YUKON 2000

REPORT ON ENERGY

Background Discussion Paper

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INTRODUCTION

Energy has been identified in numerous studies as both expensive to and a major drain on the Yukon economy. Yukon residents and industry spent some $92 million in 1985 to meet their energy needs, of which an estimated $74 million or approximately 80% was for imported refined petroleum products. While the exact extent to which energy has inhibited economic development is not clear, it is quite obvious that energy has had a negative influence on growth. Its high cost has adversely affected Yukoners' cost of living and cost of business, and its high import content has meant little spin-off benefits from energy spending in the Yukon economy.

The question for this conference and for future planning is, how can these negative aspects of energy be minimized or reversed. In the language of the Yukon 2000 discussion paper, "Building the Future", the question is, how can and should energy linkages ... the ways in which energy affects the economy ... be improved to the benefit of the region. It is to this question that this paper is addressed.

LINKAGE FACTORS

The amount of money Yukoners spend on energy and the source of their energy supply are the two key factors governing the impact of energy on the Yukon economy.

Total energy spending, a function of both the amount of energy use and the price paid per unit of energy, is important because for residents, it affects real incomes, and for industry, it affects competitiveness, profitability and the incentive and ability to invest. Clearly, the more that Yukoners can reduce their energy spending either through more efficient use of energy or through lower prices, the less will energy restrict development in the region.

Source of supply is also important, because it determines the extent to which energy expenditures support local or out-of-Yukon business. The more that energy needs can be supplied from local sources, the more will energy serve as a stimulus as opposed to a drain on the Yukon economy.

The basic energy issues are whether Yukoners are minimizing energy costs and are utilizing local sources to the most appropriate extent. More specifically the issues are as follows:

(1) how are Yukoners using energy - can this energy use be reduced

(2) what mix of energy forms are Yukoners and Yukon industry using - is this the optimal mix in terms of costs and local supply;

(3) what measures should Yukoners be taking to reduce energy use and/or reduce energy imports

(4) what prices are Yukoners paying for their energy - how can these prices be reduced.

ENERGY USE IN THE YUKON

Detailed energy consumption data are not available on an annual basis for the Yukon. The most recent estimates of consumption were developed by Marbek and by Acres[1] for the year 1982. Prior to that, energy consumption data were developed by Hildebrandt-Young & Associates and Hodge and Ehrlich.[2] Hodge and Ehrlich's analysis was for the year 1978 and was more detailed than Hildebrandt-Young, particularly in terms of end-use. What follows below, therefore, is a summary of the energy consumption estimates in Acres and Marbek for 1982[3] and Hodge and Ehrlich for 1978, serving to indicate the general patterns and trends in energy use in the Yukon. Many limitations in data and differences in methodology dictate that comparisons between the two years must be made cautiously, particularly with respect to allocations of total consumptions of each energy type into sectors and end uses. Until a detailed energy accounting system is

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(1) Marbek Resource Consultants, Yukon Energy Management/Economic Development Opportunities, May 1986. Acres Consulting Services Ltd., Yukon Remote Community Energy Overview Study, January, 1984.

(2) Hildebrandt-Young & Associates Ltd., Projected Yukon Energy Requirements 1986-1996, October 1982. R.A. Hodge and Lynda Ehrlich, Northern Energy, A Soft Path Analysis of the Yukon and Northwest Territories, October, 1982.

(3) The two sets of 1982 consumption estimates agree fairly closely on total sectoral energy use and on total consumption of each energy type. They diverge widely on consumption of each energy type for each sector. These estimates should therefore be interpreted with caution. For purposes of this summary, the overall use pattern is taken from Acres, and this information is disaggregated using breakdowns shown in Marbek which has more detail with respect to end uses, and wood use.

implemented, it will be difficult to make more accurate statements with respect to trends in energy use patterns.

(a) Residential Sector

As shown in Table 1, energy consumption in the residential sector increased from 1260 terajoules (TJ)[1] in 1978 to 1477 TJ in 1982. This increase was partly due to a growth in the number of households. There were an estimated 7000 households in the Yukon in 1978; energy use per household averaged approximately 180 gigajoules (GJ). By 1982, the number of households had increased to 7600; use per household averaged approximately 194 gigajoules.

In terms of energy types, in both years, refined petroleum products were the most important energy source, accounting for some 65% of total heating requirements. Wood use was also significant, however, accounting for some 15-20% of total heating requirements.

