A Yukon Discussion Paper

FOR TOMORROW

ENERGY FOR TOMORROW

YUKON COUNCIL ON THE ECONOMY & ENVIRONMENT

A YUKON DISCUSSION PAPER

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PREFACE

*T*his discussion paper has been prepared for the Yukon Council on the Economy and the Environment with the goal of stimulating public awareness and debate of key energy issues in the Yukon. This paper can help determine the goals and values held by Yukon people with respect to the way in which our economy uses energy and to our overall objective of ensuring a sustainable economy.

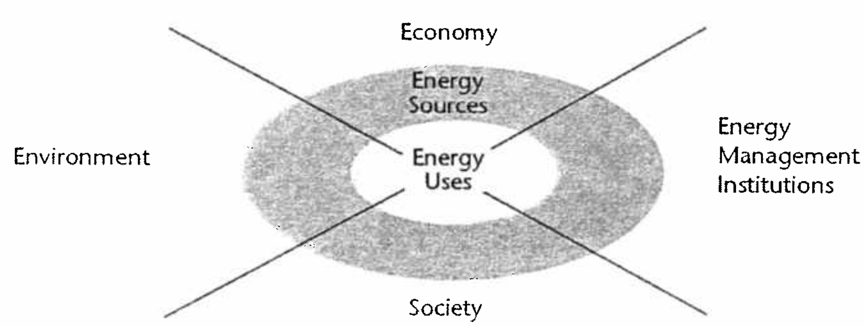
This paper does not pretend to give answers. Yukon people have shown time and again that we are determined and able to provide our own unique answers to the challenges of our unique land. If this paper contributes to that process, it will be by helping to better inform you of the critical energy issues faced by Yukon people and by stimulating our many discussions to come. Don't feel that you need to read the whole document at once. Skip through the sections. Look at the graphs. Find the issues that interest and concern you most. Eventually, you may return to look at other parts. Appendix A has a glossary to help explain terms that may be unfamiliar.

SUMMARY

*H*uman activity involves the use of energy. We rely on it to heat and light our homes and offices, heat our domestic water, cook and refrigerate our food, run our many domestic appliances, power our communications and computing devices, fuel our different forms of transportation, and meet the needs of our industry for heat and drive power.

It is not surprising, then, that just as we may talk of our social system or our economic system, we can also talk of our energy system. The energy system of the Yukon can be defined as its total set of energy sources and uses, as well as the interaction of these with society, the economy, the environment and energy management institutions. Figure 1 shows some of these components of the Yukon energy system.

YUKON ENERGY SYSTEM
Figure one



The character of the energy system in any society is largely a matter of choice. Individuals and their governments make big and small decisions that ultimately determine the energy system they will have. This paper is about choices. It looks at the Yukon energy system and asks questions about how that system reflects our values and our objectives for the economy, the environment and social development. It also looks at what we as Yukon people can do to determine the character of that energy system, to make it work for us rather than against us.

This discussion paper has four sections.

1 ***THE YUKON ENERGY SYSTEM***
2 ***ENERGY AND THE ECONOMY***
3 ***ENERGY AND THE ENVIRONMENT***
4 ***ENERGY AND SOCIETY***

The Yukon energy system is characterized by a substantial dependence on imported refined petroleum products (RPPs)[1]. These products are used to fuel transportation vehicles (gasoline, diesel), for some space heating of buildings (light fuel oil, kerosene) and for generation of about 6% of the territory's electricity (diesel). This dependence makes the Yukon economy vulnerable to changes in world energy prices and drains money from the Yukon economy. As a consequence, individuals, firms and government in the Yukon have encouraged more efficient use of RPPs and their substitution by local energy sources, especially wood and hydropower.

The experiences of recent years have challenged some of our most common assumptions about energy's role in our economy. Yes, cheap plentiful energy supplies can help to contribute to economic growth. But sustainable economic growth may require new thinking about the economic benefits of energy supply projects, because investment in energy conservation[2] can also contribute to economic growth.

* *It reduces the leakage of money from the economy for imported fossil fuels.*
* *It is often more profitable than energy supply investments.*
* *It is easier on the environment than energy supply investments.*

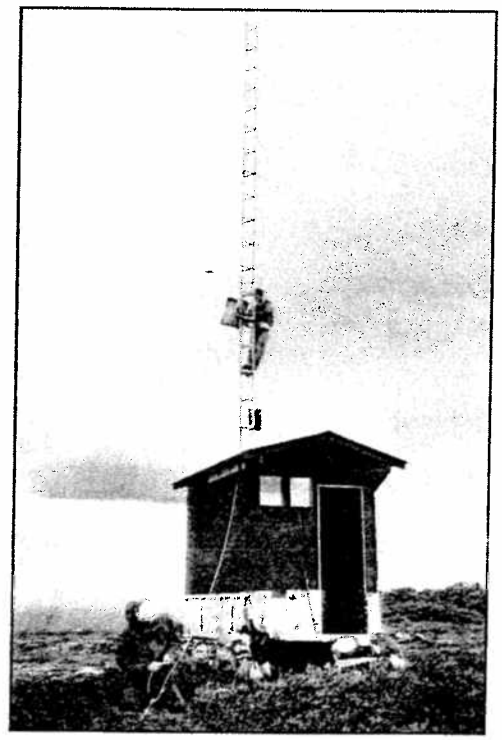
Concern for the environmental impact of energy use has increased significantly in recent years. At issue is the fear that our economic system is not sustainable, either because it is based on exhaustible resources or because it produces pollution that will damage our ecosystem. Our use of energy causes many environmental effects, ranging from local, regional and global air pollution from combustion of fossil fuels, to local land and water pollution caused by their extraction and transportation, especially in sensitive northern environments. Concern for this has led Yukon people to identify and promote energy sources and energy use technologies that are more environmentally friendly. This approach is consistent with the growing public interest in sustainable development[3] as a guiding principle for the Yukon economy.

Finally, what are the social impacts of our energy choices? This concern is all the more important when we recognize that our goals for economic efficiency and environmental protection may, if we are not careful, work against our social objectives. For example, are policies to promote energy conservation reaching all of society, or are they mostly benefitting middle and upper income groups? How can energy policies be designed so that they truly contribute to the self-determination and economic development goals of First Nations in the Yukon? How can energy policies contribute to enabling local communities to better control their destinies, finding the right balance of local resources, imports and exports? What are the social costs of energy megaprojects?

1. THE YUKON AND ENERGY: YESTERDAY, TODAY AND TOMORROW

Operation and Management of the Energy System

For the Yukon energy system, like most others, we can say that energy consumption or demand can be divided into four parts: (1) residential, (2) commercial and institutional, (3) industrial and (4) transportation. Likewise, we can say that supply can be distinguished in terms of the different sources of energy: fossil fuels (coal, oil products and natural gas), solar, biomass (peat, wood, agricultural wastes), geothermal[4], wind, hydropower, and nuclear[5]. Figure 2 illustrates the connections between energy sources and the four sectors of the Yukon economy.



The Boreal Alternative Energy Institute, monitoring wind regimes on Haekel Hill, near Whitehorse

Management of the energy system can involve several different private and public agencies. Traditionally, electricity is treated separately from other energy forms[6].

The Yukon Energy Corporation, which is publicly owned, generates almost 95% of the electricity in the Yukon. Approximately half of this electricity is sold directly to industrial customers, while the balance is purchased by the privately owned Yukon Electrical Company Ltd. (YECL) for resale to individual customers. YECL is responsible for managing the electricity assets of the Yukon Energy Corporation which is regulated by the Yukon Utilities Board.

