Oil & Gas

Each of the two wells in the Kotaneelee gas field produces the equivalent of all of the energy used, by everyone, for everything, in the Yukon. Yukon Government photo.

This article is part of a series of publications, prepared for the Cabinet Commission on Energy, on the Yukon's energy resources. It provides an overview of the extent of the Yukon's oil & gas resources and the factors affecting their development. It is intended to encourage responsible investment and to stimulate informed debate among representatives of industry, government, and members of the community. Appendices of a more technical nature accompany each of the articles in this series. You can obtain copies of these appendices through the

Department of Economic Development
Box 2703
Whitehorse, Yukon
Y1A 2C6

Yukon Economic Development

You can also contact us by telephone at 403 667 5466, or by fax at 403 667 8601.

Overview

The Yukon Government is committed to encouraging the development of local energy resources, as a way to:

- *reduce the outflow of money from the Yukon economy for imported petroleum products;*
- *increase economic independence;*
- *foster the growth of local energy industries;*
- *stimulate employment;*
- *minimize negative environmental impacts of energy development and use; and*
- *lower the cost of energy to consumers.*

Yukoners currently depend on imported refined petroleum products for about three quarters of the energy that they use. That situation could begin to change soon, with the development of a Yukon oil and gas industry.

Canada and the Yukon have signed the Canada Yukon Oil and Gas Accord to transfer the province-like responsibility for oil and gas resources to the Yukon. The Yukon and First Nations have signed a Memorandum of Agreement to work toward the development of a common regime to manage the development of the resource. The Yukon Oil and Gas Act (YOGA) is expected to be introduced during the Fall 1997 session of the Yukon Legislative Assembly following the passage of Bill C-50 by the Federal Government. The new regime will reflect the Yukon context: the climate, the small population, the largely unexplored oil and gas potential, and the limited infrastructure, and will accommodate its unique circumstances and opportunities. Complete devolution of the process for managing oil and gas is targeted for April 1, 1998.

Oil and gas development is not new to the Yukon. During the second world war there were 4 pipelines in the Yukon and a refinery in Whitehorse to supply the war effort. A fifth pipeline was built in the mid 1950s to supply military bases in Alaska, which operated until the 1970s. In the 1960s there was considerable exploration activity, spanning the Yukon north of the Ogilvie and Wernecke Mountains, and in the Labiche area in the far southeast.

continues on page 2

There are untapped gas reserves and sealed wells in the Eagle Plain area of the northern Yukon, and the Kotaneelee gas field in the southeast is currently producing approximately twice as much energy as Yukoners use. Because of its location, close to the gas producing areas of northern British Columbia and the Northwest Territories, the gas from Kotaneelee is piped southward, rather than to be available for use in the Yukon. However, with changes in economics, and in production and transportation technologies, and with the development of new resources, energy from natural gas may one day be available for Yukon consumers. Tests of crude oil production from existing oil wells at Eagle Plain can determine the quantities and flow rates available. This crude oil could be used directly in diesel engines to generate electricity on the main grid or in remote communities. In future it may also be viable to refine some diesel fuel in a small topping plant for use in transport trucks, heavy equipment and furnaces.

The Resource

Historical Use

Pipelines of the Past

In addition to the Westcoast pipeline that carries natural gas from the Kotaneelee field in the southeast Yukon, there have been five other pipelines built in the Yukon. Four of them were built during the second world war as part of the Canol project, and a fifth was built in the 1950s to supply American Air Force bases in Alaska during the Korean War.

The Canol project included construction of 2,575 km of pipeline in four separate systems, over 800 km of gravel surfaced roads and telephone line, 2,400 km of winter roads, 10 aircraft landing strips, 58 oil wells, the upgrading of 2,700 km of water routes, and a 100,000 cubic metre tank farm and refinery in Whitehorse. Crude oil produced in Norman Wells, NWT, was pumped 737 km in a 100 mm (4 inch) diameter pipeline to the Alaska Highway at Johnsons Crossing, and then 192 km in a 150 mm (6 inch) line to Whitehorse. Another pipeline, Canol #2, carried refined products between Whitehorse and Skagway, Alaska via Carcross in a 100 mm line. Canol #3 was a 50 mm pipeline from Carcross to Watson Lake, and Canol #4 a 75 mm line from Whitehorse to Fairbanks, Alaska. The project was built between May 1942 and December 1943, at a cost of $130 to $300 million.

The Canol pipeline was operated for 16 months and delivered just over 150,000 cubic metres (about one million barrels, not including the nearly 30,000 cubic metres that was unaccounted for). The diesel engines for each of the 10 pumping stations along the route were designed to operate on the crude carried in the line. The pipe was laid on the ground and followed the local topography, possible to do because of the low pour point (-56.7°C) and the low viscosity of the crude oil being transported.

The refinery in Whitehorse consisted of a crude unit and a cracking unit and just over 100,000 cubic metres of storage capacity. During just under a year of operation it produced about 8,700 cubic metres of gasoline (motor and aviation) and 40,000 cubic metres of diesel, or about double the amount required to supply military needs between Watson Lake and Fairbanks.

The Canol #2 pipeline from Whitehorse to Skagway was built on the right-of-way of the White Pass and Yukon Route railroad, and operated between 1943 and the early 1990s, first by the U.S. Army and later by White Pass.

The 50 mm Canol #3 from Carcross to Watson Lake was completed in July 1943 and transported mostly gasoline. Canol #4 from Whitehorse to Fairbanks was a 75 mm line with 15 pumping stations, and transported refined petroleum products into the mid 1950s, at which point it could not keep up with the demand for fuel in Alaska and the 200 mm (8 inch) pipeline was built from Haines, Alaska, to Fairbanks, following the Canol #4 right-of-way from Haines Junction to Beaver Creek.

With the exception of the Skagway to Whitehorse section of pipeline which was operated until the 1990s, the Canol project was abandoned on economic grounds shortly after the end of the Second World War. Annual maintenance costs for the road and pipeline were estimated at $11 million, and the project could not compete with oil brought to Skagway via tanker. The refinery in Whitehorse was sold to private interests, dismantled, and moved to Leduc, Alberta.

Construction of the 1,000 km long, 200 mm (8 inch) diameter pipeline from Haines to Fairbanks began in early 1954 and was completed by October 1955, at a cost of approximately $45 million, including docking facilities at Haines. Built as a multi-product line, transporting diesel, jet fuel, gasoline, lubricants, antifreeze and solvents, beginning with 5 pumping stations with a capacity of 2,600 cubic metres per day, it was soon expanded to 4,400 cubic metres per day by the addition of 12 more pumping stations. The pipeline was operated for 17 years until 1971, when changing military technologies reduced demand for fuel in Alaska, and the need for major repairs on the pipeline made its continued operation uneconomic. It has since been abandoned and portions of it sold and removed.

The Yukon's largest coal resources, in the Bonnet Plume basin, were discovered in the 1960s as a direct result of the search for oil. During the 1950s and 1960s oil and gas exploration activity generated considerable employment.

In the 1970s the development of oil and gas reserves on Alaska's north slope generated interest in constructing a large diameter (approximately 1.2 metre) natural gas pipeline to move Alaska gas to markets in the United States. The shortest route, across the northern Yukon and down the Mackenzie Valley, was rejected for social and environmental reasons. A right-of-way was established, and Foothills Pipe Lines Limited was granted permission to construct an Alaska Highway natural gas pipeline following the Aleyeska pipeline route to Tok, Alaska and the Alaska Highway thereafter to Alberta. The main pipeline was not built, although a prebuild section was built to export Alberta gas south to the United States. Another option for transporting Alaska north slope gas to market is the proposed Trans Alaska Gas System (TAGS), to move gas to Valdez, Alaska via pipeline and thereafter by LNG (liquid natural gas) tanker.

Potential Oil & Gas Basins Identified to Date

The Yukon is relatively unexplored and its oil and gas potential is largely untapped. The sedimentary basins of the Yukon comprise a part of the sedimentary basin that extends from Prudhoe Bay, through Alberta to Texas and beyond.

Discovered resources of 14.4 billion of an estimated 85 billion cubic metres of natural gas are located in the Liard Plateau and the Eagle Plain Basin. The discovered gas resources represent approximately 60 times the total energy used in the Yukon each year. The other six basins have not yet been assessed.