In more recent years, from 1982 to the present, total consumption has probably declined, because of limited population growth and conservation improvements.[2] The most striking trend is the shift from refined petroleum products to wood. It is estimated that use of

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(1) A terajoule is 10^{12} joules.

(2) Estimates of total energy supply for 1985 show a significant decline in overall use between 1982 and 1985. Detailed estimates of consumption by sector are not available, however.

TABLE 1

Energy Consumption in the Residential Sector

(Delivered TJ)

1978

	RPPs	Electri-city	Wood	Total	%
Heating	710	180	240	1130	90
Electricity Specific	-	130	-	130	10
Total	710	310	240	1260	100
%	56	25	19	100	

1982

	RPPs**	Electri-city	Wood	Total	%
Heating*	920	236	220	1376	93
Electricity Specific	-	101	-	101	7
Total	920	337	220	1477	100
%***	62	23	15	100	

*Typical 1982 breakdown of heating requirements was approximately 90% for space heating, 10% for hot water.

**For comparability with the 1978 figures, propane consumption is included with RPPs.

***Breakdown by fuel varies greatly between large and small communities. For example, wood served 56% of space heating requirements in communities smaller than 250 persons, but it served only 10% of these requirements in larger communities. For the latter, 70% of the requirements were met by RPPs (Marbek, p. 15).

wood for space heating more than doubled between 1982 and 1983, though this appears to have been followed by some decline in more recent years.(1)

(b) Commercial and Institutional Sector

In Table 2, energy consumption in the commercial/institutional sector is shown. The Table indicates that energy use increased from 1580 TJ in 1978 to 1760 TJ in 1982. This growth would appear to be largely due to increases in commercial and government activity in this period.

The commercial/institutional sector is made up of many different types of users. Stores and shops are the single most important component of this sector, accounting for between 35-41% of total use. Hotels and motels account for another 16-20% and government offices between 15-25%.

Throughout the sector it is clear that in both 1978 and 1982 refined petroleum products dominate energy use, accounting for over 95% of total heating requirements.

Little information is available on trends from 1982 to the present, though it is probable there has been some reduction in use in this sector, based on 1985 total energy supply figures.

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(1) Yukon Statistical Review, First Quarter 1986, Table 7.13.

TABLE 2

Energy Consumption in Commercial and Institutional Sector

(Delivered TJ)

1978

	RPPs	Electri-city	Wood*	Total	%
Heating	1272	-**	-	1272	80
Electricity Specific	-	309	-	309	20
Total	1272	309	-	1581	100
%	80	20	-	100	

1982

	RPPs	Electri-city	Wood	Total	%
Heating	1440	15	20	1475	84
Electricity Specific	10***	277	-	287	16
Total	1450	292	20	1762	100
%	82	17	1	100	

*Some use of wood in this sector was observed in 1978, but no estimate of magnitude was made.

**According to a YTG official some electricity was consumed for space heating, although Hodge and Ehrlich did not show this. It is possible some space heating loads were included in electricity specific demand.

***Refers to propane used for appliances normally served by electricity.

(c) Industrial Sector

Energy use in the industrial sector is highly dependent on mining in the Yukon and has declined significantly with mine closures. As shown in Table 3, in 1978 energy consumption totalled 2145 TJ, but in 1982 energy consumption fell to 782 TJ. The significant change was due to reduction in activity at the Cyprus Anvil mine in Faro during 1982. Mining had accounted for 78% of industrial energy consumption in 1978. The balance of the consumption was accounted for by construction (15%), forestry (4%), fishing, hunting and trapping (2%), other (1%).

In terms of mix of energy types, in 1978, when energy requirements were relatively high, energy needs were met by large amounts of refined petroleum products and a significant amount of coal. In 1982, with a much lower level of mining activity, electricity is shown as the dominant fuel type, with the remainder being refined petroleum products.

With respect to trends from 1982 to present, there was a further decline in use in 1983 and 1984 because of reduced mining activity. A significant recovery is underway, however, due to the renewal of mining activities. It was estimated by Marbek that total industrial energy use could stabilize at approximately 1700 TJ per year in the near future.

TABLE 3

Energy Consumption in the Industrial Sector

(Delivered TJ)

1978

	Coal	RPPs	Elec.	Total	%
Heating*	-	195	-	195	9
Process Heat	377	192	-	569	27
Liquids Fuels	-	813	-	813	38
Electricity Specific	-	-	568	568	26
Total	377	1200	568	2145	100
%	18	56	26	100	

1982

	Coal	RPPs	Elec.	Total	%
Heating	-	125	-	125	16
Process Heat	-	-	-	-	-
Liquid Fuels	-	140	-	140	18
Electricity Specific	-	20**	497	517	66
Total	-	285	497	782	100
%	-	36	64	100	

*As noted above, these allocations of energy consumption to end uses are subject to error. A Department of Economic Development official stated that some of the coal consumption observed in 1978 was used for space heating and that some electricity was used for this purpose in both years. It was also thought that coal use did not cease until 1983.