Yukon Energy Corporation's hydro dam on the Yukon River at Whitehorse.

Responsibilities of the Canadian federal government cover a wide range, including taxation, regulation of oil and gas exploration[7], setting environmental standards, and project assessment.

In the Yukon, energy policy is one of the mandates of the Department of Economic Development, but

YUKON ENERGY SOURCES & SECTORS
Figure two

Energy Sources	Energy Technologies	Energy Sectors: Home	Factory	Shops & Offices	Transportation
Wood	Heat	✓			
Coal	Steam		✓		
Hydrodam (electricity)	Lighting, Refrigeration, Heating, Cooking, Machine drive	✓	✓	✓	
Oil (refined petroleum products)	Heat, Automobiles	✓	✓	✓	✓

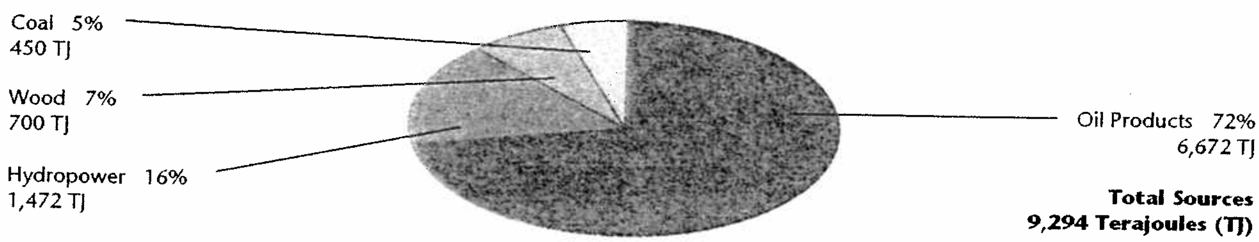
other departments are important. For example,
* residential energy conservation involves urban planning and building codes,
* greater use of wood for heating impacts on forestry and land use planning,
* construction of a hydropower dam embraces management of water, fisheries, and wildlife among other resources.

As a result of the land claims process, new institutions in the Yukon will be developed, including a Surface Rights Board and a Development Assessment Process.

Energy Resources

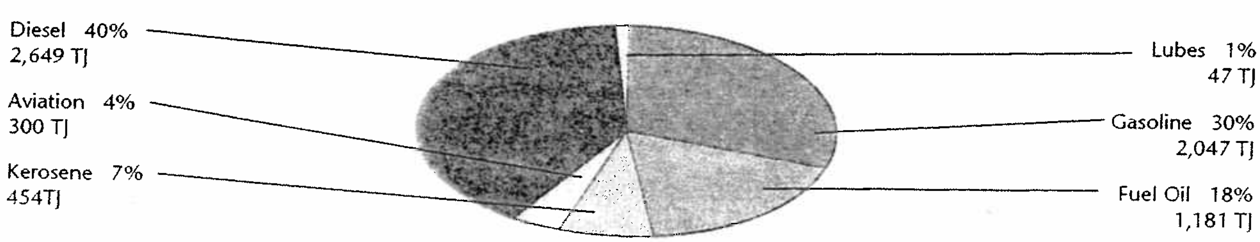
Compared to many regions, the energy supply system of the Yukon is fairly simple. As Figure 3 shows[8], the Yukon depends on primarily four sources of energy: oil, hydropower, wood and coal.

YUKON ENERGY SOURCES 1988
Figure three

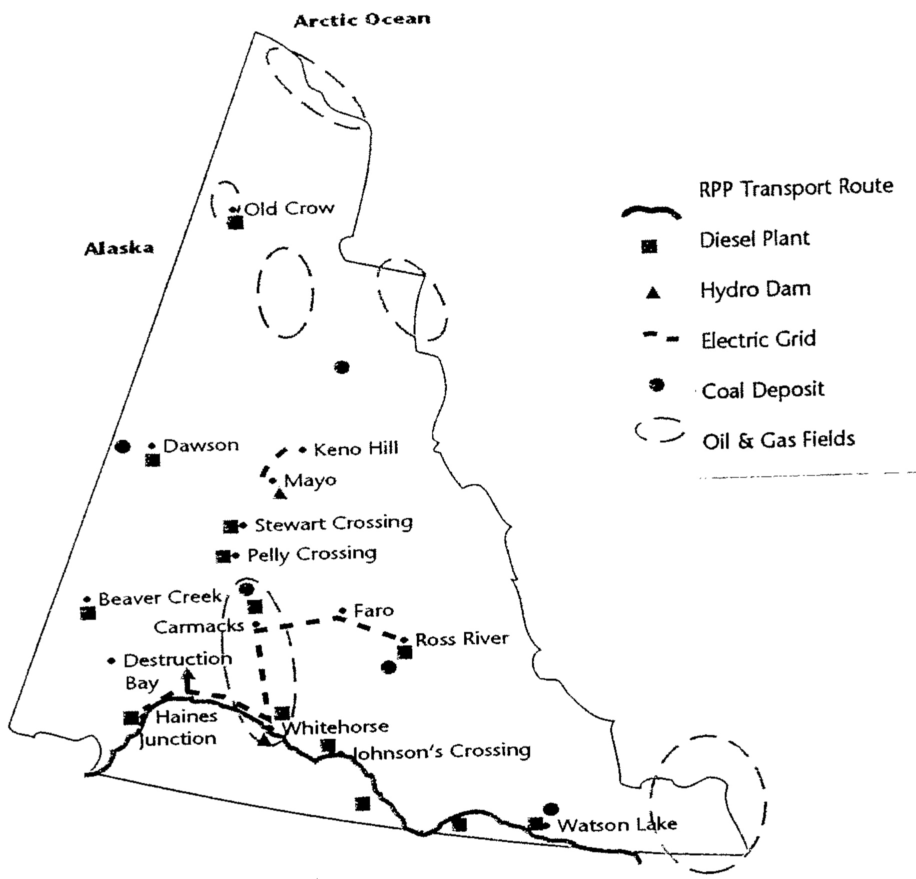


While hydropower, wood and coal resources are local, the Yukon imports all of its oil in the form of refined petroleum products (RPPs), and these account for about 70% of the Yukon energy system. Figure 4 provides a breakdown of the RPPs imported into the Yukon. Much of the light fuel oil and kerosene are used for heating. The diesel is used primarily for transport vehicles, but also to run machinery and to produce electricity in some communities.

YUKON RPP BREAKDOWN 1988
Figure four



It may seem surprising that the Yukon does not use its own petroleum resources. The territory is estimated to have probable oil reserves of 20 to 40 million terajoules (TJ)[9], enough for over 1,000 years at the Yukon's current rate of consumption. But exploitation of this resource would require massive investment in production facilities



and infrastructure. A market as small and isolated as the Yukon could not justify a development of this scale unless the project were driven by export markets, as is the case with Alaska's oil.

The map of the Yukon (Figure 5) identifies the locations of the major energy resources in the Yukon. Major areas of oil potential are the north coastal plain, Eagle Plain, Peel Plain, and possibly the Old Crow Basin.

Figure 5 shows the territory's major energy distribution networks. Two companies account for 85% of the imports of RPPs into the Yukon: White Pass (Chevron) at 48% and Petro-Canada at 27%. RPPs enter the Yukon via two routes: (1) from sea at Skagway (White Pass) and then overland by pipeline to Whitehorse, and (2) by sea to Haines (Petro Canada) and overland to Whitehorse. The remaining sources are trucked in over the Alaska Highway.

