THE ROLE OF WOOD AS A RESIDENTIAL SPACE HEATING FUEL IN MANITOBA

by

Andrew Galarnyk

A Practicum Submitted in
Partial Fulfillment of the
Requirements for the Degree
Master of Natural Resources Management

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ABSTRACT

Since the Organization of Petroleum Exporting Countries (OPEC) embargo in 1973, prices for oil and natural gas have increased eight-fold. These materials are used in great quantities in Manitoba for transportation and heating fuels - and almost all must be imported from outside the province. The overall effect of rising energy prices has resulted in a greater cash-outflow from Manitoba to finance energy imports and developments.

This study examines the use of wood as one renewable energy source indigenous to Manitoba which may help in reducing out-of-province debt for imported energy. The objective of this study is to examine the role of wood as a residential space heating fuel in Manitoba.

The study documents the historic and current use of wood, wood heating technology, physical supply and demand, and the economics of producing and consuming fuelwood. The methods used in the study include a literature review, examination of published and unpublished articles on wood use, government documents, and personal communications with persons knowledgeable in the use of wood heating.

The study indicates that because of rising energy costs, improved wood heating technology, an adequate resource base and favorable economic conditions (for fuelwood), use of wood for residential space heating has increased since 1973 and will likely continue to increase.

Based on production costs, transportation costs, prices of conventional energy sources and heating unit efficiencies,

wood use may or may not be economical to use as a space heating source. The benefits from using wood include, a reduction in cash outflow from the province for imported energy, the creation of new employment opportunities in fuelwood production and marketing and a more complete utilization of the wood resource. If the present trend of wood use continues, wood will contribute a larger role as a renewable energy source in Manitoba.

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Glossary of Terms

Btu - British thermal unit is the quantity of heat required to raise the temperature of one pound of water one degree Fahrenheit from 59.5° - 60.5°F.

Cash Outflow - money which flows out of the province as a result of payments for imported energy and investment of energy-related production.

Conventional Energy Sources - these include (for the purposes of this report) electricity, coal, natural gas and fuel oil for heating purposes.

Cord - a unit of wood cut for fuel equal to a stack 4 X 4 X 8 feet or 128 cubic feet with air spaces or 80 cubic feet of solid wood (128 cu. ft. = 3.62 cubic meters).

Cunit - a unit of wood cut when stacked equals 100 cubic feet or 2.83 cubic meters.

Efficiency - the ratio of useful energy delivered by a system to the energy supplied to it.

Forest Management Licence, Timber Sale Agreement or Timber Permit - any of these are granted under The Forest Act, or the Regulations, authorizing the cutting and removal of Crown timber.

Forest Management Unit - an area which may be subject to a separate management plan and from which sustained yield is sought as the object of management.

Fuelwood - wood which is used in direct combustion to provide heat energy.

Fuelwood Dealer - a person or business purchasing fuelwood produced in Manitoba for resale.

Fuelwood Operator - any person or business holding timber cutting rights for the production of fuelwood.

Hydrocarbon Energy - refers to coal, oil and natural gas.

kWh - kiloWatt - hour is a unit of work or energy equal to that expended by one kiloWatt in one hour.

Licensee - the holder of a valid licence.

Permittee - the holder of a valid permit.

Primary Heat Source - a heat source which provides the main requirements for space heating.

Supplementary Heat Source - a heat source which provides the additional requirements for space heating.

Sustained Yield Management - the planned use of a forest area whereby the timber produced is periodically removed without reducing the capacity of the area to continue production at an equal or greater rate in perpetuity.

CHAPTER 1

INTRODUCTION

1.1 *Background*

Man's survival is dependent upon harnessing and managing energy supplies. Historically, wood has been of considerable importance as an energy source for heating since it was readily obtainable and relatively simple to use. With time, new technologies were developed allowing for the utilization of new energy sources such as coal, oil, natural gas, nuclear energy and hydro-electricity. With the exception of hydro-electric power, these other energy sources are non-renewable.

Until recently, the net long-term social benefits of various patterns of energy use have not been evaluated by industrialized countries. Technology made low-cost energy abundantly available; consequently little consideration was given to efficient utilization of energy sources.

As a result of the Organization of Petroleum ~~and~~ Exporting Countries (OPEC) embargo in 1973, industrialized countries began to realize that the era of abundant, low-cost energy supplies had come to an end. If the present standard of living is to be maintained in these countries, increasing energy supplies and more efficient use of them are a prime requirement. At the same time, it is known that hydro-carbon fuels cannot continue to provide the major share of energy requirements as in the recent past. Consequently, energy supply issues facing society are concerned with the allocation of present and future energy sources.

If economic prosperity is to continue, three requirements must be fulfilled; first, conservation of existing supplies; second, diversification of energy sources, thereby reducing the heavy reliance on non-renewable supplies; and, third, the development of new energy sources. Whereas on a global scale renewable energy sources presently supply less than 1 percent of total energy requirements, in the future, renewable sources may provide a more significant share of total energy demand. (Energy, Global Prospects 1985-2000, 1977, p. 25). However, the economic and technological potential of these renewable energy sources has yet to be fully established.

In response to declining non-renewable energy supplies, environmental problems and rising energy costs, research and development are concerned with improving the efficiency of use of existing energy supplies and developing alternative supplies so that society can lessen its dependence on any one source of energy. These efforts should result in a more diverse and flexible pattern of energy use which will enable society to change its energy requirements accordingly.

1.2 *Energy Use in Manitoba*

Prior to settlement by Europeans, the use of energy in what is now Manitoba was modest (Young, 1977, p. 3). Primary fuel sources consisted of wood and dung which provided heat energy. Virtually all energy requirements up to the turn of the twentieth century were met by supplies from local sources.

With the advent of the coal-fired steam engine used by the railway and the coal furnace for residential and industrial space heating, coal became the first energy source imported into the province during the late nineteenth century. Since it could be burned and transported more efficiently than wood, coal replaced wood for motive and heat energy.[1]

Around 1910, petroleum products gradually came into use with the introduction of the internal combustion engine and later the oil-burning furnace. Both coal and oil were being imported. Costs of imported energy were met by income derived chiefly from exporting agricultural products such as wheat. With an abundant supply of low cost energy and a trade surplus, Manitobans experienced an increased standard of living.

Since 1925, there has been a surge in the use of imported hydrocarbon energy as a result of growth in the provincial

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[1]Efficiency in this context relates to coal having a higher Btu content by volume than wood, and therefore, producing more heat per unit weight.

economy and population. Specifically, a doubling in the numbers of cars and trucks every eight to ten years (Young, 1977, p. 4), and a shift from wood to hydrocarbon energy for space heating purposes, caused an increase in demand for imported energy.

Electrical energy sources were developed in Manitoba in the early 1900's, but it was not until 1960 that electricity provided an alternative space heating source replacing hydrocarbon energy. Similarly, the availability and development potential of natural gas supplies in Alberta and Saskatchewan were also realized during this time. Consequently, with pipeline development to eastern Canadian markets, natural gas became an attractive heating fuel in Manitoba. Its abundance, relatively low cost and clean burning properties very quickly made it the most desired heating fuel in the province.

Like most other Canadian provinces, Manitoba derives most of its energy requirements from oil, natural gas, and electricity. However, from 1961-1971 Manitoba's energy patterns have differed from the rest of Canada. Manitoba experienced a slower economic and population growth rate and therefore the growth in energy requirements have been lower in comparison with the nation as a whole. For example, total residential and commercial energy requirements in Manitoba have grown by approximately 58 percent during this 10-year period in contrast to 77 percent in Canada; industrial requirements have grown by 42 percent in Manitoba compared to 60 percent in Canada (Manitoba Energy Council, 1974, p. 3).

In 1976, approximately 50 percent of the total provincial

TABLE 1

OIL, NATURAL GAS AND ELECTRICITY USE BY CONSUMING SECTOR FOR MANITOBA - 1975 (PERCENT)

	Residential	Commercial	Industrial	Transportation
Oil	35	13	29	100
Natural Gas	43	53	39	-
Electricity	22	34	32	-
Total	100	100	100	100

SOURCE: Gander, J. E. and Belaire, F. W.

Energy Futures for Canadians, Department of Energy, Mines , and Resources Canada, Canada Government Publishing Centre, Quebec, 1978, p. 310.

energy requirements came from oil; 32 percent from natural gas; and 18 percent from electricity. Manitoba is self-sufficient in hydro-electric power generation and along with supplying its own requirements, Manitoba has a vast potential for supplying other regions on a temporary basis.[1] Crude Petroleum products and natural gas, on the other hand, must be imported from Alberta and Saskatchewan.

Considering Manitoba's total energy requirements, four major sectors of consumption can be distinguished: (1) residential; (2) commercial; (3) industrial; and (4) transportation. The percentage of energy supplied by oil, natural gas and electricity for each energy consuming sector is indicated in Table 1. Space heating in all energy consuming sectors accounts for approximately 25 - 30 percent of total energy use in Manitoba which is supplied primarily by natural gas, oil, and electricity.

In the residential energy sector of Manitoba, approximately; 53 percent of households were heated by natural gas; 32 percent were heated by oil; and 7 percent were heated with electricity; the remaining 8 percent were heated by other sources. (McVicar, 1978, p. 140).[1]

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[1]In 1970, over 96 percent of all electricity requirements in the province were generated by either the Manitoba or Winnipeg Hydro systems. Only very modest electricity requirements are presently met through transfers of power from other jurisdictions and usually occur in periods of peak demand on Manitoba and Winnipeg Hydro systems (Manitoba Energy Council, 1974, p. 20).

[2]Other sources primarily include coal, wood and bottled gas.

Other energy requirements in this sector are derived from: electricity, which supplies energy for lighting, appliances, hot water heating, and machinery; and natural gas for water heating and cooking.

In the commercial and industrial sector of the economy the demand for natural gas is greater than the demand for oil or electricity (68 percent for natural gas compared to 21 percent for oil and 11 percent for electricity) (Gander and Belaire, 1978, p. 310).[1] Energy use by source in these sectors are influenced by: relative cost of using one form of energy over another; and the commercial and industrial applications of a specific energy source.

In the transportation sector, oil provides 100 percent of the energy requirements. Coal was the only other energy source included in this sector, however, its use diminished greatly over the past 14 years (from 1966) when it supplied 4.6 percent of total transportation requirements (Manitoba Energy Council, 1974, p. 13). Clearly, the internal combustion engine and the conversion from coal to diesel engines have made oil the single most important energy source in the transportation sector.

Manitoba places a heavy reliance on imported energy sources in the form of natural gas and oil to meet most of its energy requirements. Although all of Manitoba's electrical

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[1]These figures have been averaged for commercial and industrial sectors of the economy.

energy requirements come from provincial sources, only 18 percent of the total energy demand is for electricity. Since electricity cannot ordinarily be substituted for hydrocarbons, Manitoba will continue to be a net importer of oil and natural gas.

The consequences of such a heavy reliance on imported energy have become evident over the past few years. Since 1973, prices for oil and natural gas have increased eight-fold, resulting in a leveling off in demand for hydrocarbon energy and an increase in cash outflow from the province for imported energy payments. Young (1977, p. 4) indicates that in total, Manitoba was spending approximately $700 million for imported hydrocarbons in an economy with a gross provincial product of $8,000 million in 1977. Over the four-year period from 1973 - 1977, Manitoba increased its energy payments from 4.6 - 8.8 percent of its gross provincial product (Young, 1977, p. 4). At the same time, rising costs for hydro-electric development in remote northern regions require large capital investments from outside the province resulting in an increase in the cost of electricity to the consumer.

Manitoba's economic growth has slowed considerably so that (8.5 percent in 1973, 3.0 percent in 1978)[1] further price increases for imported energy will make it difficult to maintain a balance of payments for exports and imports. The effects of rising energy costs have negative implications on Manitoba's economy and population. Inevitably, rising energy

[1]Economic growth refers to real growth rate after the effects of inflation are netted out. 1974 and 1979 Manitoba Budget Address.

costs will result in increased costs to provincial residents and consequently, lead to further erosion of consumer purchasing power. Therefore, purchases of local goods and services will decrease causing declining production of local goods and services and rising unemployment. As cash outflow for imported energy increases, Manitobans can expect further decline in growth of the provincial economy.

1.3 *Problem Statement*

Energy conservation and diversification of existing energy sources along with the development of local renewable energy sources are measures which may reduce the cash outflow from Manitoba, resulting from imported energy and out-of-province debt incurred to finance hydro-electric development.[1] Wood may prove to be an alternative with the potential to substitute or supplement hydrocarbons and electricity for some residential, institutional, commercial and industrial space heating.

Manitoba is fortunate to have a vast forest resource which could provide wood as a renewable energy source. Even though the use of wood for heating declined with the advent of abundant, low-cost hydrocarbon and electrical energy in the 1950's,

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[1]It may be observed that Manitoba Hydro, as the main supplier of electrical energy in the province, pursued an active advertising campaign in the late 1960's and early 1970's promoting the use of electricity for space heating. This resulted in an increased demand for electricity and at that time seemed to justify expansion of hydro-electric generating capacity. Consequently, large out-of-province loans were required for construction of remote northern generating stations. Later supply for electricity far exceeded demand, however, loan repayments on invested capital resulted in significantly higher costs for electricity to the consumer.

continuing price increases and uncertainty in future supplies may bring about a resurgence in the use of wood. Recently, the increase in the number of wood stove and fuelwood dealers in the province seems indicative of a return to wood as a heating fuel.[1] In rural and urban areas where natural gas, oil and electricity became the primary heating sources, some individuals have turned to using wood either for supplementary or primary space heating requirements.

There is a substantial amount of wood on Provincial Crown lands which is not commercially utilized by the forest industry (Department of Mines, Natural Resources and Environment, 1979).[2] Certain tree species such as birch and poplar, and waste wood in the form of tops, stumps and slab material, have little commercial value in lumber or pulp production. However, these could provide a potential fuelwood supply. Prior to this study, no systematic attempt has been made to examine the role of wood as a heating fuel in Manitoba. Given the increasing costs of conventional energy and the use of wood for space heating purposes, there is a need to examine the present role of wood as a space heating fuel in Manitoba.

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[1]The number of wood stove dealers increased by approximately 350 percent(5-18 dealers) from 1972 to 1978 and fuelwood dealers increased by approximately 300 percent (10-30 dealers) in this same time period.

[2]Personal Communication with John Burch, Extension Forester, Department of Mines, Natural Resources and Environment, 1979, hereinafter referred to as Burch.

1.4 *Objectives*

The objectives of this study are to examine the role of wood as a residential space heating fuel in Manitoba, focusing upon:

1. the historic and current use of fuelwood
2. wood heating technology;
3. physical supply and demand of the wood resource; and
4. fuelwood production and consumer economics.

1.5 *Methods*

The study consists of four specific methods examining the role of wood as a residential space heating fuel in Manitoba. Information from government documents and other related publications formed the basis for an overview of the historic and current use of fuelwood in Manitoba.

A review of related literature has been compiled to determine the present status of wood heating technology. Information from textbooks and magazine articles has been supplemented by personal communication with persons knowledgeable in wood heating technology.

The physical supply and demand of the wood resource is based upon information from government files and personal communications with persons from the Forest Inventory and Timber Sales Branches of the Manitoba Department of Natural Resources (M.D.N.R.).

The final component of the study examines producer and consumer economics of using wood. Information for this sector has been obtained from fuelwood operators, dealers and consumers, as well as persons knowledgeable about fuelwood. Calculations are based upon 1979 production and consumption costs.

1.6 *Limitations*

Data used in this study are limited to published and unpublished reports and information conveyed through personal communication. The study is further limited to examining the use of wood in direct combustion only. The supply and demand of the forest resource are limited to Provincial Crown lands.

Although wood from private lands is presently being used as a heating fuel, data which could quantify or qualify this wood source are scarce. Since obtaining this data is beyond the scope of this study it would be inappropriate to supply even a crude estimate of the forest resource on private lands.

1.7 *Organization of the Study*

The examination of the present role of wood as a residential heating fuel in Manitoba will be presented in the following chapters. Chapter II consists of two parts: an overview of the historic and current use of fuelwood in the province; and a description of wood heating technology. This chapter comprises the literature review section.

Chapter III discusses the physical supply and demand of the fuelwood resource in Manitoba. This chapter briefly examines: resource ownership, administration and allocation; fuelwood supply and demand; and constraints to further utilization of the resource.

Chapter IV provides an overview of producer and consumer economics of using wood as a heating fuel.

Chapter V includes the summary, findings and recommendations of the study.

CHAPTER II

USE OF WOOD AND WOOD HEATING TECHNOLOGY IN MANITOBA

2.1 *Introduction*

The literature will be presented in two parts:

(1) an overview of the historic and current use of fuelwood in Manitoba; and

(2) a description of wood heating technology.

2.2 *Historic and Current Use of Fuelwood in Manitoba*

2.2.1 Historic Use of Wood as a Heating Fuel

Although few historical statistics have been kept on the quantity of wood used for heating purposes, wood provided a major portion of the total provincial heating requirement. However, with the availability of low-cost, fossil fuels and abundant electricity, use of wood for heating declined. Its treatment as an *inferior good* made it vulnerable to replacement by hydrocarbons and electricity.[1]

Figure 1 indicates the quantity of fuelwood harvested in Manitoba from 1940 - 1974. A definite decrease is noted in fuelwood consumption over this 34 year period. Sharper decreases from 1945 - 1949, were attributed to the end of World War II which released more hydrocarbon energy for domestic, industrial and commercial use.

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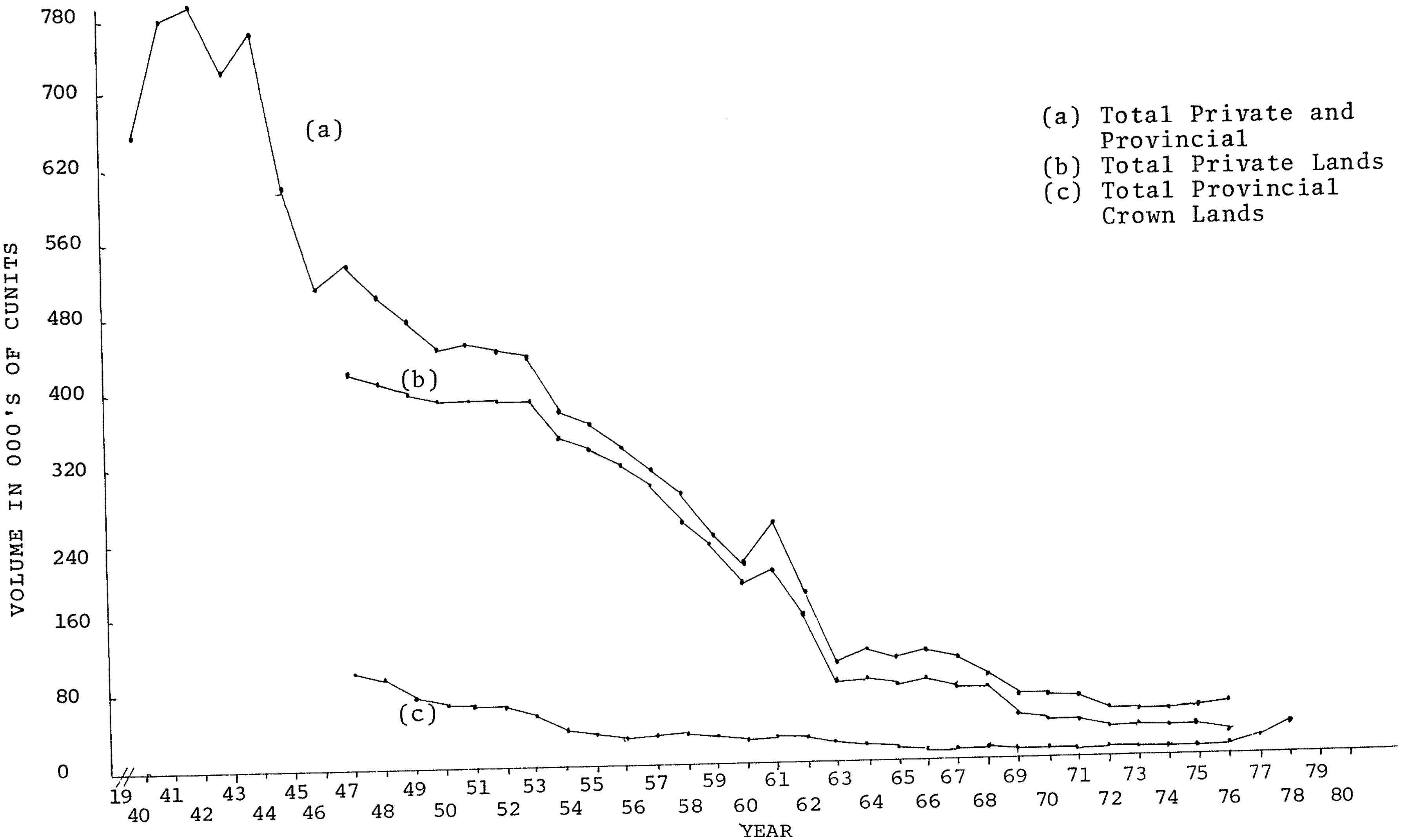
[1]The term *inferior good* refers to a good which consumers buy less of when their incomes go up and more of when their incomes go down (Watson, Holman, 1977, p. 100).



SOURCE: Dominion Bureau of Statistics, Vol. 1, Part II, -N-1 1958, Dominion Bureau of Statistics, 25-201-1956-1960, Statistics Canada No. 25-201-1960-1977. Annual Reports, Man. Dept. of Mines, Natural Resources and Environment 1947-1978.

FIGURE 1

Total Manitoba Fuelwood Harvest 1940 - 1978 For Private and Provincial Crown Lands

In addition, a sharper decrease also occurred between 1960-1964, coinciding with the availability of cheap natural gas and petroleum supplies in the Manitoba market. Generally, the continuing decrease in fuelwood use during this period is indicative of abundant, more convienient, economically competitive energy sources which gradually displaced the fuelwood market.