Natural gas, 1.3 million cubic metres per day, is produced from two wells in the Kotaneelee field located at the far southeast corner of the Yukon in the Liard Plateau. The gas is exported through the Westcoast Pipeline via Fort Nelson to southern markets. Its energy content is equivalent to approximately double the Yukon's total energy consumption. Approximately $1.8 million in royalties is collected annually from this gas production.

In the Eagle Plain Basin, the discovered oil resources of 1.5 million cubic metres represent 20 times the energy equivalent of the diesel and light fuel oil used in the Yukon each year for transportation, construction, electricity generation and space heating.

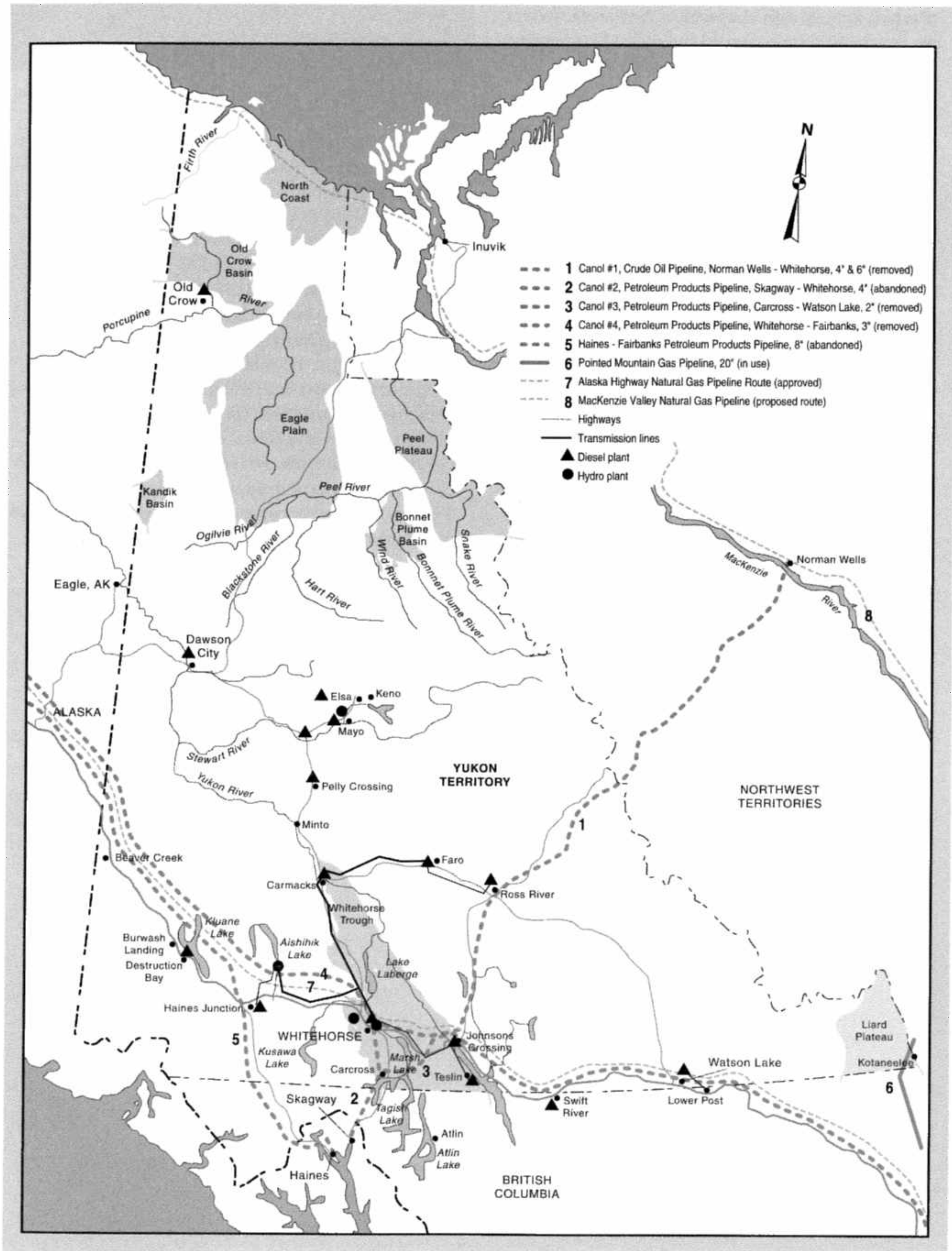
To date only 71 wells have been drilled in the Yukon, mostly during the oil and gas exploration boom of the 1960s. The majority of these wells have been

What is Natural Gas?

Natural gas is primarily methane, but it normally contains varying amounts of other light hydrocarbons of the methane or paraffin series. A methane molecule (CH_4) has one carbon atom and four hydrogen atoms. The paraffin series is a group of hydrocarbons with the formula C_nH_{2n+2}. The next, then, in the series is ethane, C_2H_6, which is also normally a gas, and is used for feedstock for various plastics, for example, polyethylene. We are familiar with propane, the third member of the series, C_3H_8. Propane is a gas under normal conditions, although it is easily kept as a liquid at normal temperatures under a few atmospheres of pressure, and becomes liquid at -40°C at atmospheric pressure. Butane C_4H_{10} is a gas at temperatures above freezing.

Natural gas also contains varying amounts of carbon dioxide (CO_2), water vapour, and sour gas or hydrogen sulphide (H_2S)—see sidebar. These impurities are normally removed at the gas plant before being transported by pipeline.

The heavier methane series hydrocarbons are found in crude oil. Pentane, hexane, heptane, and octane (C_8H_{18}) and so on to about C_{12} are used in varying amounts to make gasoline. Heavier still, cetane, $C_{16}H_{34}$, from the Latin cetus, meaning whale, is a major component of diesel fuel.


N
1 Canol #1, Crude Oil Pipeline, Norman Wells - Whitehorse, 4" & 6" (removed)
2 Canol #2, Petroleum Products Pipeline, Skagway - Whitehorse, 4" (abandoned)
3 Canol #3, Petroleum Products Pipeline, Carcross - Watson Lake, 2" (removed)
4 Canol #4, Petroleum Products Pipeline, Whitehorse - Fairbanks, 3" (removed)
5 Haines - Fairbanks Petroleum Products Pipeline, 8" (abandoned)
6 Pointed Mountain Gas Pipeline, 20" (in use)
7 Alaska Highway Natural Gas Pipeline Route (approved)
8 MacKenzie Valley Natural Gas Pipeline (proposed route)
Highways
Transmission lines
Diesel plant
Hydro plant
North Coast
Inuvik
Old Crow Basin
Old Crow
Porcupine River
Firth River
Eagle Plain
Peel Plateau
Peel River
Kandik Basin
Ogilvie River
Blackstone River
Bonnet Plume Basin
Wind River
Bonnet Plume River
Snake River
Hart River
Eagle, AK
Norman Wells
MacKenzie River
Dawson City
Elsa
Keno
Mayo
ALASKA
Stewart River
Yukon River
Pelly Crossing
YUKON TERRITORY
NORTHWEST TERRITORIES
Minto
Beaver Creek
Faro
Carmacks
Ross River
Whitehorse Trough
Kluane Lake
Burwash Landing
Destruction Bay
Aishihik Lake
Lake Laberge
Haines Junction
WHITEHORSE
Johnsons Crossing
Kusawa Lake
Marsh Lake
Carcross
Teslin
Watson Lake
Liard Plateau
Kotaneelee
Skagway
Tagish Lake
Swift River
Lower Post
Atlin
Atlin Lake
Haines
BRITISH COLUMBIA

What is Crude Oil?

Crude oil is a general term for liquid fossil hydrocarbons, and is used interchangeably with the term petroleum, from the Latin "rock oil". It is a mixture of pentanes and heavier hydrocarbons. Lighter hydrocarbons, ethane, propane and butane, are commonly referred to as natural gas liquids. Crude oil will generally contain other materials: natural gas, CO_2, sulphur, water and salts, in composition that varies greatly from field to field.

The density of crude oil is expressed as a number of degrees on the API (American Petroleum Institute) scale, the higher the number the lighter the crude. Water is assigned an API rating of 10°. Light crudes have an API higher than 32°, and condensates can be higher than 60° API. Medium crudes are in the 22° API to 31° API. Canadian pipelines generally require at least a medium crude. Heavier crudes must be blended with condensate or NGLs (natural gas liquids) to be shipped by pipeline.