The Yukon has large supplies of the other two fossil fuels, coal and natural gas. At the turn of the century, coal was burned to produce electricity in Dawson and Whitehorse, but its only current use is to heat buildings and dry concentrate at Curragh Resources' mining operation. Along with oil, the Yukon's coal reserves far exceed the territory's foreseeable needs.

Although natural gas is not currently used in the territory, the Yukon has extensive resources. Exploitation and distribution to serve the small Yukon market would be expensive. However, it is possible that future pipelines travelling through the Yukon would offer the possibility of service to some communities. A study in 1983 explored the feasibility of serving Whitehorse, Watson Lake and Haines Junction with natural gas from the proposed Foothills pipeline. There is currently some gas exported from the Kotaneelee gas field in the southeastern Yukon, into the British Columbia pipeline system. Renewable energy resources in the Yukon include wood, hydro, geothermal, wind, and solar. The latter three are essentially inexhaustible resources, which although expensive today may one day play an important role in the Yukon energy system. The discussion below focuses on the first two, which have already proven their economic potential in the Yukon.

The Yukon has extensive forest cover. Much of this forest consists of small-sized, slow growing trees for which there is limited potential for lumber production[10]. Use of wood as a fuel can:

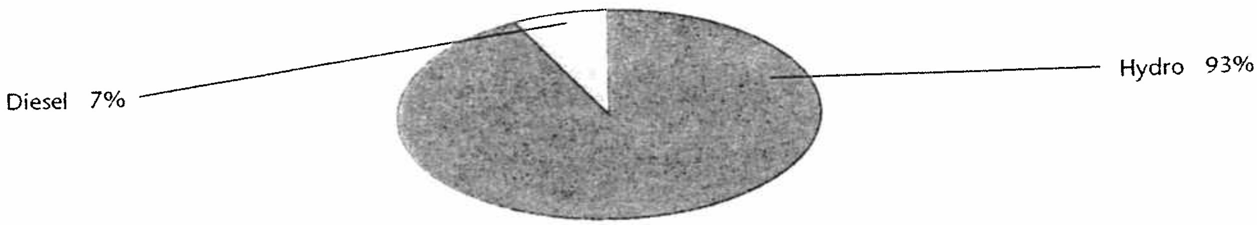
* *provide direct space heat from an air-tight stove or fireplace,*
* *produce hot water in a central boiler for district heating*[11];
* *produce just electricity or cogenerate*[12] *electricity from a wood-fired boiler and turbine.*

While wood is not currently used for electricity production in the Yukon, its use is significant for domestic space heating. Most of this is fire-kill, a resource whose availability far exceeds space heating needs. For example, the burn at Pelly has an estimated 12 million cords, or about an 80 year supply if it were to meet all of the Yukon's heating needs. Of course, accessibility of fire-kill supplies varies from one community to another.

Hydropower currently accounts for over 90% of the electricity production in the Yukon (Figure 6). The Yukon has enormous hydro potential, but many sites have substantial environmental and economic constraints. This is of special concern to the First Nations, with their awareness of the experiences of the Cree People in Quebec with the James Bay Development. Small hydro has special attraction in the Yukon, where many communities are not connected to a large transmission grid, and where the scale of electricity production must be matched to the needs of local communities.


Wood is used for residential space heating throughout the Yukon, and is especially important in the outlying communities.

YUKON ELECTRICITY PRODUCTION 1988
Figure six

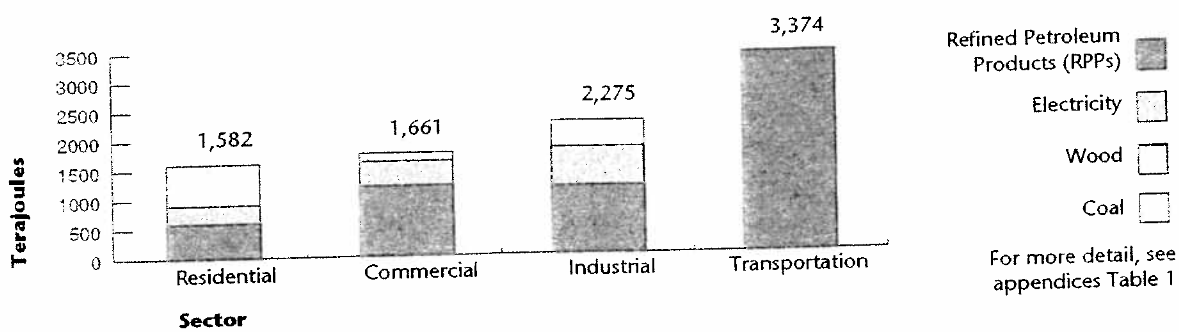


Energy Uses

A study of energy consumption should include detail of energy end-uses (also called energy services) because this is the level where we find many of the key opportunities to affect our energy system. This means that we should look not just at the four sectors of the economy (residential, commercial, industrial and transportation) but also at the end-uses in each of these sectors (space heat, lighting, industrial drive power, etc.)[13].

Figure 7 provides an overview of total energy consumption and energy shares in the four sectors of the Yukon economy. Details are presented in Appendix C. Transportation accounts for close to 40% of total consumption, and this share would be even higher if the sale of transport fuels to industrial plants were included under transportation instead of under industrial. The shares of residential, commercial and industrial are 17%, 18% and 25%. Note that coal is only used in the industrial sector and wood primarily in the residential, while transportation only consumes RPPs.

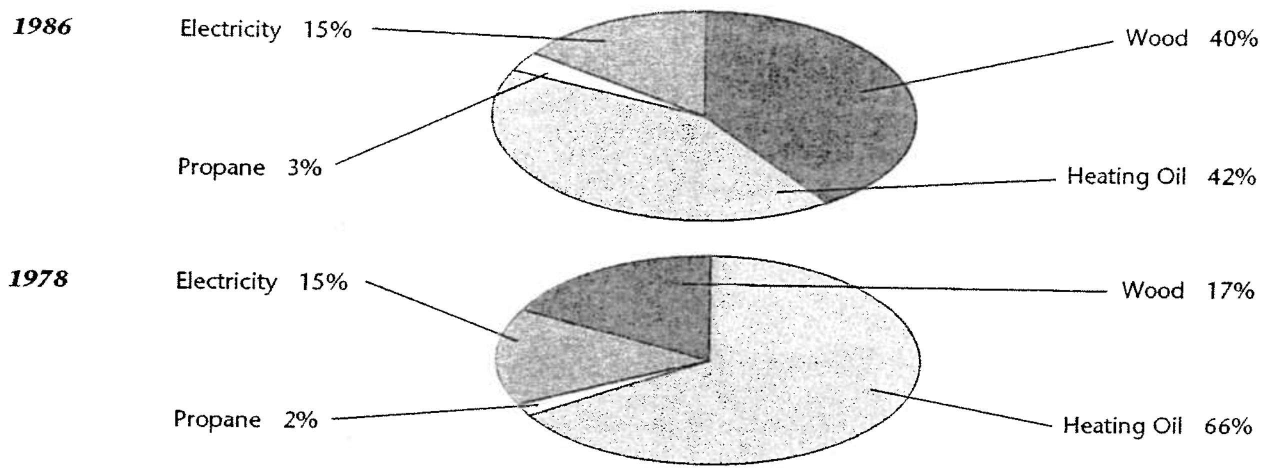
ENERGY CONSUMPTION BY SECTOR
Figure seven