2.2.2 Substitute Goods

In the context of this study, substitute goods represent any type(s) of energy source(s) which could replace fuelwood if wood fails to remain economically competitive with other energy sources. Substitutability depends upon costs of using wood, costs of other energy sources and the competitive end uses of wood.

Prior to recent significant increases in cost of hydrocarbon and electrical energy for space heating purposes, wood became uneconomic and impractical to use in many areas of the province. Production costs and inconvenience prohibited wood from remaining economically competitive and attractive,compared with other heating sources, resulting in the decreased use of wood.

However, since costs of hydrocarbon and electrical energy are rapidly increasing, wood is once again becoming economically competitive as a space heating source of energy. Although energy sources presently in use will never be completely replaced by wood, higher costs for space heating could increase the overall use of wood. Indeed, at the time of this study, it seems evident that wood is becoming a substitute good, supplementing or in some cases, replacing hydrocarbon and electrical energy sources.

2.2.3 Current Market Trends

Increases in

(1) sales of wood-burning devices (500 percent over 1976-1978), (figure 2)

(2) number of wood dealers (55 percent over (1977-78 from 20 to 31), and

(3) demand for fuelwood (figure 3)

suggest that wood is increasingly being used for space heating.[1] In some areas of the province, fuelwood has already become economically competitive with other energy sources.

Rising costs in providing hydrocarbon and electrical energy to rural and remote areas of the province have in many instances lead to a return to wood as a heating fuel where wood supplies are easily and cheaply obtainable (figure 2). However, this demand is not restricted to rural or northern regions of the province; in fact, most commercial fuelwood operators are selling wood to the Winnipeg market where demand has increased significantly (figure 3, southern and eastern regions).

As hydrocarbon and electrical energy costs continue to increase, the potential of the forest resource as a primary or supplementary energy source is also increasing. Although use of wood for heating is increasing, it is highly unlikely that the majority of residents in the province would adopt this method of space heating simply because:

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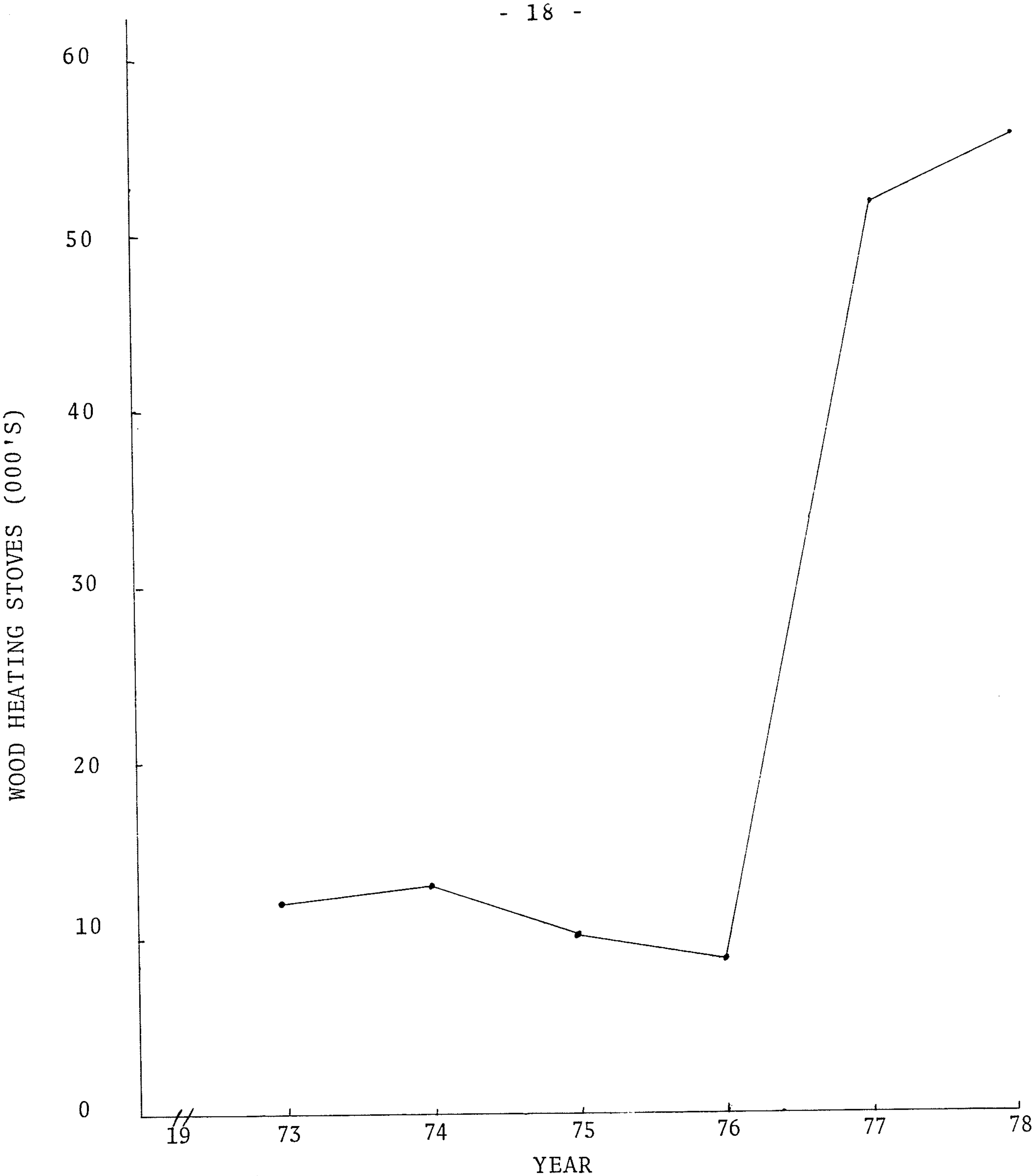
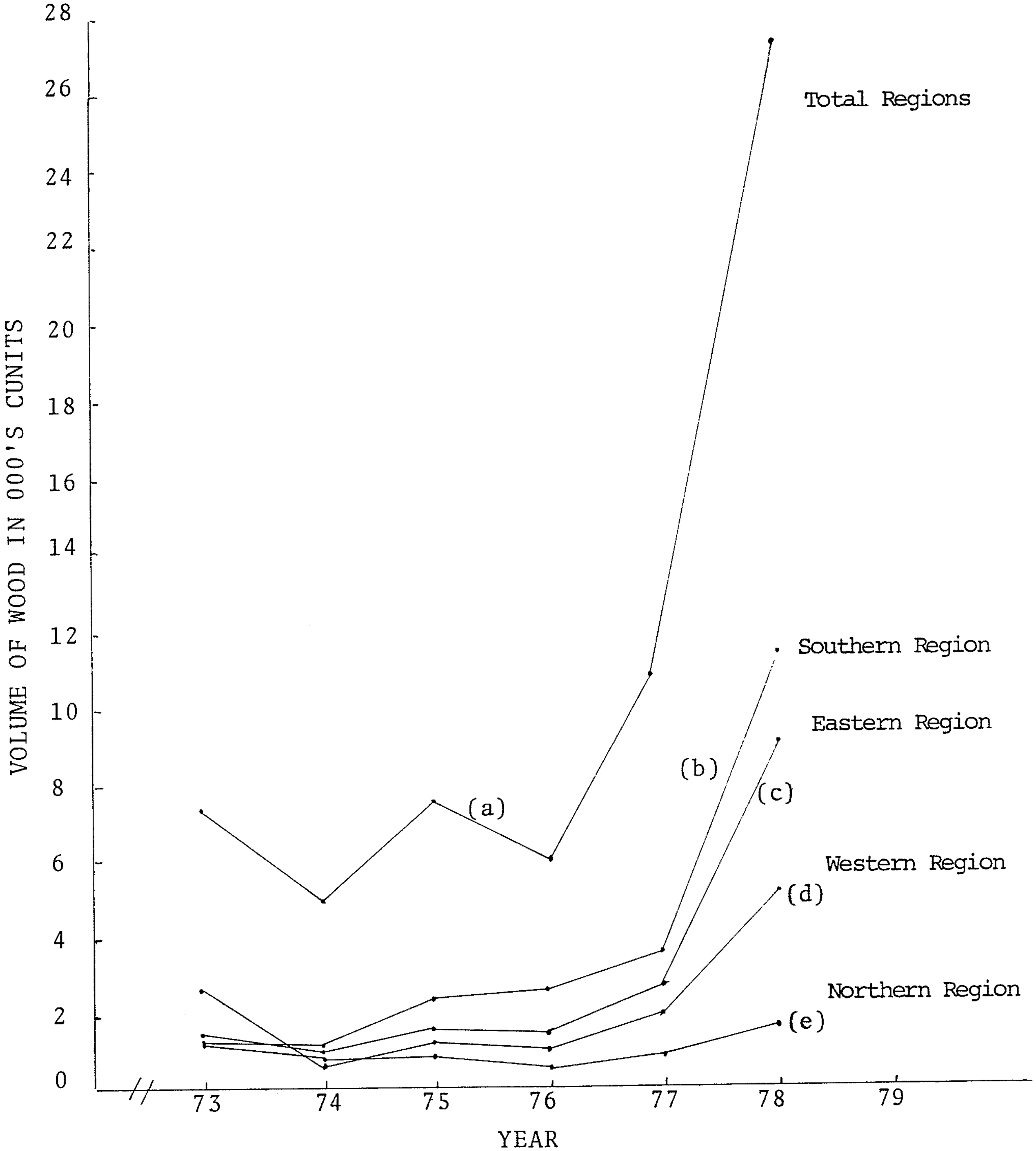
[1]These figures were obtained by means of personal communications with wood and stove dealers.



SOURCE: Statistics Canada, Household Facilities and Equipment May 1973 - May 1978, Cat. no. 64-202.

FIGURE 2

HOMES WITH WOOD HEATING STOVES IN MANITOBA 1973-1978



SOURCE: Manitoba Department of Renewable Resources and Transportation Services, Annual Reports, 1973 - 1978 (now Manitoba Department of Natural Resources).

FIGURE 3

FUELWOOD ALLOCATIONS IN MANITOBA
FROM PROVINCIAL CROWN LANDS AND REGIONS
1973 - 1978

(1) wood may not be the cheapest energy source; (since oil, natural gas or electricity, when coupled with heating unit efficiencies may be more cost and energy efficient than wood); and,

(2) consumer preference including comfort, cleanliness or ease of operation, may make wood use unattractive (McVicar, 1978, p. 62).

2.2.4 Implications of Using Wood

There are both positive and negative implications in using wood for space heating. The following is a list of positive implications associated with fuelwood use:

(1) forests are a renewable resource and many forested areas of Manitoba are capable of supplying fuelwood on a sustained yield basis; (Burch, pers. comm., 1979);

(2) supplementing or replacing space heating requirements with wood could reduce the quantity of hydrocarbons presently being used; thereby aiding conservation efforts for non-renewable fuels, and thus reducing provincial cash outflow payments for imported energy; (Young, 1977, p. 37);

(3) wood provides a source of heat independent of electricity or hydrocarbon energy;

(4) fuelwood production is labour intensive and if fuelwood use increases, new employment opportunities could be created; (Wiksten, 1978, p. 46);

(5) when properly dried, wood can be a relatively clean and safe fuel to burn; and

(6) wood may be stored for extended periods of time.

The following is a list of negative implications associated with fuelwood use:

(1) wood is bulky and requires storage space;

(2) wood fires must be stoked regularly;

(3) wood burning produces ashes which must be disposed of;

(4) potential environmental hazards; and

(5) potential fire hazards.

Although positive and negative implications are associated with any type of energy source, a decision to use an energy source would most likely be based on economic competitiveness and consumer preference. Therefore economic competitiveness and consumer preference would have to be considered by an individual deciding to use wood over other available energy sources.

2.3 *Wood Heating Technology*

Present wood heating technology has increased the efficiency rating of wood-burning stoves and furnaces from approximately 50 percent efficiency to approximately 70 percent efficiency (McCallum, 1977, p.55).[1] The basic overall effect of more efficient stove designs has been a reduction in the amount of wood required to heat a given area.

Some of the technical advances allow for greatly increased comfort and convenience in modern wood heating. Several types of stoves and furnaces have been developed so that one fuel load will last for hours (Burch, personal communication, 1978;McCallum, 1977,p.55).

A major difference between old and modern stove designs is that old stoves are not airtight. With an old stove design, more air than is required for optimal burning enters the fire box resulting in faster burning fires and more exhaust gases being discharged (McCallum, 1977, p. 54). In addition, old stoves lose additional heat since volatile gases produced by wood combustion are not being burned completely.

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[1]Efficiency of wood stoves is compared with electric resistance heating which is 100% efficient at the point of end use. Efficiency ratings for wood stoves are determined under test conditions so that these figures may differ somewhat in given instances.

Other problems associated with old stove designs include variable temperatures, high ash production and a large consumption of wood (McCallum 1977, p. 54).

Modern wood stoves and furnaces are airtight, resulting in better draft control, even temperatures and above all, longer-burning fires. Consequently, less attention is required in tending a fire. Figure 4 illustrates the draft system of a modern wood stove.

2.4 *Wood Composition and Heating Value*

2.4.1 Chemical and Proximate Analysis

In determining the economic value of fuelwood, it is necessary to consider some important characteristics of wood; namely, composition, moisture content, and heating value.[1] The composition of wood in fact, determines its heating value and how it releases useful energy. Chemical analysis indicates that composition falls within a relatively close range of values. Tables 2 and 3 provide the average chemical composition and proximate analysis for hardwood and softwood species.

TABLE 2: Average Chemical Composition of Wood
Percent by Weight

	Carbon	Oxygen	Hydrogen	Nitrogen	Sulpher	Ash
Hardwood	50.8	41.8	6.4	.1	-	.9
Softwood	52.9	39.7	6.3	.1	-	1.0

SOURCE: Arola, R.A. "Wood Fuels - How Do They Stack Up?", Energy and the Wood Products Industry, Georgia, 1976, p. 38.

[1] Moisture content refers to the amount of moisture contained in wood. Wood which is oven dried contains approximately 10 percent moisture; wood which is air dried contains approximately 20 percent moisture; and wood which is wet or green contains approximately 22 to 50 percent moisture.

TABLE 3

PROXIMATE ANALYSIS OF HARDWOODS AND SOFTWOODS

ITEM	HEATING VALUE Low Btu/lb	HEATING VALUE High Btu/lb	MOISTURE Surface Percent	MOISTURE Total Percent	Fixed Carbon Percent	Volatile Matter Percent	Ash Percent
Hardwoods							
Moisture and Ash Free	8,310	8,710	0	40	20	40	0
Moisture Free	6,600	7,000	0	32	16	32	20
Air Dried		5,764	12	44	10	20	14
Wet (Green)		3,088	30	74	6	12	8
Softwoods							
Moisture and Ash Free	8,930	9,030	0	48	9	43	0
Moisture Free	7,000	7,380	0	38	8	34	20
Air Dried		5,430	12	50	7	28	15
Wet		2,170	30	80	3	12	5

SOURCE: Chant, R., Energy Plantation and Steam Generation, Inter-Technology Corporation, June, 1974.

Procedure:

(1) Moisture and Ash free analyses from Fryling, G. R., "Combustion Engineering", Published by Combustion Engineering, 1967.

(2) Adjusted Ash so that low heating value agreed with values from Szego, G.C. and Kemp, C. C., "Energy Forests and Fuel Plantations", CHEMTECH, May, 1973.

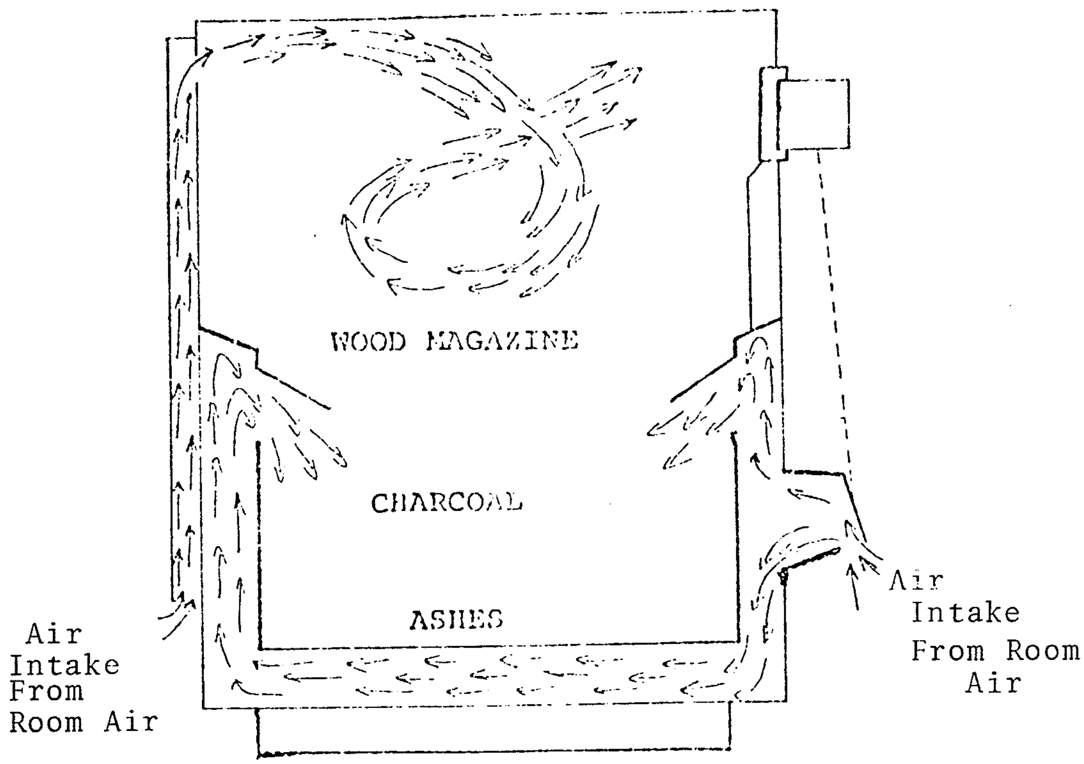
(3) Other information: Lignin-percent by weight:

C-63
H-6
O-31

Cellulose $C_6(H_2O)_5$

Bark:

66 percent Lignin
34 percent Cellulose.



NOTE: Draft system of this wood stove design preheats air entering firebox allowing for higher temperature, resulting in more complete combustion. Ducts for preheated secondary air provide the necessary oxygen at sufficiently high temperatures to burn the volatile gases given off by the wood.

SOURCE: McCallum, 1977, p. 55.

FIGURE 4

DRAFT SYSTEM OF
MODERN WOOD STOVE

2.4.2 Heating Values of Indigenous Wood Species

Most woods produce approximately the same amount of heat per unit weight (Burch, 1978; McCallum, 1977, p.63). Theoretically, 100 kg. of birch wood should provide as much heat as 100 kg. of spruce. However, as the presence of resin, gums, tannin, oils, pigments, water and densities vary among species, heating values differ accordingly. Table 4 provides a list of some native Manitoba tree species used as fuelwood and their corresponding heat value.

2.4.3 Moisture

One of the most serious problems with fuelwood is the tremendous variability in moisture content, ranging from oven dry material (10 percent moisture content M.C.) (air dry is equal to 20 percent M.C.) to green wood containing nearly equal amounts of solid fibre and water (22 to 50 percent M.C.) (Arola, 1976, p.39). Variability in moisture content greatly influences the combustion process.

When burning wood, it is essential to have it as dry as possible so that more heat value per pound of fuel combusted can be obtained. When green wood is burned the high water content causes a reduction in the heating value of wood and also lowers the combustion efficiency because of the increased amount of water to be vaporized before combustion can take place (Arola, 1976, p.39). To vaporize each pound of water, approximately 1000 Btu of heat are required, which is deducted from the total heat value of the wood.[1] Dry wood burns at a higher overall efficiency (70 percent or higher) whereas green wood

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[1]As moisture content increases more moisture is added to the stack gas, which increases the need for excess air to ensure complete oxidation of the fuel.

TABLE 4

HEATING VALUE OF SOME
MANITOBA WOOD SPECIES

HARDWOODS	AVAILABLE HEAT (DRY) Btu/LB. (.45 kg)		
	Average	Low	High
Trembling Aspen *(Populus tremuloides)*	8,433		
White Birch *(Betula papyrifera)*	10,310		
Bur Oak *(Quercus macrocarpa)*	11,069		
Balsam Poplar *(Populus balsamifera)*	8,810		
SOFTWOODS			
Larch or Tamarack *(Larix laricina)*	9,010		
Jack Pine *(Pinus baksiana)*	8,930	8,690	9,170
Red Pine *(Pinus resinosa)*	9,002		
Black Pine *(Picea mariana)*	8,610	8,150	8,710
White Spruce *(Picea glauca)*	8,530	8,340	8,630

SOURCE: Arola, R. A. "Wood Fuels - How Do They Stack Up?", Energy and the Wood Products Industry, Georgia, 1976, p. 38.

(50 percent M.C.) would have a combustion efficiency of approximately 65 percent (Arola, 1976, p. 39). Figure 5 indicates the effect of moisture on heat value and Figure 6 indicates the effects of moisture on heating unit efficiency.[1] Since green wood has a lower combustion efficiency there is an obvious advantage in burning dry wood (i.e. less wood is required to heat a given area).

Reducing moisture content will result in a higher energy yield (Konzo, 1978, p. 27). This may be achieved through the process of curing or drying. After a tree has been felled, it should be cut, split, stacked and left to dry for at least one summer. Wood cut during the fall and winter should be well seasoned and ready for burning the following winter. Moisture content can be further reduced by drying wood indoors, near the heat source for a day or more so that the wood absorbs direct heat (McCallum, 1977, p.64).

2.5 *Combustion Process*

Wood combustion occurs in three stages. In the first stage, any remaining moisture in the wood is heated and driven off when temperatures approach 150°C.