Light crude yields a higher percentage of desirable well-priced products such as gasoline, compared with heavier crude, and therefore commands a better price. Also, since it requires less energy to transport, pipeline tolls are reduced.

The term "conventional oil" refers to crude produced by natural flowing or by pumping. Secondary or enhanced recovery involves pumping, and increases production beyond what can be recovered conventionally. Secondary recovery involves injecting water, carbon dioxide, or solvents into the reservoir to stimulate production.

Bitumen refers to petroleum so heavy or viscous that it will barely flow unless heated or diluted. The National Energy Board (NEB) estimates that 86% of Canada's ultimate recoverable resource potential of 56.7 billion cubic metres is in the form of oil sands or bitumen, although much of it still cannot be economically recovered with today's technology. Given the large reserves of conventional crude in the Middle East, over 100 billion cubic metres, recoverable at a cost of less than $40/m^3, it is likely to be changes in technology rather than changes in world markets, that will make the development of most of Canada's bitumen resource economic.

The deposits of tar-like viscous bitumen in central and northern Alberta are among the world's largest petroleum resources, in energy content rivaling the conventional oil resources of Saudi Arabia. Recent improvements in technology have made it economic to produce, transport and process some of the bitumen resource into usable petroleum products. Shallow bitumen deposits (oil sands) can be mined by ordinary open pit methods. Bitumen can be produced from deeper deposits by in situ recovery methods including steam injection, solvent injection, and firefloods (injecting oxygen and burning a portion of the resource). Once produced and cooled to room temperature, the bitumen (8° to 12° API) must be diluted with condensate before it can be transported by pipeline.

Heavy crude oils and bitumens can be upgraded to produce a synthetic crude oil similar in quality to sweet light conventional crude. The long chains of carbon atoms in the hydrocarbon molecules are broken into shorter, lighter hydrocarbons by a process known as cracking, involving the use of catalysts, heat and pressure, and the removal of carbon (coking) or the addition of hydrogen (hydrogenating). Sulphur is also removed in the process, and both the sulphur and petroleum coke are recovered as salable byproducts.

Sweet crude means that it contains less than 0.5% sulphur. Producers generally pay a penalty for every 0.05% that their crude exceeds 0.5%, due to the extra processing costs involved.

Crude	API	Refined Products
	60	
Condensate 50+		Naphtha
	50	Gasoline
	40	Kerosene
Light 35-50		Winter Diesel
	30	Summer Diesel
		Light fuel oil
Medium 22-34		Heavy fuel oil
	20	Marine Diesel
Heavy 12-21		Bunker C
Bitumen/Oil Sands 8-12	10	Roofing tar
		Asphalt

drilled in the Liard Plateau and the Eagle Plain Basin. There are six other significant basins in the Yukon with the potential for petroleum reserves. These, so far, have had only cursory exploration.

Yukon Oil & Gas Wells	
Kandik Basin	3
North Coast	3
Eagle Plain	32
Peel Plateau	20
Liard plateau (Kotaneelee)	12
Other	1

How is petroleum found and produced?

Petroleum hydrocarbons are found in tiny gaps in sedimentary rocks formed hundreds of millions of years ago. They are typically in porous rocks under an impermeable layer of rock which prevents them from dispersing and migrating to the surface. The upstream industry faces the distinct challenges of

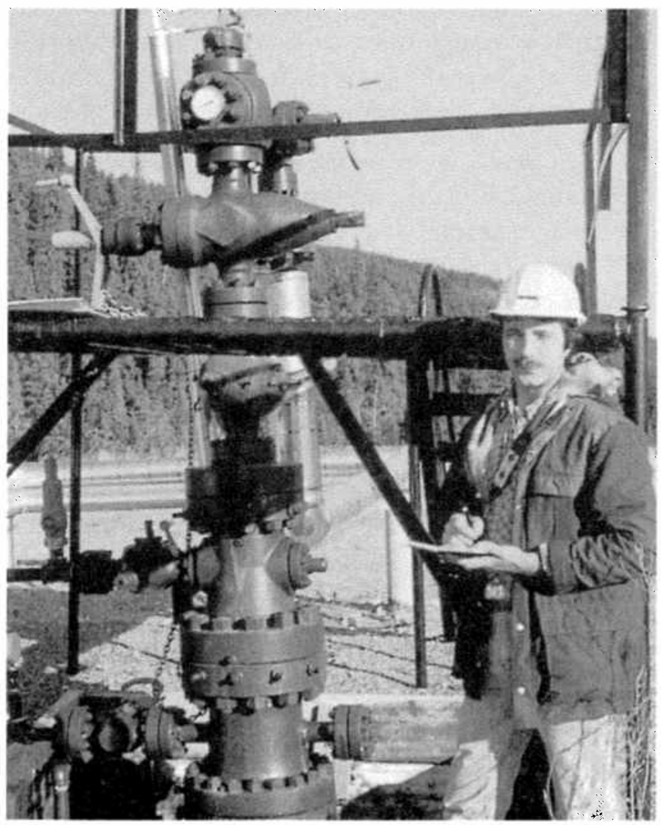
- locating the underground formations that may contain hydrocarbons;
- drilling wells to determine the presence of hydrocarbons;
- encouraging them to flow from the source rocks to the well; and
- bringing them to the surface.

Improved technology has postponed the predicted decline of Canada's hydrocarbon production, and output has actually risen in the 1990s.

The first step, locating the underground formations, involves assembling a great deal of geological and geophysical information. Some may be obtained through geologic mapping, and through gravity and geomagnetic surveys, although most of the information comes from seismic surveys. Seismic crews of between 35 to 200 workers place geophones or jugs in carefully surveyed lines or grids of several kilometres. The geophones pick up the low-frequency sound waves that are generated, normally by explosives buried in shotholes, and reflected from the underground strata. Sophisticated computer programs process, interpret and digitally record the data collected in the survey. Because sound waves travel at different speeds through the different kinds of rock, detailed three dimensional maps can be produced, describing the rocks formations thousands of metres below the surface. When the same grid is used again to monitor changes to a field during production, it is known as four-dimensional (4D) seismic.

Seismic surveys can accurately locate the underground formations likely to contain hydrocarbons, but even in existing producing areas the presence of hydrocarbons can only be determined by drilling. In 1995 some 460 rigs drilled 11,000 wells, an average of 1,000 metres deep. This average well required about 8 days and cost about $400,000. Depths and costs vary of course: shallow wells on the prairies 400 metres deep can cost as little as $100,000; wells in the Rockies as deep as 3,000 metres can cost $4 to $10 million or more. In the Yukon the likely source rocks for hydrocarbons are deep, and therefore drilling costs are expected to be high.

Work on rigs involves lifting and lowering pipe, rotating the drill bit, circulating fluid to remove the rock cuttings, and controlling the pressure in the hole. Drilling also requires services including: trucking, construction, catering and the supply of fuel, specialty



Monitoring wellhead activity at the Kotaneelee Gas Field in the Southeast Yukon (NEB photo) chemicals, food, drill bits, safety equipment, water, lubricants, drilling mud, tools, and technological services. Many other specialized services are provided by contractors, including logging (measuring and recording rock types, and properties including natural and induced radioactive properties, electrical conductivity, or sound transmission characteristics), coring (using a cylindrical bit to remove a core of rock which can be intensively analyzed by geologists to determine characteristics such as porosity and permeability), testing, cementing, pumping, and specialized trucking.

Technology has changed the way wells are drilled, from more durable bits which reduce the cost of drilling a well, to slant and horizontal drilling, which allow access to producing formations located far below sensitive environments such as lakes, and greater productivity by exposing a larger area of the producing formation to the well bore. Some wells use multiple horizontal offshoots. Nearly 10% of the wells drilled in Canada now make use of horizontal drilling. Slimhole drilling refers to the use of small diameter holes, which can provide a lower cost means of accessing primarily mature pools. Drilling muds have become more sophisticated to improve underground performance and reduce environmental impacts. The mud lubricates the drill bit far down the hole, and the weight of the column of mud counteracts the pressure of the oil and gas in the underground reservoirs and prevents uncontrolled release of oil or gas from the well. Drillers can control the pressure by adjusting the composition of the mud. Better downhole monitoring and better blowout protectors have allowed underbalanced drilling, protecting the porous rock in the reservoir from the clogging effects of drilling mud, while at the same time providing protection against the environmental and safety hazard of a blowout.