**Refers to propane used for appliances normally served by electricity.

(d) Transportation

Energy use for transportation was estimated at 3901 TJ in 1978, all in the form of refined petroleum products. In 1982 energy consumption in the transportation sector was estimated at 3250 TJ, in spite of an increase in number of registered vehicles and a similar level of tourist activity to that observed in the earlier year. This decrease is likely due to reductions in commercial and industrial traffic resulting from the Cyprus Anvil closure and the resulting reduction in economic activity.

In terms of the breakdown of use by vehicle type it was estimated by Hodge and Erhlich that 1978 requirements were accounted for as follows:

Auto	49%
Truck	37%
Air	13%
Rail	1%
Bus	.3%

Over the 1982 to 1985 period, there has been an increase in energy consumption in this sector, probably due to an increase in auto and truck registrations and a return of commercial and industrial activity. Sales of motor gasoline for example, have increased by some 11% in this period.

(e) Total Demand Summary

As shown in Table 4, total energy demand in the Yukon fell between 1978 and 1982 from 8887 TJ to 7271 TJ. This reduction is due to declines in industrial and transportation requirements. In the residential, commercial and institutional sectors energy consumption increased. Overall in both years there was a very high dependence on refined petroleum products, accounting for some 80% of total energy consumption. As shown by energy supply estimates given in the next section, there was a further significant drop in total energy consumption from 1982 to 1985.

ENERGY SUPPLY IN THE YUKON

In 1978, energy supply in the Yukon totalled 9310 TJ, 8887 TJ delivered to end users plus 423 TJ for fuel and losses. The most significant components of the fuel and losses included 271 TJ in conversion efficiency losses in generation of electricity from diesel and 132 TJ in electrical transmission and operating losses and energy used internally by the electricity supply industry. Of the total energy supply, 1786 TJ or 19% was provided from local sources, including 1169 TJ in hydro-electricity, 377 TJ of coal (used for the Cyprus Anvil Mine), and 240 TJ of wood. The balance, 7524 TJ or 81%, all refined petroleum products, were imported (7103 for direct use and 421 TJ of diesel for conversion to electricity).

TABLE 4

Total Energy Consumption Summary

(Delivered TJ)

1978

	RPPs	Elec.	Wood	Coal	Total	%
Residential	710	310	240	-	1260	14
Commercial	1272	309	-	-	1581	18
Industrial	1200	568	-	377	2145	24
Transportation	3901	-	-	-	3901	44
Total	7083	1187	240	377	8887	100
%	80	13	3	4	100	

1982

	RPPs	Elec.	Wood	Coal	Total	%
Residential	920	337	220	-	1477	20
Commercial	1450	292	20	-	1762	24
Industrial	285	497	-	-	782	11
Transportation	3250	-	-	-	3250	45
Total	5905	1126	240	-	7271	100
%	81	16	3	-	100	

By 1982, total energy supply had declined to 7892 TJ, of which 7271 was delivered to end users. Of this, 1203 TJ or 15% was provided locally, 963 TJ in the form of hydro-electricity and the remainder in the form of wood. Approximately 85% of total energy supply was imported refined petroleum products. This reduction in the share of indigenous supply between 1978 and 1982 was due to the cessation of the use of coal with the closing of Cyprus Anvil and to some reduction in the use of power on the grids, also due to the reduction in mining activity.

By 1985, total energy supply is estimated to have further declined to 6090 TJ, 5847 of which was delivered to users. Of this, 1194 TJ or 20% was indigenously produced (839 TJ of hydro, 355 TJ of wood) and the remaining 4896 TJ were imported. Detailed information on the pattern of demand by sector in 1985 would be required to determine the reasons for the further drop in supply from 1982 to 1985. Since many demographic factors were relatively constant through this period, it may be largely due to further significant reductions in mining output and the penetration of conservation measures.

