat pumps), should be based upon the same principals of economics. Owners of existing residences can also choose to cut down on home heat loss by retrofitting with insulation. Retrofitting can be considerably expensive, particularly if insulation must be blown into the walls.

[1] In calculating this, the analyst would also have to consider the age of the existing heating system. If, for example, the heating system was ten years old and had an expected depreciation period of twenty years, the cost of investing in a different system now, rather than in ten years time, would have to be compared to operating cost savings over the ten years (all in present value terms). This position is also taken by Mr. Ralph F. Smith in his report, Residential Space Heating Policy Alternatives In Saskatchewan, April 1977, p. 14.

Methods of lowering fuel bills in a residence may also include lowering the thermostat setting, properly maintaining the existing heating equipment, and not heating areas where heat is not required.

As mentioned previously by the author, lowest economic cost considerations should be the criterion upon which consumers base their heating fuel decisions. In practice, however, the application of economic cost analysis cannot, in itself, explain the actual behaviour of Manitoba consumers with regard to heating fuel choices, heating equipment, and conservation measures within the residence. As in almost all cases where simple cost accounting techniques are combined with empirical data, which are the tangible evidences of peoples' decisions, consumers' tastes, and other more or less non-quantifiable data (non-quantifiable in the accounting sense), must be taken into consideration. Some of these reasons, in the author's opinion, that consumers have not based their decisions about the type of fuel to be used, the type of heating equipment to be used, and the amount of money to be invested in conservation techniques, solely on the premise of lowest economic cost (determined by initial and discounted future costs) are:[2]

(a) many Manitoba residences are built according to the minimum standards set out by the Building Code, or according to the minimum standards needed to receive a mortgage and these standards are not based on lowest economic cost considerations;

(b) consumers prefer some heating fuels or systems because of

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[2] This list is similiar to that of Mr. Ralph F. Smith's report, Residential Space Heating Policy Alternatives In Saskatchewan, April, 1977, p. 16.

comfort, cleanliness, or ease of operation, rather than lowest economic cost;

(c) some consumers choose a particular type of fuel because of future expectations regarding the security of supply;

(d) in many cases, consumer decisions about heating fuel or heating systems are left up to the developer or the builder of the house;

(e) long-term savings on heating bills are not perceived as sufficient compensation for the present investment in a more expensive heating system or conservation measure, particularly when basic housing prices are very large, as they are at the present time;

(f) fuel choice is limited in some areas of the province (for example, in areas not served by natural gas pipelines);

(g) energy equipment which has developed and is more efficient than existing equipment is not available to the consumer (for example, the pulse-a-matic gas furnace).

The size of the heating fuel bill in relation to the size of a consumer's total budget, should normally play a significant role in influencing a consumer's decision as to the type of investment made with regards to heating. If the cost of heating remains relatively low as compared to the costs of other components of the consumer's total household budget, any decisions concerning improvements of the heating situation will decline in its importance, when compared to other economic decisions. The real price of a KWh of electricity in Manitoba actually decreased for the average consumer up the 1974.[3] The actual price of natural gas increased during the 1960's and early 1970's, but actually remained relatively unchanged in terms of constant dollars, at least until September of 1974.[4] Since 1974, energy prices have risen dramatically and, as a result, heating costs have probably assumed a more important part of most consumer's total budget. This may have resulted in a situation today where the economic criterion of lowest economic cost (present and discounted future costs) may figure more significantly in decisions pertaining to heating.

4.2 Comparative Costs of Heating a Residence Using Different Fuels

This section of the report illustrates the space heating costs in the Winnipeg area of Manitoba, in residences having the same construction characteristics, but using different heating fuels. The example chosen involves a single family residence, with one storey, having 1,000 square feet of floor area, and a full, heated basement.[5] The results are shown in Table 10. It should be noted that the prices and the consumption levels appearing in this table are averages which may not be applicable to individual circumstances. Any additional assumptions used in the derivation of Table 10 may be found in Appendix C.

If the assumption is made (for comparison reasons) that the

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[3] Manitoba Energy Council Secretariat, Energy Data For Manitoba 1975, April 1976.

[4] Ibid.

[5] This example was used because it was the same example used by Manitoba Hydro Market section in 1976.

TABLE 10*

ANNUAL FUEL COST OF HEATING A 1,000 SQUARE FOOT HOUSE IN THE WINNIPEG AREA OF MANITOBA January 1, 1978

Fuel Type	Price of Natural Units**	Annual Heating Cost at 100% Efficiency***	Annual Heating Cost at 70% Efficiency	Annual Heating Cost at 60% Efficiency	Annual Heating Cost at 50% Efficiency	Annual Heating Cost at 40% Efficiency
Natural Gas	$2.40/mcf	---	$305.66	$356.61	$427.93	$534.91
Oil	$.55/gal	---	$387.51	$452.10	$542.52	$678.15
Propane	$.46/gal	---	$486.15	$567.18	$680.61	$850.77
Electricity	$.023/KWh	$598.64	---	---	---	---

*Based upon Manitoba Hydro marketing data.

**See Appendix C for an explanation of how the table was constructed.

***See Appendix C for a comment on the efficiency of heat energy utilization in the residence.

efficiency of heat utilization for natural gas, oil, and propane is 60%, while the efficiency of electricity is virtually 100% (baseboard heaters), Table 10 shows that, in the Winnipeg area, electricity is the highest cost heating fuel, followed by propane and oil. Natural gas is the lowest cost heating fuel by a considerable margin. In general, the seasonal efficiency of oil furnaces tends to be between 45% and 60%, while gas furnaces (natural gas and propane) tend to operate in the 60% to 70% range.[6] This being the case, the actual costs of heating a home in Winnipeg with oil (assuming a 50% efficiency and January 1, 1978 prices) is much closer to the cost of heating a home with either electricity or propane (assuming 100% for electricity and between 60% and 70% efficiency for propane). If a new, more efficient oil furnace is assumed, resulting in efficiencies of 60% to 70%, the annual heating oil bill will be considerably lower than that for electricity at present fuel prices. Of course, this whole discussion assumes that the prices of heating oil, natural gas, propane and electricity stay at the same rate, relative to each other, in the future as they do in the present. This may not be the case.

4.3 Effect of Geographical Location on Fuel Prices

While the cost of heating a 1,000 square foot residence in the Winnipeg area may not be an exceptional budgetary item for an owner, the costs in the more isolated rural locations and in the North can be considerably higher. The reason for large cost differentials are related to:

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[6] See R.L. Dunning, "Fossil-fuel furnace losses detailed", Electrical World, (November 15, 1974), p. 117.

(a) lack of an option to choose the lowest between all types of fuel (in some areas, natural gas is not available);

(b) the greater number of degree days of heating;

(c) the high cost of transporting fuel to remote areas.

By assembling data prepared by the Manitoba Housing and Renewal Corporation, it is possible to observe heating cost variations for heating oil in Manitoba. Table 11 shows the annual heating cost variations of a 1075 square foot residence in various locations in Manitoba during August 1976. It should be noted that the most extreme northern locations, where fuel prices and heating costs are the highest in the province, are not included in this table.

TABLE 11[7]

ANNUAL SPACE HEATING FUEL COSTS OF A 1075 SQUARE FOOT RESIDENCE IN VARIOUS RURAL LOCATIONS IN MANITOBA, 1976

August

Area	Price/gal.	Price Index Winnipeg = 100 *	No. of Gallons of Fuel Oil Used	Costs
Bloodvein (East Manitoba) 49 - 52 parallel	$.507	127.38	582.49	$295.32
Berens River (East Manitoba) 52 - 53 parallel	$.66	165.82	617.40	$407.48
Thicket Portage (Central Man.) 55 - 56 parallel	$.65	163.31	761.26	$494.81
Illford (East Manitoba) 56 - 57 parallel	$.54	135.67	795.02	$429.31
Brocket (West Manitoba) 57 - 58 parallel	$.98	246.23	842.81	$825.95

[7] Source: The Manitoba Housing and Renewal Corporation, A Study Of Operating Costs In M.H.R.C.'s Subsidized Rural And Native Housing, (August, 1976).

*Winnipeg's August 1976 heating oil price of $.398/gallon was made equal to 100.

4.4 Comparative Energy Use Within The Residence

In Canada, it has been estimated that approximately 70% of the total energy used in a residence is for the purpose of space heating.[8] In Manitoba, space heating may very well account for a larger percentage of residential energy consumption, due to the fact that Manitoba has a greater number of degree days of heating than most of the other heavily populated areas of Canada (Toronto, for example). In order to put the amount of energy consumed by a heating system into perspective, Table 12 has been provided. This table compares the energy consumption by an electric heating system for the year for a 1000 square foot residence used as an example in Table 10, with the average annual electricity consumption of various appliances in the residence. Since electricity is assumed to be 100% efficient at point of use, 24,100 KWh annual consumption can be considered the lowest amount of energy (in BTU) that would be consumed for space heating in this type of residence during an average year.

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[8] This 70% figure is from the Housing and Urban Development Association of Canada (HUDAC), A Builder's Guide to Energy Conservation, (1976), p. 3.

TABLE 12[9]

ANNUAL AVERAGE KWh CONSUMPTION OF HEATING SYSTEM AND OTHER APPLIANCES

Appliance	Estimated Annual Consumption in KWh	Comparison to Space Heating Consumption
Electric Heating System	24,100	1.00
Electric Water Heater	4,000	.166
Electric Stove	1,200	.050
Freezer	1,200	.050
Clothes Dryer	900	.037
TV (color, solid state)	450	.019
Frying Pan	180	.007
Iron	120	.005
Toaster (pop-up)	40	.0016

4.5 Means of Cutting Costs

The expected increase in the cost of residential space heating may cause the residence owner to take some steps towards conserving the amount of heating fuel required to heat his residence. The following is

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[9] Appliance consumptions are from the Department of Energy, Mines and Resources, Canada, 100 Ways to Save Energy and Money in the Home, (March, 1975), pp. 96 - 97.

a list of some of the more important steps which can be taken in most residences:

(a) set the thermostat at a lower average temperature for day and night;

(b) do not heat rooms during that part of the day when heat is not required;

(c) weatherstrip and caulk doors and windows to reduce heat loss through air infiltration;

(d) install storm windows and doors, or put in triple-glazed windows and insulated doors;

(e) reduce the number of air changes in the residence towards the minimum acceptable level (check for leaks, particularly around electrical outlets);

(f) if oil is the primary heating fuel in the residence, install a high efficiency burner;

(g) have the furnace cleaned and maintained at yearly intervals;

(h) add insulation to the ceiling, exterior walls, and basement walls to increase the residence's thermal resistance.

Normally there is no economic cost associated with steps (a) and (b), while steps (c) to (h) involve investment by the homeowner, which should be assessed against the future benefits achieved by these measures. Some of these benefits and costs will be considered in more detail later in this chapter.

4.6 Benefits From Insulation

The major question asked about insulation is, "How much heating fuel can be saved in a residence by increasing the amounts of insulation in the ceiling, exterior walls, and along the portion of the basement which is above ground level?" Table 13 is an attempt to provide a comparison of fuel consumption and fuel costs of a residence - before and after - adding insulation. This table is based on a report of the Housing and Urban Development Association of Canada (HUDAC)[10] involving a single detached bungalow of 1080 square feet gross livable area. The 'before' house has insulation which is typical of residences constructed to meet the N. H. A. standards prior to 1975. It has combined resistance values (total of insulation and building material resistances) of R10 for the walls, R10 for the ceilings, and R2. 23 for the above grade basement walls. The 'after' R values are those recommended by HUDAC for walls, ceilings, and above grade basement walls which are R16. 13, R31. 25, and R10. 20 respectively. In addition, the air changes in the 'after' bungalow are cut in half (from . 5/hr to . 25/hr). The heating load analysis in the HUDAC report has been adopted to the degree day averages in the Winnipeg area (10, 800 degree days ^{O}F). Details of the calculations are found in Appendix C.

Table 13 indicates that an annual saving of approximately 50% can be achieved in typical residences by increasing the amounts of insulation. Depending on the type of fuel used, the annual cost savings during 1977 would vary from $243. to $469..

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[10] Housing and Urban Development Association of Canada, A Builder's Guide to Energy Conservation, (Toronto, 1976).

TABLE 13

FUEL CONSUMPTION AND COST FOR A 1,080 SQUARE FOOT (GROSS LIVING AREA)

BUNGALOW IN THE WINNIPEG

AREA

	Natural Gas	Oil	Propane	Electricity
Before 1975-Energy Consumed (Natural units)	202.2 MCF	1431.8 gal.	2033.3 gal.	24,280.6 KWh
Annual Heating Cost at Prices of Jan. 1/78 (in $ for above units)	$485.28	$787.49	$935.27	$607.02
Energy Consumed with HUDAC Recommended Insulation	100.8 MCF	713.5 gal.	1013.2 gal.	12,091.7 KWh
Annual Heating Cost for the above in $	$241.92	$392.42	$466.07	$302.29
% change in fuel consumed and annual costs (minus)	50.2%	50.2%	50.2%	50.2%

Table 13 can be compared to the results of a study done by the Manitoba Department of Public Works.[11] The residence in this case had 'before' insulation values of R10 in the ceiling and R7 in the walls, and 'after' insulation values of R20 in the ceiling and R12 in the walls. In this case, adding insulation resulted in a 36% reduction in fuel used in a year's time. It should be noted that the changes in insulation levels were not as great in this case as in the houses studied by HUDAC, nor was the rate of air change reduced in the Manitoba Department of Public Works residences, as it was in the HUDAC study. For these reasons, fuel savings were less in the residences studied by the Manitoba Department of Public Works.

