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YUKON
ENERGY MANAGEMENT/ECONOMIC DEVELOPMENT
OPPORTUNITIES
- A DISCUSSION PAPER -

Prepared for:
The Department of Economic Development:
Mines and Small Business
Government of the Yukon

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SECTION I
INTRODUCTION

1.1 BACKGROUND AND PURPOSE

The Yukon relies heavily on conventional energy supply in all sectors--residential, commercial, industrial and transportation--and is subject to some of the highest energy costs in North America. While total Yukon energy consumption is small compared with other parts of North America, per capita use is very high. Moreover, approximately $100 million is spent annually on imported refined petroleum products and debt payments for electrical generation facilities. These expenditures represent the largest single leakage in the Yukon economy--triple the cost of imported foods--and the largest single impediment to a more self reliant Yukon economy.

During the past five years, a number of Yukon energy studies have addressed Yukon energy options and have recommended the development of a Yukon energy strategy which will contribute to Yukon goals of increased energy self-reliance and economic development. This discussion paper represents the first step towards the development of such a Yukon energy policy and corresponding program initiatives.

More specifically, it focusses on the identification and assessment of energy conservation and alternative energy opportunities that are significant in the sense of offering a potential to:

- reduce overall Yukon energy use, or

- reduce use of energy derived from imported petroleum products,

and also to:

- contribute to economic development

The time frame of interest is the next five years.

1.2 SCOPE

The scope of this discussion paper is restricted to the identification and assessment of specific energy conservation and alternative energy options for the Yukon, together with a preliminary outline of possible program initiatives.

Once these initial tasks have been completed and fully discussed, the precise scope and specific objectives of subsequent work can be more specifically defined. However, at this time, it is envisioned that the objectives of subsequent work would be:

- To produce a draft set of recommendations for energy/economic development programs for consideration by the Government of the Yukon

- To carry out a consultation process to help define energy options and test potential implementation strategies

- To produce a final set of recommended energy/economic development programs.

1.3 PRESENTATION

Following the Introduction, the balance of the report is divided into six sections. Section 2 presents a brief overview of the Yukon's economic base together with demographic data related to population trends and distribution, as well as labour force characteristics. Section 3 presents a review of Yukon energy demand by sector and end-use and identifies preliminary priorities. Section 4 provides a review of Yukon energy supply options, and assesses, in a preliminary fashion, the extent to which alternative energy resources could assume a greater role in the Yukon energy economy. Building on the results of the energy demand and supply analysis developed in Sections 3 and 4, Sections 5 and 6 identify and assess specific Yukon energy management opportunities. Section 5 places particular emphasis on the technical and financial feasibility of each major energy management opportunity while Section 6 provides a broader public accounting perspective, with particular emphasis on social, environmental and territorial economic impacts. Finally, in Section 7, potential program alternatives are briefly outlined and subsequent activities are identified.

1.4 DATA AVAILABILITY

Any energy study is limited by the unavailability of much relevant data and the poor quality of much of the data that are available, particularly on end-uses. In the case of the Yukon:

- Many key pieces of data are aggregated for the two territories rather than being presented separately

- In national terms, territorial energy use is small and has not been given great attention

- Compared with most other parts of the country, the share of non-market energy use (principally wood) which may not appear in the statistics is particularly high.

Attempts have been made to cope with all of these problems, but some caution has to be exercised in the absence of detailed energy data on particular communities and particular end-uses.

SECTION 2
THE YUKON ECONOMY

2.1 INTRODUCTION

The Yukon's economy is narrowly based and is largely reliant on the government, mining and tourism sectors. Prior to the closure of the Cyprus Anvil mine in 1982, mining and government were roughly of equal importance, each accounting for between 30 and 40% of the Yukon economy, while tourism, at that time, represented about 7%. More recently, mining activity has fallen sharply while tourism has continued to grow and now ranks as the Yukon's second largest industry, behind government.

As recently as 1981, when metal prices were high (gold averaged nearly U.S. $460/oz., $100 above its value today), mining accounted for $235 million of output. By 1985, however, the value of Yukon mineral production had dropped to about $57 million, largely the result of declining world metal prices. The outlook for the next decade depends on two partially independent factors: the success of the reopened Cyprus-Anvil mine, with its new management (Curragh Resources) and more efficient plant, and international metal prices. Under optimistic scenarios the value of production could exceed earlier levels, while under worst-case scenarios it could drop below current levels. The most likely prospects, which allow for renewed operations at the Curragh Resources mine but only modest growth in world markets (and little inflation, which cuts gold prices), suggest that the value of mineral output will move slowly back toward the levels of the past, but probably not reach them prior to the end of the decade.

Government expenditures have been the most stable part of the Yukon economy. They are not only a large share of the total, but they have grown regularly year by year. Out of every $10 spent by government, $5 have come from the territorial government, $4.50 from the federal, and 50¢ from municipal governments. While government expenditures will not grow so strongly in the next decade as in the last, government activities should nevertheless continue to provide strong support for the Yukon economy.

TABLE 2.1
YUKON POPULATION ESTIMATES
- By Community, Year and Reporting Source -

SOURCE	YUKON HEALTH RECORDS					1981 CENSUS STATISTICS CANADA	RCDP YUKON OVERVIEW
	1985	1984*	1983	1982	1981	1981	1982**
1. Beaver Creek	89	---	107	105	111	---	90
2. Burwash Landing	79	---	40	40	46	000	70
3. Carcross	302	---	248	246	270	---	270
4. Carmacks	406	---	369	364	360	256	340
5. Dawson City	1,530	---	58	73	81	697	900
6. Destruction Bay	76	---	58	73	81	---	80
7. Elsa	395	---	216	432	528	---	400
8. Faro	489	---	1,478	1,916	1,913	1,652	1,700
9. Haines Junction	536	---	459	443	471	366	460
10. Mayo	477	---	456	439	479	398	500
11. Old Crow	266	---	214	206	211	---	240
12. Pelly Crossing	199	---	123	123	134	---	180
13. Ross River	369	---	275	286	275	---	325
14. Tagish	116	---	---	---	---	310	368
15. Teslin	405	---	348	366	364	310	368
16. Watson Lake	1,559	---	1,309	1,333	1,391	748	1,140
17. Whitehorse	17,742	---	15,713	16,243	17,023	14,814	15,000
18. Johnson's Crossing	---	---	---	---	---	---	10
19. Stewart Crossing	---	---	---	---	---	---	20
20. Upper Liard	---	---	---	---	---	---	130
21. Keno	---	---	---	---	---	---	90
22. Swift River	---	---	---	---	---	---	35
Other	103	---	278	297	310	3,912	---
TOTAL:	25,138	---	22,295	24,165	25,590	23,153	22,828

Notes: * Not Available

** Year assumed on basis of study date; none given.

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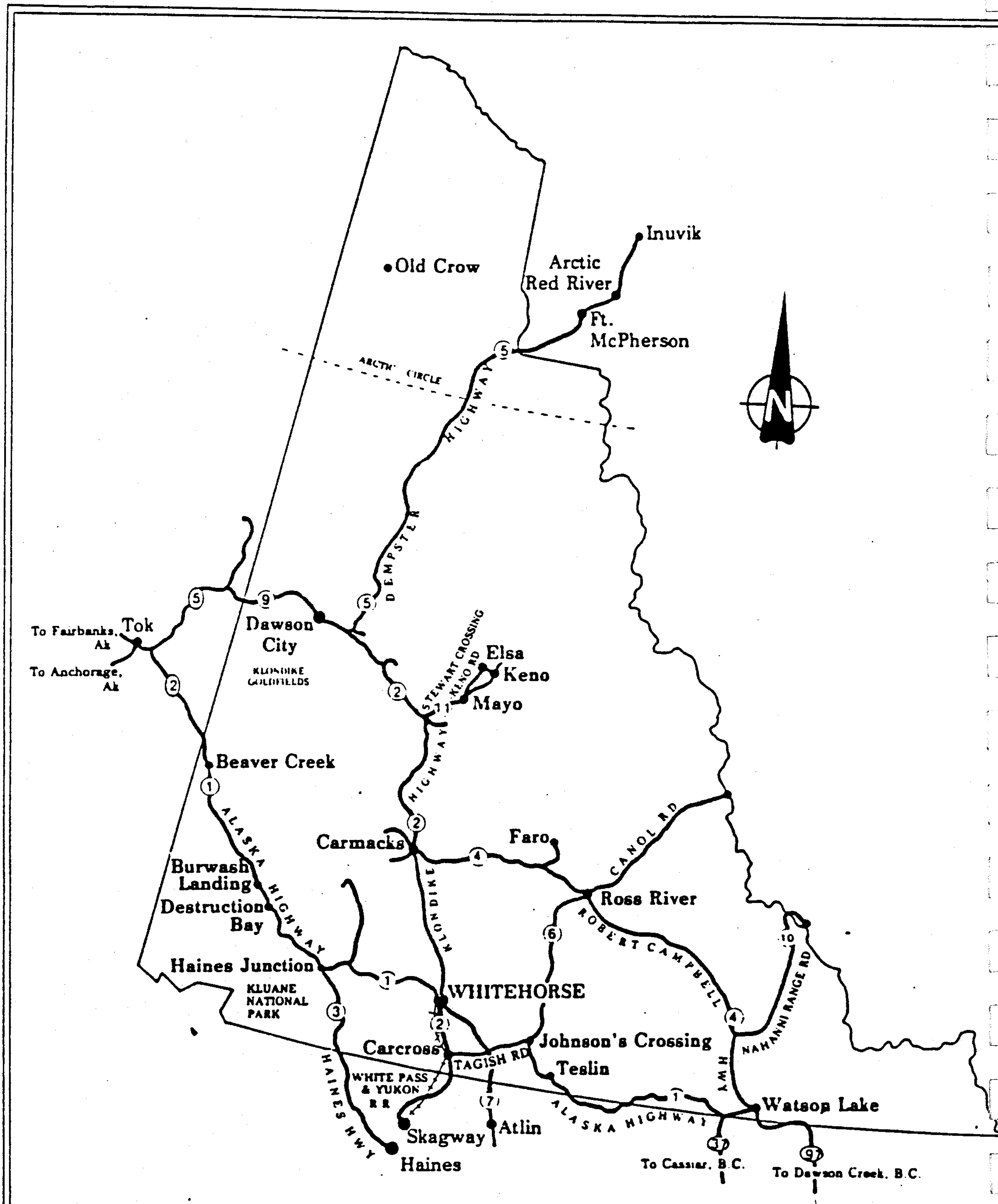
EXHIBIT 1

YUKON COMMUNITIES



Source: Yukon Statistical Review, Fourth Quarter, 1985

As an economic sector, tourism is more volatile than government but less so than mining. Accounting for about $50 million a few years ago, tourism now exceeds $75 million annually. While slower growth in incomes may reduce growth below optimistic projections, the increased emphasis being accorded to tourism and renewable resource activities as well as international events which may shift vacation travel to North American locations, are expected to benefit tourism in the Yukon. The likelihood, therefore, is that the tourism sector of the Yukon economy will grow both absolutely and relative to other sectors.

Other industries lag well behind the top three, with construction hovering around $20 million, the value of forest products at about $4 million, and the value of furs at about $1 million annually.

2.2 YUKON POPULATION: TRENDS AND DISTRIBUTION BY COMMUNITY

Available data indicate that Yukon population levels are continuing to recover from the negative impacts of mine closures experienced in the early 1980s. In fact, 1985 population levels are now approximately equal to those of 1981. Table 2.1 presents a list of Yukon communities and populations as reported by three sources--Yukon Statistical Review, Statistics Canada 1981 Census and RCDP Yukon Overview Study.

As illustrated in Table 2.1 the number of recognized communities and estimates of the actual number of residents vary by source, in accordance with their differing criteria and approaches to estimation. Discrepancies aside, the 25-year overall population trend, as recorded by Statistics Canada has been one of steady but modest growth. With the reopening of the Curragh Resources mine, this trend is expected to continue.

As with population estimates, some variation exists with respect to the number of recognized communities within the Yukon and their population. Although discrepancies in data exist, once again the overall trend is clear and relatively consistent: Whitehorse, the territorial capital, accounts for the largest portion of Yukon population (approximately 65 to 70%) and the two communities of Watson Lake and Dawson City account for an additional 6 to 12% of total Yukon population. Thus, over the 1981/85 period, these 3 communities collectively have accounted for between 70 and 80 percent of the Yukon's population and are expected to continue to account for the vast majority of the Yukon's population. As shown in Table 2.1, Faro has experienced a dramatic population decline during the past few years; this decline is a direct result of the mine closure and is expected to turn around with the reopening of the mine.

Some communities such as Destruction Bay, Johnson Crossing, and Stewart Crossing, serve primarily as service centres. They have small but relatively stable populations with employment opportunities related primarily to highway maintenance and the operation of tourist facilities.

People of Indian ancestry make up approximately 25% of the Yukon's population*; the majority of Indian people live outside Whitehorse in the smaller, more isolated communities. Indian employment consists of both subsistence and wage economy activities.

Exhibit 1 provides a map showing the location of Yukon communities.

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* Council of Yukon Indians, Lands Claim Office estimates Yukon Indian population to be about 6,000.

2.3 YUKON LABOUR FORCE

The Yukon population is a young and active one, with a low dependency ratio and nearly 50% of the total population included in the labour force. As a result of the poor economic conditions in the early 1980s, full-time employment fell from near 11,000 to below 9,000, and the unemployment rate grew to 15% or higher. Participation rates in the labour force are expected to remain high. The possibility exists that more of the labour force will become part-time workers, particularly as the tourism sector grows in importance. Yukon wage rates remain about 20% above the national average, which is roughly parallel with the higher cost of living in the Territory.

While the above statistics are technically correct, they are somewhat misleading in that they mask the disparaties between native and non-native residents. In fact, a further look at the Yukon population shows three categories of residents, each having a different relationship to the Yukon labour force. As presented by Stabler in his submission to the Royal Commission on the Economic Union and Development Prospects for Canada, these three categories are:

- Long-term non-native residents
- Transient non-native residents
- Native (Indian) residents.

Long-term non-native residents are those persons who prefer, and have made a definite commitment to, living in the Yukon. As Stabler states,

> ...they are small-business people, professionals and long-time territorial government employees or, perhaps less likely, federal government employees...Quite a few of the long-term residents have moved back and forth between the public and private sectors...Most are actively interested in territorial politics. Employment is less of a problem for long-term residents than for natives or transient non-native residents, even during recessions. Their knowledge of the economics and

> politics of the (territory) and the skills and contacts acquired in the northern setting are unique and valuable assets which are attractive to potential employers.*

Transient non-native residents are those persons whose stay may extend from a few months to a few years, but whose long-term commitment is elsewhere. Stabler describes this group, as,

> ...they are more likely to be employees of mining or oil companies or junior to middle-level civil servants in either the territorial or federal governments. A few are branch managers of national corporations. Few buy their own homes or invest in territorial businesses. They are likely less interested in territorial politics. When they receive a competitive offer from "outside," or lose their jobs, they leave and probably never return. Many simply quit their jobs after a time and return to the South to search for another job. No one really knows what percent of the non-natives are long-term northerners but it may be in the neighbourhood of 20 percent of the non-native territorial populations, more in Yukon, fewer in N.W.T.*

In contrast to non-native residents, the Yukon's Indian population has a much lower labour force participation rate (60% vs 82% for non-natives in 1981), higher unemployment rates, and average incomes that are only about 60% of those for non-natives.

There are numerous explanations for these differences. Most, however, point to factors such as:

- the relatively low level of formal education achieved by Indian residents (in 1981 only 3% of Indians had attended university vs 28% of Yukon non-natives)

- social and cultural differences which further restrict Indian mobility, including their continued desire to pursue traditional or subsistence activities.

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* M.S. Whittington (ed.) The North, 1985.

Although further analysis of the disparities between Indian and non-native Yukon residents is possible, it is sufficient for the purposes of this paper to note that these disparaties do exist, and will obviously warrant special consideration within future economic development plans as measures which generally benefit the Yukon economy can not be automatically assumed to extend to Indian residents.

SECTION 3
YUKON ENERGY DEMAND

3.1 INTRODUCTION

This section presents a compilation and review of Yukon energy demand and is presented in 3 subsections:

- Overview of Yukon energy demand
- Discussion of energy use by sector and end-use
- Summary

Further to the general data quality and availability concerns outlined in the Introductory Section, the Study Team was also confronted with a second, related problem; namely, the selection of a period for which data were not only available but also reasonably representative of conditions expected to prevail in the Yukon during the next five years. In recent years, the Yukon has experienced a widespread decline of mining activities and related population decline. Given the relative small size of the Yukon economy and the large economic (and energy) impact of mining activities, it is not surprising that, in this period, Yukon energy use has also declined. However, with the current renewal of mining activities as well as the recovery of population to 1981/82 levels, energy use data for 1983 and 1984, when the Yukon economy was most affected by mine closures, were not considered to be representative. As 1985 Statistics Canada data are not yet available, 1982, a period when the Yukon economy was slowing down from mine closures but had not yet experienced their full impact, represents the closest representation of the current (1986) and forecast Yukon economy. However, the Study Team recognizes that this period also poses problems, particularly with respect to accurately representing the degree to which conservation and fuel substitution activities have affected the Yukon energy economy. In consideration of these various constraints, 1982 has been used as the base year for the energy demand estimates contained in Section 3.2, while in subsequent subsections, relevant data from later years and those indicative of Yukon trends are cited, when available. These data will be particularly important to the development of implementation plans in later stages of the study.

3.2 OVERVIEW OF YUKON ENERGY DEMAND

Total annual (1982) energy demand in the Yukon was approximately 8,000 terajoules (TJ). Table 3.1 presents a breakdown of Yukon energy use by sector and end-use. Appendix A provides a detailed breakdown of Yukon energy demand, together with notes on the estimation method employed.

Table 3.2 provides a breakdown of Yukon energy use by end-use and energy source.

TABLE 3.1
ENERGY USE IN YUKON BY SECTOR AND END-USE
(1982)

Sector	End Use	Energy Use (TJ)	PERCENTAGE Usage Within Sector	PERCENTAGE Usage Within Territory	PERCENTAGE Sector Total Within Territory
Residential	Space/Water Heating	1,250	90	15.9	
	Electricity - Specific	130	10	1.6	
	Subtotal:	1,380			17.3%
Commercial	Space/Water Heating	1,240	83	15.4	
	Electricity - Specific	250	17	3.0	
	Subtotal:	1,490			18.6%
Institutional	Space/Water Heating	860	90	10.9	
	Electricity - Specific	90	10	1.1	
	Subtotal:	950			11.9%
Industry	Heating -** all temp.	270	23	2.5	
	Electricity - Specific	150	16	1.7	
	Liquid Fuels	510	61	6.5	
	Subtotal:	930			11.6%
Transportation	Liquid Fuels	3,250	100	41.3	40.6%
Total for Territory	--	8,000	--	--	100%

Source: Estimation by Marbek; see Appendix A
**Note: No process heat in period due to mine closures.

TABLE 3.2

SUMMARY OF YUKON ENERGY USE (1982)

- BY SECTOR, END-USE AND ENERGY SOURCE

ENERGY SOURCES(TJ)

Sector/ End-use	Coal	Natural Gas	RPPs	Electricity	Biomass Solids	Propane	Total End-Use	Total Sector
Residential								
H & C	---	---	714	290	220	26	1250	
ES	---	---	---	125	---	---	130	
								1380
Commercial*								
H & C	---	---	1198	---	12	30	1240	
ES	---	---	---	240	---	10	250	
								1490
Institutional								
H & C	---	---	834	18	8	---	860	
ES	---	---	---	90	---	---	90	
								950
Industrial								
H & C	---	---	200	---	---	70	270	
100°C-260°C	---	---	---	---	---	---	---	
PH>260°C	---	---	---	---	---			
ES	---	---	---	130	---	20	150	
LF	---	---	510	---	---	---	510	
								930
Transportation								
LF	---	---	3250	---	---	---	3250	
ES	---	---	---	---	---	---		3250
Totals:	---	---	6706	893	240	156		8000

H&C	3620
ES	620
LF	3760

3.3 DISCUSSION OF ENERGY USE BY SECTOR AND END-USE

In the following sections, information on energy use in each sector is provided. Specifically, this section emphasizes those data that will be particularly useful in the subsequent identification of Yukon energy management opportunities.

3.3.1 Residential Sector

The residential sector accounts for over 17% of Yukon energy demand --somewhat below the 21% share the sector takes in Canada as a whole. However, in the smaller communities of the Yukon, the residential sector typically accounts for 60% or more of the total community energy consumption.*

Within the residential sector, approximately 80% of energy demand is for space heating, 10% is for domestic hot water (DHW) and 10% is for electricity-specific applications.**

Estimates of average annual fuel and electricity use per household range between 3,400 and 4,400 litres of fuel oil (130 to 170 GJ) for space heating; 388 to 510 litres (15-20 GJ) for DHW, and 4100 to 5560 kWh (15 to 20 GJ) for electricity-specific end-uses.

The Yukon's (1982) residential sector consisted of about 7600 units and was dominated by single detached units (59%). The remaining units were divided among single family attached (13%), apartments (16%) and mobile homes (14%). Approximately 45% of all Yukon residential dwellings are rental units. However, in most cases tenants are responsible for fuel and electricity costs.*

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* Acres et al, Yukon Overview Study, 1984

** Electricity-specific end-uses are those for which there is no adequate or convenient alternative. Lighting and appliances are the principal examples. Depending on alternatives, cooking may or may not be truly electricity-specific, but inasmuch as available data for the Yukon do not identify cooking, electric ranges are treated as electricity-specific.

Table 3.3 shows the approximate distribution of Yukon residential units, by period of construction. The number of abandoned or demolished units in the period is not known. Based on the data in Table 3.3 plus the number of reported pre-1960 residences (1,790) and the relatively short lifespan of many northern buildings (particularly older ones), this number is estimated to be about 500.

TABLE 3.3
YUKON RESIDENTIAL UNITS
- PERIOD OF CONSTRUCTION -

Period of Construction	Number
Pre 1920	150
1921 - 1945	355
1946 - 1960	1,285
1961 - 1970	1,885
1971 - 1975	1,835
1976 - 1979	1,705
1980	300*
1981	171
1982	109
1983	117
1984	112
1985(Sept)	128
Total:	8,152

* Approximate - Statistics Canada Data conflict (340 vs 268)

Sources: Statistics Canada Census (1981) (to 1981)
Statistics Canada, Catalogue No. 64-001 (1981 - 1985)

Table 3.4 (below) shows the distribution of principal space and water heating fuels by community size, as reported in the most recently available census data (1981). As shown in Table 3.4, in 1981 fuel oil was the principal energy source (64%) for space heating in the Yukon, while electricity provided 73% of domestic water heating demand. (Water heating is not an electricity-specific use.) Even in smaller communities, nearly half of water heating was by electricity. As before, these data are strongly influenced by conditions in the larger and/or resource based communities. In the smaller communities, wood was the dominant source of space heating and a major source of water heating. Although more recent statistics are not available, the trends in energy supply presented in the following section 4, suggest that since the date of the last census, wood use for space heating has increased, while fuel oil use has declined accordingly. It may be assumed, however, that the distribution of water heating fuels has not changed significantly from that shown in Table 3.4.

TABLE 3.4
YUKON RESIDENTIAL SECTOR
PRINCIPAL SPACE AND WATER HEATING FUELS (1981)

	Communities <250		Communities >250		All Communities	
Fuel	**Space Heat %**	**Water Heat %**	**Space Heat %**	**Water Heat %**	**Space Heat %**	**Water Heat %**
Oil	36	5	70	15	64	14
Propane	2	9	2	3	2	4
Electricity	6	47	19	78	17	73
Wood	56	39	10	4	18	9
TOTAL RESIDENCES:	1,240		6,345		7,585	

Source: Statistics Canada (1981) Census Data

3.3.2 Commercial Sector

The Yukon's commercial sector consists primarily of three subsectors: stores and shops, hotel/motel/restaurants and non-government offices. The commercial sector accounts for more than 18% of the Yukon's total energy demand and is concentrated in three communities--Whitehorse, Watson Lake and Dawson. In many of the remaining communities, the commercial sector is very small or, in some cases, virtually non-existent.*

Stores and shops represent the largest commercial subsector and account for about 57% of sector energy use. Hotels/motels/restaurants are the next largest commercial subsector, accounting for approximately 26% of sector energy use. The Yukon Department of Tourism reports (1984) that there are 84 hotel/motel/lodges in the Yukon containing 1990 units. Eighty percent of these accommodation establishments operate year-round. In addition, there are 27 commercial and 50 government-operated summer campgrounds. Approximately 125 cafés, lounges and dining rooms operate in association with these accommodation facilities and about 25 operate independently. The balance of commercial sector energy use is accounted for in non-government offices.

Throughout the commercial sector, the dominant energy end-use is space and water heating (83%), followed by electricity-specific (17%). The commercial sector continues to derive over 90% of its space heat demand from fuel oil with the balance being provided by wood and propane. Some supplementary wood heating systems have been installed in commercial buildings and approval has recently been given by the City of Whitehorse for the construction of a small, wood chip fired district heating system to serve approximately half a dozen commercial/institutional buildings in downtown Whitehorse. Propane is used in tourist facilities along the Alaska Highway.

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* Acres et al, Yukon Overview Study

The combined commercial and institutional sectors (see below) play a much greater role in the Yukon energy economy than they do in most parts of Canada--30% of total energy use compared with an average of 13%.

3.3.3 Institutional Sector

The Yukon's institutional sector consists of federal, territoral and municipal government facilities such as offices, schools, hospitals, recreation centres and transportation terminals and maintenance buildings. Overall, the institutional sector accounts for approximately 12% of total Yukon energy use. As for other sectors, institutional energy use is concentrated in Whitehorse and is used to meet space and water heating (90%) and electricity-specific (10%) end-uses.

The operation of school facilities accounts for an average of 15% of institutional energy use but in many of the smaller communities, schools account for a significant portion of the total community energy consumption.

Fuel oil is the principal source of space heat within this sector. Some electric space heating occurs in Whitehorse, and two school facilities (Pelly Crossing and Old Crow) are heated by wood.

3.3.4 Industrial Sector

The Yukon's industrial sector is very narrowly based and is dominated by mining activities. The 930 TJ or roughly 11% share of energy demand for this sector shown in Table 3.1 is significantly lower than in historical periods. This reflects the dramatic curtailment of mining activity that was occurring in 1982.

With the reopening of the Curragh Resources mine at Faro, the demand for power and heat will increase significantly. Officials of the mine expect that energy consumption by the mine-mill complex will stabilize at between 90 and 100% of historical levels. With mine operation at these historical levels, the mining sector energy demand would total perhaps 1700 TJ, distributed by quality roughly as follows:

heating and cooling	680 TJ
electricity-specific	560
liquid fuels	460
	1700 TJ

Other subsectors within the Yukon's industrial sector include:

- Agriculture: There are approximately 30 full-time and 75 part-time farmers in the Yukon with an estimated 1660 ha (4100 acres) in production.* Energy demand is primarily for liquid fuels for on-site equipment (5 TJ)**

- Forestry: The Yukon forest industry produces lumber, cordwood and round timber. In 1983/84 there were approximately 20 full and part-time sawmill operators.* Energy demand is primarily for liquid fuels for on-site equipment operation (83 TJ)**

- Fishing, Hunting, Trapping: The Yukon Department of Renewable Resources reports: 750 registered Yukon trappers; a small level of commercial salmon fishing in the Yukon River system (as well as sport fishing); and, about 20 big game outfitters. Energy demand

* Department of Renewable Resources - Discussion Paper, 1985.

** Estimates only; based on previous subsector breakdowns reported in A Soft Energy Path for the NWT and Yukon, 1983.

is primarily for liquid fuels for the operation of outboard motors, snowmobiles, and all-terrain vehicles (46 TJ)**

- Food Processing: Food processing in the Yukon is limited to the operation of a few bakeries and bottling plants. Energy demand is primarily electricity-specific (4 TJ)**.

- Chemicals: The chemical industry is limited to the CIL plant in Faro, which supplies reagents to the Cyprus Anvil mines. This plant ceased operation with the closure of the Cyprus Anvil mines in 1982.

- Construction: The construction industry employed 8.1% of the Yukon work force in 1985. Apart from mining, it is the only industrial subsector with significant energy consumption (320 TJ)**. Energy demand is approximately 25% for heating and 75% for liquid fuels.

- Other Manufacturing: Very little manufacturing occurs in the Yukon. That which does exist includes jewellery, wood products, furniture, metal culverts, iron works and welders, sheet metal, concrete products, printing and publishing and native crafts. Total estimated energy demand for this subsector of 4 TJ** is divided among space heating (50%), liquid fuels (25%) and electricity-specific (25%).

** Estimates only: A Soft Energy Path for the NWT and Yukon, 1983.

3.3.5 Transportation Sector

The Yukon's transportation sector accounts for approximately 3250 TJ (1982), about 41% of total territorial energy demand. By comparison, across Canada, transportation accounts for only 28% of energy demand (and among other nations Canadian is notably high in transportation). This high level of transportation demand of course reflects the geographic and demographic conditions of the Yukon.

The demand for liquid fuels within the transportation sector is dominated by two subsectors, automobiles and trucks, which together account for nearly 85% of total sectoral energy demand (78% in Canada). Liquid fuels for aircraft account for approximately 11% of sector demand (8% in Canada). The residual demand (4%) is accounted for by buses, snowmobiles and motor cycles. No trains are currently operating.

Table 3.5(A) and Table 3.5(B) present data on road motor vehicles registered in the Yukon for the periods 1978 to 1983/84 and for 1985, respectively. Table 3.5(b) provides a further breakdown of registered vehicles (1985) by size and (assumed) fuel type.

Appendix B provides data on aircraft movement during the period 1979 to 1985.

TABLE 3.5(A)

YUKON

Number of Registered Motor Vehicles

Vehicle	1983-84	1982-83	1981-82	1980-81	1979-80	1978-79
			(no)			
Total Road Registrations(p)	15,858	19,112	18,119	18,333	17,665	15,625
Passenger Automobiles	6,444	6,879	6,702	6,778	6,660	7,411
Trucks & Truck Tractors	8,406	11,358	10,837	10,975	10,385	7,546
Buses	23	166	--	--	--	--
Motorcycles	795	709	580	580	620	668
Other Vehicles	190	--	--	--	--	--
Snowmobiles	432	475	402	398	310	395

Source: Statistics Canada, Catalogue No. 53-219, and Yukon Department of Community and Transportation Services

Note: Passenger autos includes taxi & rental vehicles; "other" includes ambusances and fire trucks.

TABLE 3.5(B)
YUKON
Number of Registered Motor Vehicles (1985)
- by type and fuel

Vehicle	Fuel	
	Motor Gasoline	Diesel
Cars:		
Under 300 cm	6,380	
Over 300 cm	794	
Trucks:		
Up to 3,000kg	6,651	
4,000kg	3,143	
5,000kg		798
8,000kg		167
11,000kg		289
20,000kg		283
30,000kg		156
40,000kg		214
50,000kg		168
60,000kg		161
Over 61,000kg		73
Motor Cycles:	718	
Snowmobiles:	437	
Buses:		
Less than 19 Pass.	96	
19-39 Pass.	7	
Over 39 Pass.		83
Total Vehicles	18,226	2,309

Source: Personal Communications: Bob Collins, Government of Yukon

3.4 SUMMARY

The data presented in the preceding subsections serve to identify the major patterns of energy use within the Yukon economy:

- In the base year (1982), liquid fuels for transportation, together with space and water heating in the residential, commercial and institutional sectors dominated Yukon energy use, accounting for over 80% of the territory's total. Even with the present renewal of mining activities, the above two end-uses will continue to dominate energy use in the Yukon. These two end-usees, therefore, warrant major consideration in the development of Yukon least cost energy strategy.

