RESIDENTIAL SPACE HEATING POLICY ALTERNATIVES IN SASKATCHEWAN

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RESIDENTIAL SPACE HEATING POLICY
ALTERNATIVES IN SASKATCHEWAN

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INTRODUCTORY NOTE

The following report is intended to serve two purposes:

(a) to be of practical value to the Government of Saskatchewan 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 will be that of the author alone and will not necessarily reflect the views of the Government of Saskatchewan or any of its agencies.

ABSTRACT

The practicum analyzes the 1976 residential space heating market in Saskatchewan, projects economic and social consequences of retaining the current provincial government policies which influence heating fuel allocation and conservation in Saskatchewan, and discusses a number of feasible alternative policies.

It is pointed out that significant fuel choice and conservation decisions will have to be made in the near future by both the individual consumer of heating fuel and by governments at all levels due, in most part, to expected real price increases and potential short-term discontinuities in supply of all conventional energy sources.

Saskatchewan's relatively cold climate and widely-distributed rural population emphasize the importance of efficient and equitable allocation, as well as conservative use, of heating fuels. Furthermore, consideration should be given to saving some fuels like petroleum products for a future use such as in agriculture (which is of central importance to the provincial economy).

There are, however, considerable problems to be faced in policy formulation in this area. In planning for an efficient and equitable allocation of heating fuel in Saskatchewan, the problem of rapidly increasing costs of incremental generation, transmission and distribution, as well as upgrading current energy delivery systems, must be kept in mind. In addition, the conservation component of a residential heating policy must cope with the fact that a high proportion of Saskatchewan residences are single detached (and therefore less energy efficient), the fact that both existing and incremental residences have much less than optimum insulation levels, and the fact that the housing market does not attach economically justified values to heating efficiency of houses for sale.

To cope with some of the above complexities, the practicum breaks residential space heating policy into two major components: heating fuel allocation and heating fuel conservation. Typical heating expenditures of the home owner and methods available for cutting operating costs are analyzed. This is followed by a discussion of overall residential heating fuel opportunity costs, as well as fuel use efficiency of the existing housing stock and incremental housing. A projection of future market shares of various heating fuels and fuel conservation given present policies is finally used as a base for discussion of feasible alternative policies which could be adopted by the Government of Saskatchewan.

Policy alternatives are assessed both in terms of their economic efficiency and their effect upon income of consumers in various parts of the residential heating fuel market. Environmental and technical feasibility are also discussed where consideration of such matters will be an important part of making a decision on a particular policy alternative. The author admits that his efforts represent only a portion of the required policy analysis in this complex area; clearly, more detailed analysis of feasible alternatives is necessary before a decision can be made.

ACKNOWLEDGEMENTS

Many persons, too numerous to thank individually here, gave me valuable advice and supplied useful statistics in the course of preparing this practicum. I wish particularly to thank the members of my practicum committee: Mr. Peter Black, Energy Secretariat, Saskatchewan Department of Mineral Resources; Dr. Robert Fenton, InterGroup Consulting Economists Ltd. (Winnipeg); Mr. Thomas Henley, the Natural Resource Institute; Mr. Roy Lloyd, Planning and Research, Executive Council, Government of Saskatchewan; and Mr. Frank Showell, Saskatchewan Power Corporation.

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CHAPTER I

INTRODUCTION TO THE PROBLEM OF RESIDENTIAL HEATING IN SASKATCHEWAN

1.1 Why Residential Heating Policy is A Concern in Saskatchewan

The heating of a residence is an essential service in a climate such as that of Saskatchewan. Essential services, whether they be related to the provision of food, shelter or health care, are matters which are occasionally taken for granted in the public mind; this was the situation of residential heating until at least 1975 and, for most parts of Canada at the present time, continues to be the situation. Unfortunately, homeowners have not been sufficiently concerned about the types of heating systems which have been installed and the energy conservation features of their residences. Low capital cost has been a much more marketable feature than has future savings in energy bills; decisions are often left to the house builder to select heating fuels and systems. Governments have also been slow to act in the area of residential heating, and it is still possible in many parts of Canada to build a home without any insulation whatsoever.

Nevertheless, there are signs that changes will occur in the future. Heating fuels are part of the energy supplies which have been brought to prominence in public discussions, as part of the so-called "energy crisis".

Beginning with the OPEC embargo resulting from the Middle East War of 1973, there has been much concern voiced over the continued supply of energy fuels and the ability of consumers to afford future fuel price increases. However, as across-the-board prices of fuel continue to rise, the benefits of a successful energy conservation program also increase - this accounts for the general interest in conservation shown by federal and provincial governments over the past few years.

In addition to general price increases affecting all fuels, there has also been a change in the relative market prices of fuels, particularly in the case of petroleum products compared to other fuels. Further changes in relative prices and in consumer demand for the various fuels can also be expected in the future. Consequently, another important role of government is to ensure that there is a satisfactory allocation of energy fuels in the market ("allocation" as it is used here means roughly the total market share of a fuel consumed in end uses). Governments should logically concern themselves with the environmental and social disruptions which might result from the way in which fuels are allocated, while at the same time they should seek the optimum where fuels are allocated to their most economically productive purposes.

Although Saskatchewan is fortunate in having significant reserves of energy fuels including oil, gas, hydro, uranium, and coal, important decisions are required to ensure that residential heating does not become a serious social and economic problem in the future. Some of the reasons that the author feels that there should be consideration in the near future of a residential heating policy (which will be elaborated in more detail in later chapters) are:

(a) low-cost energy reserves are diminishing and the incremental costs of providing new units of energy (by domestic production or by importing) are greatly in excess of the average costs of providing units from older established reserves;

(b) there should be some consideration of reserving fuels for future allocation to uses where their premium qualities (values not recognized by current pricing) are used most productively (i.e., reserving petroleum products for agriculture, transportation, and some industrial uses);

(c) since Saskatchewan wishes to pursue a program of rural revitalization, the province must consider the consequences of possible future increases in space heating costs in rural, northern, and small urban locations, especially in the case of residents who have lower than average incomes;

(d) at the present time, sufficient measures do not appear to be taken to conserve on heating fuels even though these measures are economically justified;

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

(f) Saskatchewan's relatively dispersed rural population requires elaborate and expensive energy delivery systems.

1.2 Objective, Scope and Methodology of This Report

The major objective of this report is to analyze some of the numerous factors which can enter into government decision-making in the area of residential heating and to isolate feasible policy alternatives. The focal points of the discussion will be two concepts - allocation and conservation - the crucial policy issues at the present time (concepts which will be defined in detail later on in this chapter and which, in fact, are interrelated). Following an analysis of 1976 market allocation of heating fuels and potential for conservation, the author considers likely market allocation and fuel consumption levels in the short-term future, assuming that no significant policy change occurs in this area. The stage is then set for a discussion of allocation and conservation policies which are feasible alternatives and which result in different economic and social consequences.

Throughout the report an attempt is made to analyze hitherto unassembled data and opinions which are available in literature, and within government offices and universities, in order to outline a number of options which are open to the government in residential heating.

Residential space heating will be the only topic considered in any detail. Although fuels used for water heating, cooling, and air conditioning in the residence are, in some cases, the same as those used for space heating, time constraints did not permit an in-depth discussion of these topics. However, many of the general principles of allocation (and, to a more limited extent, conservation) discussed in this report will also be applicable to these other end uses of energy in the residence.

The principles discussed here will also have some applicability to the commercial and industrial sectors. Nevertheless, a note of caution must be sounded when applying these principles since heat loads have greater variation in industrial and commercial buildings than in residential units. The solutions which are appropriate for meeting future requirements in such cases might also be considerably different - for example, it may be much more economically advantageous to use heat pumps in buildings with very heterogeneous heat loads than it is in residences where heat loads are more evenly distributed.

Most types of residential heating fuels and systems now in operation will be discussed in the report. A number of heating methods which are not in common use at present, but which show potential for making an impact on the residential heating market up to 1990, will also be discussed.

The report is intended to be an interdisciplinary effort. Policies which are suggested are implicitly subject to economic, social, environmental, technical, administrative, and political feasibility criteria.

1.3 Definitions of "Allocation" and "Energy Conservation"

Although a glossary is appended to this report, two concepts are of such importance to the matter discussed here that their definitions must appear at this early stage of the work. When concepts become the subject of widespread controversy, the key terms in such cases show evidence of having multiple and confusing varieties of definitions when these terms are used. Such is the case with "allocation" and "energy conservation", and it is necessary to forestall as much misunderstanding as possible by providing operational definitions.

"Allocation" is commonly used in two important senses - short-term and long-term allocation. Short-term allocation basically means administrative rationing of a fuel in the event of an emergency shortage of a limited time duration. A policy for dealing with emergency shortages might include such matters as the establishment of an allocation board, identification of users where disruption of fuel supply means the discontinuation of essential public services, consideration of fuel storage capability, and provision for fuel substitution in the case of large users. Fuel pricing, subsidies, and taxation are not normally the strategies which are included in a short-term allocation policy. This report will not be concerned with the topic of short-term allocation.

When the term "allocation" is used in this report, the meaning which is intended is long-term allocation. In this paper "allocation" will mean the proportionate consumption and geographical distribution of heating fuels consumed in Saskatchewan residences. Fuel allocation is, however, the result of a process - the process of allocating fuels can either rely on a long-term equilibrium achieved in a marketplace ("market share" or "market allocation") or else it can be determined by direct or indirect government allocation ("policy allocation" or "regulatory allocation"). Policy tools such as prices, taxes, subsidies, laws, or direct methods of distribution might be used by a government to influence the shares of various heating fuels which go to particular residential customers.

Some of the questions which need to be raised in the formulation of a residential heating fuel allocation policy are:

(a) What opportunity costs, security of supply characteristics, BTU efficiencies, provincial economic impacts, environmental impacts, and administrative feasibilities are there if a particular fuel is to maintain a major share of the residential heating market over a long-term period?

(b) Should residential heating fuel allocation involve separate consideration for different parts of the residential heating fuel market (i.e., new versus existing residences, urban versus rural residences, residences close to pipelines or major highways versus more distant residences)?

(c) What is the impact on annual income of space heating costs on lower-than-average income consumers, given a particular heating fuel?

"Energy conservation" is subject to a large number of definitions. The following is a range of possibilities for conserving residential heating fuels although only (d) to (g) are directly relevant to this report:

(a) decreasing the amount of energy inputs consumed in getting energy resources used for space heating out of the ground;

(b) improving the output-input efficiency of converting energy during refining or generating;

(c) improving the efficiency of transmission and distribution;

(d) improving the efficiency of the burner (in the conversion to usable residence heat energy);

(e) improving the system efficiency of the residence (by insulating, weatherstripping, architectural design features, orientation, etc.);

(f) ceasing to use heat in the home where it is not required (i.e., the decision not to heat certain rooms); and

(g) lessening the overall amount of heat energy which is required (i.e., by lowering the thermostat several degrees).[1]

It should be noted that one of the measures which is sometimes (perhaps mistakenly) referred to as energy conservation is missing from this list - the substitution of abundant or renewable forms of energy for scarce fossil fuels. The assumption that is taken by the author 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.[2]

There is an important relationship between the concepts of fuel allocation and energy conservation as they are defined here. There are several reasons why a decision to allocate an energy fuel should not be made simply on the basis of established and potential reserves of the energy source and the requirements for energy in

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[1] The idea of using functional definitions such as these for energy conservation occurred to the author after reading a memo on resource utilization efficiency written by Dennis Rogoza of the Energy Secretariat, Department of Mineral Resources, Government of Saskatchewan.

[2] This is similar to the view of the National Energy Board who argue that "decreases in the demand for petroleum products due to the substitution of other forms of energy could not be classified as conservation". National Energy Board, Canadian Oil: Supply and Requirements (Ottawa, September, 1975), p. 35.

various sectors. One reason is that there is often a greater marginal economic value resulting from the use of a fuel in one market rather than another. For example, a greater dollar value of production may be the result from the allocation of a gallon of oil away from space heating applications to use in agricultural production in Saskatchewan. The second reason why fuel allocation should not depend simply upon quantities of reserves is that different fuels have different efficiencies which are technically attainable at each stage of the delivery process from primary production to the provision of heat energy in the residence. For example, it may require 4 BTU's of coal to provide 1 BTU of usable heat energy through electric resistance heaters in the residence. On the other hand, less than 2 BTU's of natural gas may be required to provide 1 BTU of usable residence heat.[3] The decision to conserve energy (improve efficiencies as in (a) to (g) above) means that fewer reserves are required to supply the same amount of delivered heat.

Efficiency improvement in the residence can be induced by a number of measures such as a building code or by legislation. A significant conservation incentive is also provided by pricing because there is a level of

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[3] The author will discuss this topic further in succeeding chapters when the various heating fuels are considered in much more detail.

investment in insulation and in other measures to conserve residence energy which is optimal with a given future path of fuel pricing. The optimal investment in conservation for the consumer is equal to the cumulative present worth of future savings on utility bills attributable to this investment at an appropriate rate of interest.

In conclusion, conservation and allocation are integral parts of a residential heating policy. Allocation is not only dependent upon market requirements and the availability of supply, but it is also dependent upon the efficiencies which can be achieved between the resource in its raw state and when it is used as a final product.[4] Pricing is also an important aspect of a residential heating policy since it relates to the demand for reserves, investment capability in reserve additions and new sources of energy, and also to the optimal level of investment in conservation.

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[4] This is not to discount the fact that there are environmental and social consequences of alternative allocation policies as well.

CHAPTER II

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

2.1 Consumer Decisions About Heating

Fuel choices differ in the case where the consumer is in the process of having a new house constructed as compared to when he is already the owner of an existing house. From a technological perspective or from an overall society viewpoint, fuel choices are greater when a house is being planned than when it is already constructed. Nevertheless, it was often the situation until the last few years that a person had been able to exercise only a very limited range of choice since, in the majority of such cases, decisions had already been made by the builder or developer. By 1976, however, it appeared that communication links between the house owner and the builder had been strengthened and that consumers were able to exercise a greater influence on fuel installation decisions in new residences. In addition to fuel choice, there are also decisions which have to be made about the type of heating system to be installed (i.e., forced air, radiant, hydronic). Again, providing the builder has not already made the decision, there are also options concerning the amount of insulation, weatherstripping and ventilation to be installed. Different architectural features, such as the orientation of the residence and the amount and location of window space, will also affect the amount of energy required for heating. All of the above decisions will have an impact on the costs of heating the residence.

The owner of an existing house also has quite a large number of options available to reduce his space heating costs. Where these costs are very high, he might decide to retrofit his house with a different heating fuel when alternative fuels exist which have considerable cost advantages. This decision to use a different fuel must normally be based upon the expectation that the cumulative present value of future fuel cost savings at an appropriate rate of interest exceeds the incremental costs of installation of new equipment.[1] A similar economic relationship applies to the decision to change the heating system in the residence even though the same heating fuel is used

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[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 10 years old and had an expected depreciation period of 16 years, the cost of investing in a different system now rather than in 6 years time would have to be compared to operating cost savings over the 6 years (all in present value terms).

(for example, in changing from baseboard heaters to a heat pump). The owner of an existing residence can also choose to retrofit the insulation levels or to cut down on heat loss through infiltration. There is, however, a significant added cost of several hundreds of dollars associated with retrofitting, particularly when it comes to blowing insulation in walls. Finally, the existing homeowner can cut his fuel bills by turning down his thermostat to a lower setting within the range of comfort, by properly maintaining heating equipment, and by not heating areas where heat is not required.

Up to this point the author has been describing some of the economic cost considerations which can influence the consumer's decision-making about his residence. In practice, economic cost analysis cannot in itself explain the actual behaviour of Saskatchewan consumers in regard to heating fuel choices and conservation measures in the residence. As in many other circumstances where economic theory is examined from an empirical perspective, there appears to be imperfections in the market which qualify the use of the theory as an ultimate explanation. Some of the reasons why consumers have not based their decisions about the type of fuel to be used and the amount of investment in conservation on lowest economic cost (determined by initial costs plus discounted future operating costs) are:

(a) many residences are built according to the minimum standards set out in a Building Code (where applicable) or according to the minimum standards for receiving a mortgage and these standards are not based on lowest economic cost considerations;

(b) various heating fuels or systems are preferred because of comfort, cleanliness or ease of operation rather than lowest cost;

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

(d) fuel choice is limited in some areas of the province (most notably where the community is not part of the gas system);

(e) in many cases consumers leave the decision about heating fuel or heating systems to the builder of the house;

(f) long-term heating bill savings are not seen as sufficient compensation for the present investment in a more expensive heating system or conservation measures, particularly when basic housing prices are so large as at present (i.e., people discount irrationally sometimes).

One would expect that the cost of fuel relative to the size of the consumer's total budget would play a significant role in influencing the type of investment he makes in regard to heating. As long as the price of fuel remains low relative to other prices, a heating decision, such as that to invest in more insulation, declines in importance when compared to other economic decisions. From 1964 to 1974 in Saskatchewan, the price of a kWh of electricity in 1961 prices declined while the consumer price index was increasing in Saskatchewan. The price of an MCF of natural gas remained relatively constant in 1961 dollars over the same period of time.[2] In 1974, S.P.C. undertook a survey of new installations where either oil, electricity or propane was selected as the energy source.[3] One of the results was that only one out of two individuals checked into the possibility of installing an alternate heating system before actual installation. In spite of the fact that propane appeared to be the highest priced fuel in the target group studied in the 1974 survey, 910 (61%) out of 1,315 new installations were propane (natural gas was not included in the survey and, in fact, was likely not an available option for these

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[2] Saskatchewan Power Corporation, Annual Report for 1975.

[3] G. J. Seel, Business Division of the Electric System, S.P.C., Heating Survey: 1974 Heating Installations in Saskatchewan (Regina, November, 1975).

consumers). During the most recent year (1974) where data on heating decisions are available, therefore, the evidence appears to point to the fact that the economics of heating (lowest cost) was not necessarily the major factor in selecting the type of heating fuel in new residences where natural gas was not available. Since 1974, energy prices have risen and the picture may now be somewhat different.

2.2 Comparative Costs of Heating a Residence Using Different Fuels

At this point it is useful to examine some illustrative space heating costs in Saskatchewan where different fuels were used in residences with the same characteristics. The example chosen involves average size new residences (1,200 square feet) located in the Regina rural (non-farm) area.[4] Results are shown in Table 1. It should be noted at the outset that prices and consumption levels appearing in Table 1 are averages which may not be applicable to individual circumstances. Electricity is priced at the run-off rate since it is assumed that the lower stages of the declining block tariff would be used up by appliances other than the

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[4] A rural location was chosen because recent statistical price surveys of heating fuels by S.P.C. were available only for these areas.

electric furnace or baseboard heaters.[5] Additional assumptions used in the derivation of Table 1 may be found in Appendix B.

Table 1 shows that, in the Regina rural area, propane is the highest cost heating fuel while natural gas is, by a considerable margin, the lowest cost heating fuel. Oil and electricity heating costs have been merging in recent months, although any comparisons must bear in mind the efficiency of utilization of heat energy within the residence (efficiency of utilization = efficiency of heating unit - heat loss up the chimney). If, for example, September 1, 1976, fuel prices are used and a 100% end-use efficiency of electric heat (baseboard heaters) is compared to an oil heating system operating at a 50% efficiency of utilization, electric heating costs are slightly lower than oil heating costs. On the other hand, if a new, more efficient, oil furnace is assumed and the resulting overall efficiency of utilization

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[5] Several persons have expressed to the author their disagreement with this way of calculating electricity prices insofar as heating is concerned. The argument is that average costs rather than run-off rates should be used, since only in this way can one get an idea of the portion of the total electricity bill for which electric heating is responsible. Under these circumstances, electricity prices would be roughly 2¢/kWh in March, 1976, and 2.2¢/kWh in September, 1976. The author disagrees with this point of view since he believes that a consumer's decision to choose electric heating will be based on marginal costs (i.e., involves the addition of further kWh's to his current level of kWh consumption and which, therefore, should be priced at the run-off level).

within the residence is 60% or 70%, the annual oil heating bill is lower than that for electricity at present day fuel prices. However, since it is expected that the prices of petroleum products will increase at a faster rate than electricity prices in the future, oil heating will soon become more expensive than electric heating for a consumer in the Regina rural area.

TABLE 1

ANNUAL FUEL COST OF HEATING A 1,200 SQUARE FOOT HOUSE IN THE REGINA RURAL AREA (1)

Fuel Type	Price of Natural Units in $	Price/mm BTU's in $	Annual Heating Cost at 100% Efficiency (2)	Annual Heating Cost at 70% Efficiency	Annual Heating Cost at 60% Efficiency	Annual Heating Cost at 50% Efficiency	Annual Heating Cost at 40% Efficiency
I. AT AVERAGE PRICES GIVEN IN S.P.C. SURVEY, MARCH 18, 1976							
Natural Gas	1.40/MCF	$1.4	$---	$199	$232	$279	$349
Oil	.40/gal	2.4	---	341	398	478	598
Propane	.3975/gal	3.6	---	515	601	721	901
Electricity	.016/kWh	4.7	468	---	---	---	---
II. AT ESTIMATED PRICES, SEPTEMBER 1, 1976							
Natural Gas	1.66/MCF	$1.66	$---	$236	$276	$331	$436
Oil	.45/gal	2.7	---	384	448	538	672
Propane	.41/gal	3.7	---	531	620	744	930
Electricity	.018/kWh	5.3	526	---	---	---	---

(1) Based on S.P.C. statistics. In Part II, it is assumed that annual consumption will remain constant even though fuel prices are higher.

(2) See Appendix B for a comment on efficiency of heat energy utilization in the residence.

2.3 Effect of Geographical Location on Fuel Prices

While the cost of heating a 1,200 square foot residence in rural Regina 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:

(a) lack of an option to choose the lowest cost fuel (at present - natural gas);

(b) greater degree days;

(c) residences may not have as high a standard of insulation (in rural areas where residences tend to be older).

Using the S.P.C. price survey of March 18, 1976, the following annual cost differentials can be observed in Table 2 for oil and propane. The most extreme northern localities where fuel prices and heating costs are the highest in the province are not included in this table.

TABLE 2

ANNUAL SPACE HEATING FUEL COSTS OF A 1,200 SQUARE FOOT RESIDENCE IN VARIOUS RURAL LOCATIONS IN SASKATCHEWAN, MARCH, 1976 (1)

	OIL (60% Efficiency)	PROPANE (60% Efficiency)
LOWEST PRICE:		
- Oil - 40¢/gallon - Propane - 35¢/gallon	$398	$563
MEAN PRICE:		
- Oil - 42.8¢/gallon - Propane - 40.7¢/gallon	$446	$628
HIGHEST PRICE:		
- Oil - 45.9¢/gallon - Propane - 44.1¢/gallon	$550	$740
% Differential in Annual Cost (Lowest to Highest)	38.2%	31%

(1) Source: Saskatchewan Power Corporation.