IMPACT ON THE ECONOMY

(a) Total Expenditures on Energy

Energy prices vary markedly by energy type, sector and location in the Yukon. However based on information provided by Statistics Canada and Marbek, typical prices for each energy type in the Yukon are as follows:

Heating oil, diesel:	$13.00/GJ
Motor gasoline:	17.00/GJ
Propane:	17.00/GJ
Wood:	5.00/GJ
Hydro-electricity:	21.00/GJ
Diesel-generated electricity:	70.00/GJ

Applying these prices to 1985 sales figures indicates that total energy expenditures in that year were some $92.1 million, of which $68.1 million was for refined petroleum products (including propane); $1.8 million was for wood; $16.2 million was for hydro and $6.0 million for diesel-generated electricity. The total import content in these expenditures, including diesel used to generate electricity, was $74.1 million.

Clearly these are significant amounts. On a per capita basis in the Yukon, total energy expenditures were some $3700; the total import content some $2900.

(b) Impact of Energy Expenditures on Yukon Industry

The large expenditures on energy can affect Yukon industry in two ways. For those industries for which energy is a major input, high energy costs may act as a deterrent to economic growth. For those industries which supply energy products or goods and services required by the energy supply industry, the large energy spending can have significant spin-off benefits. That, of course, depends on how much of the spending remains within the Yukon.

(i) Energy Use in Yukon Industry:- In Table 5, direct expenditures[1] on energy per dollar of output are shown for selected Yukon industries. The data are based on estimates developed by Statistics Canada for the Yukon and the Northwest Territories, but given the similar nature of the two economies, the data are probably representative of the Yukon alone.

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(1) Direct expenditures refer to purchases of energy, not including the energy embodied in the non-energy goods and services used by the industry. Direct expenditures understates total dependence on energy, but not as significantly for energy supplied in the Yukon, since much of the energy embodied in non-energy goods and services is purchased and used in southern Canada.

TABLE 5

Direct Energy Inputs per $ of Output[1]

(Cents per $ of Output)

	Fishing, Hunting & Trapping	Mining	Manufact-uring	Construc-tion	Services
Refined Petroleum and Coal Products	.84	3.15	3.38	2.05	1.10
Electricity	.24	2.35	1.27	.25	1.11
TOTAL	1.08	5.50	4.65	2.30	2.21

As shown in the table, energy inputs are particularly important in mining and manufacturing, but in all cases they do not constitute a major component of the value of the output. Even in mining, energy costs are estimated at only 5.5 cents per dollar of output.[2] Thus, it is not clear how important a factor energy is in constraining growth. Other factors may be equally, if not more important. In mining, for example, metal prices will have a much

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(1) These estimates are based on Statistics Canada's 1979 inter-regional input-output table. To the extent energy prices have risen relatively to the price of the outputs of these industries, then the numbers in this table will understate the dependence on energy. This may be particularly relevant for mining given the significant reductions in metal prices in recent years.

(2) Energy costs are, of course, higher relative to total operating costs (as opposed to the total value of output); however, they are still not particularly large. In mining, for example, energy costs are approximately 8.8 cents/dollar of total operating costs. Labour costs, by comparison, account for 37 cents of each dollar of total operating costs.

greater bearing on development than the costs of energy and in construction the basic demand for new buildings will be the critical factor governing the level of activity. Nevertheless, it is possible that high energy costs act as some constraint. Examination of the national I-O table indicates that for most industries energy costs do comprise a larger share of the output value or of operating costs in the Yukon than in the rest of Canada. If these costs could be reduced, development could well be greater or certainly more profitable than otherwise.

(ii) Spin-off from Energy Spending:- In Table 6 the direct and indirect income and employment generated per dollar of expenditure and per GJ of different energy sources (including conservation) are shown. The estimates were developed with Statistics Canada's inter-regional input-output table on the basis of an analysis of the type of goods and services required to develop and provide each energy supply and on the geographical source of these goods and services (Yukon versus non-Yukon).

The impacts vary depending on whether one is considering the impact of capital expenditures (the development of the supply source) or the impact of operating expenditures (annual supply). But what is clear in both cases is that the impact of oil supply (and to a lesser extent diesel-generation) is much smaller that of indigenous supply. For heating oil there is no capital expenditure impact in the Yukon,

TABLE 6

Total Income and Employment Impact Summary

	Capital Expenditure Impacts				Operating Expenditure Impacts			
	Per $ of Expenditure		Per Annual GJ		Per $ of Expenditure		Per GJ	
	Income	Employ.	Income	Employ.	Income	Employ.	Income	Employ.
Heating Oil	-	-	-	-	0.13	2.7	2.06	43
Hydro Electricity	0.51	18.9	83.35	3433	1.22	37.7	2.44	75
Diesel Electricity	0.46	14.7	36.30	1160	0.20	6.3	0.92	58
Electricity Transmission	0.45	12.8	37.50	1065	1.14	30.8	1.90	51
Cordwood	-	-	-	-	1.12	50.3	11.20	503
Windmill	0.24	7.3	46.10	1400	0.88	27.6	3.92	123
Solar HW Heating	0.67	25.8	229.00	8824	1.01	38.8	10.10	388
Insulation	0.67	25.8	5.36	206	-	-	-	-

NOTE:

(1) Income impacts are expressed in dollars per dollar of expenditure and dollars per GJ of energy supply.