- A third important area of Yukon energy use, also identified in the preceding data, is electricity-specific end-uses. Although in the base year (1982) electricity-specific end-uses represented less than 10% of total demand, several factors increase the importance of this area:

  - many Yukon communities depend on diesel generated electricity sources which have low conversion efficiencies and high RPP dependence;

  - over one-third of total territorial electrical use in 1982 (about 15% when the mines are in full production) was taken by non-electricity-specific end-uses such as water and space heating;

  - with the renewal of mining activity, related electricity-specific demand is expected to nearly double from 1982 levels.

There exists a wide range of proven and cost-effective energy conservation technologies and measures applicable to the end-uses identified in this section. For the most part, these technologies and measures are both widely known and are best discussed not only by sector and end-use but also in conjunction with alternative energy supply options. Consequently, no further elaboration is provided at this point. Rather, specific measures are identified and assessed within Section 5, Identification and Assessment of Energy Management Opportunities.

SECTION 4
YUKON ALTERNATIVE ENERGY SUPPLY OPTIONS

4.1 INTRODUCTION

This section provides an overview of Yukon energy supply options and assesses in a preliminary fashion, the extent to which alternative energy resources could assume a greater role in the Yukon economy. Accordingly, following the presentation of Yukon energy supply and price data, the balance of this section is dedicated to further refining the potential role of alternative resources through a review of the following:

- Technology Assessment: What is the status of the technologies required to harvest, prepare and convert the identified alternative energy resources into an energy form compatible with Yukon energy requirements.

- Community-specific Considerations: What is the size and quality of each resource which is within practical harvesting and transporting distance of actual Yukon communities and to which end-uses could the energy source be applied.

Further assessment related to social, economic and environmental considerations is addressed in subsequent sections.

4.2 OVERVIEW OF YUKON ENERGY SUPPLY AND PRICES

This subsection provides an overview of both nonrenewable and renewable Yukon energy resources together with comparative energy prices. Consistent with the scope of this study, all data and/or resource assessments are derived from secondary sources, as listed in the attached bibliography.

4.2.1 Nonrenewable Resources

- **Refined Petroleum Products (RPPs):** No petroleum refining occurs in the Yukon; rather supplies are imported by truck and via a small-diameter pipeline from Skagway, Alaska, to Whitehorse.

  In the base year (1982) approximately 185 million litres of RPPs were consumed in the Yukon. About 85 million litres were used for transportation and the operation of on-site mobile industrial equipment; about 75 million litres were used for space and water heating and about 25 million litres were used for diesel generation of electricity.

  In the following year (1983) RPP consumption in the Yukon declined by about 20% to approximately 145 million litres and appears to have stabilized at this lower consumption range. It is believed that the bulk of this drop in RPP consumption was the result of three factors:

  - Reduced electrical demand on the Whitehorse grid meant that the operation of stand-by diesel generators was very dramatically curtailed with consequent savings of nearly 20 million litres of fuel. (Statistics Canada records show total Yukon diesel electrical generation to be about 76.6 GW.h and 21.8 GW.h in 1982 and 1983 respectively.) This situation may, of course, change with the reopening of the Faro mine.

  - The use of cord wood for heating (assumed to be primarily residential) appears to have more than doubled in 1983 over that of 1982 (89,300 m^3 vs. 41,200 m^3) on the basis of available data.*

- The Yukon experienced an out-migration of residents during the 1982/83 period.

Further data are provided in Appendix C.

- **Propane:** In the base year (1982), approximately 6 million litres of propane were used in the Yukon. Sales data for subsequent years show that annual volumes of propane use declined by about 20% in 1983 but by 1985 had returned to approximately 5.5 million litres. Propane use is largest in placer mining operations followed by mining exploration camps and tourist facilities. In these off-grid settings, propane is widely used for heating as well as typically electricity-specific applications such as cooking, refrigeration and lighting. These users account for approximately 80% of propane consumption; the remaining 20% of propane use is for heating and cooking in the residential sector.

- **Coal:** Although coal has been used extensively in the past, it is not currently in use. Of the several known sites, the Tantalus Butte Mine near Carmacks is the most significant. This site formerly supplied some 20,000 tonnes annually to the Cyprus Anvil mine at Faro for process heat. However, coal production at this site ceased with the closing of the Cyprus Anvil mine.

  As shown in the following Section 4.4, seven Yukon communities are located in areas known to contain coal reserves. However, none of these reserves is currently in production. The development of any of these sites is generally dependent on the existence of a large market such as a mine. Recent discussions with officials of the Curragh Resources mine indicate that when the mine is reopened,

* Acres et al, Yukon Overview Study

coal will again be used for process heat. Their current plans call for the development of coal reserves at Ross River. In the short term approximately 20,000 tonnes of coal will again be required annually for ore drying; however, the company is looking into a pressure filtering system which would eliminate the use of heat (and hence, coal) in dewatering the concentrate (ie, ore drying).

RCDP, Phase I activities have also included discussions on the option of developing coal reserves near Whitehorse for space heating applications in large Whitehorse buildings.

- **Natural Gas:** Natural gas is not currently available for use in the Yukon. However, a previous study by Stone and Webster Canada Ltd. (1983) concluded that, should the Alaska Highway Natural Gas Pipeline be built, it would be economically and technically feasible to supply natural gas to Whitehorse, Watson Lake and Haines Junction. It would be expected that natural gas would supply the bulk of the space and water heating load in the commercial and institutional sectors and the bulk of the non-biomass space heating load in the residential sector. Another, longer term option could include consideration of using CNG as a transportation fuel. The report also concluded, that no other natural gas supply configuration would be financially feasible without significant government support. Interest in pipeline development is currently at a low ebb and no development is foreseen within five years.

- **Waste Oil:** Some of the more significant sources of waste oil include: diesel electricity generators, Government of Yukon highway garages and other truck/automobile maintenance facilities. In one recent study*, annual supplies of 9,000 L of waste oil were identified for the small community of Beaver Creek. Although aggregate territorial waste oil data are not available, it is assumed that

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* Acres et al Community Energy Plan, Beaver Creek, Y.T. 1985.

other communities would also have potential access to sufficient waste oil supply for at least one or more local heating applications. Acres et al,* estimated that close to 1 million litres of waste oil may be available annually. However, the portion of this oil that may be cost-effectively recovered is unknown.

- **Diesel Waste Heat:** Based on a recent study by Acres et al*, usable waste heat from diesel prime power plants operated by YECL and NCPC is estimated to be about 85 TJ. Further detail is provided in Table 4.4 (Section 4.4) and in Appendix C.

- **Peat:** No data available.

- **Nuclear Power:** AECL now have under development an advanced version of the Slowpoke nuclear power generator which may be capable of producing both heat and electricity. The applicability of this form of energy in the North is unknown and the Science Institute of the NWT is currently examining the economics and safety of such a reactor.

4.2.2 Renewable Resources

- **Hydro-electricity:** Current hydropower developments in the Yukon have a capacity of 76.6 MW, including a recently installed fourth turbine on the Whitehorse system. Several major hydro schemes involving river diversions have been proposed for the Yukon but they all depend upon distant export markets or significant new industrial demand and are, therefore, beyond the scope of this paper.

  Appendix C provides hydro electricity generation data for the period 1977-1985 as well as diesel generated electricity for the same period together with a preliminary assessment of 12 small hydro sites identified in the Yukon Overview Study.

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* Yukon Overview Study, (1984)

- **Wood:** Several previous studies have clearly established the availability of a substantial wood resource within the Yukon. Shaeffer et al (1983) estimated the Yukon's annual sustainable timber harvest to be 2.2 million m^3/year. Assuming an average heating value of 7.1 GJ/m^3, this represents about 15.6 PJ/year, many times the Yukon's current annual heat demand. Additional wood resources are available from fire kills. The average annual fire kill in the Yukon is estimated at about 140,000 ha. In short, the Yukon's wood resource base is capable of satisfying a much greater portion of energy demand than at present.

  In the base year (1982), approximately 14,000 cords of wood were used in the Yukon, primarily for residential space heating. Based on available data (which undoubtedly are conservative due to unrecorded, personal wood cutting), cordwood consumption in 1983 was more than twice that in 1982. However, current cordwood use appears to be declining modestly from 1983 levels. Appendix C provides a breakdown of Yukon forest production for the period 1970 to 1985.

- **Wind:** Previous studies have shown that only two locations in S.W. Yukon (Whitehorse and Burwash Landing/Destruction Bay) have suitable wind regimes for consideration of power production options (greater than 5 GJ/m^2.yr). Under the federal CREDA program, wind monitoring has been carried out at the Burwash Landing/Destuction Bay site; the results showed the wind regime to be inadequate for cost-effective development at this time. Appendix C contains a map showing mean annual wind energy density throughout the Yukon.

- **Solar:** The seasonal nature of the Yukon's solar resource precludes year-round applications. However, because of the long summer days, daily solar radiation during the summer and much of the spring/fall seasons is considered sufficient for seasonal applications, such as pool heating or water heating at certain motels/resorts.

- **Geothermal:** A recent study by Schaffer and Associates, cited in the Yukon Overview Study, indicates that near-surface low temperature geothermal sources exist around Haines Junction, Whitehorse and Mayo. The most probable course of development would involve the use of groundwater heat pumps for space heating applications; in fact, such a system has been proposed under the RCDP program for several Mayo buildings. Warm ground water is currently used to provide freeze protection for domestic water in Whitehorse and Mayo.

4.2.3 Comparative Yukon Energy Prices

Table 4.1 presents the range of Yukon energy prices (1986). Prices are presented for both the normal unit of sale (eg, litres, kWh, cord) and in comparative terms ie, the cost per unit of energy ($/GJ).

TABLE 4.1
COMPARATIVE ENERGY PRICES (1986)
- YUKON -

Energy Type	Unit Price Range	Energy Price ($/GJ)
Wood	$75-100/cord	$ 4.41 - 5.88
Fuel Oil	44-55¢/L	$13.38 - 14.22
Propane	39-48¢/L	$15.00 - 18.75
Hydroelectric*	6.5-23.1¢/kWh	$18.07 - 64.21
Diesel Electric*	17.4-44.2¢/kWh	$48.37 -122.88

* Average customer price based on 1000 kWh. without subsidy

4.3 TECHNOLOGY ASSESSMENT

This section presents an initial technical assessment of the conversion technologies that could effectively utilize the alternative energy resources identified above in Section 4.2, to meet the energy end-use requirements presented in Section 3. Two factors are particularly addressed:

- the development status and potential cost-effectiveness of the technology
- the skill levels required for ongoing operation and maintenance

4.3.1 Coal

Coal-fired thermal electrical generating and process steam production technology is fully proven and has been used widely throughout Canada for decades. However, the technology is relatively sophisticated and expensive and is therefore most appropriate for large scale, non-remote applications. With most Yukon non-remote electricity demand being met by hydroelectricity, the most practical application of coal in the Territory is for direct heating.

A range of technologies are available for heating with coal and are proven for applications ranging in scale from residential to industrial. In fact, the Yukon Public Works Branch is currently planning to install a fluidized-bed combustion boiler to provide heat to the new Yukon College compus. One of the available fuel sources for the system is a low sulfur anthracite coal deposit, located near Whitehorse. Unfortunately this coal deposit has a relatively high clay, and ash content. While suitable for use in a sophisticated fuidized-bed boiler system, the clay and ash content of this coal deposit make it unsuitable for use in smaller, less sophisticated combustion systems.

Several practical considerations restrict the expanded use of coal, particularly for small heat loads:

- for most small heat loads, coal is probably the least convenient fuel to use among all of the alternatives available to the Yukon

- although considerable resource deposits exist, development of these deposits requires a very large assured market (ie, a mine); even with the reopening of the Cyprus Anvil mine, only 1 site (Ross River) will be brought into production

- no residential distribution infrastructure presently exists

- while highly efficient large scale coal burning equipment is available with the capability of eliminating most acid gas and particulate emissions, equivalent small residential scale equipment is not available. Widespread use of coal for residential heating would cause increased pollution problems, especially in valleys which experience prolonged temperature inversions.

- for most non-industrial applications, coal is more expensive than wood ($/GJ) and in many cases is only marginally competitive with fuel oil prices

4.3.2 Natural Gas

The technologies for using natural gas for heat and power production are fully proven at all scales of use. Technologies for using CNG as a transportation fuel are similarly fully proven and commercially available, although the cost of individual compresser units remains very high and, where propane has been injected into natural gas transmission lines, it must be removed before the gas can be used as a transportation fuel. These technologies are, therefore, ready for application should natural gas supplies become available to the Yukon at some point in the future.

4.3.3 Waste Oil

Specially designed furnaces which can burn both waste oil and conventional fuel oil are commercially available and are currently in use in the United States and Europe. This technology, therefore warrants consideration for application in the Yukon. However waste oil sources need to be identified, collection, storage facilities and user requirements need to be established and environmental concerns related to the potential release of contaminants which may be contained in the waste oil (eg. lead, cadmium, unburned hydrocarbons) would require detailed consideration.

The use of waste oil for space heating in the Highways Garage at Beaver Creek has been investigated previously. In this case, 9000L. of fuel oil could be replaced annually by local waste oil supplies. The simple payback period for this application was estimated to be 2.75 years.

4.3.4 Diesel Waste Heat

Diesel Waste heat recovery technology is fully developed and has already been employed in numerous northern applications. The economic attractiveness of development is site-specific and is largely influenced by the size and coincidence of heat supply and demand as well as by the required distribution distance.

4.3.5 Peat

Peat is used for large scale process heat production, district heating and electricity generation in Europe. This clean, efficient combustion technology is well developed for large scale applications but is still under development for small scale applications. Appropriate harvesting, dewatering and fuel transportation/preparation techniques are not presently proven for application under Yukon conditions. Consequently, peat technology is not considered to be ready for near term Yukon application.

4.3.6 Hydro

Hydro technology is well developed and proven for northern and remote applications, at all scales. System design, capacity etc. as well as economic attractiveness are completely site dependent. One important consideration related to further hydro grid development in the Yukon is the uncertainty related to the future need for high quality electricity-specific applications such as lighting, cooking and compressors. The future of Yukon mining activities remains tenuous at this time. Should they again decline, as in the recent past, then significant surplus capacity would again exist. While electricity can, of course, be used to provide space or water heat, these low quality end-use requirements can generally be met more cost-effectively by wood or other lesser quality fuels.

The more pressing area for future Yukon hydroelectric-development remains those communities not currently connected to the grid. In addition, many tourist facilities, highway maintenance camps etc. continue to rely on diesel generated electricity. While the location of these current facilities is usually such that it would be too expensive to connect them to the existing grid or potential micro hydro sites, it may, in some cases, be possible to locate future facilities sufficiently proximate to potential micro hydro sites to make their development economic.

4.3.7 Wood

Technologies for harvesting, transporting and preparing wood resources are developed and proven for application in Northern and remote settings. The principal determinants of an optimum wood harvesting/transportation/preparation system are scale of operation and sophistication and capability of local operators and supply/service infrastructure.

Technologies for the efficient conversion of wood resources to heat for all sectors and scale of demand are also well developed and ready for application in northern and remote settings. Developments are continuing to be made with respect to automatic wood handling and storage systems, and several automatic wood-chip heating systems are now operating in northern Canada. Wood heating technology is available to produce direct heat (eg, wood stoves), hot air (eg, warm air furnaces), hot water (eg, hydronic heating systems), or process steam (eg, boilers).

Technologies for the production of electricity from wood resources are widely available, but their use is not presently practical for application in the Yukon. As with coal, large scale wood-fired thermal generating technology using steam turbines is well proven, but is not needed in the Yukon because of the availability of hydro-electricity. Smaller scale generating systems based on wood-fired reciprocating engines or turbines, and wood gasification are either not suitable for remote application or are still under development. For example:

- Steam engines are reliable and relatively simple to operate; however, they have very low electrical conversion efficiencies (8% - 11%) and therefore require large volumes of wood. In addition, because pressurized steam is produced, licensing requirements generally require full time operator attendance. These two factors typically make such systems non-competitive even against diesel generated electricity.

- Steam turbines are reliable and more efficient than steam engines but they employ high pressure steam and also require full-time operator attendance. Wood boiler/steam turbine generator combinations have been used successfully in the forest industry to cogenerate heat and electricity using wood wastes. Generally, for this technology to be applicable in the Yukon, economics would dictate that a reliable source of waste wood be available and that both heat and electricity be required at the site. Further, the system operators would need to be relatively knowledgeable in steam turbine technology.

- Technologies for the gasification of wood and conversion of the low energy gas to electricity using an internal combustion engine are still under development and are not yet sufficiently reliable for prime power applications.

Technologies to convert forest biomass to methanol or ethanol, for use as a transportation fuel, are the subject of a great deal of current research. However, these technologies remain at the development stage and are unlikely to be applicable to Yukon conditions within the foreseeable future.

4.3.8 Wind

New developments in wind generators for grid, stand-alone or hybrid (wind/diesel, wind/hydro) applications are occurring rapidly. The latest advances are mostly in the 50 to 500 kw range. The newer models promise to have lower start-up speeds, synchronous generators and higher overall efficiency. Wind/diesel hybrid systems have been demonstrated in remote settings and are considered ready for application on a demonstration basis. Wind powered water pumping systems are also available and ready for remote application.

However, as previously presented, the Yukon's wind regime seriously restricts the potential applicability of these technologies at this time.

4.3.9 Solar

Active solar heating technology appears to have reached a plateau in development in both low temperature and high temperature applications. Collector and balance of system products, particularly for water heating, are well made, durable and reliable. Solar heating technology is ready for application, where conditions and economics permit.

Yukon's seasonal solar resource effectively restricts the application of active solar systems to seasonal hot water loads such as the heating of swimming pools or laundromat/shower facilities in seasonal tourist facilities. However, even in these applications, the coincidence of solar supply and hot water demand is important.

Passive solar heating systems have wide potential application. For example, for minimal incremental costs, new buildings can be designed to optimize solar heat gain during the spring and fall heating seasons. Solar greenhouses represent another application of passive solar design that is suitable for the Yukon.

Advancements in solar photovoltaic (PV) systems are taking place rapidly. Current products are reliable and durable and may be safely used where conditions and economics permit. The current low efficiency and high costs of PV systems, however, restrict their present use to very small loads situated in remote applications. One Yukon communications firm, Total North Communications Ltd., has already successfully demonstrated the use of solar PV systems for powering remote VHF stations. In this case, the PV system provided attractive savings, not in the site energy displaced, but rather in helicopter operating costs formerly required to regularly service each site.

4.3.10 Geothermal

All of the geothermal resources identified to date in the Yukon are relatively low temperature water supplies (typcially $10^{o}C$ to $18^{o}C$). Consequently, the only practical application of this resource, at this time, is for heating municipal domestic water supplies (freeze-protection) and for space heating through the application of ground water heat pumps. Ground water heat pump technology is fully developed for space heating applications within the scale of demand found in Yukon buildings. Since ground water heat pumps require an electricity supply, the economic attractiveness of these systems is strongly influenced by the local cost of electricity.

4.4 COMMUNITY-SPECIFIC CONSIDERATIONS

Although detailed, community-specific alternative resource data are not fully available, several recent Yukon studies, particularly those undertaken in conjunction with the Remote Community Demonstration Program (RCDP), have compiled reasonably reliable data for most Yukon communities. While these data must necessarily be considered preliminary in nature, they provide valuable indications of the size, quality and most probable, cost-effective applications of alternative resource/technology combinations within specific Yukon communities. To this end, these data are particularly valuable to further refining the potential role of Yukon's alternatives energy resources.

Table 4.2 provides a brief summary of these data.

TABLE 4.2
YUKON ALTERNATIVE ENERGY SUPPLY
- BY COMMUNITY -

COMMUNITY	ALTERNATIVE RESOURCE/APPLICATIONS				
	HYDRO	DIESEL HEAT RECOVERY	WOOD	COAL	OTHER
1. Whitehorse	• on main grid which has current surplus capacity but expected to be used by reopening of Cyprus-Anvil Mines	• diesel capacity is on a stand-by basis; increased use expected when mine reopens but probably not suitable for heat recovery due to intermittent use.	• substantial local wood resources available • nearby firekill supply adequate to meet total heat demand for 40-80 years.	• most likely source is Whitehorse coal property S.W. of town • coal has high energy content; less than 1% sulphur commercial launching would require large market (ie. mine) • space heat most probable application	• a ground water/heat pump application to provide space heat in adjacent buildings has been identified as feasible for development
2. Watson Lake	• several sites identified; feasibility not yet established • possible 1.5 - 2 MW site on Watson Creek	• 40 TJ available • potential to supply large buildings at west end of town	• substantial resource; adequate for both total space heat and electrical generation	———	———
3. Dawson City	• 1 -2 MW site on Klondike North Fork; prel. study showed technical and economic feasibility. Decision pending water licence etc.	• 25 TJ available • NCPC and Yukon Housing Corp are investigating use for space heating (160 h.holds)	• generally poor in immediate area • nearest firekill is 60 km north on Dempster Hwy. • most probable use - supplementary residential space heat	• known reserves in area • no current production • most probable use - space heat	

	HYDRO	DIESEL HEAT RECOVERY	WOOD	COAL	OTHER
4. Faro	• connected to main grid (see Whitehorse)	• stand-by only	• large resource • is in middle of a 50,000 ha area of firekill; plus good live stands could be used for space and ore drying heat (mine) and co-generation (peak shaving)	• large resource in area • no mines operating	———
5. Mayo) 6. Elsa) 7. Keno)	• connected to local hydro grid	———	• moderate resource • local firekill area near depletion • 6,883 ha firekill area - 20 km east of Mayo; requires access road • could be used for space heat plus ore drying at Elsa Mines	———	• In Mayo, a ground water/heat pump application to provide space heat in adjacent buildings has been identified as feasible for development
8. Beaver Creek	———	• 4.6 TJ available • good opportunity identified with payback of 5.5 yrs. and annual savings of 144,000 L of oil	• limited resource, though available and adequate for 100% residential space heat • further resource assessment required	———	• waste oil supply of of 9,000 l/yr. identified • use for space heating - Yukon Govt. Buildings • payback 2.75 years
9. Burwash Landing) 10. Destruction Bay)	• 2 possible sites: Halfway Cr. and Bock's Cr; feasibility not established; could serve both communities	• 4.7 TJ available • diesel sets in Destruction Bay • No data on potential heat recovery applications	• restricted resource • current supply is largely trucked in from up to 100 km	• known resource in Kluane Game Sanctuary • no current production • could be used for space heat	• wind resource may be adequate for wind/diesel hybrid or water pumping • data are being compiled

	HYDRO	DIESEL HEAT RECOVERY	WOOD	COAL	OTHER
11. Carcross	• connected to main grid (see Whitehorse)	-----	• restricted local resource but large resource within transport distance • could be used for space heat	• good quality resource located north of town • no current production • could be used for space heat	
12. Carmacks	• connected to main grid (see Whitehorse)	-----	• good resource • could be used for space heat	• Tantalus Butte Mine now closed • Other reserves documented in area; probably not suitable for large loads but adequate for space heat • no current production	
13. Haines Junction	• connected to main grid (see Whitehorse)	-----	• good resource • could be used for space heat	-----	• Geothermal resources may be available • not confirmed
14. Johnson's Crossing	• 1.5 MW site identified by NCPC on Squanga Creek - west of village • site may be developed for Teslin load or central grid; if so village connection is possible	• 410 TJ available • good potential for lodge		-----	

	HYDRO	DIESEL HEAT RECOVERY	WOOD	COAL	OTHER
15. Old Crow	-----	• 3.1 TJ available • no data on potential applications	• large resource • could be used for further space heat or electrical generation	-----	-----
16. Pelly Crossing	• low probability site • other options conditional on large scale, grid connected developments on Pelly R. or tributaries	• 3.3 TJ available no data on potential applications	• abundant resource • could be used for further space heat	-----	
17. Ross River	• connected to main grid (see Whitehorse)	-----	• relatively abundant • large fire killed area 45 km NW along Robert Campbell Hwy • space heating applications most probable	• large resource but undeveloped • development probably conditional on large demand ie Cyprus Anvil Mine	
18. Stewart Crossing	-----	• 1.9 TJ available • Hwy maintenance garage is possible load	• large wood supply;	-----	-----
19. Swift River	-----	• 1.5 TJ available • Hwy maintenance garage is possible load	• relatively abundant supply	-----	-----
20. Teslin	• connected to main grid (see Whitehorse)	-----	• relatively abundant • large % of residences already heated by wood • resource adequate to meet all space heat demand	-----	

	HYDRO	DIESEL HEAT RECOVERY	WOOD	COAL	OTHER
21. Upper Liard	-----	• Diesel waste heat available; suitable load unlikely at present	• abundant resource; already widely used for space heating	-----	• if Watson L. is connected to grid, then may be able to also benefit

TABLE 4.3
SUMMARY: YUKON
ALTERNATIVE ENERGY RESOURCE/TECHNOLOGY OPTIONS
(NEAR-TERM: 5 Years or Less)

	Resource	Usable Size	Delivered Current	Energy 5 Years	Cost Effectiveness	Application	Potential Overall Role
1.	Coal	Moderate	None	Low	Marginal	. Process Heat - Ind. . Sp. Heat - Ins/com	Small*
2.	Natural Gas	Large	None	None	--	--	None
3.	Peat	N.Av.	None	None	--	--	None
4.	Hydro	N.Av.	Moderate	N.AV.	Site Specific	. Electricity-Specific - all sectors	N.Av
5.	Wood	Large	Moderate	High	High	. Heat - All Sectors	Very Large
6.	Wind	Very Small	None	Very Low	Marginal - site specific	. Fuel Saver Diesel Hybrid	Very Small
7.	Solar	Moderate	N/A	N/A	Site Specific	. Seasonal Hot Water - Ins/Com . Passive Heat - all sectors	**Moderate
8.	Waste Oil	Small	None	Low		. sp./water heat - Ins./com	Small
9.	Geothermal/ Ground Water	Small	None	Low	Moderate	. Sp./water heat - Ins/Com	Small
10.	Diesel Waste Heat	Moderate	Low	Moderate	Site Specific	. sp./water heat - Ins/Com	Moderate

Notes: N.AV. - Not Available   Ind - Industrial Sector   Ins - Institutional Sector
* Does not include Mine at Faro
** Includes Passive Heating

4.5 SUMMARY: POTENTIAL ROLE OF YUKON ALTERNATIVE ENERGY RESOURCES

Table 4.3 (overleaf) provides a summary and preliminary rating of each alternative energy resource as previously identified and assessed above. In rating the potential role of each resource, the following criteria and ratings have been employed:

(1) • Usable Size - The size of the resource which is within practical harvesting/mining and transportation distance of all Yukon communities and, as applicable, is coincident with demand

(2) • Delivered Energy - The amount of energy which is supplied by the resource (a) currently or (b) could reasonably be expected to be delivered within 5 years given resource size and supply infrastructure considerations

(3) • Cost Effectiveness - The ability of the resource to provide useable energy at a cost that is competitive with RPPs, assuming current technologies

(4) • Application - The end-use(s) and sector(s) where energy derived from the resource could be applied, assuming only proven technologies are used.

(5) • Overall Role - A subjective rating of the size of potential role of each resource, based on criteria (1) to (4) above.

SECTION 5
IDENTIFICATION AND PRELIMINARY ASSESSMENT OF YUKON ENERGY MANAGEMENT OPPORTUNITIES

5.1 INTRODUCTION

This section provides a preliminary assessment of Yukon energy management opportunities. Energy conservation, fuel efficiency and alternative energy supply opportunities are presented by sector and end-use including, as applicable, both existing and new markets. At this point in the paper, primary emphasis is given to technical, financial and market considerations; in the following Section 6, a broader territorial perspective will be added. Thus, in this Section 5, the following areas are discussed:

- Description: Applicable energy conservation, fuel efficiency and alternative energy supply options are matched with major end-uses in each sector.

- Technology Status: The current technical status of energy conservation measures is reviewed and combined with the assessment results for alternative energy supply technologies provided previously in Section 4.

- Estimated Costs/Savings: The potential cost-effectiveness of identified options is presented based, to the extent that data permit, on recent demonstration experience.

- Market Assessment: The applicability of the cited options within Yukon communities is identified and, to the extent that data permit, appropriate sub-markets are identified and the extent of remaining energy conservation/substitution potential is identified.

As applicable, both conservation (efficiency) and alternative resource/technology options are presented, often in parallel. While the selection of an optimum mix of conservation measures and fuel efficiency or substitution options are typically site-specific, previous experience has shown that in virtually every case, it is more cost-effective to first apply conservation and fuel efficiency measures and then to consider fuel substitution options in light of the reduced, residual demand. Three considerations support this approach:

- extensive experience with building energy audits has shown that, in most cases, the implementation of low or medium cost conservation or fuel efficiency improvements require smaller capital expenditures and provide faster economic return than energy substitution options

- in most cases, conservation and fuel efficiency improvements also provide important secondary benefits (eg, increased comfort through reduced drafts or cold spots, increased building lifespan through control of moisture migration, etc.)

- once optiminal (cost-effective) levels of conservation and fuel efficiency have been achieved, then alternative or substitute energy sources can be more effectively specified; for example:

  - an alternative heating system (eg, wood) can be correctly sized to the new, reduced heat demand and therefore ensure a better match of heat supply/demand resulting in optimal operation efficiency of the heating appliance

  - by first reducing the required heating capacity, a smaller and often less expensive heating system can be installed.

The opportunities presented in this section for increased use of alternative resources/technologies have been restricted to those which were judged in the preceding Section 4 to be available and ready for application within the next five years. Consequently, other options, currently constrained by resource availability (eg, natural gas) or technology status (eg, wood gasifier), may provide further Yukon opportunities some time in the future but have been excluded from this present discussion.

5.2 EXISTING RESIDENTIAL SECTOR: SPACE AND WATER HEATING

5.2.1 Description

Opportunities within this sector include retrofit measures as well as upgrading of oil heating systems and/or substitution of wood heating systems. In general, residential electricity-specific demand is not large or subject to significant potential savings (water heating is not electricity-specific) and is therefore not addressed further. The major focus is single detached homes, although most measures are also applicable to attached or row houses. Ideally, the specification of retrofit and heating system measures should be assessed at the same time (ie. via an audit) and an optimum (cost-effective) mix of measures selected.

Table 5.1 (below) indicates the range of opportunities and provides sample measures of conservation and alternative energy measures.

TABLE 5.1
Sample Energy Management Opportunities
- Existing Residential Sector -

Options	**Sample Conservation Measures**	**Sample Alternative Resource/Technology**
1.1 Low Level Retrofit	• caulking and weatherstripping • oil furnace tuning • hot water flow restrictors • set back hot water temp to 110°F • hot water insulation blanket • manual night set-back	-----

1.2 Medium Level	(above measures plus) • upgrade attic insulation • upgrade floor/crawl space insulation • upgrade windows/doors • auto thermostat set-back • add retention-head oil burner	• add supplemental wood heating
1.3 Major Level Retrofit	(above measures plus) • rewrap/insulate exterior walls • replace heating system • add heat recovery ventilator (HRV)	• high efficiency wood stove • wood/oil combination furnace

There are numerous factors which influence the optimium selection of retrofit and heating system measures. However, two factors are particularly critical: a) the current condition of the house (eg, remaining serviceable lifespan, existing thermal characteristics and heating system type, efficiency, and remaining lifespan); and b) the availability of adequate local wood resources for consideration of wood heating alternatives.