2.4 Comparative Energy Use Within the Residence

In Canada, it has been estimated that approximately 70% of the total energy used in the residence is for the purpose of space heating.[6] In Saskatchewan, space heating may very well account for 75% to 80% of residence energy consumption since there are greater degree days and because appliance saturation is not quite as high in Saskatchewan

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

as in provinces such as Ontario and British Columbia. To put the energy consumption of the heating system into perspective, Table 3 has been provided. This table compares energy consumption by an electric heating system for one year for the 1,200 square foot residence used as an example previously (in 2.2) with the average annual electricity consumption of various appliances in the residence. Since electricity is assumed to be 100% efficient at point of use, 29,250 kWh annual consumption can be considered the lowest amount of energy (in BTU's) that would be consumed for space heating in this type of residence during an average year.

TABLE 3

ANNUAL AVERAGE kWh CONSUMPTION OF HEATING SYSTEM AND OTHER APPLIANCES (1)

Appliance	Estimated Annual Consumption in kWh	Comparison to Space Heating Consumption
Electric Heating System	29,250	1.00
Electric Water Heater	4,000	.14
Electric Stove	1,200	.04
Freezer (14 cubic feet)	1,200	.04
Clothes Dryer	900	.03
Refrigerator (12 cubic feet)	850	.03
Air Conditioner (1,000 BTU)	500	.02
TV (color - solid state)	450	.02
Dehumidifier	400	.01

(1) 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.

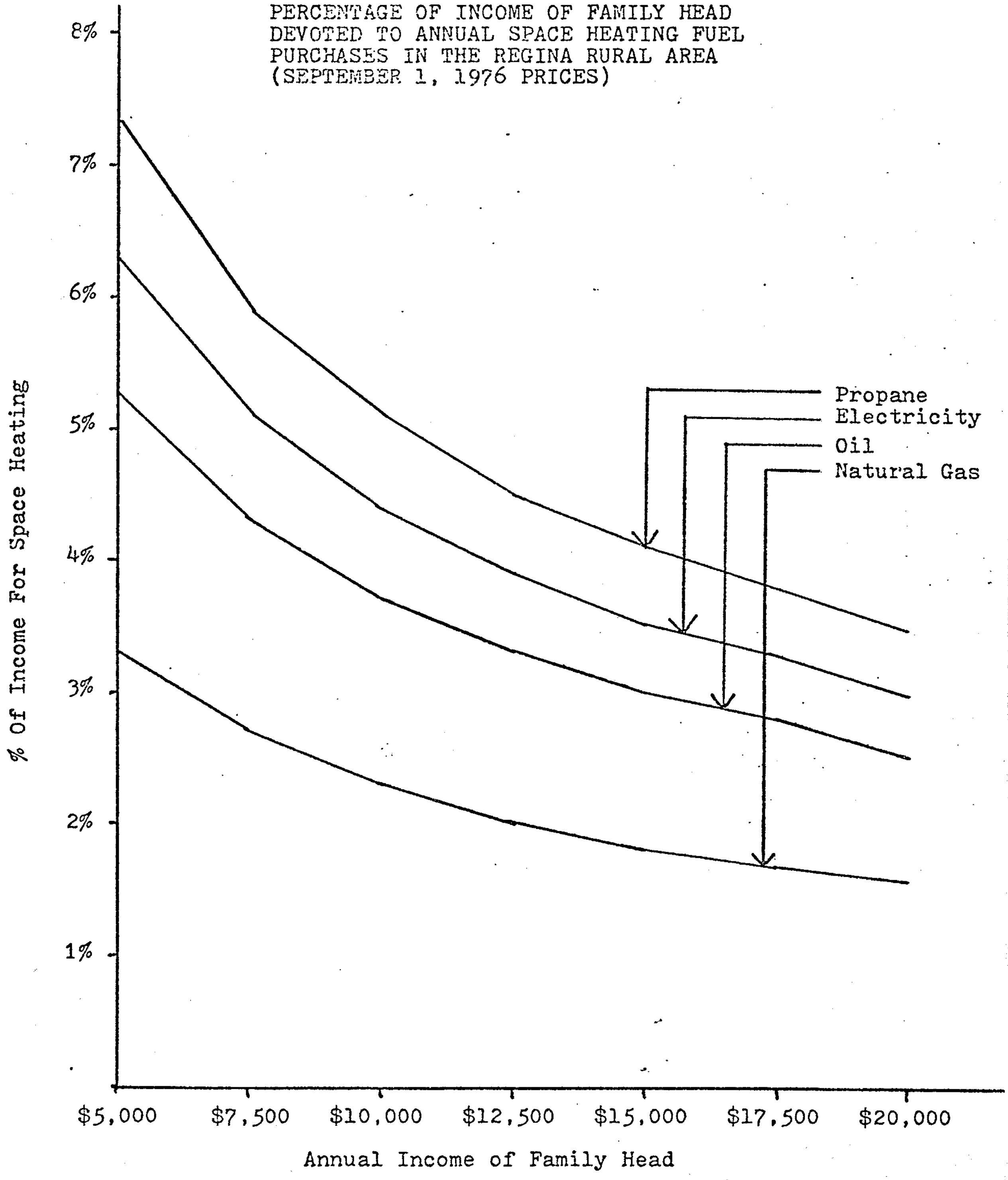
2.5 Typical Consumer Expenditures on Heating Fuels

Figure 1 illustrates the significance of consumer expenditures on the various heating fuels in relation to the annual income of the head of the family. Regina rural region fuel prices at September 1, 1976, have been used. Heating loads are typical of new single detached dwellings, although the size of the dwelling has been related to income level (for details of the calculations and a list of assumptions, see Appendix B).

Residential space heating in the cities and larger towns of Saskatchewan is predominately done by natural gas at the present time. For the most part, only 2% to 3% of income must be devoted to purchases of natural gas for space heating per year. For the lower income consumers in rural areas, annual expenditures on oil and propane are generally more than 4% of income and can, in fact, approach 7% of income in the case of propane. At present prices of electricity, consumers in rural areas would be required to have an income of nearly $10,000 in order to spend less than 5% of income on space heating operating costs in residences with heat loads as have been assumed here.

FIGURE 1

PERCENTAGE OF INCOME OF FAMILY HEAD DEVOTED TO ANNUAL SPACE HEATING FUEL PURCHASES IN THE REGINA RURAL AREA (SEPTEMBER 1, 1976 PRICES)



2.6 Future Space Heating Costs: 2 Price Scenarios for Natural Gas

Expenditures on fuel are only part of the costs of space heating. Included in total space heating costs are the annual fuel costs, the amortized capital cost of the heating system, as well as that part of the electrical bill associated with ventilation (including the furnace fan).

Illustrative total heating costs for new residences at various owner income levels are calculated in Appendix B. The most common and lowest cost fuel, natural gas, is used in this example. If it is assumed that the price of natural gas will increase at a greater rate than the average inflation rate and real increases in income, then larger proportions of the consumer's income will go towards space heating as the years go by.[7] Figures 2 and 3 show the increase in the percentage of the family head income (in 1976 dollars) which will be used for the total cost of space heating in a new residence (described in Appendix B) assuming that the real price of natural gas will rise at an annual rate of either 2% or 6% per year to 1990. In this analysis it is also assumed that maintenance and ventilation costs will stay constant in 1976 dollars.[8]

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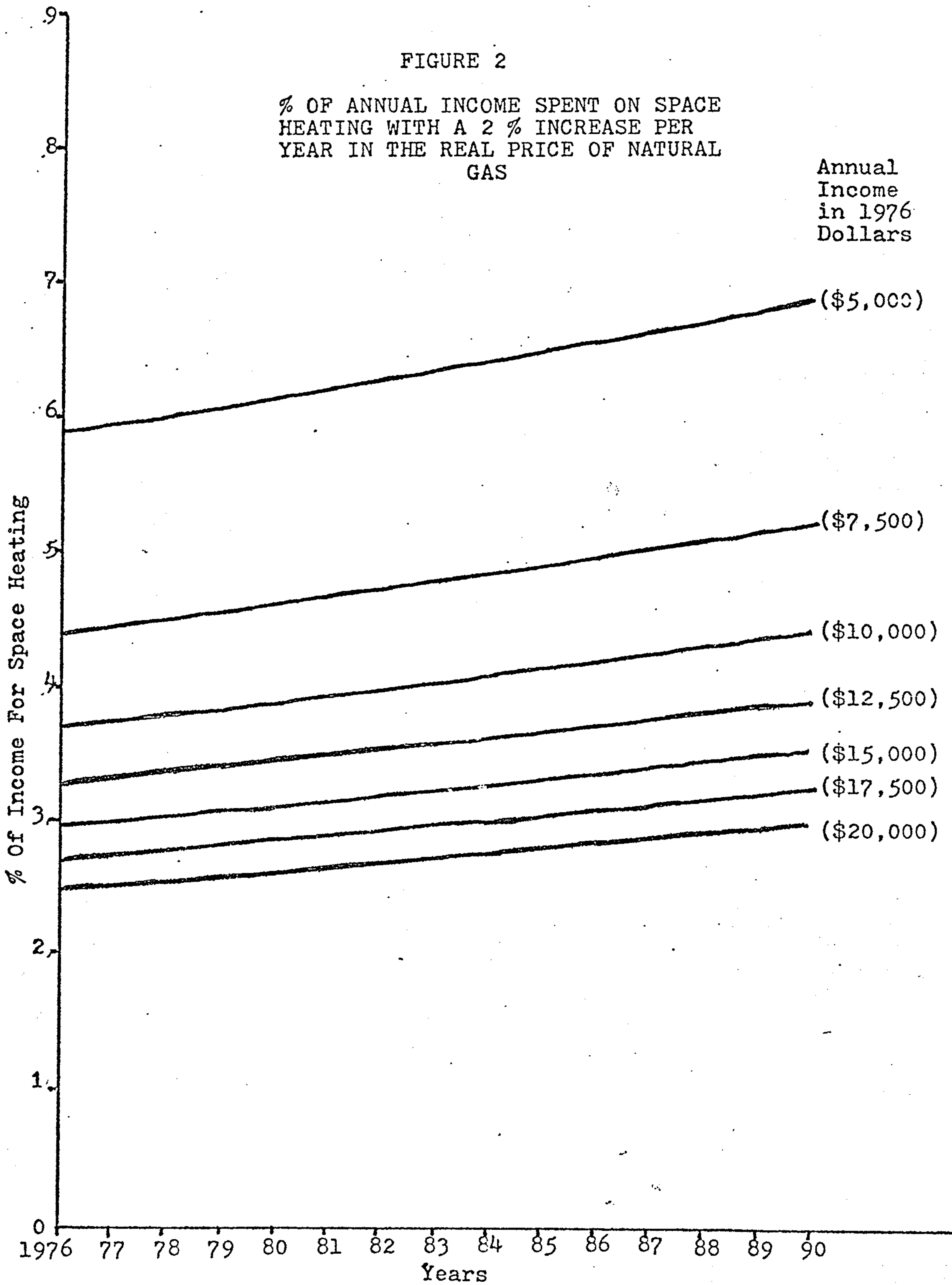
[7] Many income sensitivity studies assume a real increase in future income. However, income is kept constant in 1976 dollars here because the analysis is concerned with low or fixed income consumers who live in existing Saskatchewan residences and who will be most affected by fuel price increases in the future.

[8] Fuel price increases will be considered in more detail in Chapter 4.

FIGURE 2

% OF ANNUAL INCOME SPENT ON SPACE HEATING WITH A 2 % INCREASE PER YEAR IN THE REAL PRICE OF NATURAL GAS



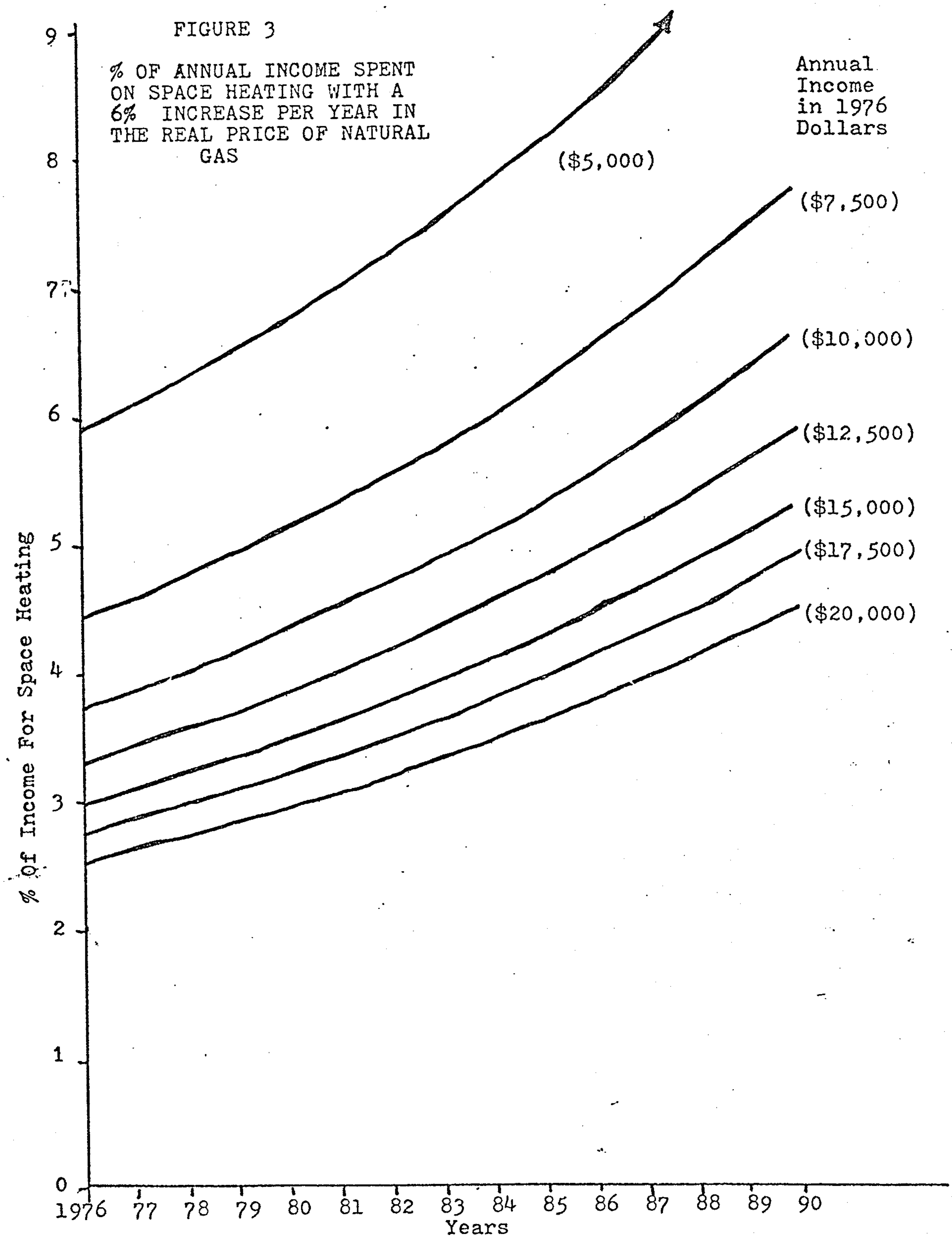


FIGURE 3
% OF ANNUAL INCOME SPENT ON SPACE HEATING WITH A 6% INCREASE PER YEAR IN THE REAL PRICE OF NATURAL GAS
Annual Income in 1976 Dollars
($5,000)
($7,500)
($10,000)
($12,500)
($15,000)
($17,500)
($20,000)
% Of Income For Space Heating
0
1
2
3
4
5
6
7
8
9
1976
77
78
79
80
81
82
83
84
85
86
87
88
89
90
Years

In the case of the lower income levels there is a point (perhaps between 3% and 5%) beyond which the consumer will find heating costs to be a very major budgetary consideration. It will then be exceedingly important for the consumer to cut costs by improving the heating efficiency of the residence or (in the more extreme circumstance) by moving to a residence where costs are lower. A consumer with a 1976 income of $10,000 would be devoting 4% of his income to space heating by the year 1982 if he were in a similar situation to the illustrative consumer described in Figure 2 where the real price of natural gas increases at a rate of 2%. If the real price of natural gas were to increase at a rate of 6% as in Figure 3, however, the $10,000 income consumer would be spending 4% of his income on space heating by 1978 and 5% before 1984. If we had not been considering the lowest cost fuel (natural gas), the consumer might contemplate retrofitting his residence with a different type of heating fuel as his costs rise, provided that the discounted value of future cost savings resulting from the use of the new fuel are expected to be greater than the current costs of installing the new heating system.

2.7 Means of Cutting Costs

Faced with future prospects of increasing space heating costs, the residence owner may decide to take some measures to conserve on fuel requirements. Here are some of the more important steps that can be taken in most residences:

(a) add insulation to the ceiling, exterior walls and basement walls to increase thermal resistance;

(b) install storm windows and doors or put in double or triple glazed windows to increase thermal resistance;

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

(d) reduce the number of air changes in the residence (approach the minimum acceptable level);

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

(f) arrange not to heat rooms during that part of the day when heat is not required.

While there is normally no economic cost associated with steps (e) and (f), steps (a) to (d) can involve investment by the homeowner which should be assessed against the benefits to be achieved. Some of these benefits and costs will be considered in more detail in the remainder of this chapter.

2.8 Benefits From Insulating

How much heating fuel can be saved in a residence by increasing the amount of insulation in the ceiling, the exterior walls and along the portion of the basement walls which is above ground level? Table 4 is an attempt to provide a "before and after" comparison based on a report by the Housing and Urban Development Association of Canada[9] (HUDAC) involving a typical single-detached 1,064 square foot living space house. The "before" house has insulation which is basically typical of residences constructed according to N.H.A. requirements before 1975. It has combined resistance values for the walls, ceilings and above grade basement walls of R10, R10 and R2.23, respectively. The "after" house has the R values that are recommended by HUDAC for walls, ceilings and above grade basement walls of R31.25, R16.13 and R10.20. In addition, the number of air changes per hour in the "after" house is cut in half (to .25/hr. from .5/hr.). The heating load analysis in the HUDAC report has been adopted to the degree day averages of the Regina rural area. Details of the calculations are to be found in Appendix B.

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

TABLE 4

FUEL CONSUMPTION AND COST FOR A 1,080 SQUARE FOOT (GROSS LIVEABLE AREA) BUNGALOW IN THE REGINA RURAL AREA

	Natural Gas	Oil	Propane	Electric
Before 1975 - Energy Consumed (Natural Units)	202.2 MCF	1431.8 gal.	2033.2 gal.	24,280.6 kWh
Annual Heating Cost with Prices of September 1, 1976 (in $ for above)	$335.70	$644.31	$833.60	$437.05
HUDAC Recommended Insulation - Energy Consumed	100.8 MCF	713.5 gal.	1013.2 gal.	12,091.7 kWh
Annual Heating Cost for Above in $	$167.33	$321.08	$415.41	$217.65
% Change in Fuel Required and in Annual Costs	-50.2%	-50.2%	-50.2%	-50.2%

Table 4 demonstrates that annual fuel savings of roughly 50% can be achieved in the typical residence which has the greater amount of insulation. Depending on the type of fuel used, the annual cost savings during 1976 would be anywhere from $170 to $420. As will be demonstrated later, fuel cost savings are large compared to the investment required to install more insulation when the house is being built or to retrofit an existing residence with additional insulation. This is particularly so when anticipated future fuel price increases are taken into consideration.

Table 4 can be compared with some of the results of a study done by the Manitoba Department of Public Works where the fuel consumption of a house with insulation levels of R10 in the ceiling and R7 in the walls was compared to the same house with insulation levels of R20 in the ceiling and R12 in the walls.[10] In this case it was found that 36% less heating fuel would be required over a year because heat loss was reduced after adding more insulation. The changes in the thermal resistances of the ceilings and walls were not as great in the houses studied by the Manitoba Department of Public Works as they were in the houses studied by HUDAC, however. In addition, the rate of air change in the Manitoba Depart-

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

ment of Public Works residence remained constant before and after insulation was added while that of the HUDAC residence was cut in half. For these reasons, fuel savings were less in the residences studied in this second example.

Under the most extreme changes in insulation, the savings in annual heating fuel costs can be as high as 70%. This can occur in a 1,200 square foot bungalow where there are 10,800 degree days and a 100° temperature difference and where initially there was no insulation but afterwards insulation levels were R36 in the ceiling, R20 in the walls and R12 in the basement.[11]

2.9 Choosing the Correct Amount of Insulation

In Chapter I it was stated that the optimal amount of consumer investment in insulation and other energy conservation measures in the residence was equal to the cumulative present worth of future savings on utility bills which is attributable to this investment at an appropriate rate of interest. It is evident from the previous section of this chapter that substantial savings will occur with the addition of more insulation, but a decision needs to be made on just what amount of insulation is optimal.

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[11] Based on figures in D. J. Anderson, former Business Manager, S.P.C., "Building Standards and Energy Conservation", a paper presented to a seminar on building standards, (Regina, May 6, 1976).

The following are some of the factors which need to be known in examining this problem:

(a) present cost of insulation;

(b) labour costs for installation plus costs of any design changes in the structure to facilitate the installation of higher insulation levels (i.e., 2" by 6" studs)[12];

(c) current fuel prices and future estimated fuel price increases;

(d) rate of interest on investment (discount rate);

(e) length of payback period; and

(f) degree days of location.

In a paper of January, 1976, Dr. D. G. Stephenson of the National Research Council[13] outlines a formula for determining optimal levels of thermal resistance in dwellings.[14] In deriving the present worth factor to be used in the formula, Dr. Stephenson assumes an annual increase in the price of electricity of 12%, in part a real increase and in part a result of the general inflation rate on goods and services. He also assumes

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[12] The decision to put insulation levels higher than R15 in the walls involves either the use of 2" by 6" studs in new residences or the attachment of plastic sheathing on the wall exterior of older houses.

[13] 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).

[14] See Appendix B for the formula and details of its application to the Regina rural area.

that the price of natural gas and heating oil will rise at a slightly higher rate of 15% until it reaches the price of electricity on a BTU equivalency basis, at which time it will also increase at 12% annually. Table 5 shows the results of an application of Dr. Stephenson's formula to the Regina rural area.