For more detail, see appendices Table 1

The major end-uses of energy in the residential sector are space heat, hot water, major appliances and lighting. Most homes have some potential to use wood for space heating, usually with an airtight stove. Surveys suggest that there has been a gradual substitution away from heating oil to wood for space heat, partly with the construction of new dwellings and partly with greater use of wood in homes that can use either wood or heating oil. Figure 8 shows that while oil was considered to be the primary heating fuel in 66% percent of Yukon dwellings in 1978, this had dropped to 42% by 1986. At the same time, wood's share increased from 17% to 40%. Except for some

YUKON CHOICE OF HOME HEATING FUEL
Figure eight

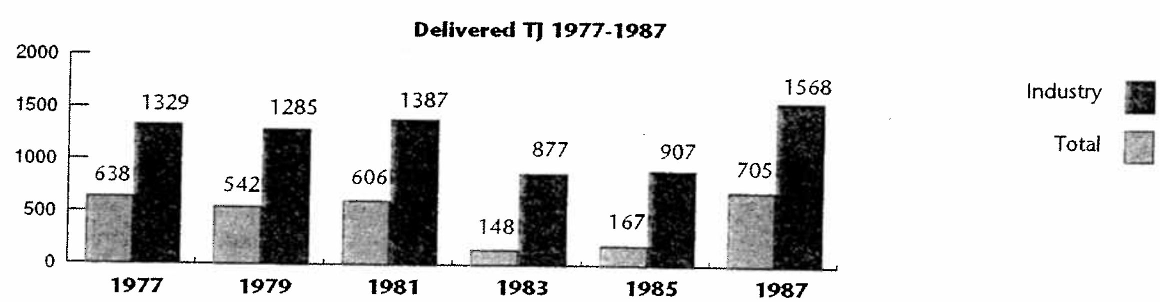


rural use of propane and kerosene, almost all private dwellings consume electricity for domestic water heating, appliances and lighting.

The commercial sector is a broad category, covering all types of retail outlets (hotels, shops, restaurants) as well as offices and institutional buildings (schools, hospitals, government). Major end-uses tend to match those of the residential sector, although appliances are less important. While electricity consumption of the Yukon's commercial sector matches that of the residential sector, there is a greater reliance on RPPs instead of wood for space heating. However, wood for commercial space heating is seen to have considerable potential in the Yukon. For example, a boiler fired with wood chips was installed in the Pelly Crossing school as a demonstration of this alternative energy application.

The industrial sector in the Yukon is dominated by the two or three mines that are open in any given year. The importance of these few industrial establishments presents a challenge for the Yukon electricity system. While the construction of generating plants and electrical grids to serve these industries also benefits nearby communities, the temporary or permanent closure of a mine can have a substantial effect on the electricity supply system. Electrical companies require steady sales in order to maintain interest payments on hydro project debt. Figure 9 illustrates the link between industrial electrical demand and total electrical demand. The dramatic decreases in electrical demand are caused by mine closure.

INDUSTRIAL AND TOTAL ELECTRICAL DEMAND
Figure nine



Unique Aspects of the Yukon Energy System

* If one includes the transport fuels purchased by mines, transportation accounts for almost half of the Yukon's energy consumption. This share, which is far higher than in southern Canada, is explained largely by the extremely low population density and by the relatively high percentage of non-resident Yukon vehicle traffic.

* The importance of transportation helps to explain why Yukon people consume 75% more RPPs per person than southern Canadians. But an equally important explanation is the lack of natural gas, a key heating fuel in most regions of the country. Many Yukon people still rely on RPPs for space heating.

* In spite of the relatively high RPP consumption and cold climate, per person energy consumption of Yukon people is very close to the Canadian average. This is primarily because the Yukon's industrial sector is relatively small.

* In the 1986 Canadian census, 40% of Yukon residents listed wood as their principal home heating fuel compared to only 7% of all Canadian households. This is partly because Yukon people do not live in large cities, but also because of the high cost of RPPs in the north. At 1988 prices, wood heating in the Yukon is estimated to cost about 30% less than heating oil. In contrast, there are few opportunities for switching away from RPPs in the transportation sector, even when prices are high.

* Compared to the rest of Canada, RPPs are expensive in the Yukon. In 1988, the Yukon government commissioned a public inquiry to identify the reasons for this. The inquiry found that both lack of effective competition and high transportation costs caused by limited pipeline access were important. These factors also explain why RPP prices can vary significantly between Yukon communities.

* Yukon electricity is also expensive relative to southern Canada. In 1988, the average cost of electricity for a Yukon customer was 9.18 cents/kWh, but averaged only 5.51 cents/kWh in all of Canada.

* Population growth in the Yukon during the next decade will be much more difficult to estimate than in southern Canada. The opening of a major mine, or construction of a pipeline through the territory would have dramatic effects. In contrast, economic activities like tourism, that do not involve such massive investments, would have a more gradual effect on the population growth rate. In its most recent forecast, the Yukon Energy Corp. projects a 1% annual growth rate for electrical demand in the 1990s.

2. ENERGY AND THE ECONOMY

There are many assumptions about how our economic system is linked to the use of energy. In this section we look critically at some of the more common assumptions and their relevance to the Yukon by posing a series of common questions.

1. Must energy consumption increase to achieve economic growth?

Most people are aware that just as economic activity has grown dramatically in industrialized countries over the last two centuries, so has energy consumption. It is no surprise therefore, that most people assume a strong link between these two.

However, the energy crisis of the 1970s presented evidence to counter simplistic assumptions about the link between a growing economy and increasing energy use. Governments responded to rising energy prices and fears of oil scarcity with policies to switch fuels and conserve energy. As a result, in some countries energy consumption slowed, and in a few cases decreased, even while the economy continued to grow.

There are a couple of reasons for this apparent breaking of the link between energy consumption and economic activity. First, new technologies are significantly improving the efficiency of energy use. Second, some types of economic activity require much less energy per dollar of output than others. Table 1 uses data from 1979 to display the approximate cost of direct energy inputs per dollar of output in different sectors of the Yukon economy. It shows that as the nature of the economy changes so do our energy demands. Depending on which sectors are increasing in importance, an economy could experience a period in which economic output grew steadily while energy demand stabilized or even fell.

TABLE 1
Direct Energy Input Costs per Dollar of Output in the Yukon
(Cents per $ 1979 of Output)

Fishing, Hunting & Trapping	Mining	Manufacturing	Services
1.08	5.50	4.65	2.21

2. Are plentiful, low cost, domestic energy resources essential for economic development?

Plentiful, low cost, domestic energy resources provide one formula for economic growth. These resources can be sold to other regions or countries in exchange for high quality manufactured goods or used as a low cost input to attract energy intensive industry to locate in the Yukon.

However, it is a mistake to assume that cheap and plentiful domestic energy is essential for economic development in the Yukon. Throughout the world there are countries that have achieved a high level of economic development without any significant energy resources.

It is ironic that the Yukon, although blessed with a wealth of unexploited energy resources, imports all of its RPPs, and that these comprise about 70% of the total energy consumption in the territory. Thus, of the over $130 million that Yukon people spent on energy in 1988, $93 million (72%) was for imported RPPs. For some time, there has been concern about the effect of this import dependence on the leakage of money from the Yukon economy and on the economy's vulnerability to dramatic changes in RPP prices.