Although somewhat simplified, the following three categories of housing conditions and applicable energy measures provide a useful planning framework:

- **Housing which is beyond rehabilitation and subject to near-term replacement:** Normally no action or only low level retrofit actions can be justified. Addition of an efficient wood stove (as supplemental heat source or replacement of inefficient wood stove) may, in some cases, be justified where the stove can be later moved and re-installed in a new house.

- **Housing which has been designated for major rehabilitation:** This situation generally presents the most cost-effective opportunity for retrofit activities. Typically, medium or major level retrofit activity can be economically justified including improvements to an oil heating system and, if wood resources are adequate, the installation of supplementary wood heating (ie. energy-efficient wood stove) or a wood/oil furnace. Normally, some form of oil heating is desirable as a back-up for periods when the home is unoccupied.

- **Serviceable housing with considerable remaining lifespan:** In most cases, low to medium level retrofits will provide the most cost-effective course of action. In oil-heated homes with access to wood resources, the addition of an efficient wood stove as a source of supplementary heat should be considered.

5.2.2 Technology Status

All of the necessry retrofit techniques and materials as well as heating and ventilating systems are technically proven and commercially available. However, conditions unique to northern settings require attention:

- The lack of proper foundations in many existing homes commonly results in serious seasonal structural shifting which may reduce or eliminate the benefits of air sealing.

- Residents must be adequately informed/trained in the operation of new energy-efficient wood stoves, ventilation systems etc. as adherence to traditional practices can reduce the effectiveness of energy measures or lead to hazardous situations (eg. slow burning of green wood in an efficient wood stove which can lead to the build-up of hazardous creosote deposits).

5.2.3 Estimated Costs/Savings

There are numerous factors which affect both the cost and savings associated with retrofit activities. For example, costs can be significantly reduced if measures are undertaken by the homeowner or resident. On the other hand, savings can be lost as a result of household lifestyles. For example, even a well insulated home will consume large volumes of fuel if windows are left open for "fresh air". Notwithstanding these considerations, Table 5.2 presents a range of costs and savings that can be expected for the above retrofit actions.

TABLE 5.2

ESTIMATED COSTS/SAVINGS*

--SPACE/WATER HEATING MEASURES

Action	Installed Cost (incl. labour)	Annual Energy Savings	Annual Cost Savings
• Low Level Retrofit	$500-1,500	10-25%	10-25%
• Medium Level Retrofit**	$3,000-5,000	20-40%	20-40%
• Major Level Retrofit**	$10,000 +	up to 65%	up to 65%
• Install supplementary wood stove/chimney***	$1,500-2,500	N/A	60-70%
• Install wood or wood/oil furnace and chimney	$4,500-5,500	N/A	60-70%

* all costs/savings estimates based on review of RCDP, CREDA, Enerdemo case examples

** Wood heating conversion excluded

*** Assumes 80% substitution of wood for oil; oil price is 45¢L. and wood price is $80/cord.

5.2.4 **Market Assessment**

The energy conservation measures cited above are applicable to all communities within the Yukon. Data are not available on the number of housing units falling into each of the categories cited in 5.2.1.

However, it is assumed that the bulk of the non-native housing stock would fall into the "Serviceable" category with perhaps 10 - 15% falling into the remaining two categories. However, Indian housing stock is widely recognized as being in much poorer repair than non-native housing.

Informal discussions with government officials indicate that no data exist with respect to actual residential energy savings achieved to date. In general, it appears that modest energy savings (perhaps 10 - 12%) have been achieved but significant (perhaps 20 - 25%) additional cost-effective savings remain untapped. These data would be consistent with experience in other parts of the country.

Although hard data are not available, it appears that non-native households have participated far more widely in retrofit programs (eg, CHIP) than Indian households. Numerous explanations--lack of capital, poor local supply infrastructures, etc.--have been advanced for the low level of Indian participation in retrofit activities. These reasons are not fully known; however, based on low historical participation rates and generally poorer housing stock, this sub-market appears to have particularly high remaining retrofit potential which warrants further consideration.

Despite the probable existence of significant untapped residential retrofit potential, the realization of further gains in this sector are seriously constrained by public perception of the current energy situation. The most effective approach may, therefore, be to promote linkages between renovation and energy retrofit activities.

The use of wood for primary or, in many cases, supplementary space heat appears to be slipping somewhat (61,000 m^3 in 1984/85 vs. 89,300 m^3 in 1982/83)*. At its period of peak use, wood provided about 40-45% of Yukon residential space heat. Wood can never completely substitute for fuel oil in Yukon residential space heating due,

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* Yukon Statistical Review, Fourth Quarter, 1985.

largely, to convenience of use and the need for homeowner attendance; however, with suitable support it may be possible to regain wood's former market share and to further expand it to, say, 60-65% of residential space heating energy use. Although data are not available, the types of support which are expected to be consistent with expanded wood use in the residential sector include:

- Upgrading of residential wood heating systems: Many of the installed residential wood stoves are believed to still be cheaper, inefficient models and even many of the more energy efficient models which have been installed have been oversized for their application. This situation aggravates the problems of convenience of use, safety and emissions as well as adversely affecting cost savings. Support could include both user education and financial incentive to upgrade to efficient models.

- Improved Infrastructure Supply: The Yukon Overview Study, prepared by Acres et al. for the RCDP program, consistently cited the need for the development of a reliable wood fuel supply system as a prerequisite to expanded wood use, particularly in the smaller communities. Although the current status of the Yukon's wood supply infrastructure is not documented, it is believed to consist largely of relatively small volume, one or two person operations. Improved co-ordination, assistance in acquisition of better harvesting/handling equipment etc. may provide opportunities to both improve supply reliability as well as reduce unit costs. This area warrants further study.

5.3 NEW RESIDENTIAL SECTOR: SPACE AND WATER HEATING

5.3.1 Description

Opportunities within this sector include:

- construction of new residential buildings to higher standards of thermal efficiency, such as those for R-2000 housing or those proposed in the draft document, Measures for Energy-Efficient Northern Housing (1985), including proper site orientation and design for optimum passive solar heat gain.

- increased use of wood for primary or supplemental space heating.

- improved planning coordination so that the use of the other heating sources such as geothermal/heat pump, passive solar or perhaps wood or diesel waste heat/district heating options can be maximized.

Much of the discussions contained in the preceding Sections 5.2 and 5.3 are equally relevant to the opportunities cited in this section. Consequently only a brief discussion is presented.

5.3.2 Technology Status

Many of the technical issues pertaining to continued developments in energy efficient housing technology are conceptually identical for both northern and southern housing. Areas particularly relevant to northern housing primarily involve improved design specifications which better integrate unique northern conditions:

- a more severe climate
- different lifestyles and cultures
- higher energy costs and larger dependence on fuel oil
- prevalence of permafrost
- reduced solar radiation
- more difficult logistics in isolated communities

Many of these unique northern conditions have been addressed in the previously mentioned Measures for Energy-Efficient Northern Housing. Areas where unresolved technical issues continue to be debated include ventilation systems and window design.

With respect to residential heating systems, high efficiency wood stoves and wood or wood/oil furnaces represent the most widely applicable options. In this area, one of the more important developments is the introduction of catalytic converters into conventional efficient wood stove designs. Catalytic converters offer the potential benefits of not only increased efficiency but also of significantly reduced emissions. Several wood stove manufacturers now market models having catalytic converters.

Improved site-planning and inter-agency co-ordination may further contribute to reduced RPP consumption in new houses. For example:

- to maximize passive solar heat gains, new subdivisions or building lots need to be laid out such that proper housing solar orientation can be attained

- although most residential district heating schemes involving diesel waste heat or centralized wood heating systems and existing residences have not proven to be cost-effective, due to the capital cost of distribution and modification of existing heating systems, such schemes may be cost-effective in the future if sufficient new housing can be clustered near the heat source and compatible heating systems incorporated within the initial housing design specifications.

5.3.3 Estimated Costs/Savings

The actual cost increment required to build new homes to the standards contained in the Measures for EE North Housing (1985) has not yet been firmly established. However, several previous northern housing demonstration projects, funded under EMR's CREDA program, have shown the cost increment (conventional 2"x4" construction vs. R-2000 standards) to be between $7,000 and $15,000 per unit. Simple payback periods ranged between 3 to 7 years. Table 5.3 presents the cost/ savings associated with selected CREDA northern housing demonstration projects.

TABLE 5.3
SELECTED COSTS/SAVINGS
NEW ENERGY EFFICIENT HOUSING

CREDA Demo Site	**Selected Costs/Savings New Energy Efficient Housing**		
	Cost Increment	**Annual Savings**	**Simple Payback**
1. 50 Super Energy-Efficient Townhouses, Yellowknife, NWT	$10,000/unit	$2,665	3.7 years
2. Northern Low Energy New Housing, Labrador	$ 7,000/unit	$2,536	2.8 years
3. Wood Heated Low Energy House - Hay River NWT	$15,225	$2,400	6.3 years

5.3.4 Market Assessment

The new residential market has been relatively flat for the past few years (about 100 homes per year) largely in response to the general economic decline. However, with the recent improved economic climate and expanding population, it is expected that the Yukon's new (non-native) housing market will similarly experience new growth. In addition, and exclusive of the stimulative impact of future land claim settlements, the Council of Yukon Indians is currently projecting the construction of 500 new homes for Indian residents over the next three years. Thus in both Indian and non-native sub-markets, there exists a very significant opportunity to improve the energy efficiency of the Yukon's residential housing stock.

According to officials of the federal R-2000 program, there has been a positive builder response to the R-2000 training workshops held in the Yukon, including good representation from Indian Bands. While interest is apparently high, there is concern as to whether new homeowners are sufficiently confident in the Yukon's economic improvement to invest the additional "front-end" capital required to build homes to optimum levels of energy efficiency. Given the related benefits to the territory, not only of reduced fuel importation but also of an improved quality of housing stock, consideration of incentives/support ensuring high levels of energy efficiency in new housing clearly warrant further consideration.

As in the existing residential sector, the applicable sub-markets for new residential construction include Native and non-Native as well as larger versus smaller communities. It is expected that maximum realization of benefits will require distinct approaches to each of these sub-markets.

5.4 COMMERCIAL SECTOR: SPACE/WATER HEATING AND ELECTRICITY-SPECIFIC

5.4.1 Description

Opportunities within this sector vary widely, primarily as result of the wide variation in "building-types" which house commercial activities. For those commercial activities (eg, small retail, small lodges etc.) that are carried out in "residential-type" buildings, opportunities will be similar to those for residential sector. Similarly opportunities for larger commercial operations such as hotels/motels (eg, those with HVAC systems, large or multiple-use floor space etc.) will be similar to those described for the institutional sector. Consequently, the reader is referred to sections 5.2, 5.3, 5.5 or 5.6, as appropriate, for a discussion of possible energy management measures applicable to the commercial sector (existing and new).

5.4.2 Market Assessment

Based on the Retrofit Potential Index (RPI)* contained in the Yukon Overview Study, the potential for cost-effective retrofit of commercial buildings is particularly large. Whereas an RPI of 6 was considered to be a practical level of energy performance for Yukon buildings, most commercial buildings were cited as having RPI's many times larger than this level. In fact, a large number of commercial buildings were reported as having RPI's in excess of 200 with some being as high as 2000. Although the RPI index is obviously not a precise measurement tool, the results contained in the Yukon Overview Study clearly show very large energy savings potential in this sector. Detailed information is not available on the level of retrofit activity which has occurred since 1983/84 (the date of RPI data) but it is unlikely that conditions have changed significantly.

* The retrofit potential index (RPI was developed by Arctech as a means of identifying buildings with the greatest payback potential for energy conserving retrofit measures. The RPI for an individual buildings is computed as the building energy efficiency (MJ/M3/DD) times the gigajoules of energy consumed during an average year. As an example, a building with an average efficiency of 0.04 MJ/M3/DD (40 KJ/M3/DD), which used an average of 150 Gigajoules of energy for space heating, would have an RPI of 6. The higher the RPI, the greater the potential for cost-effective energy conservation measures.

The hotel/motel subsector is expected to have particularly significant remaining potential for cost-effective energy savings. This reflects the larger and multi-use nature of these facilities (and hence wide range of applicable measures) as well as the high degree of owner/operator management. This subsector also represents one of the most promising markets for solar DHW applications, given the large summer demand for hot water.

The commercial sector has historically represented about 20 to 40% of new construction activity in the Yukon. During the past four years, approximately 100 units have been built each year, thus representing a continuing opportunity to promote the incorporation of more energy efficient design features.

While some small commercial operations, particularly in the smaller communities, are known to use wood as a supplemental source of space heat, further penetration of wood heating into this sector will require overcoming "convenience-of-use" constraints. Wood-fired district heating systems may provide a means of overcoming this constraint, provided that suitable site-specific conditions exist. Yukon data are not available; consequently, further assessment is not possible at this time.

5.5 INSTITUTIONAL SECTOR: SPACE/WATER HEATING AND ELECTRICITY-SPECIFIC

5.5.1 Description

Opportunities within this sector address space/water heating and electricity-specific energy demand in existing institutional buildings--offices, schools, hospitals, recreational facilities and transportation facilities. Some of these buildings, such as small offices, airport waiting rooms, etc. are similar to residential buildings with respect to their size, heating systems, etc. Specification of retrofit measures and estimated savings potential is, therefore, similar to those presented previously in Section 5.2.

In the remaining larger institutional buildings, the range of available energy management options is generally broader than for the residential sector. Two factors particularly influence this situation:

- **Size**

  - The larger heat loads of the buildings greatly improve the potential cost effectiveness of additional alternative heating options such as diesel waste heat recovery, automatic wood chip heating, waste oil burners and geothermal/groundwater heat pump systems.

  - The larger physical size of the building increases the possibility that different sections may have different patterns of use or may even have simultaneous heating and cooling loads (ie. recreational facilities) Thus, zone control of heating, ventilating and lighting systems and internal waste heat recovery may often provide attractive savings.

  - Larger institutional buildings normally pay an electrical demand charge as well as an energy consumption charge. Control devices which cycle loads to limit peak energy demand may often provide attractive savings.

- **Existence of Central HVAC Systems**

  - Larger institutional buildings typically have more complex, central heating and ventilating systems than are found in residential-type buildings. In many situations, therefore, significant energy savings can be achieved through the fine tuning of HVAC controls, by reducing the quantity of outside make-up air, and by upgrading with more energy efficent motors, equipment, etc.

Table 5.4 (below) indicates the range of opportunities and provides sample measures of conservation and alternative energy measures. Further specification of opportunities can only be carried out on a site specific basis. Appendix D presents further site specific measures and results.

TABLE 5.4

SAMPLE ENERGY MANAGEMENT OPPORTUNITIES

- EXISTING INSTITUTIONAL SECTOR -

Options	Sample Conservation Measures	Sample Alternate Resource/Technology
2.1 Low Cost	• set back hot water temp to 110^{o} • insulate hot water tank • reduce lamp wattage • balance/tune/heat mechanical and ventilation equipment • seal around entrance doors, windows, etc. • reduce window area and insulate etc.	------
2.1 Medium and High Cost	• add attic insulation • insulate crawlspace • replace incandescent lighting with efficient fluorescent, metal halide etc. lamps • install auto temperature set back • install zone control heating/lighting systems	• install cord wood and wood/oil boiler/furnace • install automatic wood chip boiler • diesel waste heat recovery • geothermal/heat pump • solar DHW system

- upgrade mechanical and ventilation equipment
- install peak electrical demand controls
- internal heat recovery (ie, recreation facilities)

5.5.2 Technology Status

All of the techniques, materials and equipment required for implementation of the identified institutional energy management options are technically proven and commercially available. For example, several institutional wood heating systems are currently in operation and diesel waste heat recovery has been successfully used for many years for heating in Northern facilities.

However, previous demonstration experience--particularly those involving new and/or more sophisticated heating and computer managed energy systems--has clearly shown the need to anticipate, and adequately plan for, potential problems in the start-up phase. As previously mentioned, thorough operator training including on-site technical assistance during start-up and an adequate parts inventory is often essential. In several cases, simple problems have led to prolonged and frustrating shut downs of diesel heat recovery systems, automatic wood-chip heating systems and computerized load management systems. In almost every case, analysis of the situation has shown that a properly trained operator, with adequate access to parts and service personnel would have avoided any serious disruption of service. For the most part, once these needs have been adequately addressed, the systems have operated reliably.

Appendix D presents case studies of several demonstration projects which highlight some of the above problems and responses a well as savings achieved. These include:

- Oxford House School - Diesel waste-heat recovery
- Lac La Martre School - Diesel waste heat recovery
- Fort Smith - Automatic Wood-Chip heating system
- Pelly Crossing School - automatic wood-chip heating system
- Rolling River School Division - Remote Computerized energy management
- Arenas and Curling Rinks - Heat recovery, electrical demand control, lighting
- Indoor Swimming Pools - Heat recovery and electrical demand control

The implementation of other less sophisticated measures, as identified previously, have typically performed as expected. Although, proper operator training and periodic site supervision is frequently necessary to ensure that proper operation and maintenance procedures are being adhered to.

5.5.3 Estimated Costs/Savings

The potential costs/savings related to the implementation of energy management measures in this sector vary widely among sites. Consequently, site-specific costs/savings are shown below in Table 5.5 for selected measures in several actual remote community demonstration projects. Further detail is contained in Appendices D and E.

TABLE 5.5

COSTS/SAVINGS

FOR SAMPLE MEASURES AND SELECTED SITES

- INSTITUTIONAL SECTOR -

Measure	Site*	Estimated Cost**	Estimated Annual Net Savings***	Simple Pay back (Years)
A) Low Cost				
1. Set-back hot water temp. (135°F-110°)	(1)	0	$53	0
2. Weatherstrip doors	(2)	$120	$1,113	.1
3. Add timer to exhaust fan	(2)	$250	$700	.4
4. Reduce corridor lampage	(2)	$100	$70	1.4
B) Medium Cost				
5. Ventilation control upgrade	(1)	$3,000	$3,350	0.9
6. Install auto temp. set-back	(3)	$4,750	$994	4.8

7. Install electrical demand control system	(4)	$15,000	$4,500	3.3
8. Icemaking heat reclaim	(9)	$5-$13,000	N/A	3-10
C) <u>High Cost</u>				
9. Install diesel waste heat recovery	(5)	$119,000 (A)	$55,000	2
	(6)	$239,000 (A)	$26,500	9
10. Install automatic wood chip boiler	(7)	$206,874 (A)	$44,500	4.6

Notes:

***Sites are:** (1) Erickson Collegiate - Erickson, Manitoba; (2) Centennial School - Lac Du Bonnet, Manitoba; (3) St. Joachim School - Lac Broquerie, Manitoba; (4) Leaf Rapids Education Centre - Leaf Rapids, Manitoba; (5) Oxford House School - Oxford House, Manitoba; (6) Lac La Martre School - Lac La Martre, NWT; (7) Fort Smith Water Plant - Fort Smith, NWT; (8) Pelly Crossing School - Pelly Crossing, Yukon; (9) Average for 12 locations across Canada.

** (A) Denotes actual cost; savings shown are also actual for first year of operation. Savings will increase as fuel prices escalate.

*** Savings shown are net (ie, projected fuel oil cost - cost of alternative fuel and O & M costs)

5.5.4 Market Assessment

As indicated above in Section 5.5.1, the potential savings resulting from energy management measures in the institutional sector are, in general, larger than for other sectors. Institutional facilities are located in communities throughout the Yukon and the sample conservation measures outlined in Table 5.2 as well as those identified in the case examples contained in Appendix D are expected to be widely applicable. Alternative energy options are, however, more site-specific in their application. As presented previously, wood resources/ technologies for space and water heating are the most widely applicable options in the Yukon. Options for diesel waste heat recovery, geothermal/heat pump applications, solar DHW systems, etc. are also expected to be applicable in selected locations. However, these latter options are particularly site-specific and, therefore, it is more difficult to generalize about their applicability.

5.6 NEW INSTITUTIONAL SECTOR: SPACE/WATER HEATING AND ELECTRICITY SPECIFIC

5.6.1 Description

The major energy management opportunities for new institutional facilities include:

- construction of new institutional buildings to improved levels of thermal as well as mechanical and lighting system efficiency and,
- incorporation of wood heating systems for primary or supplementary space and water heating, or
- co-ordinated site selection and planning so that opportunities for using diesel waste heat, geothermal, solar or waste oil resources can be optimized.

5.6.2 Technology Status

As for the residential sector, may of the technical issues involved in northern construction of new institutional facilities are similar to those existing in the south. They involve such areas as:

- determination of optimum design and levels of insulation
- use of more efficient HVAC and lighting systems and equipment including the use of micro-processor control systems

The latter area warrants careful consideration in Yukon applications, as the potential related savings are large particularly in communities where electricity is diesel generated. However, the use of more sophisticated computer control systems is more difficult in less sophis-ticated settings. With respect to the selection of optimum design levels for insulation and other related energy efficiency equipment, the application of life-cycle costing principles should be emphasized.

Potential alternative heating resources/technologies have been previously discussed in preceding sections and are, therefore, not repeated here. However, the potential benefits of co-ordinated site planning warrant emphasis. For example, the proximity of the waste heat supply to the potential load is critical to the economic feasibility of diesel waste heat recovery. If community plans are designed to group larger institutional and commercial loads within the same physical area as the diesel plant, then the probability of cost-effectively using this heat source is increased greatly. In fact, if suitable loads exist, it may in some cases (particularly during major overhauls or replacement of diesel engines) be economically feasible to relocate the diesel plant adjacent to the heat load(s). Through the use of exhaust silencers and improved sound insulation of the container building, both emission and sound levels can be made acceptable for locating the diesel plant adjacent to public buildings.

5.6.3 Market Assessment

The design and construction of new institutional facilities provides an opportunity not only to incorporate optimal levels of efficiency (life-cycle cost basis) but also to provide an important stimulus to the more widespread local use of wood resources. For example, in many larger institutional facilities automatic wood-chip heating systems can be economically justified. Once a reliable wood-chip supply has been established to serve the facility, including investment in harvesting, chipping and transport equipment, then the economics of serving additional local, smaller commercial or institutional facilities may be greatly improved.

Whereas the capital investment in wood-chip supply equipment can not generally be rationalized for smaller heat loads, once purchased to provide wood chips to the larger facility, the same equipment can be used to serve additional local wood-chip users, thus reducing unit capital costs. Even a relatively large building's demand for wood chips will require only intermittent use of wood chip production equipment.

The construction of new institutional buildings, as well as major additions/renovations represents an important and ongoing element of the Yukon construction industry, accounting for 4 to 18% of actual building permits and as much as 50% of total building expenditures during the period 1983 to 1985.

5.7 INDUSTRIAL SECTOR

5.7.1 Description

For purposes of identifying energy management opportunities, the industrial sector in the Yukon can be divided into four subsectors: hard rock mining (including coal), placer mining, and all other industry, with the last category further subdivided into liquid fuels-intensive and heat-intensive sub-subsectors. (Liquid fuel intensive industries include agriculture, forestry, hunting, fishing and trapping, and construction; heat intensive industries include food processing, chemicals, and most miscellaneous industry.) Electricity use is very unevenly distributed among industrial sectors, with mining taking a large block for use in high-volume digging equipment and a smaller amount in milling operations. Almost all other industries use some electricity, but generally in quantities more comparable to small commercial establishments. The placer mining industry is the main user of propane in the Yukon. Propane is a convenient all-purpose fuel that well suits the mobile requirements of the industry.

Because of the need to deal with the several sectors of industry separately, discussion of industrial energy opportunities is organized by sector rather than by characteristics as with other parts of this section of the report.

5.7.2 Hard Rock Mining

Energy use in conventional mining has received rather less study than that in most other sectors of industry. This is surprising inasmuch as mining, as defined statistically, is a fairly energy-intensive operation. (Statistically, "mining" includes both mining and milling operations as well as on-site ore movements.) Unfortunately, the reports of the Federal Government-Industry task forces on energy use and efficiency are of little help because they aggregate mining and metallurgy, whose combined energy use is of course dominated by the latter.

As indicated in Section 3 above, the industrial sector in the Yukon was formerly dominated by mining, and will be again with the end of the current recession in the industry. Because mines are so different one from the other, it would be useful to have mine-by-mine information on energy use patterns prior to reaching conclusions about the technical or economic potential for efficiency improvements. However, such information is not published. Therefore, this section will focus on the general sorts of approaches that are likely to prove applicable in the Yukon.

Half or more of mining energy use in the past was represented by the Cyprus-Anvil mine, and in the future the same operation, now renamed Curragh, will likely represent a comparable share of the sectoral total. Information provided by Curragh suggests that the reopened operations will not only improve overall plant efficiency (energy use per unit of output) by 10 to 20% but also that, by eliminating the surge problem on the electrical lines feeding the large shovel, the Territory's electrical supply system can be used more efficiently so that in effect, the available capacity is increased.

The Energy, Mines & Resources Soft Energy Paths for Canada (1983) study identified the following principal areas by which improvements in mining energy efficiency are "being achieved":

- utilization of waste heat
- optimizing ventilation control systems
- improved water use to reduce pumping requirements
- external air feeds to combustion chambers.

Other studies have also found savings available through a variety of no-cost/low-cost measures involving housekeeping and minor changes in operational patterns. Even larger savings are possible by process change, mainly in milling operations, by reductions in the need for process heat. These developments are still mainly in the experimental stage and will not likely be adopted within the next five years. In general, non-process charge conservation measures implemented at mines and mills in Canada often cost less than $4 per gigajoule (Diener & James).

Not included in any of the foregoing figures are savings obtainable through purchase of more efficient vehicles and improved operation and maintenance of both off-the-road and highway trucking fleets related to mine operations. These savings are large but are covered by the information in Section 5.8 on Transportation.

5.7.3 Placer Mining

Modern placer mining is really a mechanized, high-speed method of panning for gold in which large volumes of river gravel are bulldozed into sluices where the gold is allowed to separate from lighter materials by gravity. Before excavation, the overburden must be removed from the river gravels, and, if necessary, the permanently frozen ground containing the river gravel must be thawed. The land is restored following removal of the gravel.

Placer mining uses two forms of energy: diesel oil for operation of earth-moving and other mobile equipment; and propane for camp operations and for thawing frozen ground. Gold dredges (only one is currently in operation) are also operated by diesel. If electicity is needed, a small diesel generator is used.

Opportunities for energy conservation in placer mining fall into two general categories:

- selection and operation of earth-moving and other mobile equipment
- planning of mine operations.

Much of the energy used in current placer mining operations is for moving gravel using front-end loaders. One alternate method of materials handling, which is currently being demonstrated, involves the use of gravel pumping. This method involves screening out all but the material less than 15mm and then pumping the fines in a slurry to a sluce box. This method could not only decrease energy consumption in the mining operation, but could greatly simplify the land reclamation process, since the finer tailings would be available to put back on the site after the claim had been worked.

With respect to the selection and operation of earth-moving and other mobile equipment, the same principles apply to placer mining as to other industry. Energy can generally be saved cost effectively by careful operation and maintenance of equipment, by considering energy efficiency in equipment selection, and--perhaps most important--by sizing equipment purchased or used to the typical task rather than to peak requirements.

Improved planning can take several forms. By stripping overburden ahead of the time when mining will begin, the process of thawing the frozen ground with propane-fired steam generators can be largely or entirely avoided. More extensive or more careful sampling can define the gold-bearing zones of gravel, and therefore reduce the volume of material that has to be moved. The two work together. Natural thawing requires that the miner determine, a year in advance, what ground will be worked in the next season and that is exactly what sampling can help determine.

5.7.4 Liquid Fuels-Intensive Other Industry

The energy management opportunities for this collection of industries are essentially similar to those for the transportation sector. A recent analysis of conservation opportunities for agriculture in Alberta, which allowed for the higher fuel consumption of off-road vehicles as well as for improved tractor design and farming practices, determined that the potential saving was approximately 44% per dollar of output by the year 2010. Assuming that a large proportion of that gain can come quickly with a shift to better sized, more efficient equipment, but also allowing for the more rigourous conditions of the Yukon, it would appear that agricultural energy efficiency could improve by about 20% within a decade. The main gains come from smaller, better sized equipment that is operated and maintained so as to be fuel efficient. None of the changes affects output, and the costs of the new greater efficiency are roughly balanced by downsizing and reduced fuel use.

Except for construction, the other liquid fuels-intensive sectors also use energy almost exclusively for mobile equipment, so comparable gains can be expected from those sectors, again at little or no cost. Gains for construction will be lower, perhaps by 15%, because about one-fourth of the energy used in construction is for heating of construction sites where savings are difficult to achieve.

5.7.5 Heat-Intensive Other Industry

Both greater efficiency and alternative fuels can play a role in changing the patterns of energy use in the heat-intensive subsector of other industry. However, except perhaps for the small size of individual establishments, there is little to distinguish these operations from those elsewhere in Canada. While they face higher energy costs than operations located elsewhere, they also face higher costs for alternative sources and for the materials and labour needed to retrofit for greater efficiency.

Evidence from small industrial establishments elsewhere in Canada has identified four major areas where significant gains in energy efficiency can be won: 1) improved insulation in all areas where heat is being supplied; 2) more efficient and better-sized electric motors; 3) addition of minor elements of process control; and 4) much greater attention to so-called housekeeping and operations. Of these, the first and last yield the greatest energy savings--typically 20 to 30% in the case of insulation and 10 to 20% in the case of housekeeping. However, whereas the latter is all but costless apart from learning time, the investment in insulating materials can be substantial. Improved electric motors and motors that are more carefully sized to the loads placed on them yield savings in the range of 5 to 15%, not generally enough to be cost effective except at the time when a new motor is being purchased. Improved process controls vary so widely that it is impossible to generalize about cost effectiveness.

In addition to these measures, heat-intensive subsectors should find the same opportunities to economize in liquid fuels for transport and in energy used for space heating as other sectors already described.

Alternative sources for heat-intensive industrial subsectors are also similar to those available in the commercial/institutional sectors. The two most important options appear to lie with the use of wood as a heat source and with the recovery of waste heat for use in other operations. None of the operations is likely large enough to justify cogeneration. Other options involve coal or waste oil, particularly in modern clean-burning boilers. However, again the small size of existing operations may limit the cost effectiveness of shifting to these sources.

5.8 TRANSPORTATION SECTOR: LIQUID FUELS

5.8.1 Description

The major opportunities within this sector involve the private automobile/light truck and commercial truck subsectors. As shown previously, these two subsectors account for nearly 85% of total sectoral energy demand. None of the vehicles are manufacturerd in the Yukon; therefore, vehicle efficiency standards are beyond the scope of Territorial influence. Therefore, in the absence of any near term fuel substitution options (eg, CNG), the Territory's major options consist of promoting both more efficient operation of current vehicles and the selection of more fuel efficient replacement vehicles. While emphasis is accorded to the automobile and truck subsectors, similar opportunities may be applicable to local airplane firms. However, available data are insufficient for further analysis of this latter subsector.

Table 5.6 indicates sample opportunities and measures which are applicable, in the near-term, to the automobile and truck subsectors.

TABLE 5.6
SAMPLE ENERGY MANAGEMENT OPPORTUNITIES
- TRANSPORTATION SECTOR

Subsector	Options	Sample Measures
1. Private Cars/Light Trucks	1.1 Driver Education/ Awareness Programs	• Driver training - winter driving • Tune-up clinics - tire pressure - speed - maintenance • Engine/vehicle downsizing
2. Commercial Trucks	2.1 Fleet Management and Operator Education Programs	• Driver training programs • Management monitoring of driving habits, maintenance procedures and fuel consumption • Route optimization • Energy-efficient vehicle selection - power requirements - drive train selection - tire selection - fuel saving accessories

5.8.2 Technology Status

Techniques and technologies required to achieve more fuel efficient operation of cars and trucks are well established and several provincial departments of energy and/or transportation have successfully implemented a wide range of programs and measures. For example, the

Ontario Ministry of Transportation and Communications (MTC) has developed and implemented transportation programs and supporting media (booklets, seminar training materials, A/V materials etc.) directed at a wide range of specific target audiences - from private automobile owners/drivers through to individual and corporate owners/operators of large, long haul trucks. Although these and other materials would obviously require significant adaptation to Yukon conditions, it could provide a valuable basis for similar Yukon initiatives.