4.7 Choosing the Optimum Amount of Insulation

In the introductory chapter of this report, it was stated that the optimal amount of consumer investment in insulation and other energy conservation measures should be equal to the cumulative present worth value of future savings on energy bills that is attributable to the consumer's investment. The information presented in the previous section of this chapter indicates that substantial savings will occur with addition of more insulation to a dwelling, but a decision needs to be made on just what amount of insulation is optimal.

The following are some of the factors which need to be known if

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[11] Manitoba Department of Public Works, An Energy Analysis of a MHRC. 4BR House, (May, 1974).

such a decision is to be made:

(a) degree days of the location,

(b) length of the payback period,

(c) present cost of insulation,

(d) labour costs for installation, plus the costs of any structural changes needed to facilitate the installation of higher insulation levels (ie. 2" by 6" studs or strapping),

(e) current fuel prices and future estimated fuel price increases,

(f) and rate of interest on the investment (discount rate).

In January, 1976, Dr. D. G. Stephenson, of the National Research Council, produced a paper[12] which outlined a formula for determining optimal levels of thermal resistance in dwellings.[13]

In order to derive the present worth factor to be used in the formula, Dr. Stephenson assumes an annual 12% increase in the price of electricity (due, in past, to a real increase and, in past, to inflation). He also assumes that the price of natural gas and fuel oil will rise at a rate of 15% until it reaches the price of electricity on a BTU equivalent basis, at which time it will also increase at 12% annually. Table 14 shows the results of an application of Dr. Stephenson's formula to the Winnipeg area.

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[12] D. G. Stephenson, Division of Building Research, National Research Council of Canada, "Determining the Optimum Thermal Resistance for Walls and Roofs", (Ottawa, National Research Council of Canada, January 1976).

[13] See Appendix C for the formula and details of its application to the Winnipeg area.

TABLE 14

OPTIMAL RESISTANCE LEVELS IN THE WINNIPEG AREA, 1977

Ceiling Insulation	Natural Gas	Oil	Propane	Electricity
Optimum R values insulation & building materials	48.92	57.35	64.25	63.45
% increase justified over* current Standards for ceilings	40.57%	64.79%	84.62%	82.32%

*Current C.M.H.C. standards for the ceiling are R34.8.

In moving towards greater thermal resistance in the wall area, increased expenses result from higher construction costs. Dr. Stephenson uses an added cost of five cents per square foot in going from an R12.5 to an R15 wall, and an added cost of twenty cents per square foot in going from an R15 to an R20 wall. Therefore, if an R20 wall is justified, the cost per unit of R would be 25¢ ÷ 7.5 = 3.3¢. This is added to the 1.3¢/R value used to construct a wall with an R value of 12.5, equalling 4.6¢. By substituting 4.6¢ for 1.3¢ in the formula used to derive Table 14 (see Appendix C), one can determine if the additional costs are justified in Winnipeg. The results as shown below, indicate that the added investment of going to an R20 wall is justified.

	Natural Gas	Oil	Propane	Electricity
Optimum R value for walls	26	30.49	34.15	33.73

There have been arguments that a more conservative position should be taken in regards to the selection of factors used in the type of calculations developed by Dr. Stephenson. HUDAC, for example, uses a payback period of twenty-five years, rather than the thirty year payback period (which is used in this report) suggested by Dr. Stephenson. This method used by the author in this report, is also more conservative than Dr. Stephenson's method, in that it uses a sixty percent efficiency for fossil fuel, as compared to the seventy-five percent efficiency used by Dr. Stephenson. As has been noted earlier on in this section of the report, increased insulation standards are justifiable in the Winnipeg area, even if this more conservative position is taken in the calculation of optimal thermal resistance levels.

4.8 Fuel Conservation Effect of Variant Design Types

Table 15 uses heat loss calculations provided by HUDAC and applies them to the Winnipeg area to give an indication of the fuel savings which can be achieved in residences having similiar amounts of living space, but different design features.

Comparative fuel savings are slightly higher when insulation levels of the various design types are lower than those recommended by HUDAC. With pre-1975 insulation standards, the consumption ratios are 1:.72:.57 for the three design types, bungalow, semi-detached and row house, rather than 1:.81:.64 ratio resulting from HUDAC insulation levels.

TABLE 15*

COMPARATIVE FUEL REQUIREMENTS AND HEATING COSTS FOR DIFFERENT DWELLINGS WITH 1,084 SQUARE FEET OF LIVABLE AREA IN THE WINNIPEG AREA, January 1, 1978

HUDAC Recommended R Values	Bungalow	Semi-detached	Row Houses
Annual MCF Required (Natural gas at 60% efficiency)	100.8 MCF	81.3 MCF	64.6 MCF
Annual Fuel Cost at $2.40/MCF	$241.92	$195.12	$155.04
Comparative Fuel Consumption Costs: Where Bungalow = 1	1	.81	.64
Pre-1975 R Values			
Annual MCF Required (Natural gas at 60% efficiency)	202.2 MCF	145.6 MCF	115.3 MCF
Annual Fuel Cost at $2.40/MCF	$485.28	$349.88	$276.72
Comparative Fuel Consumption Costs: Where Bungalow = 1	1	.72	.57

*These figures were derived from Table 13 and HUDAC, A Builder's Guide to Energy Conservation, (Toronto, 1976).

4.9 Effect of the Size of the Dwelling

The amount of fuel used to heat a dwelling is dependent upon its square footage. If there is no difference between bungalows, other than size (ie. the insulation values are equal, the designs are equal, they are subjected to the same number of degree days, they face the same fuel prices, etc.), then the difference in fuel consumption and fuel costs is directly proportional to the difference in size of the dwellings. Using the 1000 square foot house which was the basis for the data presented in Table 10, and the 1978 costs of fuel presented in Table 10, the increment in annual heating fuel bill of a consumer for each additional 100 square feet of his residence would then be calculated by the formula, 1978 fuel costs (at the assigned efficiency rating) X 100/1000 = annual increment/100 additional square feet.

Using data from Table 10 results in annual increments/100 square feet of: (approximately)

Natural Gas (60% Efficiency)	Oil (60% Efficiency)	Propane (60% Efficiency)	Electricity (100% Efficiency)
\$35.66	\$45.21	\$56.71	\$59.86

4.10 Fuel Conservation Effect of Lowering the Thermostat

A study done by the Research Branch of the Manitoba Department of Public Works on a four bedroom house, designed by the Manitoba Housing and Renewal Corporation,[13] indicated that significant reductions

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[13] Manitoba Department of Public Works, An Energy Analysis of a MHRC. 4BR House, (May, 1974).

in annual heating fuel requirements can be achieved if the consumer lowers his thermostat. The study indicated that if the thermostat were lowered 4 ^{o}F for the sixteen hours of the day and 8 ^{o}F for the eight hours of the night, an annual reduction of 5.8% of heating fuel occurred. The annual fuel cost savings for the owner of a 1000 square foot house in the Winnipeg area which was described in Table 10 of section 4.2 would then be as follows with the lower thermostat setting (approximately):

Natural Gas (60% Efficiency)	Oil (60% Efficiency)	Propane (60% Efficiency)	Electricity (100%Efficiency)
$20.68	$26.22	$32.90	$34.72

4.11 Future Space Heating Costs

Expenditures on fuel are only a part of the costs of space heating. Included in total space heating costs are the annual fuel costs and the amortized capital costs of the heating system. However, this section of the report will only focus on the expected future prices of heating fuels, specifically oil, electricity, and natural gas.

Originally, the author hoped to provide price senerios for these three fuels for the next ten year period. However, recent large increases in the prices of oil, electricity, and natural gas have made it next to impossible to predict future trends in prices from the historical data available.

There are several factors which have caused these large increases in the price of energy fuels. One such factor which has affected all three energy fuels is the increased costs associated with labour and equipment, both of which have increased considerably over the last several years. A second factor which has affected all three fuels is the increased cost of capital. The costs of raising enough capital for oil and gas exploration, and the financing of hydro-electric projects are all eventually passed on to the consumer through higher prices. A third factor which has helped to increase the price of fuels is the increase in royalty payments to the owner of the mineral rights by the energy producer. In the case of oil and gas, these royalties are paid to provincial governments; in the case of Manitoba Hydro, they take the form of compensation to native peoples (albeit a low payment, as compared with oil and gas royalties). These three factors have caused increases in the price of all three heating fuels. There are, however, other factors which affect each fuel individually which are probably the most important factors that have caused the increases in the cost of each fuel. In the case of oil, the main factors are increased prices charged by OPEC, combined with dwindling oil reserves. In the case of natural gas, the major cost increasing factor is the concern over continuing supplies of this fuel, given the possibility of dwindling reserves. In the case of electricity, the major factor which has caused the recent large increases in price is the pricing system itself, as it has been used in the past. Historically, electrical energy has been priced , and continues to be priced, on the basis of lowest average cost (as is evidenced by the system of declining block tariffs). In the past this method benefited the electrical energy producers, in that it expanded their market, so that they could take advantage of economies of scale. However, the recent incremental costs of producing and transporting electrical energy have increased to the point where the marginal cost of producing new electrical energy is considerably higher than the previous cost of producing the same amount of energy. This has resulted in a situation where prices rise rapidly, as compared with historical price trends. These are just some of the factors which affect the prices of electricity, oil, and natural gas; there are others too numerous to mention here. It should also be noted that each one of the factors mentioned can also be broken down into variables which affect each factor.

As mentioned previously, the author felt that he was unable to produce any price senerios for oil, electricity, or natural gas, that he felt could be defended by any data that he could present. However, the author does have an intuitive feeling about the prices of these fuels, which is purely his own, but which are the distilled results of all of the research effort (including private conversations) which went into this report. Intuitively, the author predicts a 17 - 20% increase in the price of electricity for Manitobans every year for the next four years; a 17 - 20% increase in the price of residential natural gas every year for the next four years; and a 20 - 23% increase in the price of heating oil every year for the next four years.

4.12 Summary of Chapter IV

This chapter has examined some of the typical costs to the consumer of heating a residence in Manitoba. In addition, there was an attempt made to assess the impact of heating fuel conservation measures in residences and to consider the extent to which consumers can economically justify investment in these measures at the present time.

Consumers of heating fuels in Manitoba have not always based their selection of heating fuel on the economic criterion of lowest economic cost during recent years. Instead, considerations of cleanliness, ease of operation, and comfort have entered into consumer decisions. In fact, the type of heating fuel installed in a residence may not have been regarded as significantly as many other design features when the decision to purchase a residence is made. In practice, consumer decisions about the heating fuel, the heating system, as well as the amount of insulation to be installed in the residence, has been limited because the house builder or designer has already selected them. If consumers wish to have a greater ability to exercise their own preferences in determining the conservation features of new residences, then either their preferences should be reflected in the building standards, or else the links between the builder and the new home owner should be made more effective in regards to this matter.

Because the cost of heating a residence in Manitoba has not, in the past, been a very large part of the consumer's total budget, there has not been sufficient incentive for the owner to invest in larger amounts of insulation and in other conservation measures. Furthermore, the degree to which a house conserves heat energy has not been a major selling point in the past (for example, until recently, types of fireplaces installed in homes were installed for aesthetic appeal and had little to do with heating a home, which resulted in a situation where the effect of a fireplace was often a net loss of heat, with heat lost up the chimney).

However, as the price of all heating fuels rise at rates which vary from fuel to fuel, a change in consumer attitudes is likely to occur. The question of which fuel should heat the residence and what features the residence should contain which would result in a reduction in the heating load will become more important.

Currently, natural gas is the lowest cost heating fuel in Manitoba. Depending upon the efficiency of the heating equipment and the geographical location of the residence, heating costs of oil, electricity, and propane have different ranking orders. However, using the Winnipeg area as an example, and efficiencies of 100% for electricity, 60% for propane, and 50% for oil, the ranking in order of least cost would be oil, propane, and electricity.

There are many ways heating energy can be conserved within a residence, but increasing the amount of insulation is the most important step. The example studied in this chapter shows that approximately a 50% reduction in fuel requirements could result in a typical residence where pre-1975 insulation standards are upgraded to the insulation standards recommended by HUDAC. Analysis undertaken in this chapter also indicates that, given Manitoba's climate, ceiling insulation should be increased anywhere from 40% to 85% over the current C.M.H.C. standards, depending on the price of the installed fuel. Increases in wall insulation are also indicated and it appears that going to 2" by 6" studs in walls to allow for increased thickness is economically justifiable.

Although space heating considerations can only be regarded as one component of an overall housing policy in the province, the considerable fuel saving advantages of multiple unit dwellings over single detached dwellings should be noted. The savings involved can be at least 30% in a multiple unit, even though the gross livable area available for occupants is the same as in a single detached dwelling.

The size of the dwelling has a considerable effect upon the costs of heating a residence. All other thing (except size) being equal, the difference in fuel consumption between dwellings in size is directly proportional to the difference in the size of the dwellings. The implication is that smaller houses have lower fuel consumption.

Lowering the thermostat can also have a considerable effect upon home heating costs. A consumer decision to lower the thermostat by four degrees Fahrenheit for the sixteen hours of day and eight degrees Fahrenheit for the eight hours of night will result in annual savings of approximately six percent.

Finally, it can be expected that the costs of heating fuel will rise considerably in the future due to the increasing incremental costs of producing heating fuels.