The second stage of the combustion process occurs when temperatures reach between 150°C and 200°C. At this point the wood begins to break down chemically; giving rise to the volatiles composed of organic molecules, all of which can be burned to yield carbon dioxide, water and energy (Gay, 1977, p.76). This volatile matter is then distilled off and when temperatures reach 590°C or greater the volatiles ignite into flames.

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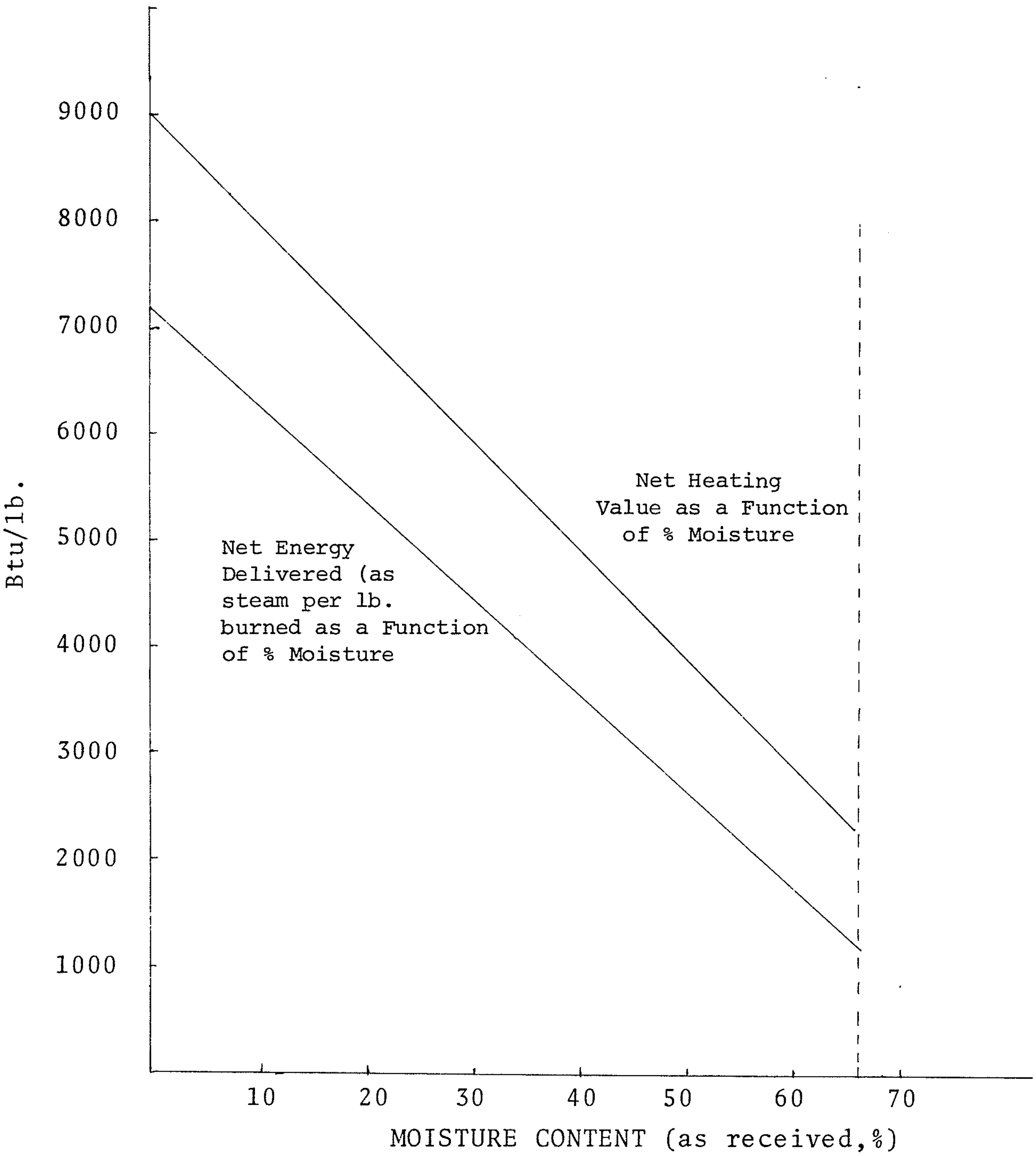
[1]The heating unit in this case was the Erie City Staling Boiler which has a higher efficiency rating than wood burning stoves due to continuous operation.



SOURCE: Arola, R. A., 1976, p. 44.

FIGURE 5

THE INFLUENCE OF MOISTURE ON THE HEATING VALUE OF WOOD

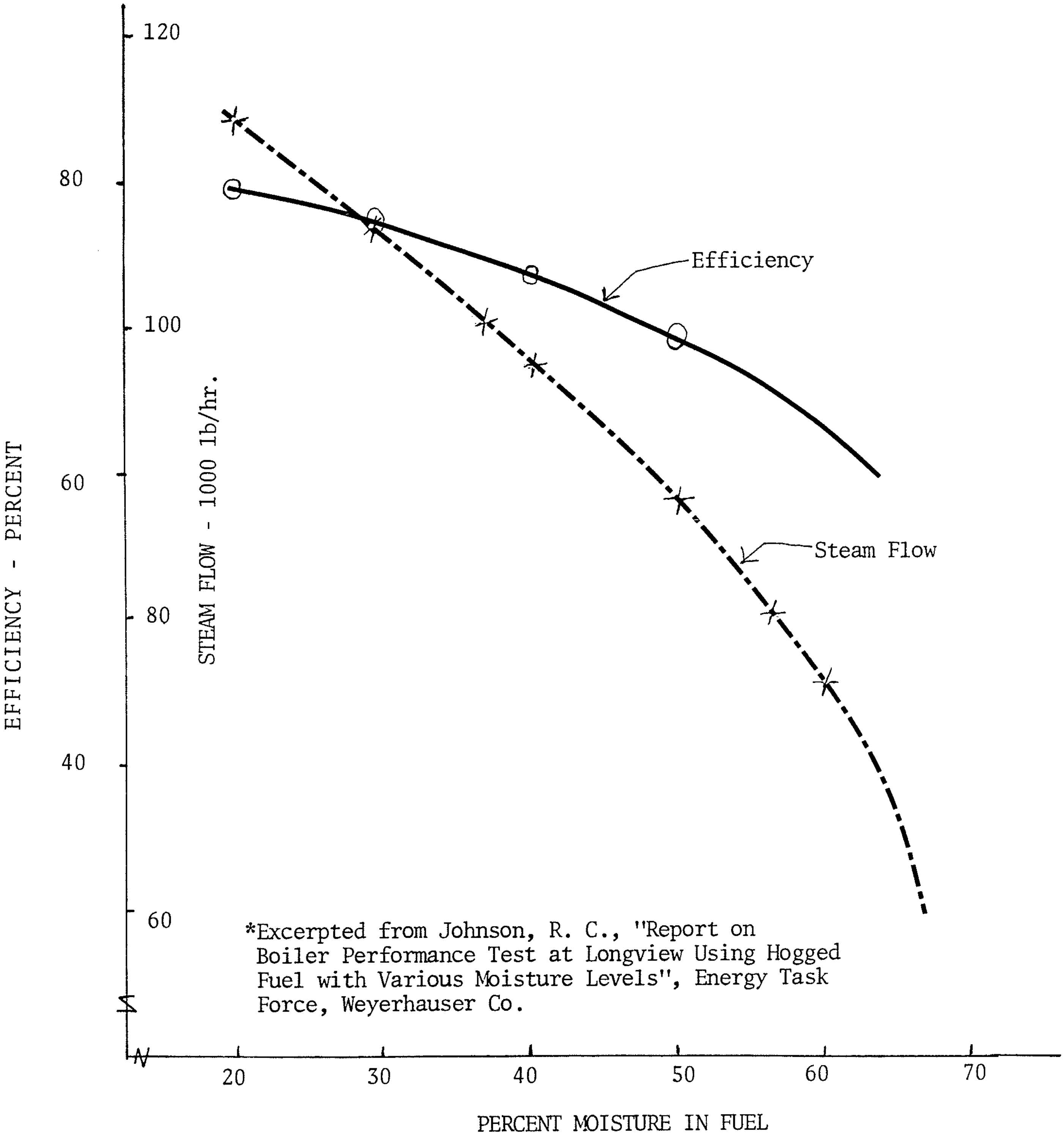


FIGURE 6
TEST RESULTS ON ERIE CITY
Sterling Boiler Rating
- 112,000 lb/hr.
Fuel Dried Bark

SOURCE: Chant, R. Personal Communication re "Report on Boiler Performance Test at Longview Using Hogged Fuel with Various Moisture Levels", 1980.

In the third and final stage of combustion,wood charcoal is burned. All three stages may occur simultaneously, however the first two stages largely occur when the fire is first started or when new fuel is added.

One of the problems associated with wood burning is creosote buildup,which results when volatiles are not completely burned off. Creosote deposits are formed when the combustion temperature drops below 590°C. At this point, the wood gases do not burn but instead condense in the cooler flue thereby forming tar-like deposits up the stack (McCallum, 1977, p.63).

Creosote deposits are a problem with modern wood stoves since temperatures can be regulated down due to a tight draft control. Chimney fires can result from creosote, however the problem can be solved by:

(1) cleaning the flue once a year;

(2) burning a hot fire every few days, thereby liquidizing creosote deposits which may then be burned off; or

(3) by burning very dry wood (less than 10 percent M.C.) or wood containing less resins, oils and gums (as in deciduous species).

2.6 *Environmental Considerations for Wood Use*

It is necessary to consider environmental impacts associated with the use of wood for space heating. Directly associated with wood burning are the effects on air quality. This report deals with these effects in detail. Other environmental effects, such as from fuelwood harvesting, should also be considered. These include impact on land, water, wildlife and tree species.

Wood burning is often incomplete so that intermediate products of combustion such as sulfur dioxide (SO_2) are liberated. In contrast to most coals and many heavy fuel oils, wood fuels have a low sulfur content (Corder, 1976, p. 30). The amount of SO_2 produced by wood burning may average .02 percent by weight whereas some coals may contain up to 15 percent sulfur.[1] The lower SO_2 content in wood results from the sulfur being in the form of sulfate minerals not readily converted into SO_2 through combustion (Gay, 1977, p. 21). In contrast, hydrocarbon fuels contain larger amounts of oxidizable sulfur which are readily activated to produce SO_2 or SO_3.

Ash is the inert substance of a fuel which is also undesirable and since ash is not combustible, it is either retained or is entrained with the stack gases leaving the furnace with the combustion process. Ash may cause corrosion of heating surfaces and ducting and poses problems of particulate emissions into the air (Corder, 1976,p. 30).

The ash content of dry wood is generally low (<2 percent) when compared to most coals which range from 5 to 25 percent ash (Corder, 1976, p. 30). Thus, wood in comparison to hydrocarbons produces significantly less air pollution.

The only significant problems with wood combustion are particulate emission control of unburned carbon in exhaust gases, waste and disposal of ash and grit and creosote buildup. Comparing the fixed carbon content of wood and coal, wood

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[1]Figures were obtained from Gay, 1977, p. 21 and Chant, R., Personal Communication, 1980.

contains an average 20 percent fixed carbon whereas coal may range from 40 to 80 percent, depending on grade.

With an increase in wood burning, there may be an increase in gaseous and particulate matter. However, when compared to some hydrocarbons, wood produces less pollution and any adverse effects on air quality from wood burning would be dependent on the concentration versus the dispersion of gaseous and particulate matter. In conclusion, environmental consideration of fuel combustion places wood in an attractive position as a heat energy source relative to some coals and fuel oils.

Some fuelwood harvesting practises may inevitably affect land, water, wildlife and certain tree species. The removal of cover and nutrients by harvesting practices may increase: soil erosion; and siltation in rivers and streams through surface runoff. In turn, food and cover for some animal and bird species may also be affected. Furthermore, siltation in rivers and streams may affect spawning and migration of certain fish species.

Another potential effect from fuelwood harvesting may be a reduction in numbers of a particular tree species. This report sites birch fuelwood as one example whereby, controlled cutting of birch in some areas of the province has come about. A solution to this problem may be to advocate cutting of more abundant species (i.e. poplar) which regenerate more quickly than birch. Under certain circumstances (i.e. forest management practices) such effects could be monitored and controlled.

CHAPTER III

PHYSICAL SUPPLY AND DEMAND OF THE WOOD RESOURCE

3.1 *Introduction*

Perhaps one of the most salient features in considering the role of fuelwood in Manitoba is determining whether the wood resource base is able to support present and future demand as an energy source. If fuelwood is to maintain or increase its role in the province it must be supported by a substantial resource base. This chapter provides an analysis of the physical supply and demand of fuelwood in Manitoba.

3.2 *Resource Ownership*

From 1870 to 1930, lands and forests in Manitoba were administered by and for the Dominion of Canada (Manitoba Department of Renewable Resources and Transportation Services, (RR& TS), 1974, p. 13).[1] It wasn't until the signing of the Natural Resources Transfer Agreement on July 15th 1930 that the lands and forests of Manitoba were placed under Provincial jurisdiction. Presently, approximately 96 percent of all productive forest land in Manitoba is under provincial crown

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[1]The Department's name was changed in 1980 to Natural Resources.

ownership.[1]

3.2.1 Resource Administration and Regulation

Part I of the Provincial Forest Act (1975, p. 2) states:

> The Minister, with respect to crown timber on behalf of the crown ... shall regulate and administer,
>
> (a) all rights properties, interest claims and demands of the Crown in timber;
>
> (b) subject to the Financial Administration Act, all revenues and money of the Crown arising from forestry;
>
> (c) management, utilization and conservation of Crown forest lands and timber;
>
> (d) afforestation, reforestation, tree preservation and tree improvement;
>
> (e) the disposition of timber;
>
> (f) the cutting and production of primary forest products and products of the forest;
>
> (g) the enforcement of statutes, rules and regulations relating to forestry and Provincial forests.

3.2.2 Resource Allocation

Under the disposition of cutting rights for crown timber in the Manitoba Forest Act (1975, p. 4), there are three methods by which wood-cutting rights may be allocated.

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[1]Productive forest land refers to forest land producing or capable of producing merchantable wood volume. For further discussion see The Forests of Manitoba, 1974, Manitoba Department of Renewable Resources and Transportation Services, p. 21.

These methods are included in Section 12(1) of The Forest Act under: (1) forest management licence; (2) timber sales; and (3) timber permits.

According to the Forest Act (1975, p. 6):

> A forest management licence is a licence granted to a company where the investment in a wood-using industry established or to be established is sufficient to require the security of a continuous timber supply.... A licence granted under subsection (1) shall be for a period of not more than twenty years, but may be renewed with or without change or amendments to the terms and conditions under which it was granted, for further periods of not more than twenty years each.

Although no cutting rights are assigned under a forest management licence presently, holders of such licences are required to forward a cutting plan to the provincial forestry department for approval (Committee on Forest Allocation, 1965, p. 16). In addition to fulfilling the requirements of obtaining and retaining a forest management licence, the company must bear most of the costs incurred in the management of a forest area. Consequently, in most instances, companies applying for this kind of licence are large. One of the benefits of the extended tenure agreement with this licence is that the licencee is provided with the opportunity of maximizing benefits through long-range planning of the timber operation.

Other timber allocation methods include the issuing of timber sales (and/or quotas) and timber permits in a forest management unit. Timber sales and permits may be awarded by public competition or by agreement between the Minister of

Natural Resources, and persons established or intending to become established in commercial timber operations (RR & TS, 1977, p. 46). Prior to 1965, all timber sales were awarded to the highest bidder competing for cutting rights. This system was changed in 1965 so that persons who held timber sale or permit agreements for at least three years, were awarded quotas to 1980. The size of the quota awarded is based on the average production of the three years prior to 1965.

Unless commercial operators are cutting wood on private lands, each operator must acquire a timber sale or timber permit for resale in order to cut and market wood. The cost of this kind of cutting agreement will vary depending on: (1) the kind and amount of wood being cut; (2) the area from which it is cut; and (3) other stipulations as stated in the agreement by the forestry branch.

3.3 *Wood Supply and Demand*

3.3.1 Annual Allowable Cut, Volume and Species

To provide assurance of a continuous supply of timber to established industries and operators, proposed annual cuts are calculated on a sustained yield basis (RR & TS, 1977, p.44).

According to The Forests of Manitoba report (MNRE, 1978, p. 1, reprint), the volume of wood available on an annual allowable cut (AAC) basis is now estimated to be 2,668,240 cunits; consisting of 1,890,720 cunits of coniferous species and 777,520 cunits of deciduous species.

It is estimated that total supply currently exceeds peak demand by about four times (The Forests of Manitoba, 1978, p. 2). However, a large portion of this supply is located in currently inaccessible areas. In addition, approximately 30 percent of the total AAC is composed of deciduous species which are presently underutilized by the forest industry. The figures presented above apply to areas outside the agricultural zone as no forest inventory has been conducted in this area to date (figure 7).

Although virtually any species of tree may be used for fuelwood, this study examines only those species which are underutilized by the forest industry;and which are classified as fuelwood by the Forestry Branch. These include: (1) black spruce; (2) jack pine; (3) poplar;[1] (4) birch; (5) dry wood;[2] and (6) slabs and tops. The species which

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[1]Poplar includes both *Populus tremuloides* and *balsamifera* and will be referred to as "poplar".

[2]Drywood refers to any tree which is dead.

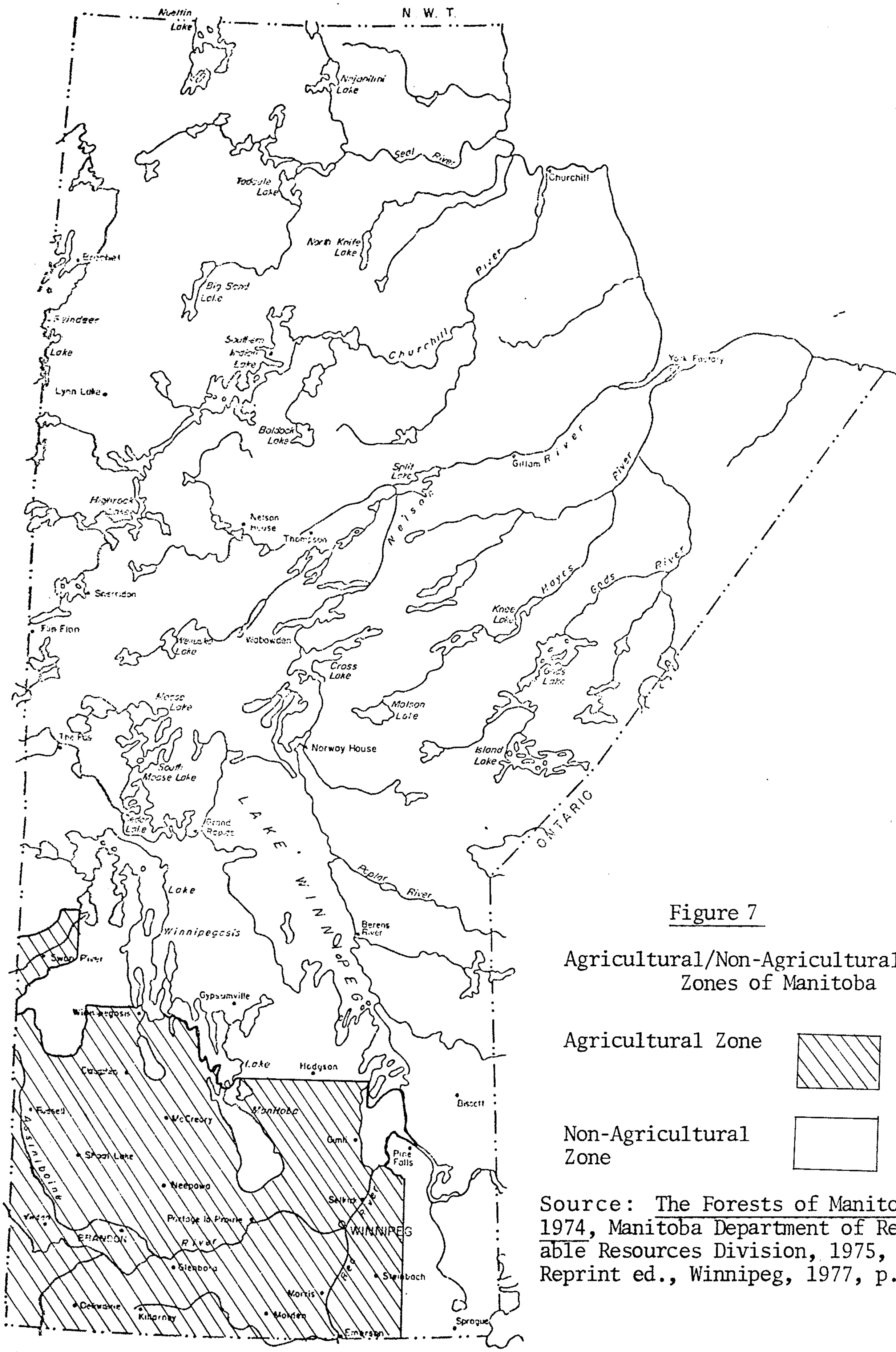

Figure 7

Agricultural/Non-Agricultural Zones of Manitoba

Agricultural Zone

Non-Agricultural Zone

Source: The Forests of Manitoba 1974, Manitoba Department of Renewable Resources Division, 1975, Reprint ed., Winnipeg, 1977, p. 14.

are used mainly for fuelwood are poplar and birch (93 percent) whereas the remaining seven percent are comprised of black spruce, jack pine, dry wood and slabs and tops.[1] Since only a small percentage of spruce, jack pine, drywood and slabs and tops are used for fuelwood, further discussion of fuelwood will focus on poplar and birch.