(2) Employment impacts are expressed in person-years (or annual jobs) per million dollars of expenditures and per million GJ of energy supply.

Source: Marvin Shaffer & Associates Ltd., The Economic Impact of Selected Energy Sources in Yukon, March, 1984.

and only a limited operating expenditure impact related to distribution. Generally, the impacts of conservation, wood, electricity and other sources are much greater.

Given the large proportion of Yukon energy needs that is supplied by oil, it is clear that energy expenditures provide relatively little spin-off benefits to the Yukon economy. Any shift in supply to indigenous energy sources would have a significant effect in increasing the income and employment supported by energy in the region.

ALTERNATIVES

There are only three basic alternatives that Yukoners can consider to reduce the adverse effects of energy on their economy:

- conservation
- different sources of supply
- more efficient (lower cost) delivery of supply

(a) Conservation

Study after study has indicated that conservation is by far the most beneficial way to reduce energy costs and reduce leakages from the Yukon economy, particularly in the residential and commercial/-institutional sectors. While the costs and benefits of conservation investments vary depending on structural characteristics and current

insulation and energy management levels, the returns are generally quite high. For example, it has been estimated that in the residential, commercial and institutional sectors, for measures ranging from insulation and weatherstripping to zone heating, the average cost per unit of energy saved is about one-half the cost of wood and one-quarter (or less) the cost of refined petroleum products or electricity. In addition, conservation measures have the added benefits of (i) generating local employment and income directly through installation activity and indirectly through respending of energy savings and (ii) reducing adverse environmental impacts associated with displaced fuels such as refined petroleum products, electricity development and wood.

In Table 7, the most important conservation opportunities are described in terms of potential energy savings, cost-effectiveness and barriers. The key points are as follows:

- There is considerable potential for cost-effective space and water heating conservation in the residential and commercial-/institutional sectors. Native housing, in particular, offers large potential because of current low levels of retrofit and the potential for application of higher energy efficiency standards to new housing which may arise from land claims agreements. Savings in the commercial/institutional sector can be achieved through measures to improve thermal efficiency as well as the efficiency of heating and lighting systems.

- There is some potential for conservation in transportation (the single largest energy consuming sector in the Yukon) through more efficient vehicle replacements (i.e., downsizing), driver education and fleet management measures, but potential savings in the Yukon are limited by the large proportion of consumption accounted for by visitors and by driver attitudes and requirements.

- It is difficult to generalize about energy conservation potential in the industrial sector since there is such a diverse range of activities involved. Savings in space heating costs could be achieved by a similar range of measures

TABLE 7

Summary of Energy Conservation Opportunities by Sector in Yukon

Sector/End Use	Most Important Conservation Opportunities	Potential Energy Savings/Participation	Cost Effectiveness / Pay Back Period	Constraints / Barriers	Overall Potential
1. Residential					
a. Existing	- low to high level retrofit of thermal envelopes and HW systems depending on condition and expected lifespan of housing	- significant remaining potential, particularly for Native housing in poor repair	- generally good, particularly in conjunction with renovation activity	- current perception of energy situation and lack of information - front end costs - ineffective delivery mechanisms for Natives	- low to moderate for non Native - moderate to high for Native
b. New	- construction to higher standards - planning re solar orientation	- significant potential particularly for new Native housing resulting from land claim settlement	- good	- same as above.	- high
2. Commercial	- broader range of measures possible for larger buildings - eg. zone heating, fine tuning of central HVAC controls, more efficient lighting	- high potential particularly with owner/operators as in hotels/motels	- generally good, but wide variation among sites	- potential problems for larger buildings during start-up of complex energy management systems - front end costs - lower degree of owner occupation	- high for hotels/motels - n.a. for other commerc types
3. Institutional	- similar opportunities as in residential and commercial depending on size and nature of building type	- good potential, particularly for larger buildings which are new or are undergoing improvements	- similar to commercial	- similar to commercial	- high