Of course, it is important to recognize that not all of the $93 million leaked directly from the economy. For example, while the 1988 price of regular unleaded gasoline in Whitehorse was 56.5 cents/litre, 20 cents of that total (35%) went to retailer's margin, transport and distribution, and territorial tax (which was found to be high by the Fuel Price Inquiry). Another 9 cents (16%) was paid in federal taxes. Also, although RPP prices fluctuated dramatically in the 1970s, they are currently no higher than they were at the beginning of that period once inflation is taken into account.

If Yukon residents decide that they wish to decrease their dependence on RPP imports, they must carefully weigh the costs and benefits of different approaches. It may be both economically and technically logical to replace RPPs for electricity generation and for space heating, but not for transportation. If all residential use of RPPs for space heating in the Yukon were replaced by wood, expenditures on RPPs would fall by about $6 million. If RPPs were replaced by small hydro for electricity generation, RPP expenditure would fall by another $2.5 million.

3. Do energy supply projects always create economic growth?

An energy investment project in the Yukon could be one of several types of activities, such as oil and gas exploration and extraction, hydrodam construction, and installation of a wood-fired district heating system. Historically, large energy projects have been seen as a way of stimulating growth in the economy. They are associated with a substantial and highly visible concentration of employment opportunities.

However, the immediate creation of jobs does not mean that a major investment is good for the economy in the long run. For example, the Yukon Government could employ 100 people to dig holes and fill them up again. In the short run, this investment would appear to create economic growth because of the direct jobs in the project and other jobs created when the workers spend their money on goods and services. But in the long run, this project would not lead to economic growth. Somebody must be willing to pay for the product or service provided by a project, and they must be willing to pay enough to make the project profitable, if it is to contribute to long run economic growth.

Profitability of energy investments has become a big issue in recent years. A crisis in the U.S. in the 1980s occurred when several nuclear power plants either had much higher costs of production than expected, or were completed in regions that did not need the electricity. In both cases, the result was unprofitable investments that in the long run decrease the potential for economic growth. The recent investment to rebuild the hydrodam near Mayo in the Yukon may become a similar example. It was built to serve the communities of Mayo and Keno City, and especially the United Keno Hill Mine. If the mine's closure in 1989 is permanent, and if no alternative demand for the dam's electricity is found, investment in the dam, instead of in a profitable alternative venture, will have a negative rather than a positive impact on Yukon economic growth. Even if a transmission line is built to connect the dam to Dawson City, this unforeseen requirement will make electricity from the dam more expensive than originally assumed.

This issue of profitability has been especially important in the debate over supply versus conservation investments. There is a growing consensus that, in many instances conservation can be a more profitable investment from society's point of view. Yet research repeatedly shows that most investment opportunities for energy conservation are not pursued.

4. How can we compare the profitability of conservation and supply investments?

Investments in oil and gas development and in large electrical plants have often been very profitable. However, this is not always the case. Large energy supply projects involve enormous debt and long development periods, leaving investors vulnerable to changing market conditions and interest rates. High interest rates and falling fossil fuel prices in the 1980s proved disastrous for many large energy supply investments.

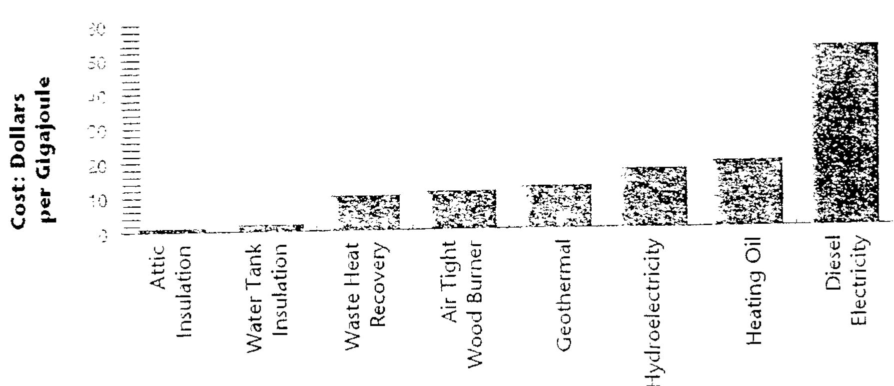
In contrast, investments to conserve energy are smaller in scale and quicker to complete, thereby reducing the risk of changing conditions. Moreover, many of these investments are highly profitable. For example, an investment to improve the insulation in a poorly insulated house in the Yukon may, in some cases, pay for itself by reduced bills for heating fuel or electricity within just a few years. This is also the case for an investment to cover an electric water heater with a thermal blanket.

An energy conservation investment is essentially an alternative to an energy supply investment because it is not the actual consumption of energy that households and firms require, but rather the services that energy-using equipment can provide. The refrigerator provides a simple example. An efficient fridge of say 15 cubic feet may use 75 kWh/month while an inefficient fridge of the same size might use 150 kWh/month. If electricity costs 8 cents/kWh, the efficient fridge saves $6/month or $72 per year. If the efficient fridge costs $216 more than the inefficient fridge, the purchaser would recoup this extra cost in three years from the lower electricity bills. Therefore, this investment in an efficient fridge is the same as depositing $215 in the bank and receiving $72 per year in interest, an interest rate equivalent to 33%.

In both cases, the same level of energy service is obtained, refrigeration at a certain temperature. However, if the inefficient fridge is purchased, the electric utility must provide an additional 900 kWh per year (12 months x 75 kWh) for this one household. When this is extended across all households in the Yukon, and to other uses of electricity, a need is created for more electricity supply investments. For these investments to be more profitable than conservation, they must earn a return greater than 33% when selling electricity at 8 cents/kWh. Few if any electricity supply opportunities in the Yukon are this profitable.

Research throughout Canadian provinces and territories has consistently shown that the most profitable energy investments currently facing Canadians are those which conserve rather than produce energy[14]. This is best illustrated by a least cost graph, a graph which shows the unit cost[15] of either saving or producing energy. Figure 10 illustrates part of the least cost graph for the Yukon using 1983 data. Some of the technologies save energy while others produce it. Each technology has a different unit cost. On this graph, the three most economic investments are all conservation measures: attic insulation, water tank insulation and waste heat recovery.

LEAST COST ENERGY ALTERNATIVES YUKON
Figure ten



Source:
Marvin Shaffer & Associates, Yukon Energy Inventory & Utilization Review, 1983

5. If energy conservation is profitable, how do we make it happen?

If many energy conservation investments are more profitable than energy supply investments, why do households and firms make so few energy conservation investments?

* First, the electrical rate structure is based on average costs, which may be lower than the cost of the next supply option. Therefore, consumers lack an incentive to make investments that are lower cost than the next supply investment but higher cost than the average price.
* Second, consumers tend to lack information about the profitability of energy conservation investments.
* Third, consumers lack money for conservation investments. Compare the average consumer's ability to borrow money for conservation with that of an electric utility or large oil company borrowing money for a new supply project.
* Fourth, in what is generally referred to as the tenant / landlord split incentive, the party responsible for the conservation improvements to a building (the landlord) will often not capture the benefits of lower energy bills.

The combination of these effects results in under-investment in energy conservation. Studies of households and even private firms show that most energy conservation measures are only implemented if they repay the initial investment within about two years.

However, there are mechanisms for governments and utilities to overcome these problems with energy markets. These can be divided into four categories: information, disincentives, incentives and regulation.

* Information includes product labelling, advertisements, demonstration projects and energy audit programs.
* Disincentives involve taxes, hook-up fees or electrical rate structure.
* Incentives are subsidies to cover part of the cost of conservation investments, including grants, rebates and low interest loans.
* Regulation includes things like appliance and vehicle efficiency standards and building codes.