TABLE 5

OPTIMUM THERMAL RESISTANCE LEVELS IN THE REGINA RURAL AREA (FREE SPACE) (1)

	Natural Gas	Oil	Propane	Electricity
R_{opt} (optimum thermal resistance level - insulation + building material)	R40.68	R51.88	R60.73	R56.30
% Increase Justified over CMHC Current Standards for Ceilings (2)	85%	136%	176%	156%

(1) Free space means where incremental construction costs, such as going to 2" by 6" studs, are not a factor (Table 5 basically concerns ceiling insulation).

(2) Assuming a current CMHC ceiling standard of R20 insulation plus R2 for building materials (the R_{opt} values are net figures which include building materials).

In moving towards larger thermal resistance in walls, increased expenses result from higher construction costs. Dr. Stephenson uses an added cost of 5¢/square foot in going from an R12.5 to an R15 wall and an added cost of 20¢/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 $\frac{25¢}{7.5}$ = 3.3¢ construction + 1.3¢/R = 4.6¢. By substituting 4.6¢ for 1.3¢ in the formula used for deriving Table 5 (see Appendix B), one can determine if the additional construction costs are justified in the Regina rural area. The results, as shown below, indicate that the added investment of going to an R20 wall is justified.

	Natural Gas	Oil	Propane	Electricity
R_{opt} - Walls	R22	R28	R32	R30

In recent months there have been arguments that a more conservative position should be taken in regard to selection of factors to be used in the above type of calculation. HUDAC, for example,[15] uses a shorter pay-back period for insulation investment (25 years instead of 30 years) and a lower rate of interest on future fuel price increases (a rate which is identical to the interest rate on insulation investment). Nevertheless, even with these more conservative assumptions, R_{opt} for the Regina rural area in free space would still be 32.2 for natural gas at September 1, 1976 prices. In a report done by Scanada Consultants Ltd. for CMHC[16] a revision of Dr. Stephenson's report was developed using more

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[15] In A Builder's Guide to Energy Conservation, (Footnote 11).

[16] Scanada Consultants Ltd., "Conservative Position on New Housing Guidelines", (Ottawa, June 16, 1976).

conservative assumptions about every factor in the formula, including a higher construction price increment for walls of 7¢/square foot in going from an R12.5 to an R15 wall and 34¢/square foot in going from an R15 to an R20 wall.[17] R_{opt} for natural gas would then be 29.4 in free space. After the incremental wall costs of the Scanada report are assumed, the construction of an R20 wall in the Regina rural area is not justified when natural gas is used. Nevertheless, the incremental costs of constructing an R15 wall would be justified for every fuel when these conservative assumptions are used.

2.10 Effect of Variant Design Types

Table 6 uses heat loss calculations of HUDAC and applies them to the Regina rural area to give an indication of fuel savings which can be achieved in residences possessing a similar amount 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 standards the fuel consumption ratios are 1:.72:.57 for the three design types identified above rather than 1:.81:.64.

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[17] The method the author has used in this report is also more conservative than Dr. Stephenson's method in that an efficiency of .60 for fossil fuel use is used compared to the .75 efficiency used by Dr. Stephenson. Scanada Consultants use .70.

TABLE 6

COMPARATIVE FUEL REQUIREMENTS AND HEATING COSTS FOR DIFFERENT DWELLINGS WITH 1,080 SQUARE FEET OF LIVEABLE AREA IN THE REGINA RURAL AREA (1)

	Bungalow	Semi-Detached	Row House
Annual MCF's of Fuel Required - Natural Gas (60% Efficiency)	100.8 MCF	81.3 MCF	64.6 MCF
Annual Fuel Cost in $ at $1.66/MCF	$167	$135	$107
Comparative Fuel Consumption and Costs Where Bungalow = 1	1	.81	.64

(1) Having thermal resistance as recommended by HUDAC (for details see Section 2.9 and Appendix B).

2.11 Effect of the Size of the Dwelling

The amount of fuel used to heat a dwelling is dependent upon its square footage. For bungalows in a size range of 500 sqaure feet to 1,900 square feet with R28 insulation in the ceilings, R12 in the walls and R7 in the basement walls, the annual increment in the electricity required for heating is roughly 17,500 kWh or 6 million BTU's for each additional 100 square feet of area.[18] The increment in the annual heating fuel bill of a consumer for each additional 100 square feet of his residence above 500 square feet would then be (approximately):

Natural Gas (60% Efficiency)	Oil (60% Efficiency)
$17	$27

Propane (60% Efficiency)	Electricity (100% Efficiency)
$37	$32

2.12 Effect of Lowering the Thermostat

The study carried out by the Research Branch of the Manitoba Department of Public Works on a Manitoba Housing and Renewal Corporation 4-bedroom house indicated that significant reductions in annual heating fuel

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[18] Derived from figures in Manitoba Hydro, Electric Heating: Application in Various Types of Building Construction, (Winnipeg, December, 1975), pp. 41-42. Heat loss calculations assumed that DD = 10,700 and C (the constant or "experience factor") = 14.

requirements can be achieved when the consumer lowers his thermostat. For each of the residences studied, an annual reduction of 5.8% of heating fuel occurred when the thermostat was lowered 4° F for the 16 hours of the day and 8° F for the 8 hours of the night. The annual fuel cost savings for the owner of a 1,200 square foot house in rural Regina which was described in Table 1 of Section 2.2 might then be as follows with the lower thermostat setting (approximately):

Natural Gas (60% Efficiency)	Oil (60% Efficiency)
$16	$26

Propane (60% Efficiency)	Electricity (100% Efficiency)
$36	$31

2.13 Summary of Chapter II

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

It has not always been the lowest cost heating fuel which has been selected for residence installation in Saskatchewan 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 has not been as significant as many other optional design features when the purchase is made. In practice, consumer choice has been limited because it is often the house builder who selects the heating fuel and heating system as well as the amount of insulation to be installed in the residence. If consumers are to have a greater ability to exercise their own preferences in determining conservation features of new residences, it appears that their preferences should either be reflected in building standards or else the vehicles for communication between the builder and the homeowner should be made more effective in this regard.

Because the cost of heating a residence has not, in the past, been a very large expense relative to the consumer's total budget, there has not been a sufficient incentive for the residence owner to invest in more insulation and in other conservation measures. Furthermore, the degree to which a house conserves energy has not been a major selling point in the past (for instance, the current fashion of fireplaces has nothing to do with energy conservation and more often results in a net heat loss up the chimney).

However, a change in consumer attitude is likely in the future. As the real price of all heating fuels rises at rates which vary from fuel to fuel, the questions of which fuel should heat the residence and what features the residence should require to allow for a reduction in the heating load become very important.

At the present time natural gas is, by a considerable margin, the lowest cost heating fuel in the province. The cost of heating with either oil or electricity are similar in many localities but many people believe that electric heating will soon have cost advantages (at least in terms of operating costs). Propane is the most expensive of the common heating fuels used in Saskatchewan.

The percentage of income the consumer will have to devote to space heating in the future is an indicator of whether or not the decision to invest in a different heating system or else in conservation measures will be an important consideration for him. Even in the case of the lowest cost fuel (natural gas) a consumer with a 1976 income of $10,000 in a typical residence would have to devote around 4% of his income to space heating by 1978 and around 5% of his income before 1984 if a real price increase of natural gas of 6% per year is assumed.

There are many ways heating fuel can be conserved in the residence, but increasing the amount of insulation is the most important step. The example studied in this chapter shows that a 50% reduction in fuel requirements could result in a typical residence where pre-1975 insulation standards are upgraded to electric heating insulation standards. The analysis undertaken in this chapter indicates that, in the Saskatchewan climate, ceiling insulation should be increased by anywhere from 85% to 175% over the current CMHC standards, depending upon the price of the installed fuel. A large increase in wall insulation should also be undertaken and it appears that going to 2" by 6" studs in walls to allow for increased insulation is economically justified as a building practice.

Although heat energy consumption 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 kept in mind. The savings involved can easily be higher than 30% even though the same gross liveable area is available for occupants of multiple units as for single detached dwellings.

Smaller dwellings mean further reductions in the heating load of around 6 million BTU's for each 100 square feet of area for a residence insulated to current electric heating standards. This is a sizeable reduction when it is considered that the 1,200 square foot residence considered in this chapter (with less insulation than that called for by electric heating standards) has a heat load of roughly 100 million BTU's.

Finally, if the consumer decides to lower his thermostat he can achieve substantial cost savings. If the thermostat is lowered by an average of 4° F for 16 hours of day and 8° F for 8 hours of night, annual heating fuel savings of 5% to 6% can result.

CHAPTER III

AN OVERVIEW OF HEATING FUEL USE IN SASKATCHEWAN

3.1 Method of Giving an Overview of Heating Fuel Use

This chapter attempts to give, within the time available for undertaking this report, as complete a picture as possible of the present day pattern of space heating fuel use in Saskatchewan. A description such as this is a necessary prerequisite to any discussion of future heating fuel trends or, indeed, of the submission of any suggestions whatsoever as to feasible alternatives for a government residential heating policy.

The following are the components of the overview:

(a) historical growth comparisons between consumption of heating fuel and total energy consumption;

(b) comparative consumption of heating fuels among the provinces;

(c) nature of seasonal demand for heating fuels;

(d) principal heating fuels used in households;

(e) annual space heating installations for various fuels;

(f) geography of heating fuel use;

(g) heating equipment used; and

(h) energy use features of the current housing stock.

3.2 Growth of Heating Fuel Use in Saskatchewan

A considerable proportion of total energy consumed in Saskatchewan (roughly 21% during 1974) was accounted for by the residential sector.[1] Energy consumed in residences, nevertheless, is a major end-use and probably 80% (see Chapter II) on average of urban and rural residential consumption is for space heating.

The proportion of fuels consumed for residential space heating out of total energy consumption and the mix of fuels used to meet space heating requirements have changed over time in Saskatchewan. Figure 4 compares the consumption growth in BTU's of heating fuels to total energy consumption in Saskatchewan between 1963 and 1974.[2] Curves A to E were plotted by making the 1963 consumption level equal to 100 for each fuel and by calculating the relative annual consumption levels to 1974.

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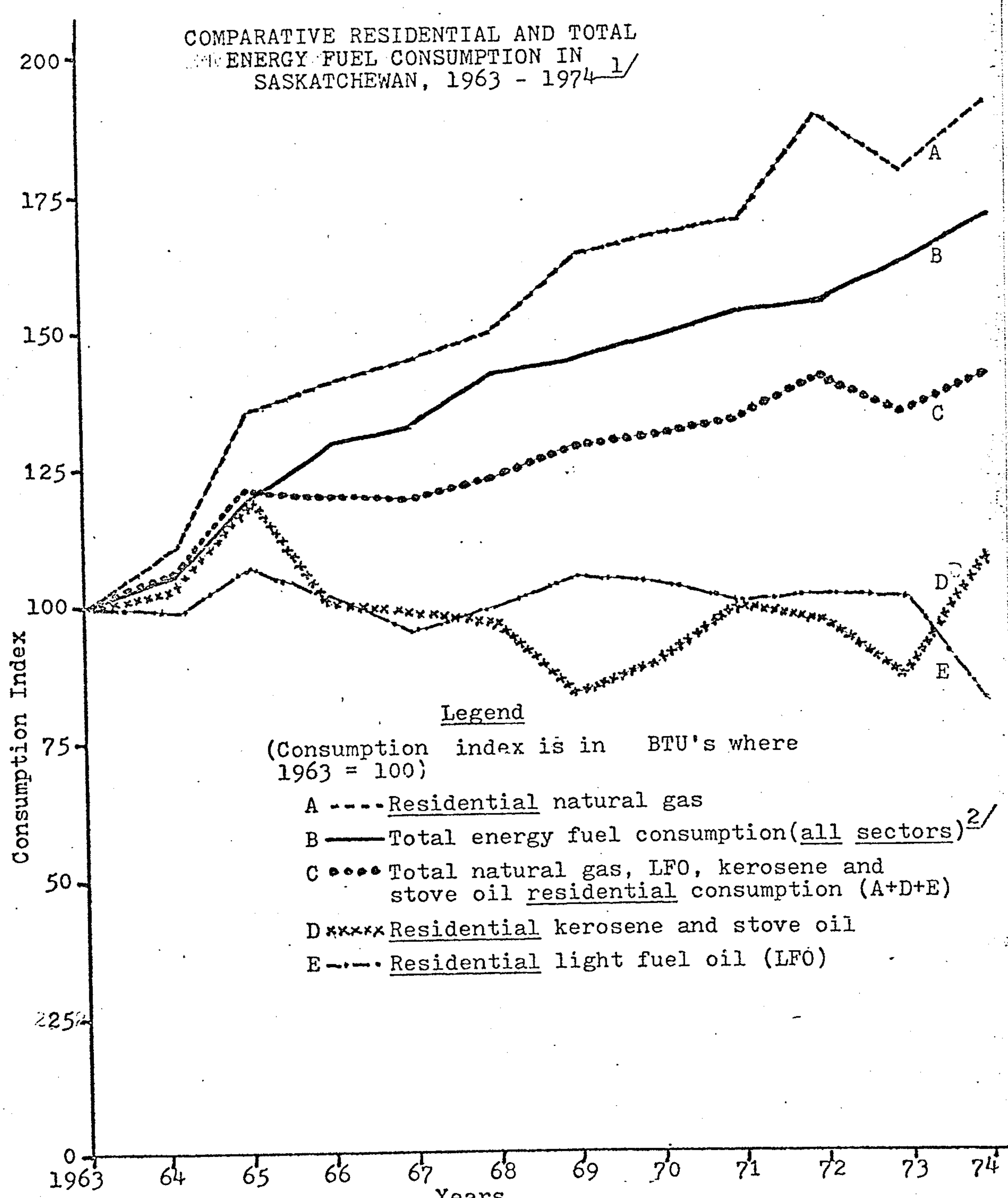
[1]Personal Communication: Peter Black, Energy Secretariat, Saskatchewan Department of Mineral Resources, October, 1976.

[2]Not all energy fuels are included in the total consumption curve since Saskatchewan data on some fuels was not available. However, the excluded fuels (see footnote 2 of Figure 4) amounted to only 3.9% of total fuel consumption (in BTU's) in Saskatchewan during 1973 according to Statistics Canada 57-207, Detailed Energy Supply and Demand in Canada, 1973. Consequently, Curve B in Figure 4 should be a fairly accurate representation of the relative increase in Saskatchewan's total energy consumption.

FIGURE 4



[1]Source: Energy Secretariat, Department of Mineral Resources, Government of Saskatchewan, and the Saskatchewan Power Corporation.

[2]Includes electricity, natural gas, aviation turbo fuel, heavy fuel oil light fuel oil, diesel fuel, kerosene motor gasoline. Excludes the following end-use fuels: coal, coke, LPGs, still gas, petroleum coke and aviation gas.

Figure 4 presents two interesting trends which should be commented upon here - the first concerns total energy consumption in all sectors as compared to space heating fuel consumption in residences, while the second concerns changes in relative shares of different types of heating fuels within the residential sector.

Total energy consumption increased at a faster rate than residential heating fuel consumption between 1963 and 1974. This is understandable since the demand (in BTU's) for residential heating fuels will not normally change very much in response to small changes in the real price of fuel. Only substantial changes in the stock of dwellings, in new dwelling designs or in efficiencies of residence heating fuel use can be expected to significantly affect total residential heating fuel consumption (and, as will be shown later on, no radical changes in any of these factors occurred in Saskatchewan between 1963 and 1974). On the other hand, certain other types of energy end uses have more price elasticity. In Chapter II it was noted that the real price of electricity and natural gas relative to average price increases of goods and services in Saskatchewan declined until 1974. The fact that energy use was greater in industry, agriculture and business relative to residences reflects both the growth of these sectors in Saskatchewan and an increasing use of energy as an input over the period considered. In addition, new technology resulted in the introduction of more energy intensive appliances such as color televisions and frostfree refigerators. The acquisition of second family cars as well as new automobiles, equipment and machinery which were less efficient in gasoline use were also factors which increased energy consumption between 1963 and 1974.[3]

It should also be noted that the relative increases in energy consumption of Figure 4 occurred over a period of time when the Saskatchewan population varied considerably. The province's population increased by 3.3% between 1961 and 1966, dropped by 3% between 1966 and 1971, and dropped by a further 2% between 1971 and 1974.[4] A closer examination will show that Saskatchewan's rural population was declining at a rapid rate while the urban population was showing moderate to substantial increases. For example, rural population declined by 7.6% between 1961 and 1966 and declined by 10.6% between 1966 and 1971. Over the same two periods of time, the urban population increased by 17.6% and 4.8%, respectively. This rural-urban population shift, together with cost advantages and the spreading of the natural gas system to new communities and subdivisions, help explain the rapid increase in the residential natural gas consumption curve and the decline in kerosene and light fuel oil.

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[3]Personal and business motor gasoline consumption amounted to 35% of total refined petroleum consumption in Saskatchewan during 1974 compared to 26% during 1963 (Energy Secretariat, Department of Mineral Resources, Government of Saskatchewan).

[4]Saskatchewan Bureau of Statistics, Saskatchewan Economic Review, 1975 (Regina, 1975).

3.3 Comparative Heating Fuel Consumption Among the Provinces

Each province relies on a different mix of energy resources for meeting residential space heating requirements. Figure 5 compares proportionate fuel use (excluding diesel) in the domestic and farm classification among Saskatchewan, Manitoba, Alberta, British Columbia, Ontario and Canada overall for 1973. The major portion of each of the listed fuels is normally used for space heating. Electricity is an exception, however, since it is normally used for residential appliances other than a furnace and because the amount of electric space heating varies from province to province. In Saskatchewan, for example, only 219 residences were heated electrically in 1973 and on farms roughly 45% of electricity consumed was in the farm yard rather than in the farm residence.[5] Given these limitations, the following points are notable in regard to the proportionate fuel consumption by domestic and farm in the provinces and Canada in 1973:

(a) On a BTU/capita basis, domestic and farm total energy consumption in Saskatchewan was second only to Alberta during 1973 and considerably above the national average.

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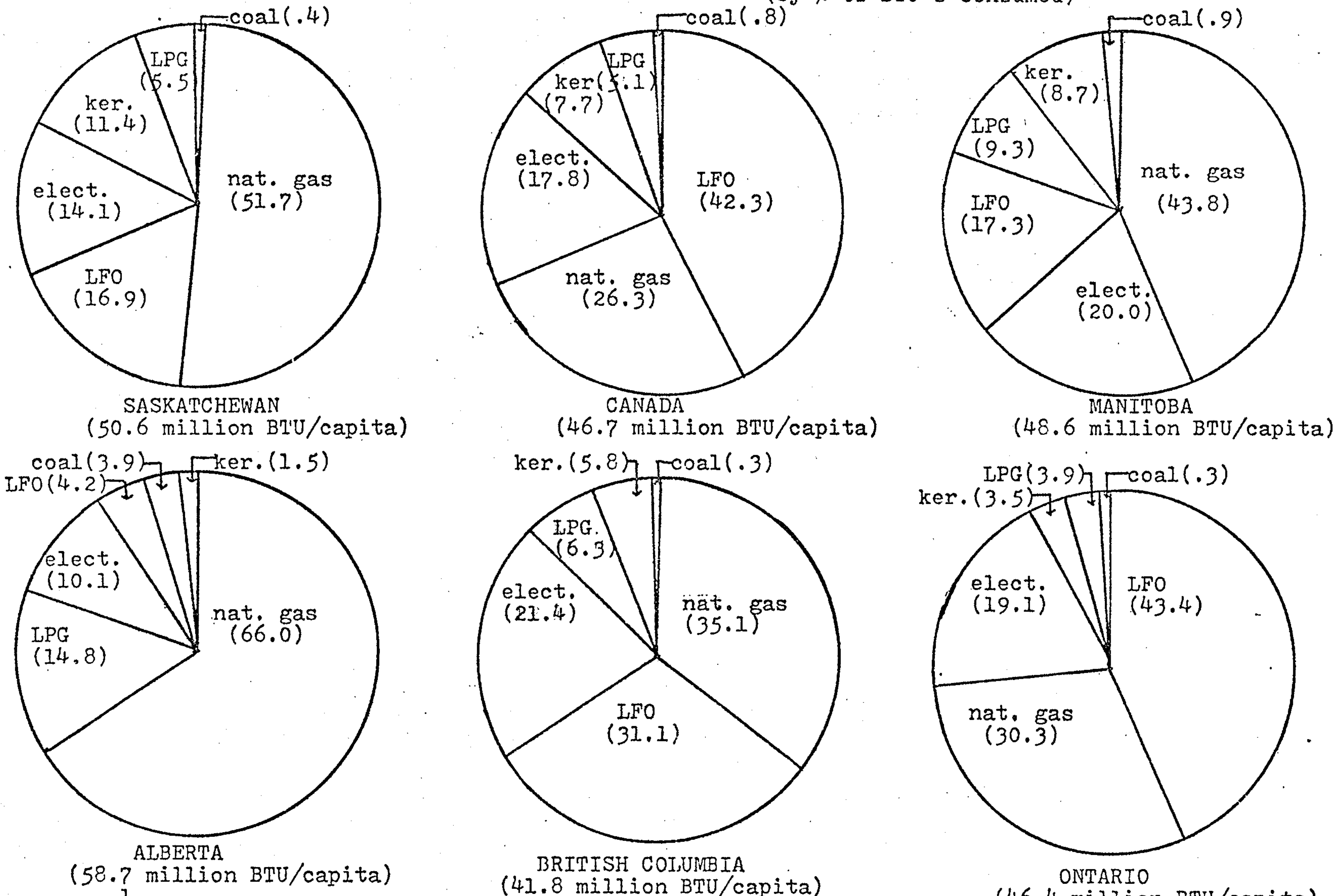
[5] S.P.C. estimates.

FIGURE 5

FUEL USE BY DOMESTIC AND FARM IN CANADA AND SELECTED PROVINCES, 1973[1]
(by % of BTU's consumed)



[1]Source: Statistics Canada 57-207 _Detailed Energy Supply and Demand in Canada, 1973_. Diesel fuel and heavy fuel oil are excluded from the above. Population is as of June 1 each year. LPG=liquid petroleum gases, LFO=light fuel oil, ker.=kerosene.

(b) Saskatchewan was second only to Alberta in its reliance on natural gas for meeting domestic and farm energy demand. Natural gas is mainly used for space heating but lesser quantities are used for water heating, cooking and drying clothes.

(c) Saskatchewan consumed a higher proportion of electricity than Alberta, but less than Manitoba, British Columbia, Ontario and Canada. Ontario and Manitoba have relied more on electricity for space heating than has Saskatchewan because of the hydro-electric potential and the lack of natural gas supplies in the former two provinces.

(d) Saskatchewan consumed a higher proportion of kerosene than Manitoba, Alberta, British Columbia, Ontario and Canada.