Sector/End Use	Most Important Conservation Opportunities	Potential Energy Savings/Participation	Cost Effectiveness / Pay Back Period	Constraints / Barriers	Overall Potential
4. Industrial					
a. Mining	- reduction of peak electricity requirements of digging machinery, utilization of waste heat, optimizing ventilation control systems, improved planning of earth-moving	- insufficient information re site-specific potential and likely participation. Cyprus Anvil has already implemented measures to reduce energy use and peak power requirements	- moderate	- measures to reduce process heat requirements still in experimental stage. - front end costs	- n.a.
b. Other Industries	- replacement of inefficient and inappropriately sized mobile equipment, improved insulation and more efficient operations	- data insufficient on site specific opportunities but likely low potential and participation	- moderate	- front end costs; otherwise insufficient data	- low
5. Transportation	- more efficient operation and more efficient replacement vehicles in the private auto/truck and commercial truck sectors	- moderate potential but participation probably low	- moderate	- front end costs - driver attitudes - large proportion of fuel consumption is by vehicles passing through Yukon	- lower to moderate
6. Electrical Generation					
a. Diesel	- computerized load matching, intermittent charge generating systems, downsizing as replacements are needed	- limited site specific gains possible	- moderate to good	- load matching requires more than one generating set of different sizes - larger intermittent-charging systems not currently ready for application	- low

Source: Marbek Resource Consultants, op. cit.

applicable to the commercial/institutional sectors or utilization of waste process heat. Liquid fuel usage could be reduced for onsite mobile equipment.

- It may be possible to achieve energy savings in the generation of diesel power by such measures as load matching/generator down-sizing or intermittent charge generation systems.

- Barriers to conservation in most sectors include high front-end costs (capital constraints) and lack of knowledge about the user-specific costs and benefits of conservation alternatives.

(b) Different Sources of Energy Supply

Shifting away from high cost, high import content sources of supply, in particular shifting away from refined petroleum products or diesel-generated electricity, would also be beneficial to the Yukon economy. While practical opportunities are limited in the Yukon because of the small size and geographic dispersion of the market, there are a wide range of energy resources available in the Yukon that could in principle substitute for oil.

The development of domestic energy sources as substitutes for imported forms can result in impacts on the surrounding environment which may affect important local economic activities such as tourism or subsistence hunting, trapping and fishing. Hydro, wood or coal resource developments all can have serious localized environmental impacts if not planned or managed properly. The widespread combustion of wood, coal or waste oil can create serious air pollution problems. However, combustion of imported refined petroleum products also has air pollution impacts.

In Table 8, costs, technical and resource constraints, environmental and economic impacts, and other characteristics of alternative energy supply sources potentially suitable for the residential and commercial/institutional sector are shown. Refined petroleum products and conservation investments are shown as well as for purposes of comparison. The key points are summarized below.

- Wood is probably the most promising opportunity as an alternative energy source because it is very cost-effective in space heating uses, and because of the significant direct and indirect economic spin-offs resulting from its use. Wood use in the residential sector has levelled off in recent years, probably due to the inconvenience of handling, storage and use. However, there are still good opportunities remaining for chip-fired systems in commercial/institutional sectors. Chip-fired systems also have lower air pollution impacts.

- The Yukon has reserves of natural gas, oil and propane which are large (in comparison to annual Yukon energy demand) and could be very cost-competitive if developed in conjunction with very large non-Yukon resources, but this is unlikely in the near future. Waste oil may have some potential in space heating application when used in special furnaces.

- Hydro-electricity is another relatively abundant energy resource in the Yukon. New production capacity is not warranted until more cost-effective conservation, load management measures and wood substitution have been implemented. Development of a major new hydro site can be a risky investment because of the small size and inherent vulnerability of the Yukon economy to international fluctuations. Large scale hydro development can have major impacts on other resources and yet creates very minor long term employment. Smaller scale hydro or grid extension will likely be the most cost-effective means of meeting incremental load growth or displacing diesel generation.

- The Yukon has other indigenous energy sources which have only limited potential to displace imported fuels. For example, geothermal may have some potential but cost-effectiveness is very dependent on the site characteristics. Smaller, local deposits of coal have some potential as a heating fuel. Wind and solar are likely to have only very minor application in the near future.