To be effective, information programs need to be backed with incentives, as is the case with the Yukon Government's SEAL (Saving Energy Action Loan) program which serves the commercial sector. It includes both energy audits (information) and no-interest loans (incentives). Disincentives have been found to be at least partially effective in fostering conservation, such as the Yukon's proposed increase in block electricity rate. Customers pay the lowest price for the first 1000 kWh, then the price increases to reflect the higher cost of providing additional electricity. Finally, regulation can be very important in achieving profitable conservation, depending on the energy service. While the Yukon Government can do little to influence appliance and vehicle efficiency standards, it is free to determine the insulation standards of new buildings in the territory.

3. *ENERGY AND THE ENVIRONMENT*

People have different meanings for the term sustainable development. Some argue that there is little if any need to modify our current economic practices. According to this argument, rapid economic growth stimulates the technological advances that are necessary to offset pollution from our economy. Others argue that our current economic system must be dramatically and quickly changed if we are to avoid environmental catastrophe, and that this may require questioning the very notion of economic growth.

However, while it is difficult to achieve consensus, it is nonetheless possible to sketch some of the implications of sustainable development for our energy system. Two key questions are:
* Is the pollution created by the energy system destroying the planet's ecosystem?
* Is there a balance between the rate of availability of renewable energy supplies with our rate of energy use?

Sustainable Energy: How Much Pollution is Acceptable?

It is clear that our economic system should not create pollution by-products that irreversibly damage the planet's ecosystem. This does not mean that all pollution must be eliminated because in some cases the ecosystem may be able to absorb pollutants without harmful effects. For example, the carbon dioxide emitted into the atmosphere from the combustion of fossil fuels (say from your vehicle) is also emitted by human beings when they breathe. Carbon dioxide emissions are only harmful when they exceed the earth's absorption rate. When this occurs, they build up in the atmosphere, threatening to augment the greenhouse effect and cause global warming.

Unfortunately, there are many instances in which our energy system can be very harmful to the environment. Combustion of fossil fuels damages local air quality, intensifies acid rain, and concentrates greenhouse gases in the atmosphere. Transportation and processing of fossil fuels threatens soil, water, plants and animals with contamination from spills and explosions. Nuclear energy threatens large areas of the planet with radiation fallout from accidents. The environmental effects of key

YUKON ENERGY SOURCES & ENVIRON-MENTAL IMPACT
Figure eleven

ENERGY SOURCE	IMPACT SUMMARY
Coal	– loss of land to minesite – soil and water contamination from mine tailings – ecosystem disruption from transport and processing – local air pollution: particulate and other byproducts – regional air pollution: acid rain emissions – global air pollution: greenhouse gas emissions
RRP	– ecosystem disruption from oil exploitation – ecosystem disruption from pipeline construction – ecosystem contamination from transport accidents – local air pollution: particulate and other emissions – regional air pollution: acid rain emissions – global air pollution: greenhouse gas emissions – air pollution less damaging than coal
Natural Gas	– ecosystem disruption from exploitation – ecosystem disruption from pipeline construction – local air pollution: particulate and other emissions – regional air pollution; acid rain emissions – global air pollution: greenhouse gas emissions – air pollution less damaging than coal or RPPs
Wood	– collection of forest residues affects nutrient cycle – dedicated harvesting disrupts forest ecosystem – local air pollution: particulate and other emissions – negligible global and regional air pollution
Large Hydropower	– loss of productive land to reservoir and facilities – disruption of wildlife habitat and migration patterns – disruption of fish habitat and migration patterns – water quality: heavy metal leaching (e.g. mercury) – disruption of downstream wetlands – loss of wilderness aesthetic character of site
Small Hydropower	– some projects may have small impact on fish habitat – loss of wilderness aesthetic character of site
Geothermal	– loss of wilderness aesthetic character of site – some risk to water quality
Solar	– impact depends on technology: most have little impact

energy sources are summarized in Figure 11.

As Figure 11 suggests, there are no easy choices among energy sources. Substitution of wood for fossil fuels to reduce greenhouse gas emissions is only effective if forests are not harvested for fuel faster than their rate of regeneration. Also, wood can create local air pollution problems because of particulate emissions, as is now a concern in Whitehorse. Even hydropower has mixed blessings. It does not have the air emission

An accumulation of wood smoke from residential space heaters in the Riverdale subdivision (Whitehorse).

problems of fossil fuels, but land lost to hydro reservoirs may have high social impacts.

When the consumption of energy creates environmental damage, economists say it has an external cost. For example, by driving your truck to work in Dawson City you emit greenhouse gases that contribute to global warming. When you buy gasoline at say 60 cents/litre, you pay only for the processing and distribution costs, not for any of the present or future environmental damage (external cost) caused by global warming. If the government estimated this cost at about 10 cents/litre and made you pay for it, the price of gasoline would rise to 70 cents/litre. This new price is called the social cost because it includes the private cost and the external cost.

Establishing taxes to indicate external costs is an idea that is rapidly gaining momentum, especially for dealing with the greenhouse effect. Since carbon dioxide accounts for about half of the greenhouse gases, these taxes are commonly referred to as carbon taxes. Carbon taxes have two main effects:
* improve the economics of energy conservation,
* improve the economics of alternatives to fossil fuels, especially to coal and oil.

Although Canada has not yet endorsed carbon taxes, several industrial countries have recently implemented or proposed carbon taxes for their own economy. However, taxes are not the only available policy response to the climate change threat. As noted in Section II, governments can also launch information campaigns[16], provide grants and loans, and enforce tougher emission regulations. The Yukon Government's SEAL and YEAP (Yukon Energy Alternatives Program) work in the same direction as carbon taxes by providing financial aid to energy conservation and the development of alternative energy forms.

The threat of global warming has produced an interesting challenge because of uncertainty about its danger. One way of grasping the problem is to distinguish between no-regrets policies and insurance policies.

No-regrets policies are those that reduce greenhouse gas emissions, but which are economically desirable even if the threat of global warming proves to be unfounded. In other words, these are investments that are justifiable in their own right. For example, in the Yukon there is a wide range of profitable investments to conserve energy or to substitute away from fossil fuels. These range from diesel generator waste heat recovery, to district heating, to better building insulation.

Insurance policies are those greenhouse gas reduction measures that are costly, but which are similar to buying insurance to protect yourself from risk. An example would be government support of microhydro electrical projects in the Yukon. Some of these might be more expensive than diesel electricity, but the extra cost may be worthwhile if, at a later time, dramatic reductions in greenhouse gas emissions are required.

Sustainable Energy: Should We Use Non-Renewable Resources?

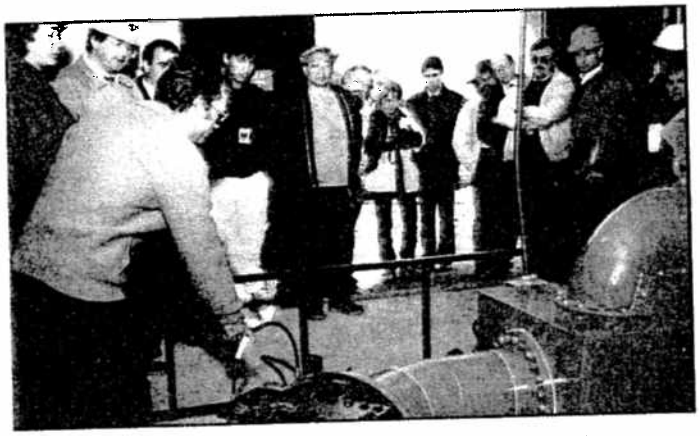
Our sources of energy can be roughly split into renewable and non-renewable. As non-renewable, we count fossil fuels and uranium. As renewable, we count any energy based on the sun (wind, hydro, solar, biomass) as well as geothermal and tidal[17].