(e) Saskatchewan consumed a higher proportion of light fuel oil than Alberta, but less than Manitoba, British Columbia, Ontario and Canada.

(f) Saskatchewan consumed a higher proportion of liquid petroleum gases than Ontario, but less than Manitoba, Alberta, British Columbia and Canada.

(g) Saskatchewan consumed a slightly higher proportion of coal than British Columbia and Ontario, but less than Manitoba, Alberta and Canada. Nevertheless, the amount of end-use coal used for space heating is so small as not to be significant on an overall basis.

Using 1973 as a point of comparison, one might attempt a brief characterization of space heating fuel use in the Saskatchewan domestic and farm sectors in comparison with the rest of Canada based on (a) to (g) above:

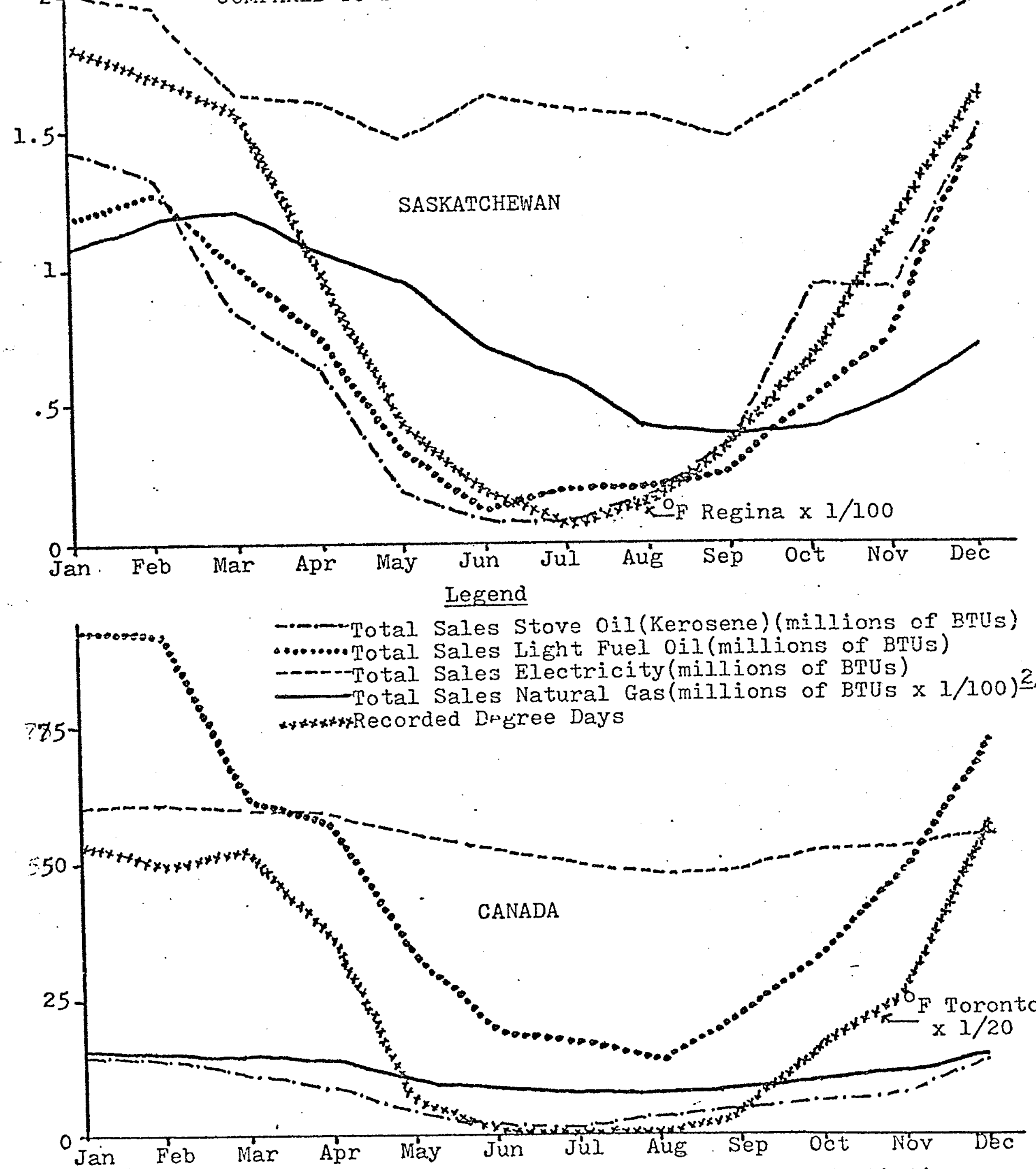
> *Saskatchewan has a relatively high level of domestic and farm fuel consumption on a per capita basis with a reliance for a majority of its space heating requirements on natural gas which is second only to the reliance of Alberta for this purpose. Saskatchewan has a much greater than average reliance on kerosene, but uses a lower proportion of light fuel oil than most provinces. Saskatchewan consumption of liquid petroleum gases is significant although less than average in Canada. On a comparative basis, Saskatchewan residences consume a lower than average amount of electricity.*

3.4 Seasonal Demand for Space Heating Fuel

Consumption in all end-use sectors varies on a seasonal basis, with peak demands usually occurring in December or January because of space heating requirements. Because some fuels are not used as extensively for space heating as are others, they are not as responsive to seasonal variation. Figure 6 illustrates this relationship for Saskatchewan and Canada during 1975 (by fuel sales) to all consumer classes. As can be seen from the diagram, electricity is not as responsive to seasonal demand as other fuels since it is used for many other purposes than space heating. To a lesser extent, this comment is also true of natural gas. Sales of light fuel oil and stove oil (kerosene) follow the monthly degree day pattern quite closely, however. Seasonal variation in space heating demand has implications for both the fuel delivery and system and fuel storage capability.

FIGURE 6

TOTAL FUEL SALES TO ALL CONSUMER CLASSES[1]
COMPARED TO DEGREE DAYS, 1975



[1]Source: Statistics Canada 57-001 Electric Power Statistics, 57-002 Service Bulletin-Energy Statistics, 55-002 Gas Utilities, and the Meterological Division, Canada Department of the Environment.

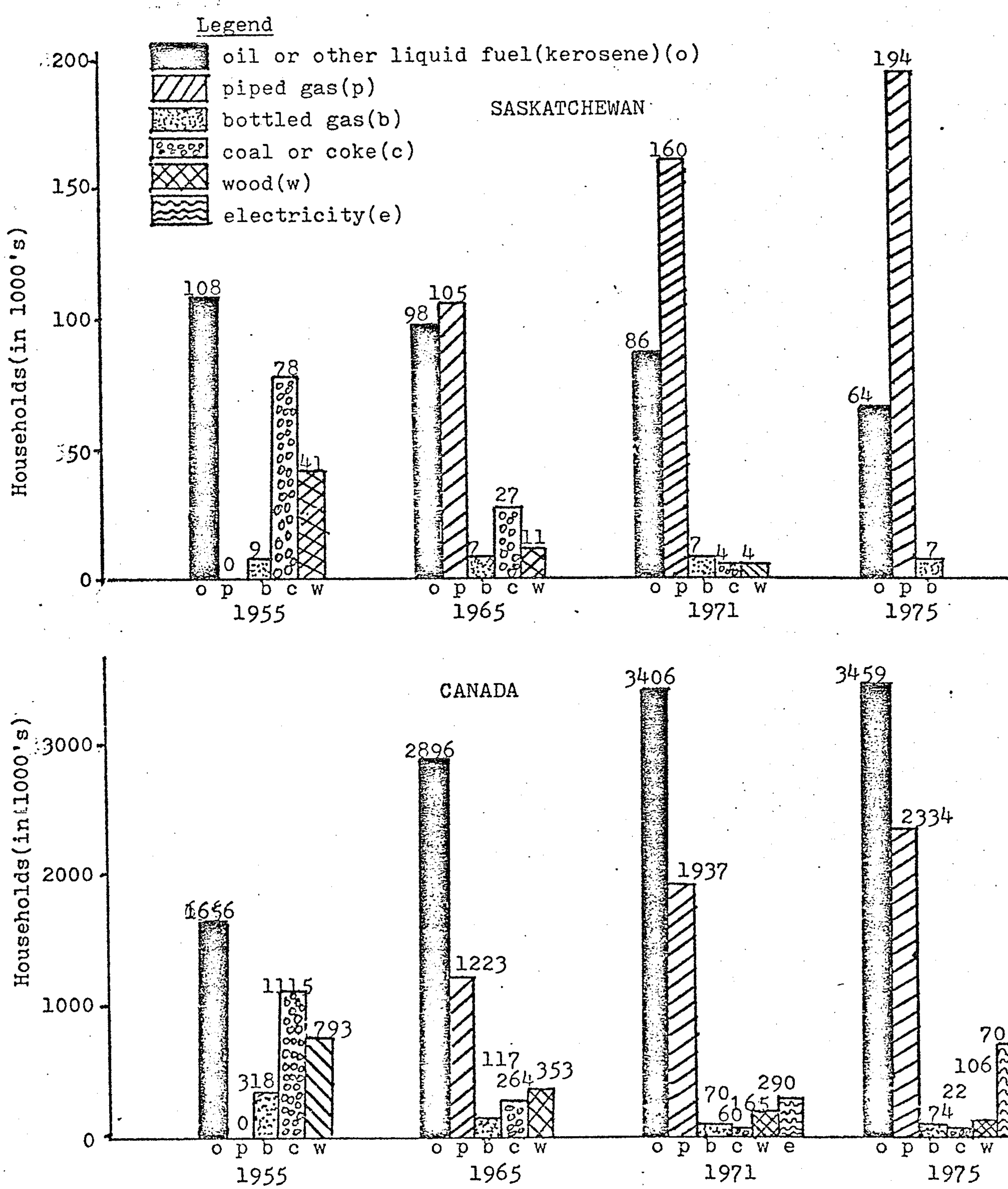
[2]Because natural gas sales are plotted on a scale 100X smaller than the other fuels in both diagrams, monthly variations in sales are not as apparent.

3.5 Heating Fuel Use as Shown by Household Data

Rather than examining data on consumption levels, useful information on heating fuel use can be had from household data on principal heating fuels. The Statistics Canada household data are derived through a survey where estimates of the number of households which consume heating oil, coal or wood (where supply is from private dealers) are very approximate. With the above limitation in mind, Figure 7 demonstrates the relative significance on a household basis of the various heating fuels from 1955 to 1975 for both Saskatchewan and Canada. Canada has had a regular increase in the use of heating oil (and other liquid fuels) for space heating between 1955 and 1975, and this remains the predominate household heating fuel in the country. In Saskatchewan, however, there has been a gradual decline in the use of oil and other liquid fuels for space heating (over 40% between 1955 and 1975). Both Canada in total and Saskatchewan have shown dramatic increases in the use of natural gas as a principal heating fuel between 1955 and 1975. However, more than two-thirds of Saskatchewan households were heated by natural gas in 1975 compared to an amount of less than one-third in the case of the Canadian total. The use of coal and wood have drastically declined in amounts proportionate to the increase in natural gas use in Saskatchewan and Canada over the period considered, according to Statistics Canada.

FIGURE 7

PRINCIPAL HEATING FUELS IN HOUSEHOLDS, SASKATCHEWAN AND CANADA[1]/



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

Saskatchewan has not experienced a similar increase in the use of electric space heating compared to much of the rest of Canada.

3.6 New Space Heating Installations

Table 7 is an estimate of new residential installations for various heating fuels in Saskatchewan from 1970 to 1975. This table is also an indicator of the current popularity of certain heating fuels. Natural gas installations have rapidly increased over this period of time. Heating oil installations have decreased substantially, but propane installations have had a considerable increase between 1974 and 1975, possibly due to the mobile home market where fuel choice is very limited. In 1974 and 1975, electricity installations have shown a rapid increase such that the number of electrically heated homes in the province had more than tripled between 1973 and 1975.

TABLE 7

NEW INSTALLATIONS AND CONVERSIONS -
SPACE HEATING IN SASKATCHEWAN RESIDENCES, 1970 - 1975

Year	Natural Gas (1)	Heating Oil (2)	Propane (3)	Electricity (4)
1970	1,867	594	1,698	Not available
1971	5,260	384	1,591	Not available
1972	5,855	295	1,253	Not available
1973	6,651	323	1,455	Not available
1974	7,295	252	1,508	110
1975	9,090	159	2,096	436

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

(2) Source: Saskatchewan Department of Labour, Annual Report of The Fire Commissioner, 1975.
90% of the total oil burner permits for each year was estimated as the number of residential oil installations for each year.

(3) Source: Gas Safety Unit, Saskatchewan Department of Labour (number of residential inspections of new or converted gas heating units -can include mobile homes).

(4) Source: Business Branch of the Electric Division, S.P.C.
The total number of electrically heated residences was estimated at 219 in 1973.

3.7 Geography of Heating Fuel Use

An indication of space heating fuel geography can be achieved by use of the census division estimates of principal heating fuels in occupied Saskatchewan dwellings at the time of the 1971 Census. The following comments are based on Figure C-1 of Appendix C. Appendix C also discusses the reliability of the census estimates.

(a) Natural gas was used in more than 50% of dwellings in 8 out of 18 census divisions. Given the rapid increase in new gas installations since 1971 (see Section 3.6), the proportion of residences using gas would have had further substantial increases since that time. As might be expected, the geographic pattern of natural gas use closely follows the more dense urban population distribution in the province and the natural gas distribution system.[6]

(b) Heating oil and other liquid fuels (kerosene) were used in more than 50% of dwellings in three census divisions and were the dominant fuels in a total of 8 out of 18 census divisions in 1971.

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[6] As can be seen by reference to J. Howard Richards and K. I. Fung, The Atlas of Saskatchewan (Saskatoon, University of Saskatchewan, 1969), pp.28-29, and Figure C-2 in Appendix C.

(c) Wood had a substantial use in the most northerly census division (18), and was also of some importance in other northern census divisions. However, the proportion of wood use as a principal heating fuel will have decreased since 1971.

(d) Coal had some use as a principal heating fuel in 1971, most notably in the Estevan area.

There is a considerable difference between the mix of heating fuels used in farm and rural areas as compared with the fuels used in urban centres.[7] According to the 1971 Census, 132,490, or 89%, out of 149,055 urban dwellings had natural gas as their principal heating fuel. The above percentage compares to 34% of rural non-farm homes heated by natural gas, while less than 2% of farm homes were heated by natural gas. While only 8% of urban dwellings were heated by oil and other liquid fuels, 49% of rural non-farm and 78% of farm dwellings were heated by oil and other liquid fuels. Since 1971, as has been mentioned earlier, the proportion of total residential heating fuel requirements met by natural

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[7] Table C-a of Appendix C is the basis for the following comments.

gas has increased and so some revisions of the above would be necessary for 1976.[8]

3.8 Heating Equipment

Only very limited information is available on the heating equipment in use in Saskatchewan. According to the 1971 Census of Canada, occupied dwellings in the province were heated by the following types of equipment:

Total	Steam or Hot Water Furnace (Hydronic)	Hot Air Furnace	Stove or Space Heater	Other
267,610	26,895	191,860	42,150	6,710

Urban dwellings were heated by roughly 77% hot air furnaces, 16% hydronic systems and 5% space heaters or stoves. Rural and farm dwellings, on the other hand, were 65% heated by hot air furnaces and 30% heated by space heaters or stoves.

The most recent estimate[9] of heating equipment in Saskatchewan dwellings indicated 44,000 steam or hot water furnaces, 205,000 hot air furnaces, and 19,000

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[8] Nevertheless, extension of natural gas to rural non-farm and rural farm customers would not have increased that much by 1976. By 1976, S.P.C. was no longer extending natural gas service to additional communities because of the cost of new extensions and uncertainties about long-term availability of supply. At the time of writing this report, however, new sub-divisions in communities which were already part of the natural gas system would be able to connect to the system.

[9] Statistics Canada 64-202, Household Facilities and Equipment, April, 1975.

heating stoves. It is unlikely that the number of steam or hot water furnaces would have increased so much since 1971, however, so this estimate may not be very accurate.

3.9 Energy Use Features of the Saskatchewan Housing Stock

From Chapter II it can be seen that heating fuel requirements in a residence are related to a large number of factors including the residence size, the design type (single or multiple unit), thermal resistance of materials, infiltration rate, efficiency of the furnace, weather, conservation habits, etc. In examining residential heating fuel use in Saskatchewan, therefore, it is important to consider the qualities and location of residences in addition to the quantities of residences which are in place. The distance of residences from transmission lines or fuel distribution centres is also an important matter to consider, particularly where interfuel substitution is contemplated.

Previous to 1940, many houses were constructed in Saskatchewan without any wall insulation. More variability was exercised in regard to ceiling insulation. Wood shavings were the most common insulating material and these constituted an R value averaging around R7 to R9. During the 1940's, wall insulation began to be used much more extensively and, once again, wood shavings were the most common insulating material. Although wood shavings had an adequate insulating value, they suffered from a number of faults, such as:

(a) they did not act as a fire deterrent;

(b) insects and vermin were able to live in them except when the shavings were treated with a chemical such as silver nitrate (which caused as many problems as it solved); and

(c) wood chips tended to sag inside a wall leaving a gap of several inches near the top of the stud space where the greatest part of the heat could escape.

After 1950, mineral wool and glass fibre began to take over the insulation market. The most common wall insulation was a 2-inch glass fibre batt with a potential R value of R6.5 to R7. In 1975, construction standards for financing under The National Housing Act were changed. The resistance value of walls and ceilings were, to some extent, made dependent upon the degree days of the location where the residence would be located. In the Regina area, for instance, the thermal resistance values (including construction material of walls and ceilings) are now 13.7 and 14.1, respectively, for non-electrically heated residences.[10]

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[10] This historical sketch was written after discussions by the author with the Building Research Division of the National Research Council and with the Central Mortgage and Housing Corporation. (Table C-6 in Appendix C lists insulation levels in residential construction standards financed under The National Housing Act in codes from 1954 to 1975.)

With the preceding historical sketch on insulation levels in mind, it is now possible to turn to the existing housing stock in Saskatchewan. Table 8 is an estimate of occupied dwellings in the province by period of construction.[11]

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[11] The assumptions used in preparing this table are contained in Appendix C. Until the results of the 1976 Census of Canada are known, estimates such as these can only be regarded as being very approximate.

TABLE 8

ESTIMATE OF OCCUPIED DWELLINGS DURING 1975 IN SASKATCHEWAN BY PERIOD OF CONSTRUCTION (1)

Period of Construction	1975 Occupied Dwellings	% of Total 1975 Occupied Dwellings	1975 Single Detached Dwellings	Single Compared to Total (%)
1920 or before	43,240	15	36,832	85
1921 - 1945	59,987	21	52,733	88
1946 - 1960	86,181	31	73,930	86
1961 - 1969	63,095	23	43,205	68
1970 - 1975	28,126	10	22,144	79
TOTAL	280,629	100	228,844	82

(1) Source: Estimates based on 1971 Census of Canada and Statistics Canada 64-002, Housing Starts and Completions (1970-75). Appendix C describes the method of updating estimated periods of occupied dwellings to 1975. The total of Saskatchewan occupied dwellings (280,629) is in excess of the Statistics Canada estimate (see p.70) by 7,629 because a lower replacement rate is used here.

Table 8 indicates that roughly one-third of Saskatchewan occupied dwellings were constructed in 1945 or earlier, one-third were constructed between 1946 and 1960, and one-third were constructed since 1961. By considering the comments made previously about insulation, it is possible to make the following very rough approximations of insulation features of Saskatchewan residences:

(a) one-third of Saskatchewan occupied residences have no insulation in their walls and none or small amounts (up to R7) of insulation in their ceilings;

(b) one-third of Saskatchewan occupied residences have R7 insulation in their walls which has lost much of its efficiency through aging and sagging, and R7 insulation in their ceilings; and

(c) one-third of Saskatchewan occupied residences have R7 of effective insulation in their walls and R10 to R14 of insulation in their ceilings.[12]

The construction period (and hence the insulation features) of residences vary from one part of Saskatchewan to another. By considering census

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[12] These are perhaps optimistic estimates since they assume that many residences have insulation levels close to the NHA requirement for financing at the time of construction.

division data from the 1971 Census, it can be seen that the oldest dwellings (built in 1945 or earlier) are in the southern and western parts of the province. Census divisions in which the larger cities are located (10,000 occupied dwellings or more) tend to have between 55% and 60% of occupied dwellings constructed after 1945. In the farthest north census division, more residences were constructed between 1946 and 1960 than in any of the other periods considered in Table 8.[13]

In addition, as might be expected with the growing urbanization of Saskatchewan during recent decades, there is a considerable difference between the construction period of urban and rural dwellings. Rural farm and non-farm dwellings are much older on average than are urban dwellings.[14]

In Chapter II it was stated that single detached dwellings require more BTU's of heating fuel for the same liveable area as compared to multiple housing units with similar thermal insulation features and air infiltration rates. In April, 1975, Saskatchewan was estimated to have 273,000 dwellings,[15] of which 215,000,

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[13] Refer to Figure C-5 in Appendix C for a map of construction period of occupied dwellings in Saskatchewan in 1971 by census division.

[14] Refer to Table C-c of Appendix C for the period of construction of urban and rural occupied dwellings in Saskatchewan in 1971.

[15] Statistics Canada 64-202, Household Facilities and Equipment, April, 1975.

or 79%, were single detached dwellings. In Canada as a whole, there were 6,703,000 dwellings on the same date, of which 3,987,000, or 59%, were single detached dwellings. In Saskatchewan, therefore, there is a considerably higher proportion of single detached dwellings than there is in Canada as a whole. A further illustration of proportionate design types is given in Table 9 which lists housing completions in Saskatchewan by type of dwelling from 1965 to 1975.

TABLE 9

HOUSING COMPLETIONS IN SASKATCHEWAN BY TYPE OF DWELLING, 1965 - 1975 (1)

Year	Completions	Single Detached (%)	Two Family (%)	Row (%)	Apartment and Other (%)
1965	7,218	66	5	4	25
1966	6,830	75	3	5	17
1967	5,873	57	4	1	33
1968	7,712	54	11	-	35
1969	6,103	54	8	1	37
1970	3,265	54	7	3	36
1971	2,761	82	4	3	11
1972	3,967	91	2	2	5
1973	5,421	76	3	1	20
1974	6,487	79	3	4	14
1975	7,705	83	3	3	11

(1) Source: Statistics Canada 64-002, Housing Starts and Completions.

Another factor affecting fuel consumption in the residence is its size (area of the roof). Unfortunately, the information available on average sizes of Saskatchewan residences is highly speculative at the present time. It is believed, for example, that residences being constructed by the same income group of individuals are larger in the small urban or rural areas where the price of land is lower.