5.8.3 Estimated Costs/Savings

The actual costs and savings associated with the private implementation of measures such as those outlined above in Table 5.6 will, of course, depend on specific circumstances. For example, an individual's decision to replace their V-8 powered car or truck with a smaller more fuel efficient version can yield savings in the initial purchase price as well as fuel savings in the order of 50%. On the other end of the spectrum, fleet management techniques have been demonstrated by numerous large trucking firms where, along with driver education and improved maintenance savings have reached as high as 25% of pre-change use. In many cases, significant savings in annual maintenance costs have also been realized through the implementation of these measures (as much as 50¢ for each $1 saving in fuel costs*)

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* Fuel Saver; Spring/Summer 1985

5.8.4 Market Assessment

Although the above measures are theoretically applicable throughout the Yukon, it is expected that they would be particularly applicable in Whitehorse and perhaps one or two of the other larger centres, as they represent not only the largest concentration of drivers and vehicles but also are the centres for most local trucking/hauling firms.

Is should be noted that a large portion (precise data are not available) of the fuel consumption attributed to the transportation sector is consumed by vehicles passing through the Yukon. This includes both summer tourist vehicles and truck traffic originating outside of the Yukon.

5.9 ELECTRICITY GENERATION

5.9.1 Description

As noted in preceding sections, about 85-90% of the Yukon's current electricity supply is hydro generated and is distributed via two separate local grid systems. At present, the main Whitehorse grid, in particular, has significant (20-30%) surplus capacity. However, with the reopening of the Curragh Resources' mine at Faro, it is expected this surplus capacity will not only be fully utilized but also that stand-by diesel generating capacity may again be required despite activation of a recently installed fourth 20 MW turbine. As further noted in preceding sections, the future prospects of the mining operation remain uncertain at present. For example, should the Faro mine close again, or significantly curtail its level of operation, it is possible that the Yukon will again find itself with a surplus of hydroelectic grid power. Conversely, should new mining activities increase significantly within areas served by the grid, the increased use of diesel generating capability would similarly be required. Consequently, until these uncertainties are clarified, there is no clear case for further expansion of the current hydroelectric grid systems.

The major area of the Yukon's electricity supply system that does clearly warrant emphasis are off-grid community diesel power systems.

Energy management opportunities for these diesel electricity generating sets can be grouped into two categories;

- alternative resources/technologies which can be used as a partial or complete substitute for diesel generated electricity

- measures which will increase the overall electrical efficiency of existing diesel sets.

The former category of opportunities have been previously discussed in Section 4, but for easy reader reference, the major conclusions are repeated below:

- Hydro: Additional hydroelectric capacity exists within the Yukon which could, in theory, be used to replace diesel sets either through grid extension and/or through development of small or micro hydro sites proximate to specific communities not connected to the grid. Based on available data, it appears that only Dawson City (small hydro) has any significant short term probability of development. Consideration of hydroelectric developments at these and the remaining diesel electric generation sites is, however, highly dependent on site specific considerations which are beyond the scope of the report.

- Wood: A wood-boiler/steam turbine generator combination could potentially provide a cost-effective alternative for the cogeneration of electricity and heat in select locations where a large heat load is present (e.g. concentrate drying, district heating etc.) together with a compatible electrical load or grid connection.

- Other: No other resource/technology combination offers a cost-effective near-term opportunity for replacing diesel electricity generation in the Yukon.

Opportunities for improved system efficiency include:

- computerized load matching in diesel power installations with multiple generating sets

- addition of a heat recovery generator to existing diesel sets
- intermittent charge AC/DC diesel generating systems with battery storage

Each is further discussed below.

5.9.2 Technology Status

- **Computerized Load Matching:** In remote power systems with several diesel generating sets of different sizes, it is common practice to activate and de-activate the sets in response to daily or seasonal load changes so that the power output form the engines closely matches the load. This improves fuel efficiency and reduces maintenance costs. In some cases, further savings can be realized by installing a computerized control system to automatically activate or de-activate units in response to load changes.

  Computerized load matching control systems have already been introduced at a number of remote community power sites in Alberta and Ontario and have been shown to be reliable and effective. Fuel savings of 20% with a payback of just over 1 year have been realized at the Alberta demonstration site.

- **Heat Recovery Generators:** The addition of a heat recovery generator to existing diesel generating sets can increase electrical conversion efficiency. About 70% of the fuel energy used in a diesel generator system is lost as waste heat. Some of this waste heat can be used to generate additional power using an organic Rankine cycle engine and generator. An organic Rankine cycle engine works in a similar fashion to a steam turbine, but at a much lower temperature. Instead of water being evaporated into steam with the high pressure steam driving a turbine, an organic fluid is evaporated and the pressurized vapour is used to drive a turbine. When used with a diesel generator, waste heat is used to drive the organic Rankine cycle engine which produces additional electricity in a separate generator, thus increasing the overall electrical conversion efficiency of the generating set.

Organic Rankine cycle heat engine genertors designed to be used to recover waste heat from diesel power systems and increase the electrical conversion efficiency of the ysstem are only in the planning stage and have not yet been demonstrated in a remote community power site. However, these generators are already being used in industry to convert waste heat into electricity and are often included as the final stage in multiple stage gas-fired cogeneration systems. It is possible that equipment for use at remote community power sites may be available within 5 to 10 years; however, further development and demonstration work as well as confirmation of cost-effectiveness is required before this technology will be applicable in the Yukon. This option is, therefore, not included as a near term option.

- **Intermittent Charge AC/DC Diesel Generating Systems:** An intermittent charge diesel generating system consists of a conventional diesel driven AC generator connected to a reversible DC motor/generator and a high capacity battery system. The AC generator and DC motor generator are on the same shaft. When the load can be met by the battery system, the DC motor is driven from the battery and generates AC for the load through a conventional AC generator (which is automatically declutched from the diesel engine). If the battery system cannot supply the load, the diesel engine starts, and generates AC for the load and DC to recharge the batteries (through the now reversed DC motor). Under these conditions, the diesel engine(s) operate(s) under optimum load conditions, thus improving efficiency performance and reducing engine wear associated with operation under low load factor conditions. Major fuel and maintenance cost savings are, of course, realized during the extended periods when the diesel engine is not operating and the load is supplied by the battery storage.

Intermittent charge 10-12 kW AC/DC diesel generating systems with battery storage for communiations loads are now operating reliably in Newfoundland and are being tested in Ontario. Average annual savings for both fuel and maintenance costs appear to be in the range of 60%-70%.

Larger intermittent charge diesel generating systems with battery storage are now under active development. Performance analyses have shown these systems to be cost-effective against conventional diesel generator sets in remote communities with average loads in the 30 to 150 kW range.

Intermittent-charge diesel generating systems are particularly compatible for hybrid use with DC wind turbine or photoelectric generators, as power can be fed directly to the battery system. Because no synchronization is necessary, and because there is energy storage capability, the wind turbine or PV system can be sized to provide a much higher percentage of the load. The diesel unit can be switched off for long periods saving both fuel and maintenance costs.

Small intermittent diesel generating systems are therefore, technically ready for application, when conditions permit. Larger systems are not currently ready for application but may be within 5 years.

5.9.3 Market Assessment

Computerized load matching control systems are potentially applicable to most new and existing diesel power installations which utilize more than one generating set.

Small intermittent diesel generating systems are applicable primarily only to remote communications sites or other very small, uninterruptable electrical loads not served by community power systems.

If and when, larger intermittent diesel generating systems become commercially available, they could be applicable in small Yukon communities such as Johnson Crossing, Swift River and Stewart Crossing.

5.10 PRELIMINARY PROGRAM PRIORITY AREAS

Table 5.7 provides a summary and preliminary rating of the potential for realizing further cost-effective energy savings in each of the sectors previously discussed. Although both preliminary and partially subjective in nature, the Overall Rating accorded to each sector does provide a valuable basis for identifying those areas of the Yukon energy economy where energy management initiatives are most likely to yield the greatest returns.

Further discussion, related to the nature and scope of possible returns, is provided in the following Section 6.

TABLE 5.7
PRELIMINARY PROGRAM PRIORITY AREAS

SECTOR	SUB MARKET	POTENTIAL/ PARTICIPATION	OVERALL RATING
1. Existing Residential	1.1 Non-Native	• Significant remaining potential but further gains constrained by public perception of energy situation • Renovation and retrofit linkages should be promoted	• Low to Moderate
	1.2 Indian	• Large untapped potential • Good potential to integrate retrofit and renovation activities • New delivery mechanisms required to ensure participation	• Moderate to High
2. New Residential	2.1 Non-Native	• Increased construction activity projected over next few years • High degree of builder interest in energy efficiency • Overall, very good potential to realize high participation	• High
	2.2 Indian	• 500 new houses to be constructed over next 3 years • With land claims settlement, construction activity expected to further expand • Overall, very good potential to realize high participation but new delivery mechanisms required	• High

TABLE 5.7
PRELIMINARY PROGRAM PRIORITY AREAS
cont'd

SECTOR	SUB MARKET	POTENTIAL/ PARTICIPATION	OVERALL RATING
3. Commercial	3.1 Hotels/Motels	. High potential; probably most receptive sub market re: participation	. High
	3.2 Other	. Apparent high potential for energy gains, but insufficient data to estimate likely participation	. N/A
4. Existing Institutional	4.1 Large Facilities	. Good remaining potential; continued integration of energy upgrading with capital improvement programs is desirable	. High
5. New Institutional	5.1 Large Facilities	. Major gains possible . Particularly important re: stimulating expanded wood supply systems . Participation expected to be high	. High

TABLE 5.7
PRELIMINARY PROGRAM PRIORITY AREAS
cont'd

SECTOR	SUB MARKET	POTENTIAL/ PARTICIPATION	OVERALL RATING
6. Industrial	6.1 Mining	. Data insufficient re: remaining potential and/or likely participation	. N/A
	6.2 Other	. Small potential; likely participation unknown but probably low	. Low
7. Transportation	7.1 Private Vehicles	. Moderate potential; participation probably low	. Low to Moderate
	7.2 Commercial Vehicles	. Moderate potential; participation probably low	. Low to Moderate
8. Electricity Generation	8.1 Diesel	. Site-specific gains possible	. Low

SECTION 6
YUKON ENERGY MANAGEMENT OPPORTUNITIES: THE DEVELOPMENT POTENTIAL

6.1 INTRODUCTION

Previous chapters of this report have disaggregated the Yukon energy economy in order to identify options for energy conservation and for substituting local for imported energy. Preliminary assessment has indicated that the following sectors and end-uses offer moderate to high opportunities for energy management in the Yukon:

- Space and water heating in existing residential buildings
- Space and water heating in new small buildings (residential units and small commercial establishments)
- Space and water heating plus electricity-specific use in existing large buildings (institutional and commercial)
- Space and water heating plus electricity-specific use in new large buildings (institutional and commercial)
- Liquid fuels for transportation

In previous sections the focus has been on the technical potential to improve efficiency or develop alternative sources within the various sectors of the Yukon economy. However, an economic dimension has already been incorporated in the sense of deleting options that are unlikely to prove economic (or to be available at all) in the Yukon within the coming five years. In this chapter, the analysis will be broadened in two ways. First, the economic dimension will be extended in order to get an idea of which options offer the best returns to the economy as a whole, not just to its individual components. The difference is essentially that between microeconomic and macroeconomic aspects of the analysis, where the latter really reflect the broader development potential of the energy management opportunities. (As indicated at the start, these opportunities include only those relevant to a least-cost energy system for the Yukon. The potential for developing Yukon energy resources for export is not included in the analysis. Also excluded are the spillover effects of an improved Yukon economy on the rest of Canada (which some analysts believe to be substantial).

The analysis will also be broadened in a second way by going beyond the strictly economic accounts to identify related social, cultural and environmental effects. In many cases, these effects will have economic dimensions, but it is rare that the full effect can be captured in dollar terms. In addition, social and environmental concerns typically exhibit mismatches between costs and benefits--in economic terms, market failures--because the individual or firm that, for example, dumps waste into a river will be different from the one that suffers from the damages created by the dumping. As indicated by the wide range of regulatory roles taken on by government, societies choose to act in many areas where the market is deemed inadequate or inappropriate. Similarly, governments act to promote greater equity. For example, although it might not be economically justified to support housing retrofit programs in smaller communities, a sense of equity might lead the government to offer such programs everywhere within its jurisdiction. Finally, a government can balance across different accounts. For example, retrofit housing programs in the energy sector might reduce payments required (as for income maintenance) in other sectors.

Thus, net development benefits--including macroeconomic, social, cultural and environmental effects--need to be added to private microeconomic considerations in assessing the energy management opportunities for the Yukon. This chapter will focus on these effects. Of course, the conceptual categories cannot be kept entirely separate. For example, a reduction in the differential energy costs between the Yukon and southern locations will be one factor in individual or business decisions about locating in the Yukon, and those decisions will have broader implications for development. However, neither the data nor the models available allow us to make quantitative links among these variables. The next three sections of the chapter cover, respectively, the nature and size of the macroeconomic, the social and cultural, and the environmental effects of the options noted above. The final section then presents an overall summary of their development potential.

For two reasons, the opportunities discussed in this section are more limited than those identified in Section 5. First, in order to focus on the major opportunities, consideration is restricted to those opportunities that showed significant remaining potential. Second, some opportunities that may have a significant potential are not discussed because of the absence of sufficient information by which to judge the extent of the potential market. For example, it is likely that waste oil could play a role in the Yukon energy economy, and that some tourist facilities could use solar water heating, but there is little indication as yet as to how much or how many.

6.2 MACROECONOMIC EFFECTS

There are important conceptual differences between individual and economy-wide savings. In particular, some economic gains (or losses) can be realized by the larger economy, but not be attributable to individual accounts. For example, if an individual home owner converts from an oil-fired to a wood-fired space heating system, he or she will compare conversion costs (a capital investment) with annual savings (an operating cost). However, with the purchase of a wood stove or furnace, more of that individual's energy dollar will remain within the Yukon economy than if he or she had continued to use imported oil.

The macroeconomic effects just described occur in two general ways. First, households in the Yukon would have some proportion of their disposable income that is now available for expenditures other than energy; similarly, firms will have a greater proportion of their surplus that can be spent on non-energy expenditures. Gains of this type will occur even if the energy management activity involves no expenditure at all, and itself stimulates no additional business activity in the Yukon. The extent of the gain depends on how consumers and businesses tend to use increments of unallocated income. If, at one extreme, money that had been spent on energy is now used to shop via a mail order catalogue from southern Canada, the gain will be negligible--indeed, the Yukon might even lose the small retailing margin that petroleum products provide now. If, on the other hand, the money is used to buy locally produced commodities, the gain will be substantial. Most cases will fall between these two.

Second, macroeconomic benefits will occur as Yukon businesses begin to supply products or services that are required to satisfy the new demands created by energy management. The supply of wood fuel is a good example. For the first round of spending, all of the money spent on wood fuel would circulate within the Yukon (and therefore stimulate further activity) compared with only a relatively small retailing and delivery component of the cost of the oil. For subsequent rounds of spending, the results depend upon the source of inputs to the preparation and delivery of wood fuel and upon how the suppliers of wood fuel spend their labour income. For that portion of their expenditures that go to wages and salaries, subsequent rounds will be similar to the first case and depend upon household expenditure patterns. The impact of other expenditures will depend on the Yukon share of the goods and services they buy.

Only with extreme examples (as with the catalogue shopping case cited above) can the macroeconomic benefits from improved energy management be negative. Even if households save the added money, or if businesses invest it in monetary instruments, there will be some benefit to the Yukon--unless again the entire savings or investment is sent to financial institutions in southern Canada. To the extent that these benefits occur, they reflect a "deepening" of the Yukon economy, as that term was used in the Socio-Economic Program Report.

With individual accounts, the information required for analysis may be difficult to obtain, but at least the nature of the data requirements is clear. With macroeconomc or social accounts, even defining the required information can be a problem. As owner of a stock of capital in buildings, vehicles etc, government starts with the same concerns as any individual owner and makes comparable calculations. Even these calculations will be more complex because of the differences between individual and institutional budgeting. Moreover, in many cases, including many residential units in the Yukon, the government plays the role of landlord with the usual problem of split incentives. However, none of these complications are as serious or far-reaching as those introduced by the government's concern for economic development and for the social and environmental effects of its decisions. The following partly overlapping considerations are suggested as the sorts of criteria that would be of interest when comparing with program costs:

- increased circulation of money within Yukon (import substitution)
- opportunities for business development
  - energy sector
  - other sectors
- infrastructure requirements/opportunities
- job creation
  - short term
  - continuing

- capital requirements
  - conventional energy supply
  - energy management
- security of energy supply
- reduced transfer payments (subsidies)

In many cases, the nature and even the importance of the considerations just listed will be specific to the individual opportunity or even to the program for realizing that opportunity (the nature of infrastructure, for example). Others are important but not subject to much quantitative analysis, as with enhanced security of supply. Still others are clearly important and determinable, but beyond the scope of ths study; reduced need for peaking capacity in the electrical system is a good example. However the macroeconomic benefits resulting from greater economic activity can be derived in a preliminary way from the work undertaken by Alaska Economics Inc. and the Department of Economic Development and Intergovernmental Affairs, YTG, for the Yukon River Basin Committee.*

The following section discusses the major Yukon energy management opportunities within the framework of assessing the macroeconomic effects. Because broader macroeconomic effects cannot be distinguished in such fine detail as

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* The main source of information used for the broad purposes of this report is the Socio-Economic Program Report prepared by the Socio-Economic Working Group of the Yukon River Basin Study (June 1984). Further information was obtained directly from Dr. David Reaume of Alaska Economics Inc. The report by Professor Jack Stabler "Development Planning North of 60" in The North (ed. M. Whittington, 1985) was used as a supplemental source. The input-output tables in the Socio-Economic Program Report were based on work developed by Stabler. However, certain of Stabler's results can be questioned. In particular, employment multipliers of 2.7 or more appear to be much too high and import leakage of 15% on consumption expenditure (and comparable for other sectors) appear to be too low. The figures of 2.0 for the former and 30% for the latter, as used in this report, were set after the conversation with Dr. Reaume. If anything, these results still overstate the employment multiplier and understate the import leakage.

microeconomic, the discussion here is under more aggregated categories than in Section 5:

- Building retrofit
- New energy-efficient building
- Transportation
- Wood fuel industry

No discussion appears on the macroeconomic effects of greater efficiency in the industrial sector (Section 5.7) or in electrical generation (Section 5.9) because these operatons vary so much from site to site that it is impossible to generalize about shifts in labour and income. On the other hand, the potential for use of wood as a heating fuel turns up as an energy opportunity in all sectors except transportation. Hence, it is convenient to define it as a separate topic for purposes of macroeconomic analysis.

6.2.1 Building Retrofit

What specific gains might be expected in the Yukon from building retrofit activities? While the published sectors in the input-output tables are too broad to distinguish energy management industries by themselves, a start can be made based on information for southern Canada which determined the effects of retrofitting existing houses (Brooks, 1978). In that study, employment gains were realized for both the production and the installation of insulation. In the Yukon only the latter would be included. On the other hand, allowance also had to be made for losses in the energy supply industries which can be neglected in the Yukon, apart from those houses already supplied with wood fuel. The Canadian results indicate that approximately 0.02 person-years of employment are produced on-site at each house to which retrofit measures are applied in quantities sufficient to cut energy use (assuming oil heating) by 60 GJ (30-40% reduction for an average Yukon residence). Therefore, to retrofit, say, 1000 houses to this level would yield approximately 20 person-years of employment directly, and, assuming an employment multiplier of around 2.0, another 20 person-years indirectly, for a total of 40 person-years.

The macroeconomic effects of energy retrofits would be still more extensive than shown in the last paragraph because this calculation does not allow for the respending in subsequent years of the money no longer needed for energy purchases. (For a cost-effective investment, such savings will by definition occur, though not necessarily in the first year.) If on average the investment in insulation yields a $800 saving (60 gigajoules per house at $13.50 per gigajoule--roughly 45¢/litre), we can assume that about 30% would be spent immediately for imported goods with no significant impact on the Yukon economy. The other 70% would be spent locally, but data available are not sufficient to determine the additional employment and income effects of this spending. For the sake of determining orders of magnitude, one could assume that this remaining $560,000 ($560 for each of 1,000 households) can be treated as an exogenous increase in disposable income, which then becomes comparable to the Special Stimulation 4 in the Socio-Economic Program Review. Income in the Yukon would be augmented by about 35% after two years to a total of about $750,000, and between five and seven additional jobs would be created.

Thus, the overall macroeconomic impact of 1,000 retrofits in the Yukon would be around 46 person-years of employment, from the following sources:

- 20 direct jobs
- 20 indirect jobs
- 6 induced jobs.

Further, assuming the savings of 60 GJ per house, and further assuming that 60% of these houses are heated by oil, fuel oil imports into the Yukon would be cut by about 1,000,000 litres per year.

Comparable employment creation data are not available for larger commercial and institutional building retrofits. However, given the generally greater scope for cost-effective energy savings in these buildings and their greater reliance on fuel oil for space heating (nearly 100%), fuel oil import savings would be correspondingly larger than for residential units.

6.2.2 New Energy-Efficient Buildings

The construction of more energy-efficient new buildings requires more materials and also more labour. It has been estimated that about three added person-days of on-site labour are required in each new single family home constructed in southern Canada to energy efficient standards, about one added job for every 80 new dwellings constructed to higher efficiency standards. Additional labour will be required in other stages of construction, and, if local materials can be used, the gains will be even larger. During the mid-1980s, some 110 to 120 building permits (unit permits only excluding improvements) were issued annually in the Yukon. By implication about 1-1/2 more jobs would have been created annually in construction had these houses been built to higher efficiency standards. Current plans call for some 1,000 new housing units to be constructed in the Yukon over the next three years--about half of them through a program at CYI--so the potential employment gains might total eight to ten jobs per year:

- 3.5 direct jobs
- 3.5 indirect obs
- 8 to 10 induced jobs

The estimate for the number of induced jobs is based on the assumption that the new construction is built to R-2000 standards, which effect an 80% improvement in energy efficiency for heating. Assuming further that funds would otherwise have been spent on fuel oil, the savings--and thus the increase in uncommitted disposable income--would be about $1 million (representing 2 million litres).

Of course, larger quantities of labour and comparably greater macro-economic benefits will be realized with commercial and institutional buildings. The number of permits issued for non-residential buildings has typically been nearly twice as large as for residential, so the potential for additional employment is significant.

The data presented in the preceding paragraph are of course only generally applicable to the Yukon. Nevertheless, they indicate the nature if not the full scale of the effects to be anticipated. Further investigation of typical bills of goods and services used in construction in the Yukon, in combination with the information in the Socio-Economic Program Report, would permit the generation of sound numbers to determine the macroeconomic potential from the construction of more energy-efficient buildings in the Yukon.

6.2.3 Transportation

It is possible to calculate potential energy and dollar savings to the individual or the firm from gradual conversion to a more efficient vehicle fleet (including private autos, trucks and mobile industrial equipment) in the Yukon. However, benefits to the Yukon economy are more difficult to determine, partly because there are few data on which to base estimates of macroeconomic effects in the transportation sector but also because of the complicated relationships that one finds between vehicle purchase and use, on one hand, and the provincial tax base and road construction costs, on the other. Putting taxes and road costs to one side, there would in fact be no immediate net benefit to the Yukon economy from the purchase of more efficient or down-sized vehicles. There might even be a small loss in retailing margins inasmuch as such vehicles cost less to purchase, but at the same time capital funds become available for other purchases that may have a greater impact on the Yukon territorial economy. Over the longer term, of course, benefits will be potentially much larger as savings from the lower fuel bills begin as soon as vehicle use begins. The size of the savings will be magnified by the usual multiplier relationship to the extent that the money saved from lower fuel bills is spent on goods and services with a larger Yukon component. Most fuels entail a very high import leakage, so a shift from energy to other commodities, even other imported commodities, benefits the local economy. However, as indicated above, because the actual import share of the dollar spent on motor fuel is substantially lowered by the role of provincial territorial taxes, any general benefits from shifting away from gasoline and diesel oil will also be lowered.

The one area where specific employment gains might be realized via energy managment in the transportation sector involves improved maintenance of both private and business vehicles. Maintenance expenditures have a high labour content, yet are of proven effectiveness for energy efficiency. A priori, it would seem that some additional jobs could be created in the Yukon if people and businesses were convinced of the importance of good tuning and upkeep of vehicles.

6.2.4 Wood Heating

A special macroeconomic opportunity is provided by the opportunity to expand the Yukon's wood fuel industry. The high proportion of labour in the inputs to the production of forest products is shown by the difference in multipliers for forest products with and without the expenditures of labour incomes included (1.85 vs 1.19 for the Yukon as a whole). On the other hand, neither output nor income multipliers for the industry are particularly high, which suggests that in other ways it is not well linked to the rest of the economy. Of course, these figures relate to the forest industry of 1978, and they may not be representative of a wood-fuel industry. Specific data on the inputs to the production and delivery of wood fuel in either unprocessed form (logs) or semi-processed form (chips) would have to be collected to determine the potential macroeconomic impacts of an enhanced role for the locally produced wood fuel in the Yukon. Ideally, the data would be collected in both physical units (hours of labour time, litres of gasoline) and value units (dollars of wage labour, cost of gasoline).

Some indication of the potential effects of a wood fuel industry can be obtained from data gathered for New Brunswick. In that province, feasibility studies have demonstrated that a profitable wood fuel industry can be operated alone or preferably in combination with pulpwood harvesting. The wood is processed into chips and trucked to markets. Environmental benefits are also captured because collection of the wood residues and felling of noncommercial species reduce costs for site preparation prior to reforestation. In some cases, areas that would not have been economical to cut at all were made profitable by the joint product approach to harvesting.

Macroeconomic benefits can be realized in several ways. For one thing, a typical operation provided about eleven jobs, though not all full time, for production of about 12,000 tonnes on an annual basis. (Actual demonstrations were carried out over an eight-month season.) Using the multiplier, a total of about 15 full-time equivalent jobs might be created by a similar operation in the Yukon--half on-site and half elsewhere in the Territory. Total costs were $29 per tonne. Assuming that 70% of the costs are represented by labour, the same analysis as in the simulation case used in the retrofitting example would suggest that some $20 would appear immediately in the Yukon economy per tonne of chips produced and eventually about $27 per tonne (1.35 times the wage bill).

Additional macroeconomic benefits would be derived from the displacement of fuel oil. Roughly, one tonne of wood fuel (bone dry basis) replaces 200 litres of light fuel oil equivalents. Further, to the extent that the market for the wood chips is found in institutional buildings--which achieve scale economies sufficient to justify the special equipment required--government budgets for fuel would also be reduced.

The above estimates are, of course, relevant to more mechanized fuelwood harvesting systems than are commonly found throughout the Yukon. However, if the case is carried forward for illustrative purposes, and it is assumed that about 10,000 tonnes of wood chips were produced annually (approximately equal to the difference between the recorded cordwood harvests in 1983 vs. 1985) then the following annual effects would be expected:

- 15 direct, indirect and induced jobs
- a reduction of about 2 million litres of imported fuel oil.

The wood harvesting systems employed generally throughout the Yukon are more labour intensive than for the example presented above. Thus, while fuel oil import impact would remain the same, it is expected that the labour impact would be significantly higher.

6.2.5 Macroeconomic Effects: Summary

Table 6.1 presents a summary of the macroeconomic effects to be anticipated from the energy management activities discussed above. As elsewhere in this section, no attempt is made to generalize about the effects of energy management activities for industry. In Table 6.1, the words "high", "moderate", and "low" are only meaningful for a single line at a time; one line cannot be compared to another. For example, high cost effectiveness indicates a payback of less than one year, and moderate a payback of one to five years. High job creation indicates the potential for 25 or more jobs, and low for five or less.

TABLE 6.1 (A)

SEMI-QUANTITATIVE COMPARISON
OF ECONOMIC EFFECTS OF
ENERGY MANAGEMENT OPPORTUNITIES

BUILDINGS

	Minor Retrofit of Existing	Major Retrofit of Existing	Energy-Efficient New
PRIVATE ACCOUNTS			
Cost Effectiveness	High	Moderate	High
Asset Improvement	Low	Moderate	Moderate
PUBLIC ACCOUNTS			
Recirculation of Income	High	Moderate	Moderate
Business Development	Opportunities to develop businesses specializing in energy-efficient building techniques, products and services.		
Infrastructure Requirements	Low	Standards, Guidelines and TT	Standards and TT
Job Creation			
• Short Term	High	High	Moderate
• Continuing	Low	Low	Moderate

TABLE 6.1 (A)
cont'd

	Minor Retrofit of Existing	**Major Retrofit of Existing**	**Energy-Efficient New**
Capital Requirements			
. Conventional Energy	Little effect	Significantly reduced requirements for new energy supply investments.	
. Energy Management	Low	Moderate	Low
Security of Supply	Overall effects positive in proportion to savings.		
Reduced Transfer Payments			

TABLE 6.1 (B)
SEMI-QUANTITATIVE COMPARISON
OF ECONOMIC EFFECTS OF
ENERGY MANAGEMENT OPPORTUNITIES

	WOOD FUEL INDUSTRY	TRANSPORTATION	
		Vehicle Selection	Vehicle O & M
PRIVATE ACCOUNTS			
Cost Effectiveness	Moderate	High	High
Asset Improvement	N/A	Low	Moderate
PUBLIC ACCOUNTS			
Recirculation of Income	High	Nil	Low
Business Develoment	High	Nil	Low
Infrastructure requirements	Standards and organization needed	Nil	Low
Job Creation			
• Short Term	High	Nil	Low
• Continuing	High	Nil	Low

TABLE 6.1 (B)
cont'd

	WOOD FUEL INDUSTRY	TRANSPORTATION Vehicle Selection	Vehicle O & M
Capital Requirements			
• Conventional Energy	Potential for significant reduction	No effect in Yukon	
• Energy Management	Moderate	Nil	Moderate
Security of Supply	Positive provided storage near point of use	Substantial improvement	
Reduced Transfer Payments			

Futher quantification of macroeconomic benefits depends upon better definition of targets and programs for energy management and upon the introduction of these programs into the existing models of the Yukon economy. It is not yet clear whether the definition of these models is sufficiently fine to distinguish energy managment activities from other sorts of economic activity. In the event that it is not, approximations could be made by looking at comparable sectors--just as forestry was used to represent a wood fuel industry in Section 6.2.4--or additional data could be gathered to permit further disaggregation of the sectors currently represented in the model. In some cases, as with building construction, the latter would be the preferable and relatively simple option.

6.3 SOCIAL AND CULTURAL EFFECTS

A wide variety of social and cultural effects can and are taken into account in the selection and development of government programs. Difficult though it is to be precise about cause-and-effect linkages in the social and cultural areas, governments have generally felt that it was their legitimate role to try to make adjustments in order to obtain conditions closer to those desired by the various communities and groups of people they represent.