CHAPTER V

FUTURE MARKET SHARES AND CONSUMPTION OF HEATING FUELS IN MANITOBA WITHOUT SIGNIFICANT POLICY CHANGES

5.1 Procedure to be Followed in this Chapter

Chapter II of this report discussed Manitoba's fuel supply position. Chapter III discussed, for both the present and the recent past, the levels of energy consumption in the residential sector, and the pattern of heating fuel allocation in Manitoba. Chapter IV concerned itself with the impact of fuel choice on a residential homeowner's expenses and the potential for heating fuel conservation in typical Manitoba residences. This chapter will look into the short-term future and will assume that no significant policy changes in fuel allocation or conservation are taken by the Manitoba Government. Given this assumption, the author will briefly predict likely future fuel choices and expected levels of consumption in the residential sector by projection of past trends that were appropriate, and by referring to available analysis and forecasts of government departments and other agencies. This will lay the foundation for Chapter VI, where significant policy changes will be discussed.

5.2 Heating Fuel Market Shares

(a) Heating Oil, Kerosene, and Propane

As can be seen on Figure 3 in Section 3.5, the use of petroleum products for residential heating purposes in Manitoba has declined over the past few years. If the price of crude oil moves progressively towards world levels throughout the remainder of this decade, the decline in popularity of petroleum products used for residential space heating purposes in Manitoba is likely to continue, particularly since there are substitutes available in most cases. In some rural locations, the cost of heating with petroleum is similiar or perhaps even greater than heating with electricity. Propane may prove to be an exception from the decline in the use of petroleum products, due to its extensive use in the mobile home market. Even though propane is a high cost fuel in most locations at the present time, mobile homeowners often select it because it is cleaner than oil or kerosene and there exists the possibility of a direct conversion to natural gas (without any heating equipment change) if such a connection becomes possible in the future.

Heating oil and kerosene also have disadvantages such as characteristics of having an odor and leaving an oily film on the inside of the house and the household furnishings. Oil furnaces tend to be less efficient (5 - 10%) than natural gas furnaces and usually require more maintenance (cleaning). Unlike the fuels, natural gas and electricity, a fuel storage system is mandatory. In many cases, customers are concerned about the future supply of petroleum products and are thus motivated to substitute other fuels. Afurther disadvantage in remote rural residences is the highly expensive and often irregular means of transporting fuel (particularly remote northern areas where heating oil is flown in, or brought in by winter road in winter or barges in the summer).

Nevertheless, under present policy, some homeowners can be expected to continue using heating oil, kerosene and propane, since they are not willing or are unable to invest in alternative heating systems. Although consumption of petroleum products is not expected to increase significantly in the residential sector (ie. few new installations), many existing residences may continue to use petroleum products as their primary heating fuel. This is in agreement with the National Energy Board which forecasted an increase in the use of light fuel oil and kerosene (stove oil) from their 1975 (actual) levels of 6.5 thousand barrels per day to 6.7 thousand barrels per day in 1985.[1]

(b) Natural Gas

Previous chapters have shown that natural gas is the dominant heating fuel in Manitoba. The main reason for the large demand for natural gas is its continuing low price relative to other heating fuels. A considerable change in relative fuel prices will be required if the cost advantage of natural gas is to disappear in the next five to ten years.

In addition to its price advantages, natural gas is clean burning, odorless, and is burned in a relatively inexpensive furnace which requires little maintenance over its life time.

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[1] National Energy Board, Canadian Oil: Supply and Requirements, (ottawa, February, 1977), p. 139.

As has been stated previously in this report, Manitoba does not have any indigenous source of natural gas, but relies solely on imports from Alberta. A continued supply from Alberta can be expected, although it may not be possible to increase the supply as required to meet Manitoba's increasing demands during every year up to the 1990's. It is also a possibility that natural gas from the frontier areas may be available for consumption by Manitobans in the next decade. The National Energy Board forecasts that the demand for residential natural gas in Manitoba will increase from 25.8 Billion Cubic Feet per year in 1975 to 29.2 BCF per year in 1980 and 32.4 BCF per year in 1985.[2]

Natural gas pricing in Manitoba will be affected in the future by national price movements due to imports from Alberta. As Alberta's prices increase, so will the price of natural gas in Manitoba. These prices have increased rapidly in the past few years which may account for the fact that new installations of natural gas in the province dropped rapidly from the large numbers of new installations of just a few years ago.

The federal government has stated that the price of crude oil will gradually rise towards international price levels. There has been less certainty about natural gas pricing, although it is known that there will have to be substantial increases in the price if it is

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[2] National Energy Board, Canadian Natural Gas: Supply and Requirements, (Ottawa, April, 1975), p. 28.

to be economically feasible to bring frontier supplies into the market in the 1980's. The National Energy Board, in its report of September, 1975 presented the following views on oil and natural gas pricing:

> "Regarding prices, it was assumed that the Canadian crude oil price would approach the world price of crude by the end of the decade. It was also assumed that the price of natural gas at the city gate in Toronto would equal the price of crude oil at the refinery gate in Toronto by 1978, on a BTU equivalent basis. This assumption implies that the cost of natural gas at the city gate in Northern Ontario, Manitoba, Saskatchewan, and Alberta will be less than the equivalent cost of crude oil, since the cost of transporting gas is greater than the cost of transporting oil. Further it was assumed that the price equivalence on a BTU basis at the city and refinery gates in Toronto would result in relative prices on a BTU basis at the burner tip in the residential/commercial sectors such that natural gas will be the slightly preferred fuel in these sectors because of its premium qualities."[3]

It appears that national pricing policies will not change the fuel cost advantages of natural gas in comparison, at least, to refined petroleum products. Nevertheless, substantial increases in the Canadian price of natural gas can be expected in the future.

Under the present policy, new residences which are constructed in Manitoba communities served by the natural gas system have the option of installing this fuel as their principal heat source. High proportions of natural gas fuel installations will likely continue in

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[3] National Energy Board, Canadian Oil: Supply and Requirements, (Ottawa, September, 1975), p. 33.

such communities, until such a time as the fuel cost advantage of natural gas disappears or no new installations are allowed. For reasons previously stated, it does not appear that this cost advantage (at least in comparison to petroleum products) will change as a result of national pricing trends in the short-term future.

(c) Electricity

When considering future consumer demand for electric heating, assuming no policy change, it is important to divide consumers into two categories: those in localities served by both the natural gas and the electric system, and those (mostly) rural, farm and isolated consumers in localities which are not included in the natural gas system.

In localities which are connected to the natural gas system, there is a considerable gap at present between the costs of heating with natural gas and the costs of heating with electricity. Assuming that there is no change in Manitoba's distribution policy, the rate of substitution of natural gas by electricity will depend on relative price increases of natural gas (as compared to electricity), as supplies decline and become more costly to produce and expectations of consumers as to the security of future natural gas supplies. In all probability, it will be some time before the price gap closes.

Manitoba is not likely to adopt a rural gasification program similiar to Alberta's, and, as a result, consumer choices about heating fuel in rural and isolated areas of Manitoba will remain more restrictive than in larger urban areas. Consequently, electric heating is a more viable option in these areas. At the present time, the costs of heating a residence with petroleum products approach, and in some regions of the province where transportation costs are a major component of prices, exceed the costs of electric heating. In addition, electricity has quality advantages (such as cleanliness) and is less likely to suffer from supply disruptions over an extended period of time. However, there are some additional costs to the consumer resulting from the decision to choose electric heating:

(i) wiring and equipment costs which may total slightly more than the cost of a conventional oil furnace;

(ii) some customers have to pay for a larger capacity wire being extended from the yard pole to the residence at a cost of perhaps $300. 00, and more than twice that amount if underground cable is used;

(iii) the charges for the installation of a 200 amp panel may cost between $350. and $450.;

(iv) a more expensive ventilation system (humidistat fans) must be installed if damage to walls, ceilings, and insulation is to be prevented; and,

(v) although maintenance costs are usually lower for an electric heating system than an oil heating system, this is not the case if the electric heat is provided by resistance wires embedded in plaster, which can be very expensive to repair, should problems occur.

The price of electricity (in relation to other available fuel prices) will be the key determinant of its use in both the rural and urban localities of Manitoba. If larger and larger numbers of residences use electricity as their primary heating fuel, Manitoba Hydro will have to make significant additional expenditures to increase their capacity to provide service to customers. The costs of providing electrical energy can generally be broken down into the following components:

(i) generation;

(ii) transmission;

(iii) distribution; and,

(iv) customer overhead (billing, meters, salaries, and other administrative costs).

Although the costs to an electrical utility decrease as more customers are added to its system at a given capacity of generation, transmission, and distribution, incremental costs of generation, transmission, and distribution have been higher in recent years than the average costs of previous installed capacity, resulting in large price increases of electrical power. Until the early 1970's, the marginal costs of adding a kilowatt of new generation capacity were lower than the average kilowatt capacity costs for Manitoba Hydro.[4] Since that time, new generation capacity costs have in-

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[4] This comment was made to the author by Mr. F. A. MacTavish, Director of the Corporate Energy Utilization Division of Manitoba Hydro.

creased dramatically all over Canada, due, in most part, to escalating construction costs, higher costs of money, remaining undeveloped hydro sites becoming more distant from the larger population centres, the costs of more environmental projection measures, and the monetary compensations to Native Peoples for land used for hydro projects. These same factors also effect the cost of transmission lines, and have resulted in large increases in the cost of building and maintaining them.

As was mentioned in Chapter II, Manitoba's installed hydro electric capacity amounted to 2, 538 megawatts, with construction commitments to increase the capacity to 3, 644 MW by 1980. Beyond 1980, further hydraulic capacity is possible, promising an additional 5, 945 MW of additional generating capacity. Added to this, Manitoba had a total thermal capacity of 420, 988 kilowatts as of March 31, 1977. It seems likely that, in light of this information, that future electrical requirements up until the late twentieth century in Manitoba will be met mainly by hydro-electric energy generated in Manitoba.

If a major switch to electrical customers took place rapidly, the electrical distribution system would have to be upgraded to handle the peak heating load. The capital costs of upgrading the system would be quite significant even though the distribution system is in good physical shape at the present time. Of course, the cost of upgrading the system would increase the price of providing electrical power to the consumer.

Under the Manitoba Hydro Act, rates are set by the corporation's board and are subjected to appeal to the Public Utilities Board. The basic principle governing the financial operations of the Corporation, as expressed in the Act, is that service shall be provided at cost, including charges for operation, power purchased, maintenance, and fixed charges. The fixed charges comprise interest, depreciation, and annual provisions to reserves as deemed necessary by the Corporation. However, the Corporation may operate at a deficit in any fiscal year.[5] Present electricity rates, therefore, tend to reflect average costs of all components of the electric system, rather than the marginal costs of adding an increment to the capacity for power deliverability. Since rates, which reflect incremental capacity costs are postponed, there will likely be a necessity for large future increases in total rate revenues as electricity consumption increases, unless rates are subsidized out of general government revenues.

Future demand for electrical space heating will be affected by the overall increases in the price of electricity and by the type of electrical tariff rate structure which is used. The current tariff charges are 3.6¢ for the first 150 KWh's and 2.21¢ for the remaining electrical energy used each month. Currently, most residential customers

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[5] This information was contained in a Propectus (Reg. no. 2-54575) filed with the Securities and Exchange Commission, Washington, D.C., September 30, 1975.

consume all of the electrical energy in the lower stages of the tariff (the first 150 KWh) for purposes of operating lights and appliances, without having any space heating applications. Therefore, the cost to the customer of electric heating normally comes in at the run-off (lowest) price range, which is currently 2.21¢ per KWh. Retention of the declining block tariff would tend to stimulate new electric heating installations and conversions to electric heating while increasing the burden on the capacity to deliver electrical energy.

(d) Coal and Wood

Although direct combustion of coal may still take place in a number of existing residences, it is likely that conversions away from coal will continue and that few, if any, new residences will choose direct heating by coal unless major technological, economic, or policy changes occur. Coal has quality disadvantages and adversely affects the environment when it is burned in large quantities in the urban setting. Other heating fuel choices are available in the areas of the province where coal heating is most common. The lack of coal (which can be recovered economically) in Manitoba, combined with the high costs of transporting it from other areas, result in a situation where the use of coal for home heat is uneconomic at the present time.

As the costs of petroleum products continue to increase and the costs associated with electric heating remain high in relation to the budget of people in the more remote areas of Manitoba not served by natural gas, wood may begin to have a return to popularity as a heating fuel. This will be the case, particularly in areas where wood is available locally at a relatively low cost. Further increase in wood heating will also probably be influenced by the use of the more efficient wood stoves, furnaces, fireplaces, etc. which are currently available in the market.[6]

(e) Alternate Sources of Energy

Up to this point, the main concern of this report has focused upon the conventional fuels used in Manitoba for residential space heating purposes. However, there are alternatives which might have a significant role to play in Manitoba's residential heating market within the next decade, or at least, before the end of the century. Only a selected number of alternate energy sources will be discussed in this report. It is assumed for the purposes of this discussion that there will be no significant policy change affecting heating fuels over this period of time.

Manitoba receives a large amount of sunshine which could be utilized as an important supplementary or alternative source of residential heating. In a paper presented to the Third Canadian National Energy Forum in April of 1977, Dr. R.E. Chant indicated that in Winnipeg, the solar energy life cycle unit cost was approximately 2.5¢/KWh for a single family dwelling with 25% of the heat provided by solar energy, 2.7¢/KWh if 50% of the heat was sup-

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[6] For further information on wood burning technology, see Jay Shelton and Andrew B. Shapiro, The Woodburners Encyclopedia, (Waitsfield, Vermont, 1976).

plied by solar energy, and 3.35¢/KWh if 75% of the heat was supplied by solar energy.[7] The cost of most residential solar systems, including storage capacity, total between $10,000 and $30,000.