In recent years, only 10% to 20% of new residences in Saskatchewan have been financed through The National Housing Act. Table 10 gives an indication of relative areas of new houses in Regina and Saskatoon financed under the NHA between 1970 and 1975. Caution should be exercised in using this table as being representative of average new housing sizes, however, since NHA financing would likely relate to the smaller sized residence than to the larger. Nevertheless, the table shows that financed houses have tended to decrease in size since 1970, possibly as a function of the increasing cost of land.

TABLE 10

SIZES OF NEW HOUSES FINANCED UNDER THE NATIONAL HOUSING ACT IN REGINA AND SASKATOON, 1970 - 1975 (1)

Location and Year	% Distribution of Square Feet				
	0-999	1,000-1,199	1,200-1,399	1,400-1,599	1,600+
REGINA					
1970	42.7	38.8	8.6	5.3	4.6
1971	52.5	32.0	10.0	2.8	2.7
1972	70.8	16.6	8.1	1.9	2.6
1973	53.6	29.7	8.8	3.3	4.6
1974	68.2	24.7	5.7	0.6	0.8
1975	69.9	22.9	5.3	1.1	0.8
SASKATOON					
1970	29.7	50.4	9.5	5.0	5.4
1971	44.3	46.8	4.2	1.9	2.8
1972	72.8	21.2	3.1	1.9	1.0
1973	73.4	21.3	3.0	1.8	0.5
1974	75.2	19.8	3.0	1.3	0.7
1975	78.9	18.6	2.4	0.6	0.4

(1) Central Mortgage and Housing Corporation, Canadian Housing Statistics, 1970-75.

3.10 Summary of Chapter III

(a) Heating Fuel Allocation

According to Statistics Canada, more than two-thirds of Saskatchewan households in 1975 were heated by natural gas. This compares to the Canadian average of less than one-third of households with natural gas heat. Examination of consumption figures shows that a majority of the residential energy requirements in Saskatchewan were met by natural gas by 1973. The growing use of natural gas has been a relatively recent phenomenon because it was not until the late 1950's that gas distribution for residential heating began. This consumption growth coincided with a decline in the rural population and with medium to rapid growth in Saskatchewan urban centres.

If data on the relative annual consumption levels of residential heating fuels from 1963 to 1974 are examined, it can be seen that natural gas consumption growth was much more rapid than the total consumption of the common heating fuels (including natural gas) in the residential sector. Over the same period, residential consumption of kerosene and light fuel oil declined slightly relative to 1963 consumption levels.

In recent years, new principal heating fuel installations in Saskatchewan residences also demonstrate the popularity of natural gas. During 1975, new natural gas installations in residences were over 50 times the number of new heating oil installations, 4 times new propane installations (many of these were in mobile homes), and 20 times new electric heating installations. Nevertheless, the number of new electric heating installations in 1975 was significant in that it more than doubled the amount of electrically heated residences in the province that existed during the previous year.

Although heating oil, propane and kerosene do not have the significance they once had (as recently as 1965) in filling the majority of Saskatchewan residential heating fuel requirements, they are very important today in certain regions. As may be expected, the natural gas system follows the more dense distribution of population in the province. The average per customer cost of delivering natural gas is inversely related to the density of the distribution of residences to be connected to the system. The result is that, with Saskatchewan's widely distributed population, many rural non-farm and rural farm dwellings cannot expect to be connected to the natural gas system because of cost considerations. At the time of the 1971 Census, therefore, 89% of urban dwellings had natural gas as a principal heating fuel compared to only 34% of rural non-farm and 2% of farm residences. It is in these latter residences where refined petroleum products and liquified petroleum gases are so significant and where the possibility of substitution by a fuel such as electricity becomes an important consideration. During 1973 over 80% of liquified petroleum gases, kerosene and light fuel oil were consumed in the farm and domestic sector, primarily for space heating.

Heating by wood and coal has become almost insignificant in Saskatchewan compared to 1955 when, together, these fuels heated about one-half of Saskatchewan residences. A small amount of coal was still being burned directly in residences in the southeastern part of the province in 1971. In the far North (from La Ronge and going north), about 40% of occupied dwellings used wood as a principal heating fuel in 1971.

(b) Total Residential Heating Fuel Consumption

Roughly 21% of total energy consumed in Saskatchewan was accounted for by residential use. In the Statistics Canada "Domestic and Farm" classification, Saskatchewan consumed 50.6 million BTU/capita (excluding diesel) during 1973, which was more than Manitoba, Alberta, British Columbia, Ontario and the Canadian overall average, but less than Alberta. Between 1963 and 1974, total fuel consumption in all sectors increased at a considerably more rapid rate than the consumption of the common heating fuels in residences.

The major type of heating equipment used in Saskatchewan residences is the forced air furnace. Nevertheless, at the time of the 1971 Census, about one-tenth of total dwellings had steam or hot water systems and about one-sixth had stoves or radiation space heaters. With the continued increase of natural gas installations since 1971, however, a higher proportion of forced air systems can be postulated.

It is difficult to assess the energy use features (and potential for conservation) of the current stock of Saskatchewan residences because an inventory is not yet available. The results of the 1976 Census and future housing research by the Government of Saskatchewan will make this assessment more accurate in the future. Nevertheless, the author made some estimates on insulation levels based on 1971 Census data on construction periods of occupied dwellings, assumptions about replacement housing since 1971, and historical practices of installing insulation.

A somewhat optimistic estimate of the insulation features of Saskatchewan residences is as follows:

(i) one-third of Saskatchewan occupied residences have no insulation in their walls and none or small amounts (up to R7) of insulation in their ceilings;

(ii) one-third of Saskatchewan occupied residences have R7 insulation in their walls which has lost much of its efficiency through aging and sagging, and R7 insulation in their ceilings; and

(iii) one-third of Saskatchewan occupied residences have R7 of effective insulation in their walls and R10 to R14 of insulation in their ceilings.

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

As of 1975, 79% of Saskatchewan occupied dwellings were single detached compared to the Canadian overall average of 59%. All other things being equal, these dwellings are less energy efficient than multiple unit dwellings. Since 1971, between 75% and 80% of housing completions in Saskatchewan have been single detached units.

There was no provincial estimate on average sizes of dwellings and trends in sizes of new dwellings that could be consulted for the purposes of this report. Some individuals expressed the view that the high price of land in urban centres such as Regina and Saskatoon tended to decrease the size of new dwellings. In Regina and Saskatoon, the area of new dwellings financed under The National Housing Act dropped substantially between 1970 and 1975. It should be noted, however, that only 10% to 20% of new residences have been financed through The National Housing Act in recent years.

CHAPTER IV

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

4.1 Subject Matter and Procedure to be Followed in This Chapter

Chapter II of this report was concerned with the impact of fuel choice on a residence owner's annual expenses and on his future income. In addition, Chapter II assessed the potential for heating fuel conservation in typical residences. Chapter III discussed, for both the present and the recent past, the levels of energy consumption in the residential sector and the pattern by which heating fuel is allocated in Saskatchewan. This chapter will look to the short-term future and will assume that no significant policy changes in fuel allocation or conservation are taken by the Saskatchewan Government. Given this assumption, the author will briefly predict likely future fuel choices and expected levels of energy consumption in the residential sector by projection of past trends where appropriate and by referring to available analyses and forecasts of government departments and agencies. This will lay the groundwork for Chapter V where significant policy changes will be discussed.

4.2 Heating Fuel Market Shares

(a) Natural Gas

Previous chapters have shown that natural gas is the dominant heating fuel in Saskatchewan residences. New installations of natural gas numbered about four times that of all other new heating installations in residences put together in 1975. By 1976, most residents in Saskatchewan communities with populations of 500 or over had the option of choosing natural gas for heating purposes. The main reason for the sustained 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 odorless, clean-burning and is used in a relatively inexpensive furnace which requires little maintenance over its lifetime of use. The popularity of natural gas is such that, after a period of five years when it is first made available to a community, approximately

84% of residences in the community convert to natural gas as a principal heating fuel.[1] The reason that this saturation rate does not approach 100% has been attributed to the fact that some older and smaller-sized residences have heating stoves and, due to the relatively low income of the occupants of many of these dwellings, the first cost of installing a gas furnace is considered to be prohibitive.

Saskatchewan has reserves of 1,450 BCF of natural gas - 750 BCF proven reserves and 700 BCF probable reserves as of 1975.[2] Future supplies will also come from indigenous sources. During 1975, over one-half of natural gas used in Saskatchewan was from Alberta. A continued supply from Alberta can be expected, although the amounts may vary considerably from year to year up to 1990. It is also possible that frontier natural gas will be available for the Saskatchewan market within the next decade.

Table 11 shows that natural gas consumption in 1975 totalled 101 BCF (excluding gas consumed by TransCanada PipeLines and sales to Medicine Hat).

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[1] Saskatchewan Power Corporation estimate.

[2] Personal Communication: Peter Black, Energy Secretariat, Saskatchewan Department of Mineral Resources, August, 1975.

If natural gas consumption remained at its present level and only provincial reserves were used for meeting demands, the supply from proven and probable reserves would be used up in about 14 years. Demand, however, is expected to increase as shown by Table 11. S.P.C. forecasts an annual increase of residential natural consumption of 2.1% from 1975 to 1980 and 2% from 1981 to 1985. Industry is expected to increase its requirements annually by 6.6% from 1975 to 1980 and by 1.5% from 1980 to 1985.

Natural gas pricing in Saskatchewan may be affected in the future by national price movements due to imports from Alberta. The prices of these imports have increased rapidly and have boosted the average cost to S.P.C. of gas delivered to customers. Gas rates will be affected and indications are that the resulting rate increases because of imports might be substantial.

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 price increases if it is to be economically feasible to bring frontier supplies on market during the 1980's. The National Energy Board, in a report

TABLE 11

S.P.C.'s GAS REQUIREMENT FORECAST FOR SASKATCHEWAN, 1975 TO 1985
(Vols. in BCF @ 14.65 Psia)

Year	Residential	Commercial	Industrial	Other [1]	Total
1975 (Actual)	27.1	11.9	49.5	12.5	101.1
1978	28.9	10.8	60.7	11.2	111.6
1982	31.4	11.6	70.3	9.1	122.4
1985	33.2	12.3	73.6	9.5	128.6

(1) Includes Farm (about .2 BCF/year), Internal and Unaccounted For.

of September, 1975, presented the following views on comparative 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 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, therefore, 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 Canadian prices of natural gas can be expected for the future.

Under the present policy, new residences which are constructed in Saskatchewan communities that are part of the natural gas system have the option of installing this fuel as a principal

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

heating source. The high proportion of new principal heating fuel installations which are natural gas will continue, abetted by rural-urban population movements, until the fuel cost advantage disappears. 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.

(b) Heating Oil, Kerosene and Propane

The price differentials identified in Chapter II are indicative of the decline in popularity of petroleum products for space heating, particularly in communities where natural gas is available. If the price of crude oil moves progressively towards world levels throughout the remainder of this decade, the decline in popularity of petroleum products for heating in Saskatchewan will continue, particularly since there are substitutes available in most cases. In some rural locations the cost of heating with electricity is similar or perhaps even lower than heating with petroleum products. An exception may be the use of propane in the mobile home market. Even though propane is the highest cost fuel in most locations at the present time, mobile homeowners often select it because it is cleaner than oil and kerosene and because of the lack of substitutes in some locations.[4]

Heating oil and kerosene also have the disadvantage of having quality deficiencies such as leaving a dirt film on furniture and having an odor. Maintenance is required more often and furnaces tend to be less efficient (about 5% less) than gas furnaces. Unlike electricity and natural gas, fuel storage is necessary. Many consumers at present are concerned about the future security of supply of petroleum products and are thus motivated to substitute other fuels. An additional disadvantage in the North and remote rural areas is the highly expensive and often irregular means of transporting fuel. Heating costs can be very high since many remote residences are poorly insulated and, if farther north, have a greater heating load.

Nevertheless, under present policy, some homeowners can be expected to continue using heating oil, kerosene and propane since they

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[4] About one-half of the persons installing new propane heating systems consulted in the S.P.C. Heating Survey (1974) stated that the possibility of being hooked up to the natural gas system in the future was a factor in their choice of propane.

are not willing or are unable to invest in an alternative heating system. Although consumption of petroleum products cannot be expected to increase in the residential sector (i.e., few new installations), many existing residences may continue to use petroleum products as heating fuels. The National Energy Board, for example, forecasted that consumption of light fuel oil, stove oil and kerosene in Saskatchewan (which, to date, have been mainly used for residential heating) will decline only to 6.7 thousand barrels per day in 1985 from its 1976 consumption level of 7.2 thousand barrels per day.[5]

(c) Electricity

In considering future consumer demand for electric heating assuming no significant policy change, it is important to divide consumers into two categories: those in localities served by the natural gas system and those rural, farm or isolated consumers in localities not part of the natural gas system.

In localities which are connected to the natural gas system, there is a considerable price gap between natural gas and the next highest

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[5] National Energy Board, Canadian Oil: Supply and Requirements, (Ottawa, September, 1975), p. 97.

priced heating fuel at present. Without a change in distribution policy, the rate of substitution by electricity will depend mainly upon relative price increases of natural gas as supplies decline and become more costly to produce and expectations of consumers as to security of future natural gas supplies. It will be some time before the price gap closes.

Because Saskatchewan is not likely to adopt a rural gasification program similar to Alberta's, consumer choices about heating fuel in rural and isolated areas of Saskatchewan are more restrictive than in the larger urban localities. Consequently, electric heating is now a more viable option in these areas. At the present time (see Chapter II) oil heating costs approach those of electric heating in some regions of the province and, in fact, are higher than electric heating in other regions where transportation is a major component of price. Propane costs are already considerably higher than electricity. In addition, electricity has quality advantages and is less likely to suffer from supply disruptions over an extended period of time. There are, however, some additional customer costs when electric heating is chosen:

(i) electric service charges for installation of a 200 Amp panel ($300 - $400);

(ii) wiring and equipment costs which total slightly more than the cost of a conventional oil furnace, although electrical maintenance costs are lower in most cases;[6]

(iii) 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 and more than twice this amount if an underground cable is used; and

(iv) a more sophisticated and expensive ventilation system must be installed if damage to walls, ceiling and insulation is not to occur.

In both urban and rural localities, the price of electricity will be a key determinant of its use in residential heating. S.P.C. will have to make additional expenditures if large numbers of residences opt for electric heating. The costs of providing electrical energy are generally

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[6] If electric heat is provided by resistance wires embedded in plaster, maintenance can be expensive should problems occur.

regarded as being divisible into the following components:

(i) generation (facility costs plus variable fuel costs);

(ii) transmission;

(iii) distribution;

(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 generation, transmission and distribution costs have been higher in recent years than the average costs of previous installed capacity. Increasing generation capacity costs are the most significant upward push on utility revenue requirements. Until around 1971, the marginal costs of adding a kilowatt of new generation capacity were lower than average kilowatt capacity costs for S.P.C.[7] Since that time, new generation capacity costs have increased dramatically all over Canada due to (among other

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[7] Comment made in personal discussion with the author by D. J. Anderson, former Business Manager of the Electrical System, S.P.C.

things) escalating construction costs, higher costs of money, remaining undeveloped hydro-electric sites becoming more distant from larger population centres and more environmental protection measures.

In Saskatchewan, the Poplar River Power Project, a coal-fired thermal plant of 300 mW capacity, is expected to be completed in 1979 at an estimated cost of $150 million or $500/kW. This is nearly twice the cost of certain coal-fired thermal plants to be completed in Canada in 1976 (the later completion date, the size of the plant and the fact that Poplar River is expected to be the first of a series of plants help explain the capacity cost differences).[8]

A 300 mW addition to the Boundary Dam Power Station is expected to be completed in 1977 at a cost of $70 million or $233/kW. In the spring of 1976, the Government of Saskatchewan announced its intention to examine the social and economic feasibility of constructing a 250 mW hydroelectric station on the Saskatchewan River near Nipawin.

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[8]See the Canadian Electrical Association's figures on representative capital costs for new generation facilities in Canada during 1976 as reported in The Financial Post, (May 29, 1976), p. 91.

During 1975, 30% of the electrical energy generated in Saskatchewan came from hydro, 55% from coal, 7% from natural gas and 8% was purchased from Manitoba. Saskatchewan is estimated to have 2,238 mW of hydroelectric potential when 11 sites on the Saskatchewan River and 1 site on the Churchill River are considered. Adding this to the current installed capacity of 467 mW gives a total of 2,705 mW. Estimated coal reserves in Saskatchewan in 1976 are 5.6 billion tons. S.P.C. expects that future electrical requirements to 1990 in Saskatchewan will be met mainly through coal and hydro.

If a major switch by rural customers to electric heating took place rapidly, a large stumbling block would be a lack of sufficient capacity in the existing rural distribution system to handle the peak heating load. Saskatchewan has 64,546 pole miles of distribution lines with 14,400 volt capacity. This problem would apply most specifically to rural farm customers. Capital costs of rebuilding the distribution system would be in the tens of millions of dollars and rates would have to be raised proportionately if the principle of cost of service were to be used in assessing rates.[9]

The method used by most utilities in setting electricity rates is to apply to the rate-making authority for an amount in annual revenues which will cover operating costs plus an additional amount for amortization of investment, and a rate of return on investment. In Saskatchewan, S.P.C. prepares rates on roughly this basis for submission to Cabinet, which is the ultimate rate-setting authority. The Report of The Board of Inquiry Into The Poplar River Power Project stated that "current pricing policy requires S.P.C. to establish prices that reflect the costs of production and distribution plus a specified rate of return on investment".[10] 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 power capacity. Since rates which reflect incremental capacity costs are postponed, there will likely be, unless rates

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[9] Even without a rural electric heating trend, it may be necessary to rebuild the rural distribution system in any case due to its age.

[10] Report of The Board of Inquiry Into The Poplar River Power Project (Regina, January, 1975), p. 27.

are subsidized out of general government revenues, a necessity of large future increases in total rate revenues as electricity consumption increases.

Future electricity demand for space heating is affected by both overall increases in total revenue requirements and by the type of electrical tariff which is used. Under the current tariff, most residential customers consume all the electrical energy in the lower stages of the tariff (the first 320 kWh's) for appliances and lighting without having any space heating applications. Therefore, the customer cost of electric heating normally comes in at the run-off (lowest) price range (at present 1.8¢/kWh). Retention of the declining block tariff would tend to stimulate new electric heating installations and conversions to electric heating.

(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 before 1990. Coal has quality disadvantages and adversely affects the environment when it is burned in the urban setting. There are other heating fuel choices in the geographical areas of the province where coal heating is most common. District heating with coal is a more attractive prospect than combustion in individual residences.

As the prices of petroleum products increase and the costs of electric heating remain above the budget of some of the lower income Saskatchewan residents in the more remote areas, wood may begin to have a limited return to popularity. This would be particularly so where wood resources are locally available at a relatively low cost. A further increase in wood heating might also be influenced by use of the more efficient wood stoves and furnaces which are currently available on the market.[11]

(e) Alternate Sources of Energy

Up to this point, the main concern has been the conventional fuels of today - petroleum products, gas and electricity - but there are alternatives which might have a significant role

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[11] For a description of some of these units, see Bruce MacCallum, Environmentally Appropriate Technology (Ottawa, Environment Canada, 1976).

to play on the residential heating market within the next ten years or at least before the end of the century. Only a selected number of alternate energy sources will be discussed below. It is also assumed in this discussion that there will be no significant policy change affecting heating fuels over this period of time.

Saskatchewan receives a large amount of sunshine that could be utilized as an important supplementary or alternative source of residential heating or cooling. Sun radiation measurements undertaken by Dr. John E. Hay at Swift Current indicated that 20% - 40% of the annual heating demand of a Saskatchewan residence could be met by solar energy. The precise contribution of solar energy would be determined by the heat load of the residence, the efficiencies of the collector and the method and volume of storage.[12] The costs of most residential solar systems, including storage capacity, total between $5,500 and $30,000. Saskatchewan does receive a considerable amount of sunlight. However, one of the difficulties of solar space heating here is that the amount of

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[12] Dr. John E. Hay, "Aspects of the Radiation Climatology of Southern Saskatchewan of Relevance to Solar Energy Engineers", a paper presented to the Solar Energy Conference, University of Regina, March 26, 1976.

solar energy available per month is inversely related to space heating demands. Thus, if a reserve electric heating system were installed, nearly the same kilowatt capacity would have to be built in to meet heating requirements during the coldest day as if there had been no solar heating whatsoever. Utilities would then have high fixed costs for serving this customer but they would not receive a proportionate amount of revenue in return since load factors would be very low. Mr. Jack Wadsworth of CMHC Technology Group has proposed an alternative to this. He suggested that mini-utilities could be established for distribution of solar energy where the higher efficiencies and lower average 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.[13] The difficulty with this in a climate such as that of Saskatchewan is that it has never been either technologically or economically demonstrated that seasonal storage is feasible.

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

Solar energy is most relevant to rural and isolated residences or settlements in Saskatchewan. If optimal levels of thermal insulation are combined with other residential energy saving measures discussed above, large reductions of the necessary heating load can take place and solar energy becomes more attractive. Further heating load reductions can occur through maximum utilization of passive solar energy, possibly incorporating some storage capability for sun entering the residence through southern windows in winter months. Furthermore, back-up heating does not need to be provided by electricity but, as in the case of the Mistassini Prototype House in Ontario, efficient wood burning stoves or other sources not requiring a high fixed cost central delivery system could be used, especially in the more northern localities. If electricity is used as a back-up source, a water-to-air heat pump which utilized the solar storage could cut down on the required electrical capacity (although capital and maintenance costs of the homeowner would be much higher).

Nevertheless, current government policy does not provide many incentives for use of alternate energy sources such as solar.[14] The high capital costs of solar systems and the additional costs of reserve heating systems will likely act as a disincentive to significant use of solar systems under the current policy climate.

There is a potential within Saskatchewan for using wind energy in remote and rural localities, although a more common use of this energy is for electricity requirements apart from space heating applications. In the extreme northeast part of the province and in the Swift Current area, average wind power is relatively high, between 300 and 400 kW/square mile. This compares to an average wind speed of about 200 kW/square mile in the rest of the province.[15] The variability of wind energy, the capital costs of generating equipment and the costs and

[14] The Government of Saskatchewan has, however, decided to construct an "energy efficient residence" as a demonstration project in which solar energy will provide supplementary heating.