3.3.2 Species Location and Supply

Table 5 indicates the annual allowable cut (AAC) for the white birch, balsam poplar and the trembling aspen species of fuelwood while figure 8 denotes the forest region in which these wood supplies are located. Of the total AAC of these species in the nine forest regions of Manitoba (figure 8); approximately 10 percent are comprised of birch; 11 percent poplar; and 79 percent aspen.

3.3.3 Designated Cutting Areas

Present fuelwood supply areas have been determined by the Manitoba Department of Natural Resources.
These supply areas can be divided into two working classes: private use and commercial use.

The establishment of designated cutting areas for private use is largely dependent upon the demand for fuelwood in a

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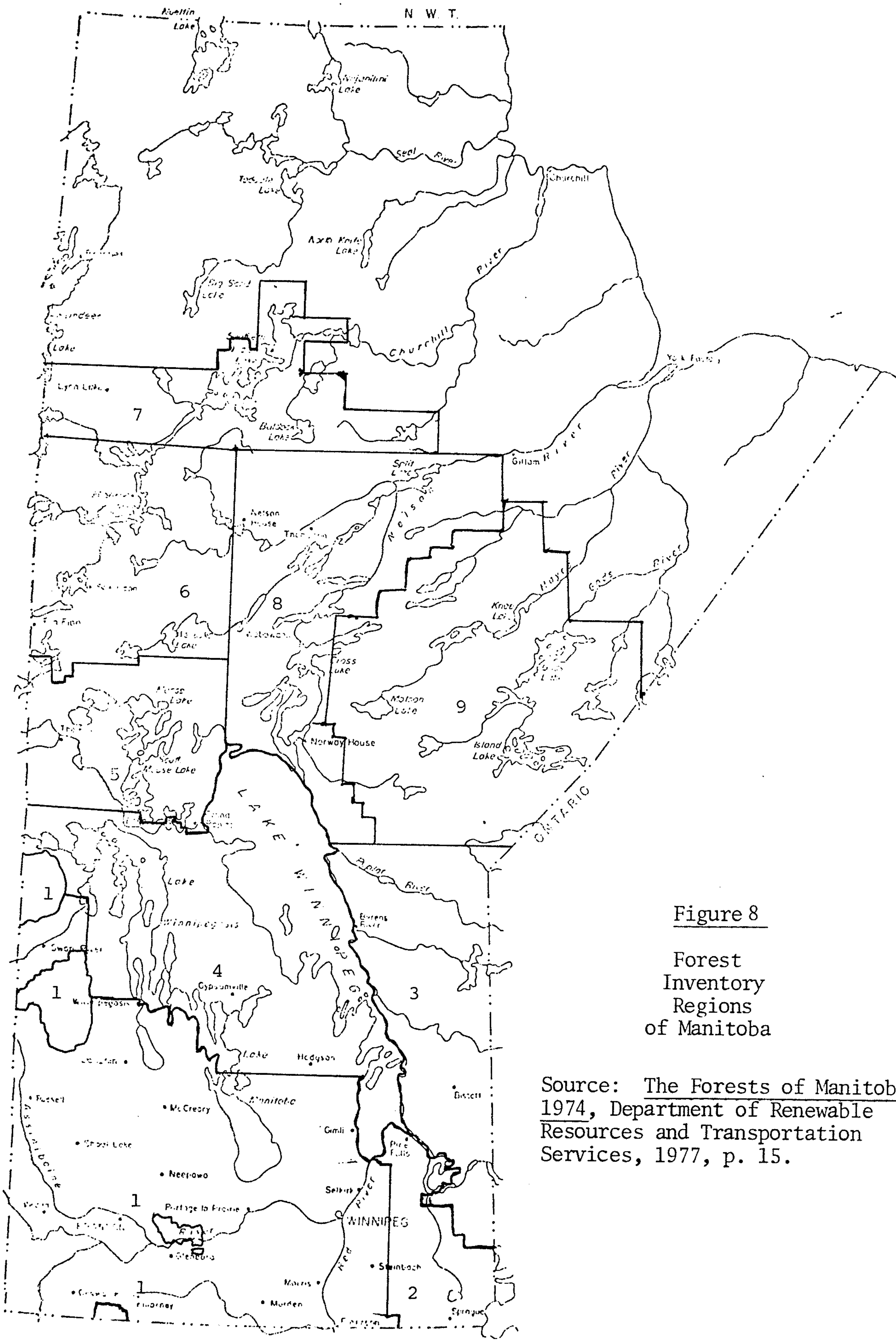
[1]Figures calculated from 1978 Annual Report of MNRE.

TABLE 5

ANNUAL ALLOWABLE CUT ON PROVINCIAL CROWN LAND OPEN ZONE, IN CUNITS

	Species		
Forest Region	White Birch	Balsam Poplar	Trembling Aspen
1	14,440	34,920	126,200
2	5,450	11,130	45,400
3	7,660	3,140	122,860
4	8,940	7,700	41,020
5	4,940	4,990	33,830
6	9,000	5,510	73,800
7	1,010	360	1,070
8	8,230	8,100	69,840
9	17,600	11,580	95,060
TOTAL:	77,270	87,430	609,080

SOURCE: Bob Lamont, "Status of Manitoba's Forest Resources", Manitoba Department of Renewable Resources and Transportation Services, 1977, p. 7-8, mimeographed.


N. W. T.
Seal River
Churchill
North Knife Lake
Big Sand Lake
Churchill River
York Factory
Lynn Lake
7
Gillam
River
Split Lake
Nelson
Nelson House
Thompson
6
8
Hayes
Gods River
Knee Lake
Cross Lake
9
Norway House
Island Lake
Scott
Moose Lake
5
Grand Rapids
LAKE WINNIPEG
ONTARIO
Berens River
1
Lake Winnipegosis
Swan River
1
4
Gypsumville
3
Lake
Hodgson
Manitoba
Bissett
Russell
McCreary
Gimli
Shoal Lake
Pine Falls
Neepawa
Assiniboine
1
Selkirk
Portage la Prairie
River
WINNIPEG
Red River
Steinbach
Morris
1
2
Morden
Sprague

particular area (Klaus Vogel, personal communication, February 1979). Much of the fuelwood demanded for private use comes from the southern and southeastern portions of the province, where population concentration is greatest. Therefore, cutting locations are established in several areas of these regions to accommodate those individuals supplying their own fuelwood requirements. Other regions of the province, have not designated fuelwood cutting areas (because of a lower demand). However, individuals may obtain their allowable supply of wood from anywhere within these regions providing there are no cutting restrictions.

Designating cutting areas where wood demand is significant provides a means for monitoring and regulating wood cutting. This in turn allows for data to be kept on the amounts and species of wood being cut.

Areas chosen for fuelwood cutting have roads and parking facilities provided for the private user. Although these facilities represent a cost to the forestry branch, they are essential in order that indiscriminate cutting be avoided in non-designated areas.

Individuals seeking fuelwood for personal use may obtain a cutting permit from the MDNR or through district conservation officers. Persons cutting their own fuelwood are given maps of designated cutting areas and must follow Forest Act and Fire Act regulations. Permits for private use do not allow for resale of fuelwood and an individual may not apply for more than one permit per season.[1]

Areas designated for commercial use are assigned in accordance to the commercial operator's timber agreement. Each operator has specified on his agreement the amount and type of fuelwood allocated to the operation. The sustained yield management system ensures that any particular species will not be overcut by commercial operations and that operators will harvest wood according to the regulations set out on the timber agreement. Any portion of a forest management unit may be allocated to a commercial operator providing there are no previous restrictions and any commercial operation is subject to periodic inspection by forestry personnel.

3.3.4 Fuelwood Demand

The demand for fuelwood over the past six years is shown in tables 6, 7, and 8. These tables include the total amount of fuelwood allocated according to: region, species, and method of timber disposal. In the context of this study demand refers to the physical quantity of wood harvested by both private individuals and commercial timber operators for personal use or for resale as a heating fuel.

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[1]Permits cost $1.00 each and an additional $0.50 to $1.00 for each cord of wood cut depending on the species. In the case of birch and poplar only 2 cords of birch and 3 cords of poplar may be cut per permit per year.

TABLE 6

FUELWOOD CUT ON PROVINCIAL CROWN LANDS BY REGIONS
April 1, 1972 to March 31, 1978 (BY CUNITS)

Year	North	South	East	West	Whiteshell	Total Provincial Forests	Total Provincial Lands	Total
1973	1,410	1,414	1,638	2,709	8.75	2,068	5,110	7,178
1974	1,131	1,624	1,429	906	10	1,609	3,491	5,100
1975	1,070	2,645	1,895	1,500	10	2,985	4,149	7,134
1976	408	2,439	2,000	1,648	41	3,023	3,513	6,535
1977	604	3,816	3,194	2,585	684	5,563	5,320	10,883
1978	1,958	12,006	9,680	5,123	80	11,368	15,904	27,271

SOURCE: Manitoba Department of Renewable Resources and Transportation Services, Annual Reports 1973-1978.

TABLE 7

FUELWOOD CUT ON PROVINCIAL CROWN LANDS BY SPECIES
April 1, 1972 to March 31, 1978 (BY CUNITS)

Year	Spruce	Jack Pine	Poplar	Other Hardwoods[1]	Dry[2]	Slabs & Tops	Total	% Change
1973	738	351	1,769	650	2,945	725	7,178	- 10%
1974	249	260	1,061	930	1,578	1,023	5,100	- 40%
1975	306	693	1,009	986	3,148	996	7,134	+ 28%
1976	183	383	1,221	2,399	1,813	538	6,535	- 9%
1977	215	288	1,936	4,845	2,375	1,224	10,883	+ 39%
1978	301	311	4,073	15,255	5,255	1,469	27,271	+ 60%

[1]White birch primarily.

[2]Any felled or dead trees.

SOURCE: Manitoba Department of Renewable Resources and Transportation Services Annual Reports 1973 - 1978.

TABLE 8

FUELWOOD CUT ON PROVINCIAL CROWN LANDS BY METHOD OF DISPOSAL
April 1, 1972 to March 31, 1978 (BY CUNITS)

Year	Total	Timber Permits	Timber Sales	Timber Berths	Seizures
1973	7,178	6,586	5,912	4	6
1974	5,100	3,613	1,471	--	16
1975	7,134	5,726	1,350	38	23
1976	6,535	5,446	1,056	--	33
1977	12,015	9,641	1,220	--	21
1978	27,271	25,666	1,580	--	25

SOURCE: Manitoba Department of Renewable Resources and Transportation Services Annual Reports 1973 - 1978.

The data from the Timber Sales Office of the Forestry Branch indicate that a total of 27,271 cunits of fuelwood have been allocated in 1978. Approximately 65 percent of this wood is allocated to private individuals from the purchase of fuelwood permits for private use, while 35 percent has been allocated to commercial operators who cut and sell fuelwood to registered timber dealers. In 1978, only 33 percent of registered dealers (from a total of 36) have recorded fuelwood sales and of this 33 percent, two dealers have 74 percent of the total fuelwood sales. Personal communications with timber dealers indicate that wood sold in 1978 comprises 71.8 percent birch, 23.4 percent poplar, 3.3 percent pine slabs and 1.5 percent oak.[1] It is clearly evident that birch wood is in great demand by both private individuals and commercial timber dealers because of its clean burning properties and aesthetic appeal.

3.4 *Constraints on the Wood Resource*

Although wood for heating is again increasing in popularity, there are a number of physical resource factors which should be considered as possible constraints in the continued use of fuelwood. Two of these factors will be discussed in this section of the text. They include: (1) resource allocation; and (2) the wood resource and its management.

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[1]Pine slabs and oak will not be considered as a major fuelwood source in this study (since they comprise only 3.3 and 1.5 percent of the total) and therefore do not merit further discussion.

3.4.1 Resource Allocation

Section 3.2.2 (Resource Allocation) of the study outlines the system presently used in allocating wood to private individuals and commercial operators. There are certain concerns regarding wood allocation to commercial timber operators which may impose a constraint on the continued commercial harvesting of fuelwood.

The principal method of timber allocation to commercial timber operators in Manitoba is through timber sales (on a quota basis) or permits in a specified forest management unit. A document released by the Committee on Forest Allocation in 1965 states that:

> when a forest management unit is established, all existing operators would first be allocated a quota of which they will be allowed to cut annually (p. 9).

One reason for the adoption of this system was that issuing sales or permits on a yearly basis did not provide any medium or long-term security to an established operator. Prior to the quota system, a timber operator would be forced to compete for timber rights each time a timber sale expired (RR & TS, 1977, p. 46). Initially, this system was to provide existing operators with a guaranteed AAC so that their operations could continue on a yearly basis with the security of having an assured volume of wood.

Furthermore, the system provides each quota holder with a transferability option.[1] Transferability of quotas is designed with the hope of achieving more efficient timber operations by allowing inefficient operators to recover some of their equity through the sale of their quota to another operator (A Forest Allocation System for Manitoba, 1965, p. 11). The objective of this system was to reduce the total number of quota holders so that there would be fewer, but larger (more efficient) timber operations.

Fourteen years after the document, "A Forest Allocation System for Manitoba" (1965) was written, closer examination of the quota system seems to indicate that some problems exist with this method of allocation. Discussion with some timber operators indicate that the quota system makes it very difficult for interested persons to become involved in fuelwood production (R. Dupas, G. Newman, personal communication, February, 1979).

When the quota system was adopted,most existing timber operators received small quotas.[2] Many small quota holders eventually had to sell their quotas, (in most cases to larger ones), since small operators could

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[1]Where the operator could sell or purchase his own or another's quota in order to cease or expand his operation.

[2]Quota sizes were based on the average timber harvest three years prior to 1965.

not be provided with a reasonable return. Currently there are a small number of quota holders, most of whom have large quotas for timber operations. When the quota system was adopted, the fuelwood market was small and declining annually, therefore, few persons were interested in becoming established fuelwood operators.

However, with an increased sale of wood stoves in the past few years, the fuelwood market has been continually increasing. Consequently, there are a number of individuals who would like to enter into fuelwood production but cannot because it is virtually impossible to obtain a guaranteed supply of fuelwood for resale on a continuing basis. Presently, commercial fuelwood production is dependent on large quota holders who may sell their quotas to individuals interested in fuelwood production or decide to produce fuelwood themselves.

Most of this discussion pertains to the southern and eastern portions of Manitoba which are currently satisfying 74 percent of the province's demand for fuelwood. Since it is difficult to obtain permits for commercial fuelwood production, and because existing quota holders have a better chance of obtaining new timber sales than non-quota holders, people interested in fuelwood production are dependent on the large quota holders for obtaining a guaranteed fuelwood supply. As a result, the present quota system makes it difficult and expensive for non-quota holders to become involved in fuelwood production thereby limiting expansion of the industry.

3.4.2 Constraints on the Wood Resource

Although there are abundant supplies of wood in Manitoba which may be used for fuelwood there is some concern as to the extensive utilization of certain species which are not as abundant, namely birch wood. Table 7 (other hardwoods) indicates that in the southern and eastern portions of the province, birch wood is in greatest demand as a fuelwood source. Consequently, the present and future demand for birch wood is placing a strain on mature birch stands (which are in short supply when compared to other species such as poplar). A solution to this potential problem would be to promote the use of species such as poplar which is approximately nine times more abundant than birch.

Another aspect to consider in the potential constraints to continued fuelwood use is the accessibility of the available supply and its marketability. Despite the abundance of underutilized wood supplies (figure 7) approximately 45 percent are located in presently inaccessible areas (forest regions 5, 6, 7, 8, and 9). However, 44 percent of the demand for fuelwood comes from the southern portion of the province; resulting in a situation whereby region 2 in close proximity to major southern markets, is supplying much of the total fuelwood demand (figure 8).[1]

Although present wood demand is significantly less than supply in most regions of the province, those areas which are considered inaccessible should be examined for the purpose

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[1]The percentage demand by region is calculated from table 5 for the southern region.

of making available fuelwood supplies for future use. Thus pressures which may be exerted on local supplies may be avoided.

CHAPTER IV

FUELWOOD PRODUCTION AND CONSUMER ECONOMICS IN MANITOBA

4.1 *Introduction*

In determining how fuelwood fits into the Manitoba energy budget, an examination of the production and consumer economics of fuelwood is required. More specifically this section of the study will address itself to (a) providing a description of various methods and techniques used in fuelwood production; and (b) comparing the energy efficiency and costs of fuelwood with other conventional energy sources.

4.2 *Fuelwood Production and Marketing*

There are a number of ways fuelwood may be harvested and marketed. Figure 9 illustrates three methods this study will examine. They include: the consumer as supplier; the operator as supplier; and the dealer as supplier.

With the first method an individual becomes his own supplier. This means that a person supplying his own fuelwood will: (1) fell the tree; (2) buck logs into desired lengths; (3) transport wood to the consumption point; (4) cut and split logs into suitable lengths; and (5) stack the wood. With this method an individual need only an axe or chainsaw, a truck and perhaps a hydraulic splitter, or maul.[1]

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[1] In many instances individuals use only an axe or maul to split wood since hydraulic splitters are costly.

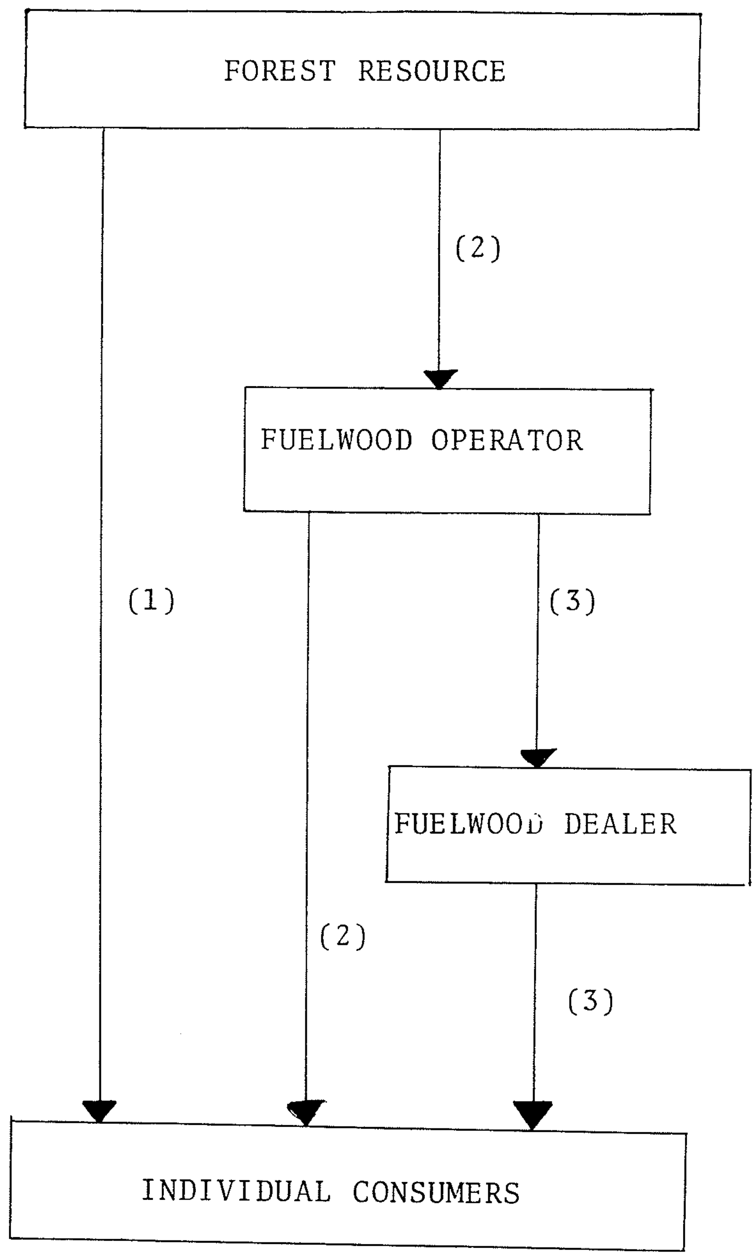

FIGURE 9

FUELWOOD PRODUCTION AND MARKETING METHODS

With the second method, a fuelwood operator harvests and markets the wood himself. There are three production methods which may be used in producing fuelwood on a commercial scale. The first of these is the "full-tree" method whereby a tree is felled and then skidded (plates 1 and 2) to the loading area.[1] Here the tree is delimbed. The second cutting practice which is used by commercial operators is the "tree-length" method. This method differs from the "full-tree" method in that the tree is delimbed in the stump area, where the logs are skidded to the loading area. The third cutting practice is the "cut and pile" method whereby the tree is cut as in the "tree-length" method. However, instead of skidding the logs to the loading area, they are piled in the stump area to be forwarded to the loading area at a later time.

After the extraction phase of the operation,an operator may cut logs into 1.2 - 2.4 meter lengths,or may cut and split logs into fireplace or stove lengths ($\approx$ 35 cm). Some of the equipment used by commercial operators includes: (1) chain saw; (2) skidder; (3) forwarder; (4) feller buncher; (5) limber buncher; (6) loader; and (7) truck. If cutting and splitting is carried out by the operator a hydraulic splitter

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[1]Skidding is a process of removing downed trees out of the cutting area by a skidder or tractor.

Plate 1
Front View of Skidder

Plate 2
Rear View of Skidder

may also be involved.