What sorts of social and cultural considerations would be of concern to a government considering the energy management opportunities described above? While there are no doubt many ways to define those considerations, the following list illustrates perhaps the main areas of interest:

- required level of direct subsidies to individual families
- improved comfort and other living conditions
- preservation of viability and cultural characteristics of Yukon communities
- equality of opportunities among Yukon communities
- community health
- extent of fire hazards
- education, training and skills development

Th question of direct subsidies here is the other side of the coin of government expenditures. A gain in social conditions can be obtained to the extent that individual families whose energy costs currently need to be subsidized can move toward greater self-reliance. Energy conservation and the use of local sources work toward this end. Even if no reduction in the level of, say welfare payments results, the resulting expenditures would be less constrained and some additional benefit to the Yukon economy might result. Furthermore, comfort levels in their homes and other community buildings would be much improved.

The question of the viability and character of smaller Yukon communities is to some degree a function of their patterns of energy use. The energy management opportunities identified in this report can aid, in exactly the same ways as they aid an individual family but on a broader scale, to protect the economic base and enhance the quality of life in the community. Moreover, because they in effect transfer some part of the community economy from a monetary to a non-monetary basis (as, for example, from the purchase of fuel to a community-based retrofit effort and subsequent self-supply of wood fuel), a more traditional pattern of community organization may be sustained.

The situation with respect to both community health and to fire hazards could prove to be either a benefit or a cost depending upon how the programs are implemented. If poorly done, exterior and indoor air quality problems could arise (see Section 6.4), and, with the increase in wood heating, the number of residential fires could increase. However, there is no reason for any of these adverse effects to occur. Properly undertaken, the energy management opportunities should both improve community health and safety. As indicated above, comfort levels will increase by reducing drafts and sharp temperature variations within a structure from over-heated to under-heated portions. Air quality should improve with good air circulation and heat recuperation measures. Moreover, properly installed and well-maintained wood stoves and furnace heating systems do not constitute fire hazards. However, what is implicit in such suggestions is the need for community training and education in energy management, including both general concepts and specific techniques. Few of the benefits described in this (or the next) section can be realized without parallel efforts and sustained efforts in the educational area.

6.4 ENVIRONMENTAL EFFECTS

The environmental effects of least cost energy strategies must be addressed in two parts: those effects related to energy at the point of use, and those related to the energy supply system. For the most part, energy conservation measures that reduce the overall requirements for energy are fully consistent with reduced environmental impacts. For example, more energy efficient homes and heating systems can reduce current household consumption levels of cord wood by up to 70% as well as reduce wood stove emissions. Gains will also be realized from better tuned vehicles because of lower emissions.

On the other hand, increased levels of air tightness in retrofitted homes without attention being paid to ventilation can lead to indoor air quality concerns. The proper use of mechanical ventilation systems also require proper householder training. More important, the burning of wood fuel can contribute to local air pollution and thereby present a potential health hazard. The Riverdale area of Whitehorse, Yukon, has become a widely known case in point. The extent of air pollution in Whitehorse is influenced by:

- a valley topography which tends to create stable thermal inversions, trapping air at ground level, and preventing normal mixing and dispersion of the pollutants

- widespread use of old design, inefficient and oversized stoves resulting in very incomplete combustion and hence high pollution levels.

This situation obviously requires serious consideration; however, proper operation of modern, efficient wood combustion units can significantly reduce pollutant emissions.

One of the least environmentally damaging ways to obtain energy is to import it, but this option is exactly what causes economic problems for the Yukon. Also, transportation of energy is not free of environmental dangers. Of the options being considered for the Yukon, the only one that would seem to warrant significant environmental planning is wood harvesting. Proper wood management programs will have to be instituted if the levels of wood harvesting are significantly increased in the Yukon, and in particular if the wood fuel becomes a joint product of pulp or timber harvesting. Schaffer et al concluded not only that the environmental impacts of wood harvesting, including loss of wildlife habitat, soil erosion and depreciation of fish streams, could be largely mitigated by appropriate management and operating procedures but also that cutting of deciduous species and thinning could enhance saw timber values. Because Yukon forests tend to be understocked, intensive management could increase future forest productivity*

Of course, the nature of the environmental threat can only be judged in comparison with the alternative. None of the options for supplying energy is free from potential adverse effects. In a general sense, conservation is environmentally less damaging than energy use, and renewable sources are less damaging than nonrenewable ones. However, in the Yukon, most of the former would be local, whereas the latter would be imported, which may shift the balance somewhat.

* Shaffer et al, op cit, 1983.

6.5 SUMMARY: DEVELOPMENT BENEFITS

Clearly, there are macroeconomic benefits to be obtained by pursuing some of the energy management opportunities described in Section 5. Income and employment gains, both expanded via multiplier effects, will form the base of these benefits, but others not calculated here, such as reductions in peak power requirements and improved security of supply, have both economic and non-economic benefits that also deserve to be recognized.

Judging from the preliminary estimates contained in Section 6.2, the greatest macroeconomic gains will come from activities directed toward further improving the thermal integrity of existing and new buildings, and from further development of a stable, profitable wood fuel industry. Macroeconomic gains can certainly also be won from the other sectors analyzed and from improved energy efficiency in industry and in electrical generation. However, the immediate effects appear likely to be smaller. The most important effect may be a more subtle one: to improve the overall climate for business in the Yukon.

SECTION 7
SUMMARY AND NEXT STEPS

7.1 OVERVIEW

The analysis presented in the preceding sections has shown that, among the range of energy management opportunities available to the Yukon, those which offer the greatest potential to address energy as well as economic development goals can be grouped into two categories:

- continued improvement of the thermal performance of existing and new buildings

- further development of a Yukon fuel wood industry

7.1.1 Buildings

With respect to building energy performance (Category 1, above), the analysis has further shown both the existence of sub markets within each sector and the need to define distinct approaches to each. Consistent with the scope of this paper, the market assessments presented herein must be considered preliminary in nature. Thus, the confirmation/refinement of market assessments is an important next step in the program development process. More specifically, the following next steps are proposed:

- Select markets/sub markets for further investigation

- Confirm/refine the market assessments contained within this paper, through consultations with key players in each market/sub market

- Establish extent of services/supports available to each selected marekt/sub markets from other government agencies (eg. DIAND, EMR, CMHC etc.)

- Establish adequacy or gaps in existing support (if any) as provided by other agencies

- Define optimium YTG support level and method of approach for each selected in light of above findings.

Throughout the YTG's efforts in this area, the major goal should be the continued upgrading of its building stock. As the preceding analysis has shown, achievement of this goal will provide important energy, economic and social benefits to residents of the Yukon. One of the major "spin-offs" of past efforts to develop more energy efficient buildlings has been the development of construction practices which result in better quality buildings--not only in terms of energy efficiency, but also in terms of comfort, durability and reduced maintenance and operation costs. Although the perceived urgency of energy savings has recently declined somewhat among Yukon residents, the available evidence suggests that the emphasis on better quality buildings remains high.

Thus the opportunity to realize energy savings in the Yukon building stock also remains good, although future approaches will undoubtedly require that energy efficiency measures be integrated within other buildings quality areas.

7.1.2 Fuel Wood Industry

Wood already provides an important contribution to the Yukon economy and to the territory's energy supply. However, this paper (together with other previous studies) has shown that wood could potentially play an even larger role and thus further contribute to both Yukon energy and economic development goals. In the short term, two sectors/markets appear to be particularly important:

- The Institutional and large Commercial Sectors - Particularly in new facilities, it is proposed that a policy promoting the more widespread use of alternative wood heating systems be investigated

- The Residential Sector -- Continued consumer education and promotion of high efficiency wood combustion appliances should be pursued.

In the first (above) market, convenience of use and availability/-reliability of supply (wood-chips) represent significant bottlenecks. Although modern automatic systems can overcome many of the "convenience-of-use" concerns, the supply bottleneck remains and is often "circular" - ie. an automatic wood heating system could be considered if a reliable supply of wood chips was available and, its corollary, a wood chip supply system could be established if an adequate and assured local market existed. Thus in the institutional (and large commercial) sector, a major goal of the Yukon government should be to address this supply/demand bottleneck and to stimulate development of a wood chip supply capability.

Related next steps, therefore, include:

- Documentation of the Yukon's wood supply industry (actual and potential) by geographic area, as appropriate.

- Determine market potential through consultation with prospective institutional and large commercial wood users in order to identify and document conditions required for incorporation of wood heating systems. (eg. supply, convenience, return on investment etc.)

- Consultation with potential fuel wood (cord or chip) suppliers, in order to identify constraints and/or conditiong required for suppply.

- Identify supply/demand compatibility and prepare development strategy

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YUKON

Energy Management/Economic Development Opportunities

- Appendices -

APPENDIX A:

Estimation Methodology

APPENDIX A

Energy use figures for the year 1982 for the Yukon were developed from two principal sources: (1) Statistics Canada catalogue 57-003 (IV-1982), which provides basic energy use data by sector for the two territories summed: and (2) the expanded version of the territorial chapter prepared by R.A. Hodge and L. Ehrlich for the Friends of the Earth Soft Energy Study and published by the Yukon Conservation Society under the title Northern Energy (1983). The former report was used for control totals and the latter for allocation of sectoral energy use between the two territories and for the distribution of energy use within any sector among quality categories. In addition, significant elements of judgement were used to adjust for the differences in economic conditions between the original soft energy path study (which was based on 1978 data) and the conditions in 1982. In particular, the Yukon was living through a period of mine closures (including the largest single mine) and as a consequence has experienced some out-migration.

In more detail, the figures that appear in the text were prepared by the following steps:

1. Energy use for the two territories combined was distributed among the categories defined in 57-003. This permits distinction of commercial from government (institutional) activities and also of primary industries from maufacturing. Appropriate information is found in Table 13B on primary and secondary energy for the full year, under the section entitled "Energy Use - Final Demand".

2. Sectoral energy use data from 57-003 was adjusted to shift transportation activities shown within the commercial and government sectors to the transportation sector. Appropriate information is found in Table 13D on use of refined petroleum products for the full year.

3. Sectoral energy use was divided between the two territories in a preliminary way by the ratios of use in the soft path study.

4. The results of step 3 were adjusted to allow for lower population and reduced mining activity in the Yukon. Population figures were down by about 2,000 and residential energy use was adjusted proportionally. (Assistance in this adjustment was provided by earlier work done by Marbek on energy use in the Northwest Territories as part of an ENERDEMO study.) Mining dominates both the Yukon and the Northwest Territories industrial sectors. In 1978 mining accounted for 78% of Yukon industrial energy use or about 1,674 terajoules. Cyprus Anvil alone accounted for 80% of sectoral electricity use. To allow for the closure of mines, the preliminary industrial energy use figure (as developed in step 3) for the Yukon in 1982 was reduced by 1,300 terajoules. Figures for the Northwest Territories were adjusted in parallel to accord with the totals reported in Catalogue 57-003.

5. Based on information in the soft energy path study, sectoral energy use was distributed among quality categories (space and water heating, electricity-specific and liquid fuels). The category for liquid fuels is restricted to usage for vehicles and therefore applies only to the transporation sector and to the on-site use of mobile equipment in the industrial sector.

6. All other energy data that appear in the text tables were developed as simple ratios or percentage distributions.

APPENDIX B:

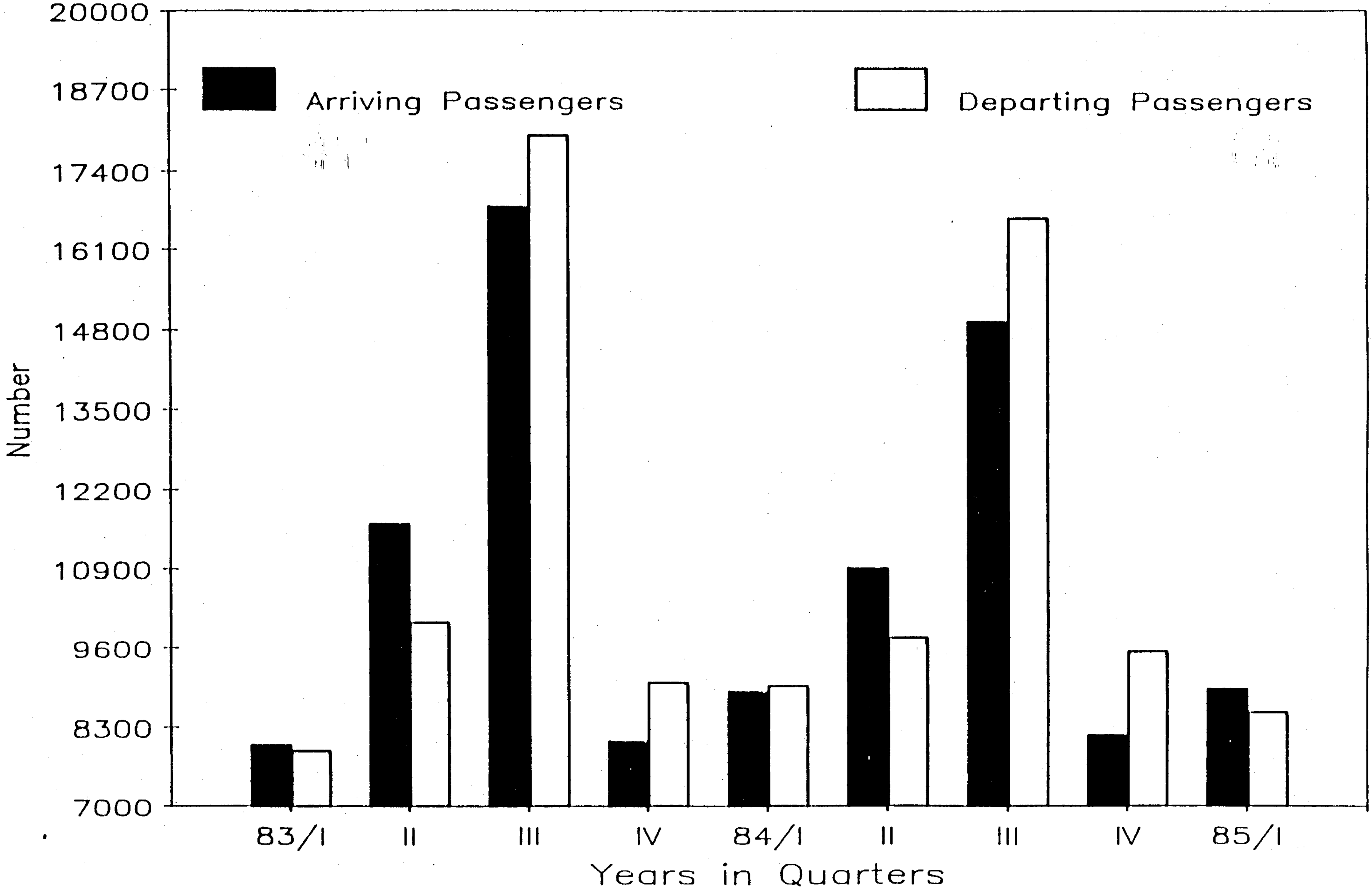
Yukon Aircraft Movement: 1979-1985

9.4 WHITEHORSE SCHEDULED AIR CARRIER TRAFFIC, CP and PWA

		Flights		Passengers		Mail		Cargo	
		arrive	depart	arrive	depart	arrive	depart	arrive	depart
		(no)				(000 kg)			
1985	I(p)	142	142	8,937	8,554	58	27	119	42
1984		738	741	42,980	44,962	262	128	771	424
	IV(p)	151	151	8,198	9,558	73	38	184	85
	III(p)	254	254	14,966	16,633	65	28	197	159
	II(p)	194	192	10,924	9,790	67	32	220	90
	I	139	144	8,892	8,981	57	30	170	90
1983		813	808	44,605	45,026	235	113	738	350
	IV	138	138	8,094	9,034	70	38	180	77
	III	359	349	16,825	18,004	56	23	244	162
	II	195	200	11,650	10,047	55	26	193	65
	I	121	121	8,036	7,941	54	26	121	46
1982		1,025	1,014	51,777	52,426	218	120	787	332
	IV	146	146	7,321	8,633	61	41	151	67
	III	391	385	19,068	20,606	49	24	209	118
	II	262	256	13,536	12,045	55	25	227	72
	I	226	227	11,852	11,142	53	30	200	75
81		1,597	1,593	79,120	80,881	243	138	1,415	638
80		1,478	1,511	73,301	74,850	220	130	1,172	570
79		1,526	1,528	69,476	71,746	221	136	1,073	593

Source: Statistics Canada, Catalogue #51-005
Note: the Passengers columns includes both revenue and non-revenue passengers

9.5 Whitehorse Air Carrier Passengers



Source: see table

9.6 AIRCRAFT MOVEMENTS, by Class & Type of Operation (June 1985)

		Domestic			International		Government		
	Total	Carrier	Comm.	Private	Comm.	Private*	Civil	Military	Local
					(no)				
Beaver Creek	72	–	8	31	2	25	6	–	–
Burwash Landing	132	–	53	52	–	27	–	–	–
Dawson	832	141	85	496	5	69	28	8	–
Faro	96	22	41	25	–	–	4	–	4
Mayo	264	83	131	50	–	–	–	–	–
Old Crow	211	68	85	18	–	2	2	2	34
Ross River	155	2	116	20	5	3	4	5	–
Teslin	111	–	8	67	2	2	–	4	28
Watson Lake	1,562	72	528	923	3	16	10	10	–
Whitehorse	5,844	348	1,357	1,203	148	369	56	67	2,296

Source: Aviation Statistics Centre, Statistics Canada
Note: Number of days during which flights are reported may vary slightly from month to month. *International Private aircraft movements includes some military.

9.7 AIRCRAFT MOVEMENTS, by Month

		Beaver Creek	Burwash Landing	Dawson	Faro	Mayo	Old Crow	Ross River	Teslin	Watson Lake	Whitehorse
						(no)					
1985	jun	72	144	914	96	272	211	155	111	1,678	5,866
	may	58	78	474	87	176	130	86	102	999	5,790
	apr	102	34	231	89	130	121	72	23	509	4,041
	mar	29	32	213	79	141	161	103	119	427	2,897
	feb	2	20	125	76	86	77	58	33	261	2,045
	jan	18	13	119	107	130	99	77	27	275	1,958
1984		858	1,231	6,630	2,690	2,981	1,203	3,639	1,209	13,210	40,026
	dec	24	18	104	73	100	115	135	24	282	1,462
	nov	36	30	141	96	62	73	186	115	297	1,592
	oct	32	64	329	91	248	-	160	86	629	1,558
	sep	59	92	733	149	382	12	387	97	1,269	3,853
	aug	142	310	1,286	321	409	192	1,668	207	2,284	5,052
	jul	144	300	1,442	702	518	177	307	164	2,400	6,382
	jun	208	194	1,272	552	421	212	229	164	2,690	3,616
	may	92	103	626	248	201	109	226	115	1,652	5,365
	apr	48	42	300	177	225	107	99	64	732	3,879
1983		..	1,473	6,569	1,082	4,207	1,167	2,243	1,260	11,482	38,755
82		..	657	6,338	2,256	4,189	1,084	..	1,185	16,474	46,347
81		..	1,265	8,070	3,785	8,825	1,326	..	1,225	19,314	74,513

Source: Aviation Statistics Centre, Statistics Canada
Note: Number of days during which flights are reported may vary slightly from month to month.

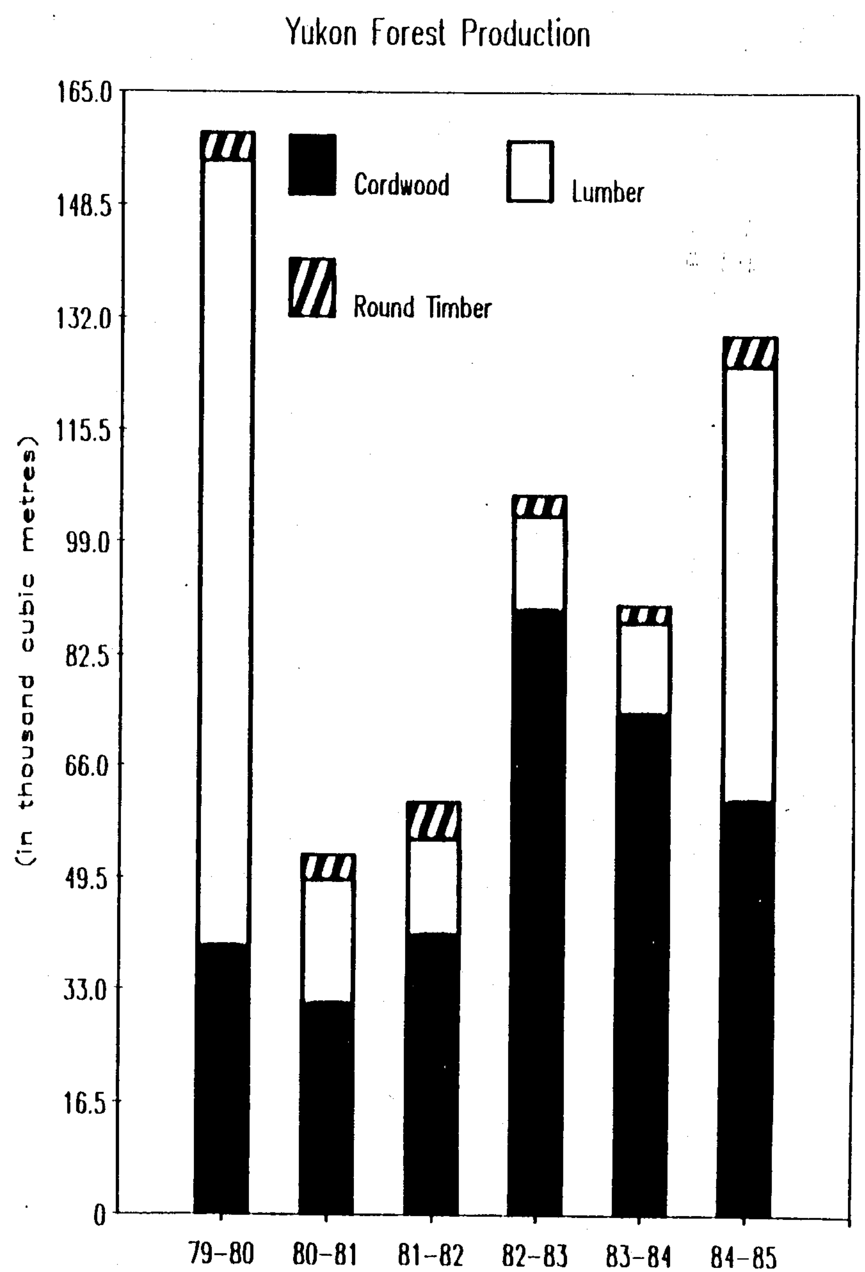
APPENDIX C:

Yukon Energy Supply Data

7.13 PRIMARY FOREST PRODUCTION

	Total	Round Timber	Cordwood	Lumber
		(000 m³)		
1984-85	129.8	4.6	61.0	64.2
83-84	90.1	2.5	74.2	13.4
82-83	106.2	3.1	89.3	13.8
81-82	60.9	5.4	41.2	14.2
80-81	53.1	3.7	31.0	18.4
79-80	159.2	4.0	39.5	115.6
78-79	113.2	4.2	28.9	80.0
77-78	117.8	3.0	21.8	92.9
76-77	75.3	2.9	25.3	47.1
75-76	98.3	2.4	26.0	69.9
74-75	100.9	11.0	23.2	66.6
73-74	105.7	9.1	19.2	77.5
72-73	59.5	3.2	18.6	37.7
71-72	49.8	5.1	17.9	26.7
70-71	49.1	4.9	13.2	30.9

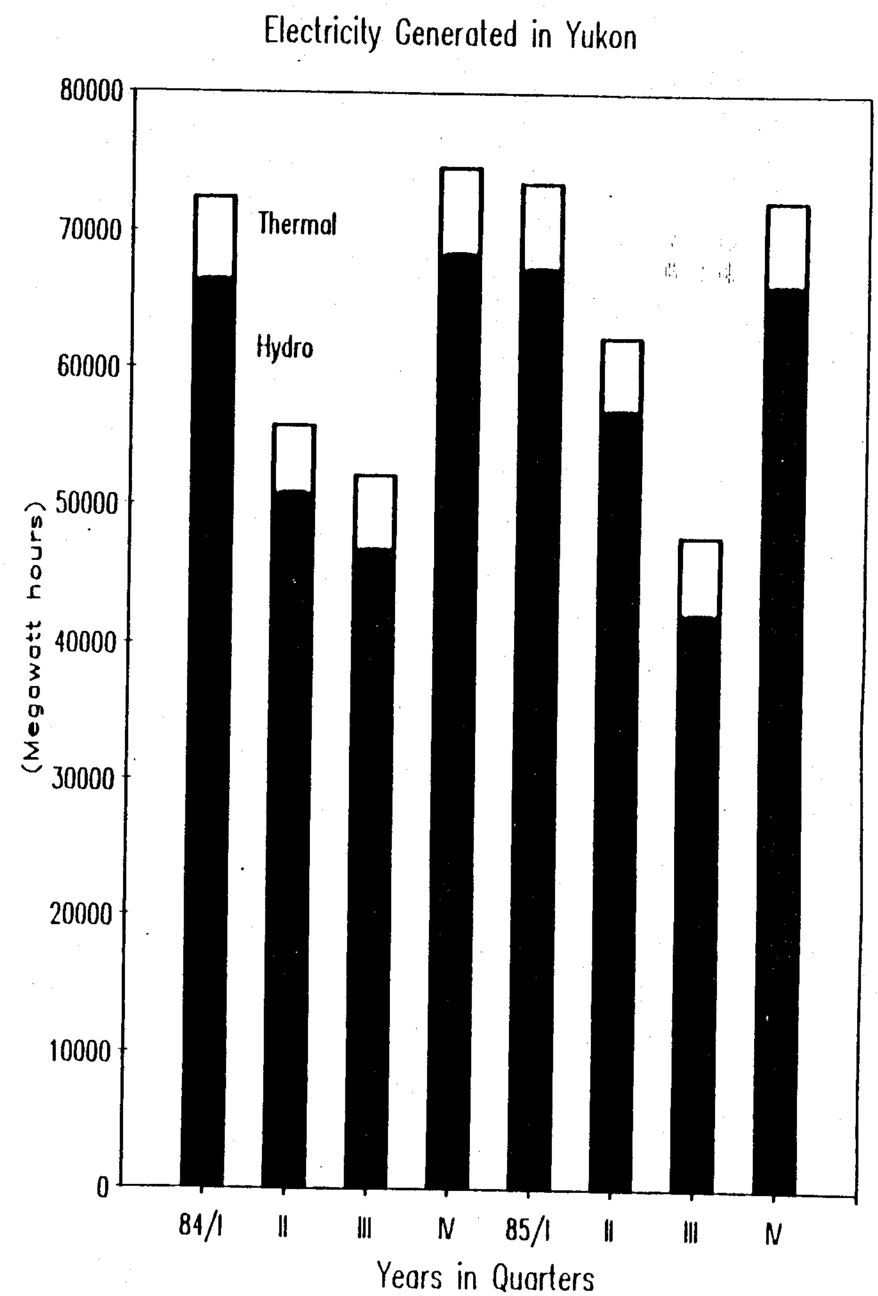
Source: Forest Resources, D.I.A.N.D.



7.14 ELECTRICITY GENERATED

	Total	Hydro	Thermal
		(MW.h)	
1985	256,509	232,985	23,524
IV	72,471	66,219	6,252
III	47,996	42,366	5,630
II	62,403	57,036	5,367
I	73,639	67,364	6,275
1984	255,449	232,659	22,790
IV	74,726	68,454	6,272
III	52,258	46,835	5,423
II	55,920	50,883	5,037
I	72,545	66,487	6,058
1983	242,828	221,022	21,806
IV	73,998	68,218	5,780
III	49,951	44,926	5,025
II	50,121	45,177	4,944
I	68,758	62,701	6,057
1982	345,819	269,179	76,641
81	393,547	290,045	103,502
80	384,373	321,658	62,715
79	353,434	317,305	36,129
78	368,966	323,521	45,445
77	367,092	324,281	42,811

Source: Statistics Canada, Catalogue #57-001



7.15 PETROLEUM PRODUCTS SALES

	Total	Aviation Gasoline	Motor Gasoline	Aviation Turbo Fuel	Stove Oil Kerosene	Diesel Fuel Oil	Light Fuel Oil	Lube Oils & Greases
				(m^3)				
1985	127,973	3,242	51,976	3,741	13,462	43,940	22,348	948
dec	9,834	60	2,835	189	1,881	1,845	2,975	47
nov	9,631	80	3,073	75	1,499	2,284	2,571	45
oct	10,854	128	3,974	217	1,201	3,562	1,703	66
sep	12,890	418	4,914	301	867	5,180	967	137
aug	16,659	579	6,967	558	739	6,549	1,117	147
jul	17,819	627	9,504	508	423	6,138	484	130
jun	11,826	516	5,427	390	601	3,947	846	97
may	10,572	262	4,270	529	639	3,213	1,543	110
apr	9,986	188	3,153	176	1,173	3,352	1,895	45
mar	9,556	190	2,444	292	1,267	2,965	2,349	45
feb	9,338	109	2,467	246	1,451	2,327	2,702	35
jan	10,834	85	2,948	260	1,721	2,578	3,196	44
1984(r)	147,297	3,852	51,123	4,201	12,815	50,998	23,195	1,065
dec	8,635	97	2,385	199	1,132	2,243	2,529	48
nov	12,471	213	3,294	152	1,788	3,712	3,236	74
oct	13,037	237	4,269	338	1,147	5,023	1,927	92
1983	137,921	3,790	48,673	3,898	19,157	30,131	30,663	1,025
82	181,933	4,348	46,809	7,185	35,762	28,748	57,424	1,622
81	205,357	4,864	53,684	8,415	34,309	38,073	63,468	2,245
80	192,452	3,583	49,146	6,616*	34,444	33,738	54,655	6,859

Source: Statistics Canada, Catalogue #45-004

Note: Total includes other fuel sales; *Kerosene type, not naphthalene.

7.17 PETROLEUM FUEL SALES

		Motor Gasoline	Aviation Gasoline	Aviation Turbo Fuel	Liquified Gases	Diesel Fuel	Other Fuel
				(000 litres)			
1985		56,015	3,494	3,464	5,420	48,793	32,576
	IV	10,901	397	365	1,519	8,320	10,013
	III	21,926	1,774	1,270	1,627	19,614	3,632
	II	14,232	899	1,037	1,058	12,081	5,903
	I	8,956	424	792	1,216	8,778	13,028
1984		55,823	3,735	4,211	4,406	54,884	34,743
	IV	11,055	480	713	1,489	11,920	12,115
	III	21,207	1,658	1,782	1,303	21,491	4,464
	II	15,318	1,189	1,005	1,117	14,030	5,041
	I	8,243	408	711	497	7,443	13,123
1983		54,487	3,748	3,982	4,981	45,350	34,535
	IV	11,020	427	509	1,102	9,828	13,627
	III	20,773	1,797	1,692	1,224	18,066	4,706
	II	13,976	1,048	1,171	608	11,267	2,259
	I	8,718	476	610	2,047	6,189	13,943
1982		54,717	4,137	6,620	6,356	65,233	48,979
81		59,836	6,426	9,374	4,216	98,949	48,808
80		60,846	6,157	9,330	2,519	78,119	52,907
79		55,365	3,438	9,644	2,461	58,728	56,103
78		58,053	3,807	11,144	1,969	64,350	65,982
77		56,306	3,323	9,533	2,029	56,734	64,511

Source: Yukon Department of Finance
Note: 'other' includes rail use and home heating oil; liquified gases--road use only.