TABLE 8

Residential/Commercial/Institutional Sectors Multiple Account Summary

Energy Source	Average Levelized Cost Per Output GJ (Space Heating)	Technical Constraints / Resource Availability	Environmental Factors	Economic Impacts
1. Conservation - Overall Audit Results	3.70 - 5.20	- front end costs inhibit adoption, particularly in non-owner occupied structures - wide range of returns depending on existing dwelling and measures selected	- reduces environmental impacts of displaced sources	- employment in installa only
2. Natural Gas - Alaska Highway offline purchase	7.80	- Alaska Hwy. line may not be built - other natural gas sources much more expensive (2 1/2 to 7 times more)	- pipeline impacts - 'clean' fuel	- employment in pipeline struction - limited on-going emplo
3. Wood - woodchip boiler - air tight	6.60 - 11.20	- may be high access costs in some communities - inconvenience of use	- high CO and particulate emissions; particular concern in populated areas	- wood harvesting, chipp and management labour-intensive
		- rudimentary delivery/handling systems - safety	- requires proper forest management to mitigate impacts on habitat and water	- local production of wo heaters could be expan - use of local sawmill w would improve their viability
4. Coal - briquettes in small scale burners	14.70	- costs highly variable depending on source of supply; may be more favourable in larger boilers - development costs for small market may be prohibitive - inconvenience of use but less than wood	- ash and sulphur emissions a concern in population centres - environmental impact of coal more localized than wood	- coal mining and distri provides substantial de lopment and on-going er ment

Energy Source	Average Levelized Cost Per Output GJ (space heating)	Technical Constraints / Resource Availability	Environmental Factors	Economic Impacts
5. Heating Oil - existing sources	19.00	- indigenous supplies inaccessible without Dempster oil line - waste oil sources and user requirements to be identified	- air pollution, particularly for waste oil	- existing sources provi limited employment - topping plant in White would provide some on-employment
6. Electricity - existing mix of sources	19.50	- costs from new sources of of supply, diesel and grid extension generally much higher	- flooding impacts site specific - 'clean' fuel	- employment in construc limited on-going emplo
7. Propane - existing sources	25.40 - 27.40	- indigenous sources inaccessible without Alaska or Dempster oil line - safety	- 'clean' fuel	- existing sources provi limited employment - propane pipeline distr tion would provide cor struction and some on-employment
8. Peat	37.50	- based on southern examples - resource exists but problems of extraction in north not known - small scale combustion technology still under development	- water disposal - land reclamation	- labour intensive in extraction
9. Solar - active or passive retrofit	48.40 - 98.20	- likely feasible only for seasonal HW loads and as supplement to other fuels - lower costs possible combining space with water heat - lower passive costs in new structure or for greenhouses	- reduces environmental impacts of displaced fuels	- employment in install - some opportunities to local fabrication of ment

Energy Source	Average Levelized Cost Per Output GJ (space heating)	Technical Constraints / Resource Availability	Environmental Factors	Economic Impacts
10. Diesel Waste Heat Recovery	7.40 - 10.00	- distribution distance - may not meet full heating loads depending on level and coincidence of supply and demand for diesel generation	- negligible	- small initial employment impacts
11. Geothermal	7.30 - 12.10	- generally low temperature resources feasible for freeze protection and space heating with ground water heat pumps - distribution distance - cost effectiveness of heat pumps strongly influenced by local cost of electricity - risk of high exploration and development costs	- limited	- significant development employment but most personnel likely to be outside region

Notes:

(1) Cost estimates are rough, in some cases subject to considerable uncertainty.

(2) Source: Shaffer & Associates, Yukon Energy Inventory and Utilization Review.

From a sectoral/end use perspective, most of the fuel substitution opportunities discussed above are applicable to space and water heating in the residential, commercial, institutional and industrial sectors. Other fuel substitution opportunities in the industrial sector are limited. Co-generation of power and heat (e.g. wood-fired steam boilers in sawmills) offer some potential in the industrial sector and in certain situations may also serve broader community needs. In the electric power industry there may be site specific opportunities to displace or supplement diesel generation with micro-hydro or grid extensions, and on a much smaller scale, with wind. Other potential sources of electric power in the Yukon, including interconnection, coal, large scale wind, wood, municipal waste or solar must be developed at too large a scale to be economic or have serious technical constraints. Transportation offers very little opportunity for fuel substitution, unless Yukon sources of gas, oil or propane are made economic by pipelining of non-Yukon fossil fuels through the Territory.

(c) More Efficient Delivery

While best efforts should be made to conserve energy in the Yukon and to shift away from oil where it is possible and efficient to do so, it is clear that refined petroleum products will always be the most important energy source in the Yukon. There is little opportunity to shift off oil in transportation and oil will still be an important source for purposes of space heating in the foreseeable future.