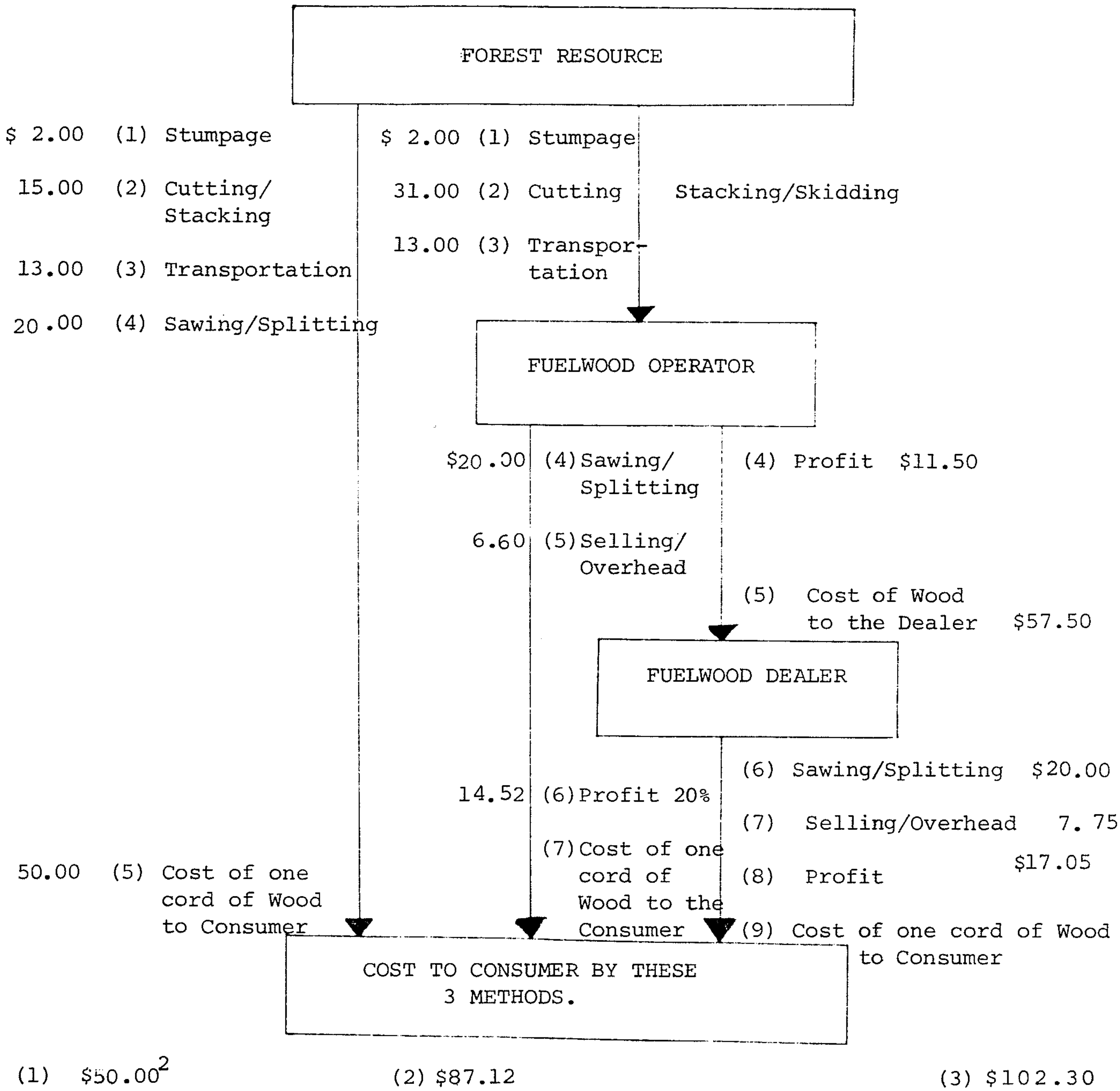
When the operator acts as the marketing agent, an often used strategy is the advertisement of his product in local newspapers. When wood is sold the operator may deliver the product to the consumer or the consumer may pick up the supply himself. In the latter case, the cost of the fuelwood will be somewhat cheaper as the consumer does not pay delivery costs.

In the third method of production and marketing, a fuelwood operator will supply wood to registered fuelwood dealers who will market the product. Depending on consumer preference, the dealer may either sell wood in log lengths (1.2 - 2.4 m), or may cut and split wood into fireplace or stove lengths ($\approx$ 35 cm).

After a dealer purchases wood from an operator, there are two main channels through which the product may be sold. The first is through advertising, in which case wood is sold directly to the consumer. The second method is by selling the wood to larger dealers or retail stores (i.e. Slivinski's Fuel Company, Beaver Lumber, Sutherland Supply), who in turn sell to consumers.

4.3 *Production and Marketing Costs of Fuelwood*

Figure 10 provides the costs for the various component stages involved in the production and marketing of fuelwood. Costs for each of these components have been determined through discussions with commercial operators, fuelwood dealers and forestry personnel. Furthermore, costs are based on section 4.2 of the study which outlines production and marketing



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[1] Cost calculations are included in Appendix B of the study. The example above are representative costs for a 80 km haul for 1 cord (3.62 m^3) of Birch (December 1979).

[2] Opportunity cost of $5.00 per hour is included in this calculation.

FIGURE 10
COST COMPONENTS IN PRODUCTION AND MARKETING FUELWOOD[1]

methods of fuelwood.[1]

The production and marketing costs will vary slightly for different individuals, operators and dealers because of variations in: (a) opportunity cost; (b) equipment cost; (c) transportation costs; and (d) marketing costs. Therefore, the preceeding figures are averages of the various component stages in fuelwood production and marketing.

Table 9 presents the selling prices in December 1978 of fuelwood delivered to consumers in Winnipeg. The prices in this table are the average prices quoted by several Winnipeg area fuelwood dealers.

4.4 *Possible Opportunities and Constraints in Fuelwood Production and Marketing*

4.4.1 Background

Demand for fuelwood declined in the past because of competition with more economical energy sources. Economic competitiveness of fuelwood was hampered by traditional methods of production and delivery which were highly labour intensive. Furthermore, efficient production required large capital investments. Consequently, production and marketing costs were driven up making wood use uneconomical when compared to other heating fuels. Costs of conventional energy sources have increased to the point where, in some instances, wood use for space heating is again becoming economically competitive as a fuel source. Furthermore the significant increase in

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[1] Only cost of birch wood production will be examined.

TABLE 9

AVERAGE SELLING PRICE OF FUELWOOD DELIVERED TO CONSUMERS IN WINNIPEG FOR DECEMBER 1978 IN $/CUNITS (CORDS)[1]

WOOD	CUT INTO 244-CM LENGTH (8-FOOT)	CUT INTO 122-CM LENGTH (4-FOOT)	CUT INTO 36 CM LENGTH (16-INCH) BUT UNSPLIT	CUT/SPLIT INTO 36 CM LENGTHS (16-INCH)
Birch	$35.00	$39.00	$50.80	$79.92
	($45.00)	($50.00)	($65.00)	($102.30)
Poplar	$23.00	$27.00	$35.15	$48.30
	($30.00)	($34.00)	($45.00)	($61.83)

[1]Based on average selling price for eight Winnipeg fuelwood dealers.

the number of fuelwood permit allocations from 1976 - 1978 (table 8) may indicate that wood use is increasing because of its renewed economic competitiveness.

4.4.2 Possible Opportunities and Constraints

There are a number of possible opportunities and constaints associated with increasing fuelwood use. Some of these include: market size, capital, labour, transportation, and demand.

4.4.2.1 Market Size

If fuelwood use is to continue increasing, determining whether a market for this heating source exists is a priority. This study has already indicated that a sizeable market of fuelwood users does exist and that fuelwood produced and marketed (at competitive prices) would be consumed by those persons presently using wood and others who might switch over to wood as a result of escalating fuel and electricity costs. Therefore, it does not seem evident that the market size for fuelwood would pose any constraint to increased use.

4.4.2.2 Capital

As in any other industry, the availability of capital for future fuelwood production is a key concern which merits some discussion. If the economic viability of fuelwood use is to be maintained fuelwood must remain economically competitive with other energy sources. A major requirement therefore should be the efficient production of fuelwood by commercial operators. However, in order to achieve production efficiency, significant capital investment is required for purchase of equipment used in forestry operations.

If capital is scarce, further expansion of the fuelwood industry may be restricted, however, several other sectors of the economy would also be affected. Some suggestions indicate that tight capital markets may prevail due to expanding needs for investment in a number of other sectors (Nickel, et. al., 1978, p. 104). Therefore, capital requirements may be one constraint affecting the fuelwood industry since fuelwood competitiveness depends to a large extent on efficient, low production cost.

4.4.2.3 Labour

In general, continued expansion of the fuelwood industry could provide a means of increasing employment in Manitoba. Jobs could be made available in cutting operations down to fuelwood marketing. Since almost all fuelwood is harvested during winter there should not be a shortage of labour for the fuelwood industry. In many areas of the province some individuals pursuing seasonal occupations (farming to an extent) find themselves unemployed in the winter months. Since many rural areas are near the fuelwood resource those persons interested could participate in fuelwood production. It seems indicative that by expanding fuelwood production more unemployed labour could be put to work thereby increasing the amount of fuelwood for space heating and in turn strengthening the economy.

4.4.2.4 Transportation

Another crucial factor to be considered as a potential constraint in the fuelwood industry is the cost and availability of transporting fuelwood to market. Generally, transportation costs will vary depending on: (a) load density; (b) regularity; (c) loading and unloading conditions; and (d) distance.

Density is a factor which ultimately controls the payload. As density increases there is a corresponding reduction in the quantity of wood which can be transported and an increase in transportation costs. In order to control transportation costs it is important to transport well-seasoned wood which weighs considerably less than green wood.[1]

There are three methods by which wood can be transported to market. They include common carrier, contract hauling and operator hauling. Usually common carrier transport is the most costly of the three methods since common carriers charge a general tariff which is quite high in comparison to

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[1] Seasoned birch (20% M.C.) weighs approximately 997 kg. (2194 lbs) per cunit (2808 lbs per cord), while green birch weighs approximately 1279 kg. (2,813 lbs) per cunit (3601 lbs per cord).

contract hauling. The reason for this is that contract hauling serves the fuelwood operator on a seasonal basis or point to point runs whereas common carriers may be used sporadically for transport. If the size of the fuelwood operation economically justifies operator owned equipment the final method of transport (operator hauling) may be the cheapest of the three.

According to the Manitoba Trucker's Association (personal communications, December 1978) the cost of transporting fuelwood to market will range anywhere from \$24.00 to \$28.00 per hour if the transporting distance is less than 160 km. This cost would include loading and unloading times and transport with no back haul. If the distance is greater than 160 km the charge is \$0.50 per loaded kilometer. In estimating transportation costs it is best to determine the components involved in transport (i.e. load-unload time, density of material and distance) in order to arrive at a cost per cunit of wood hauled.

Transportation of fuelwood, however, is not restricted to tractor trailers, whose load capacity may range from 8 - 16 cunits (10 - 20 cords), wood may be transported by vehicles as small as half-ton pick up trucks with a capacity of .5 cords (1.81 m^3). Whether or not it will be worthwhile to transport wood by various trucking modes (i.e. maintaining a net energy saving of Btu value of wood per unit of fuel saved) will depend again on factors of density, load and unload time and distance.[1]

[1] See Fossil Fuel Savings from the Use of Wood for Space Heating, Appendix C.

Furthermore wood may also be transported by rail. Some rates have been calculated in table 10 according to payload weight, number of cunits per load and distance. As the table indicates the larger the payload and the longer the distance, the cost per 45.4 kg load decreases. In some cases therefore, it may be more economical to use rail transport over truck transport.

Transportation of wood to market is one of the more crucial factors in determining the economic competitiveness of wood to other heating fuels. One way in which transportation may place a constraint on the economic competitiveness of fuelwood is if the distance from the wood resource to the market increased disproportionately to the relative price increases for conventional energy sources. In this manner the fuel savings realized from wood use would slowly decrease to a point where no fuel savings would be realized.

4.4.2.5 Demand

Perhaps the only way in which demand could act as a constraint in the use of wood for heating is if wood fails to remain economically competitive with other fuels so that little or no energy savings are made from heating with wood. If this were the case then all other elements comprising fuelwood use would also deteriorate to a point where fuelwood would become an inferior good. At present and in the near future demand for fuelwood is unlikely to decrease significantly so as to affect use of wood for space heating, so long as fossil fuel costs continue to increase and the use of fuelwood generates a cost savings.

TABLE 10

RAIL COST TRANSPORT OF FUELWOOD WITHIN
A 75-100 KILOMETER RADIUS TO WINNIPEG[1]

Minimum Weight Per Load kg (lbs.)	No. of Cunits/ Load (cords)	75 Kilometer (45 mile) Radius Cost/ 45.4 kg (100 lbs.)	Total Cost	Total Cost/ Cunit (Cord)	100 Kilometer (60 mile) Radius Cost/ 45.4 kg (100 lbs.)	Total Cost	Total Cost/ Cunit (Cord)
18,182 (40,000)	11 (14)	45¢	$180.00	16.36 (12.86)	46¢	$184.00	16.72 (13.14)
22,727 (50,000)	13 (17)	44¢	$220.00	16.92 (12.94)	45¢	$225.00	17.31 (13.23)
27,273 (60,000)	16 (21)	39¢	$234.00	14.63 (11.14)	44¢	$264.00	16.50 (12.57)
31,818 (70,000)	20 (25)	38¢	$266.00	13.30 (10.64)	39¢	$273.00	13.65 (10.92)

Source: Canadian Pacific Railways, Personal Communication, Rate Information for Freight, January, 1979.

[1]As distance increases so do shipping charges. The above calculations are based on the weight of seasoned birch which weights approximately 1273 kg/cord (2,800 lbs./cord).

4.5 *Economics of Wood Utilization*

This section of the report examines the economics of wood utilization based on: the selling costs of fuelwood; the cost of conventional energy sources; and heating unit efficiencies. Table 11 provides an economic cost comparison of fuelwood with electricity, oil and natural gas.

A number of possible heating costs are calculated in table 10 which would correspond to varying cost differences of fuels due to various heating unit efficiencies. After having established the various cost levels of fuelwood use with electricity, oil and natural gas, it is necessary to determine at which price and efficiency levels fuelwood could be economically substituted for electricity, oil and natural gas. The following formulae[1] are used in determining the cost at which wood can economically replace or supplement electric, oil, or natural gas space heating.

$E_v = Vx \times Px$

where E_v = economic value of wood \$/ton

Vx = units of electricity, oil or natural gas per ton of wood (.9072 tonnes)

Px = price of electricity, oil, or natural gas per unit cost.

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[1] The formulae used are from N.A. Wiksten's report "Using Wood for Energy", 1978, p. 26 (mimeograph).

TABLE 11

HEATING FUEL COST COMPARISONS FOR WINNIPEG
(March 1980)

Fuel Type and Btu Per Natural Unit	Unit Cost of Fuel	Fuel Volume Required to Produce One Million Btu of Heat Energy	Heating Cost/1,000,000 Btu @ Heating Unit Efficiency[1]								
			100%	90%	80%	70%	60%	50%	40%	30%	20%
Electricity[2] 3,413 Btu/Kwh	2.53¢/kwh	293 kwh	7.41	-	-	-	-	-	-	-	-
Oil #1[3] 168,000 Btu/gal (4.5 litres)	75.9¢/gal (4.5 litre)	5.95 gal (26.78 litres)	4.51	5.02	5.65	6.45	7.53	9.03	11.29	15.05	22.58
Natural Gas [4] 1,000,000 Btu/mcf	2.84/mcf	1000 $ft.^3$ (28.32 m^3)	2.84	3.16	3.55	4.06	4.74	5.68	7.10	9.47	14.20
White Birch (20% MC)	$100.00	.043	4.30	4.82	5.38	6.15	7.18	8.60	10.75	14.36	21.50
8,335 Btu/lbs.(.45 kg)	80.00	(120 lbs. or	3.44	3.85	4.30	4.92	5.74	6.88	8.60	11.49	17.20
23.4 X 10^6 Btu/128 $ft.^3$	60.00	54.55 kg)	2.58	2.89	3.23	3.69	4.31	5.16	6.45	8.62	12.90
cord (3.62 m^3)	40.00		1.72	1.93	2.41	2.46	2.88	3.44	4.30	5.74	8.60
@ 2,808 lbs./cord											
Trembling Aspen(20% MC)											
9,316 Btu/lbs.(45 kg)	$ 80.00	.056	4.48	5.02	5.60	6.41	7.48	8.96	11.20	14.96	22.40
17.7 X 10^6 Btu/128 ft^3	60.00	(107 lbs. or	3.36	3.76	4.20	4.80	5.61	6.72	8.40	11.22	16.80
cord (3.62 m^3)	40.00	48.79 kg)	2.24	2.51	2.80	3.20	3.74	4.48	5.60	7.48	11.20
@ 1,900 lbs./cord	20.00		1.12	1.25	1.40	1.60	1.87	2.24	2.80	3.74	5.60

[1] To determine heating 'costs' for 1 million Btu: $\frac{100}{\text{efficiency}}$ X Unit fuel price X Fuel Volume.

[2] Winnipeg Hydro, March, 1980.

[3] Imperial Oil, Marketing Division, March 1980.

[4] Greater Winnipeg Gas, Residential Sales, March 1980 (Electricity and Natural gas are given in runoff costs).

TABLE 12

HEATING FUEL COST COMPARISONS FOR WINNIPEG
WITH FUEL AT WORLD IMPORT AND EXPORT PRICES

Fuel Type and Btu Per Natural Unit	Unit Cost of Fuel	Fuel Volume Required to Produce One Million Btu of Heat Energy	Heating Cost/1,000,000 Btu @ Heating Unit Efficiency								
			100%	90%	80%	70%	60%	50%	40%	30%	20%
Electricity											
3,413 Btu/Kwh	2.53¢/kwh	293 kwh	7.41	-	-	-	-	-	-	-	-
Oil #1[1]											
168,000 Btu/gal	1.70¢/gal	5.95 gal									
(4.5 litres)	(4.5 litre)	(26.78 litres)	10.12	11.24	12.64	14.45	16.86	20.23	25.29	33.72	50.58
Natural Gas[2]	5.32¢/mcf	1000 $ft.^3$	5.32	5.92	6.65	7.60	8.87	10.64	13.30	17.74	26.60
1,000,000 Btu/mcf		(28.32 m^3)									
White Birch (20% MC)	$100.00	.043	4.30	4.82	5.38	6.15	7.18	8.60	10.75	14.36	21.50
8,335 Btu/lbs.(.45 kg)	80.00	(120 lbs. or	3.44	3.85	4.30	4.92	5.74	6.88	8.60	11.49	17.20
23.4 X 10^6 Btu/128 $ft.^3$	60.00	54.55 kg)	2.58	2.89	3.23	3.69	4.31	5.16	6.45	8.62	12.90
cord (3.62 m^3)	40.00		1.72	1.93	2.41	2.46	2.88	3.44	4.30	5.74	8.60
@ 2,808 lbs./cord											
Trembling Aspen(20% MC)											
9,316 Btu/lbs.(45 kg)	$ 80.00	.056	4.48	5.02	5.60	6.41	7.48	8.96	11.20	14.96	22.40
17.7 X 10^6 Btu/128 ft^3	60.00	(107 lbs. or	3.36	3.76	4.20	4.80	5.61	6.72	8.40	11.22	16.80
cord (3.62 m^3)	40.00	48.79 kg)	2.24	2.51	2.80	3.20	3.74	4.48	5.60	7.48	11.20
@ 1,900 lbs./cord	20.00		1.12	1.25	1.40	1.60	1.87	2.24	2.80	3.74	5.60

[1]The cost of oil is determined on a straight ratio calculation excluding, refining costs from crude oil to heating oil, profit markup and other factors which would make the actual price higher than $1.70/gal.; therefore $\frac{\$.759}{14.75} = \frac{x}{33.00}$ where $.759 is cost per gal. in March 1980, $14.75 is the domestic price per barrel and $33.00 is import price per barrel (Manitoba Department of Energy and Mines, March, 1980).

[2]Natural gas costs determined by the April 1, 1980 export price of $4.47 U.S. therefore 19 percent exchange + $4.47 = $5.32 (Winnipeg Free Press, March 26,1980).

TABLE 13

FUEL COSTS AT DOMESTIC PRICES VS
IMPORT AND EXPORT PRICES WITH
STATE OF THE ART HEATING TECHNOLOGY[1]
per 1,000,000 Btu

Fuel Type and Btu Per Natural Unit	Unit Cost of Fuel	Heating Unit Efficiency	Cost at Domestic Prices (March, 1980)	Unit Cost of Fuel	Cost at Import and Export Prices (March, 1980)
Electricity	2.53¢/kwh	100%	$7.41	2.53¢/kwh	$7.41
Oil	75.9¢/gal	65%	$6.95	$1.70/gal	$15.56
Natural Gas	2.84¢/mcf	75%	$3.79	$5.32/mcf	$7.10
Birchwood	$102.30/ cord	60%	$7.33	$102.30/ cord	$7.33
Poplar	$61.83/ cord	60%	$5.77	$61.83/ cord	$5.77

[1]Based on Tables 11 and 12.

Vx is determined by:

$$Vx = \frac{Heffw \times Heffwu}{Heffx \times Heffxu}$$

where: Heffw = heating value of wood/ton

Heffwu = efficiency of wood burning unit

Heffx = heating value of electricity, oil or natural gas

Heffxu = efficiency of electricity, oil, or natural gas heating unit

Therefore, at various cost and efficiency levels the crossover point can be determined. The following example illustrates this.

If: Px is $0.76/gallon (4.5 litres) oil;

Heffw = 16,670,000 Btu/ton Birch wood;

Heffwu = 60%;

Heffx = 168,000 Btu/gal. (4.5 litres) oil; and

Heffxu = 70%

The volume of oil needed to equal the heating value of one ton of Birch wood is 85 gallons of oil (382.7 litres). From this, the maximum economic replacement cost of wood should not exceed $64.55/ton (.9072 tonnes) or $90.43/cord of birch (3.62 m^3).

The following graphs (fig. 11-13) may be used to facilitate calculations for other crossover levels of wood use from electricity, oil and natural gas.[1] These graphs provide a method for

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[1] These graphs have been taken from and modified for this study from N.A. Wiksten, 1978, p. 28A.