[15] Based on a provisional map in R. J. 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), V-3 to V-7.

inefficiencies of storage have been the impediments to widespread use of wind energy in recent years. However, if electricity is being considered for space heating in northern Saskatchewan residences where electricity has previously been generated from diesel fuel, it may be economically feasible to supplement diesel generators with large windmills. This subject has been given much recent attention by the Ontario Ministry of Energy and by Ontario Hydro and the conclusion has been that, at current Ontario diesel fuel prices, wind/diesel hybrid systems are cost-competitive with diesel power for the loads that were studied.[16]

Given the large amount of agricultural activity in Saskatchewan, it is natural to contemplate the possibility of using biomass energy to meet some future residential energy needs. "Biomass" means the weight of organisms, living or dead, which is present at any one time.

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[16] C. K. Brown and D. F. Warne, An Analysis of the Potential for Wind Energy Production in Northwestern Ontario, Proposal No. P-2062/6, (Toronto, Ontario Research Foundation, November, 1975), and Energy and Environmental Studies Department, Ontario Hydro, A Review of Large Scale Power Generation Using Windmills, Report No. 75117 (Toronto, December, 1975).

Similar weights do not mean the same amount of productive or metabolic activity or heat energy potential, however.[17] For example, an amount of straw with the same dry weight as a piece of coal will have only one-half the heat energy potential of the coal. There are a number of methods by which a high energy gas can be produced from biomass such as straw or animal wastes: heating in the presence of oxygen, heating without oxygen, or anaerobic decomposition at lower temperatures by either batch or continuous processes. Anaerobic decomposition is the most common method considered for farm use. The resulting gas is about 70% methane and 30% carbon dioxide, but the latter can be scrubbed to produce clean-burning and efficient methane, the main constituent of natural gas.

Some of the main advantages of anaerobic decomposition to produce methane are:

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

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

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

(iii) sludge produced in the digester is of considerable value as a fertilizer; and

(iv) it is readily available in locations (farms and rural areas) where heating energy supply problems are most serious in Saskatchewan.

There are, however, some impediments to the widespread use of biomass digesters at the present time, although future research may solve many of these problems. Some of the disadvantages are:

(i) capital costs of a digester, including a scrubber and storage capacity, can be high;

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

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

(iv) the biological reaction can be poisoned in a number of ways so that hydrogen sulfide gas and corrosion of the digester might result.[18]

From the results of experimental work carried out at the University of Manitoba on biomass energy production from the manure of 1,000 pigs, methane gas produced from a 6,533 cubic foot capacity digester would be 4,550 cubic feet/day or 1,661 MCF/year.[19] The 1,200 square foot residence referred to in Table 1 (see Section 2.2) required about 16 MCF of natural gas per year for space heating. Even assuming that 50% of methane production would be for heating the digester, there would be an abundance of gas for space heating of the farm residence and farm buildings from this source.

The opportunity cost of using straw for heating fuel production is the value lost in not using the straw for fertilizing land and for feeding cattle. Nevertheless, it is probably accurate to say that a surplus of straw presently

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[18] See The Biomass Energy Institute, Inc., The Renewable Biomass Energy Guidebook, (Winnipeg, March, 1974), and P. J. Catania, "Conversion of Biomass to Methane", The Potential of Solar Energy for Canada, Conference of the Solar Energy Society of Canada, Inc., (Ottawa, 1975), II-15 to II-20.

[19] Agriculture Canada, Methane Gas Production From Animal Wastes, Publication 1528, (Ottawa, 1974), p. 5.

exists beyond the requirements for non-energy use. R. C. McGinnis of the University of Manitoba claimed that, of the estimated biomass production from major crops in Western Canada in 1973, a total heating value of straw of 603.8 x 10^{12}BTU, or 25% of the petroleum requirements of Western Canada in 1973, could potentially be produced.[20]

Fuel cells can convert fuels such as natural gas, oil or coal directly into electricity by combining oxygen and hydrogen to produce an electric current and water. Efficiencies in laboratory tests have been as high as 75%. Fuel cell units are flexible in that they can be used separately or jointly and present very little environmental hazards. Maintenance requirements are few. Capital investment can be made almost immediately when added power is required. The catalyst used in the cell is expensive. Nevertheless, Hydro Quebec has estimated that there could be cost savings of 30% if fuel cells were used in remote villages instead of the conventional fuels.[21]

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

[21] For recent information on the fuel cell, see William Clark, Energy for Survival: The Alternative to Extermination (Gorden City, New York, 1975).

Fuel cells might have some possible use in remote areas of Saskatchewan.

There are other methods of fuel production which might influence the Saskatchewan residential heating market, although they would likely require larger and more centralized plants than do solar, wind and biomass. Methanol can be produced from wood and there may be a good potential for production of this fuel in Saskatchewan's North. Nevertheless, a greater value may result from allocating methanol to transportation rather than to space heating applications. Alcohol can also be made from corn stalks, cobs and husks. Research undertaken by the Saskatchewan Department of Industry and Commerce and by the Saskatchewan Science Policy Secretariat indicated that if the price for a bushel of corn were $2.00, the total cost of producing a gallon of alcohol would be 84.2¢.[22] Such subjects will receive further study at the federal-provincial industrial fermentation complex to be established in Saskatoon.

Another possibility is steam production from garbage combustion which can be used directly for space heating or for conversion to electricity (or both). By-product heat which is currently

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[22] Starch Utilization Study (Regina, May 18, 1976).

regarded as waste in thermal generation plants can also serve space heating needs. The economics of using such heat to date have indicated greater advantages for space heating use in higher density cities and for industrial or commercial heating needs. It is, however, conceivable that some multiple unit residences could be heated by waste heat or heat generated from wastes in the future in Saskatchewan.

4.3 Future Energy Consumption in Saskatchewan Residences

In the previous two chapters there was discussion of some of the important determinants of present and past energy use in Saskatchewan residences. Some of the factors which will affect the total fuel requirements for residential heating are listed below:

(a) the size of the housing stock and the average energy consumption features of residences:

(i) 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 stock of dwellings,

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

(iii) size of new dwellings,

(iv) geographical location of new dwellings (those towards the North have a greater heating load); and

(b) success of conservation measures such as:

(i) increasing thermal insulation levels in new and existing dwellings,

(ii) cutting down on heat loss through infiltration,

(iii) lowering thermostats,

(iv) construction of more energy efficient residences by developers,

(v) maintenance and use of more efficient burner units,

(vi) more energy conservation-minded urban planning induced by a co-operative effort of all levels of government and the public.

In examining these factors in somewhat more detail, there are good reasons to believe that net increases in the present stock of dwellings will occur during the short-term future at least.[23] Two of these reasons are:

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[23] This does not imply an increasing population rate. Increases in the housing stock can be expected even when some of the Statistics Canada population projections showing either stable or slightly declining population in Saskatchewan are assumed. Of course, different results would occur with a more pessimistic projection such as a population decline by 20% or 50%.

(a) the "crowding index" is expected to decline by 13% between 1974 and 1985;[24] and

(b) world demand for agricultural products and the fact that agricultural productivity gains have been larger than in any other sector in recent years, would indicate that per capita income of Saskatchewan residents will be relatively high, allowing for more investment in housing.[25]

The increasing price of land will have an effect upon the size and design type of dwellings. In the larger urban locations, demand for residential land and land taxes are higher than in rural locations. Thus, new dwelling sizes may be somewhat smaller and more multi-unit dwellings constructed on average in urban as compared to rural locations. Real price increases of heating fuel may also have some influence in reducing residence size and in increasing proportions of multi-unit dwellings constructed. Nevertheless, as indicated in Chapter III (Section 3.9), the proportion

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[24] Prediction of the Economic Council of Canada, Options of Growth, (the Twelfth Annual Review of the Economic Council of Canada, Ottawa, 1975). The crowding index is defined as the number of persons per room, and had declinded from .64 to .61 between 1971 and 1974.

[25] However, by late 1976, international markets for agricultural commodities did not appear as favourable for the Saskatchewan economy as had been the case over the previous 2 or 3 years.

of single detached dwellings out of total residential completions in Saskatchewan did not decline from 1971 to 1975 and so the transition to more energy efficient dwelling designs may be very gradual given present trends and policies.

The rate of resource development and construction of processing plants in northern Saskatchewan will influence the quantity of dwellings which will consume heating fuel in the North. These residences will have greater heating loads than similar residences in more southern locations. Transmission losses may also be greater in the North if, for example, electricity is used to heat these residences and the distance from the generation facility to the residence is great.

Conservation measures could reduce the heat energy requirements of a new dwelling by 50% - 70% and that of an average existing dwelling by 20% - 50%. Some of the measures for reducing energy used in the residence were discussed in Chapter II but a more complete list appears below. In construction of new houses in the future, insulation levels can be increased to an optimal level with 2" by 6" studs or by use of plastic sheathing on the wall exterior (although this latter measure has been regarded as causing moisture retention within walls on some occasion). Weatherstripping and caulking can be used to reduce the number of air changes to an optimal level, although enough ventilation must be allowed to prevent damage to walls and insulation by moisture. Windows can be double or triple glazed. The houses should be orientated so that one of its long sides is facing south and, on this side, window space is maximized so that advantages can be taken of the lower southern path of the sun in winter.[26] In summer, the overhang will prevent the sun from overheating the residence. On all other sides of the residence, window space should be minimized. Coniferous trees could be planted on the long north side to act as a wind break during winter and, on the south side, deciduous trees will provide shade in summer while allowing the sun to strike the building in winter. The cost of trees would have to be assessed against the energy savings and the aesthetic value they represent to the residence owner. If care is taken to install the correct size heating unit within the residence and that it is properly adjusted, some energy will also be saved in this way.

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[26] The National Research Council has been examining the net impact of windows on dwellings in terms of heat loss through conduction and reduction and heat gain by solar radiation. Although the final results have not as yet been made public, one of the conclusions will be that double or triple-glazed windows facing south, or 45° from south, wind up with a net heat gain. ASHRAE uses only a thermal conduction (U) value for window space in heat loss calculations.

There is less which can be done to make existing dwellings as energy efficient as dwellings in the process of being constructed. Nevertheless, the owner can add insulation to his ceiling and basement walls, and can have insulation blown into the exterior walls. At more expense, single-glazed windows can be double or triple-glazed. Doors and windows can be weatherstripped. Trees could be planted in the same manner as in the new dwelling. The furnace can be maintained and the thermostat lowered.

Without any significant future policy changes, the success of residential heating fuel conservation within the province will depend upon a number of incentives, including the following:

(a) <u>The Price Incentive</u>

As the price of fuel climbs relative to the cost of insulation and other conservation measures, it will become more attractive for the consumer to invest now in reducing heating requirements and receive future reductions in his heating bill. At the present time this incentive already exists but anticipated fuel price increases in the future will strengthen this incentive.

(b) The Average Income of the Consumer

Income would appear to have a two-sided impact on the action of consumers in regard to residential conservation of heating energy. On the one hand, if the consumer's income is very low, particularly in older residences, the first cost of increasing insulation and other conservation measures may be prohibitive even though energy cost savings would result over the long term. On the other hand, if per capita incomes are very high and expenditures on residential heating are not a very significant part of the consumer's budget, then heating decisions will not be a priority item among other decisions. Unless the consumer is very conscious of the substantial savings which will occur on a life cycle basis due to reduction of heating load, he may not acquire enough incentive to make the initial investments.

In the short-term future in Saskatchewan, it appears that per capita incomes will be reasonably high relative to the rest of the country because of the strength of the province's agricultural production. Funds should be available for residential conservation investment, therefore, but actual investment levels (without a government incentive program) will depend upon the degree of public awareness of the merits of conserving energy.

(c) Building Standards

At the present time there is no requirement within the Building Code of Canada concerning the thermal insulation of dwellings or, indeed, relating to any other matters than the stability of the structure and protection from fire. The matter is under consideration and it is thought that a supplement to the Building Code could be issued dealing with insulation. In the meantime, Ontario and Alberta have issued their own Codes and Manitoba and Saskatchewan are considering the possibility of taking a similar step. Undoubtedly, building codes would 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 other measures than increasing thermal insulation to save on energy used for heating (see above);

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

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

4.4 Summary of Chapter IV

Chapter IV considers the market shares and total consumption of residential heating fuels over the short-term future, assuming no significant policy changes by the Saskatchewan Government in this area.

It appears that the considerable cost advantage of natural gas will continue for some time in communities which are connected to the natural gas system and that new gas installations will also continue here. Nevertheless, the price of natural gas can be expected to increase in future due, in large part, to rising prices for Alberta imports which have a substantial impact on S.P.C. costs. Saskatchewan's natural gas prices may also be affected by national price increases which are due mainly to the high costs of bringing in frontier supplies and the policy of the federal government to gradually increase natural gas prices on a BTU equivalency basis towards international oil prices.

A continuing price and quality disadvantage of heating oil and kerosene will greatly inhibit new heating installations of these fuels. Conversions to alternates can be expected but it is likely that a number of older or lower-income residence owners in rural areas will not be willing or able to invest in conversions. Propane is likely to be used in a considerable number of mobile homes in the future where lower cost substitutes are often not available.

Electric heating of residences is more relevant to rural locations than it is in areas currently served by the natural gas system. The future rate of electric usage for heating is largely dependent upon its price. If consumption of electricity substantially rises 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 (assuming that the present policy of pricing at average costs of production is followed). Since this will push rates upwards, it will tend to slow the growth of new electric heating installations. However, a force which will accelerate electric heating is the type of pricing schedule (the declining block tariff). Since electric heating will normally come 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. However, wood heating may stabilize at its present level or increase in areas where it is readily available and as the cost of other heating fuels increase.

Alternate sources of residential energy such as solar, wind, biomass, waste heat capture, etc., may have some use as the cost of the more conventional fuels increase. Nevertheless, the high capital costs of collectors, plants, storage and supplementary energy are impediments to the wide usage of these sources of supply. Many technical and economic unknowns are associated with renewable energy sources. Present policy does not provide incentives for residential heating through such methods.

The total amount of energy consumed for residential space heating in the future will depend upon the size, the design and area characteristics and the location of the housing stock, as well as conservation measures undertaken by homeowners. Assuming that there will not be a major population decrease, the total stock of dwellings in Saskatchewan can be expected to increase as the crowding index declines and as investment by Saskatchewan consumers in housing increases. The increasing price of land, particularly in urban centres, will tend to reduce dwelling size and to increase the proportion of multi-unit dwellings in new construction. However, the consistent high percentage of single detached dwellings out of total new residential construction in Saskatchewan indicates that the change in design types will be very gradual.

Development of Saskatchewan's North where residences require greater heating loads will be an upward influence on total residential fuel consumption.

With no significant policy changes, fuel conservation investments will depend for the most part upon the extent of cost saving incentives for residence owners as heating fuel prices rise. The average income available for investment in conservation and the application of building standards (which are currently being discussed) will also influence heating fuel conservation in the residence.

CHAPTER V

POLICY ALTERNATIVES

5.1 Objectives and Qualifications Regarding Chapter V

This chapter discusses the advantages and disadvantages of alternative policy directions in regard 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. National and international uncertainties are serious impediments to the recommendation policies in the future. Political uncertainties are one of the most serious impediments to the recommendation of policy at the provincial level, particularly in regard to energy. There must be recognition of the fact that uncertain international and national events, which are out of control of the province's sphere of influence, will affect energy supply and demand within the province, as well as influencing other aspects of the provincial economy. Nevertheless, the author believes that there is a present need for clear and concise provincial energy policies which also possess, at the same time, a necessary degree of flexibility.

The policy alternatives listed are not intended to be exclusive and, in fact, the Government of Saskatchewan may regard alternatives as being more general or more detailed than those listed here. Nevertheless, in light of the discussion in the previous four chapters of this report, the distinctions made here among general policy directions appeared to be meaningful.

Allocation and conservation policy alternatives are kept separate, but it should be noted that these areas are interrelated. The economic and technical feasibility, for example, of using energy sources such as solar energy for residential heating is dependent upon the average residence heat load required which is, in turn, influenced by conservation measures.

5.2 Allocation Policy Alternative One: No Significant Policy Changes

Future allocation under this alternative was discussed in Chapter IV.

Relative prices of heating fuel would change, but natural gas would remain the lowest-cost fuel (except for wood and coal) for at least five or ten years. The gas system would not be extended to new communities, but new subdivisions would be connected in communities which are already part of the system.

There would be a gradual movement towards electric heating in rural (non-gas distribution) areas, the rate of which would depend upon relative fuel prices, the availability of funds for investment in conversion, and the increase in the housing stock.

The use of oil, kerosene and propane for heating would decline at a slow to moderate rate.

(a) <u>Advantages of Allocation Policy Alternative One</u>

Saskatchewan has substantial reserves of coal for generating the electricity required for increased electric heating. Electric heating growth would likely be slow enough to provide the lead time necessary for capacity expansion of both generation and distribution. In addition, it would be easier and less expensive for S.P.C. to provide electricity for space heating rather than has been the experience with residential electricity supplied for other home appliances since daily heating load factors are more even (in spite of the fact that residential heating would add to the seasonal peak).

A gradual transition to electric heating in rural areas and 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 term period as might occur in the case of 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 large quantities of natural gas would continue to be consumed in residential heating. The opportunity cost of using gas for this purpose is not having it available for consumption at a later date and not being able to use it in certain industries where its productive value may be higher. If supplies of natural gas diminish in the future and then it becomes necessary to switch to an alternative, more abundant fuel, there may be social and economic dislocations associated with this rapid conversion.

The declining block tariff used for electricity pricing can result in misallocation of resources in the Saskatchewan economy. Economic theory shows that prices must approximate marginal production costs if resources are to be optimally allocated. An optimal marginal cost pricing structure means that "the cost to any consumer of changing the level or pattern of his consumption equals the cost to the electricity supply industry of his doing so".[1] Retention of the declining block tariff means that marginal cost pricing is not approximated. The cost of electric heating comes in at the lowest price 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 S.P.C., revenues from rates will have to be raised. Assuming that a declining block tariff similar to that used at present 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

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

for the electricity they consume in the higher price blocks of the tariff. Heating customers, on the other hand, will not have a strong incentive to conserve electricity since the incremental kWh's they consume will be at constant costs. The declining block tariff, under the above circumstances, can be regarded as a type of income redistribution from non-electric heating customers to electric heating customers of S.P.C.[2]

Reasonably large quantities of kerosene and light fuel oil would continue to be used under this policy alternative. An important opportunity cost associated with using petroleum products for space heating is the value foregone in not being able to use them as fuel in agriculture or in transportation at a later date. There does not appear to be any petroleum substitutes in agricultural production which are economically or technically feasible at present. Saskatchewan also has a much less densely distributed population than most other provinces

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[2] This consequence may or may not be considered as a disadvantage. It is listed as a disadvantage here because the Poplar River Project Study Board claimed that S.P.C. should not be expected to play a significant role in income redistribution in the province. See Report of The Board of Inquiry Into The Poplar River Power Project, (Regina, January, 1975), p. 28.

in Canada. Intercommunity transportation will contribute to a high non-substitutable demand for petroleum in future transportation.[3]

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 in their residence or to know when to convert to a different fuel type. In new residences it will often be the builder who makes the fuel choice and his decision will more often be with lowest first cost rather than lowest life cycle owning and operating costs.

5.3 Allocation Policy Alternative Two: Electric Heating in Non-Gas Distribution Areas

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

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[3] The economics of substitution away from petroleum use in transportation appear to be more favourable in areas of greater urban densities than Saskatchewan. In large urban areas electrification of fixed path transportation and use of more efficient storage batteries in powering electric private vehicles may become feasible in the future.

existing gas system to new subdivisions would be halted.

(a) Advantages of Allocation Policy Alternative Two

More petroleum products and liquified petroleum gases would be saved for future use or for allocation to agriculture or transportation.

The growth in consumption of natural gas for residential heating would be slowed down or stopped, permitting supplies of this fuel to be available for future use in the residential or in other sectors.

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

Since S.P.C. would distribute electricity for this purpose, it will be easier to regulate prices so that they will be in line with other government objectives when this is desirable.

(b) Disadvantages of Allocation Policy Alternative Two

A rapid transition to electric heating in non-gas areas would necessitate additional generation and distribution capacity. The lead time required (about five years in the case of coal thermal plants) from the initial planning stage to the installed capacity might make this policy difficult to achieve over the short term. Capital requirements for new generation capacity and for rebuilding the rural distribution system to handle the much-increased electric load would also be very large.[4]

Electricity rates would have to rise as capacity expands if S.P.C. is to meet its total revenue requirements. The Government of Saskatchewan could adopt one out of several

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[4] A means of slowing down peak demand attributable to electric heating might be to make the use of off-peak furnaces an economic proposition to rural customers. S.P.C. has a patent on such a furnace, but as yet no Canadian manufacturer has been found to make this furnace available to the public. However, certain limitations to their widespread use exist:

(a) off-peak furnaces would not conserve energy and, in Saskatchewan, where much of the power is thermally generated, not as great an advantage would result as in provinces where base load nuclear or hydro generation predominated;

(b) capital costs ($3,500 and upwards) of off-peak furnaces would not be competitive with capital costs of conventional heating units although, as a rural line's capacity is approached, the installation of a few off-peak units may be the lowest cost solution overall; and

(c) there is a limit to staging of off-peak furnaces since they need to be turned on for about 8 hours per day.

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 (i.e., a low run-off rate for electricity), non-electric heating customers of S.P.C. 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 decide to give direct subsidies to rural electric heating customers or to keep down rates by financing S.P.C.'s capacity expansions out of general government revenues.

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

Also associated with rapid electric capacity expansion are potentially adverse environmental impacts such as the following:

- -- environmental damage through strip-mining
- -- air and water pollution
- -- flooding of biologically productive valleys
- -- land and wildlife habitat damage through construction of electric transmission corridors

5.4 Allocation Policy Alternative Three: Diversified Allocation

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

Allocation decisions would be made following a study which examined in detail the lowest heating cost methods which will result over a 10 or 15 year period for different groups of residences. Departments and agencies such as S.P.C., the Saskatchewan Housing Corporation (S.H.C.), Saskatchewan Department of Mineral Resources (D.M.R.), the Saskatchewan Research Council (S.R.C.), and Planning and Research, Executive Council, could be involved in such a study. The study would:

(1) Categorize Saskatchewan residences along such lines as existing heating fuel, urban or rural, distance from generation facilities or fuel distribution centre, heating load, density of other residences at immediate and intermediate distances, etc.

(2) Examine various fuels and determine which ones would be lowest cost over a 10 or 15 year period based on shadow prices[5] of fuel and appropriate interest rates. All energy sources, including renewable energy, would be considered.