YUKON

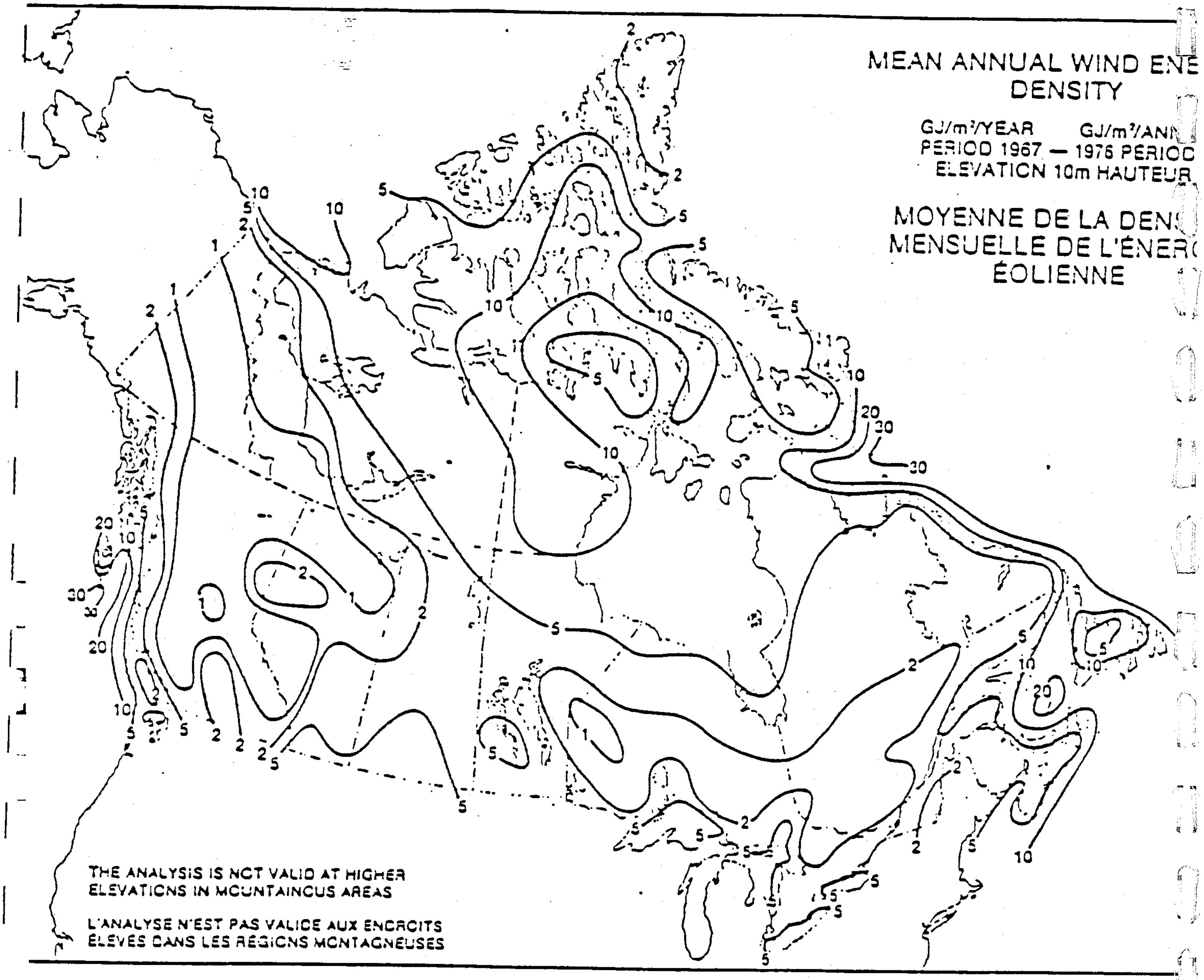
DESK STUDY OVERVIEW OF SMALL HYDRO SITE POTENTIAL

COMMUNITY	NO. HOUSEHOLDS	ANN. PRECIPITATION mm.	HYDRO SITE	GROSS HEAD m	DRAINAGE AREA km^2	MEAN Q m^3/s	PENSTOCK LENGTH m	PENSTOCK DIAM. mm	TRANSMISSION LENGTH km	SITE CAPACITY kW	REQ'D CAPACITY kW	ENERGY AVAILABLE MWh/YR	ENERGY REQ'D MWh/YR	C.C. HYDRO PLANT ($1000's)	P.V. OIL DISPLACED ($1000's)	RANK	REMARKS
Beaver Creek	40	442	-	-	-	-	-	-	-	-	400	-	2,000	-	1,390	N	No apparent site available
Old Crow	65	205	-	-	-	-	-	-	-	-	650	-	3,300	-	2,260	N	Land relief - very flat - no sites available
Burwash-Destruction	50	328	Halfbreed Cr.	122	50	44	2,600	533	17	650	500	3,400	2,500	2,600	1,740	P)	Moderately promising. Long penstock indicated
Destruction (only)	20	"	Duchs Cr.	103	28	.25	2,600	406	5	550	200	2,900	1,000	2,200	650	P)	
Teslin	95	331	Canyon Cr.	152	150	1.31	8,000	914	32	2,300	1,000	12,000	4,800	9,200	3,300	P)	Very long penstock required. Potential sites on Wolf Cr. and Morley R. not investigated
"	"	"	Strawberry Cr.	160	90	.78	3,800	685	26	1,400	"	7,600	"	5,600	"	P+)	
Johnson Crossing	10	300	-	-	-	-	-	-	-	-	100	-	500	-	350	N	No sites other than previously identified Squanga Creek apparent
Pelly Crossing	45	300	Ptarmigan Cr.	103	50	.40	7,000	560	17	860	450	4,500	2,300	3,400	1,560	P-	Long penstock indicated
Stewart Crossing	10	325	-	-	-	-	-	-	-	-	100	-	-	-	350	N	Not sufficient map detail
Watson Lake	285	420	Allen Creek	90	260	3.0	6,000	1,420	85	3,330	2,900	17,500	14,200	13,300	9,900	P-	Long Transmission. Not very promising
"	"	"	Hyland River	60	700	8.2	9,000	2,290	75	6,000	"	31,600	"	24,000	"	P	Very long penstock indicated
"	"	410	Frances River	207	12,800	145	-	-	40	50,000	"	200,000	"	152,000	"	P+	Large Scale Development indicated. Too large for community alone

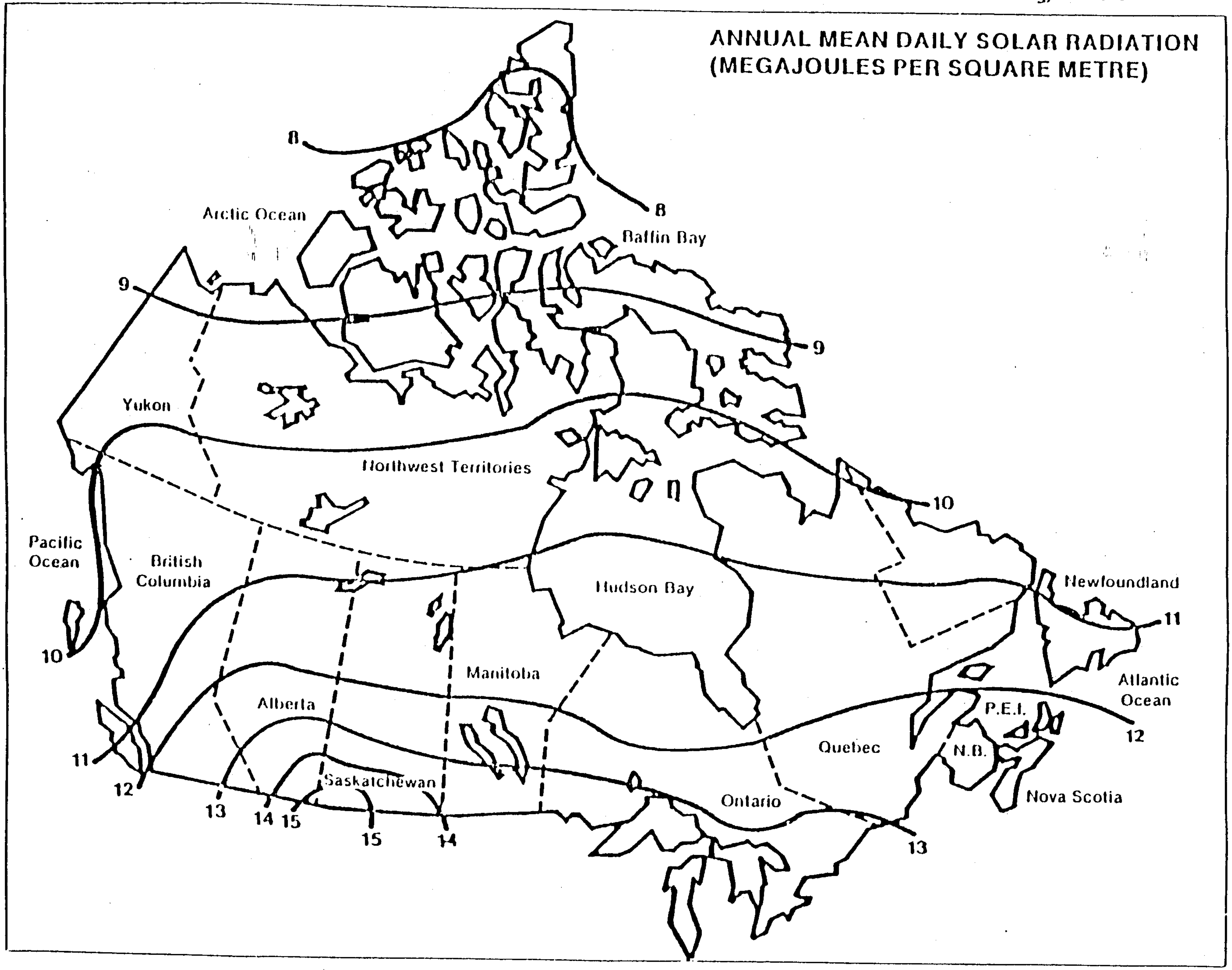
Legend:
P = Promising
N = Not promising
Q = Annual Mean Flow
C.C. = Capital Cost
P.V. = Present Value

SOURCE: Yukon Overview Study

WIND



Source: Robert J. Morris (1985) Environment Canada, Canadian Climatic Centre Atmospheric Environment Services. 4905 Dufferin Street, Downsview, Ontario, M3H 5T4


ANNUAL MEAN DAILY SOLAR RADIATION
(MEGAJOULES PER SQUARE METRE)
Arctic Ocean
Baffin Bay
Yukon
Northwest Territories
Pacific Ocean
British Columbia
Hudson Bay
Newfoundland
Manitoba
Alberta
Saskatchewan
Ontario
Quebec
P.E.I.
N.B.
Nova Scotia
Atlantic Ocean
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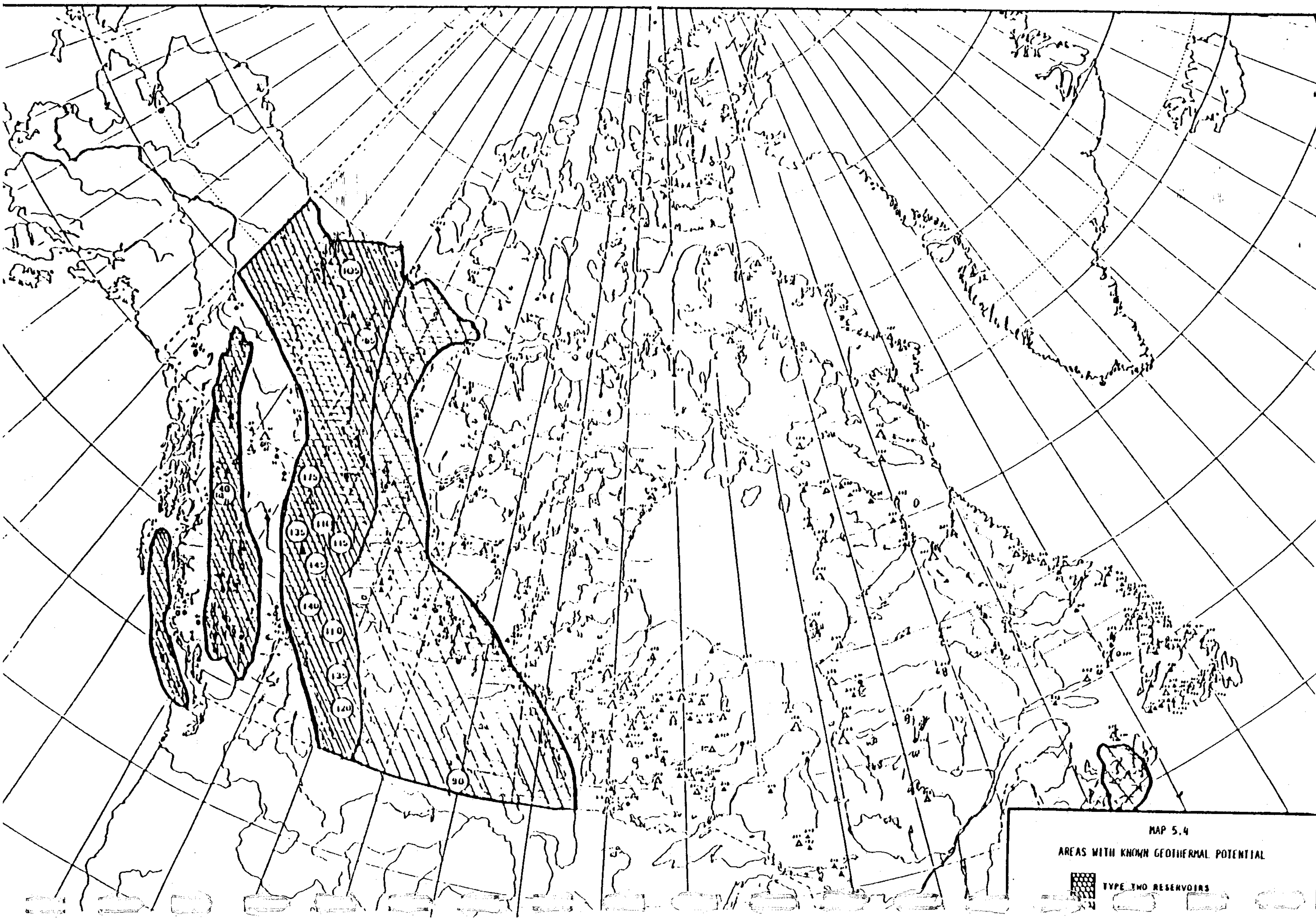
Source: Victor and Burrell.



APPENDIX D:

Selected Case Examples

Skookum Jim Friendship Centre

Technology:
- Training
- Building retrofit and renovation

Demonstration Project Manager:
Stan Boychuk
Skookum Jim Friendship Centre
3159-3rd Avenue
Whitehorse, Yukon
Y1A 1G1

Location:
Whitehorse, Yukon

Annual Savings:
- almost 75% per unit volume for the Centre
- average 40% for building retrofits

Payback Period: Not applicable

Applicable to:
- Native communities
- Remote communities

Description:

The combination of planning foresight and energy-efficient building technologies has paid off handsomely for Whitehorse's Skookum Jim Friendship Centre and eight Yukon native communities. By 1983 the twenty-two year old native centre was experiencing serious operational constraints due to extremely high energy costs and a general need to expand and upgrade its facilities. At the same time, similar concerns — high energy costs and a need for building upgrading — were being expressed throughout all of the Yukon's remote native communities. Consequently, the Skookum Jim Friendship Centre chose to address both its own immediate needs and those of other Yukon remote native communities in this one project.

The project was conducted in two phases. Phase I of the project stressed proper energy conservation construction techniques. This 3-month segment of the project consisted of both formal classroom training as well as practical "hands-on" experience — by actually retrofitting and renovating the Skookum Jim Friendship Centre.

In Phase II, the newly acquired energy conservation skills of the 10 carpenter trainees were put into practice in each of the 8 participating communities. This Phase of the project served to both demonstrate building retrofit techniques in each community and to provide on-site project management experience for each of the trainees.

Installing fibreglass insulation during a total retrofit in Mayo, Yukon

ENERCPTICNS provides you with the results of successful technologies and techniques demonstrated under the Conservation and Renewable Energy Demonstration Agreements (CREDA) Program. ENERCPTICNS is funded by the energy departments of Canada, New Brunswick, Newfoundland, Manitoba, The Northwest Territories, and The Yukon.

As a result of the project:

- The Skookum Jim Friendship Centre now has a completely renovated, energy-efficient facility which is twice as large as the original facility but costs only half as much to heat;
- More than 40 building energy retrofits and 2 new ene efficient homes have been completed within the participating communities; and
- Each of the 8 participating native communities now h trained Band member to assist them in future energy efficiency improvements to their community buildings.

Benefits:

The project has resulted in substantial direct energy savings and is considered to be an excellent model for energy retrofit training programs in other remote native communities. The specific benefits are:

- The new Centre offers an improved facility for its continuing programs and services. The size of the building has been increased from 850 m³ (30,000 ft³) to 1,713 m³ (60,500 ft³), yet annual heating costs for the new larger facility are about 50% less than for the original smaller facility;
- Average annual energy savings of about 40% are expecte in each of the more than 40 homes retrofitted within th participating communities;
- The 10 carpenter trainees have received extensive prac cal experience in energy-efficient construction techniques which will be directly applicable to constructi activity within their respective communities; and
- The formal classroom training has resulted in the develo ment of curriculum material which will be useful for related future projects.

Performance:

The retrofit training program proceeded as expected and has met its major objectives — improved Centre facilities, participant skills training and improved Band housing.

At the conclusion of the training program, each participant successfully completed a certification exam.

The previous heating costs for the old Centre were abo $10,600 annually. The renovated Centre, with double th volume, had an annual heating bill of about $5,000 for 198 As Phase II of the project was just completed in early 19 performance data for the Band housing retrofits are not available.

Technical Details:

Phase I of the retrofit training program commenced in June 1983. The ten carpenter trainees were selected by the Skookum Jim Friendship Centre in conjunction with local Band councils.

The formal classroom portion of the training program was based on modified curriculum material, originally developed by the Advanced Education Branch of the Yukon Department of Education. The material covered all aspects of energy retrofit as well as low-energy building design and construction techniques.

Practical experience was gained under the supervision of a journeyman carpenter and a site foreman. The actual construction work required on the Centre involved both the retrofit of the existing facility and the addition of a second storey. Consequently, it afforced a practical demonstration of both energy retrofit and new, energy-efficient construction techniques.

Throughout Phase I, emphasis was placed on techniques which were most cost-effective and appropriate for remote communities. For example, in the retrofit of the existing facility:

- Disassembly techniques were demonstrated and the importance of salvaging as a method of reducing materials costs was emphasized;
- A Curtain Wall system was used to retrofit the main floor walls of the original building to an insulation level of RSI 7.7 (R 44);
- The concrete basement walls were insulated on the exterior with RSI 1.8 (R 10) of styrofoam to the footings and double that amount for the top 61 cm (24 in);
- When examples of moisture damage were discovered in the old building, they were used to emphasize proper air and moisture management techniques.

Similarly, during the new construction phase:

- "Double stud-walls" were used on the second storey to gain additional space and allow for RSI 7.7 (R 44) insulation;
- Ten mil polyethylene was used for an air-vapour barrie due to its greater puncture resistance, and proper seali techniques were demonstrated with particular empha given to sealing techniques around doors, windows, plumbing stacks and electrical penetrations;
- A lumber and plywood beam was used as an alternative to dimensional lumber; these can be fabricated in a remote community and are less expensive than long-span, wide-dimension lumber joists;
- Despite the availability of prefabricated trusses, site-bui lumber-plywood roof trusses were used as they are th most practical option in remote communities; these featured "high heels" to accommodate RSI 10.6 (R 60) insulation levels all the way to the edge of the wall;
- New vestibules were built at either end of the building provide buffer zones as people entered during cold weather and to accommodate new stairwells from the basement to the second storey. The vestibules were balloon-framed and insulated to RSI 3.5 (R 20);
- Preserved wood foundations were used for the construction of the new vestibules in order to give the crew experience with a method of basement construction which is less expensive and more appropriate in remo communities. They were insulated to RSI 3.5 (R 20) below grade;
- A cathedral ceiling was constructed on the north vesti bule using a modified plywood and lumber beam syst which allowed for RSI 10.6 (R 60) insulation;
- Window openings were relocated and strengthened to accommodate the new triple-glazed windows;

- Tyvek was used in place of conventional exterior sheathing;
- The HVAC system consists of two air-to-air heat exchangers interconnected to achieve variable volume air recycling with electric resistance duct heaters to provide zoned temperature control.

Phase II of the project commenced in May of 1984 and was completed on March 31, 1985. This Phase involved 4 weeks of intensive retrofit activities in each of the 3 participating communities. Delivery of this project in each community was as follows:

- Several weeks prior to the commencement of activities, the community trainee and one of the course instructors conducted a detailed assessment of all Band-owned houses and prepared a retrofit/renovation plan for each house;
- Based on the individual house assessments, the trainee and instructor prepared a proposed work plan for review and approval by the Band Council. In order to maximize local training and technology transfer objectives, several different levels and types of retrofits were included in each work plan. The actual number of homes to be retrofitted in the 4 week period was determined by the level of retrofits and by the number of local carpenters (in addition to the 10 project trainees and 2 instructors) that the Band Council was able and willing to dedicate to the project. Consequently, the actual number of homes retrofitted in each 4 week period varied from a low of 3 major retrofits to as many as 18 major, medium and low level retrofits;
- In each case, the local trainee assumed the role of project manager and was responsible for all site requirements (e.g., materials procurement, timetable, etc.);
- Approximately 2-3 weeks after the initial site visit, the crew of 10 trainees, 2 instructors and the local carpenters chosen for the task began the intensive 4 week period of work.

This procedure was repeated in each of the 3 communities and in each case the roles of project manager, site foreman, crew boss, etc. were rotated among the trainees. At the completion of the project, each of the trainees returned to their community, where, in many cases, they assumed the role of local Housing Coordinator.

Economic Analysis:

The major objective of this project was technology transfer to the 3 participating remote native communities through skills training and demonstration. Consequently, a substantial portion of both direct and indirect project costs was incurred in meeting this primary objective. The consensus among all parties involved in this project is that this primary objective has been effectively met. Therefore, a conventional economic analysis of only the project's actual retrofit activities would be inappropriate and would seriously undervalue the project's achievements.

Nonetheless, consideration of the project's total costs versus actual and projected energy savings shows very favourable economic returns. Specifically:

- The total cost of Phase I, including the development and presentation of the formal training sessions and supportive audio-visual and written materials as well as all materials and labour for the renovation of the Skookum Jim Friendship Centre, was $\$355,000$. This cost is approximately equal to $\$710/m^2$ ($\$66/ft^2$) for the new facility and compares with a prevailing northern construction cost of about $\$775/m^2$ ($\$72/ft^2$) for a similar facility, constructed to conventional energy standards under normal contracting arrangements. Hence, despite the inclusion of an extensive training component, the new Centre was actually built below market cost. This cost savings resulted from:
  - — the Centre assuming the role of general contractor
  - — extensive use of salvaged materials
  - — labour rates paid to the trainees which were below market rates normally charged by general contractors.
- The total cost of Phase II was $\$253,000$. Approximately 40 native buildings received retrofit measures and 2 new energy-efficient buildings were constructed. Energy savings were from 20 to 60%, with an average savings of 40%.

Availability:

The building materials used are readily available in most of Canada; although, in remote communities, availability of some materials may be restricted and hence alternative techniques may be necessary.

ARCTECH Community Energy Research Associates, a local Whitehorse energy conservation firm, assisted in the building design, presented the formal classroom training and assisted in the delivery of the community retrofits.

Further Information:

Further information and a copy of the final project report are available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Audio-visual and curriculum material developed for the program are available from:

- Stan Boychuk
  (re: ENEROPTIONS)
  Skookum Jim Friendship Centre
  3159-3rd Avenue
  Whitehorse, Yukon
  Y1A 1G1
  (403) 668-4465

DATE: March 1985

DOCUMENTATION OF NON-RCDP PROJECTS

PART A REFERENCE

1. Project Name:	Oxford House Waste Heat Recovery
2. Technology:	Diesel waste heat recovery
3. Location:	Oxford House, Manitoba
4. Status:	Operation commenced in September, 1981.
5. Project Manager and/or Contractor:	Sanson Yee, DIAND, Winnipeg, (403) 949-2842
6. Agencies/Programs Involved and Role:	DIAND; Manitoba Hydro
7. Information Sources:	Conversation with Sanson Yee (as above); Review of RCDP Overview Study - Oxford House.
8. Project Report:	None

PART B DESCRIPTION

1. Project Summary:

Oxford House is a remote Native community (population 1250) located in North-Central Manitoba. Community power is diesel generated (2 x 350 kw) and is supplied by Manitoba Hydro. The power plant is, by chance, located within 200-300 feet of the community school.

The DIAND operated community school complex is about 15 years old and consists of: the main school building (2886m^2 or about 31,000 ft^2); a detached classroom (224m^2 or about 2400 ft^2); and 8 teacherage buildings - 1 sixplex, 1 triplex, 1 two-storey duplex, 2 single houses and 3 trailers (1014m^2 or about 11,000 ft^2). Prior to the installation of the waste heat recovery system, all of the buildings were oil heated by individual heating systems.

During a site visit in 1980, Sonson Yee, DIAND's Co-ordinator of the Engineering and Architect Group in Winnipeg, noted the favourable siting of the school facilities vis-a-vis heat recovery from the existing community diesel power plant. He subsequently pursued this opportunity with Manitoba Hydro who also supported the idea.

In the summer of 1981, a waste heat recovery system (jacket water only) was installed on the diesel sets and connected, in parallel, to the school's hot water heating system. The school's original oil-fired hot water boilers have been retained for back-up. A heat sensor, installed in the supply water line, automatically activates the back-up oil system if the temperature of the supply water from from the diesel falls below 167°F. To date, the waste heat recovery system has provided almost 100% of the school's space and domestic hot water heating requirements. DIAND records indicate that the school boilers have operated a total of 18 hours since 1981.

DIAND and Manitoba Hydro have been monitoring the temperature of both the outlet water and the return water. The average outlet and return temperatures are respectively 189°F and 177°F. This means that the school is, on average, using only a portion of the waste heat available from the system. Consequently, consideration is being given to extending the heating system to additional buildings within the school complex. This will, however, require a longer distribution distance of about 800 ft. No commitment to extend the system has yet been made.

2. Technical Performance

2.1 Installation:

Installation proceeded smoothly and was completed within a 2 week period in July of 1981. Manitoba Hydro carried out the installation of modifications to the diesel power plant and the remaining system components were installed via normal contract tendering.

2.2 Operation:

The system has operated without any problems since commissioning.

2.3 Maintenance: The system has reduced DIAND's normal heating system maintenance requirements as the oil boilers rarely operate. Under special arrangements with Manitoba Hydro, DIAND pays 1¢/kWh of heat used up to an annual ceiling fee of $10,000. This fee compensates Manitoba Hydro for their capital investment (see 4.1 below) and, in addition Manitoba Hydro has accepted full responsibility for maintaining the system up to the point where distribution piping actually enters the school.

2.4 Performance Data: n/a

3. Energy Benefits: The current system is displacing approximately 200,000 litres of fuel oil annually. Further fuel oil savings will be realized if the system is extended to other DIAND buildings.

4. Economic Performance

4.1 Capital Cost (Energy Portion Only): The total cost (capital and installation) in 1981 was $119,000. DIAND contributed $97,000 and Manitoba Hydro paid the balance of $22,000.

4.2 Installation Cost (Energy Portion Only): (in above)

4.3 Annual Savings: Based on 1981 fuel oil prices, DIAND saved approximately $26,000 in the first five months of the system's operation. 1982 savings were estimated to be about $55,000.

4.4 Simple Payback: The simple payback period for the system is estimated, by DIAND, to be about 2 years.

4.5 New Local Employment: none

4.6 Local Economic Impact: None directly, but DIAND's annual operating savings (of $55,000 1982 dollars) could be used to provide local benefit at no net cost to DIAND.

4.7 Environmental/Social Impacts: Minor benefit -- less environmental damage from oil spills associated with fuel oil delivery.

Lac La Martre School Waste Heat Recovery

Technology:
Waste heat recovery from diesel generator

Demonstration Project Manager:
Mr. Dana Ferguson
Ferguson, Simek, Clark Ltd.
Box 1777
Yellowknife, N.W.T.
X1A 2P4

Location: Lac La Martre, N.W.T.

Annual Savings: $26,485
99% of oil consumption without heat recovery

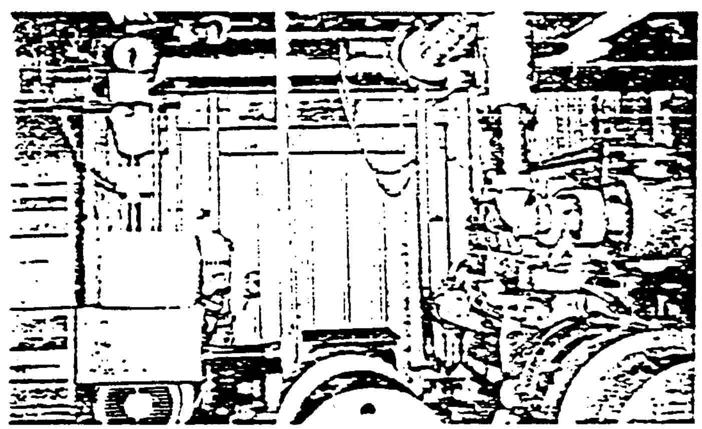
Payback Period: 9 years

Applicable to:
Remote communities served by diesel power plants and having suitable space heating/domestic hot water loads.

Description:

A school in a remote N.W.T. community is heated by waste heat from a diesel generator. In the summer of 1981, a new community school of 1,800 square metres (19,380 sq. ft.) was built at Lac La Martre, 164 km. northwest of Yellowknife. The new school incorporated many new energy conservation features and was situated 100 metres from an existing Northern Canada Power Commission (NCPC) diesel power plant.

A system to recover waste heat from the jacket water and exhaust was designed and installed on the existing NCPC diesel power plant. The waste heat is now transferred to the adjacent school where it provides space and domestic water heating. This process effectively reduces the school's boiler operation to a minimum, without affecting the NCPC plant production.



Benefits:

A number of benefits are realized through recovering waste heat from the generator's jacket water and exhaust. These benefits include:

- The waste heat recovery system provides almost 100% of the school's space and water heating requirements.
- The exhaust recovery unit cuts noise transfer from the generator so that it is now almost inaudible when standing outside the NCPC enclosure.

Performance:

The design and installation of the heat recovery system proceeded as expected, without encountering major problems. The system's performance has slightly exceeded expectations and no maintenance problems have been encountered.

After one complete heating season (1982-83), the project is considered to be very successful by all parties involved — the community, NCPC, maintenance staff, and the Government of the Northwest Territories (GNWT).

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It was found that the NCPC load and the school's heat requirements are in phase. The actual quantity of heat supply and demand are well matched, particularly in the crucial winter months. It was determined that for each 1 kW of generator electrical output, 1.32 kW of recoverable waste heat is produced.

NCPC reported no operational or maintenance problems with the heat recovery system. NCPC indicated that the generators' engine temperature was being maintained at a satisfactory 80° C (176° F) with flue gas temperature fairly steady at 210° C (410° F).

The community and GNWT are similarly pleased wit resulting savings in the school's fuel oil requirement Actual consumption for the first year of operation wa litres.

This represents an annual fuel oil savings of about 4 litres from the projected consumption — a 99% savin

Problems encountered in the second year of operati been attributed to a lack of trained and motivated sta routine maintenance on the distribution system.