The energy system of a Native community in the Yukon, prior to contact with Europeans, would provide an example of an early sustainable energy system based completely on renewable resources. Wood provided thermal energy for heating dwellings, cooking meals, and producing tools and craftwork. Lighting came from burning animal fat or wood. Mobility was provided by human and animal power. Such a community was sustainable because it was based on renewable resources exploited at a sustainable rate, and its waste products were at a level that the surrounding environment could easily absorb.

In contrast, our modern industrial societies are heavily dependent on non-renewable resources. This raises the question of whether or not a sustainable energy system needs to rid itself completely of non-renewable resources.

One might assume that truly sustainable development would be based exclusively on renewable energy sources. However, in a world of changing technologies and costs, one could argue that there is nothing wrong in also using non-renewable resources, if the environmental consequences are not too severe.

For example, if non-renewable natural gas were preferable in every way (economic, environmental, social) to renewable wood for electricity generation, we might decide to use natural gas. As natural gas became scarce, its price would rise until eventually wood generated electricity would be able to compete and gradually take over the market. However, it is important that the energy appetite of this natural gas based society does not evolve beyond the energy capabilities of the renewable replacement.



New ERA Hydro's micro hydro generator, at the Yukon Government's highway maintenance camp, Fraser, B.C.

Some argue that this has already occurred in advanced industrial societies.

If we are to be cautious, we should be looking for opportunities to develop renewable energy sources, especially in those cases where such forms are either close to being economic or help to achieve some other objective. For example, some of the microhydro initiatives in isolated Yukon communities meet objectives to reduce RPP imports, to increase local energy independence, and to move the Yukon energy system closer to a sustainable path.

4. ENERGY AND YUKON PEOPLE: THE SOCIAL EFFECTS

The increased use of energy over the last centuries is associated with a dramatic increase in material well-being. More intensive energy use has allowed us to live in greater comfort, with control over internal air temperature and lighting. It has given us greater mobility. Indeed, every aspect of our well-being, from health care to physical comfort, is associated with energy-using technological advances.

It logically follows that our efforts to achieve economic and environmental sustainability of our Yukon energy system may sometimes be at odds with our social goals. These social goals might include for example:
* self-determination and economic development for First Nations,
* equality of social services to all sectors of society,
* employment creation,
* gender equality,
* decentralization of government services and authority,
* regional development,
* cultural integrity,
* infrastructure development.

In this section we look at some of the ways in which our economic and environmental goals for our energy system may conflict with our social goals. We also look at some of the ways we might counter some of these negative effects. The issues are presented in a question format.

What are the Social Impacts of Large Energy Supply Projects?

The MacKenzie Valley Pipeline Inquiry in the late 1970s significantly increased awareness of the potential social impacts of energy megaprojects in the north. Oil and gas exploration and pipeline construction was especially seen as a threat to First Nations. Not only their culture, but their very means of subsistence, could be threatened depending on the effects of construction activity on the viability of key game species.

The James Bay Project in northern Quebec provides a case history of the northern impacts of another type of energy megaproject, massive hydroelectrical development. In this case, the Cree Natives were not only impacted by construction, but also by loss and disruption of hunting territory and by accumulation of mercury in fish. Concerted resistance to the second phase of this development has grown dramatically in recent years, both in and outside Quebec.

The social impacts of energy megaprojects have been well documented. These include:

* the undermining of traditional rural economies, notably hunting, trapping and fishing,
* a boom and bust economic cycle in local communities,
* disruption of the rural social fabric with the arrival of a transitory workforce,
* cultural deterioration of Native communities.

The growing experience with megaprojects has motivated efforts to reduce where possible negative social impacts. These efforts cover a wide range and include:

* measures to protect traditional rural economies,
* separation of the transitory workforce from the local economy,
* careful extension of community services to meet growing needs without overexpanding,
* transfer of administrative, planning, management and financial powers and resources to First Nations,
* delay or prevention of projects to ensure that they occur only when First Nations and other residents are prepared.

What are the Social Impacts of Efforts to Use Energy More Efficiently and With Reduced Environmental Damage?

Dissatisfaction with the social and environmental impacts of energy megaprojects is a key factor driving us to encourage energy conservation and smaller-scale renewable energy sources. However, we must recognize that our efforts in this direction are not themselves free of social impacts, impacts that we must be aware of if we are to wisely design our energy policies. Some examples are presented here.

* It may be desirable to increase the price of energy either to reflect the high costs of new supply or the external pollution costs (carbon taxes) from using energy. However, lower income groups tend to experience the greatest increases in energy bills because they possess the least efficient equipment and they are least able to make conservation investments to offset higher prices.

* Utility and government energy conservation programs tend to especially benefit middle and upper income groups who have the knowledge and financial resources to deal effectively with bureaucracy.

* Regulations to promote energy efficiency also have effects similar to rising prices and conservation programs. It is lower income groups who are least able to afford the higher cost of energy efficient equipment.

* Government efforts to decentralize management of the energy system may have negative social effects because smaller communities may be less able to acquire the necessary expertise and financial resources.

As these examples suggest, efforts to conserve energy and develop smaller-scale renewable resources can have negative social impacts, unless carefully designed and implemented. Some of the ideas presented below have already been developed by the Yukon Government.

* Lifeline electrical rates ensure a low price for a basic level of consumption, with steep increases to cover the total costs. This is the intent of the Yukon's new electrical rate initiative.

* Some energy taxes can be adjusted to protect low income groups. The Yukon has eliminated the off-road fuel tax in order to help rural people.

* Energy efficiency standards should be followed in the construction of all housing, including public and private housing for lower income people.

* Local control over energy planning must be accompanied by expertise and financial resources. This is a key objective of the Yukon Government's YEAP grants.

APPENDIX A: GLOSSARY

Cogeneration - the use of steam from a boiler to produce first electricity in a turbine and then to provide steam or hot water to some other need, such as an industrial process or space heating of a building.

District Heating - a network of pipes, usually underground, distributing steam or hot water from a central boiler to a space heating system in one or several other buildings.

Energy Services (end-uses) - the ways in which we use energy to make our lives easier. Includes, for example, lighting, cooking, refrigeration, space heating, transportation of people and materials, and industrial process heat.

Energy System - the total set of energy sources and uses, as well as the interaction of these with society, the economy, the environment and energy management institutions.

External Costs - the extra costs from consuming a product that are not included in the market price. A classic example is the air pollution costs that are not included in the price of gasoline. While we may know that these costs exist, they are difficult to estimate.

Heat Pump - an energy device that uses one energy source (usually electricity) to raise or lower the temperature inside a building or appliance. A fridge is a heat pump, as is an air conditioner.

Joule - a measure of energy that allows comparison of different forms of energy in common units. One hundred cords of wood are equal to about 2 TJ. A terajoule (TJ) is equal to 1 trillion joules.

Kilowatthour (kWh) - the common measure for electrical energy, equal to running a 100 watt bulb for 10 hours. One kilowatthour (kWh) is equal to 3.6 million joules.

Least Cost Graph - a graph which shows the unit cost of either saving or producing energy, in an order from least to most expensive.