(3) Develop a plan for fuel allocation based on heating costs, but also with consideration of any social, economic, environmental, or administrative constraints which might apply. Public discussion of the plan could be beneficial at this stage. Allocation policy would also be co-ordinated with other important policy considerations such as rural revitalization. The more experimental fuels may require the use of pilot projects before decisions can be made in regard to them.

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[5] Shadow prices, as the term is used here, means that prices would be based on long-run incremental production costs (thus, taking account of resource scarcity) and the premium qualities of various heating fuels.

(a) <u>Advantages of Allocation Policy Alternative Three</u>

The policy would consider all alternatives and come up with conclusions which are much more economically, socially and environmentally sound over a longer term period.

Co-ordination with other government policy initiatives is more feasible under this alternative.

There would also be more scope for public involvement in decision-making, hopefully leading to a greater public understanding of the necessity of fuel price increases and a greater realization of the importance of making the right decisions about the heating systems in the residence.

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

Diversified allocation would be more complex to administer than would be the case if the large majority of heating requirements were filled by electricity and natural gas supplied by S.P.C.

The study would be costly and require a considerable amount of time before recommendations are formulated. Consumer fuel choices may continue in the meantime which result in overall economic inefficiency and in inequitable annual heating costs for the consumer.

Since pilot projects would likely be required to assess the use of heating sources such as solar and biomass, it would be some time before these could significantly influence the residential heating market.

It may also be difficult to determine shadow prices, appropriate interest rates and to collect the necessary housing characteristics to be used in such a study.

Feasible alternatives for the second major component of a residential heating policy -- conservation -- will now be outlined.

5.5 Conservation Policy Alternative One: No Significant Policy Changes

With this policy alternative, increasing fuel prices would be considered a sufficient incentive to induce the existing residence owner to undertake or to invest in conservation measures. Fuel prices would not, however, be specifically designed to encourage conservation in various portions of the heating fuel market. It would also be assumed that buyers of new residences would become more interested in energy efficient designs and in increased insulation levels as fuel costs become a larger part of annual income.

(a) Advantages of Conservation Policy Alternative One

As demonstrated in Chapter II, a strong financial incentive already exists in Saskatchewan to greatly increase insulation of existing houses and houses under construction and to opt for other energy conservation features in the residence. Consumers will become more aware of this incentive as heating fuels annually increase in price at a rate higher than average annual personal income increases.

Another advantage is that the administrative costs of a conservation program for residential heating can be avoided or lowered considerably if market prices of fuels are relied upon as the key incentive for conservation. In addition, the consumer is completely free to make whatever amount of investment (including no investment whatsoever) he wishes in conservation features of his home and heating system.

(b) Disadvantages of Conservation Policy Alternative One

Many consumers are not at the present time aware of the fuel cost savings they can achieve through increasing insulation and undertaking other conservation measures in the home. Therefore, the fuel cost incentive itself will not likely induce a very rapid response in consumer selection of optimum insulation and efficient design features in new residences or in re-insulation activities by owners of older residences. Heating fuel will continue to be wasted during at least the short-term future.

Furthermore, incentives based on future operating cost savings will be effective only insofar as it is the owner of a residence who can make decisions about conservation features at the time the residence is being constructed. If the practice continues whereby the builder, whose main interest is the sales potential and the first cost of a residence, makes a large proportion of the decisions about conservation features, then new houses are not likely to approach optimum heating efficiency.

5.6 Conservation Policy Alternative Two: Financial Incentives, Intensive Advertising and a Consulting Service

Under this policy alternative, low cost loans which could be paid back by installments on the monthly electrical bill could be provided for increasing insulation. Alternatively, homeowner grants could be used for this purpose. In addition, advertising would highlight the benefits of residential conservation measures of all types.

A counselling service in S.P.C. or in another government agency or department could advise individual homeowners on appropriate conservation measures for their type of residence and expected costs.

(a) <u>Advantages of Conservation Policy Alternative Two</u>

A substantial reduction in heating fuel requirements of existing residences could occur as re-insulation activities and other measures such as double or triple-glazing of windows made possible through homeowner grants or loans proceeded. Because of counselling and advertising, public awareness of savings through conservation could make house buyers demand new residences which are more energy efficient; builders could respond to these consumer demands in designing new residences.

In addition, residence owners would have an incentive to design their own home conservation plans in order to qualify for loans or grants resulting in the reduction of operating costs of their heating systems. Counsellors could assist in the design of conservation plans.

Consumers could save on operating costs while some fuel supplies (which otherwise would have been consumed) could be saved for future use in the residential or in other sectors. Not as much investment by S.P.C. would have to be made in increasing the capacity of the distribution system where electricity heating is being used.

(b) Disadvantages of Conservation Policy Alternative Two

If loans or grants were made available to all residence owners in the province, the costs of such a program might be very large. Heavy administrative costs for residential inspections and counselling could also be a considerable disadvantage. If S.P.C. were to administer this program it may lead to financial problems for S.P.C. over the short run.

Care would also be required to ensure that loans or grants were large enough to make an effective difference in the amount of re-insulation activities and in the adoption of other conservation measures by consumers in the province. In other words, low cost loans or grants should not simply subsidize homeowners who would have invested in conservation measures in the absence of the incentives provided by the program. The planning and administration of the program could, therefore, be a complex matter if its fuel conservation objectives are to be effectively achieved.

5.7 Conservation Policy Alternative Three: Reliance on Legislation and Standards

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

Assuming that the Building Code of Canada will, in the near future, incorporate some thermal efficiency requirements for residential buildings, Saskatchewan could decide to enforce the Code throughout the province. Alternatively, Saskatchewan could develop its own building code or separately legislate specific thermal efficiency requirements for new construction. In fact, the possibility of establishing a provincial building code was being discussed by departments and agencies of the Government of Saskatchewan in 1976.

(a) Advantages of Conservation Policy Alternative Three

This is the most effective measure that could be taken to ensure that residences to be constructed will be more energy efficient. Codes could also be designed to reflect an informed viewpoint of the majority of new house buyers on the incremental amounts they would be willing and able to pay for increased energy efficiency of the residence - this would resolve the problem discussed earlier of the lack of effective communication between the house buyer and the builder.

Regardless of any other conservation program implemented, the Government of Saskatchewan should contemplate introducing a code for new residential construction with a thermal efficiency component.

(b) Disadvantages of Conservation Policy Alternative Three

There are a number of disadvantages to a policy alternative where conservation is made dependent upon standards or legislation to the exclusion of other program initiatives.

Standards would not likely apply to existing houses. Many rural residents of Saskatchewan live in older homes, where heating costs are a substantial burden. A policy dependent on standards would not, therefore, help equalize annual heating costs in the province.

In addition, consumers would not have a personal incentive to conserve energy under this policy alternative. Given the precedents for such standards elsewhere (i.e., Ontario), it would also be unlikely that conservation features such as the orientation of the residence, amount and direction of window space, tree shelter, etc., would be included in building standards.

The inspection cost of residences under construction is also a factor to be considered in implementing a building code.

5.8 Conclusion to Chapter V

Chapters I to IV of the practicum demonstrate that there are large benefits for both the individual heating fuel consumer and for the Province of Saskatchewan as a whole if heating fuels are judiciously selected by consumers, efficiently and equitably allocated by government, and if consumers are induced to conservatively use these fuels. Chapter V discusses the advantages and disadvantages of three feasible policy alternatives for each of the allocation and conservation components of a comprehensive residential heating policy.

It is to be noted that the policy alternatives are not intended to be exclusive of each other. It does appear, however, that the difference of emphasis embodied in each of the various policy alternatives is a useful method of discussing the parameters of decision-making in this complex area. Obviously, more detailed analysis of alternatives is required before a policy decision can be made by the Government of Saskatchewan.

Regardless of what decisions are made, residential heating is certain to become a greater public issue in the future than it has been in the past. It is fortunate that many options to meet future requirements and to reduce waste are available.

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 °F difference between 65°F and the mean temperature for the 24-hour day when the latter is below 65°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°F (70°F indoor, -30°F outdoor).

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 outside or inside the building (i.e., entrance is not through someone else's living quarters).

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

Household: 1971 <u>Census</u> definition used, where a household consists of a person or 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.

Price Elasticity: The percentage change in quantity demanded of a good resulting from a 1% change in the price of the good.

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 - replacements = 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, 1966, 1961 Census definitions): 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 where population 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 occurred 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°F. The resistance (R) is the reciprocal of thermal conductivity (U).

Abbreviations

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

BCF: Billions of cubic feet

BTU: British Thermal Units

CMHC: Central Mortgage and Housing Corporation

CSA: Canadian Standards Association

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

R: Thermal resistance

SPC: Saskatchewan Power Corporation

U: Thermal conductivity

APPENDIX B

APPENDIX TO CHAPTER II

B.1 Assumptions Used in the Derivation of Table 1, Section 2.2

House Size	- 1,200 square foot bungalow
Thermal Resistance Values[1]	- walls R12 - ceiling R20 - basement walls R7
Location	- Regina rural (10800 degree days)
Design Temperature Differences	- 100°F
Not Included	- Ancillary costs such as fan operation and storage tank rentals are not included in estimates

The Business Division of the Electrical System, S.P.C., provided both prices and annual heating cost estimates that are used in Section 2.2. The following formula adapted from C.S.A. C273.1-1971, Planning Guide for Residential Electric Heating was used by S.P.C. in calculating annual heating costs:

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[1] Levels presently recommended by the Canadian Standards Association, Planning Guide for Electric Heating, C273.1-1971. At the time of writing this report, a revision of this document with higher levels of insulation was expected in the near future.

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 heat gain and ambient heat gain. S.P.C. generally uses a C value of 18.

Relative annual costs of oil and electric heating were different in the S.P.C. calculations than they turned out to be when the author applied the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) formulae in Section 2.9 of this report. In the latter case, oil heating costs were relatively higher than electric heating costs.

Conversions used in Table 1 are as follows: 1 million BTU's = 6 gallons of heating oil = 9 gallons of propane = 293 kilowatt hours = 1 MCF of natural gas.

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 residence heat loss calculations.

Some articles have argued that heat utilization efficiency for natural gas systems are as low as 40% while oil furnaces are 5% to 10% lower than this.[2] In other cases, it is assumed that overall heating efficiencies of gas or oil furnaces can be as high as 75%.[3] The 40% to 70% range included in Table 1 is where estimates usually appear. In heat loss calculations used further on in the report, a 60% efficiency of utilization is assumed for 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.

B.2 Assumptions of Section 2.5

To derive typical expenditures on heating fuels, the author had to make some assumptions about the average size of dwellings that would be owned by individuals of various income levels. Larger dwellings, of course, have higher heating loads if the same amount of insulation is present in both. Unfortunately, the author was unable to locate any survey data to relate

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[2] See Paul H. Rickert, "The True Facts About Flame Heating System Efficiencies", Electric Heating Journal; and R. L. Dunning, "Furnace-Efficiency Variations Explained", Electrical World, (February 1, 1974), pp. 60-62.

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

these two variables. The alternatives then were to forego this type of analysis, to make some guesses about house size as related to income, or to correlate house size with its market value (where income information is available). The latter alternative was chosen. It should be recognized, however, that annual heating costs are very approximate.

1971 Census data was consulted for the relationship of average income of household head to value of dwelling during 1970.[4] These figures were then projected to 1976 assuming an average annual increase in average income of 10% and an annual increase in the value of the dwelling of 15%. It was then assumed that, over a range of 8 increasing income averages, houses would increase by roughly 150 feet for each income level. Sizes were estimated by judging that the value of a new 1,200 square foot dwelling (of Table 1) would be closer to a 1976 mean value of $48,700 than it would be to $36,500 or $67,000. A head of household - house size curve was then plotted (see Figure B-1).

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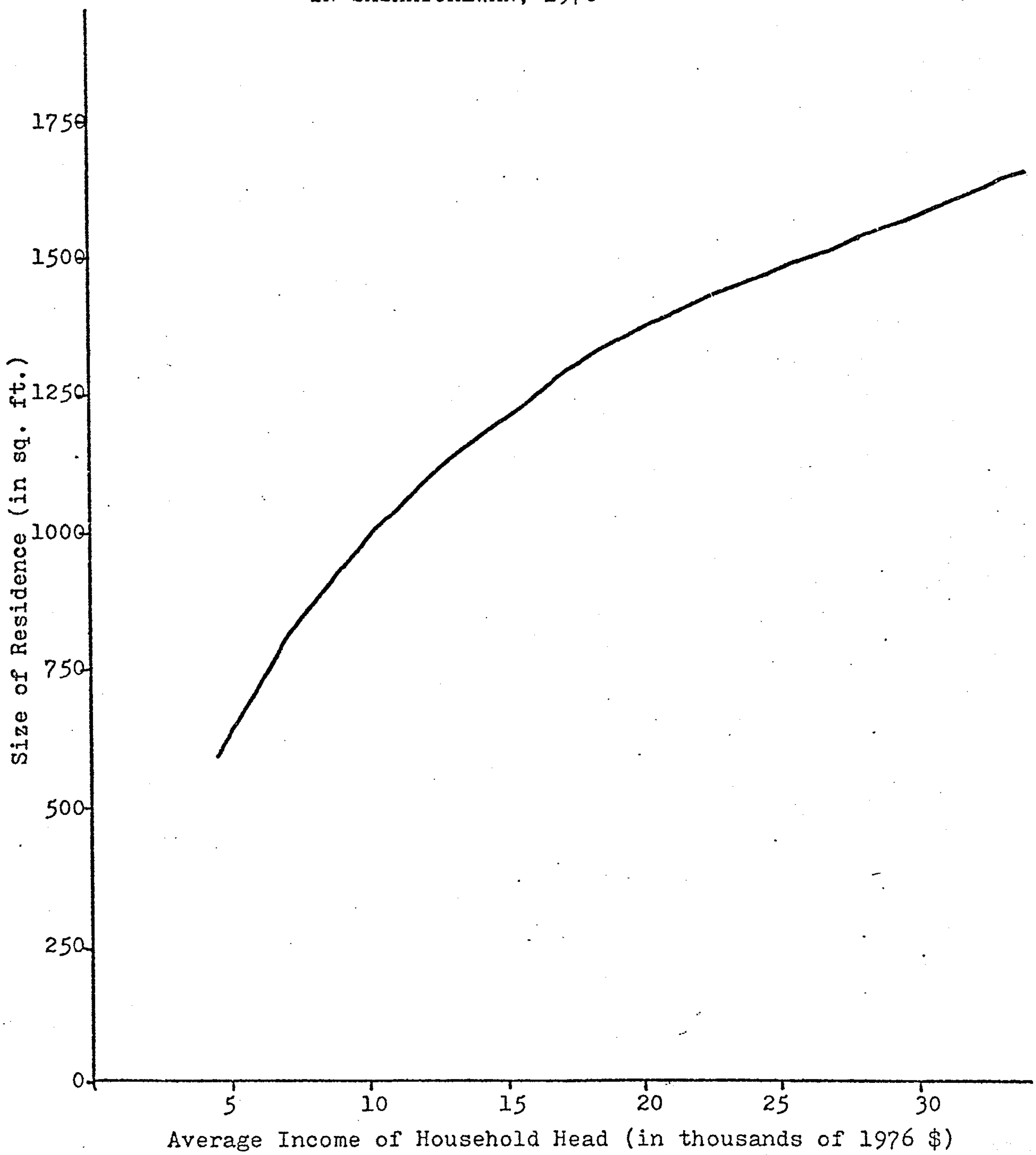
[4] Statistics Canada, Households: Incomes of Household Heads Showing Dwelling Characteristics, 1971 Census of Canada, 93-711, Vol. II, Part 1, (Bulletin 2.1-11), p. 79-5.

FIGURE B-1

ESTIMATED SIZE OF RESIDENCE BY
AVERAGE INCOME OF HOUSEHOLD HEAD
IN SASKATCHEWAN, 1976



It was estimated that 7.5 million BTU's would be required to heat each additional 100 square feet as the residence size increased upwards from 500 square feet.[5] Heating costs were then based on Table 1, with prices as of September 1, 1976, 100% efficiency for electric heating, and 60% efficiency for heating with oil or gas.

B.3 Assumptions of Section 2.6

No reliable data was available on the average cost of installed gas heating systems for different sizes of houses. The Saskatchewan Housing Corporation provided one cost estimate which they believed was a 1976 competitive price for a 1,064 square foot residence. On the basis of this estimate, it was assumed that an installed gas furnace in a 1,200 square foot house would cost $1,100 and that for each house size by 100 foot increments larger, the capital cost would be an additional $100. Houses smaller than 1,200 square feet would have capital costs for installed gas furnaces that decreased by $100 per 100 square feet up to a minimum of $800. These estimates were regarded as sufficient for derivation of typical costs since an error of $100 in the $1,100 estimate for the 1,200 square foot house,

[5] In Section 2.12, a figure of 6 million BTU's for each additional 100 square feet is estimated, but the house used as an example in Section 2.12 had R7 more insulation in the ceiling than does the house in this example (accounts for the higher figure here).

for example, would only result in a 3% error in total annual heating costs and only a 0.1% error in the final graphed as a percentage of income figure.

The same estimated house sizes as used in Section 2.5 (see B.2) for a range of income from $5,000 to $20,000 were used in this section. Capital costs for the installed gas heating system in 1976 dollars were determined for each case. Annual capital costs were then determined for the heating system by multiplying by the capital recovery factor which involved a 10% interest rate over a 16-year period of time (the ASHRAE minimum depreciation period for gas furnaces). Added to annual cost was a charge of $20 for the furnace fan and ventilation and a $10 charge for maintenance of the system (it was assumed that these costs would remain constant in 1976 dollars to 1990).

To get the final figure that was graphed (% of income), the levelized annual total cost (composed of capital cost plus furnace fan and ventilation plus maintenance) for each income level was added to annual fuel costs for each income level (derived in Section B.2) that increase upwards at rates of either 2% or 6% annually. It is assumed that income stays constant in 1976 dollars to 1990.

B.4 On Adapting the HUDAC Heat Loss Figures to the Regina Rural Area (Section 2.8)

The table below is a comparison of thermal resistances, air change rates and hourly heat losses of a bungalow with 1,080 square feet of gross liveable 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 for 1976 by HUDAC.

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

	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/°F/hour	295 BTU/°F/hour
Heat Loss at 72°F Temperature Difference (TD)	42,624 BTUh or 12.49 kWh	21,240 BTUh or 6.22 kWh

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

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

$$F = U \times HL \times D \times C_f$$

where:

F = annual fuel consumption

U = quantity of fuel used per degree day

HL = heat loss at the design temperature per hour

D = annual degree days

C_f = temperature correction factor[6]

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

TYPICAL COSTS UNTIL 1975

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
C_f = .768	C_f = .768
F = 2022.3 therms = 202.2 MCF	F = 1431.8 gallons
Cost @ $1.66/MCF = $335.70	Cost @ $.45/gallon = $644.31

[6] See ASHRAE, 1973 Systems Handbook.

ASHRAE does not give factors for 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 propane consumption on the typical residence up to 1975 is 1431.8 x 1.42 = 2,033.16 gallons. The annual cost at $.41/gallon is $833.60.

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

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

Electricity - Typical Until 1975

HL = 12.49 kWh
D = 10,800
C = 18
TD = 100°

F(kWh) = 24280.6 kWh

Cost @ $.018/kWh = $437.05

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 the above table in the equations used here. The final results then appear in Table 4 of Section 2.9

B.5 Formula for Determining Optimal Insulation Levels (Section 2.9)

A paper of January, 1976, by Dr. D. G. Stephenson of the National Research Council[7] gives a formula for determining optimal levels of thermal resistance:

$$R_{opt} = \sqrt{\frac{C \cdot P_f \cdot D \cdot P_w}{B \cdot E}}$$

where:

- C = constant used in degree day calculations
- P_f = price of fuel
- D = degree days
- E = efficiency of heating system
- P_w = 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 thermal resistances to the increase in the price of fuel over a payback period. Dr. Stephenson uses an interest rate on insulation investment of 10%, an annual increase in the price of heating fuel (electricity) of 12% (partly inflation and partly real increase), and a payback period

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

of 30 years. Under these circumstances, $P_w = 40.1$.[8] Althouth P_w varies slightly for all fuels because expected price increases are not the same, 40 is used throughout in order to be conservative.

Table B-a shows the application of the formula using prices and degree days which are appropriate for a residence in the Regina rural area.

TABLE B-a

OPTIMUM THERMAL RESISTANCE LEVELS IN THE REGINA RURAL AREA (FREE SPACE)

	Natural Gas	Oil	Propane	Electricity
C	18	18	18	18
P_f (C/BTU) (from Table 1)	.000166	.00027	.00037	.00053
D	10,800	10,800	10,800	10,800
P_w	40	40	40	40
B (¢)	1.3	1.3	1.3	1.3
E	.60	.60	.60	1
R_{opt}	40.68	51.88	60.73	56.30

The optimum thermal resistance levels (R_{opt}) are then placed in Table 5 of Section 2.10.