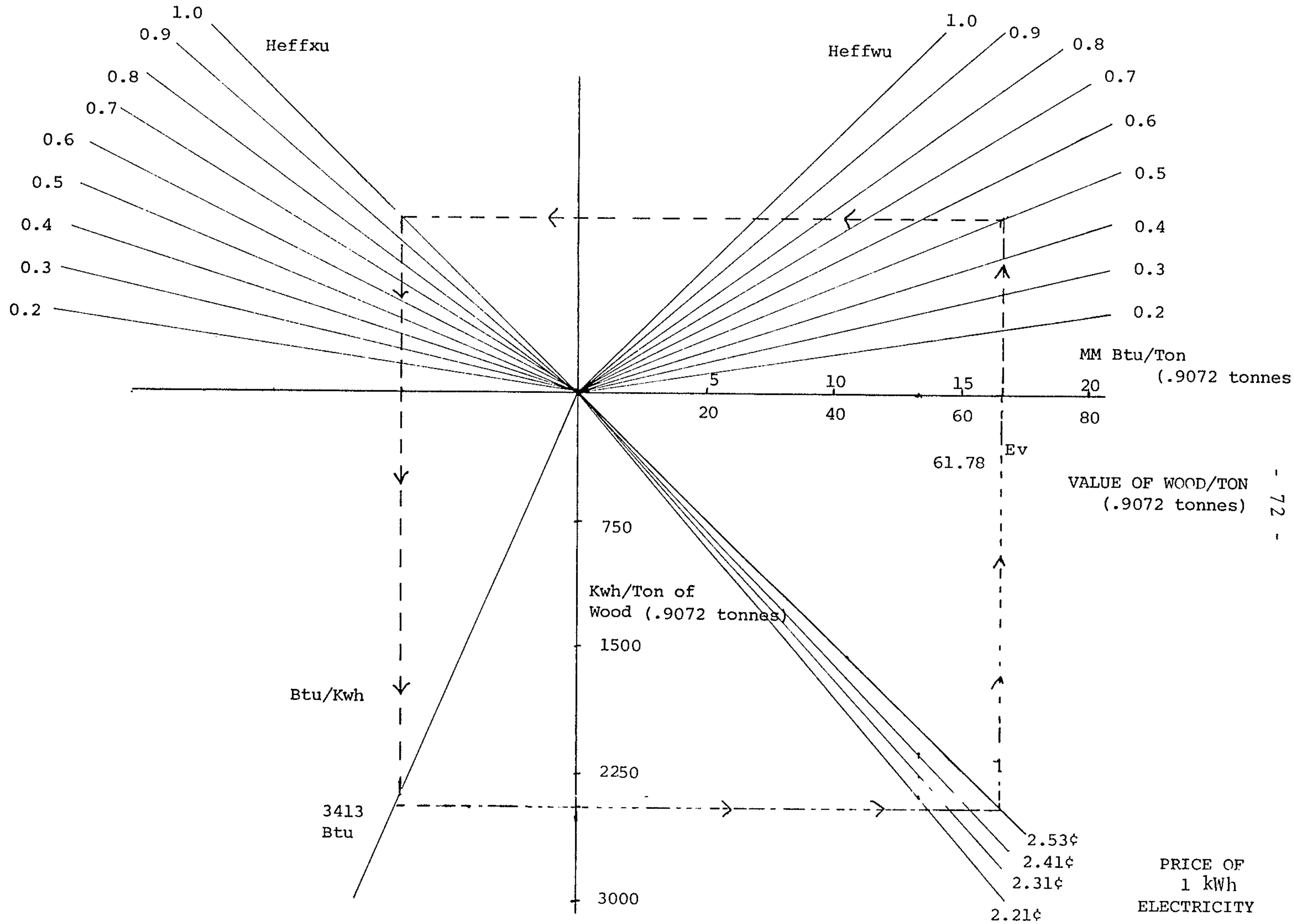

FIGURE 11
CROSSOVER VALUES FOR
ELECTRICITY AND WOOD

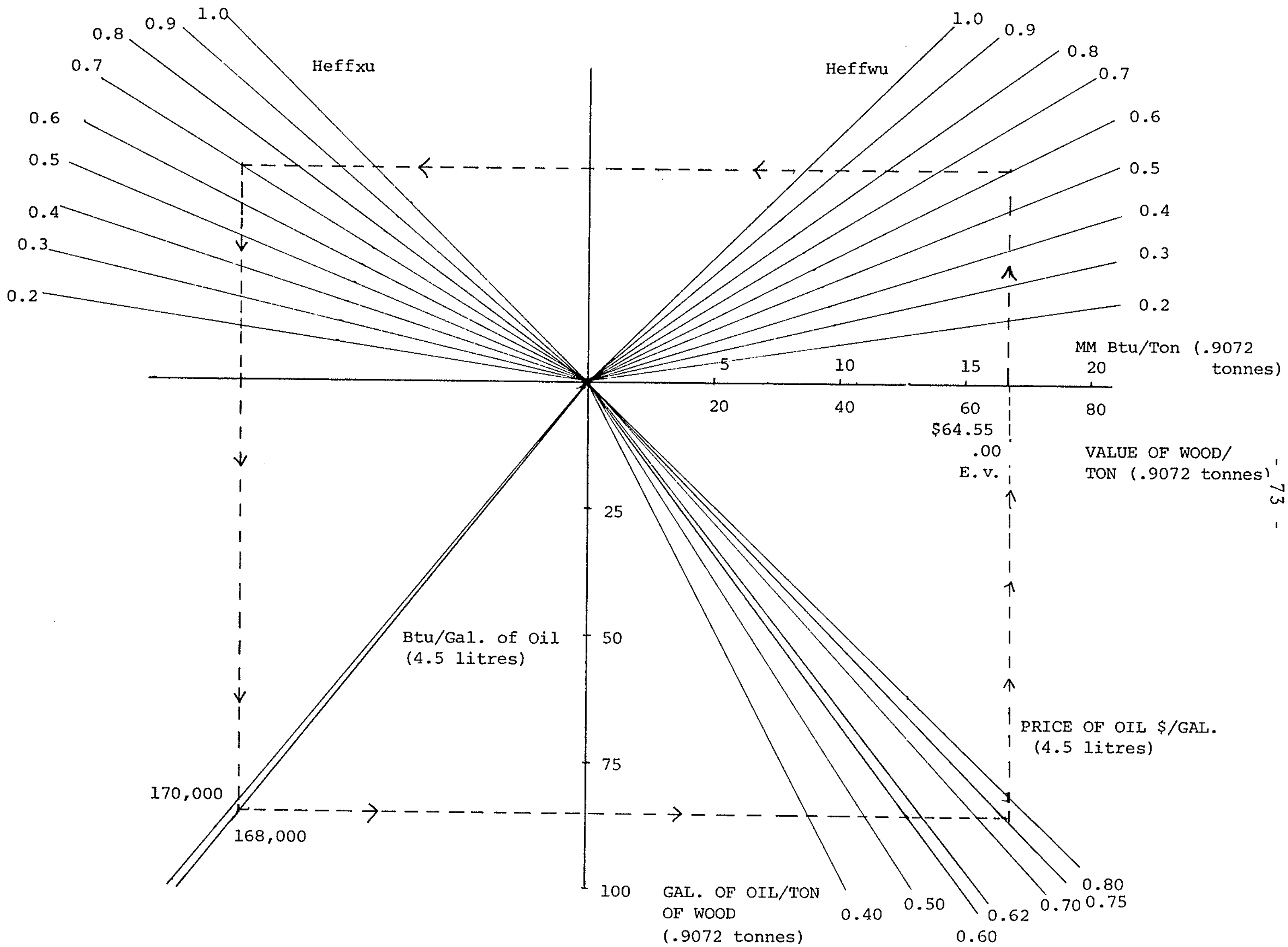

FIGURE 12
CROSSOVER VALUES FOR OIL AND WOOD

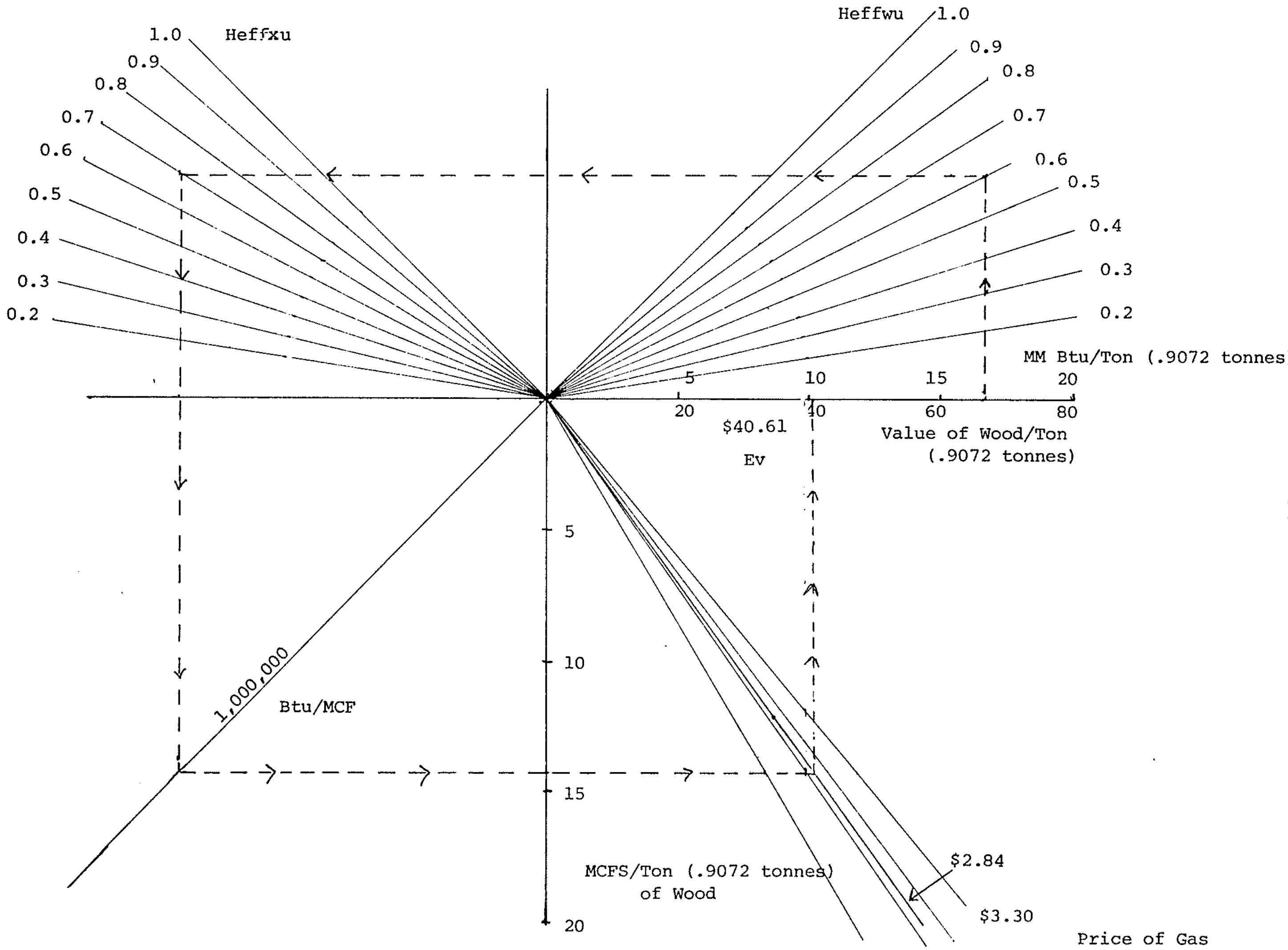

FIGURE 13
CROSSOVER VALUES FOR
NATURAL GAS AND WOOD

determining the maximum value of wood that will break even with the cost of replaced electricity, oil and natural gas.

Figures 11, 12, and 13 illustrate various heating values of fuelwood and for various efficiency ratings of heating units, the value of wood corresponding to the cost of electricity, oil and natural gas replaced by fuelwood. These graphs show that when prices of electricity, oil and natural gas increase, there will be a corresponding increase in the value of wood. As in the example for wood replacing oil an increase of 10¢ per gallon will result in the value of wood increasing by $11 - $12 per ton.

In each of the three graphs, birch wood is used as the replacement fuel with a Btu rating of 16.67 million Btu per ton (.9072 tonne). The graphs' functions will be illustrated by use of figure 12. Step one: From the 16.67 million Btu rating for birch wood on the right of the horizontal axis proceed upward to the efficiency rating of .60 (for wood). Step two: Proceed left to the .70 efficiency rating for the oil heating unit.[1] Step three: Proceed downward until the desired Btu rating for oil (in this case 168,000 Btu) is reached. Step four: Move to the right, crossing the vertical axis (indicating the gallon equivalent of oil per ton of wood)

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[1]In general, the seasonal efficiency of oil furnaces tends to range from 45 to 60 percent, while gas furnaces tend to operate in the 60 to 70 percent range. However, for illustration any combination of efficiencies may be used to determine the economic value of wood. For further discussion on heating unit efficiency see R. L. Dunning, "Fossil-Fuel Furance Losses Detailed", Electrical World, (November 15, 1974, p. 117.)

until the price of oil per gallon (i.e. 60¢) is reached. Step five: Moving upward to the horizontal axis, economic value of wood is $51.00 per ton (.9072 tonne) is obtained, which is the maximum price per ton affordable for birch wood before a zero fuel equivalent savings is realized.

4.6 Conclusion

Fuelwood can be a desirable and economical energy source if the following conditions are maintained: minimized production costs; minimized transportation distances (i.e. less than 120 km); continued price increases for oil, natural gas and electricity; and maximum efficiencies for wood heating units (i.e. 45 - 60 percent).

With these factors in mind, an individual may determine whether or not wood use will be economically feasible when compared to an existing heating system. Figures 11, 12, and 13 indicate that by considering heating unit efficiencies cost of fuel to be replaced by wood and Btu content of wood an individual will realize whether or not a net energy savings will result. Clearly, either these factors as a sum or in combination may make fuelwood use economical.

CHAPTER 5

SUMMARY, FINDINGS AND RECOMMENDATIONS

5.1 *Summary*

With the OPEC oil embargo of 1973, oil importing and consuming countries realized that the era of low-cost energy supplies had come to an end. Three requirements were determined as being necessary in order to reduce the burden of escalating prices and to reduce the cash outflow from importing regions of the world: (a) conservation of existing energy supplies; (b) diversification of energy sources; and (c) development of new energy sources.

Energy consumption in Manitoba began with the use of wood for space heating. With low-cost abundant and convenient hydrocarbon and electrical sources,coal, oil, electricity and natural gas replaced wood as a major energy source. The effects of rising energy costs in a province which imports approximately 82 percent of its energy requirements have grave implications on Manitoba's economy and population. Rising energy costs result in increased costs of energy to consumers and consequently greater cash outflow from provincial coffers for energy payments resulting in a declining provincial economy.

Although Manitoba is a heavy net importer of natural gas and oil,the province is fortunate to have a vast forest resource which may provide a renewable energy source for space heating. Recent increases in the number of wood and wood stove dealers along with increases in the number of cutting permits, seem to indicate that wood is gaining in popularity as a space heating fuel.

Although positive and negative impacts are associated with any type of energy use, a decision to use any kind of energy source would most likely be based on its economic competitiveness and consumer preference. Therefore, these criteria would have to be considered in any decision made by an individual to use wood over other available energy sources.

One reason for an increase in the use of wood has to do with wood stove designs which have lead to a reduction in the amount of wood required to heat a given area. Many modern stove designs are airtight, resulting in better draft control; even temperatures and longer burning fires.

Efficient wood burning requires that moisture content be reduced to low levels (10 - 20 percent M.C.),as a higher M.C. reduces the total heat value of wood. Some of the environmental concerns with wood burning have to do with air quality. However, when compared to coal or fuel oil, wood produces less air pollution. Any adverse effects on air quality would be dependent upon the concentration of wood burning.

Approximately 96 percent of all productive forest land in Manitoba is under provincial crown ownership.

Birch and poplar are the most popular fuelwoods in Manitoba accounting for approximately 74 percent of all fuelwood allocations in 1978.

Although there is an abundant supply of wood on provincial crown lands which could be used for fuelwood, there are three concerns which could restrict further increases in the use of wood. These include: (a) wood allocation to commercial operators; (b) the wood cutting allocation of less abundant fuelwood species; and (c) the accessibility of future supplies and their marketability. Overall, the annual allowable cut (AAC) of wood in Manitoba indicates that the total supply currently exceeds peak demand by about four times, and of this total supply, approximately 30 percent comprises underutilized species.

Supplying fuelwood to a consumer may be done in three ways: (a) the consumer is the supplier; (b) the operator is the supplier; or (c) the dealer is the supplier. Various production stages and costs will vary depending on method of production, opportunity cost, equipment cost, transportation costs, and marketing costs.

Various potential constraints and opportunities including market size, capital, labour, transportation, and deamnd are discussed as possible indicators in the future energy competitiveness of fuelwood in Manitoba.

Heating cost calculations will vary depending on selling costs of fuelwood; cost of conventional energy sources; and heating unit efficiencies. Furthermore, it is possible to calculate the crossover point at which wood becomes competitive to use based on: wood heating unit efficiency; gas, oil or electrical heating unit efficiency; heating value of wood; heating value of gas, oil or electricity; units of gas, oil, or electricity per ton (.9 tonne) of wood; and the price of gas, oil or electricity per unit cost. The resulting figure determines the economic value of wood per ton (.9 tonne) which is the maximum price the consumer can afford to pay for wood to realize a break-even point in fuelwood substitution.

5.2 Findings

1. The history of fuelwood use in Manitoba has been declining dramatically from the end of World War II up to 1973, where a levelling off began,and in subsequent years,a resurgence in the use of wood for space heating purposes. The reasons for this trend are reflected by the availability of cheap, abundant, and convenient fossil fuel and electricity supplies which made fuelwood use virtually obsolete. The reasons that decline in fuelwood use began to level off and then increase may be attributed to: the 1973 OPEC embargo which increased prices of oil and natural gas tremendously; and to the development of more efficient wood burning stoves

which greatly reduced the amount of wood required to heat a given area.

2. Burning wood may be carried out efficiently, or inefficiently, in which case it may or may not be economical as a substitute fuel source. Old stove designs and fireplaces are generally not as air tight nor do they allow for a good draft control which many modern stove designs offer. Consequently, this is one factor which determines economical wood space heating. Another factor to consider is the type of wood to be used. Generally speaking some species of wood have a higher Btu content than others. Therefore, choosing wood with a high Btu content will provide for increased efficiency. Furthermore, in connection with the type of wood being used, moisture content will greatly affect the economic feasibility of wood use. Wood with a high moisture content will require more heat energy to drive off excess moisture thus reducing the potential energy content of the wood. Therefore, burning wood with a low moisture content is desired as a greater amount of the potential Btu energy content of wood may be extracted. These are contributing factors in wood burning efficiency.

3. The overall supply potential of the fuelwood resource in Manitoba is great. Presently, approximately one percent of the total annual allowable cut of wood from provincial crown land is being used for fuelwood (27,271 cunits out of a total of 2,668,240 cunits). However, despite this amount, some species of trees and some areas of the province have a greater demand than other species and areas. As a result, birch is in short supply in some sections of southern Manitoba

while some species, such as poplar, are more than nine times as abundant (77,270 cunits birch to 697,510 cunits poplar). The largest demand for fuelwood presently comes from the southern region (Winnipeg area) of the province (12,006 cunits). The supply potential for this region is 195,640 cunits, (poplar comprising 93 percent and birch comprising 7 percent of this total) or 16 times the present demand. The implications indicate that fuelwood demand in these two forest regions could supply the Winnipeg area on a significantly larger scale. While any species of tree may be used for fuelwood, those species which are more abundant and underutilized should be used as fuelwood.

4. Given the current state of the art for wood heating technology and the use of selected fuelwood species, wood heating technology is currently competitive in the urban areas of the province (table 13). With a widening price difference between wood and other fuels in the future, use of fuelwood will become competitive with oil, natural gas and electricity (table 13).

As the economic competitiveness of wood increases and given the anticipated applications in the economies of scale for the fuelwood industry, it is a finding of this study that the price of fuelwood may decrease at a time when alternative fuels are forecast to undergo rapid price increases.

By using wood as an alternative or supplementary space heating source several benefits can be experienced.

a. As Manitoba is a net importer of all energy, the use of wood for space heating represents a cost saving to the province for energy ordinarily imported. The result of this is a reduction in cash outflow from the province for imported energy.

b. Increased wood use will provide new opportunities for employment not only in fuelwood production but also in equipment development and sales. The development of a renewed fuelwood industry would benefit the provincial economy by stimulating growth in other industries directly associated with fuelwood production.

c. The use of unmerchantable wood for replacing hydrocarbon energy or electrical energy may introduce a more complete utilization of the wood resource. In addition, more efficient methods of production may be implemented to improve forest management and maximize the utilization of the forest resource.

Wood for space heating is one supplementary or primary energy source among others available to the economy and population of Manitoba and its contribution should be understood within this context. This study indicates that with continued price increases for conventional energy sources, fuelwood use will continue to increase. Although it is difficult to project by what percentage this increase will be, it is known that fuelwood use will be regionally specific, especially in wood-producing areas that must import oil at higher than average prices.

Wood use should provide one renewable indigeneous energy source available to the Province. Manitoba should begin to divert from a heavy dependence on expensive hydrocarbon fuels for space heating,and begin to develop a broader base of energy supplies (i.e. biomass, solar, wind, etc.). Fuelwood is shown to be a growing space heating source which, (despite its regional market limitations) may capitalize on a productive resource base. If the present trend of wood use is any indication of future trends,wood will play a larger role in the total energy supply to the Manitoba economy over the next 20 years.

5.3 Recommendations

Escalating prices for non-renewable energy sources seem to indicate that the economic value of wood will be increasing more quickly than production costs. With this in mind, wood use for space heating is once again becoming an economically viable space heating source.