Refined Petroleum Products - a term for the various consumer products into which crude oil can be transformed. These include gasoline, diesel, kerosene, propane, light and heavy heating fuel, aviation fuel and lubes and greases.

Social Cost of Energy - a price of energy that includes the market price plus all "external costs" (see above).

Sustainable Development - current human activity that does not hinder the opportunity for future generations to achieve a level of well-being equal to what we enjoy today. In other words, "making sure that we have the things we need to live, without hurting the earth"

Yukon Electrical Company Ltd. - privately owned corporation responsible for most electrical distribution in the Yukon.

Yukon Energy Corporation - publicly owned corporation responsible for most electrical generation in the Yukon.

Yukon Utilities Board - public agency responsible for regulating utilities in the Yukon.

APPENDIX B: ENERGY CONSERVATION TECHNOLOGIES

Energy conservation has been noted as an important consideration throughout this document. Here we briefly describe a few of the key energy conservation opportunities in the Yukon.

Building insulation - Much of the energy we use in our residences and commercial buildings is for space heating. Cost-effective improvements in the insulation airtightness of the building shell can reduce energy consumption in today's average building from 25 to 50 percent, and sometimes more.

Hot water blankets - The second most important use of energy in the residential sector is for heating domestic water. A hot water blanket, costing from $30 to $35, can significantly reduce heat loss from the hot water tank, thereby reducing the use of electricity (or propane) to keep the water at the desired temperature. In many cases the energy bill savings repay the initial cost of the blanket within two years.

Energy efficient windows - Most buildings lose a significant amount of heat through windows. Even double-paned windows have an insulation value only about one tenth (R2 to R3) that of typical wall insulation in the Yukon (R20 to R30). However, recent innovations in window design are significantly changing this situation. Specially coated, triple-paned windows, with argon gas between the panes, achieve an insulation value of almost R8.

APPENDIX B: ENERGY CONSERVATION TECHNOLOGIES CONT.

Efficient appliances - Electric utilities throughout North America now run conservation programs in which they use advertisements and subsidies to encourage consumers to purchase more efficient appliances. For example, the Yukon Energy Corporation offers low-flow shower heads at a discounted rate in efforts to reduce electricity consumption.

Efficient furnaces and wood stoves - Improvements have also been achieved in the design of furnaces (oil, propane, natural gas) and air tight wood stoves. Efficiency can be improved by 10 to 15%. For wood stoves, greater efficiency usually is associated with a reduction in particulate emissions, thereby reducing local air pollution.

Efficient lighting technologies - Most electric utilities in North America are also running various programs to encourage more efficient lighting technologies, including compact fluorescents, lighting reflectors and lower wattage fluorescent lights.

Automatic control systems - Many technologies are emerging which reduce the use of electricity through automation. Examples are timers on car block heaters and security lights, and motion detectors for outdoor lights.

Variable speed drives - In industry, electricity is primarily used by electric motors in mechanical systems that grind and move material, pump liquid, and blow or compress gas. Recent research shows that more efficient electric motors connected to variable speed drives can reduce the electricity required for these tasks. Again, electric utilities throughout North America have programs, including subsidies, to help encourage industry to acquire these more efficient technologies.

Fuel-efficient vehicles - The average fuel-efficiency of the vehicle stock (trucks and cars) in North America increased significantly in the late 1970s and early 1980s, as energy prices rose and governments set efficiency standards. Continued research has led to the development of prototype vehicles with yet further dramatic efficiency gains. Most experts agree, however, that mass production of these vehicles will only occur if energy prices rise again or government sets higher fuel-efficiency standards.

APPENDIX C: ESTIMATED YUKON ENERGY CONSUMPTION

TABLE 1
ESTIMATED YUKON ENERGY USE (1988)
In Terajoules

	RPPs	Coal	Elect.	Wood	Total	%
Residential	600		352	630	1582	17
Commercial	1200		391	70	1661	18
Industrial	1175	450	647		2272	25
Transport	3374				3374	37
Unallocated			191		191	2
Total	6349	450	1581	700	9080	100
Percent	70	5	17	8	100	

Notes
1. Wood estimate is from the 1987-88 heating season.
2. RPP breakdown for industry, commercial and residential is only approximate. Motive fuels sold direct to industry are counted in the industrial category.
3. Commercial sector includes institutional.
4. Electricity converted at a ratio of 1 MWh = 3.6 GJ.
5. Diesel consumed by electric utilities to generate electricity (323 TJ) is subtracted from the RPP total to avoid double counting.

FOOTNOTES TO TEXT

1. Refined petroleum products (RPPs) is a short term for all the various consumer products into which crude oil can be transformed. These include gasoline, diesel, kerosene, light and heavy heating fuel, aviation fuel and lubricants and greases.

2. The term energy conservation is a misnomer. While energy is always conserved, it may be converted to do useful work at varying levels of efficiency. So when we talk of energy conservation in this paper, we really mean an improvement in the efficiency with which energy does work for us: for example, either improving the efficiency of your home heater or better insulating your house will improve the efficiency with which you use energy to provide home space heating. Appendix B describes some of the energy conservation options available to Yukon people.

3. Sustainable development is defined here as energy systems (and economic activities) that do not hinder the opportunity for future generations to achieve a level of well-being equal to that which we enjoy today. In other words, "making sure that we have the things we need to live, without hurting the earth".

4. Geothermal energy is heat in the form of hot water or steam rising from the earth's interior, such as that found at a hot springs.

5. Biomass, hydropower and wind are actually forms of solar energy. Even fossil fuels were produced from solar energy, although they are now used at a rate thousands of times faster than the pace at which the sun can reproduce them.

6. Electricity is not a source of energy, but a form into which energy sources (fossil fuels, solar energy, nuclear power) can be converted to better serve our needs.

7. Although administration of oil and gas is being passed to the Yukon government via the Northern Accord.

8. The year 1988 is used in all graphs because this is the latest year for which full data is available.

9. A terajoule (TJ) is equal to 1 trillion joules. A joule is a measure of energy that allows comparison of different forms of energy in common units. One hundred cords of wood are equal to about 2 TJ. The total annual energy consumption of the Yukon is about 9,000 TJ. A gigajoule is equal to 1 billion joules.

10. This wood could be used for pulp and paper production, if such an operation in the Yukon were desired and could be internationally competitive.

11. A district heating system is a network of pipes, usually underground, distributing steam or hot water from a central boiler to a space heating system in one or several other buildings. The Champagne-Aishihik First Nations recently constructed a wood chip-fired district heating plant.

12. Boiler-turbine units that co-produce hot water (or steam) for one purpose as well as electricity are referred to as cogeneration systems.

13. Because the last in-depth research on the end-uses of energy in the Yukon was completed in 1983, we rely on educated guesses for estimating the current consumption for energy end-uses.

14. It is important to note that conservation is currently the most economic investment. As the investment potential in conservation is exhausted, we could move to a situation in which supply investments were once again the cheapest option.

15. Unit cost is simply operating cost plus annual capital cost, divided by energy saved or produced. Using the same annuity formula as a life insurance company, capital cost is converted into an annual capital cost for this calculation.

16. This is the main thrust of the federal government's Green Plan for dealing with the climate change threat.

17. The definition of renewable and non-renewable depends on the application of a human time scale. In cosmic time, our solar energy source will end with the death of the sun in about 5 billion years. On a shorter time scale, geothermal energy is destined to reach exhaustion, although some geothermal sources will endure several thousands of years.