Completing a well involves installing production tubing to facilitate control and protect the production casing from corrosion. Wells can be completed by

Precise location of sensors is required for seismic surveys. (Yukon Government photo) smaller servicing rigs, which also return to wells to maintain and replace equipment and to enhance production. Completion costs average about $100,000. With production tubing in place, the casing is perforated throughout the producing formation. Often the well is stimulated by hydraulic fracturing (pumping in a fluid at very high pressures) or acidizing (dissolving portions of the producing formation and cleaning out debris, such as drilling mud) to increase the flow from the reservoir rock.

If a well is not deemed commercial, the wellbore is plugged with cement and abandoned, and the site is restored as closely as possible to its previous condition.

New technologies, including more refined monitoring equipment and more sophisticated computer programs, have facilitated the collection and interpretation of data. Wellhead monitoring equipment has allowed automated responses to changes in both reservoir performance and market conditions. The use of coiled steel tubing in continuous lengths of up to 7,000 metres and special equipment for placing it in the wellbore have increased the speed and decreased the cost of completing a well. A modified service rig can even use a combination of coiled tubing and downhole motors to drill horizontal re-entries from existing wells.

Normally, less than a third of the oil in an underground reservoir can be recovered using primarily methods: natural flow, pumping (normally using familiar walking-beam jacks—maybe you've seen the cowboy riding one at the Calgary airport) and infill drilling. Secondary or enhanced recovery involves injecting water or natural gas, or in some cases CO_2 to maintain reservoir pressure. In light and medium crude oil fields recovery can be enhanced through miscible flooding of the reservoir with natural gas liquids, while in heavy oil fields enhanced recovery normally involves heat, through steam injection or in situ combustion. Horizontal drilling has been used successfully in some formations to increase recovery.

Economic Issues

The oil industry is an important source of employment and provides Canada with a degree of economic stability and energy security. Canada accounts for about 2.5% of the world's crude oil consumption, and a slightly higher share of world production.

The petroleum industry is generally divided into two major parts, the upstream or producing sector, and the downstream refining and marketing sector.

Export Markets

The world price of oil has been subject to sudden price shocks several times in the past three decades, usually as a result of conflict in the Middle East. Current crude prices have been approximately $20(US) per barrel or about $125 per cubic metre. Given the cost of exploration, production, and transportation, it is unlikely that Yukon oil will be exported until a large enough quantity is discovered to justify the building of a pipeline, or until the world price reaches new and stable highs.

Oil prices are determined by international demand and supply, a situation that is made possible by the low cost of transporting oil great distances by

Pipelines

In Canada a total of 540,000 kilometres of energy pipelines carry oil and gas from wellhead to domestic consumers and export markets in the United States. Crude petroleum products from the wellhead, which include natural gas (methane), other methane series hydrocarbons (NGLs), crude oil, and impurities such as water and CO_2, are gathered in approximately 200,000 km of flowlines and gathering systems in the producing areas of western Canada and transported to processing facilities.

About 70,000 km of transmission pipelines carry natural gas from processing plants to consuming regions and export points. Typical natural gas mainlines and laterals are constructed of coated steel pipes ranging in size from 0.2 to 1.2 metres (8 to 48 inches) and carry gas that is compressed at up to 100 times atmospheric pressure at a speed of about 40 kilometres per hour. From the mainline, steel distribution pipelines ranging in size from 50 to 600 mm (2 to 24 inches) carry gas to industrial customers, and neighbourhoods, where it is further distributed in 25 mm steel or flexible plastic tubing in home service lines.

tanker. Most Canadian crude oil exports are transported via the Interprovincial Pipe Lines Inc., and Trans-Mountain Pipe Line Company Ltd. systems.

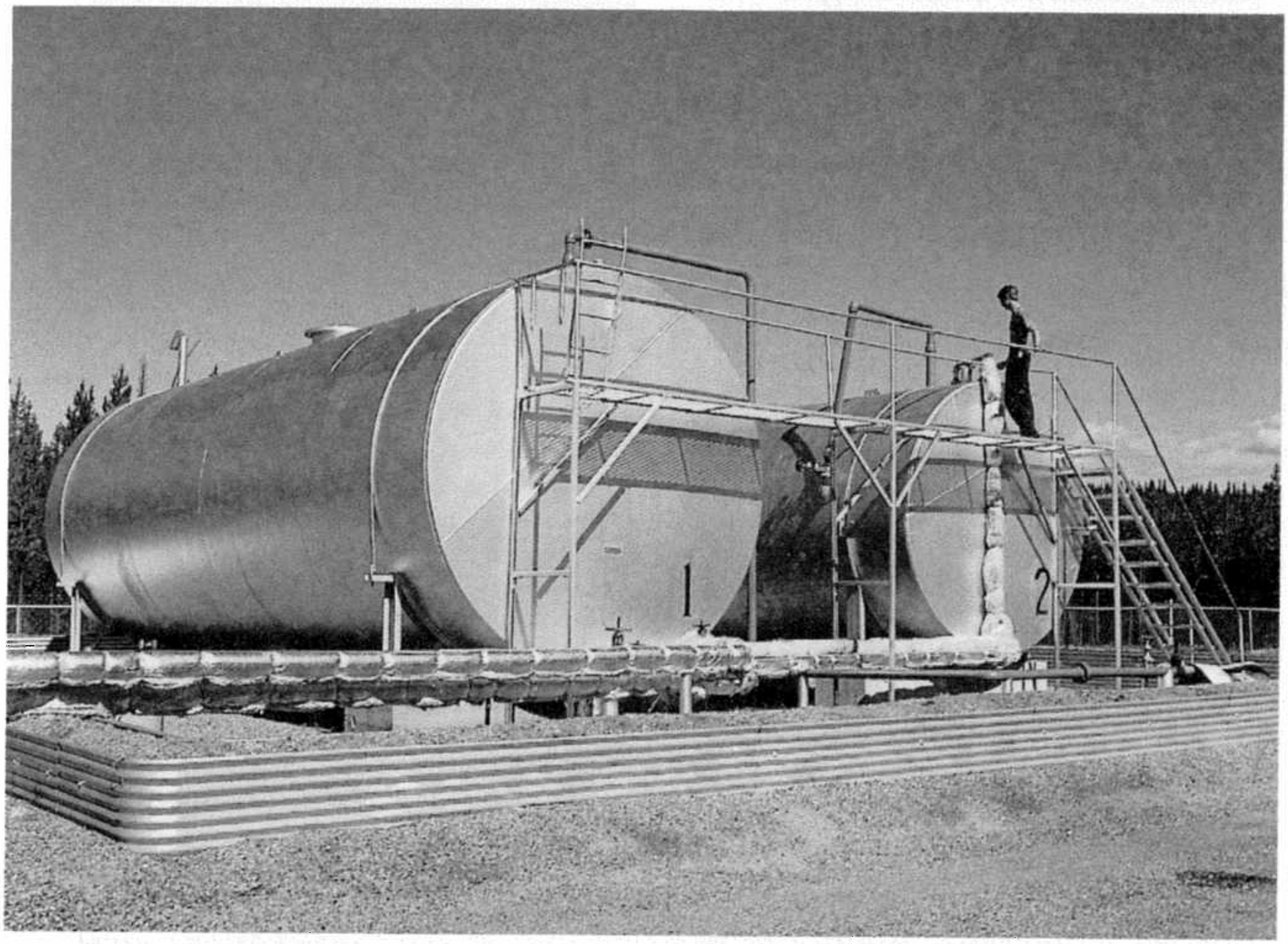
The price of natural gas is determined by recently deregulated North American markets. Canadian exports of natural gas are increasing due to an expanding North American pipeline system.

From a local employment perspective, exploration for oil and gas is a benefit in itself. Rises in world oil prices generate considerable oil and gas exploration activity, which generates employment throughout the service sector.

The cost of transporting a cubic metre of crude oil a distance of 1000 km

Transport truck	$70–90
Pipeline	$4–$12
Double hulled ocean tanker	$2–$6

Natural gas transport via compressed natural gas (CNG) or liquid natural gas (LNG) is used in gas producing areas for short distances, up to a few dozens or hundreds of kilometres, but export from the



These tanks contain enough fuel to generate Watson Lake's electricity for about a week. (Yukon Government photo)

Yukon to the major gas terminal at Fort Nelson by these methods is unlikely in the foreseeable future. Thus, with the exception of current exports from the Liard Plateau, a large discovery or a pipeline coming through the Yukon carrying Alaska gas Alberta would be required to make gas viable from the other potential producing areas of the Yukon.