The findings of chapter four illustrate when wood can be used for heating at costs lower than that of electrical, oil or gas heating. Based on the research conducted in this study on the present role of wood as a space heating fuel the following recommendations can be made:

5.3.1 Forest Management and Policy

A re-examination of the present quota system should be conducted for the purpose of attracting interested persons into commercial fuelwood production. The present difficulty in obtaining a commercial timber sale or permit to persons without a quota could be alleviated by issuing provisional quotas on a short term basis (for 2 to 3 years),afterwhich quota renewal would be based on past production techniques and market sales. Production performance would be based on efficient methods of wood production which would maximize the recovery of forest biomass. Good forest management and a flexible forest policy would: provide for a continual supply of unmerchantable wood for space heating; and allow for the continued development of the fuelwood industry in Manitoba.

5.3.2 Wood Supply

In areas where the supply of certain tree species is being reduced by rising demand, the province should attempt to promote the use of more abundant species for space heating. For example, birch wood supplies in the southern portion of the province are declining at a faster rate than forest regeneration. In contrast there is a significantly larger supply of poplar which has only a 15 percent demand of all fuelwood allocated on provincial crown lands. To reduce demand on birch wood (presently 55 percent of fuelwood allocations), the province should consider: (a) restricting birch wood permits in areas where demand may endanger standing timber supply; and (b) promote the use of less utilizes species such as poplar by increasing the price for birch wood permits while maintaining a lower price structure for poplar.

5.3.3 Socio-Economic Factors

The increasing use of wood for space heating will create new employment opportunities not only in fuelwood production but also in the manufacture of wood heating equipment. With the co-operation of private and government bodies, efforts should be made to offer employment or incentives to that sector of the labour force which is currently unemployed.

The increasing use of wood as a space heating source might require both financial and technical assistance. Providing assistance should be conducted in a manner which thoroughly examines the logistics of using wood over other energy sources on a regional basis within the provinces total energy budget.

5.3.4 Government Involvement

Based on information presented in this study and with other available research on wood burning, the Provincial

Government should critically assess the viability of burning wood for space heating. Depending on the findings (if it is determined wood is economically competitive) government might begin an active advertising campaign for using wood for space heating thereby contributing to the provincial economy and reducing dependence on imported energy sources.

5.4 Areas of Further Study

With respect to wood heating the following projects appear to be of interest in establishing the future role of wood as a heating source:

a. Establish scenarios of the total provincial energy budget to the year 2000;

b. Estimate the total use of various wood fuels including wood to the year 2000;

c. Determine the amount of wood residue available from the forests for heating, gassification, distillation and hydrolysis, through examination of all commercial forestry operations.

d. Establish the total amount of wood available from private lands.

e. Develop more research into wood heating technology with the purpose of further increasing attractiveness and efficiency in wood use.

f. Determine the effects of wood burning in conjunction with safety regulations.

g. Determine the specific environmental effects from wood harvesting and combustion on a regional scale.

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APPENDIX A

SAMPLE TIMBER PERMIT AND SALES APPLICATIONS FOR CROWN LAND TIMBER CUTTING AND SELLING

DEPARTMENT OF MINES AND NATURAL RESOURCES

PROVINCE OF MANITOBA

FOREST SERVICE

APPLICATION FOR LICENSE TO DEAL
IN FOREST PRODUCTS

To the Provincial Forester,
Winnipeg, Manitoba.

I / We .... of ....

hereby make application for a license authorizing me / us to deal in lumber fuelwood, pulpwood, boxwood or other forest products and enclose the required license fee of $2.00.

My / Our business is located at ....
with branches at ....
....

I am / We are wholesale or retail dealers in the following forest products
....
....

I / We usually secure our forest products from the following sources
....
....

Shipments are received by truck / rail

I / We will carefully observe all the provisions of "The Forest Act" and Regulations made thereunder.

Dated at .... in Manitoba, this .... day of
...........................19 ....

....
Signature

Approved by.........................

Date ....

For Use of Forestry Department

New Record Books Required - Purchase ....

Sales ....

MNR-f-82

MANITOBA
DEPARTMENT OF MINES, NATURAL RESOURCES AND ENVIRONMENT
FORESTRY BRANCH

PERMIT
81067

PERMIT TO CUT TIMBER

FMU
Region

THIS IS TO CERTIFY THAT

of ¼ Sec. Tp. Rge. P.M.

having paid the following:

Permit fee $1.00 Dues $ Total $ C.N.

Is hereby authorized under the provisions of "THE FOREST ACT" and Regulations made thereunder, subject to the special conditions set out below, to cut the following quantity of timber AND NO MORE

From the following location, viz:
Conservation Officer at will supervise cutting

SPECIAL CONDITIONS

1. No green timber shall be cut within 500 feet of any Provincial Highway or any other Government Road unless the timber is marked or otherwise designated for removal by the Officer.
2. Brush and logging debris shall be cut, lopped and spread so as to lie close to the ground.
Brush and logging debris on landings must be spread.
Brush disposal must at all times keep pace with the cutting operations.

PERTINENT EXCERPTS FROM FOREST REGULATIONS

38. Within ten (10) days after the completion of the cutting operations of a permittee, the permittee shall complete and sign the declaration on the reverse side of the permit and submit it to the supervising officer.

39. Where a permittee cuts timber in an amount less than the amount authorized in the permit, and his cutting operations have been conducted in a manner satisfactory to an officer, the permittee, upon application therefor, is entitled to a refund of the amount of timber dues equivalent to the difference between the amount paid by him and the amount payable for the timber actually cut; but no refund of less than one dollar ($1.00) shall be made.

40. (1) Where an application for refund is received within thirty (30) days after the date of expiry of a permit, the permittee is entitled to the full amount of any refund payable to him.

(2) Where an application for refund is received later than thirty (30) days after the date of expiry of a permit, but within three months after that date, the permittee is entitled to only fifty per centum (50%) of the amount of refund payable to him.

41. No refund shall be made to a permittee who applies therefor after the time specified in Subsection (2) of Section 40.

42. Any overcut not exceeding ten per centum (10%) of the amount authorized shall be paid for at the rate specified in the permit; and that portion of any overcut exceeding ten per centum (10%) of the amount authorized in the permit shall, unless otherwise ordered by the director, be paid for at four (4) times the rate specified in the permit.

THIS PERMIT EXPIRES

Dated at Winnipeg

Director

2.11

If you are in doubt, or wish further information — ASK THE OFFICER

PROVINCE OF MANITOBA

DECLARATION

OF TIMBER CUT

Permit returned to Head Office, checked and approved

Date ______ Regional Director ______

________ ________ of ______ ¼ Sec. ______ Tp. ______ Rge. ______ W. E. P.M. declare —

That I am the person named in the within Permit, and that all the timber that I have cut or caused to be cut since the date of issue of this Permit to the resent date is as follows:

KIND	QUANTITY CUT	OVERCUT	UNDERCUT

hat I have utilized all merchantable material in the trees cut, have disposed of the brush as instructed and have complied with all the special conditions of this ermit. And that all timber cut under authority of this Permit, except that which I have been authorized to sell, will be used on my own land, namely:

______ ¼ Section ______ Township ______ Range ______ W. E. P.M.

id further, that timber cut under authority of this Permit, which I am allowed to sell, was disposed of as follows:

DATE	SOLD TO	ADDRESS	MATERIAL

Witness to signature of declarant ______ Date Declaration Completed ______ Signature of Declarant ______

FOR USE OF OFFICER

nount of dues on Overcut $ ______ Undercut $ ______

ercut dues collected: Date ______ 19 ______ Amount $ ______ Int. Rec. ______

nount of refund recommended $ ______ Payable to ______ Officer ______ Regional Director ______

quence of Ownership ______

arance Recommended - Contract No. ______ or Contract Year ______

gional ector ______ Date ______ Officer ______ Date ______

DEPARTMENT OF MINES, RESOURCES AND ENVIRONMENTAL MANAGEMENT

FORM MNR - fin-22
2M-5-75

ORIGINAL

PROVINCE OF MANITOBA
FORESTRY BRANCH

PERMIT

№ 4961

THIS IS TO CERTIFY THAT

Permit fee $1.00	Dues $	Total $	C.N.

Is hereby authorized under the Manitoba Forest Act and regulations thereunder also special conditions endorsed on the back of or attached to this permit to:—

HELP TO PREVENT FOREST FIRES

During the currency of this permit, the permittee is responsible for payment of any taxes levied under Cap. M226, Sec. 31 S.M. 1970.

This Permit Is Not Transferable and Expires

Dated at Winnipeg

Director

DEPARTMENT OF MINES AND NATURAL RESOURCES

FORESTRY BRANCH — APPLICATION FOR GENERAL PERMIT

Date

s

ity requested to

of Provincial Forest

escription

s

Signature of Applicant

REPORT OF CONSERVATION OFFICER (To be accompanied by Map Sheet Form F-17)

IAL INFORMATION

ements to be made

: use be commercial or non-commercial

lo. of head of stock for which applicant holds grazing permit

PLICATION FOR SAW MILL SITE

: mill

mill

y

er of products to be manufactured

of timber to be sawn

ty under which timber is to be cut

during which saw mill may be operated

: use involve monopoly?

:NG IMPROVEMENTS

)f person these improvements were made by

;

plicant properly use them?

SED IMPROVEMENTS

t of timber required from provincial forest or land for improvements contemplated by applicant

argeable on this timber

ING OF LAND INVOLVED

uch clearing will be necessary?

nt-of-way been applied for? State width required.

it be cleared? If so, why?

applicant pay for timber cut or destroyed in clearing the land?

timber be used in connection with his permit? If not, explain how he will use or dispose of it.

ould the refuse resulting from the clearing be disposed of?

ssible injury which might result from granting the permit

azing enclosure or pasture, what will the effect be upon timber growth?

e any complications which might result due to privately owned lands or prior permits granted?

the applicant's reputation and financial standing?

hat section of Forest Regulations is this application made?

nual charge should be made?

recommend that a permit be issued under the following special conditions:

ition Officer	Approved by Regional Director
	Date

MANITOBA
DEPARTMENT OF RENEWABLE RESOURCES
AND TRANSPORTATION SERVICES

TIMBER SALE AGREEMENT

Between:

HER MAJESTY THE QUEEN IN RIGHT OF MANITOBA,
REPRESENTED HEREIN BY THE HONOURABLE,
THE MINISTER OF RENEWABLE RESOURCES AND TRANSPORTATION SERVICES

(hereinafter called the "VENDOR")

OF THE FIRST PART

— and —

OF

IN THE PROVINCE OF MANITOBA, Timber Operator

(hereinafter called the "PURCHASER")

OF THE SECOND PART

WHEREAS the lands hereinafter described are Crown Lands within the meaning of the Crown Lands Act;

AND WHEREAS there is estimated to be standing upon said lands timber of the quantity, and description hereinafter mentioned;

AND WHEREAS the Crown desires to grant to the purchaser timber cutting rights with respect to the said estimated quantity and description of timber in, over and upon the said lands;

AND WHEREAS the purchaser agrees to accept the said cutting rights subject to The Forest Act and Regulations thereunder and to the terms and conditions hereinafter set out:

NOW THEREFORE THIS AGREEMENT WITNESSETH:

1. The vendor hereby grants to the purchaser the right to cut timber in, over and upon the following described lands until

(b) Notwithstanding clause (a) of this section, where because of a diminution in the volume of timber it becomes necessary to reduce the total annual allowable cut in the Forest Management Unit, in which the purchaser is authorized to cut timber, the vendor may in his absolute discretion reduce the amount of timber in direct ratio that may be cut by the purchaser.

3. The purchaser, before commencing cutting operations under authority of this agreement, shall apply for and obtain from the Vendor an annual operating permit for each year during the life of this agreement and shall pay for such permit the fee prescribed by the regulations under The Forest Act.

4. The permit under Section 3 is valid only for the period for which it was issued and shall be renewed by the purchaser if he desires to continue his cutting operations under this agreement.

5. Renewal of the permit mentioned in Section 3 may be refused where the purchaser has failed to comply with the provisions of The Forest Act, the regulations made thereunder and the terms and conditions of this agreement.

6. Unless otherwise provided by an operating permit or by anything herein contained, the purchaser shall commence cutting operations within sixty days of the date hereof and continue cutting operations progressively and diligently so that all timber cutting operations under the authority of his operating permit shall cease on or before

7. An operating permit is subject to the provisions of The Fires Prevention Act.

8. The vendor has the right and may authorize a person other than the purchaser to enter in, over or upon the lands hereinbefore described and to cut timber of a size, class or type other than that authorized to be cut by the purchaser. Any timber of the same species in excess of the quantity sold under this agreement is hereby reserved and the area covered by this agreement may be reduced in case it is considered advisable to dispose of excess timber to other applicants.

9.

10. The purchaser shall so conduct his operations as to prevent as far as is practicable any damage to young trees or trees not designated for cutting.

11. Timber designated to be cut and removed by the purchaser, but left standing or cut but unremoved by him within such reasonable time as may be prescribed by the Vendor, shall be scaled and the purchaser shall pay dues thereon at the Sale rate.

12. The purchaser shall keep and maintain or cause to be kept and maintained a record of his timber operations in such form as may be required from time to time by the Vendor, and shall submit such returns on forms prescribed by the Vendor at such times as may be set out on such forms; and without restricting the generality of the foregoing the purchaser shall keep and maintain or cause to be kept and maintained

(a) A Camp Record Book;
(b) A Sawmill and Planer Mill Record Book,
(c) A Sales Record Book; and
(d) A Load Slip Book;

all of which books shall be prescribed by the Vendor and to be kept and maintained by the purchaser in accordance with the instructions contained or prescribed in such books.

13. All brush and debris resulting from the operation of the purchaser shall be disposed of as outlined in Section 9. In addition brush and other logging debris shall be cut, piled and burned, or cut, lopped and spread so as to lie close to the ground on all Crown lands on a strip up to 500 feet in width, depending on land topography, along both sides of Provincial Trunk Highways, Provincial Roads, railway right-of-way, hiking trails, riding trails, portages, rivers, streams and lake shores.

14. Unless otherwise authorized by an Officer, no timber cut by the purchaser shall be removed from the area on which it was cut until scaled or measured by an Officer or a scaler, and every purchaser shall so conduct his operations as to allow for complete and accurate measurements of timber to be made with a minimum expenditure of time and labour, and where the scaling or measuring is done by an Officer or scaler employed by the department, the cost of such scaling or measuring may be charged to the purchaser.

15. The purchaser shall, prior to scaling or measuring, prevent the mixing or confusing of timber cut from the Sale area with timber cut from other lands and shall keep separate the different classes of timber cut from the said area; and where necessary, he shall mark clearly with crayon, the small ends of all logs to be scaled.

16. All timber cut on the Sale area shall be scaled in such manner and at such times and places as are prescribed by an Officer.

17. All timber when scaled shall be stamped or marked by the scaler or Officer.

18. The purchaser, or his authorized agent who has personal knowledge of the facts, shall, at the end of the periods ending March thirty-first (31st), June thirtieth (30th), September thirtieth (30th), and December thirty-first (31st) of each calendar year, and at such intermediate dates as may be required by an Officer, submit to the Vendor Timber Returns in a form prescribed by the Vendor showing the quantity of timber cut and the quantity manufactured during the period covered by such returns, and showing any other information that may be required by the Vendor.

19. Dues shall be charged on the quantity of timber declared on such returns as scaled or manufactured, and shall forthwith become due and payable. The rate of dues shall be as follows:

AT THE OPTION OF THE MINISTER THESE RATES MAY BE ADJUSTED ANNUALLY.

20. In the event that the purchaser fails to declare or show in any return all of the timber cut or cut and manufactured by him, the difference between the amount of timber actually cut by him and the amount shown in such return may be deemed to be timber cut without lawful authority, and subject to the payment of dues at four times the sale rate, unless the Vendor otherwise orders.

21. The rate of interest on all rates, fees, royalties, assessments, dues and charges not paid within 30 days after they become due and payable is seven percentum (7%) per annum.

22. Timber shown by the purchaser in Part I of the Timber Returns submitted by him as cut but not declared as scaled or manufactured in Part II in two or more subsequent Timber Returns may, at the discretion of the Vendor, be scaled or measured by the Officer and dues assessed on the basis of such scale or measurement; and the assessment may be adjusted when the timber is finally manufactured or scaled.

23. No refund or remission of dues shall be allowed with respect to logs or other forest products lost or destroyed by any means.

24. In the event that the purchaser desires to put any of the timber to a higher or more lucrative use than that stipulated in this agreement, he shall first obtain the written consent of the Vendor therefor and shall pay the appropriate rate of dues for such higher use as set out in Section 19 or as may be set by the Vendor.

25. (a) Timber operation as defined by The Forest Act and Regulations made thereunder means every activity involving the cutting, removal or primary manufacture of timber.

(b) The purchaser shall at all times during his operations keep the timber operation as defined in a clean, orderly and sanitary condition, satisfactory to an Officer and in compliance with The Public Health Act, The Clean Environment Act and The Fires Prevention Act.

26. (a) All buildings, structures and works, logging camps, equipment, storage or piling areas, or such other items as are necessary or essential to the timber operation of the purchaser shall first be approved in writing by an Officer as to their character and location, and shall not be located within 500 feet from any designated publicly used road or route, rail line, or water body without the written consent of an Officer.

(b) Within 30 days after the expiration of the period during which the right to cut timber is granted to the purchaser or within such other extended period of time that the Vendor may in writing specify, the purchaser shall remove all buildings and structures erected or constructed by him over or upon the area of his operation.

27. Failure to comply with items 26 (a) and/or 26 (b) the purchaser may be subject to penalties as prescribed in The Forest Act and Regulations made thereunder.

28. Where, owing to weather or other conditions the hauling of timber is likely to cause damage to a forest access road or a road within a Provincial Forest, the vendor may, by posting a notice,

(a) close any such road to traffic until the road, in his opinion, is fit for traffic; or
(b) impose weight restrictions with respect to such road.

29. No agreement or contract shall be entered into by the purchaser or any sub-contractor for the cutting of any timber on the sale area unless and until a copy of the agreement or contract has been submitted to the Vendor and he has given his written consent thereto.

30. The purchaser's operations may be suspended or this agreement cancelled as provided under The Forest Act; and any timber cut or sawn under this agreement may be seized as provided in the said Act and regulations made thereunder.

31. The purchaser shall, to the satisfaction of the Vendor, within such period of time as may be allowed by the Vendor, repair any and all damage to Crown property caused by the purchaser or his employees or contractors, at his own expense.

32. The purchaser shall forthwith upon the execution of this agreement pay to the vendor the sum of $ which said sum shall be held by the Crown as a guarantee that the purchaser will fulfill and carry out and perform all his obligations under this agreement.

33. The said guarantee deposit is subject to the provision of the regulation under The Forest Act and shall be maintained undiminished by the purchaser.

34. In addition to the guarantee deposit mentioned in Section 32, the Vendor may require the purchaser and the purchaser shall provide the Vendor, within 30 days, after the execution of this agreement with a bond or other surety satisfactory to the Vendor in the sum of $

35. This agreement, unless otherwise cancelled or terminated, expires on the date set out in Section 1; but may at the discretion of the vendor and upon application by the purchaser be extended for such further period of time as the vendor considers advisable.

36. Subject to Section 38, any extension of the term of this agreement, or of any increase in the quantity of timber that may be cut hereunder may be granted on such terms and conditions as the vendor considers advisable.

37. The Vendor has the right and where in the interest and benefit of Forest management the vendor considers it advisable, he may authorize the purchaser to cut timber other than that hereinbefore mentioned.

38. The vendor hereby agrees that upon the termination of this agreement, if the purchaser has carried out this agreement to the satisfaction of the vendor, he will make available to the purchaser, his heirs, successors or assigns, another timber sale agreement or other timber sales agreements (the aggregate term of such agreement or agreements not to extend beyond June 14th, (1980) for cutting a pro rata percentage of the annual allowable cut of timber or a pro rata percentage of the equivalent volume of timber as was initially allowed under this agreement within Forest Management Unit.

39. Notwithstanding Section 38 where the purchaser fails, refuses or neglects to cut and remove that portion of the timber designated for cutting and removal under the authority of this agreement the vendor may by a notice in writing given to the purchaser, terminate this agreement and cancel any and all right of the purchaser, hereunder subject to such terms and conditions as the vendor considers reasonable, or may reduce the volume of timber by like amount from any further timber sale agreement.

40. The vendor may waive the application of Section 39 if he is satisfied that the default or neglect or refusal of the purchaser is due to circumstances beyond the control of the purchaser.

41. The purchaser acknowledges and declares that he has read this agreement and that he fully understands the same and that he covenants and agrees to abide by the terms and conditions thereof.

42. This agreement and everything herein contained shall enure to the benefit of and be binding upon the heirs, executors, administrators, successors and assigns, as the case may be, of the parties hereto.

43. Where in this agreement it is provided that any function shall or may be performed by the Vendor, that function may be performed by the Minister of Renewable Resources and Transportation Services, or any other person authorized by law to perform that function or to sign documents of the character of this agreement on behalf of Her Majesty the Queen in Right of Manitoba.

IN WITNESS WHEREOF the parties hereunto set their hands and seals this day of 19

or

IN WITNESS WHEREOF the vendor has hereunto set his hand and affixed his seal of office and the purchaser has hereunto affixed its corporate seal attested to by the hands of its proper officers in that behalf, this day of 19

....
Minister of Renewable Resources and Transportation Services.

Signed, sealed and delivered in the presence of;

....	....
(Witness)	(Purchaser)
....	....
(Witness)	

APPENDIX B

COST COMPONENTS IN PRODUCTION AND MARKETING FUELWOOD

APPENDIX B

Cost Components in Production and Marketing Fuelwood

The first component to be considered in figure 9 is the stumpage rate. According to the Timber Sales Branch (Pers. Comm., 1979) stumpage rates may vary from $0.50 to $2.00 per cord (3.62 m^3) depending on species and availability. Both private individuals and commercial operators must pay this fee.