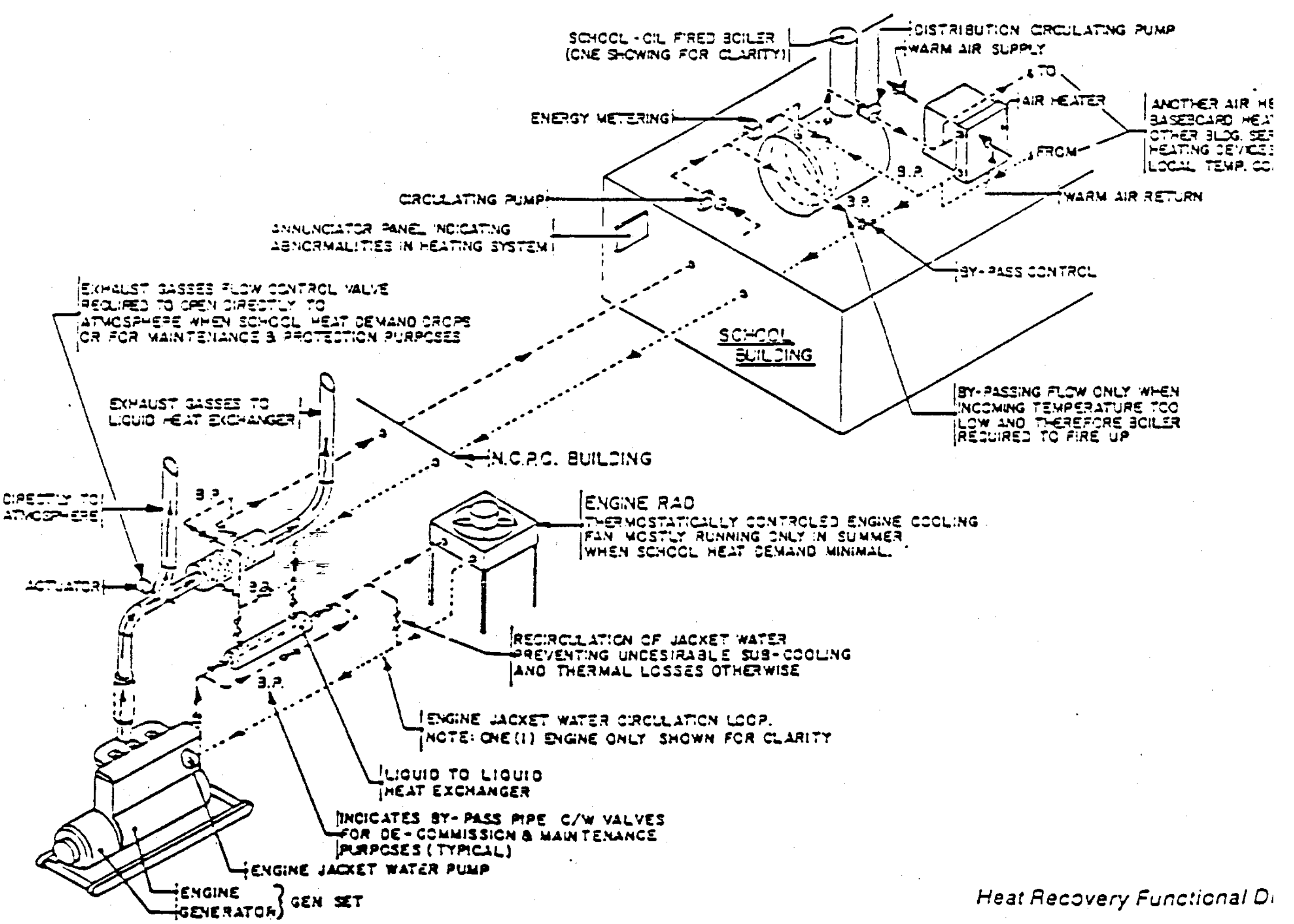
Technical Details:

Three NCPC generators provide the total community power supply. Two of these units — a Caterpillar 3406 with a 281.25 kVa generator and a Caterpillar D-342 with a "Kato" 187.5 kVa generator — are connected to the heat recovery system. Below is a functional diagram of the installed system.

Due to the size of the projected heating load and the plant's output capacity, waste heat is recovered from both the generators' jacket water and exhaust flue gas via installed heat exchangers shown in the functional diagram. When the generator output exceeds the school's load requirement, jacket water heat is rejected via the remote engine radiator which is equipped with a thermostatically controlled cooling fan. A control valve directs the flue gas to the atmos via a conventional muffler when exhaust heat recove required.

The heating system is filled with a pre-mixed solutio propylene glycol and 50% water. The diesel waste he transferred to the school using 63 mm schedule 40 w steel pipes. The pipes are insulated with 38 mm thick ethylene insulation wrapped in a 45 mil polythylene b jacket.

The insulated pipe was installed at a depth of .6 m. Sc not thaw-stable in permafrost, consequently, timber s were used extending beyond the influence of the tha created by the pipes.



Heat Recovery Functional Di

The school heating system was designed to be completely self contained. It consists of: two oil-fired boilers, each with a rated output of 159 kW; perimeter baseboard heating; and two ventilation systems supplying tempered outside air as required. The domestic ~~hot~~ water is also supplied by the diesel waste heat, with ~~cold~~ water being circulated through tankless heat ~~exchangers and~~ stored in insulated tanks. An electric heater was installed as emergency backup only.

The school heating system was designed to operate at 62° C (144° F) which would normally be supplied from the NCPC recovery lines. The hot water passes in series from the NCPC recovery lines through the boilers, which will bring the water up to 62° C (144° F), if necessary. An operating aquastat controls the boilers when NCPC cannot supply enough heat.

If the NCPC water supply temperature falls below 49° C (120° F), the heat recovery line aquastat modulates a 3-way valve to recirculate the water back to NCPC rather than through the school heating system. A thermostat installed on the heating water supply line will initiate an alarm if the temperature drops below 43° C (109° F).

Separate circulating pumps for the school heating system and for transferring the hot water between the school and NCPC building are both located in the school boiler room.

Economic Analysis:

1. Capital and Installation Costs: $239,000

2. Cost of Heating School:

	Without Heat Recovery (estimated)		With Heat Recovery (actual)	
• Fuel oil (@ $0.58/L)	50,150 L =	$29,087	370 L =	$ 215
• Boiler electrical and oil transfer pumps (@ $0.573/kWh)	745 kWh =	427	6 kWh =	3
• Recirculating pump (@ $0.573/kWh)	none		4,906 kWh =	2,811
		$29,514		$3,029

Net Savings = $26,485

3. Simple Payback Period: 9 years

Availability:

Ferguson, Simek, Clark Ltd. of Yellowknife, N.W.T. designed and supervised installation of the heating system.

NCPC personnel carried out all modifications to the power plant equipment. Similar consulting services and equipment are generally available across Canada.

Further Information:

Further information and a copy of the final technical report are available from:

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  YK Centre, 5th Floor
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

Information on this demonstration project is also available from the consultant:

- Ferguson, Simek, Clark Ltd.
  (re: ENEROPTIONS)
  Box 1777
  Yellowknife, N.W.T.
  X1A 2P4
  (403) 920-2882

Wood Heating of Fort Smith Water Supply

Technology:
Large-scale, direct combustion of wood chips

Demonstration Project Manager:
Jack Dueck
Apsco Engineering Ltd.
P.O. Box 270
Cremona, Alberta
T0M 0R0

Location:
Fort Smith, N.W.T.

Annual Savings: $44,471
100% of fuel oil previously used

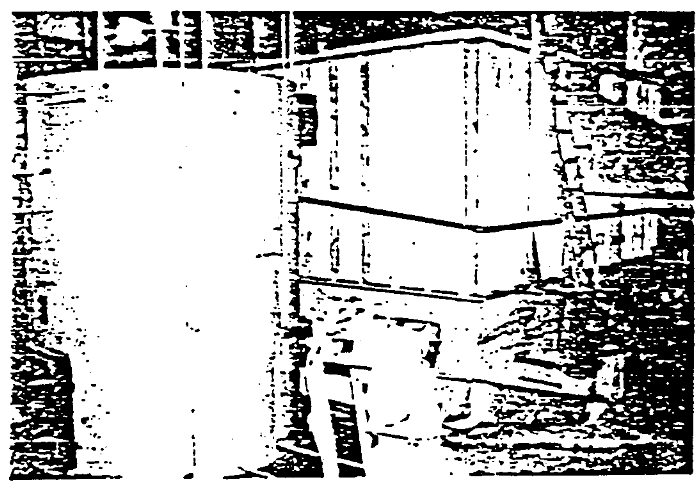
Payback Period: 4.6 years

Applicable to:
- a wide range of institutional, municipal and commercial space and water heating applications
- of particular interest to northern communities requiring heated water supply.

Description:

Fort Smith, N.W.T. is saving over $44 000/year and creating local employment by heating its water supply with wood. Fort Smith, located approximately 300 km (185 miles) south of Yellowknife, must heat its water supply during much of the year. As in many communities in the Northwest Territories, the town's water supply was previously heated by conventional oil-fired boilers. However, escalating fuel oil prices dramatically increased the system's operating costs and prompted the search for a less expensive alternative.

The town's water supply is now heated by means of a 4.0 MBtu/hr Apsco Model WW1000 wood-fired hot water boiler unit. The boiler is fuelled by wood chips, processed on-site from locally purchased cordwood.



The wood-fired boiler is seen to the left and the wood-chip storage bunker is to the right. The inclined auger is seen in the foreground.

Benefits:

- In its first year of operation, the project resulted in the displacement of approximately 160,000 litres (35,195 gallons) of No. 2 fuel oil.
- Once start-up problems, related to chip bridging in the storage bin, are overcome, it is expected that the project will result in the total displacement of approximately 200,000 litres (45,000 gals) of No. 2 fuel oil by approximately 400 cords of local wood.
- The new wood boiler has a larger capacity than the oil boilers. This enables the water supply to be maintained at a higher and more optimal temperature (4.4°C) for more effective water treatment than previously (2°C).
- Three permanent part-time jobs have been created in connection with the harvesting, delivery and chipping of local cordwood. Funds spent on fuel now stay in the community.

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Performance:

The design and installation of the system proceeded as expected and no problems were encountered. The boiler has performed at, or above, expectations since installation. A minor start-up problem was encountered with the wood chipper but was quickly identified and eventually remedied. There has been a continuing problem, however, with the wood-chip handling system. Each problem is outlined below.

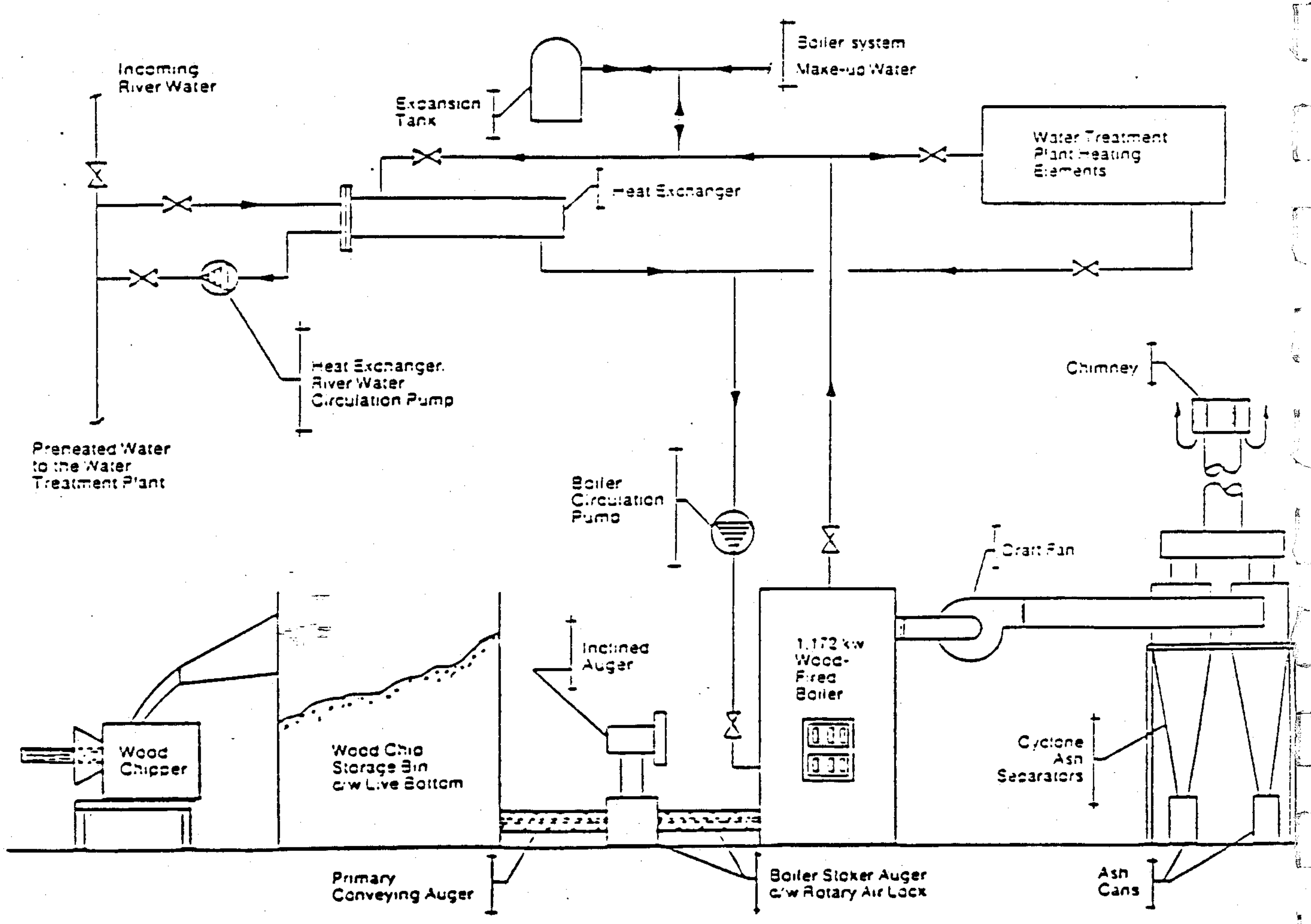
- Wood chipper — The attachment blades originally provided by the supplier were shorter than those specified by the design engineer. As a result, the chips were not being adequately thrown from the chipper unit to the conveyor belt. The problem was quickly identified and proper replacement blades were provided by the supp However, due to the inexperience of the on-site pers nel, the replacement blades were not installed for sever months. Once the replacement blades were installed, th chipper unit performed well.
- Wood-chip handling system — A continuing chip br ing problem exists with the hydraulic live bottom in the storage bin. This problem has lowered the system's availability to about 80% and is currently under inves tion but is felt to be correctable.

Technical Details:

The schematic diagram shows the new wood boiler system. All facilities, including the chipper and storage bunker, are located indoors in an insulated steel building.

Wood fuel is chipped to allow automatic feeding of the boiler. The wood-chip storage bin has a live bottom which allows the primary auger at the base of the storage bin to meter the flow as required. The primary auger has a variable speed drive enabling the boiler feed rate to be adjusted according to heating requirements and/or fuel moisture content. A rotary air lock provides a separation between fuel and the firebox.

The Apsco Model wood-fired boiler is a three-pass, vertic fire tube boiler with a design thermal efficiency of 75%. design allows the hot gases from the firebox to travel vertically through the boiler in three passes before exitin Primary combustion air is provided from beneath the boil The gases produced during primary combustion are bu above the wood chips when mixed with secondary air. the fuel feeding rate and the air supply are adjusted to achieve an efficient fuel/air mixture under various operating conditions.



Wood Boiler Heating System Schematic

The boiler is supplied with a complete set of controls to maintain a preset boiler supply water temperature. The water side of the boiler supplies two separate loops. The primary loop feeds the new heat exchanger which heats part of the incoming river water before it enters the water treatment plant. The portion of the river water (at .5° C) that passes through the heat exchanger has its temperature raised to a point that, when mixed with the remaining portion, results in a water temperature of approximately 4.4° C (40° F).

The second loop from the boiler heats the water treatment plant. The existing oil-fired boilers now serve as backup.

As a result of the extremely high boiler hearth temperatures, almost all of the hydrocarbons are consumed and only fly ash remains. The fly ash is separated from the exhaust emissions with high efficiency cyclones.

Economic Analysis:

Capital and Installation Costs: $206,874

Avoided Cost of Fuel Oil (195,138 L @ $0.353):		$ 68,835
Annual Operating Cost for Wood Boiler		
• Cost of wood supply:		
- Harvesting and delivery (392 cords @ $37.50)	$14,700	
- Labour for wood chipping (336 hrs @ $8)	$ 2,688 (1)	
• Incremental maintenance cost:	$ 469 (1)	
• Incremental electricity cost:	$ 6,507 (2)	
Total	$24,364 (3)	($ 24,364)
Net Annual Savings		$ 44,471

Simple Payback Period: 4.6 years.

Notes:

1. Incremental labour costs for wood chipping and regular maintenance are site-specific and are dependent on current labour loading. In many locations, these tasks may be handled by existing staff.
2. Incremental electricity costs are primarily for operation of the electric chipper: in Fort Smith the levy of an energy demand charge of $4,771 makes the operation of an electric chipper far more expensive than the comparable operating cost of a gas-powered chipper. Additional annual operating cost savings of approximately $4,000 are possible through the use of a gas-powered chipper.
3. In those locations where a gas-powered chipper is used and existing staff are able to perform wood chipping and regular maintenance duties, annual operating costs for a comparable wood system may be as low as $21,000. This would result in a simple payback of 4.3 years.

Availability:

The system was designed and installed by Apsco Engineering Ltd. of Cremona, Alberta.

The technology is available through contractors, suppliers and engineering consultants in major centres throughout Canada.

Further Information:

Further information and a copy of the final report are available from:

- ENEROPTICNS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7202

Information on this demonstration project is also available from the consultant:

- Mr. Jack Dueck
  (re: ENEROPTICNS)
  Apsco Engineering Ltd.
  P.O. Box 270
  Cremona, Alberta
  T0M 0R0
  (403) 296-2199

Pelly Crossing Wood-Chip Furnace

Technology:
Automatic wood-chip boiler

Demonstration Project Manager:

Mr. Al Fedoriak
Maintenance Division
Department of Education
Government of Yukon
P.O. Box 2703
Whitehorse, Yukon
Y1A 2C6
(403) 667-5143

Location:
Pelly Crossing, Yukon

Annual Savings: $11,425
60% net savings on cost of oil heating

Payback Period: 11 years

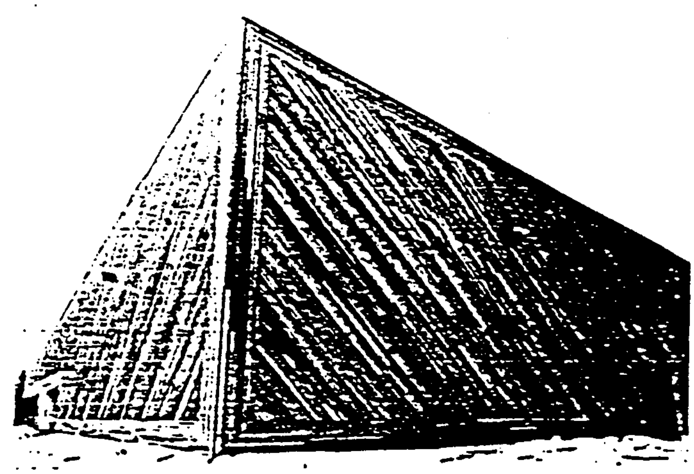
Applicable to:
Space and hot water heating applications in remote communities —

- Schools
- Hospitals
- Commercial buildings

Description:

A wood-chip heating system in the new school is saving oil and money, utilizing a local resource and providing employment in Pelly Crossing — a small, relatively isolated and predominantly native community approximately 230 km (175 miles) north of Whitehorse, Yukon.

In 1980, approval was received to build a new 1,300 m² (14,000 ft²) school which was also to serve as a community and recreation center. In the original design, the Eliza Van Bibber School was to be heated by two oil-fired boilers. However, in the final design stage a wood-chip heating system, providing both space heat and domestic hot water, was selected as a substitute for the oil system. The biomass system consists of a 350 kW Vyncke wood-chip boiler, an underfed stoker, and a 50 m³ (1,765 ft³) silo. Chips are provided from local fire-killed wood using a Bruks wood chipper powered by a diesel tractor. Backup is provided by a boiler and a domestic water heater, both fired by propane.



When the Government of Yukon constructed this new school for the community of Pelly Crossing it chose wood chips as the fuel source.

Benefits:

- The net annual savings from the wood-chip heating system appear to be $11,425 (1984), equivalent to 60% of the cost of operating a conventional, oil-fired system.
- The wood-chip heating system provides significant local economic benefit. Local cordwood is purchased from the Selkirk Indian Band at $60/cord — approximately 1/3 of the equivalent cost of fuel oil. Money formerly spent outside of the community for fuel oil is now spent within the community and provides an important local economic stimulus.

- The harvesting and chipping of wood has created two local part-time jobs in a community of about 200 plagued by chronic unemployment.
- Both the local wood fuel supply and the wood-chipping system have considerable unused capacity. Further applications of wood-chip heating, as a substitute for conventional oil heating, are being pursued within the community. When implemented, these will further contribute to the local economy by reducing fuel c[illegible] increasing local disposable incomes and creating [illegible]ditional employment.

Performance:

The system is now operating consistently and efficiently. Performance data are being collected and the results of a complete year's operation will be available by June 1985.

The approximate price of delivered heat from fuel oil (@ $0.46/litre) was estimated to be $20.10/GJ, or $19,295 annually (1984). Preliminary estimates indicate that the comparable cost using local wood chips is $8.20/GJ, or $7,870 annually based on: $60/cord for the harvested wood: $1,500 for labour and $450 for operation and maintenance of the chipper; $1,000 for propane backup; and $120 for electricity to power the augers. The 1984 net savings are therefore estimated at $11,425.

During the first few months of operation, a variety of technical problems were encountered. Although the problems were relatively minor they were exacerbated by the lack of technical services available within the community and by the community's remote location. Technical problems were encountered in the following areas:

- wood chip blockages in the auger system
- excessive exhaust fan noise
- system controls

In its initial operation, frequent blockages occurred at [illegible] first transfer point in the auger system. These blockages occurred as a result of oversized chips or splinters and [illegible] design of the transfer point. During one such incident [illegible] auger itself was damaged. The blockage problem at th[illegible] transfer point was overcome by replacing the original co[illegible]rugated metal sleeve with an angled sleeve made of met[illegible] three sides with a plexiglass front. Greater attention w[illegible] also paid to achieving uniform chip size. A slip clutch [illegible] also installed to prevent damage to the auger or motor i[illegible] event of future blockages.

Excessive fan noise was remedied by decreasing the s[illegible] of the forced draft fan. This also brought the air supply [illegible] in line with optimum levels and increased the overall boi[illegible] efficiency.

One of the boiler's safety controls created a minor pro[illegible] A sensor located upstream from the exhaust fan measur[illegible] the flue gas temperature and, if the exhaust temperatur[illegible] too low, the sensor automatically shuts down the boile[illegible] 25 minutes of operation. The sensor which was install[illegible] initially had too high a temperature range and caused th[illegible] boiler to shut down frequently. A new sensor with a pro[illegible] temperature range will eliminate the problem.

Technical Details:

The school is a 1,300 m², (14,000 ft²) single-storey building of slab floor construction (built in 1982). In the interests of thermal efficiency, it includes roof insulation of RSI 9.2 (R 52), wall insulation of RSI 3.5 (R 20) and triple-glazed windows. The designed space heating temperature is 21° C (70° F) during occupied hours and 13° C (55° F) during setback hours. The total space heating and domestic water heating requirements are about 960 GJ per year.

Local fire-killed timber is harvested as cordwood by members of the local Selkirk Indian Band and is then chipped on site using a Bruks MTH922 wood chipper powered by a 40 hp John Deere 1040 diesel tractor.

The chips are fed into a 50 m³ (1,765 ft³) underground concrete silo, which provides storage capacity for about 10 days during maximum demand periods. The silo is equipped with a heat loop (to prevent freezing) and a live bottom consisting of trapezoidal cylinders, which are pulled across the bottom of the silo by hydraulic pistons in order to supply wood chips to the first of three 30 cm (12 in) diameter fuel augers. A rotary air lock is installed at the second transfer point to prevent burn-back. Burn-back is also prevented by means of a supply of water which will flood the final auger housing should it attain unacceptably high temperatures.

The heating system — a 350 kW Vyncke model WW300S underfed wood chip boiler with automatic feed — was installed during the fall of 1982. Operation began in February 1983.

The boiler is a three-pass vertical fire tube unit, which [illegible] fed either with wood chips through the underfed stoker, [illegible] manually with cordwood through its door. An oil burner [illegible] also be fitted to an alternate door, if desired. Draft is pr[illegible]vided by means of a blower located at the top of the bo[illegible] immediately beyond the fire tubes. Fly ash passes from th[illegible] hearth through the fire tubes and is removed in a cyclone located just beyond the blower. The blower and cyclon[illegible] constructed of heavy gauge metal to resist the abrasive action of the fly ash. The boiler is designed to operate wit[illegible] 80% excess air at a combustion temperature of 1,320° C (2,400° F) and with virtually 100% combustion efficienc[illegible] Efficient heat exchange is achieved both through direc[illegible] radiation and through the vertical fire tubes. The exhau[illegible] gases exit the boiler at a fairly cool 150° C (300° F) and ar[illegible] relatively clean.

Both the air intake and auger speeds have been adjuste[illegible] deliver the maximum requirements of the building. In th[illegible] manner, maximum efficiency can be achieved during the shoulder periods, when a reduced boiler output is neede[illegible] The boiler contains more than 3,000 litres (660 gallons) [illegible] water, which stores approximately 120 MJ of heat. This [illegible] supplies the building's heat requirements between boiler cycles. During normal operation, the boiler runs for abo[illegible] 20 minutes and then shuts down until further heat is required. The hearth will maintain a fire for longer than 24 hours during periods of very warm weather.

Economic Analysis:

Capital Cost:

Vyncke Model WW300S	$ 77,500
Warranty	3,000
Concrete silo & modifications	20,489
Glycol heat loop	4,000
DHW heat exchanger	19,226
Boiler electrical and automatic controls	14,394
Markup	7,908
Miscellaneous	4,684
Sub total:	151,201
Credit (oil boiler and propane backup):	(28,340)
Incremental capital cost for wood-chip system:	122,861
Incremental costs of boiler installation:	5,000
Total Capital and Installation:	$127,861

Annual Operating and Maintenance Costs:

Estimated annual fuel oil savings (41,850 litres @ $0.461):	$19,295
Estimated (annual) wood heating cost:	
• 80 cords of wood @ $60	4,800
• chipper operation and maintenance	450
• labour for chipping	1,500
• propane backup	1,000
• electricity for auger operation	120
	($ 7,870)
Net Annual Savings:	$11,425

Simple Payback Period: 11 years.

Availability:

The system was designed, supplied and installed by Apsco Engineering. Automatic wood-chip heating systems are available through suppliers and consulting engineering firms in major centres throughout Canada.

Further Information:

An interim technical report on this demonstration project is available from:

- ENEROPTIONS
  Energy Branch
  Department of Mines and Small Business
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5382

Further information on this demonstration project is available from:

- Mr. Jack Dueck
  (re: ENEROPTIONS)
  Apsco Engineering Ltd.
  P.O. Box 270
  Cremona, Alberta
  T0M 0R0
  (403) 254-1049
- Mr. Al Fedoriak
  (re: ENEROPTIONS)
  Maintenance Division
  Department of Education
  Government of Yukon
  P.O. Box 2703
  Whitehorse, Yukon
  Y1A 2C6
  (403) 667-5143

Arenas and Curling Rinks

Measures:

- Night setback and timers
- Icemaking heat reclaim
- Electrical demand charge reduction
- Energy efficient lighting
- Architectural items

Estimated Annual Saving: $1,500 to $34,000
17% to 55% of pre-demonstration energy consumption

Applicable to:

- Arenas
- Curling rinks
- Winter sports centres

Locations:

Stonewall, Man. — Arena
Neepawa, Man. — Arena and Hall
Carman, Man. — Arena & Curling Rink
Roblin, Man. — Arenas
The Pas, Man. — Arena & Curling Rink
Lorette, Man. — Arena & Curling Rink
St. Leonard, N.B. — Arena
Lameque, N.B. — Arena
Riverview, N.B. — Arena
North Battleford, Sask. — Arena
Yellowknife, N.W.T. — Arena
Pine Point, N.W.T. — Arena

Description:

A number of communities across Canada have implemented cost-effective energy conservation measures in their local arenas and curling rinks.

All the facilities are equipped with systems to reclaim heat from ice-making equipment. Most use this recovered heat to preheat water, while others use the recovered heat for space heating.

Lighting systems are improved in most of the arenas by replacement of incandescent lighting and mercury vapour with more efficient types of illumination such as fluorescent, metal halide or high pressure sodium.

A number of other measures were demonstrated and proven to be cost-effective. Examples include:

- Reduction in peak power consumption;
- Electrical power factor improvement;
- Changes in space heating systems; and
- Selective increases in insulation levels.

Simple measures, such as the following, yield very rapid paybacks:

- Weatherstripping and sealing doors, windows and other cracks in the building shell;
- Insulating steam piping;
- Maintaining minimum ice thickness;
- Night setback thermostats and fan timers; and
- Good operational and general maintenance practices.

Benefits:

- The implementation of a wide range of measures yielded the following estimated reductions in energy consumption at the six Manitoba facilities:

Lorette Sports Centre, Lorette	55%
Roy H. Johnston Arena, The Pas	40%
Roblin & District Arena, Roblin	40%
Carman Community Arena, Carman	32%
Yellowhead Centre, Neepawa	20%
Stonewall Arena, Stonewall	17%

- In the three New Brunswick arenas, heat recovery from icemaking refrigeration equipment, coupled with the conversion to energy efficient lighting sources, saves $4,000 to $10,000 annually, or approximately 25%.
- Changes made at the North Battleford arena in Saskatchewan, are projected to cut energy costs by $17,000 per year, a savings of approximately 30%.
- Incorporation of energy conservation items—primarily, the recovery of heat from the refrigeration plant—at a new arena in Yellowknife, saves an estimated 100,000 litres (22,000 gallons) of oil annually.

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Details:

A wide range of energy conservation measures were demonstrated in these arenas and curling rinks. Details on a number of these measures follow.

Night Setbacks and Timers

Cost-effective energy savings can generally be obtained by using timers and other simple control equipment to reduce space temperatues, shut-off exhaust fans and close dampers in arenas when they are not in use. These types of minor control improvements were made in many of the facilities for payback periods in the range of 1 to 3 years.

Icemaking Heat Reclaim

Heat reclaim is the process whereby heat normally rejected to the outdoors from the refrigeration system is reclaimed for use somewhere else in the building. The refrigerant gas is repeatedly heated, compressed, cooled and condensed into a liquid. In the process, heat must be removed between the compressor and condenser and can be used for:

- Domestic hot water (DHW) preheating;
- Flood water preheating; or
- Space heating.

Variations on this measure were implemented in all of the facilities.

Available monitoring data on the heat reclaim systems indicates they are operating as designed and are achieving estimated energy savings.

Some operators report that maximum heat recovery is achieved by flooding the ice just prior to periods of high recovered heat demand (i.e., just before a game).