Electricity too will also likely remain the second most important source of energy in the Yukon. While measures may be taken to use it more efficiently, there undoubtedly will be continuing and growing demand for it.

Thus, while many of the studies of energy in the Yukon have focussed on conservation and interfuel substitution, it would seem that concentrating on the efficient delivery of these important energy sources will become increasingly important in the future.

With respect to refined petroleum products, concern has already been expressed about the high prices paid in the Yukon as compared to other centres, high prices which cannot be explained by transportation costs alone. It may well be the case that more efficient or more competitive delivery of refined petroleum products may reduce the energy costs borne by Yukoners. Also, the impact of price subsidies on heating fuel outside Whitehorse needs to be examined more carefully.

With respect to electricity, again there has been considerable discussion and concern about the rates in the Yukon. Indeed, one of the factors leading to the planned Yukon take-over of NCPC operations in the region relates to concerns about inefficiencies and excessive costs. Once control of NCPC is in the hands of the Yukon it will be very important to analyze all ways in which costs can be reduced for Yukoners. Some measures that clearly warrant consideration

include the provision of small hydro and grid extensions to reduce reliance on diesel (diesel is not only very expensive but provides little spin-offs to the region because of the high import content) and pricing and other measures which will serve to reduce peak demand and allow for a greater capacity utilization of electricity facilities in the Yukon. Such measures could significantly reduce average costs of electricity supply.

GOVERNMENT POLICY OPTIONS

Trends apparent in energy demand and supply over the past several years suggest that conservation and fuel substitution activities in the Yukon are already underway. These trends have undoubtedly been influenced by government programs although it is difficult to determine the extent of this influence. Continued or further government intervention is justified where significant barriers or market failures impede the full penetration of cost-effective alternatives. Such barriers include lack of information or uncertainties with respect to the applicability or feasibility of alternatives, uncertainties with respect to the technology which is unproven in northern conditions, and high front end costs. Industry organization and pricing policy can also have a significant bearing on energy price levels in the Yukon. At the same time, government programs designed to mitigate the impact of high energy costs (e.g. price subsidies) can impede appropriate conservation or fuel substitution behaviour and in some cases may also result in higher fuel prices to the region.

There are a number of government programs available in the Yukon which address many of the barriers to alternative energy investments outlined above. In recent years, several major federal government energy programs in the Yukon have been eliminated and there has been a shift in emphasis from financial incentives to information transfer or project demonstration. Federal programs in the Yukon are primarily aimed at super energy efficient new housing, demonstration of alternative energy projects in remote communities and information transfer with respect to energy management in federal and Yukon Territorial government buildings. Yukon Territorial Government programs include interest-free loans for conservation activities in the residential/commercial sectors, contributions for demonstration/-feasibility studies for energy alternatives in all sectors, and low interest loans for energy development.

Based on a review of past studies and discussions with various government officials, a number of general initiatives are suggested here which might be given further consideration to complement current programs.

- improved conservation program delivery mechanisms for Native people
- further consideration of conservation potential in the transportation sector
- provision of technical advisory services to small businesses
- assess the impact of direct and indirect energy subsidies on energy use and the effectiveness of other government programs (e.g. subsidies for conservation or fuel substitution may be more cost-effective than subsidizing energy use)

- impact of industry structure on prices of imported fuels, a recently proposed Yukon Territorial Government study will be the first step in the process
- assess impact of electricity pricing structure on energy conservation and fuel substitution goals.

SUMMARY AND CONCLUSIONS

Based on the foregoing analysis, conservation measures, substitution of cost-effective Yukon fuels for imported refined petroleum products, and measures aimed at reducing the delivered prices of imported fuels will have the most significant impacts on economic development in the Yukon. These alternatives will increase Yukon incomes directly through user cost savings, as well as indirectly through respending of energy savings and increased spending on local versus imported energy sources. Although less significant perhaps, the competitiveness of Yukon industry and attractiveness to potential investors will also be enhanced.

Trends in Yukon energy consumption in recent years indicate that conservation and fuel substitution is already underway in Yukon, particularly in the residential sector. It is likely that such trends will continue, as a result of market forces and current government

energy programs. Additional government intervention may still be warranted where significant barriers have not yet been addressed and where the broader social benefits in terms of increased Yukon incomes and economic development outweigh the costs of such programs. It does appear that aside from Native housing, more policy emphasis may be warranted in the non-residential sectors and on issues such as the impact of energy subsidies, electricity pricing structure and industry structure on energy conservation, fuel substitution and costs.