Manitoba receives a considerable amount of sunlight each year, approximately 2,200 hours in Winnipeg.[8] However, one of the difficulties of using solar space heating here is that the amount of solar energy available per month is inversely related to space heating needs. Thus, if a reserve electric heating system were installed (in the 50% solar energy heated home), nearly the same kilowatt capacity would have to be built in to meet heating requirements on the coldest day as if there had been no solar heating system whatsoever. The electric utility would then have the high fixed cost of serving this customer, but it would not receive a proportionate amount of revenue since load factors would be low. Mr. Jack Wadsworth of the C.M.H.C. Technology Group has proposed an alternative to this. He suggests that mini-utilities

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[7] Dr. R.E. Chant, "The Role of Solar Energy", a paper prepared for the Third Canadian National Energy Forum, Hotel Nova Scotian, Halifax, April 4 - 5, 1975. These figures were based upon the single family unit, with a liquid-base, short term storage solar heating system, with a 20 year system life. The capital cost of the system was $190.00/m^2 for the installed solar collector, $9.90/m^2 for the storage system, and $750.00 for the fixed cost per dwelling. Annual maintenance costs were assumed to be $75.00 per dwelling.

[8] This figure was obtained from the Meteorological Division, Canada Department of Transport.

could be established for the distribution of solar energy where the higher efficiencies and lower costs of joint storage can be realized. The idea would be to concentrate on the attainment of 100% heating reliance through seasonal storage, but with the use of lower cost collectors.[9] The difficulty with this is that it has never been either technologically or economically demonstrated that seasonal storage is feasible in Manitoba's climate.

Solar energy is most relevant to the rural and isolated residences of Manitoba. If optimal levels of insulation are combined with other residential energy saving measures discussed previously, large reductions in the necessary heating load can take place and, thus, solar energy becomes much more attractive. Further heating load reductions can occur through the utilization of passive solar technology. For example, using columns of water to store solar energy entering the residence through southern oriented windows during the winter months. Also, back-up heating does not have to be provided by electricity or petroleum products, but, where it is available locally, efficient wood burning stoves, which do not require a high fixed cost central delivery system, could be used.

Nevertheless, current government policy does not provide many incentives for the use of alternative energy sources such as solar energy. The high capital costs of solar systems and the add-

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[9] Presentation to the Solar Energy Conference, University of Regina, March 26, 1976.

itional costs of reserve heating systems will likely act as a disincentive to significant use of solar systems under the current policy climate.

Potential exists for using wind energy in remote and rural localities of Manitoba, although a more common use of this energy is for electricity requirements other than space heating applications. The average wind power in the extreme northern part of the province (ie. roughly the latitude of Churchill) is fairly high, between 300 and 400 KW/square mile. This compares to an average wind power of approximately 200 KW/square mile or less for the remainder of the province.[10] The variability of wind energy, inefficiencies of storage, and the high capital costs of generating equipment have acted as impediments to the widespread use of wind energy in recent years. However, if electricity is being considered for space heating in northern Manitoba residences where electricity has previously been generated by diesel powered generators, it may be economically feasible to supplement diesel generators with large windmills. The Ontario Ministry of Energy and Ontario Hydro have given this idea a lot of attention recently and have come to the conclusion that, at current Ontario diesel fuel prices, wind/diesel hybrid systems are cost-competitive with diesel power for

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[10] Based on a provincial map in J.R. Templin, NRC, "Availability of Wind Energy in Canada", in The Potential of Solar Energy for Canada, Proceedings of the Solar Energy Society of Canada, Inc., (Ottawa, 1975), p. 20.

the loads which were studied.[11]

Given the large amount of agricultural activity (both grain and livestock) and the large tracts of wooded land in Manitoba, there exists a good possibility that biomass energy may meet some of Manitoba's future residential energy needs. The term "biomass" means the weight of organisms, living or dead, which is present at any one time. However, similiar weights do not mean the same amount of productive or metabolic activity or potential for heat energy.[12] For example, a bundle of straw with the same dry weight as a piece of coal contains only one-half the potential heat energy of coal.

There are a number of methods by which a high energy gas can be produced from biomass such as straw or animal anaerobic decomposition. Anaerobic decomposition is the most common method considered for farm use. The gas which results from this operation is about 70% methane and 30% carbon dioxide. The carbon dioxide can be scrubbed from the gas resulting in pure methane which is the main component of natural gas. Some of the main

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[11] C.K. Brown, and D.F. Warne, Preliminary Assessment of the Potential for Large Scale Wind Generators as Fuel Savers in AC Community Diesel Power Systems in Ontario, (Toronto, Ontario Research Foundation, March, 1976).

[12] See Eugene P. Odum, Ecology: The Link Between The Natural and The Social Sciences, (New York, Hold, Rheinhart, and Winston. 1975), p. 25.

advantages of anaerobic decomposition are:

(i) it is an environmentally appropriate method of waste disposal;

(ii) sludge produced in the digester is a good fertilizer;

(iii) it is a renewable form of energy with a highly efficient and clean burning product; and,

(iv) it is available in the farms and rural areas where the provision of heat energy supplies is a problem for Manitobans.

However, there are some problems with the use of biomass digestors at the present time. These problems may be solved by future research, but at the present time they are:

(i) methane is explosive and so production must proceed with care even in the best designed plants;

(ii) the biological reaction can be poisoned in a number of ways so that hydrogen sulphide gas and/or corrosion of the digester might result;

(iii) the control of the operating temperatures and acidity of the process requires considerable amounts of knowledge and time on the part of the operator; and,

(iv) the capital costs of a digester, including a scrubber and storage capacity can be quite high.[13]

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[13] See The Biomass Energy Institute, Inc., <u>The Renewable Biomass Energy Guidebook</u>, (Winnipeg, March 1974) and Agriculture Canada, <u>Methane Gas Production from Animal Wastes</u>, (Ottawa, 1974).

Results of experimental work carried out by the University of Manitoba on biomass energy production, from pig manure, indicate that 4, 500 cubic feet/day or 1, 661 MCF/year of methane gas could be produced from a 6, 533 cubic foot capacity anaerobic digester using the manure from 1000 pigs.[14] The 1000 square foot house used approximately 150 MCF of natural gas per year for space heating purposes. Even if the assumption is made that 50% of the methane produced was needed to heat the digester, there would still be an abundance of methane left over for use as space heating fuel for the farm residence and other farm buildings.

The opportunity cost of using straw for heating fuel production is the value lost by not using the straw as cattlefeed, bedding, and for fertilizing the land. However, a large surplus of straw probably exists which could be used for heating requirements. R.C. McGuiness, of the University of Manitoba, estimated that the heating value of straw produced from the major crops in Western Canada in 1973, totaled 603. 8 x 10^{12} BTU or 25% of Western Canada's petroleum requirements during 1973.[15]

As stated in Chapter II, Manitoba has large tracts of forested land. Methanol can be produced from wood, including any

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[14] Agriculture Canada, Methane Gas Production from Animal Wastes, (Ottawa, 1974), p. 5.

[15] Paper presented to the International Biomass Energy Conference, (Winnipeg, May 13 - 15, 1973).

waste wood resulting from production processes. This may also be a source of fuel, particularly in Manitoba's north. However, it may be of greater value to allocate methanol to the transportation rather than to space heating applications.

Alcohol can also be made from crop residues as well as crops themselves. As is the case with methanol, it may prove more valuable to allocate alcohol to the transportation sector of the economy rather than the residential space heating sector. The use of crops to produce alcohol may also have another side effect which would be good for the Manitoba economy. The production of alcohol from crops would produce a greater demand for agricultural products, which would in turn be a boon to the Manitoba farmer, who, at the present time, finds himself able to produce a surplus of grain for which there is little market. The methods for producing alcohol along with the advantages of producing it have been known for years. The 1950 edition of Encyclopedia Americana (Canadian Edition) had this to say about alcohol:

> "It has been truly said of alcohol that, in the present state of the world's knowledge, it is the only fuel which man is able to manufacture in unlimited quantities and within a reasonable time without drawing upon the reserves of natural fuels; and this is especially important as to those parts of the earth where there are no natural fuel deposits. Alcohol is easily produced from any form of vegetable growth containing sugar or fermentable starch and at a cost of about 21 cents per gallon from such relatively costly material as the sugar cane and the sugar beet---which may be grown in four months. The so-called gasoline motors run

> readily on 84 percent alcohol (a higher degree has been found of no advantage) without material change in the mechanism. The only difficulties to be overcome are those of starting from the cold, and the necessity of a more abundant supply of fuel than with gasoline. The calorific value of fuel---alcohol is about 11,500 BTU per pound (91,100 BTU per gallon). With alcohol, internal combustion motors show a somewhat higher efficiency than with gasoline and run with much less noise."[16]

It would appear that the use of alcohol as an energy source was viable more than 25 years ago. If this was the case, then surely it is just as technically and economically viable today.

Another possibility is steam production from garbage combustion which can be used directly for heating purposes or can be converted into electricity (or both). Waste heate or by-product heat which is currently lost in thermal generation plants, cement plants, foundaries, etc., can also serve space heating needs. However, the economies of using such heat dictates that it be used in areas of high population density, meaning cities, and that it is better suited for industrial and commercial needs. Nevertheless, it is within the realm of possibility that some large multiple unit dwellings could be heated by waste heat or heat generated from wastes in the future in Manitoba.

5.3 Future Energy Consumption in Manitoba Residences

Previous chapters discussed some of the important determin-

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[16] Americana Corporation of Canada Limited, The Encyclopedia Americana, Canadian Edition, Vol. 12, 1950, p. 146.

ants of present and past energy rise in Manitoba residences. Some of the factors which will affect the total fuel requirements for residential space heating is as follows:

(a) the success of conservation measures such as:

(i) lowering thermostats;

(ii) construction of more energy efficient residences by developers;

(iii) more energy-minded urban planning induced by a co-operative effort at all levels of government;

(iv) better maintenance and use of more efficient burner units;

(v) cutting down on heat loss through air infiltration;

(vi) increasing insulation levels in new and existing residences; and,

(b) the size of the housing stock and the average energy consumption features of dwellings:

(i) the size of new dwellings,

(ii) the design types of new and existing dwellings (the relative proportions of single detached, row, apartments, etc.)

(iii) the annual rate of dwelling completions and the proportion of these which are replacement dwellings as compared to those which represent an increment in the numbers of dwellings,

(iv) the geographical location of new dwellings (those located in the north have greater heat loads).

There are at least two good reasons to assume that the net increases in Manitoba's present housing stock will occur, at least in the short term future:

(a) Manitoba's population is increasing, albeit slowly, and

(b) the "crowding index" is expected to decline by 13% between 1974 and 1985.[17]

Increases in the price of heating fuel can be expected to have an effect upon the size and types of dwellings constructed in Manitoba. It can be expected that there will be reductions in the proportions of single detached units and increases in multiple dwelling units. That this will be the case is indicated by <u>Table B - d</u> in Appendix B, which shows that since 1975, a reduction in the proportion of single-detached dwellings has already occurred, while a greater proportion of row houses are being constructed.

The increasing price of land will also have an effect upon the size and design of dwellings. In the larger urban centres, the price for land and land taxes are considerably higher than in rural areas. This may probably result in new dwellings being somewhat smaller on the average in urban areas as compared to rural areas.

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[17] Prediction of the Economic Council of Canada, <u>Options to Growth</u>, (Ottawa, 1975). The crowding index is defined as the number of persons per room.

The rate of resource development in northern Manitoba will probably be the main determinant of the number of dwellings which will be located in the North. These northern residences will have greater heating loads than similiar residences located in the southern portions of the province.

Conservation measures could reduce the heat energy requirements of a new dwelling by 50% to 69% and that of an average existing dwelling by 20% to 50%. Some of the measures for reducing the amounts of energy used in a dwelling were listed in Chapter IV, but a more complete list appears below. In construction of new houses, insulation levels can be increased to optimal levels in exterior walls through the use of 2" by 6" studs. Weatherstripping and caulking can reduce the number of air changes to the optimal level, although one must make certain that enough ventilation is allowed to prevent damage to walls and insulation due to moisture buildup. Windows should be triple-glazed. Dwellings should be oriented so that one of its sides is facing south and, on this side, window space should be maximized to take advantage of the sun during the winter months. In summer, an awning will prevent the sun from overheating the residence. On all other sides of the dwelling, window space should be minimized. Either berms or coniferous trees should be placed along the north side of the house to create a wind break during the winter. On the south side, deciduous trees should be planted, as they will provide shade during the summer while still allowing the sun to strike the building during the winter. If care is taken to install the correct sized heating unit in the dwelling and it is maintained properly during its life time, energy savings will also be realized.

Less can be done to make existing dwellings as energy efficient as dwellings which are in the process of being constructed. Nevertheless, the owner of an existing home can upgrade the insulation in the ceilings and basement and have insulation blown into the exterior walls.

Doors and windows can also be weatherstripped and caulked. Windows can also be triple-glazed, although this is quite expensive. Trees can be planted in the same manner as would be for a new dwelling. The furnace can be maintained and the thermostate lowered.

Without any changes in future heating policy, the success of residential heating fuel within the province of Manitoba, will depend a number of incentives:

(a) Building Standards

Undoubtedly, buildings codes dealing with insulation standards can be one of the most successful means of inducing energy conservation in new dwellings. However, controls such as these can only be regarded as a first step for the following reasons:

(i) there are many other measures besides increasing insulation which also save on energy used for heating a residence;

(ii) personal incentive, rather than a mandatory requirement to conserve energy, will cause a consumer to consider other methods to conserve energy rather than just installing a higher degree of insulation as required, and

(iii) it is likely that the amount of insulation required by a building code could fall short of that justified by life cycle cost analysis (see Chapter IV).

(b) The Price Incentive

As the price of fuel climbs relative to the cost of conservation measures, it will become more attractive for a consumer to invest at the present time in methods which will reduce his heating requirements so that he will receive future reductions in his heating bill. This incentive exists at the present time, but anticipated fuel price increases will save to strengthen this incentive.