Low-Cost Mechanical Measures

A number of no-cost and low-cost improvements were made to the mechanical systems in many of the facilities. These included:

- Following operating procedures designed to minimize energy waste;
- Maintaining the heating and ventilating system in top condition, including regular cleaning of all air filters;
- Reducing domestic hot water temperature;
- Maintaining minimum ice thickness;
- Placing a locking cover over thermostats;
- Repairing dampers and seals;
- Insulating steam pipes; and
- Cycling the brine pump.

Electrical Demand Charge Reduction

The cost for electrical energy can be reduced by improving the power factor associated with the facilities' electrical load. This was accomplished at most of the Manitoba facilities by installing capacitors on large compressor motors. Typically, this measure provided a one- to two-year payback.

Demand costs can be further reduced by reducing electric consumption during peak periods. This was accomplished in the Stonewall, Manitoba arena by installing a smaller compressor (50 hp) to operate during the winter months and in some other facilities via the use of demand controllers to turn off non-essential loads during peak periods.

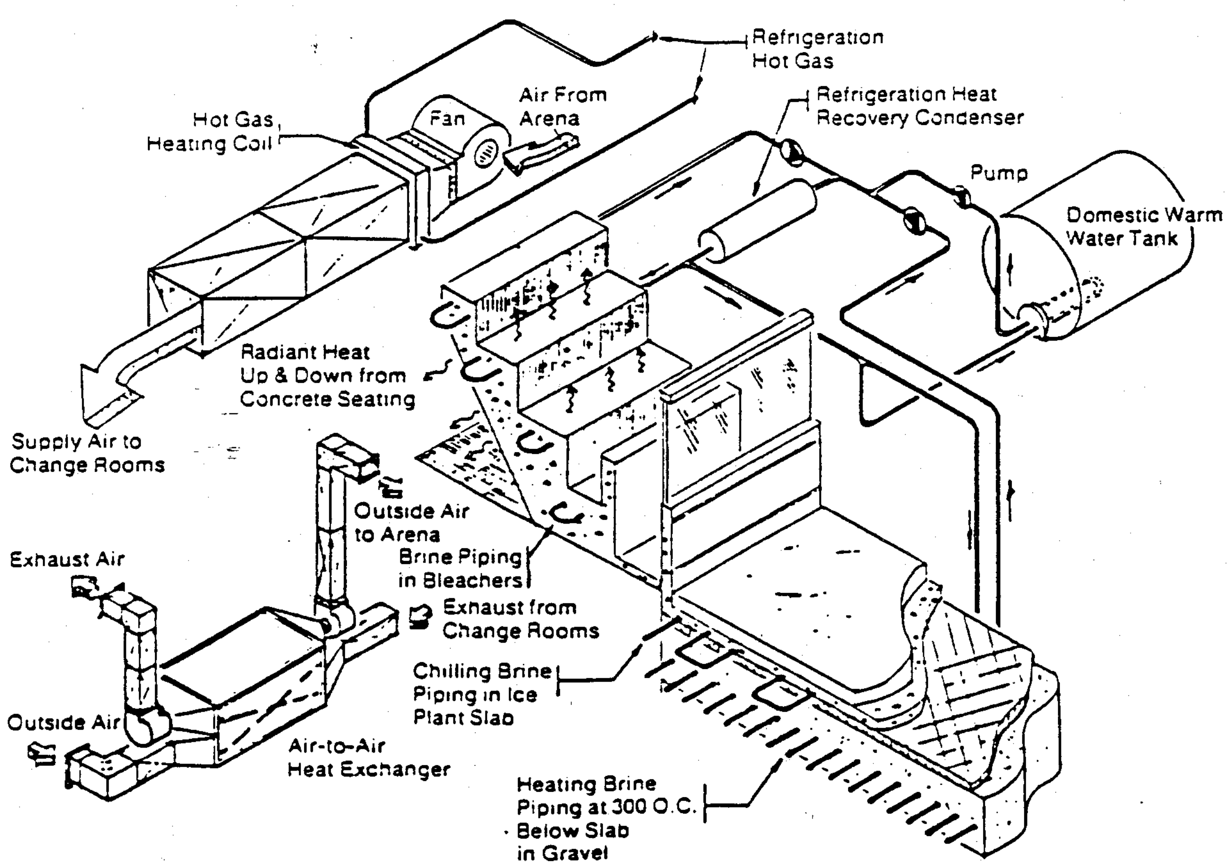

Figure 1— Yellowknife Arena Heat Reclaim System

Energy Efficient Lighting
A range of approaches were demonstrated for reducing lighting costs. No-cost and low-cost measures included: establishing guidelines for lighting use, cleaning fixtures, repainting reflectors and removing unnecessary lights and fixtures.

In many of the Manitoba facilities, incandescent lighting in lobbies, change rooms and other general purpose areas were converted to fluorescent. Metal halide lighting is used to illuminate ice surface in Lorette Manitoba and North Battleford, Saskatchewan.

In the three New Brunswick arenas, even greater savings were obtained by replacing mercury vapour arena lighting with high pressure sodium lamps. Use of this long life, highly efficient energy source to increase illumination levels, has been well received by the public.

A light dimming system was also installed in the Riverview, New Brunswick arena. Dimmers were found to be cost-effective only when the buildings were used for a wide variety of purposes. Otherwise, use of selective switching can produce similar results at substantially lower costs.

Architectural Measures
Application of weatherstripping, caulking and sealing on doors, windows and other cracks in the building shell was undertaken in all the facilities. These low-cost approaches for reducing infiltration of cold outside air yielded very rapid paybacks.

Implementing more costly architectural measures such as: adding or upgrading insulation levels, replacing doors, adding vestibules and replacing single glazing with double glazing, was found to be highly dependent on site-specific factors.

Insulation of selected areas of several Manitoba arenas was undertaken and payback periods between 5 and 25 years are estimated. One interesting measure was the insulation of the wall between the arena and the heated lobby. This particular measure saved energy and solved a soft ice problem at the lobby end of the rink.

In general, higher cost architectural measures are only cost-effective if performed in conjunction with other renovation measures.

Economic Analysis:

Implementation of energy conservation measures at these 12 facilities in various parts of Canada provides a good information base on the economics associated with energy conservation retrofits in community arenas and curling rinks.

Estimates of typical costs and payback periods associated with a range of measures are provided below. It should be noted that the actual costs and savings at individual facilities are largely dependent upon site-specific factors.

Mechanical Items	Range of Cost Estimates	Range of Estimated Payback Periods
• Night setback temperature controls and locking cover over thermostat	$100-2,000	1-3 years
• Timer controls or light switch control for exhaust fans	$100-500	1-3 years
• Insulate steam piping	$2,000-4,000	1-2 years
• Repair or replace dampers (backdraft(1), makeup air, exhaust) (1) note local codes	$500-3,000	1-2 years
• Heat recovery from ice plant for preheating ice flood and/or domestic hot water	$5,000-13,000	3-10 years
• Heat recovery from ice plant for space heating	$15,000-55,000	5-10 years
Electrical Items		
• Install power factor correction capacitor on compressors	$1,000-1,500	1-2 years
• Install peak demand controllers in facilities with heavy electrical heating loads	$2,000-3,000	2-4 years
• Replace incandescent lighting—in lobbies and change rooms—with fluorescent lighting	$500-1,000	2-3 years
• Convert arena lighting from lower efficiency incandescent or mercury vapour to higher efficiency (high pressure sodium or metal halide)	$7,000-17,000	3-10 years
Architectural Items		
• Tighten building shell by weatherstripping and sealing doors, windows and other building openings	$1,500-2,500	1.5-6 years
• Add insulation to walls and ceilings or replace doors and windows with insulated panels	$500-50,000	5-25 years
• New doors or windows	$2,000-10,000	14-25 years

Availability:

Most low-cost measures can be implemented by building maintenance staff using readily available supplies.

Balancing and tuning of HVAC systems can be performed by HVAC contractors throughout the country.

Selection and design of the most cost-effective heat recovery system, and determination of the most attractive package of higher cost measures for a particular facility, likely require the services of an experienced engineering consultant.

Further Information:

A manual on "Energy Conservation for Indoor Ice Rinks" is available from:

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

Individual reports on a number of facilities discussed in this case study are available from the appropriate provincial/territorial office listed below:

For Facilities in Manitoba

- ENEROPTIONS
  Energy Information Centre
  Manitoba Energy and Mines
  117-234 Donald Street
  Winnipeg, Manitoba
  R3C 1M8
  (204) 945-4154

For Facilities in New Brunswick

- ENEROPTIONS
  Energy Secretariat
  Government of New Brunswick
  P.O. Box 6000
  Fredericton, New Brunswick
  E3B 5H1
  (506) 453-3897

For Facilities in the N.W.T.

- ENEROPTIONS
  Energy Conservation Division
  Department of Public Works and Highways
  Government of the Northwest Territories
  YK Centre, 5th Floor
  Yellowknife, N.W.T.
  X1A 2L9
  (403) 873-7203

APPENDIX E:

Cost/Savings Data

--Selected Institutional Facilities

Note: The followng cost/saving data are for school facilities located in rural and remote Manitoba communities. While facilities are comparable to those in the Yukon, the energy costs are NOT comparable. The applicable energy costs in these facilities are: fuel oil 29¢/L and; electricity 3.5¢/kwh. These costs are far lower than those found in the Yukon and, therefore, the potential cost savings shown are dramatically less than for the Yukon. However, the measures shown and their respective energy savings are indicative of specific opportunities for Territorial facilities.

* Source: Underwood McLellon Ltd. Enerschool Final Report CREDA, 1984.

TABLE 1

CENTENNIAL ELEMENTARY SCHOOL
LAC DU BONNET
AGASSIZ SCHOOL DIVISION NO. 13

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWh/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Weather-strip Doors	Poor Weather-stripping	Good Weather-stripping	Install Weatherstripping	42,406	$1,113.00	$ 120.00	0.1
Place Exhaust Fan on Timer	Continuous Operation	Timed Operation	Install a Timer on the Fan Circuit	26,670	700.00	250.00	0.4
Repair Out-side Air Dampers on Air Handling Unit	Inoperable	Repaired	Repair Damper Operator and Linkage	114,300	3,000.00	2,400.00	0.8
Reduce Corridor Lighting Levels	50FC	20FC	Disconnect Every Second Hallway Fixture	2,030	70.00	100.00	1.4
Reduce the Run Time on Air Handling Unit	Continuous Operation	Timed Operation	Put Air Handling Unit on Time Clock With Outside Air Override Below 55^{o}F	6,520	225.00	500.00	2.2

TABLE 1

CENTENNIAL ELEMENTARY SCHOOL
LAC DU BONNET
AGASSIZ SCHOOL DIVISION NO. 13

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
hift 50% f Heating oad to lectrical	Totally Oil Heat	Partially Oil Heat	Install a 50 kW Electric Boiler	0	$2,900.00	$8,000.00	2.8
prove ilding ainage and awlspace sulation	Poor	Improved	Construct an Earth Berm Around School Perimeter; Extend Roof Drainage; Re-Insulate Crawlspace	34,630	900.00	4,400.00	5.0

COMMENDED RETROFITS

Total Implementation Cost		$7,610.00
Total Cost Saving		6,008.00
Payback		.8
Capital Budget	13,850 ft.^{2} x $.33/ft.^{2}	4,570.00

TABLE 2

CENTENNIAL ELEMENTARY SCHOOL
LAC DU BONNET
AGASSIZ SCHOOL DIVISION NO. 13

POSSIBLE RETROFIT OPTIONS

(GREATER THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWh/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Improve Attic Insulation	R5	R20	Remove Existing Lights and Acoustic Tile. Add Vapour Barrier, New Drywall and Paint. Add R20 Insulation in Ceiling	176,185	$4,624.00	$46,150	10.0

TABLE 1

ERICKSON COLLEGIATE
ERICKSON
ROLLING RIVER SCHOOL DIVISION NO. 39

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Hot Water Tank	135°F	110°F	Reduce Temperature by 25°F	4,100	53.00	0.00	0
Gym Ventilation Unit	Normal Controlled Operation	Ctl. Fresh Air Based on Occupancy	Install Timer to Determine Occupied/Unoccupied Periods and Reduce Fresh Air When Unoccupied.	25,900	700.00	500.00	0.7
Exh. Fans F1, F2, F4, F12, F15	Manual Ctl.	Timed Control	Install Timer to Reduce Operating Period	62,500	1,650.00	1,500.00	0.9
Corridor Ventilation Unit	Continuous Operation	Timed Control	Connect to Central Computer and Control Based on Occupancy	38,800	1,000.00	1,000.00	1.0
HPR Room Lighting	Excessive Levels	70FC	Disconnect 12 Fluorescent Fixtures	2,000	100.00	105.00	1.1

RECOMMENDED RETROFIT

TABLE 1

FRICKSON COLLEGIATE
ERICKSON
ROLLING RIVER SCHOOL DIVISION NO. 39

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
m Relief ns	Manual Control	Install Controlled Relief Hood	Remove Gym Relief Fans and One Inlet Damper and Install Motorized Damper and Relief Hood at Remaining Inlet Damper Location. Control from Mixed Air of Gym Ventilation Unit.	62,800	1,700.00	2,000.00	1.2
ience Lab ghting	110-130FC	100FC	Disconnect 4 Fixtures in Center Area	940	33.00	50.00	1.5
m Inc. ghts	All On	Reduce	Disconnect 8 Fixtures and Time Control Remainder to Shut Off After Mercury Fixtures are On.	9,100	315.00	525.00	1.7
awlspace	Wet and Vented	Regrade and Close Off	Regrade around Old Building and Close off Vents in Winter	45,500	1,230.00	2,400.00	2.0
			Total Implementation Cost			$8,080.00	
			Total Cost Saving			6,781.00	
			Payback			1.2 Years	
			Capital Budget	26,829 Ft.^{2} x $0.33/Ft.^{2}		8,855.00	

COMMENDED RETROFIT

TABLE 2

ERICKSON COLLEGIATE
ERICKSON
ROLLING RIVER SCHOOL DIVISION NO. 39

POSSIBLE RETROFIT OPTIONS

(GREATER THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
rridor c. Lights	All Incandescent	Use Fluorescent	Replace Incandescent Fixtures with Fluorescent Fixtures (12 - 2 Lamp Fixtures)	6,200	1,400.00	245.00	5.7
nand Ctl.	Uncontrolled Demand	Limit Electric Demand	Utilize Central Computer to Control Electric Loads Including Heating Loads	18 kVA	775.00	5,200.00	6.7
eam ller	Oil Fired Heating of Old Building	Hybrid Oil and Electric	Replace about 1/3 of Existing Oil Capacity with Electric Heating.	73,900	2,000.00	17,000.00	8.5

TABLE 1

McCREARY SCHOOL
McCREARY
TURTLE RIVER SCHOOL DIVISION NO. 32

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Gymnasium Lighting	60-65FC	30FC	Turn off 6-400W Mercury Vapour Fixtures	5,607	$ 220.00	$ 0.00	0.
Gymnasium Lighting	500W	200W	Reduce Lamp Wattage in Standby Incandescent Lighting	5,040	198.00	45.00	0.2
Repair and Maintain Unit Ventilator and Associated Controls	Damaged	Maintained	Replace Blower Motor and Steam Control Valve in One Classroom Set Up O.A. Damper to 16% Fresh Air	4,687	127.00	285.00	0.5
Investigate and Set Up Demand Controller Operation	Inoperative	Reset Controls	Verify Operation and Revise Load Shedding Schedule and/or School Operation	0	3,517.00	2,000.00	0.6
Place Exhaust Fans on Timers	Manual Control	Timer Control	Place Exhaust Fans E2, E4, F-7, F-10 and F-13 on 7 Day Timers	59,063	1,091.00	900.00	0.8

RECOMMENDED RETROFIT

TABLE 1

McCREARY SCHOOL
McCREARY
TURTLE RIVER SCHOOL DIVISION NO. 32

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Reduce Corridor Lighting in Open Elementary Area	90FC	20FC	Disconnect 12 Fluorescent Fixtures	2,593	$ 102.00	$ 117.00	1.2
Reduce Lighting in Kindergarten, Science and Open Elementary Area	90FC	70FC	Disconnect One 2 Lamp Ballast in 35 4 Lamp Fluorescent Fixtures	6,993	275.00	350.00	1.3
Set Up Air Handling Unit Controls	Misadjusted	Recommission	Re-establish Proper Control Sequences on Air Handling Units	29,268	360.00	500.00	1.4
Reduce Lighting in High School (Old Building) Classrooms	90FC	70FC	Disconnect 3 2 Lamp Fixtures in 6 Classrooms	3,591	140.00	200.00	1.4

RECOMMENDED RETROFIT

TABLE 1

McCREARY SCHOOL
McCREARY
TURTLE RIVER SCHOOL DIVISION NO. 32

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
0. Reduce Lighting in Home Economics Area	120FC	100FC	Remove 16 Lamps and 8 Ballasts in Home Economics Area	1,596	$ 60.00	$ 100.00	1.7
1. Gymnasium Lighting	Continuous Operation	Timed Operation	Put Standby Incancescent on a 10 Minute Timer	3,360	132.00	350.00	2.7
2. Replace Fuel Oil Boiler with Electric	Oil Fired	Electric Fired	Replace Fuel Oil Steam Boiler with Electric Boiler. Existing Service is Large Enough	0	2,720.00	9,700.00	3.6

RECOMMENDED RETROFIT

Total Implementation Cost		$14,547.00
Total Cost Saving		8,942.00
Payback		1.63 Years
Capital Budget	36,000 ft.^{2} x $.33/ft.^{2}	11,880.00

TABLE 2

McCREARY SCHOOL
McCREARY
TURTLE RIVER SCHOOL DIVISION NO. 32

POSSIBLE RETROFIT OPTIONS

(GREATER THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
:lose in Iindows in ourtyard xcept cience Room	Excessive Window Area	Reduce Window Area	Close in Windows with 2 x 4 Studs, R12 Insulation. Interior and Exterior Finish to Match	6,638	$ 290.00	$1,500.00	5.2
eroof Phase Building nd Insulate o R20	R5	R20	Remove Old Roof and Replace with New Roof. 4" SM Board Insulation (R20)	172,098	4,516	41,500.00	9.2

TABLE 1

MINITONAS INTERMEDIATE SCHOOL
MINITONAS
SWAN VALLEY SCHOOL DIVISION NO. 35

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Hot Water Tanks	150^0F	120^0F	Reduce Temperature by 30^0F	7,900	$ 257.00	-	0
Corridor Relief Damper	Controlled Relief	Delete	Remove Damper and Seal Roof Opening	104,700	4,700.00	250.00	0.1
Unit Ventil-ation	Malfunctioning Ctl. Valve	Replace	Service Unit Ventilators to Ensure Proper Operation (9 units)	58,000/unit	1,475.00/unit	250.00/unit	0.2/unit
Doors	Unsealed	Seal	Weatherstrip Doors	30,450	775.00	200.00	0.3
Hall Inc. Light Fixtures	30-40 FC	20 FC	Replace all 150W Bulbs with 60W Bulbs	2,700	90.00	30.00	0.3
Exhaust Fans F2, F3 and F4	Manual Control	Timed Control	Provide Units with Manual Reset Timers	61,000	1,550.00	900.00	0.6
Vestibule Inc. Lights	150W	75W	Replace Vest. and Exterior Light Bulbs with 75W Size and Place on Timer	3,500	120.00	150.00	1.3

RECOMMENDED FOR RETROFIT

TABLE 1

MINITONAS INTERMEDIATE SCHOOL
MINITONAS
SWAN VALLEY SCHOOL DIVISION NO. 35

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Windows	Excessive Area	Reduce Area	Blank Off 50% of Window Area				
			Method #1: - Window Remains, Blank Off Interior to Match	30,000	$1,200.00	$1,500.00	1.3
			Method #2: - Remove Window and Blank Off to Match Exterior and Interior	30,000	1,200.00	3,500.00	2.9
Oil Fired Boiler	Old Boiler	New Boiler	Replace Existing Oil Fired Boiler with New Boiler of Correct Size	165,000	4,200.00	10,000.00	2.4
Boiler	Oil Fired	Combined Oil and Electric	Install Companion 60 kW Electric Boiler and Operate Oil for Peak Loads	130,000	3,700.00	10,000.00	2.7

RECOMMENDED FOR RETROFIT

Total Implementation Cost		$5,280.00
Total Cost Saving		21,967.00
Payback		0.24 years
Capital Budget	$17,556\ ft^2 \times \$.33/ft^2$	5,795.00

TABLE 2

MINITONAS INTERMEDIATE SCHOOL
MINITONAS
SWAN VALLEY SCHOOL DIVISION NO. 35

POSSIBLE RETROFIT OPTIONS

(GREATER THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Parking Plugs	Uncontrolled	Controlled	Control Bus Heaters with Time Clock and Thermostat	3,900	$ 135.00	$1,000.00	7.4
Gym Lights	Incandescent	High Pressure Sodium	Replace Inc. Fixtures with High Pressure Sodium Fixtures to Improve Light Level, Reduce Energy Use and Maintenance Costs.	19,000	660.00	5,700.00	8.6

TABLE 1

NEELIN HIGH SCHOOL
BRANDON
BRANDON SCHOOL DIVISION NO. 40

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Hot Water Temp.	$150^{0}F$	$110^{0}F-120^{0}F$	Reduce Temperature by $30^{0}-40^{0}F$	37,000	$ 515.00	$ 0.00	0
Gym Inc. Light Fixture	500W	200W	Reduce Lamp size to 200W	3,276	108.00	15.00	0.1
Gym Relief Damper	Inoperative Motor	as per System Requirement	Replace Damper Motor and Set up with System	377,100	5,200.00	650.00	0.1
Unit Ventilator	Inoperative Damper or Steam Valve	Replace	Service Unit Ventilators to Restore to Normal Operation (19 units)	43,500	600.00/unit	200.00/unit	0.3
Old School Vent. System Control	Controls & Dampers Inoperative	Repair	Service Vent. Unit Control System to Restore Controlled Operation	325,500	4,500.00	1,700.00	0.4
Old School Vent. System Outside Air Reset	Single Set Point M.A. Control	M.A. Control c/w Outside Air Reset	Replace Mixed Air Controller with Outside Air Reset Model	86,700	1,200.00	850.00	0.7
MPR Vent. System	Continuous Operation	Night Set Back	Provide Night Set Back Thermostat and Timer Clock	19,200	265.00	275.00	1.0

TABLE 1

NEELIN HIGH SCHOOL
BRANDON
BRANDON SCHOOL DIVISION NO. 40

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (KWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
.8 Gym Vent. System	Continuous Operation	Night Set Back	Provide Night Set Back Thermostat and Timer Clock	45,000	$ 620.00	$ 675.00	1.1
9 Demand Control	No Control	Limit Max. Demand and Implement Scheduling of Loads	Control Operation of Fan Units, Exh. Fans and Hot Water Heaters	24 kVA (Average) & 188,000 kWHr.	4,100.00	12,000.00	2.9
.10 Gym Inc. Lights	No Control	Timer Control	Wire Time Delay to Shut off Inc. Lights After Merc. Fixtures are on	2,180	75.00	260.00	3.5

RECOMMENDED RETROFITS

Total Implementation Cost		$20,225.00
Total Cost Saving		27,983.00
Payback		1.0 years
Capital Budget	$68,852\ ft^2 \times \$.33/ft^2$	22,720.00

TABLE 2

NEELIN HIGH SCHOOL
BRANDON
BRANDON SCHOOL DIVISION NO. 40

POSSIBLE RETROFIT OPTIONS

(GREATER THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
1 Corridor Inc. Lights	Inefficient Light Source	Use More Efficient Source	Replace Inc. Fixtures with 2 Lamp Fluorescent Fixtures	23,751 kWHr. + 8.7 kVA Demand	$ 790.00	$ 4,200.00	5.3
2 Windows	Excessive Area	Reduce Area	Blank Off Part of Window Area				
			Method #1 - Window remains blank off interior to match	105,000	1,450.00	9,000.00	6.2
			Method #2 - Remove window and blank off to match ext. and interior	105,000	1,450.00	20,100.00	13.9
3 Crawlspace	No Insulation	Insulate	Add exterior rigid insulation and regrade	32,600	450.00	12,000.00	26.7

RECOMMENDED RETROFIT

Summary of Tables 1 and 2 for Recommended Retrofits

Total Implementation Cost		$24,425.00
Total Cost Saving		28,773.00
Payback		0.85 years
Capital Budget	$68,852\ ft^2 \times \$.33/ft^2$	22,720.00

TABLE 1

ROSEAU VALLEY COLLEGIATE
DOMINION CITY
BOUNDARY SCHOOL DIVISION NO. 16

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Air Handling Units Mixed Air	Continuous Operation	Override During Unoccupied Cycle	Disable M.A. Control During Unoccupied Cycle via Time Clock	370,700	$ 5,200.00	$ 650.00	0.1
Gym Inc. Light Fixture	500 W	200W	Reduce Lamp Size to 200W	2,520	99.00	15.00	0.2
Air Handling Unit Damper	Leaking	Seal	Weather Edge all Dampers Around Units	16,250	230.00	85.00 (annualized)	0.4
Gym Air Handling Unit	Continuous Operation, Manual Ctl.	Timed Ctl. with M.A. Override	Operate unit via Manual Reset Timer and Disable Mixed Air Ctl. when Outside Temperature below -10°C	146,000	2,070.00	850.00	0.4
Exhaust Fans F6, F7 & F16	Manual Control	Timed Control	Provide units with Manual Reset Timers	109,500	1,550.00	700.00	0.5
Doors	Unsealed	Seal	Weatherstrip Doors	56,500	800.00	400.00	0.5
Staff Rm. Lights	150W/Fixt.	60W/Fixt.	Replace all Bulbs with 60W size	2,500	97.00	60.00	0.6
Library Lights	100FC	70FC	Disconnect 8 Fluorescent Fixtures	1,600	125.00	100.00	0.8

RECOMMENDED RETROFITS

TABLE 1

ROSEAU VALLEY COLLEGIATE
DOMINION CITY
BOUNDARY SCHOOL DIVISION NO. 16

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Classroom B.41 Lights	100FC	70FC	Disconnect 22 Fluorescent Fixtures	4,400	$ 172.00	$ 200.00	1.2
0 Corridor Lights	50FC	20FC	Disconnect 35 Fluorescent Fixtures	7,350	290.00	400.00	1.4
1 Classroom A15 Lights	95FC	70FC	Disconnect 9 Fluorescent Fixtures	1,800	72.00	100.00	1.4
2 Multi Purpose Room Lights (Inc.)	150W	75W	Replace Bulbs with 75W Size	475	55.00	85.00	1.6
3 Classroom A05, A06, A07 and A13 Lights	95FC	70FC	Disconnect 36 Fluorescent Fixtures	7,200	290.00	450.00	1.6
4 Classroom A08 & A11 Lights	95FC	70FC	Disconnect 8 Fluorescent Fixtures	1,600	63.00	100.00	1.6
5 Air Handling Units	Continuous Operation	Occupied/ Unoccupied Operation	Set Up Units on Time Clock with Temperature Override	55,400	725.00	2,500.00	3.4
6 Gym Inc. Lights	No Control	Timer Control	Wire Time Delay to Shut Off Inc. Lights after Merc. Fixtures are on	1,680	65.00	275.00	4.2

RECOMMENDED RETROFITS

Total Implementation Cost		$16,370.00
Total Cost Saving		11,983.00
Payback		1.4 years
Capital Budget	45,750 ft^2 x $.33/$ft^2$	15,100.00

TABLE 2

ROSEAU VALLEY COLLEGIATE
DOMINION CITY
BOUNDARY SCHOOL DIVISION NO. 16

POSSIBLE RETROFIT OPTIONS

(GREATER THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
Demand Ctl.	No Control	Limit Max. Demand & Schedule Loads	Control Operation of Air Handling Units, Exhaust Fan and Parking Plugs	15 kVA (average)	$ 800.00	$5,400.00	6.75
Crawl Space	Wet	Regrade	Regrade and Sod Around School To Prevent Moisture Entry Into Crawl Space	-	-	4,000.00	See Description
Gym Merc. Lights	End of Life	Replace Bulbs	Bulbs are Approaching End of Life Span. Replace as Part of Normal Maintenance			See Description	

RECOMMENDED RETROFITS

Summary of Tables 1 and 2 Recommended Retrofits

Total Implementation Cost		$25,770.00
Total Cost Saving		12,783.00
Payback		2.0 years
Capital Budget	45,750 ft^2 x $.33/$ft^2$	15,100.00

TABLE 1

ST. JOACHIM SCHOOL
LA BROQUERIE
SEINE RIVER SCHOOL DIVISION NO. 14

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
1. Reset Domestic Hot Water Temperature	140°F	110°F		1,161	$ 40.00	$ 0	0.
2. Reduce Lighting in Corridors	95FC	70FC	Turn Off One Half of the Fixtures in the Hallway by Putting "Locking Dogs" on Breaker Panel	2,467	85.00	20.00	0.3
3. Remove Hot Water Heater From Flat Rate	Flat Rate	General Service Rate	Advise Manitoba Hydro that You Wish to Eliminate Flat Rate on the 6 kW of Domestic Hot Water Heating	0	290.00	100.00	0.4
4. Improve Door Weatherstrip	Nap Type (Poor Seal)	Vinyl Type (Good Seal)	Change Type of Weatherstripping to More Efficient Style	8,412	214.00	200.00	0.7
5. Reduce Lighting in Classrooms	90FC	70FC	Remove Centre Fixture in Back Two Rows of Each Classroom	3,483	120.00	200.00	1.7
5. Night Setback	None	Drop Space Temp 5° for Unoccupied Time	Install a 5° Night and Weekend Setback System	39,074	994.00	4,750.00	4.8

RECOMMENDED RETROFITS

Total Implementation Cost		$5,270.00
Total Cost Saving		1,743.00
Payback		3.0
Capital Budget	(20,300) x $.33/ft.^{2}	6,699.00

TABLE I

BERENS RIVER SCHOOL
BERENS RIVER
FRONTIER SCHOOL DIVISION NO. 48

RECOMMENDED RETROFIT OPTIONS

(LESS THAN 5 YEAR SIMPLE PAYBACK)

	ITEM	CONDITIONS EXISTING	CONDITIONS REVISED	DESCRIPTION	ENERGY SAVED (kWH/Yr.)	COST SAVING ($/Yr.)	IMPLEMENTATION COST ($)	AVERAGE PAYBACK PERIOD (YEARS)
*1.	Hot Water Tanks	140^{0}F	120^{0}F	Reduce Temperature by 30^{0}F	2,700	$ 100.00	-	0.
*2.	Repair of Mixed Air Reset Schedule on Classroom A/H Units	Control Inoperative	Repair and Revise Control	Set up Reset Schedule and Remove Minimum Fresh Air Control	2,800/day	75.00/day	300.00	0.
*3.	Doors	Unsealed	Seal	Weatherstrip Doors	38,200	1,040.00	108.00	0.1
*4.	Gym Lighting	500W	200W	Replace 500W Gym Standby Lighting Bulbs with 200W	2,520	99.00	15.00	0.2
*5.	Eliminate Crawlspace Ventilation	Operative	Delete	Blank-off Ducts. Blank-off Relief Openings	60,640	1,651.00	390.00	0.2
*6.	Reduce Gym Air Relief	4' x 8'	Reduce Size to 4' x 3'	Seal Off 60% of Opening With Drywall and Studs	18,932	516.00	250.00	0.5
*7.	Reduce Classroom Lighting in Phase I	95FC	70FC	Delete 4 Fixtures/Class	7,182	280.00	700.00	2.5
*8.	Delete Skylights in Phase I Corridor and Repair Roof		Delete	Seal Off Skylights With a New Ceiling Flush with Existing	112,417	3,064.00	8,500.00	2.8