A second component adding to the overall cost in fuelwood production is cutting and stacking of the timber. Costs for this component vary depending upon: (a) type of wood being cut; (b) equipment used; (c) cutting and stacking time; and (d) woodcutter's wage rate.

In method 1 of fuelwood production it has been indicated that the wage rate being paid to woodcutters in 1978 averaged $10.00 per cord for birch (R. Dupas and G. Newman, personal communications, 1979). This wage rate plus a cost of $5.00 per cord (3.62 m^3 at $\approx$ .50 hrs) for the operation of a chainsaw,[1] brings the cost of cutting and stacking to approximately $15.00.

In method 2 we assume a skidder is being used therefore the cost of wages remains at $10.00 the cost of using the chainsaw is $5.00 and the cost per cord for the skidder is approximately $16.00 (see Cost of Skidding, Table B-2). Therefore the total cost for this component is $31.00.

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[1]Table B-1 . See next page.

TABLE B-1

Cost of Cutting and Splitting Fuelwood/Hour ($)
Chainsaw @ 500 hours for 3 Years

Cost $250.00

Depreciation $\frac{250}{500} = .50$

Insurance .01 @ $\frac{\$1.30}{\$100.00}$ Invested

Operator at $5.00/hr.

at 80% Machine Availability

$6.25 @ $\frac{100\%}{80\%}$ X $5.00

Fuel @ $0.90/gal. (4.5 litres) .60

2/3 gal. used/cord

Oils and Lubrication .05

Repairs at 100% of Depreciation

of which 50% is Labour .50 (.25 + .25 labour)

Fringe Labour Costs at 20% 1.30

(6.25 + .25) X .20

Interest - 12% .08 (over 3 years)

$$\frac{500}{250} \times \frac{.12}{3} = .08$$

TOTAL COST/HOUR = $9.29

COST PER ENGINE METER HOUR
FOR SKIDDING FUELWOOD
(C-5 SKIDDER)*

	Cost Per Engine Meter Hour
Depreciation - $\frac{45,000 - 5,000}{10,000}$	$4.00
Interest on Average Investment - 12% Simple Interest on (Cost per engine meter hour) $\frac{.12 \times 1/2\ (45,000 + 5,000) \times 10}{10,000}$	3.00
Insurance - $1.30/$100 Investment	0.30
Operator at $5.00 per Shift Hour at 80% Machine Availability - $\frac{100\%}{80\%} \times \$5.00 =$	6.25
Fuel at 8 - 10 gal/8 hr. shift/hr. -	0.85
Oils and Lubricants -	0.40
Repairs and Servicing, Except Tires at 100% of depreciation, of which 50% is labour - ($2.00 + 2.00)	4.00
Tires	0.50
Fringe Labour Costs at 20% (CPI, UIC, Vacation Pay - 4%, Workmen's Compensation - 9%) - ($5.00 + $2.00) X .2 =	1.40
TOTAL COST PER METER HOUR -	$20.70

* Production by a C-5 skidder is 1.25 cords (4.525 m^3) per hr.

In the number 3 component of production (i.e. transportation) it was determined that the cost of hauling wood averaged out to \$0.25/3.62 m^3 kilometer, for a total of approximately \$13.00 per cord. (R. Dupas, G. Newman, personal communication, 1979).

The final cost component for the operator is the profit charged on cordwood production. Some operators charge approximately 25 percent on the production cost, therefore total cost to the dealer at this stage is \$46.00 + \$11.50 = \$57.50.

From this point in the production stage the wood is usually cut and split from 2.4 meter lengths into 36 cm lengths. In the sawing and splitting stage it is assumed that: (a) a chainsaw and axe are used; (b) the cost of the chainsaw for cutting 3.62 m^3 of wood (per .5 hour) is \$5.00 and it takes 2 hours to split wood at a wage rate of \$5.00 per hour. Total cost for cutting and splitting cordwood into 36 cm lengths is \$15.00. Therefore is an individual were supplying his own fuelwood it would cost him approximately \$45.00 per 3.62 m^3 of wood taking into account: (a) opportunity cost; (b) transportation; (c) chainsaw; and (d) axe.

Selling and overhead are also to be considered in the total production cost if wood is being sold by the operator or dealer. Components in selling and overhead would include: (a) advertising; (b) administration; (c) salaries; (d) insurance; (e) storage; and (f) delivery cost. The figure attached to this component usually amounts to approximately 10 percent of total cost.

As with the operators profit margin, the dealer usually places a 20 percent profit on production and marketing costs so that with a 20 percent profit margin the cost of wood to the consumer by method number two is $80.42 while in method number three (via dealers) the cost is $95.70.

APPENDIX C

FOSSIL FUEL SAVINGS FROM THE USE OF WOOD FOR SPACE HEATING

Middleton Associates

Research Consultants
Energy, Resources and Environment

FOSSIL FUEL SAVINGS FROM THE USE OF WOOD FOR SPACE HEATING

Prepared for

Renewable Resources Branch
Department of Energy, Mines and Resources

April 13, 1978

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WOOD AS A HEATING FUEL SOURCE

An increasing number of Canadians are considering the use of wood for space heating. Wood appears to be an excellent replacement fuel for oil and gas because it is renewable. It is, however, necessary to determine whether the use of wood actually results in fossil fuel energy savings.

The homeowner may think of energy savings only in terms of reduction within the household. In fact fossil fuels are used in all the processes involved in supplying wood and must be taken into account when assessing savings. For example, chainsaws, transport trucks and hydraulic splitters are all powered by some form of petroleum.

A real question, therefore, exists as to whether and under what conditions burning wood for space heating actually results in fossil fuel savings. This pamphlet outlines the fossil fuels required to use wood. These requirements are then compared with the fossil fuels consumed in delivering and burning oil for home heating.

It is important to note that this assessment of the use of wood deals only with energy savings and does not include purchase costs.

FOSSIL FUEL SAVINGS

The difference between the energy expended in supplying wood and the energy requirements of heating by oil (or gas) constitutes the fossil fuel savings. This saving is expressed in terms of litres of fuel oil per cord of wood.

The six case studies, outlined on the following pages, are representative of the various situations most wood users might find themselves in. Four major wood delivery methods are analyzed along with two additional 'extreme' cases. These are compared with standard oil delivery and use to determine savings.

Data relating to the components that comprise each of these case studies are given in Table 1. It is important to note the indirect energy used to make fossil fuels available has been included in all calculations.

The makeup of these typical wood delivery and heating systems will of course vary according to individual circumstances. It is thus helpful to know how much one factor, such as transportation distance, can change before the use of oil or gas for space heating makes more sense. Values for components in each representative system have therefore been varied in order to discover the point at which the use of wood no longer results in fossil fuel savings. Those factors of wood use are discussed.

SMALL TOWN

Wood heater	-	40% efficiency
Homeowner	-	uses one ton pick-up truck
	-	drives 64 km to woodlot (round trip)
	-	uses combination hardwood and softwood immediately (no seasoning)
compared to		
Oil furnace	-	65% efficiency
Resultant savings	-	132 litres per cord

When the distance travelled is varied in this system, the result is that wood can be transported up to 460 km (round trip) before wood fuel consumption becomes equal to fossil fuel consumption.

A variation in wood heater efficiency results in the following change in savings.

Wood heater efficiency (%)	40	20	10	6
Savings (litres/cord)	132	53	15	0

Wood heater efficiency in this system can then be reduced to 6% before the "break-even" point is reached.

A variation in the amount of energy used in the harvesting process has no significant effect on energy savings. Note that even if a "Stickler" is used (consuming 2.84 l/cord) rather than an hydraulic splitter (using 1.14 to 1.89 l/cord) there is no significant change in savings.

LARGE TOWN

Wood heater	-	50% efficiency
Dealer	-	uses stake truck
	-	drives 32 km (round trip)
Homeowner	-	buys combination hardwood and softwood, seasoned from dealer
compared to		
Oil furnace	-	65% efficiency
Resultant savings	-	246 litres per cord

Varying wood heater efficiency in this case study shows that the efficiency can be reduced to 3% before the "break-even" point is reached.

Density and heating value of wood used and the transportation distance were also varied in this system. None of these factors proved to have significant effect on the savings achieved by the use of wood.

RURAL

Wood heater	-	60% efficiency
Homeowner	-	has wood on land
	-	uses half ton pick-up truck
	-	drives 18 km to woodlot (round trip)
	-	uses combination hardwood and softwood, seasoned

compared to

Oil furnace	-	65% efficiency
Resultant savings	-	300 litres per cord

The following components were all varied with no significant effect on fossil fuel savings:

transportation distance

number of cords per truckload

miles per gallon

As in Case #2, the use of a "Stickler" rather than an hydraulic splitter does not effect energy savings.

When wood heater efficiency is varied the results are as follows:

Wood heater efficiency (%)	60	40	20	10	5	2	1
Savings (litres/cord)	300	200	98	45	23	8	0

CITY

Wood heater (fireplace with, for example, tubular grate)	-	20% efficiency
Dealer	-	uses 12 ton truck
	-	drives 96 km (round trip)
Homeowner	-	buys combination hardwood and softwood, unseasoned from dealer

compared to

Oil furnace	-	65% efficiency
Resultant savings	-	64 litres per cord

Varying the distance travelled to obtain the wood shows that the dealer can drive up to 725 km (round trip) before the "break-even" point is reached.

A similarly minor effect on savings results if the energy used in harvesting is varied. The total energy consumed in harvesting processes in this system is 5 litres per cord. If this figure changes, savings will change as follows:

Energy used in harvesting (litres/cord)	5	19	38	60
Savings (litres/cord)	64	53	3.8	0

Fireplace efficiency (%)	50	30	20	5	3
Savings (litres/cord)	182	106	64	8	0

Note that if the fireplace flue is left open during the night, that decreased efficiency will result in effects on savings as indicated above.

LOW EFFICIENCY

Wood heater (fireplace)	-	10% efficiency
Homeowner	-	uses half ton truck
	-	drives 128 km (round trip)
	-	uses unseasoned hardwood and softwood

compared to

Oil furnace	-	60% efficiency
Resultant savings	-	-80 litres per cord

When distance travelled is varied in this case study, results are as follows:

Distance (km)	128	97	64	56	42
Savings (litres/cord)	-80	-49	-23	-15	0

Therefore, in order to achieve energy savings, transportation distance would have to be decreased to less than 42 km.

Calculations show that the wood heater would have to prove more than 30% efficient in order to achieve energy savings.

HIGH EFFICIENCY

Wood heater	-	70% efficiency
Homeowner	-	uses one ton pick-up truck
	-	drives 32 km (round trip)
	-	uses seasoned hardwood
compared to		
Oil furnace	-	70% efficiency
Resultant savings	-	454 litres per cord

This system shows such a high level of efficiency that factors have to be varied by relatively large amounts in order to reach the "break-even" points.

Varying wood heater efficiency produces the following results:

Wood heater efficiency (%)	70	50	30	15	10	5	2
Savings (litres/cord)	454	322	190	87	53	23	10

TABLE 1

The following Table outlines the figures assigned to each of the six sample supply systems discussed in this pamphlet. The fossil fuel saving (or loss) in each system was calculated from these figures.

	SMALL TOWN	LARGE TOWN	RURAL	CITY	LOW EFFICIENCY	HIGH EFFICIENCY
HARVESTING						
Fuel required for:						
felling (l/cd)	1.89	1.89	1.89	1.89	2.27	0 (by hand)
splitting (l/cd)	0	1.14	0	1.14	1.51	0 (by hand)
hauling (l/cd)	1.89	1.51	0	1.89	1.89	0 (by hand)
Conversion factor[1] in J/l	4.55×10^7	4.55×10^7	4.55×10^7	4.55×10^7	4.55×10^7	4.55×10^7
TRANSPORTATION						
Distance - km/truckload (round trip)	64	32	.8	96	128	32
Cords/load	1.5	2.5	.5	3.5	.5	1.5
km/l (round trip)	1.9	3	2.1	3	1.9	1.9
Conversion factor[2] g (gas) d (diesel) J/l	4.55×10^7	4.55×10^7	5.06×10^7	4.55×10^7	4.8×10^7 g - 50% d - 50%	5.06×10^7
PREPARATION						
Fossil fuel required for splitting at home l/cd	1.14	0	1.14	0	0	0 (by hand)
COMBUSTION						
Wood						
Density - tonnes(1000 kg)/cd	1.81	1.36	1.36	1.91	1.81	1.63
Quality of wood	unseasoned hardwood - softwood average	seasoned hardwood - softwood average	seasoned hardwood - softwood average	unseasoned hardwood - softwood average	unseasoned hardwood - softwood average	seasoned hardwood
Heating value - J/tonne	8.6×10^9	14.68×10^9	14.88×10^9	8.6×10^9	8.6×10^9	16.38×10^9
Efficiency - %	40	50	60	20	10	70
Oil burner efficiency - %	65	65	65	65	60	70
Heating value - oil J/l	4.75×10^7	4.75×10^7	4.75×10^7	4.75×10^7	4.75×10^7	4.75×10^7
Distance to transport oil - km	40	40	40	40	40	40
Net energy required to deliver l. oil - J/l	5.95×10^6	5.95×10^6	5.95×10^6	5.95×10^6	5.95×10^6	5.95×10^6

Footnotes:

1. The conversion factor used for converting from litres of gasoline to Joules includes the indirect energy required to make the gasoline available.

2. The conversion factor used for converting from litres to Joules for gasoline and diesel includes the indirect energy required to make the gasoline or diesel fuel available.

Note:

All savings were converted into litres of fuel oil saved per cord of wood utilized for space heat.

EXPLANATORY NOTES

THE WOOD FUEL SUPPLY SYSTEM

Fossil fuels can be consumed at every stage of the firewood supply system as illustrated in the diagram opposite. These energy expenditures have been outlined and totalled. Various processes are also involved in delivering oil for heating but these systems have not been detailed in the diagram.

The heating supply systems discussed are most representative of those across Canada. There are four major components: harvesting, transportation, preparation and combustion. Since the use of fossil fuel in these processes can be quite extensive, the energy related elements in each must be identified and examined in order to assess overall savings.

HARVESTING

Four operations are involved in this process:

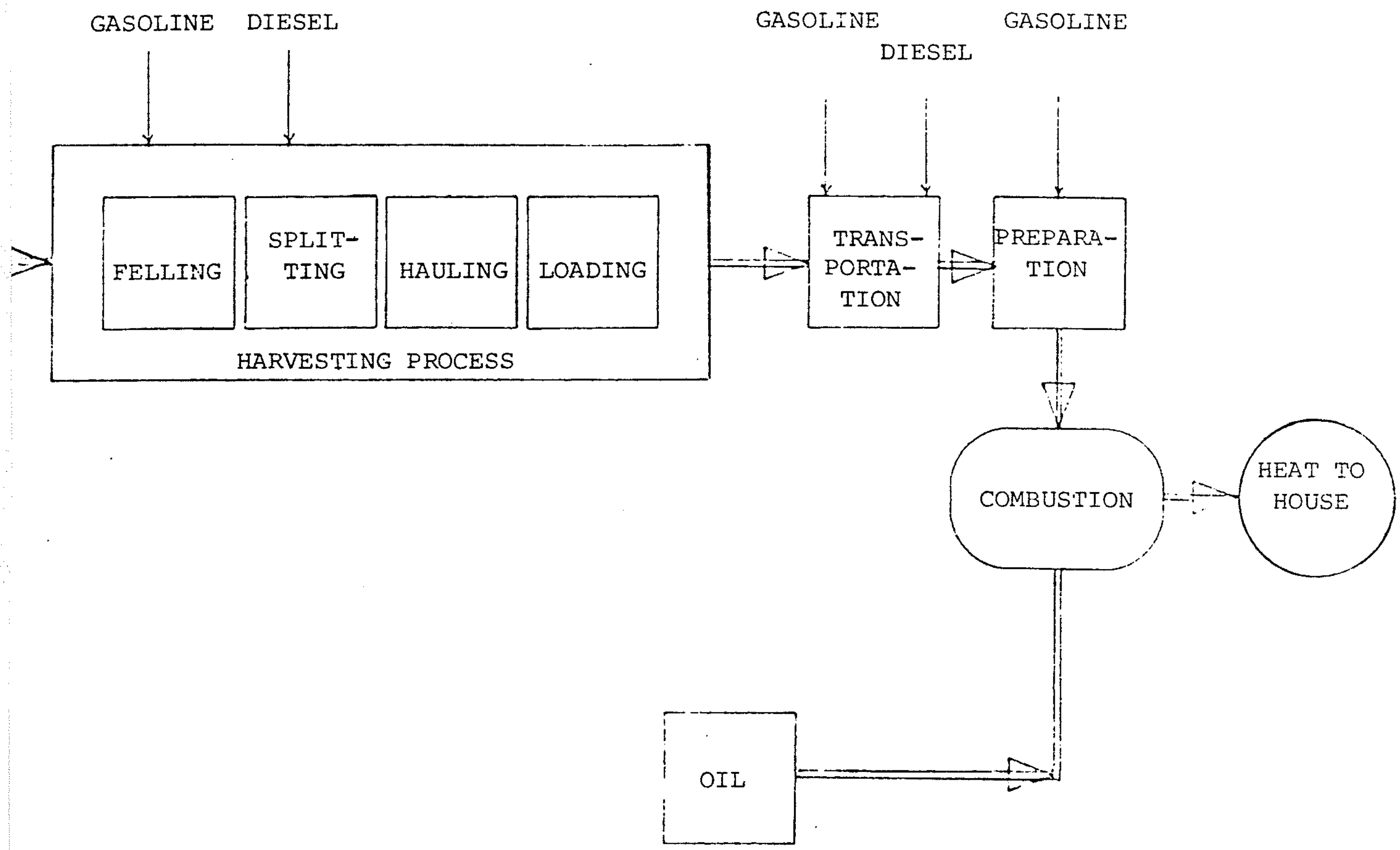
Felling includes cutting down the trees, de-limbing and cutting to length with a chainsaw (powered by gasoline) or an axe.

Splitting can be done either by hand, with an hydraulic splitter or a "Stickler" attached to a car, truck or tractor.

Hauling or skidding involves moving the wood to a central location such as to a roadside.

Loading the cut wood onto trucks is usually done either by hand or mechanically.

The type of wood harvested is a significant factor. Most woodlots contain a mixture of hard and softwoods. On average, hardwood has a greater heating value than softwood. Since it also has a greater density, more potential joules of energy can be transported per unit volume. However, the greater weight also means that more energy is required to transport the same volume, resulting in a slightly reduced energy advantage for hardwoods.



FOSSIL FUEL ENERGY INPUTS ASSOCIATED WITH

WOOD AND OIL HEATING SYSTEMS

Seasoned wood weighs less and burns better. Most green wood contains more than 50% moisture. If allowed to season for six months, the moisture level can be reduced to 20%, thereby increasing the heating value by roughly 50%.

TRANSPORTATION

Homeowners and dealers most commonly use trucks of the following types with energy related factors shown:

TYPE	CAPACITY (cords)*	FUEL USAGE FOR AVERAGE TRUCK	AVERAGE DISTANCE (round trip) (km)	MILEAGE (km per l)
half-ton pick-up	.5	gasoline	130 - 160	1.9
one ton truck	1.5	gasoline	160	1.9
3-5 ton stake truck	2.5	gasoline	160	3
tandems up to 12 tons	3.5 - 6	gasoline - 50% diesel - 50%	240	3
semi-dump trucks	5 - 10	gasoline - 50% diesel - 50%	320	3
tractor trailers	10 - 20	gasoline - 50% diesel - 50%	640	3

* Cord - 128 cu. ft., or 3.62 metres.

PREPARATION

Splitting may be done at the home rather than in the woodlot using an hydraulic splitter, a "Stickler" attachment, or an axe. An hydraulic splitter uses 2.84 litres per cord while a "Stickler" consumes 1.14 to 1.89 litres per cord. An axe does not of course require any fossil fuel.

COMBUSTION

The fireplaces most commonly used in the average home today are about 10% efficient although this figure depends strongly on the pattern and method of operation. This figure is calculated by dividing the quantity of usable heat produced by the quantity potentially available in the wood.

Note, however, that if the flue is left open during the night, the overall efficiency is reduced to 0% as all the heat that entered the room now escapes through the chimney.

Modern, well-designed heaters now provide much more efficient conbustion and slower burning. More heat is available to the room as many of these units are free standing. The most important distinction between the modern heater and the ordinary fireplace is that the gases carrying heat up the chimney are slowed down internally, passing the heat to the room through the walls of the heater. Long fires can thus be maintained. In fact, some will burn without reloading through the night. These new units are commercially available in many sizes and designs. Their efficiency ranges from 40% to 70%.

Combination heaters are also available. These use wood until the supply is exhausted and then switch automatically to oil.

Ordinary fireplaces can be adapted with the use of a specially designed tubular grate or glass doors to prevent loss of room air to the chimney. With duct work added around the fireplace to distribute the heat, efficiency can be increased to 20 to 30%.

CONCLUSIONS

In all but one case, the fossil fuel consumed to provide wood for heating is less than that required to supply the same amount of heat using an oil furnace.

Transportation distance and furnace efficiency have the greatest impact on the degree of savings achieved. Note, however, that all factors must be considered in order to accurately assess energy savings.

For example, it is commonly argued that increases in transportation distance may rapidly reduce or eliminate fossil fuel savings. Distance travelled certainly does have an impact. However varying this factor through the six representative cases indicates that the effect of transportation distance is negligible in two cases (Rural, High Efficiency) and does not affect energy savings to any large degree in the other four systems (Small Town, Large Town, City, Low Efficiency).

A thorough examination of all case studies shows that a reasonable variation of several factors (e.g. fossil fuel required to split wood, heating value of the wood) has no major impact on energy savings. Similarly, the number of cords per truck load and the miles per gallon achieved by the trucks have no significant effect. The study also shows that energy savings are not altered to any degree when the density of the wood varies or when softwood is used rather than hardwood.

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