(c) The Average Income of the Consumer

Income appears to have a two-sided effect on the actions in regards to the residential conservation of heating energy. On one side, if the consumer's income is very low, the initial cost of increasing insulation and other conservation measures may be prohibitively high, even though substantial energy cost savings would result in the long term. On the other side of the coin, if the consumer's income is very high and expenditures on residential heating are a small part of the consumer's overall budget, then heating decisions will be a low priority item as compared to other decisions. Thus, the consumer may not acquire enough incentive to make the initial investment even though substantial future savings may be realized.

The lifting of wage and price controls will probably result in an increase in the incomes of Manitobans, at least for the short term future. As a result, funds should be available for residential conservation investment, but actual investments will probably depend upon the degree of public awareness of the merits of conserving energy.

5.4 Summary of Chapter V

Chapter V considers the market shares and total consumption of residential heating fuels over the short term future, assuming that no significant policy changes are made by the Manitoba government in this area.

Increasing prices and quality disadvantages of heating oil and kerosene will result in fewer new installations of these fuels. Conversions to alternates can be expected, but it is likely that many residences will continue to use these fuels as their primary heating fuels. Propane is likely to maintain its position as the primary heating fuel for mobile homes.

It appears that the considerable cost advantages of using natural gas for heating purposes will continue for some time even though Manitoba has to rely solely on imports for its requirements. Supplies of natural gas from Alberta will, in all probability, remain sufficient to meet Manitoba's needs at present levels of consumption, although increases in consumption may not fare so well until natural gas becomes available from the frontier areas.

The use of electricity to provide residential heat in Manitoba is increasing rapidly. The future rate of increase in electric heating will depend largely on its price relative to other heating fuels. If consumption of electricity for residential heating purposes rises quickly in the future, there will have to be much larger revenues collected through rates, in order to cover increasing incremental generation, transmission, and distribution costs. This will push the rates upwards rapidly, which will tend to slow down the growth somewhat. However, a force which will promote electric heating is the declining block tariff currently used by Manitoba Hydro. Since electric heating normally comes in at the lowest price block, the tariff will make electric heating more attractive to customers.

Coal and wood are unlikely to be very significant parts of the residential heating market under present policy conditions. However, wood heating may increase in areas where it is readily available and the cost of the other heating fuels increase.

Alternate sources of residential energy such as solar, wind, biomass, waste heat capture, etc., may have some impact on the residential heating market as the costs of conventional fuels increase. High capital costs, combined with many technological and economic unknowns are impediments which are associated with these alternate energy resources. Present policy does not provide incentives for residential heating through use of such methods.

The total amount of energy consumed in Manitoba for the purpose of residential space heating in the future, will depend on the size, design, and the location of the housing stock, as well as conservation measures undertaken by residence owners. Although the total stock of Manitoba dwellings is expected to increase, the increasing price of land in the urban centres is expected to decrease the dwelling sizes, and to increase the proportion of newly constructed multiple-unit dwellings.

The heating fuel consumption of Manitoba's North (where heating loads are greater) will depend upon Manitoba's development of its northern natural resources. An increase in the development of the north will tend to increase total residential fuel consumption.

If no significant policy changes occur in Manitoba, fuel conservation measures will depend upon the extent to which cost saving incentives are perceived by residence owners, as the costs of heating a residence continue to rise. The average income available for investment in conservation and the application of building standards will also influence fuel conservation in future residences.

CHAPTER VI

POLICY ALTERNATIVES

6.1 Objectives and Qualifications Regarding Chapter VI

This chapter discusses the advantages and disadvantages of alternative policy directions in regards to the allocation and conservation of residential heating fuels.

The author admits that there are future economic, technical, and political uncertainties which may affect the comparative merits of these policies. There must be recognition of the fact that uncertain national and international events, which are out of the province's sphere of influence, will affect energy supply and demand within the province, as well as influencing other aspects of the political economy. Nevertheless, the author believes that there is a present need for clear and concise energy policies which also posess, at the same time, a necessary degree of flexibility.

The policy alternatives listed here are not intended to be exclusive and, in fact, the Manitoba government may regard alternatives as being more general or more detailed than those listed here.

Allocation and conservation policy alternatives are kept separate in this report, but it should be noted that these areas are interrelated. The economic and technical feasibilities, for example, of using an energy source such as solar energy for residential heating purposes is directly related to the heat load required which is in turn influenced by conservation measures.

6.2 Allocation Policy Alternative One --- No Significant Policy Changes

Future allocations under this policy were discussed in Chapter II. The relative prices of heating fuels would change, but natural gas would remain the lowest-cost fuel. The natural gas system would not be extended to new communities, but new subdivisions would be connected in communities which were already part of the system. The use of oil and kerosene and propane for heating purposes would only increase slightly. The movement towards electric heating would depend upon the relative price of electricity as compared to other fuels and the availability of other fuels in areas served by electricity.

(a) Advantages of Allocation Policy Alternative One

Manitoba has the possibility of tripling its hydro-electric generation capacity if need be. However, electric heating growth will likely be slow enough, due to the recent large rate increases, to provide the lead time necessary for expansion of the generation facilities and the upgrading of the distribution system.

A gradual transition to electric heating in rural areas and a continuation of natural gas supply in urban centres would not unduly obligate residence owners to make large expenditures on new heating systems over a short period of time as might occur with other policies.

In addition, this alternative relies on known technology. The methods and costs of heating with natural gas and electricity are well understood.

(b) Disadvantages of Allocation Policy Alternative One

Acceptance of this alternative means a continued reliance upon an energy source which is completely outside of Manitoba's political control. If supplies of natural gas diminish quickly in the future, it is likely that Alberta would cease to export gas to Manitoba. If this happens suddenly and it becomes necessary to switch to an alternative fuel quickly, there may be extreme social and economic dislocations associated with this rapid conversion.

Reasonably large quantities of kerosene and light fuel oil would continue to be used under this policy alternative. An important opportunity cost associated with the use of petroleum products for space heating is the opportunity cost of not using them in the agricultural and transportation sectors of the provincial economy. At the present time, there does not appear to be a petroleum substitute in either agricultural production or transportation which is either economically or technically feasible (unless alcohol is used).

The declining block tariff used for electricity pricing can easily result in a misallocation of resources in the Manitoba economy. Economic theory shows that prices must approximate marginal production costs if resources are to be optimally allocated. An optimal cost pricing structure means that "the cost to any consumer of changing the level or pattern of his consumption equals the cost to the electrical supply industry of doing so."[1] Retention

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[1] Ralph Turvey, Optimal Pricing and Investment in Electricity Supply: An Essay in Applied Welfare Economics, (Cambridge, Massachusettes, the Press, 1968), p. 86.

of the declining block tariff means that the marginal cost pricing is not approximated. The cost of electric heat comes in at the lowest block in the tariff, where the consumer can increase his consumption at constant costs per KWh even though marginal production costs are rising for the utility as capacity expands.

As more electricity is consumed in electrically heated residences and generation, transmission, and distribution expansion costs mount for Manitoba Hydro, revenues from rates will have to be raised. Assuming that a declining block tariff similiar to that now in use, is retained, overall residential electricity rates, including the run-off rate, will have to be increased to meet new total revenue additions attributable to space heating. Non-electric heating customers will be required to pay more for the electricity they consume on higher price blocks of the tariff. Heating customers on the other hand, will not have a strong incentive to conserve electricity because the incremental KWh's which they consume will be at constant rates.

Without a clear policy statement on desirable end use allocation of heating fuels, consumers will be unaware of the fuel type which is to their long term benefit to have installed or to know when to convert to a different fuel type, As a result, fuel choices will probably be made on the basis of lowest first cost rather than on lowest life-cycle costs.

6.3 Allocation Policy Alternative Two: Electric Heating in Rural and Non-Gas Distribution Areas

Under this alternative, the government would actively influence new heating installations and conversions to electric heating in rural areas and areas which are not a part of the natural gas distribution system. One, or a combination of the following strategies would be used to induce more electric heating: potential electricity pricing, regulation, loans and grants. Expansion of the existing gas system into new areas and new subdivisions would be halted.

(a) Advantages of Allocation Policy Alternative Two

Greater amounts of petroleum products and propane would be saved for future use for allocation to the agricultural or transportation---sectors of the economy.

The growth in consumption of natural gas for residential heating would be slowed down or stopped altogether, thus, reducing Manitoba's future dependence upon an imported energy fuel. This would also permit these energy supplies to be used by the industrial and commercial sectors of the economy.

Residents of rural areas who would heat their homes with electricity would be assured of a secure high quality fuel, possibly at a lower price.

It is likely that Manitoba Hydro could meet all of Manitoba electrical needs by expanding its generating, transmission, and distribution facilities.

(b) Disadvantages of Allocation Policy Alternative Two

A rapid transition to electric heating in non-gas and rural areas would necessitate the development of additional generation, transmission, and distribution capacity. The lead time required (8 - 10 years in the case of a hydro-electric generating plant) from the initial planning stage to the installed capacity might make this policy difficult to achieve in the short term. Capital costs for new generation capacity and for upgrading the rural distribution system to handle the increased electrical load would be very large. Also associated with the rapid hydro-electric capacity expansion are the environmentally adverse impacts of flooding biologically productive valleys, and damage to land and wildlife habitat caused by the construction of electrical transmission corridors for power lines.

Electricity rates would have to rise as capacity expands if Manitoba Hydro is to meet its total revenue requirements. The Manitoba government could adopt one of several strategies to keep electric heating costs from becoming an excessive burden to rural residents, but each of these have certain disadvantages:

(i) if the declining block tariff were designed so that electric heating and natural gas heating costs were roughly equal (ie. a low run-off rate for electricity) non-electric heating customers of Manitoba Hydro would have to pay considerably more for household electricity consumption than would otherwise be the case (see Allocation Policy Alternative One), or

(ii) the government might to decide to give direct subsidies to rural heating customers or to keep down rates by financing Manitoba Hydro's capacity expansions from government revenues.

A rapid expansion in electric heating of rural customers would mean that either they would have to make large investments in heating system conversions or else the government would have to make substantial subsidies available for this purpose.

6.4 Allocation Policy Three: Mixed Allocation

Under this policy alternative, it would be assumed that the Manitoban residential heating market was complex enough and differentiated enough so that different fuels and heating methods might have advantages over others in different parts of the market.

Allocations decisions would be made following a study which examined in detail the lowest heating cost methods which will result in the next 10 to 15 year period for different groups of residences. The Study would:

(1) Categorize Manitoba residences along such lines as existing heating fuel, distance from generation facilities, or fuel distribution centres, urban or rural, heating load, etc..

(2) Examine various fuels and determine which ones would be lowest cost over a 10 to 15 year period based on shadow

prices[2] of fuel (including alternative sources of energy) and appropriate interest rates.

(3) Develop a plan for fuel allocation based upon heating costs, but also considering any social, economic, environmental, or administrative constraints which might apply. Public discussion of the plan could prove useful at this stage. Allocation policy would be coordinated with other important policy decisions such as the stay-option at this point. It may be decided that pilot projects are required before decisions can be made regarding the new alternative energy sources are made.[3]

(a) Advantages of Allocation Policy Alternative Three

The policy would consider all of the alternatives and come up with conclusions which should be economically, socially, and environmental sound over a longer period of time than Allocation Policies One and Two.

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[2] Shadow prices, as the term is used here, means that prices would be based upon long-run incremental production costs (thus, accounting for future resource scarcity) and the premium qualities of various heating fuels.

[3] The author of this report borrowed these ideas from the report by Mr. Ralph F. Smith, Residential Space Heating Policy Alternatives In Saskatchewan, (Winnipeg, Natural Resource Institute, April, 1977).

Coordination of other government policies is more feasible under this alternative.

There is also a greater scope for public involvement in the decision making process which would lead to a greater public awareness of the necessity of fuel price increases and a greater realization of the importance of making the right decision in choosing a residential heating system.

(b) Disadvantages of Allocation Policy Alternative Three

A mixed allocation would be more complex to administer than is the case at the present time (fewer fuel types).

The study would be costly and would require a considerable amount of time before recommendations could be formulated and acted upon during which time consumer choices would continue resulting in overall economic inefficiencies and inequitable annual heating costs.

The use of pilot projects to assess alternative heating technologies would stretch the decision making time line farther out into the future.

Shadow prices, appropriate interest and discount rates, and the necessary housing characteristics needed for the study may be difficult to determine.

6.5 Conservation Policy Alternative One: No Significant Changes

This policy alternative assumes that increasing fuel prices are a sufficient incentive to cause the existing residence owner to undertake energy conservation measures. It is also assumed that prospective owners of new residences would become more interested in energy conservation measures as fuel costs became a larger part of annual income.

(a) Advantages of Conservation Policy Alternative One

As demonstrated in Chapters IV and V, a strong financial incentive already exists in Manitoba to increase insulation of existing dwellings and dwellings under construction and to adopt other energy conservation measures. As fuel prices increase, consumers will become more and more aware of this incentive.

A second advantage is the costs of administrating a conservation program can be avoided if market prices are relied upon to cause implementation of conservation measures. Also, the consumer is completely free to make whatever amount of investment he wishes on whatever kind of conservation measure suits his particular needs.

(b) Disadvantages of Conservation Policy Alternative One

If consumers are not at the present time aware of the potential fuel cost savings that they can achieve through implementation of conservation measures, then the fuel cost incentive is not likely to induce much response in consumer desires to implement conservation measures.