Local Markets

In this section we will look at a few options for supplying some of the existing Yukon markets for petroleum products with indigenous supplies. While most of the options examined in the past have proven uneconomic due to a combination of small markets and large distances, changes in technology and economic climate indicate that a periodic review of the studies is in order. Options that have been examined in the past include supplying selected Yukon communities with natural gas and propane from sources at Eagle Plain and Kotaneelee, via pipeline, and compressed natural gas (CNG) and liquid natural gas (LNG) transported via truck.

Sometimes our smaller size can work to our advantage too, in that there is room for innovation. The ingenuity and imagination that Yukoners continually employ in adapting technology to meet their needs for transportation and shelter will be a major force in the development of indigenous energy resources to meet local requirements.

The direct use of crude oil in diesel engines has the potential to reduce the cost of the diesel electricity required in remote communities and for meeting winter peaks on the Yukon's electrical grid, and to reduce the

What is LNG?

When natural gas is compressed and cooled to a temperatures of about -160°C it turns to a liquid. Liquid Natural Gas (LNG) is normally stored in vacuum jacketed, superinsulated stainless steel tanks (yes, biiiig thermos bottles) under about 10 atmospheres of pressure. At those temperatures ordinary steel becomes brittle as glass, but extraterrestrial metals are not required: nickel stainless steel, aluminum, and brass are suitable materials for tanks and fittings.

LNG is being used on a large scale to transport trillions of cubic metres of natural gas from Nigeria and the Persian Gulf in tankers to supply pipelines around the world, and has been proposed as a means of transporting Alaskan north slope gas to markets in Japan. The Trans Alaska Gas System (TAGS) would transport gas from Prudhoe Bay via pipeline to Valdez and thence via LNG tanker. On a smaller scale LNG is being developed to supply local markets in Alaska with gas from the Kenai Peninsula.

LNG can be used as a means of storing gas for use in periods of peak demand, and as a portable pipeline to supply consumers in the event of damaged underground pipes or required maintenance. LNG is also being developed as an alternative transportation fuel.

WTI (West Texas Intermediate) refers to a benchmark crude, which is traded on the New York Mercantile Exchange (NYMEX). The value of Western Canadian crude oil is generally determined by the price of WTI at Cushing, Oklahoma, with adjustments for density and sulphur content, transportation, currency exchange, import tariffs, and the US Environmental Superfund levy.

The only oil that has been discovered to date in the Yukon from the wells at Eagle Plain has an API of about 32°, so is known as light crude. The difference in price between conventional light sweet and heavy sour crudes is about $5 per barrel or 30%. The gap tends to narrow in summer when demand is higher for asphalt, which is produced in greater quantities from heavy crude.

Factors that affect the economic viability of crude oil production include:

- changes in world prices,
- technological changes,
- availability of transportation and other infrastructure,
- changes in environmental issues and concerns,
- policies reflecting concern for regional development and energy security.

estimated $130 million annual leakage from the economy due to the use of imported refined petroleum products. About 10% to 15% of the diesel fuel currently brought into the Yukon is used to produce electricity.

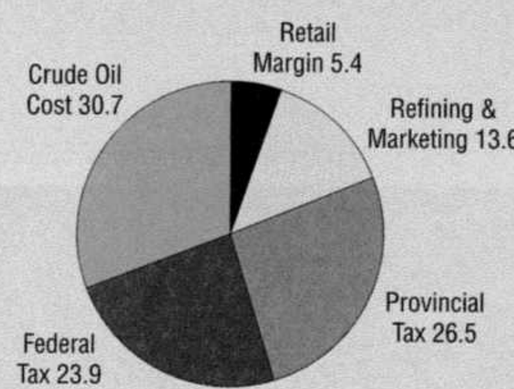
Gasoline

Gasoline is a volatile mixture of liquid hydrocarbons suitable for use in spark-ignition internal combustion engines. Gasoline is formulated from the "light" end of refinery runs and generally contains petroleum molecules having between four and 12 carbon atoms. Gasoline also typically contains small amounts of additives to prevent icing and corrosion and to improve engine performance.

Gasoline prices vary from place to place and from time to time, primarily due to five major factors:

- Competition—Gasoline prices are driven by market forces, not necessarily by costs. Different competitive conditions and marketing strategies usually explain variations in price.
- Taxes—In April 1997, provincial and federal taxes accounted for about 50 per cent of the average price of regular unleaded gasoline in Canada. Provincial taxes vary from a low of 6.2 cents per litre in the Yukon (nine cents in Alberta) to a high of 21.3 cents per litre in Newfoundland. Some areas in Canada also have municipal taxes.
- Refining and marketing costs—Refineries, service stations and other distribution facilities must be upgraded and modernized to meet present and future environmental standards. The distance gasoline has to be transported to market can affect prices, too. Marketing costs also vary from region to region.
- Retail portion—This covers station operating costs such as wages, property taxes, utilities, maintenance and local promotion. Companies

Pump Price Components—Canada Average



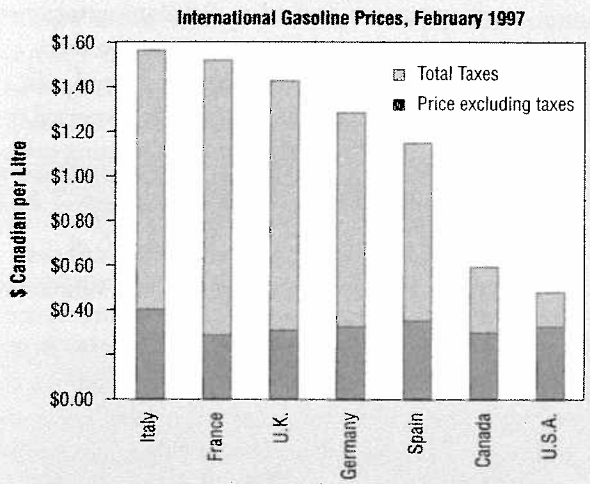
Making Electricity from Crude Oil

Electricity in the Yukon is generated approximately 70% from hydroelectricity. The balance, approximately 100 GWh, is generated from diesel which requires almost 30 million litres of fuel. In addition to supplying increased winter demand on the Whitehorse Aishihik Faro grid, diesel generation is used in several communities that are not connected to the grid.

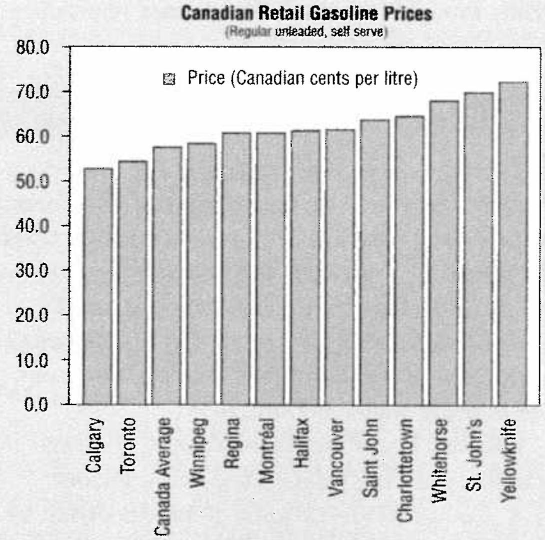
The Yukon Energy Corporation and the Anvil Range Mining Corporation have recently examined the viability of relocating some diesels from Whitehorse to Faro. This option has several advantages: the waste heat, approximately 60% of the energy contained in the fuel, becomes available for use by the mine to heat buildings and to dry concentrates; transmission losses are reduced; and noise and emissions are moved away from the population centre in Whitehorse.