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

APPENDIX C

APPENDIX TO CHAPTER III

C.1 Background Information to Section 3.7

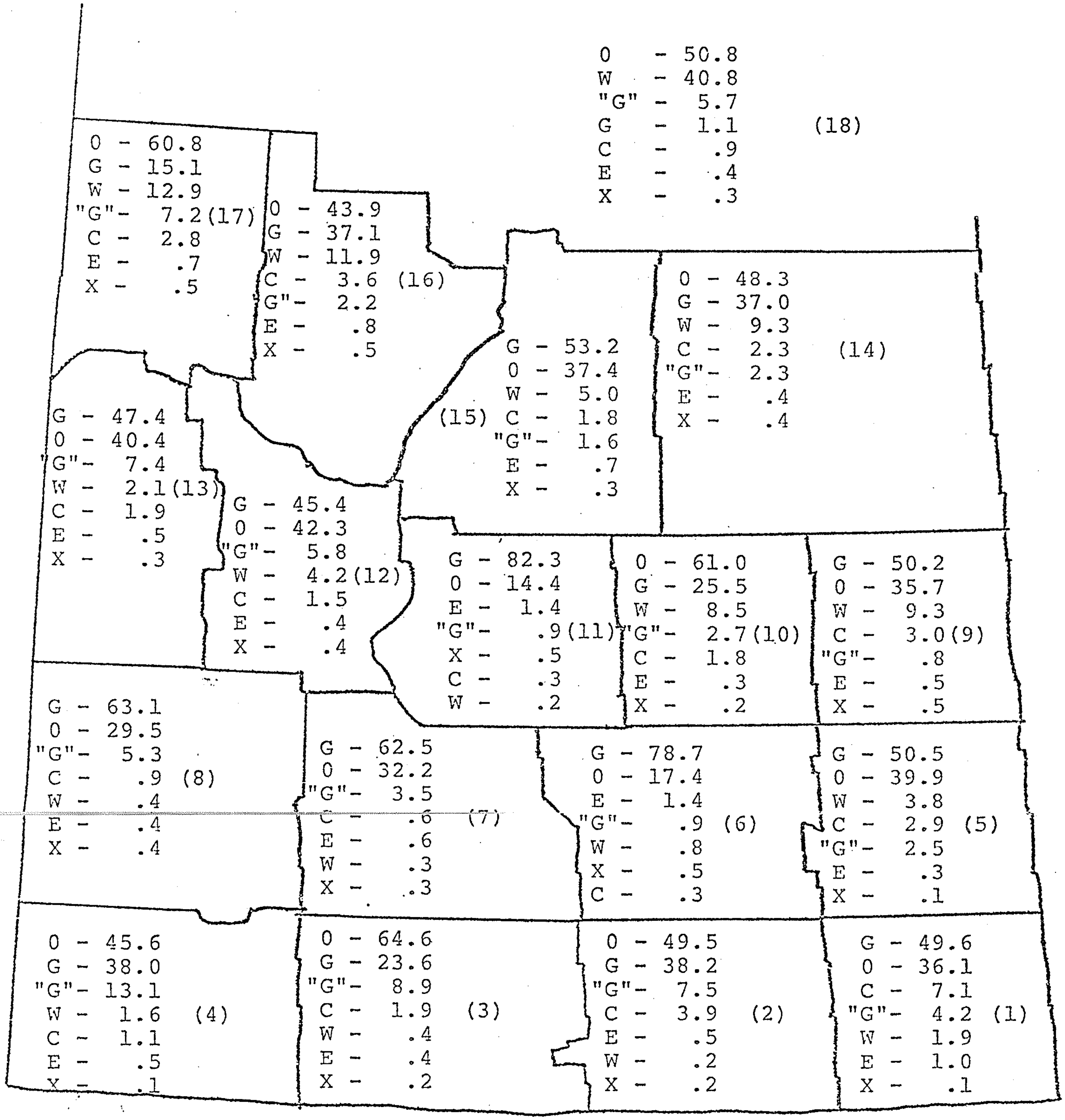
Figure C-1 is a census division map for the 1971 *Census* upon which are superimposed percentages of principal heating fuels used in each census division at that time.

There has been some reason to doubt the accuracy of this information, particularly in regard to estimates of oil, wood, electricity and coal use (in some cases the estimates are too large). Mr. Frank Showell of the Saskatchewan Power Corporation has contacted the officials responsible for the *Census*, and it has been admitted that some of the estimates are incorrect.

For the purposes of this report, the general geographical features of fuel use rather than a precise list of the number of fuel users will suffice. The author assumed that this data would serve a useful purpose even though it lacked precision.

FIGURE C-1

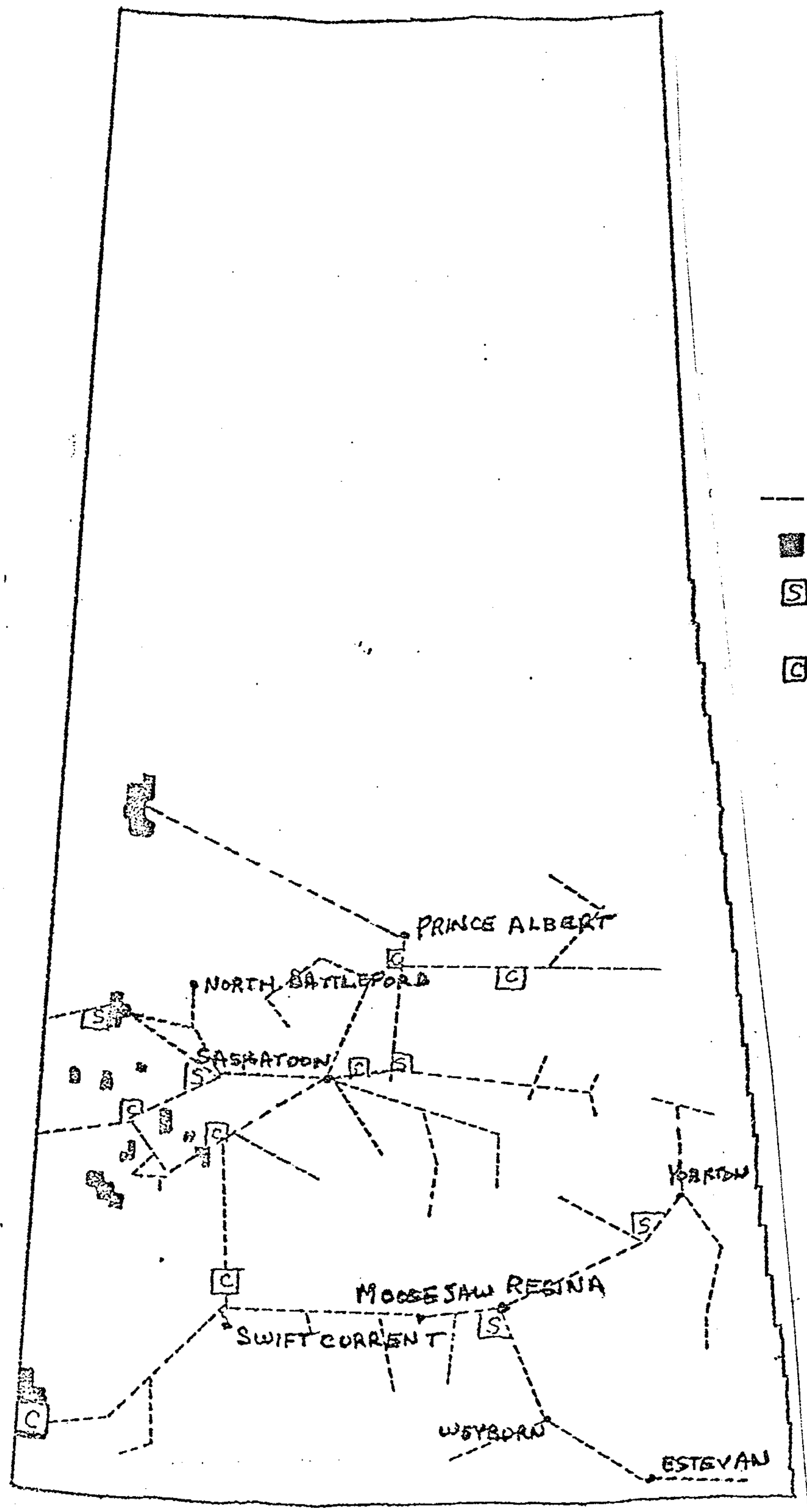
PRINCIPAL HEATING FUELS USED IN OCCUPIED DWELLINGS FOR CENSUS DIVISIONS IN SASKATCHEWAN, 1971 (by %)



Legend:
C = coal or coke
W = wood
O = oil or other liquid fuel (kerosene)
G = piped gas
"G"= bottled gas
E = electricity
X = other
( )= census division

FIGURE C-2

THE NATURAL GAS SYSTEM[1]



Legend

---- gas transmission line

gas fields

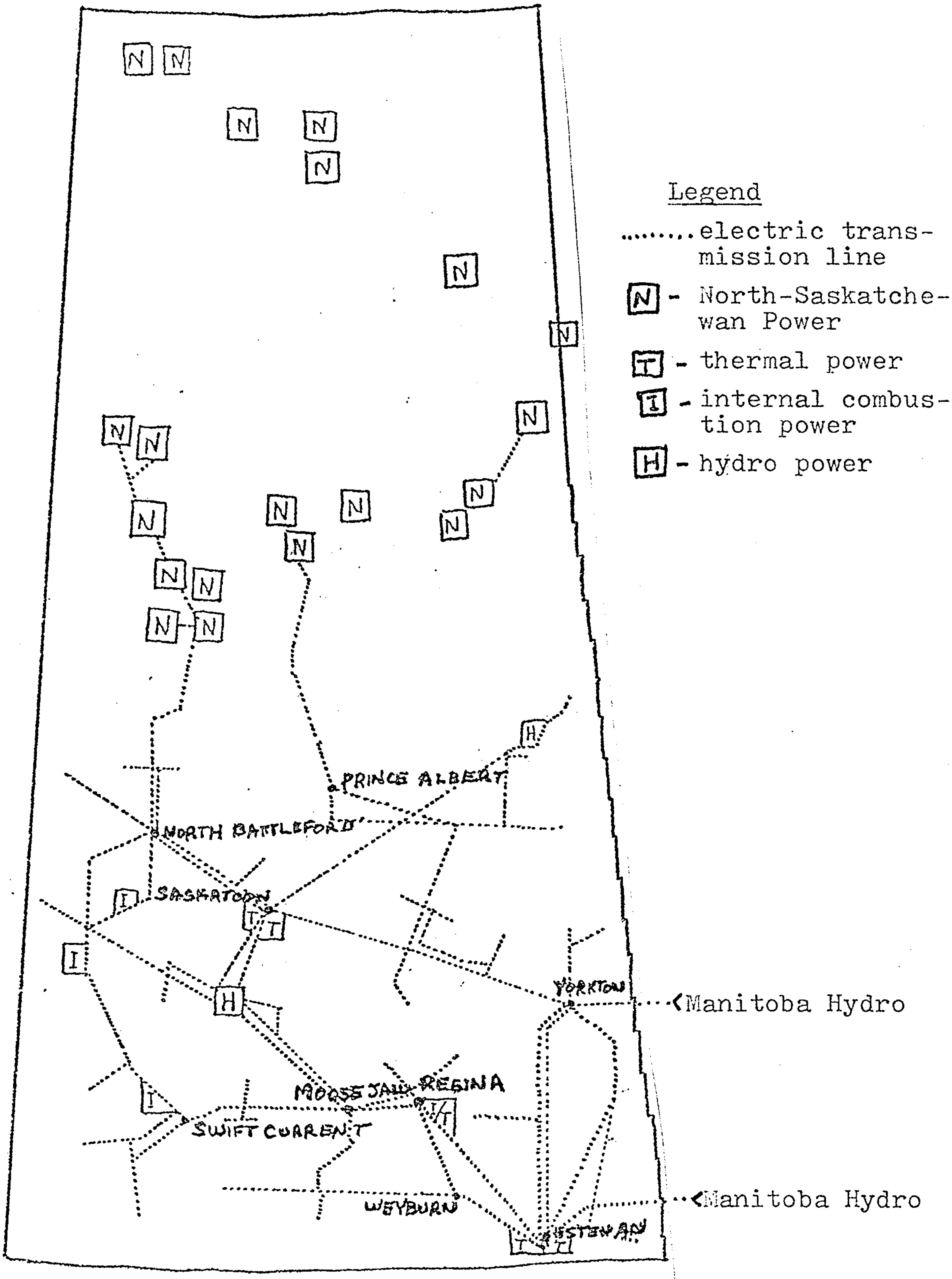
S gas storage and compressor

C gas compressor station

[1]Adapted from S.P.C. Annual Report, 1975.

FIGURE C-3

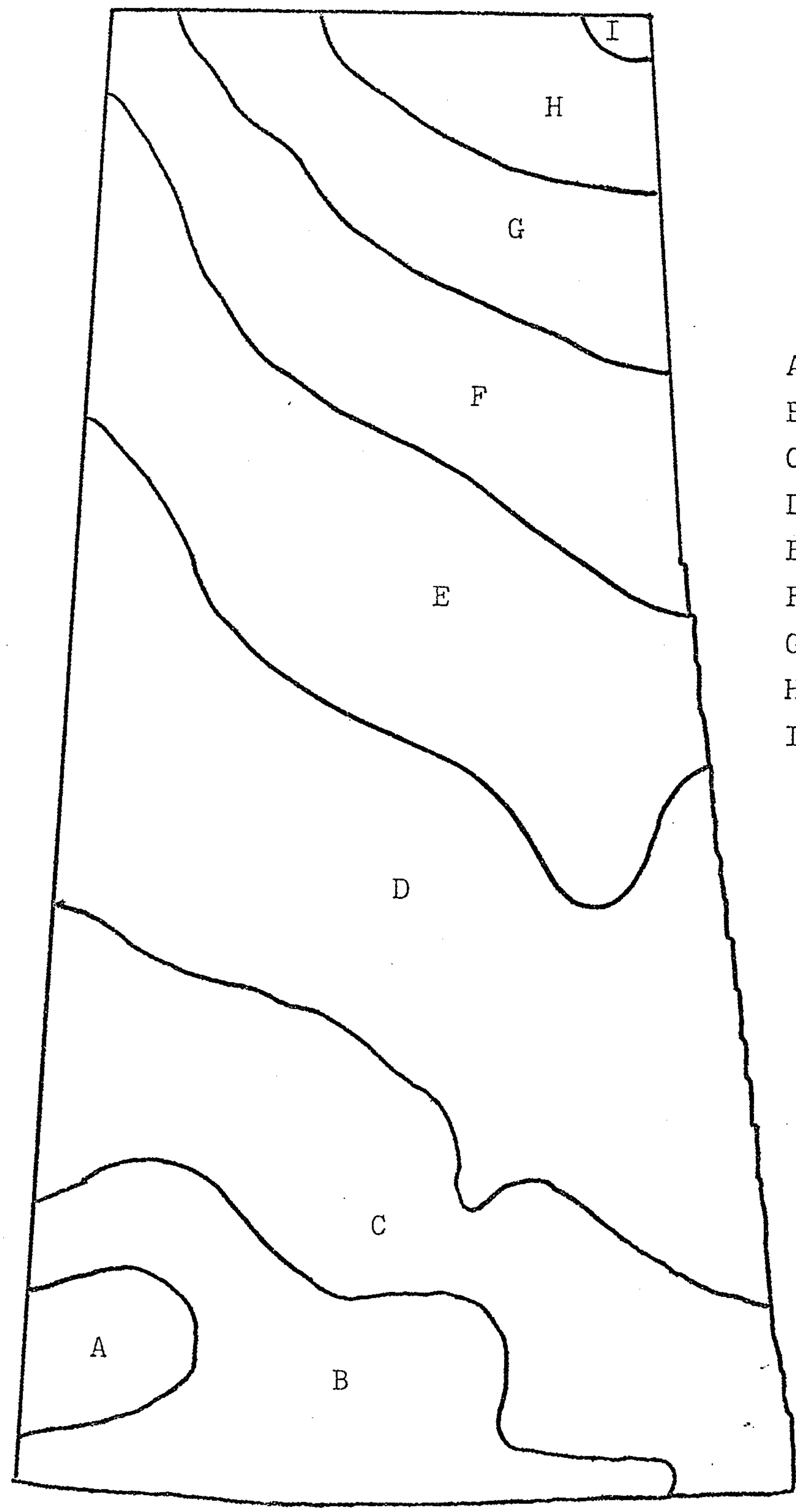
THE ELECTRIC SYSTEM[1]



[1]Adapted from SPC Annual Report, 1975.

FIGURE C-4

APPROXIMATE TEMPERATURE REGIMES IN[1] SASKATCHEWAN



January Normal Mean Daily Temperature (in °F)

A - above 10°F
B - above 5°F
C - above 0°F
D - above -5°F
E - above -10°F
F - above -15°F
G - above -20°F
H - above -25°F
I - below -25°F

[1] Adapted from J. Howard Richards and K.I. Fung, The Atlas of Saskatchewan, (Saskatoon: University of Saskatchewan, 1969):54. Temperatures were based on recorded averages between 1921 and 1951.

TABLE C-a

PRINCIPAL HEATING FUELS FOR OCCUPIED DWELLINGS IN SASKATCHEWAN, URBAN AND RURAL, 1971 (1)

	Coal or Coke	Wood	Oil or Other Liquid Fuel	Piped Gas	Bottled Gas	Other
URBAN						
100,000+	55	50	4,730	74,035	190	1,800
30,000 - 99,999	20	5	990	8,790	35	120
19,000 - 29,999	45	65	1,400	19,465	130	385
5,000 - 9,999	40	5	475	7,295	65	65
Under 5,000	135	435	4,850	22,895	270	190
Total Urban	305	560	12,450	132,490	690	2,560
RURAL						
Non-Farm	1,160	5,645	29,500	20,530	2,720	295
Farm	2,865	4,385	45,650	995	4,345	480
Total Rural	4,020	10,030	75,150	21,520	7,065	770
GRAND TOTAL	4,235	10,585	87,600	154,015	7,750	3,330

(1) Source: 1971 Census of Canada.

TABLE C-b

STANDARDS GOVERNING RESIDENTIAL INSULATION FOR CONSTRUCTION FINANCED UNDER THE NATIONAL HOUSING ACT, 1954-1976 (1)

Code Date	Non-Electric R Values (2)		Electric Heating R Values	
	Walls	Ceiling	Walls	Ceiling
1954		6.66 (both walls and ceiling)		
1958		6.66 (both walls and ceiling)		
1962		8.33 (both walls and ceiling)		
1963		8.33 (both walls and ceiling)		
1965	6.67 (3)	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 (Current)	13.7	14.1	14.0	16.8

(1) Source: C.M.H.C.

(2) Includes resistance value of insulation plus construction material. Where R values vary by degree days, 10,800 degree days (Regina) is used.

(3) For gas heat priced at less than 8¢ per cubic foot.

The following assumptions were made in regard to Table 9, Estimate of Occupied Dwellings in Saskatchewan by Period of Construction:

(a) additional occupied dwellings since 1969 are equivalent to 95% of the annual dwelling completions;

(b) the annual rate of new dwellings which are replacements for destroyed or abandoned dwellings is 1% of the total stock of dwellings;[1] and

(c) replacements occurred according to the following proportions: 60% from dwellings constructed in 1920 or before; 30% from dwellings constructed between 1921 and 1945; and 10% from dwellings constructed between 1946 and 1960.

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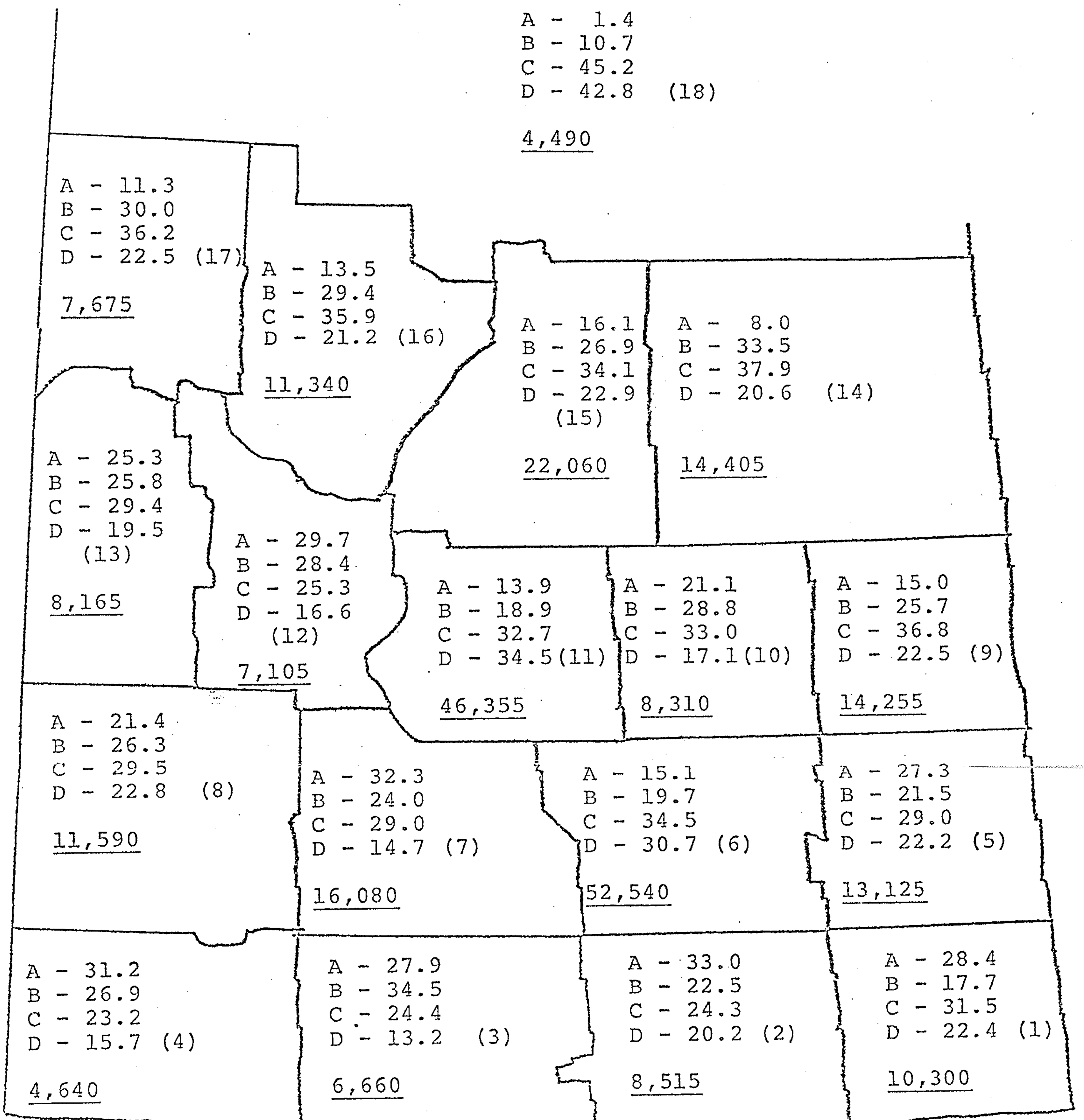
[1]Although C.M.H.C. generally uses an annual replacement rate of 2%, research undertaken by Planning and Research, Executive Council of the Government of Saskatchewan indicated that a 1% rate was more accurate. This trend has been projected to the years following 1970 in Table 9. The same research also indicated that replaced houses tended to be from the oldest housing stock, and this accounts for the percentages used in (c) above.

FIGURE C-5

CONSTRUCTION PERIOD OF OCCUPIED DWELLINGS IN SASKATCHEWAN, 1971 (by %)



Legend:
A = Constructed in 1920 or before
B = Constructed between 1921 and 1945
C = Constructed between 1946 and 1960
D = constructed between 1961 and 1971
() = census division
__ = total dwellings in census division in 1971

TABLE C-c

PERIOD OF CONSTRUCTION OF URBAN AND RURAL OCCUPIED DWELLINGS IN SASKATCHEWAN, 1971 (1)

	Urban	Rural Non-Farm	Rural Farm
Total Dwellings	149,055	59,850	58,710
Constructed 1945 and Before (%)	33	49	58
Constructed 1946 - 1960 (%)	35	30	29
Constructed 1961 - May 31, 1971 (%)	31	21	13

(1) Source: 1971 Census of Canada.