Also, incentives based on future operating cost savings are only effective in so far as the owner of a new dwelling can make decisions about conservation features of a dwelling while it is being constructed (unless retrofitting is practical). If the practice continues where the builder or developer makes the decisions about conservation features, then new houses are not likely to approach optimum use of energy, due to the builder's or developer's preoccupation with the lowest first cost and sales of a residence.

6.6 Conservation Policy Alternative Two: Legislation and Standards

In this case, building standards and regulations dealing with energy efficiency requirements for residential heating systems would be relied upon as the major aspect of a Manitoba conservation policy.

Manitoba could develop its own building code or separately legislate specific thermal efficiency requirements for new construction, instead of following federal requirements as it does now.

(a) Advantages of Conservation Policy Alternative Two

This is probably the most effective means that could be taken to insure that new residences will be more energy efficient than their predecessors. Manitoba's codes could be designed to reflect the majority of new house buyers' viewpoint about the incremental amounts they are willing to pay for increased energy efficiency of the residence, or they would be designed to reflect optimal thermal insulation values.

(b) Disadvantages of Conservation Policy Alternative Two

Standards are not likely to apply to existing homes. Thus, a policy dependent on standards would not help to lower the costs of heating an existing residence.

Furthermore, consumers would not have a personal incentive to conserve energy under this policy alternative. It is also unlikely that such construction features as orientation, window area, facing directions of windows, tree shelters, etc. would be contained in building standards.

Lastly, there are inspection costs associated with implementing standards.

6.7 Conservation Policy Alternative Three: Financial Incentives Through Reduced Income Tax, Plus an Advertising Campaign and a Consulting Service

Under this policy alternative, insulation costs incurred by the consumer would be eligible for deduction from the consumer's income tax. In addition, advertising would highlight the benefits of residential energy conservation measures of all types.

A counciling service in Citizens Inquiry or some other provincial agency would be set up to advise residence owners on appropriate conservation measures and the expected costs for their individual home. counseling

(a) Advantages of Conservation Policy Three

A substantial reduction in heating fuel requirements of both existing and new residences would occur as consumers would be better able to approach the optimal thermal resistance levels.

Because of councilling and advertising, public awareness of savings through conservation could pressure builders into designing more energy efficient residences.

Councillors would be available to assist people in the design of their own conservation plans, thus increasing peoples' confidence in conservation measures which, in turn, increases individual's incentive to implement conservation measures.

The provincial income tax already contains a vehicle, called the Manitoba Property Tax Credit Plan, through which insulation costs could be deducted from the individual's taxable income.

(b) <u>Disadvantages of Conservation Policy Alternative Three</u>

The costs to the provincial government in forgone income tax revenue would be considerable. The costs of advertising and operating the councilling service would also be considerable. councelling

Spot checks would probably have to be performed to insure that the individuals were not padding their insulation costs so as to decrease their income taxes. The costs of these spot checks would also have to be a factor to be considered.

6.8 Conclusions

Chapters I to V of the practicum illustrate the space heating situation existing in the Province of Manitoba.

From the information contained in Chapter II, the author concludes that Manitoba has sufficient resources of hydro-electricity and wood for its own use, but will have to continue to rely on imports of coal, oil, and natural gas for its future energy needs. To date, Manitoba's uranium supply is an unknown factor, but exploration in this area is occurring at the present time.

Chapter III deals with the pattern of heating fuel usage which occurs in Manitoba. Conclusions reached in this chapter fall under two main categories; heating fuel allocation and total residential fuel consumption. In the category of heating fuel allocation, the data collected shows that Manitoba relies heavily upon natural gas as its primary heating fuel, as compared to Canada as a whole. The data also shows that the number of new natural gas heating installations has continued to grow steadily, and that the majority of natural gas users are located in the urban areas of the province. The author concludes from the data that this heavy reliance upon natural gas as the primary heating fuel for Manitoba residences will continue.

Data contained in Chapter III also indicates a growing trend towards the use of electricity as the primary heating fuel in Manitoba residences. The author concludes that much of this growth is a result of the trend away from such heating fuels as coal, kerosene, light fuel oil and wood.

In the category of total residential fuel consumption, the author concludes that factors such as higher levels if insulation in new homes, the increasing ratio of new homes to old homes, the trend toward more efficient heating systems, and the trend toward slightly smaller homes will result in the continuation of the trend in which residential heat energy needs will increase at a less rapid rate than Manitoba's total energy consumption.

Chapter IV examined some of the costs to the consumer of heating a residence in Manitoba and assessed the potential for conservation of heating fuel within the residence. The author concluded that natural gas is currently the lowest cost heating fuel in Manitoba, assuming a residence was located where natural gas was available. The ranking of oil, electricity, and propane was found to depend upon the efficiency of the heating equipment and the geographical location of the residence.

The author concluded that current insulation standards for ceilings were a minimum of 40% below what was economically justified. The author also concluded that building walls with 2" by 6" studs to allow for increased insulation is economically justifiable.

The author concluded that fuel saving advantages of up to 30% could be obtained by building multiple dwelling units as opposed to single dwelling units with the same gross livable area.

The author concluded further that the lowering of the thermostat created considerable fuel savings.

The author also concluded that consumers of heating fuels in

Manitoba have not always made decisions dealing with the residential space heating on the criterion of lowest economic cost analysis. The author concludes that if they had, there would be no need for this report.

Chapter V considers the market shares and total consumption of various residential heating fuels over the short term future, assuming that there are no significant policy changes made by the Manitoba government in this area.

The author concludes that price increases and quality disadvantages will result in fewer installations of heating oil and kerosene, while propane will maintain its position as the primary heating fuel for mobile homes. Natural gas will continue to maintain its number one position as the main primary heating fuel, due to its considerable cost advantages and the probability of sufficient supplies.

The use of electricity to heat residences has increased rapidly and future increases will depend upon the price of electricity. Increasing incremental costs of new generation, transmission and distribution systems will tend to push the price of electricity up rapidly, which will tend to slow down the growth somewhat. On the other hand, the fact that electricity currently used for residential space heating purposes is sold to the consumer at the lowest price block in the rate structure will tend to make electricity more attractive to the consumer.

The author concludes that alternative sources of energy such as solar, wind, biomass, waste heat capture, etc. may have some impact upon the residential space heating market as the costs of conventional fuels increase. However, present policy does not provide incentives for residential heating through the use of these methods.

Chapter VI discusses the advantages and the disadvantages of three feasible policy alternatives for both of the components of a comprehensive residential heating policy---allocation and conservation.

The policy alternatives discussed in Chapter VI are not intended to be mutually exclusive. They were used as a framework around which the parameters of making a decision in this complex area were discussed. Obviously, a more detailed analysis of alternatives will be required before a residential space heating policy can be implemented by the Government of Manitoba.

Regardless of what decisions are made, residential space heating seems certain to become a greater public issue in the future than it has been in the past.

APPENDIX A

GLOSSARY OF TERMS AND ABBREVIATIONS

Terms

Average Cost Pricing: Unit pricing is based on total production costs divided by the number of units produced.

British Thermal Unit: The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

Degree Days: For each day there are as many degree days as there are ^{o}C (^{o}F) difference between $18^{o}C$ ($65^{o}F$) and the mean temperature for the 24 - hour day when the latter is below $18^{o}C$ ($65^{o}F$).

Design Temperature Difference: The difference between the outdoor temperature and the indoor temperature for which the heating system of a residence is designed. The design temperature difference used in this report is $100^{o}F$.

Design Type: Distinguishes single detached dwellings from various types of multi-unit dwellings.

Dwelling: Structurally separate set of living quarters with a private entrance from the outside or inside the building (ie. entrance is not through someone else's living quarters).

Heating Load: The number of BTU required for delivery from the burner units to maintain the temperature of a residence at a designated level over a heating season.

Household: 1971 Census definition used, where a household consists of a person or a group of persons occupying one dwelling. For the purposes of the practicum, it can be assumed that there is a one-to-one relationship between households and occupied dwellings.

Load Factor: The average use of facilities as a percentage of maximum use .

Marginal Cost Pricing: Pricing at a level where the cost to any consumer of changing the quantity consumed of a good equals the cost to the producer of this change in quantity demanded.

Replacement Dwellings: The annual number of new dwelling completions which are equal to the number of dwellings which have been abandoned or destroyed each year. Total completions minus replacements equals net additions to housing stock.

Residence Heat Utilization Efficiency: The efficiency at which chemical energy of fuel delivered to the burner is used in the residence. Inefficiency in the burner, heat loss up the chimney, and heat loss through infiltration are included in the calculations.

Retrofit: Used in two senses: (a) Replacement of an existing heating system with a different type of system or one that uses a different fuel; or (b) adding insulation to an existing residence.

Rural Non-Farm Dwellings: 1971 Census definition: dwellings in rural localities which are not classified as census forms. Rural localities are areas other than incorporated cities, towns, or villages, with populations of 1,000 or more, unincorporated places wherepopulation is at least 1,000 persons per square mile, or fringes of urbanized areas. Census farm dwellings are located on at least 1,000 acres of land where at least $50 of agricultural production occured within a year previous to census day.

Thermal resistance: The amount of resistance to heat transfer offered by one square foot of construction material or air space of given thickness for a design temperature difference of $1^{o}F$. The resistance (R) is the reciprocal of thermal conductivity (U).

Thermal Conductivity: The time rate of heat flow per unit of area, under steady conditions from the air on the inside of the structure to the air on the outside, per unit of temperature difference. The thermal conductivity (U) is the reciprical of thermal resistance (R).

Abbreviations

ASHRAE: American Society of Heating, Refrigerating and Air Conditioning Engineers

BCF: Billions of cubic feet

BTU: British Thermal Units

C.M.H.C.: Central Mortgage and Housing Corporation

EMR: Department of Energy, Mines and Resources, Government of Canada

HUDAC: Housing and Urban Development Association of Canada

KWh: Kilowatt hours

MCF: Thousands of cubic feet

NEB: National Energy Board

NEMA: National Electrical Manufacturers Association

NRC: National Research Council

OPEC: Organization of Petroleum Exporting Countries

MMStb: millions of stock tank barrels

R: Thermal Resistance

U: Thermal conductivity

TABLE B - a*

STANDARDS GOVERNING RESIDENTIAL INSULATION FOR CONSTRUCTION FINANCED UNDER THE NATIONAL HOUSING ACT, 1954 - 1977

Code Date	Non-Electric R Values**		Electric Heating R Values	
	Walls	Ceiling	Walls	Ceiling
1954	6.66	6.66		
1958	6.66	6.66		
1962	8.33	8.33		
1963	8.33	8.33		
1965	6.67	6.67	12.5	16.67
1967	6.67	6.67	12.5	16.67
1968	6.67	6.67	12.5	16.67
1970	9.09	11.11	12.5	16.67
1972	10.0	12.5	12.5	20.0
1975	13.7	14.1	14.0	16.8
1977	13.7	14.1	14.0	16.8
Current	12.4	34.8	12.4	34.8

*Source: C.M.H.C..

**R value is based upon 10,800 degree days Fahrenheit (Winnipeg) after 1970.

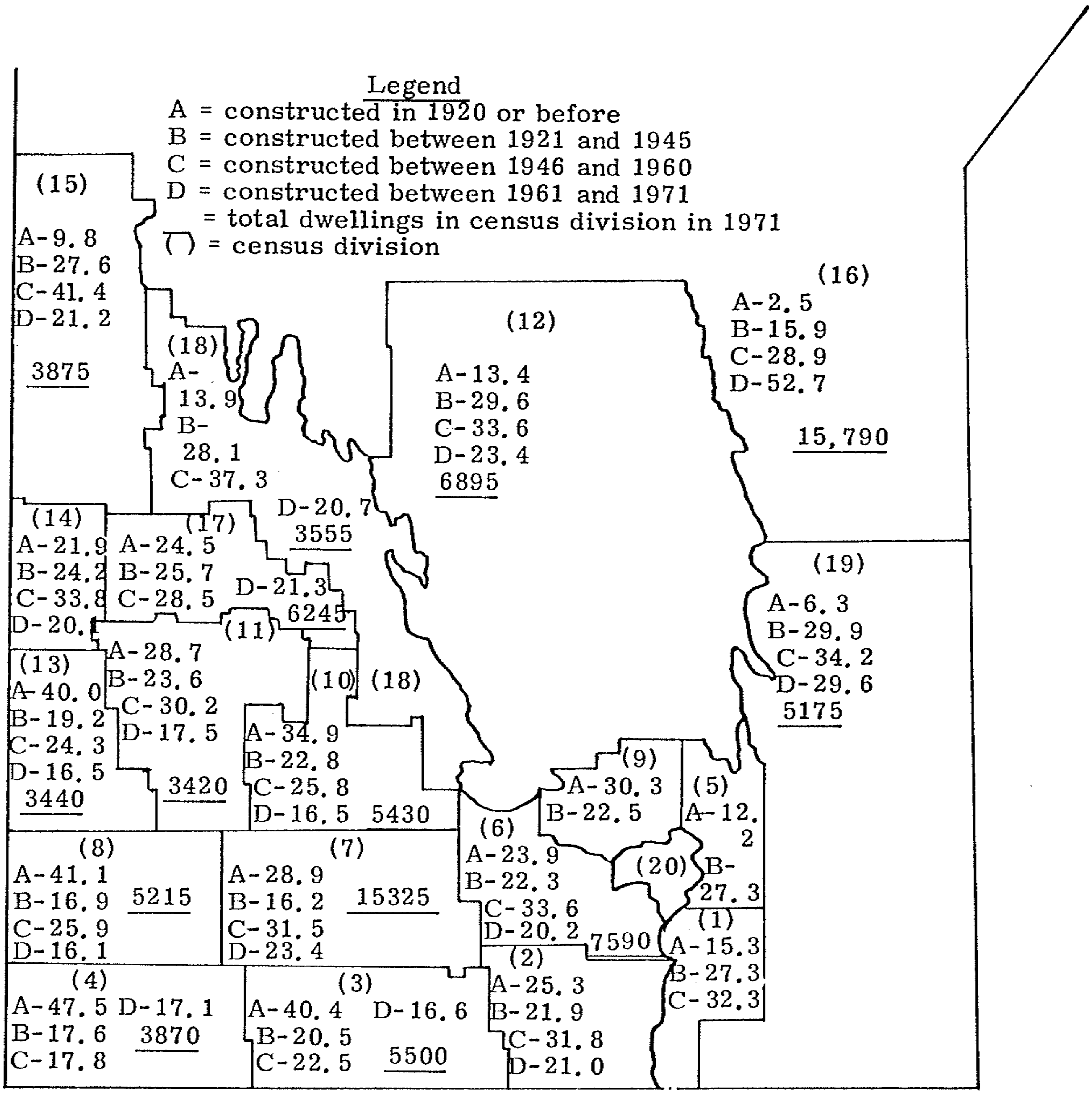
The data used to derive Table 6 was from the 1971 Census, C, M. H. C. housing completions since 1971, and a Gallup Poll taken in February of 1976. The table itself was constructed for C. M. H. C. by Scanada Consultants.