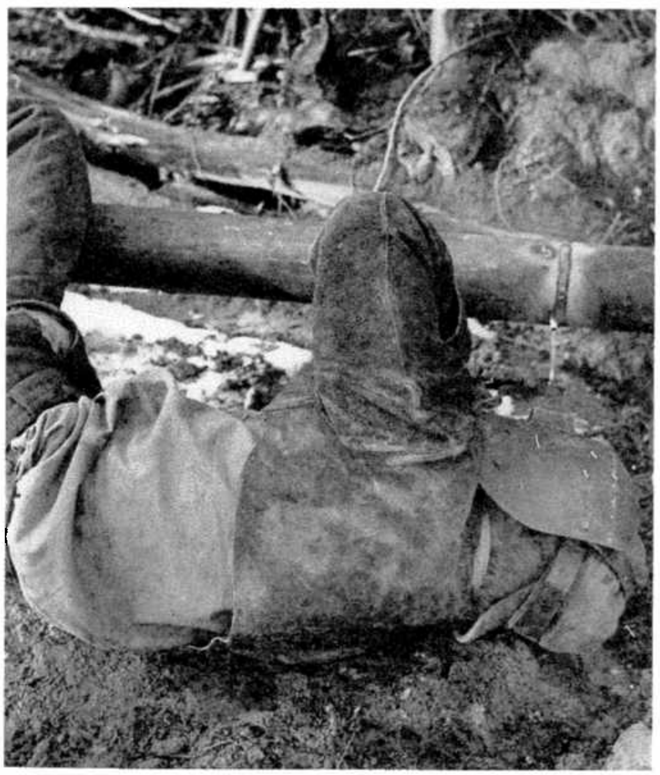
By choosing diesel engines with the right characteristics: slow speed, and adequate fuel filtration and exhaust control systems, crude oil, such as the crude that has been discovered at Eagle Plain could be substituted for imported diesel fuel. The use of crude oil directly in diesel engines has the advantage of eliminating the energy consumed in the refining process, although it carries the disadvantage of higher sulphur emission at the point of use. The concept is not a new one: the diesel engines that pumped crude oil from Norman Wells to Whitehorse in the Canol pipeline were powered by the crude oil carried in the line. If electricity were generated by approximately 10 MW of diesel capacity at the mine, the fuel required could be supplied by a pair of transport trucks making a thrice weekly trip to the supply well during the winter months.

International Gasoline Prices, February 1997



Canadian Retail Gasoline Prices





Welder at work on the Canol project near Skagway, winter of 1942–43. The portion of the Canol pipeline between Skagway and Whitehorse remained in use until the early 1990s. Welding technology has changed considerably over the last 50 years; the need of the oil and gas industry for welders remains constant. (Yukon Archives/Richard Finnie Collection, 81/21, #478)

Can't Tell Cetane from the A-Train?

Gasoline and diesel are rated by octane and cetane numbers, respectively. The cetane number provides a measure of the performance characteristics of diesel engine fuels. It is the percentage of cetane (value = 100) in a mixture of cetane and alpha-methylnaphthalene (value = 0) that gives the same ignition performance as the fuel being tested. The octane rating in gasoline is a measure of the antiknock properties of gasoline, that is, of the evenness of combustion. The octane number is expressed as the percentage, by volume, of isooctane (2,2,4-trimethylpentane) than must be blended with normal heptane until the mixture has the same knock rating as the gasoline under test.

and individual outlets may have to reduce or eliminate their profit from time to time to protect their market share.

- Crude oil costs—Because Canadian crude is priced on the international market, Canadian crude costs are affected by world supply and demand changes, as well as by political events. Crude costs make up about one third of the price of gasoline.

Gasoline prices in an area tend to go up, or down, at the same time due to competition. Many consumers look for the lowest price, so there is enormous pressure on all stations in an area to match that price or lose customers. This is often referred to as a price war.

Gasoline generally costs less in the United States due to tax. In February 1997, state and federal taxes in the United States averaged about 14 Canadian cents per litre, compared to an average 30 cents in Canada. Also in Canada transportation costs are higher because of Canada's low population. Canadian gasoline prices are lower than in many other countries. The graph on page 12 compares international pump prices and government taxes.

Several provincial governments monitor gasoline prices, and Prince Edward Island actually regulates prices of motor fuels. Federally, Industry Canada, and in particular its Bureau of Competition Policy, has the mandate to enforce the Competition Act, the primary purpose of which is to maintain competition in the marketplace.

Numerous techniques are used to increase the octane rating of gasoline. Reformulating involves turning linear hydrocarbon chains into rings, such as benzene (C_6H_6). Oxygenate additives such as ethanol (pure beverage alcohol), methanol (methyl hydrate, a poisonous alcohol which causes blindness and death, also used to de-ice aircraft, and to keep windshield washing fluid and fuel lines from freezing), and MTBE (methyl tertiary butyl ether), can increase fuel performance by decreasing the speed of the burn, thus reducing knock. Lead tetraethyl was once a popular gasoline additive, until its use was discontinued in the 1980s for environmental reasons. Ethanol, like the other oxygenates, helps reduce some emissions from engine exhausts, but can increase other emissions. "Gasohol" is a blend containing up to 10 per cent ethanol. The vapour pressure and boiling point of Canadian gasoline vary considerably from season to season: if the vapour pressure is too high in summer it can lead to vapour lock (the engine cannot get fuel) and too low a vapour pressure in winter makes starting difficult.

These ARE the Good Ol' Days!

If you take account of inflation, you're paying about the same now for gas as you did four decades ago (if you were alive to do it then at all). You bought it in gallons with bigger dollars, and likely you put it in a bigger car that guzzled as much on the way home as your car today uses in a week (okay, you get the idea). Today's fuel, reformulated and lead free, bought at the same real cost as in 1957, provides the same energy service, transportation, at an even lower cost than before. Now to reincarnate an efficient Studebaker.

Additives such as detergents, de-icers and performance-enhancing compounds can be mixed with gasoline at the refinery or distribution terminal loading facility or in the delivery truck. These additives are the principal difference between competing brands of gasoline. Currently, 12 companies operate 21 refineries across Canada. The refineries, which receive crude oil by tanker or pipeline, are sophisticated manufacturing facilities. They use heat, pressure and catalysts to process the hydrocarbon molecules of crude oil into useful products.

Only about one-quarter of the product obtained from a simple refinery run of a typical medium crude oil is gasoline. A refinery can increase gasoline output by additional processing or by purchasing lighter, more expensive crude oils.

Consumers can get more value from their gasoline dollar and also reduce environmental impacts in several ways:

- ensure vehicles are properly tuned and lubricated;

As the carbon number goes up in the methane series, so do the specific gravity and the viscosity; the energy content by weight, the API degree, and the octane numbers, go down. By volume, the higher the carbon number, the more energy. A litre of diesel fuel weighs about 70% more than a litre of propane and contains about 50% more energy.

- maintain tire inflation;
- avoid sudden acceleration and obey speed limits;
- do not leave vehicle idling for long periods
- choose the correct grade of gasoline for engine compression;
- compare fuel efficiency when buying vehicles, and shop around for the best combination of price, quality and service;
- consider the broad range of alternatives that may allow you to drive less: take a bus, carpool, bike, ski, walk, telephone...

Large, heavy vehicles with many accessories will use more fuel than smaller, lighter vehicles with fewer accessories. Newer models of all vehicles will use less fuel than older models.

Natural Gas as a Transportation Fuel?

Natural gas is becoming a popular transportation fuel for fleets of taxis and urban delivery vehicles because of its low cost, its contribution to longer engine life, and its clean-burning characteristics. To date most vehicles have operated on compressed natural gas, which suffers from the disadvantages of short cruising range, limited refueling stations, and vehicle cost. To address these disadvantages, some fleets are experimenting with the use of liquid natural gas (LNG). There are two key factors to the expansion of the use of LNG-fueled vehicles: the development of fueling infrastructure, and the development of an engine with satisfactory performance and good exhaust emissions that can use LNG of varied gas composition, or crude LNG. From the point of view of the fuel container's weight and space requirements, the LNG vehicle is most suitable for long cruising range natural gas vehicles.

Like vehicles that use CNG, the initial cost is higher than for gasoline or diesel-fueled vehicles. Much of the added cost for LNG is due to the cryogenic fuel tanks.