The annual rate of new dwellings which are replacements for destroyed or abandoned ones used in construction of Table 6 is 2%.

There has been some reason to doubt the accuracy of information contained in the 1971 Census, according to officials responsible for the Census. The author assumes that data presented in this report which is based upon the 1971 Census would serve a useful purpose, even though it lacked precision.

FIGURE B - a

CONSTRUCTION PERIOD OF OCCUPIED DWELLINGS BY CENSUS DIVISIONS IN MANITOBA , 1971 (by %)



*Note - information missing from figure is as follows:
Div. (1) - D-25.1, 7265 ; Div. (2) - 9130; Div. (5) - C-34.1, D-26.4, and 9135; Div. (9) - C-27.9, D-19.3 and 3135; Div. (14) - 1715; Div. (20) - A-20.1, B-21.4, C-33.4, D-25.1 and 166,220.

TABLE B - b*

PERIOD OF CONSTRUCTION OF URBAN AND RURAL OCCUPIED DWELLINGS IN MANITOBA, 1971

	Urban	Rural Non-Farm	Rural Farm
Total Dwellings	209, 305	46, 830	31, 775
Constructed 1945 and before (%)	40. 5	42	57
Constructed 1946 - 1960 (%)	33. 0	30. 4	29. 2
Constructed 1961 - May 31, 1971 (%)	26. 5	27. 6	13. 8

*Source: 1971 Census of Canada.

TABLE B - c*

DWELLING TYPES (1000's) - MANITOBA AND CANADA, 1963 - 1977

Year	Total Households		Single Dwelling		Single Attached		Apartment	
	Can.	Man.	Can.	Man.	Can.	Man.	Can.	Man.
1963	4671	242	3141	195	265	7	1265	4
1965	4853	246	3261	197	315	7	1277	42
1967	5034	256	3262	189	320	9	1452	48
1969	5514	263	3503	203	368	9	1643	51
1971	5779	270	3626	204	406	9	1747	57
1973	6226	292	3820	205	418	14	2038	73
1975	6703	311	3987	221	458	12(?)	2258	77
1977	7022	319	4164	223	550	21	2307	75

*Source: Statistics Canada, 64 - 202, Household Facilities and Equipment.

TABLE B - d*

HOUSING COMPLETIONS IN MANITOBA, BY TYPE OF DWELLING

1969 - 1977

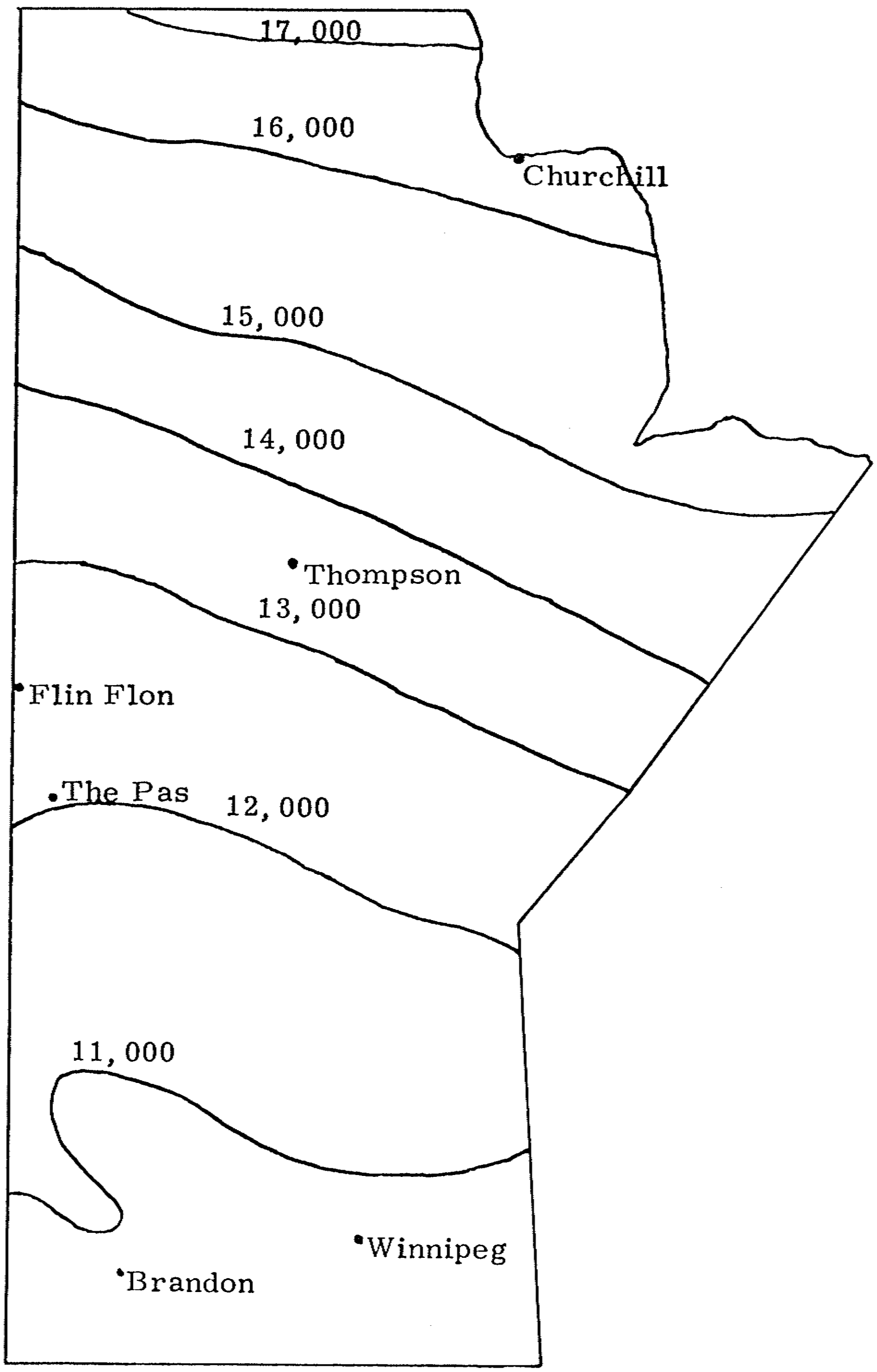
Year	Completions	Single Detached	%	Two Family	%	Row	%	Apartment & Other	%
1969	7588	3,235	42.6	376	5.0	248	3.3	3,729	49.1
1970	9320	2,933	31.5	479	5.1	641	6.9	5,267	56.5
1971	10,093	3,111	30.8	928	9.2	1016	10.1	5,038	49.9
1972	10,071	4,426	43.9	886	8.8	730	7.3	4,029	40.0
1973	10,727	4,989	46.5	640	6.0	335	3.1	4,763	44.4
1974	12,164	6,244	51.3	588	4.9	209	1.7	5,123	42.1
1975	8,760	4,787	54.6	517	5.9	330	3.8	3,126	35.7
1976	8,492	4,416	52.0	548	6.4	346	4.1	3,182	37.5
1977	8,720	4,332	49.7	740	8.5	635	7.3	3,013	34.5

*Source: Statistics Canada, 64 - 002, Housing Starts and Completions.

B. 2 Background Information to Section 3. 8

FIGURE B - b*

ANNUAL TOTAL OF DEGREE-DAYS (below 65°F.) IN MANITOBA

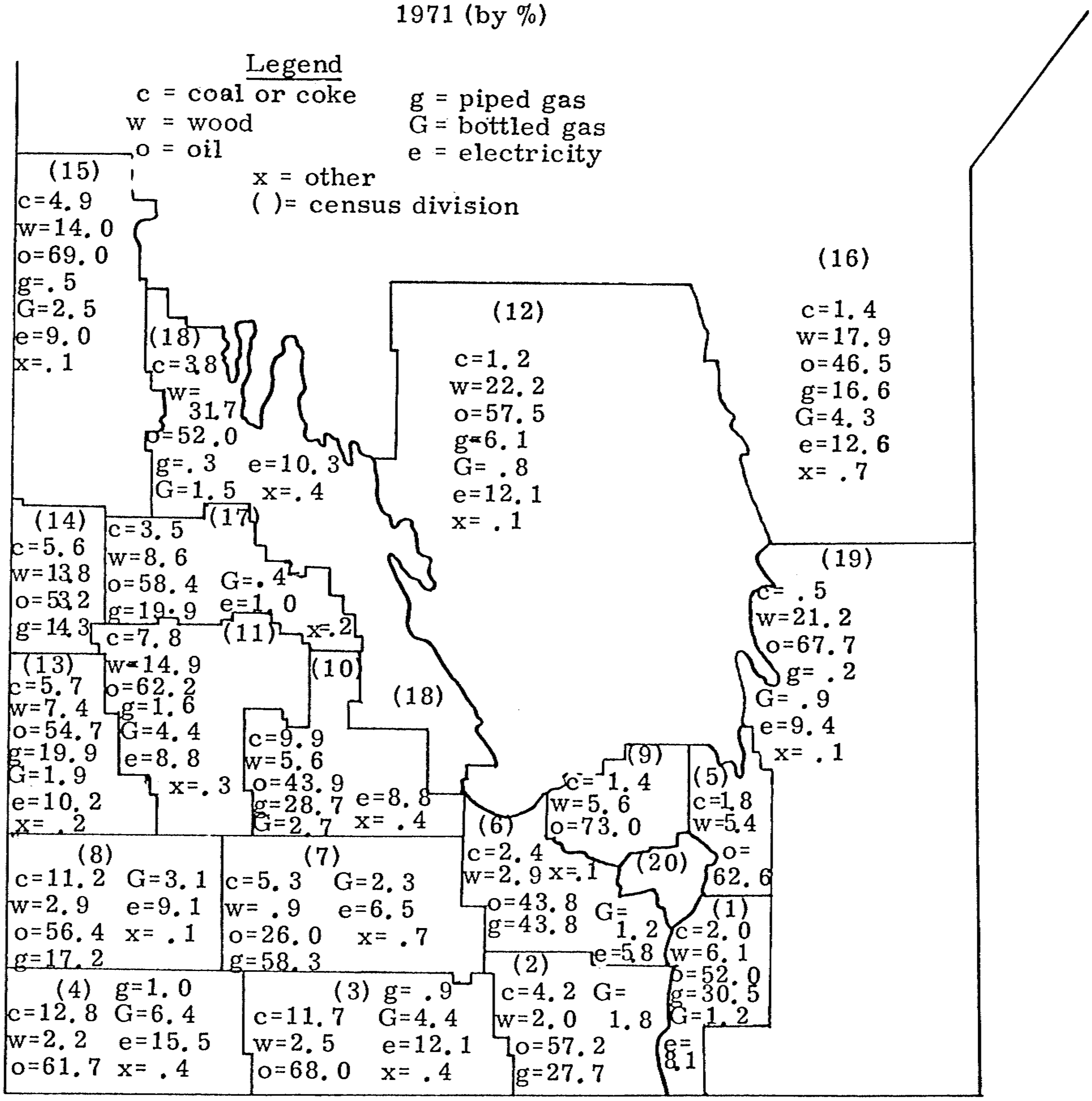


*Source: National Research Council, and the Meteorological Branch, Department of Transport, Canada.

B. 3 Background Information to Section 3. 9

FIGURE B - c

PRINCIPAL HEATING FUELS IN MANITOBA BY CENSUS DIVISIONS, 1971 (by %)



*Note: information missing from figure is as follows: (1) - x = .1; (2) - e = 7.0, x = .1; (5) - g = 21.7, G = 1.3, e = 7.0, and x = .2; (9) - g = 10.1, G = 2.9, e = 6.5 and x = .5; (14) - G = .9, e = 12.2, and x = 0.0; (20) - c = .4, w = .1, o = 17.6, g = 75.9, G = .3, e = 4.9 and x = .8.