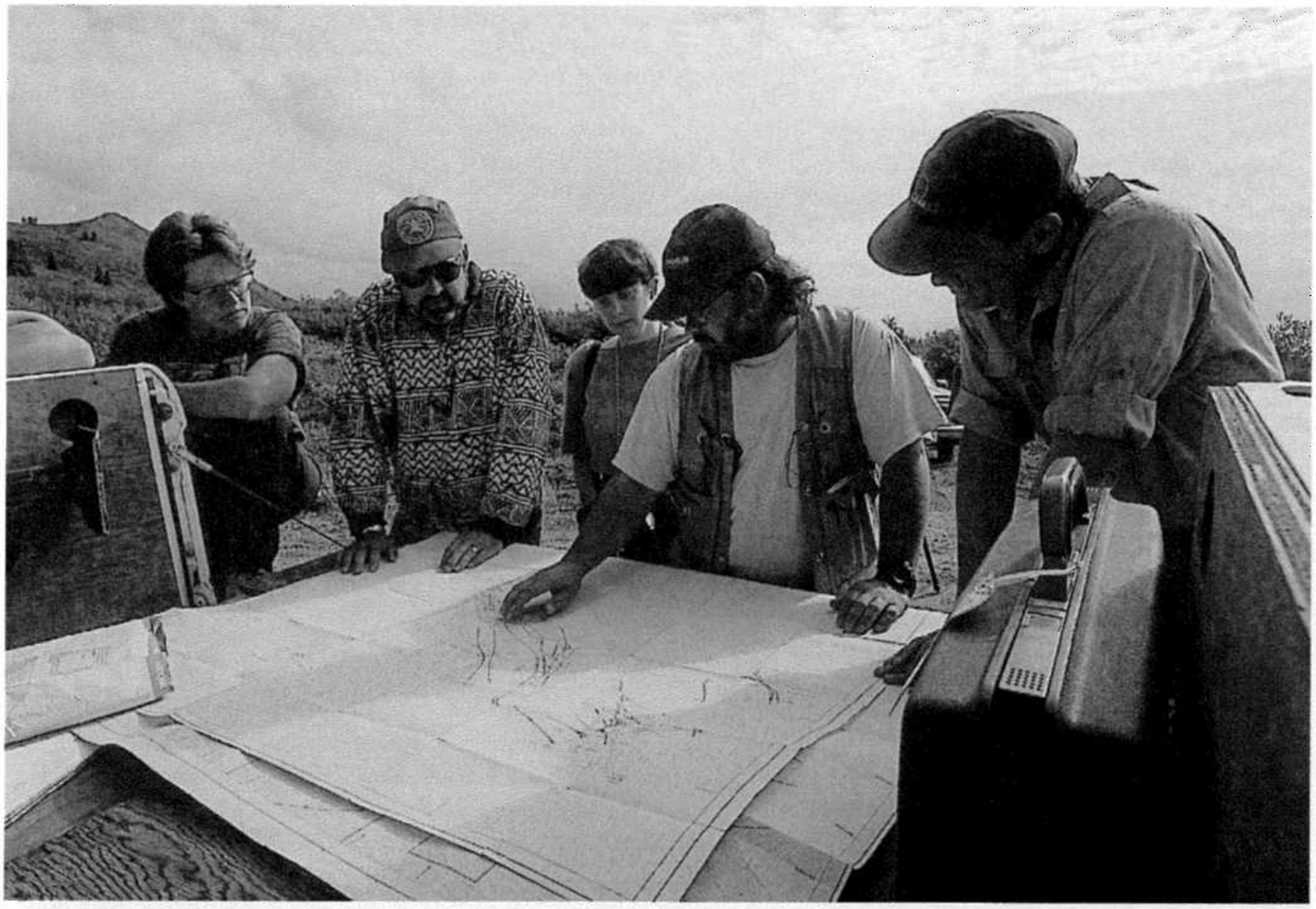
The economics of natural gas vehicles (NGVs) and other vehicles using alternative fuels (fuels other than diesel and gasoline) may be given a boost by the federal *Alternative Fuels Act,* which requires federal departments and crown corporations to convert 75% of their fleets to alternative fuels when economics are favourable.

Bits used for oil and gas wells break rock into fragments. However, once the drilling rig has reached the petroleum bearing formation, diamond drilling can allow geologists to study core and chip samples in greater detail. (Yukon Government photo)

Employment

Most field activities for oil and gas exploration and development are contracted out. Crews are needed for geological and seismic surveys, well drilling, and production. In turn, these crews require further services such as restaurants, hotels, catering, safety equipment, first aid, and transportation of staff and equipment. Other related contract services include surveying, heavy equipment operation for site clearing, shothole drilling and handling of explosives.

Due to the lack of access roads in most of the areas of the Yukon with oil and gas potential, exploration and production work is normally carried out in winter when rivers and the ground are frozen. Because activities are conducted in winter, disturbance to sensitive environments is minimized, and infrastructure developed for other industries is used more fully, for example, hotels and restaurants developed for tourism, and helicopters used primarily in summer for mineral exploration and fire fighting.



The oil and gas industry is an employer of earth scientists and highly skilled technologists. (Yukon Government photo)

Sour Gas

Natural gas is referred to as sour when it contains more than one percent (10,000 parts per million) hydrogen sulphide (H_2S), a poisonous, colourless gas. Most of the natural gas discovered in the Yukon to date can be classified as sour. Sour gas is poisonous, and can be deadly to humans in concentrations as low as 0.05% (50 parts per million) in air. Its distinctive rotten egg odour, characteristic of many mineral hot springs, sewers, and cabbages that have spent too long in the fridge, is noticeable in concentrations as low as 0.1 ppm. We can normally detect its presence long before the levels become toxic; however, if the concentration of the gas is above the 100 ppm range the sense of smell is quickly deadened, giving a false sense of security that the danger has passed. The industrial maximum safe exposure limit is 10 ppm.

Workers in the oil and gas industry must be aware of its deadly properties. The same is true for sewer maintenance crews.

The acute effect of H_2S on the body is twofold. It acts as an irritant to eyes, nose, throat and lungs and it acts as an internal poison causing unconsciousness by paralysis of the respiratory system.

It is VITALLY IMPORTANT that everyone working around or near H_2S have a good working knowledge of artificial respiration (rescue breathing). Training in CPR (cardio-pulmonary resuscitation) is a valuable addition to a worker's knowledge and skill in first aid.

Continues next page

Effects of H_2S *(10,000 parts per million = 1 percent, by volume)*

<1 ppm	Can be smelled.
10 ppm	Occupational Exposure Limit (OEL) for 8 hours (Alberta).
15 ppm	OEL allowable for 15 minutes of exposure.
20 ppm	Ceiling OEL. At this level workers must wear appropriate breathing apparatus.
100 ppm	Loss of sense of smell in 2 to 15 minutes. Possible headache, nausea, throat irritation.
200 ppm	Sense of smell lost rapidly. Burns eyes and throat.
300 ppm	Immediately Dangerous to Life and Health (IDLH) level. Positive pressure breathing apparatus required.
500 ppm	Loss of reasoning and balance. Respiratory disturbances in 2 to 15 minutes.
700 ppm	Immediate unconsciousness. Death will result if not rescued promptly.
1,000 ppm	Causes immediate unconsciousness. Causes seizures, loss of control of bowel and bladder Breathing will stop and death will result if not rescued promptly. Immediate resuscitation needed. Besides being a health hazard, sour gas, upon being burnt, results in corrosive acids which can damage equipment.

Natural gas can be sweetened by removing hydrogen sulphide (H_2S). In some cases the sour gas is flared, or, where economic, it can be changed to elemental sulphur, a valuable chemical used in the production of fertilizer. New technologies allow the economic recovery of sulphur from gas wells containing up to 90% sour gas.

Safety

Most worker and public safety issues are regulated under the Yukon Occupational Health and Safety Act and associated regulations. The need for further regulations under the *Yukon Oil & Gas Act* (YOGA), specific to the oil and gas industry, is currently being evaluated.

Natural gas is highly flammable but is lighter than air and disperses rapidly into the atmosphere in the event of a pipeline rupture. It is non toxic, although one can drown in it. Natural gas is odourless, and for that reason, small concentrations of very stinky mercaptans are added to natural gas to give it a pungent smell and facilitate the detection and repair of leaks. Good equipment design and regular maintenance reduce the risk of leaks.

Regulatory Issues

Who Owns Subsurface Oil & Gas Rights in the Yukon?

Ownership of land for most people means fee simple title, or surface rights, in which the landowner does not own the resources below the ground. Subsurface rights are normally owned separately. Land on which individuals own the mineral rights is known as freehold.

Currently, with the exception of First Nations Category A settlement lands and a small amount of freehold land, the Federal Government maintains ownership and administrative control over the oil and gas resources in the Yukon, although the transfer of administrative processes has been underway since the signing of the Canada Yukon Oil and Gas Accord. After the transfer of federal responsibility for oil and gas, the Yukon will have province-like authority for subsurface oil and gas on all Crown and First Nations' Category B settlement lands. First Nations will own subsurface rights on Category A settlement lands.