TABLE B - e*

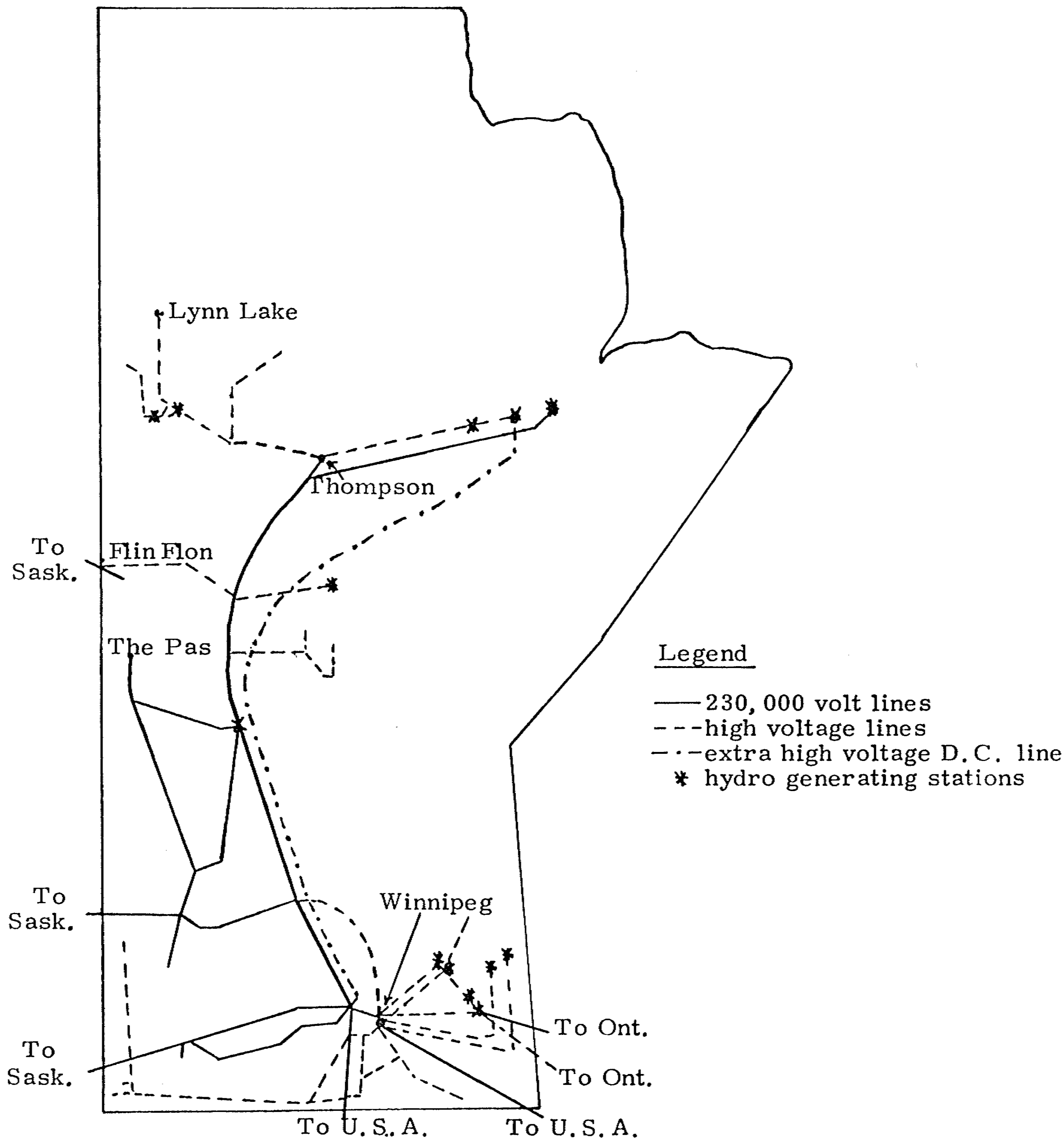
PRINCIPAL HEATING FUELS FOR OCCUPIED DWELLINGS IN MANITOBA, URBAN AND RURAL, 1971

	Electricity	Coal or Coke	Wood	Oil or Other Liquid Fuel	Piped Gas	Bottled Gas	Other
Urban							
500,000 +	8,005	665	200	27,910	124795	380	1,240
30,000 - 499,999	385	295	10	1,030	7,600	15	90
10,000 - 29,999	1,485	135	30	3,945	5,115	290	50
5,000 - 9,999	690	50	50	3,555	3,750	175	20
Under 5,000	1,620	335	160	8,000	6,885	315	40
Total Urban	12,185	1,490	450	44,440	148,145	1,175	1,440
Rural							
Non-Farm	4,610	1,485	6,590	28,000	4,810	1,195	140
Farm	2,530	3,125	4,170	20,470	435	975	65
Total Rural	7,140	4,610	10,765	48,470	5,245	2,170	205
Grand Total	19,325	6,100	11,215	92,910	153,390	3,345	1,645

*Source: 1971 Census of Canada

FIGURE B - d*

MANITOBA'S HYDRO-ELECTRIC SYSTEM



*Source: The Manitoba Hydro-Electric Board 26Th Annual Report For The Year Ended March 31, 1977.

B. 4 Background Information to Electrical Residential Space Heating

The information contained in Table B - f was calculated by the Manitoba Energy Council. The table contains the total amount of electrical energy used in each year for the purposes of space heating in single residences, bulk metered apartments and non bulk metered apartments. The number of non bulk metered apartments were assumed to be 15% of the number of bulk metered apartments. Single residences were assigned consumption values of 25, 000 KWh per year while both the bulk metered and the non bulk metered apartments were assigned consumption values of 12, 400 KWh per year for space heating purposes.

TABLE B - f

Electricity Used For Residential Space Heating Purposes (billions of BTU)

Year	Billions of BTU	Year	Billions of BTU	Year	Billions of BTU
1963	17	1968	519	1973	1337
1964	31	1969	590	1974	1930
1965	114	1970	794	1975	2215
1966	185	1971	1141	1976	2694
1967	398	1972	1250		

APPENDIX C

C. 1 Assumptions Used in the Derivation of Table 10, Section 4. 2

House Characteristics	-1000 square foot bungalow -single family dwelling -full heated basement
Thermal Resistance Values	-ceilings R13. 5 -walls R13. 5 -basement R8. 4 (to one foot below ground level)
Location	-Winnipeg area (10, 800 degree days)
Design Temperature Difference	-100°F.
Not Included	-Ancillary costs such as storage tank rentals are not included in the estimates.

The actual fuel consumption figures for natural gas, oil and electricity were calculated by Manitoba Hydro. However, they only used 10,000 degree days F. The author upgraded the fuel consumption figures so that they were based on 10, 800 degree days F. (which C. M. H. C. uses for the Winnipeg area).

Consumption figures for propane were not calculated by Manitoba Hydro. In order to obtain them, the author used the same system as Mr. Ralph F. Smith,[1] (ie. 9 gallons of propane equals the heating value of 9 gallons of oil).

The heating value used for each type of fuel by Manitoba Hydro were:

Electricity -	1 KWh	= 3413 BTU
Oil -	1 gal.	= 167, 000 BTU
Gas -	1 mcf	= 1, 000, 000 BTU

The Marketing Division of Manitoba Hydro calculations used the following NEMA formula for calculating the annual heating costs:

$$\text{Annual Heating Costs} = \frac{\text{Heat Load x Degree Days x C x Rate}}{\text{Design Temperature Difference}}$$

The heat load is a function of the efficiency of fuel use at the burner, heat loss up the chimney (where applicable), the area of the residence, the resistance value of the walls, windows and ceilings, and the number of air changes per hour.

C is an experience factor related to the number of hours per day that heat is required and which is dependent upon the outside temperature, the wind strength, passive solar gain and ambient heat gain. Manitoba Hydro used a C value of 16 for these calculations (18 is used by C.M.H.C., Saskatchewan Power Corporation, and Fibre-Glass Canada).

The fuel prices used were fixed after talking to Manitoba Hydro (electricity), Greater Winnipeg Gas (natural gas), Metro Propane (propane), and Winnipeg Supply (heating oil).

There is a considerable difference of opinion about the average efficiency of energy utilization in the residence where heat loss up the chimney is a factor to be included in the heat loss calculations. Some articles argue that heat utilization is as low as 40% for gas systems while oil furnaces are 5 - 10% lower than that.[2] Other

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[1] Ralph F. Smith, Residential Space Heating Policy Alternatives in Saskatchewan, (April, 1977), p. 145.

[2] See R.L. Dunning, "Fossil-fuel furnace losses detailed", Electrical World, (November 15, 1974), pp. 116 - 118.

articles assume that overall heating efficiencies for both oil and gas are as high as 75%.[3] The 40% to 70% range is included in Table 10 because this is where the estimates are usually pegged. In heat loss calculations, used further on in this report, a 60% efficiency of utilization is assumed for all fossil fuel heating systems. In this case, it is assumed that the heating units are the more efficient, newer types, and that they are properly maintained and not oversized for the residence described in the example.

C. 2 Adaptation of the HUDAC Heat Loss Figures to the Winnipeg Area, (See Section 4. 6)

Table C - a contains a comparison of thermal resistances, air change rates and hourly heat losses of a bungalow with 1, 080 square feet of gross livable area under two types of insulation levels and air change rates. The first type possesses insulation levels which were typical until 1975, while the second type is that which was recommended by HUDAC.

Using these figures, the probable annual fuel consumption can be calculated according to the following ASHRAE formula:*

F = U x HL x D x Cf

F = annual fuel consumption

U = quantity of fuel used per degree day

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[3] Dr. Stephenson of the National Research Council uses a 75% efficiency rate for both oil and gas heating systems in his calculations.

* Neither the ASHRAE or the NEMA formula make any provision for heat loss through the wind chill factor.

HL = heat loss at the design temperature per hour

D = annual degree days

Cf = tempertaure correction factor.[4]

If the residences were located in the Winnipeg area, the following results occur in the case of oil and natural gas:

Typical Costs Using pre-1975 R Values

Natural Gas	Oil
U = .00572 therms (at 60% efficiency)	U = .00405 (gallons at 60% efficiency)
HL= 42.624 thousand BTU/hour	HL= 42.624 thousand BTU/hour
D = 10,800	D= 10,800
Cf = .768	Cf = .768
F = 2022.3 therms (202.2 MCf)	F = 1431.8 gallons
Cost @$2.40/MCf = $485.28	Cost @$.55/gal. = $787.99

ASHRAE does not give factors for the calculation of annual propane consumption. However, if it is assumed that on a BTU equivalency basis, 1 gallon of heating oil is equal to 1.42 gallons of propane, then the annual consumption of propane in a typical residence insulated with pre-1975 R value is 1431.8 gal. x 1.42 = 2033.16 gallons. The annual cost at $.46/gallon is $935.27.

In order to find the annual consumption of electricity, the NEMA formula is used:

$$F(KWh) = \frac{HL \times D \times C}{TD}$$

[4] See ASHRAE, 1976 Systems Handbook.

TABLE C - a*

COMPARATIVE THERMAL RESISTANCE, AIR CHANGE, AND HEAT LOSS FOR 1,080 SQUARE FOOT (GROSS LIVABLE AREA) RESIDENCE

	Typical Until 1975	HUDAC Recommended Levels
R value, ceiling	R10	R31.25
R value, Exterior walls	R10	R16.13
R value, Basement walls Above grade	R2.23	R10.20
Air changes/hour	.5/hour	.25/hour
Total heat loss	592 BTU/^{o}F. /hour	295 BTU/^{o}F. /hour
Heat loss at 72^{o}F. Temperature Difference (TD)	42,624 BTUh or 12.49 KWh	21,240 BTUh or 6.22 KWh

*Source: HUDAC, A Builder's Guide to Energy Conservation, (Toronto, 1976).

Electricity

HL = 12.49 KWh

D = 10,800

C = 18

TD = 100^{o}F.

F(KWh) = 24280.6 KWh

Cost @ \$.023/KWh = \$607.02

Annual fuel consumption levels and heating bills can then be calculated for the residence constructed according to HUDAC recommendations merely by substituting the lower heat loss value (21,240 BTUh) given in Table C- a in the equation used here. The final results then appear in Table 13 of Section 4.6.

C.3 Formula For Obtaining Optimal Insulation Levels (Section 4.7)

A paper dated January, 1976, by Dr. D.G. Stephenson of the National Research Council[5] gives a formula for determining optimal levels of thermal resistance:

$$R_{opt} = \sqrt{\frac{C \times Pf \times D \times Pw}{B \times E}}$$

where: C = constant used in degree day calculations

Pf = price of fuel

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5 D.G. Stephenson, Division of Building Research, National Research Council, Determining the Optimum Thermal Resistance for Walls and Roofs, (Ottawa, N.R.C. 1976).

D = degree days

E = efficiency of heating system

Pw = present worth factor (defined below)

B = cost of insulation per unit of resistance.

The present worth factor relates the rate of interest on money invested now (determined by the opportunity cost) in improving insulation to the increase in the price of fuel over a payback period. Dr. Stephenson uses an interest rate of 10%, an annual increase in the price of heating fuel (electricity) of 12%, and a payback period of thirty years. Under these circumstances, Pw = 40.1.[6] Although Pw varies slightly for all fuels because expected price increases are not the same, 40 is used throughout in order to be conservative.

Table C - b shows the application of the formula using prices (January 1, 1978) and degree days which are an appropriate number for the Winnipeg area.

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[6] By use of the formula, $P = \frac{1 - (1 + y)^n}{y}$ where y is the effective interest rate equal to i - x / i + x, where i is the nominal interest rate (10%) and x = the annual increase in the price of fuel.

TABLE C - b

OPTIMUM THERMAL RESISTANCE LEVELS IN THE WINNIPEG AREA

	Natural Gas	Oil	Propane	Electricity
C	18	18	18	18
Pf (C/BTU) (From Table 10)	.00024	.0003293	.000414	.000673
D	10,800	10,800	10,800	10,800
Pw	40	40	40	40
B (¢)	1.3	1.3	1.3	1.3
E	.60	.60	.60	1.00
R_{opt}	48.92	57.35	64.25	63.45

The optimum thermal resistance levels are placed in Table 14, Section 4.7.