The Yukon Oil and Gas Regime

The development of a Yukon oil and gas regime began in 1985 with the revision of federal energy policy. Steps toward the complete devolution of the responsibility for oil and gas have included:

- Commitments by the Federal Government outlined in *A Political and Economic Framework for the North*, June 1987:
  - transfer of all remaining provincial type programs to the territorial governments, and
  - a new Northern Mineral Policy and Northern Oil and Gas Accord to improve the investment climate for business;
- The *Canada Yukon Oil and Gas Accord Agreement in Principle*, September 1988;
- The May 1991 Yukon/Northwest Territories *Memorandum of Understanding Respecting Principles for Oil and Gas Arrangements in the Beaufort Sea*;
- The *Canada Yukon Oil and Gas Accord*, May 1993, commonly called the Northern Accord, which establishes the main elements of the regime and indicates the timelines and implementation processes. Under the *Canada Yukon Oil and Gas Accord* the Federal Government agrees to transfer the administration of onshore oil and gas to the Yukon Government. It outlines the basis for legislation which is modeled after existing Canadian oil and gas regimes, will respect aboriginal rights and be consistent with Yukon land claim settlements, and promotes safety, environmental protection, and oil and gas resource conservation. Under the *Accord* the Yukon will share in the revenues from the entire Beaufort Sea; and
- The January 1997 *Memorandum of Agreement* between Yukon Government and Yukon First Nations to work toward a common oil and gas regime. At the time of the writing the common regime has not been completed but significant progress has been made.

The Yukon Government and Yukon First Nations have agreed to work toward the development of a common oil and gas regime for the Yukon. This may include a system of common management measures including legislation, regulations, policy, programs,

In January 1997 the Yukon and First Nations Governments signed a Memorandum of Agreement to work toward the development of a common oil and gas regime for the Yukon. (Yukon Government photo) guidelines and processes, to manage the Yukon's oil and gas resources and to provide clear direction for resource developers throughout the Yukon. The regime will be similar to those in neighbouring jurisdictions, but will be developed within a Yukon context. It will recognize the Yukon's climate, scale of doing business, degree of infrastructure development, including the limited knowledge of the extent of the oil and gas resources in the Yukon, other Yukon legislation, and other obligations that arise out of federal legislation, in particular aboriginal rights recognized under the *Umbrella Final Agreement on Yukon First Nation Land Claims*. At the same time it will be developed to provide the flexibility required to take advantage of unique opportunities as they arise.

Aboriginal and treaty rights are entrenched in the *Constitution Act* of 1982 and are reflected in the Umbrella Final Agreement on Yukon First Nations Land Claims and in the Final Agreements of individual First Nations. These rights and agreements will prevail over the proposed *Yukon Oil & Gas Act* (YOGA) in the event of any inconsistencies.

Land Tenure

The *Yukon Oil & Gas Act* (YOGA) will govern the disposition of subsurface rights. The process of obtaining land for exploration and development is different for petroleum than it is for the mineral industry. Normally the petroleum companies nominate land where they wish to explore for oil and gas, and the resource owner responds by putting certain blocks up for bid. Normally subsurface rights are awarded through a process involving either of two methods: a bonus bid is a cash settlement paid to the resource owner; a work bid specifies expenditure commitments towards oil and gas development. Oil and gas dispositions give companies the right to explore and produce the oil and gas that they find.

When oil and gas are produced, the companies pay a royalty on the production, normally a percentage of the revenue obtained from its sale. Royalties are paid as compensation for the depletion of the resource; they are not a tax. Royalty payments may be structured to reflect the changes in cost of production during the life of an oilfield, to be sensitive to changing market

A Common Yukon Oil & Gas Regime

On January 24, 1997, a Memorandum of Agreement on the devolution of the Yukon's oil and gas resources was signed by the Yukon Government, the Council of Yukon First Nations, the Kaska Dena Council, the Kaska Tribal Council, and all Yukon First Nations. The Memorandum of Agreement establishes a process and sets a course for concluding the transfer of oil and gas to the Yukon. The Yukon Government and First Nations have agreed to work jointly toward the development of a common oil and gas regime, consisting of a combination of legislation, regulations and administrative processes, which may be adopted by the Yukon and First Nation Governments. However, the Memorandum of Agreement recognizes that any party may, at any time, choose to opt out of all or a portion of the common regime.

The *Canada Yukon Oil and Gas Accord* (Northern Accord) calls for the Yukon Government to enact legislation, applicable on Crown land only, to control the oil and gas activity in the Yukon prior to the federal transfer of authority. Under the Settlement Agreements, individual First Nations have control over the oil and gas resources on Category A Settlement Land.

The Memorandum of Agreement on oil and gas marks an important and essential step in the course of the development of the Yukon's oil and gas regime. It sets out a process for cooperation between the Yukon and First Nation Governments for addressing issues of mutual concern, and ensures that the development of the Yukon's oil and gas regime reflects the broad interests of all Yukon residents.

There are compelling economic reasons for the Yukon and First Nation Governments to develop and implement a common Yukon-wide oil and gas regime: it is cost efficient to develop and administer, and it strengthens the Yukon's competitive position in the world market by offering to industry a consistent, streamlined regulatory approach throughout the Territory.

conditions as indicated by world prices, or in some cases as a profit sharing arrangement. The Yukon Government will share royalties with First Nations in accordance with Chapter 23 of Final Agreements.

Regulation of Oil and Gas Activities

To ensure worker and public safety, environmental protection and resource conservation, licenses are required for all activities related to oil and gas exploration and development, such as seismic surveys, drilling, gas plants, well batteries, and pipelines. All oil and gas exploration and development activity must comply with regulations governing land use, protection of historic sites, workers' compensation, health and safety, water use, waste disposal, and fuel storage, among others.

Development Assessment Process (DAP)

The *Environment Assessment and Review Process* (EARP) was replaced in January 1995 by the *Canadian Environmental Assessment Act (CEAA)*. The

Yukon Oil & Gas Act (YOGA)

Upon the passage of the *Yukon Oil & Gas Act (YOGA)* by the Yukon Legislative Assembly and the transfer of full legislative and administrative responsibility for oil and gas from the Federal Government, the Yukon Government will deliver the oil and gas program, which will include:

- issuing and recording land tenure;
- authorizing geophysical surveys;
- resolving surface rights access;
- authorizing wells and facilities;
- accounting for production;
- managing resource development and information, including core storage, well files, data, mapping, and statistics; and
- collection of royalties.

Regulation and Deregulation

The National Energy Board (NEB) regulates the tolls and tariffs of interprovincial and international pipelines, and the exports and imports of natural gas. Companies are entitled to recover reasonable operating costs and to receive a return on invested capital commensurate with business risk, although increasingly, tolls on major pipelines are being determined through negotiated settlements between shippers and pipelines, as opposed to traditional cost of service regulation. The NEB also regulates exploration and development of oil and gas resources in non-Accord frontier areas.

The deregulation of the gas industry in the late 1980s and early 90s has resulted in a more competitive and efficient market. Deregulation has obligated pipeline companies to separate the transportation and marketing functions into independent arms-length operations. Pipelines became open-access common carriers, enabling customers to buy directly from producers and middle marketers.

Deregulation is partially responsible for the growth in gas storage facilities in both producing and consuming areas, typically using depleted gas reservoirs, to help the industry cope with seasonal fluctuations in demand. Increasingly also, LNG facilities are being used as a storage medium. Deregulation in both the natural gas and the electricity sectors has encouraged a convergence of these two sectors, as the technical, economic, and institutional barriers to the use of natural gas for industrial cogeneration of heat and electricity are removed.

In the ten years since price deregulation was introduced, natural gas exports have almost quadrupled, while estimates of the ultimate resource potential of the Western Canada Sedimentary Basin have increased by nearly 50%.

Development Assessment Process (DAP) will be the Yukon's new assessment process once legislation is in place, and will address the environmental and socio-economic impacts of development projects now assessed under CEAA, such as seismic surveys, drilling, pipelines, road building, and power line construction. DAP is part of the *Umbrella Final Agreement* which comprises the provisions of the Yukon First Nations' land claims.

Final Transfer

The transfer of responsibility for the management of Yukon oil and gas is tentatively scheduled to take place April 1, 1998, by which date the Federal Government will have passed Bill C-50, legislation that will allow it to transfer ownership of the resource to the Yukon, and the Yukon Government will have passed the *Yukon Oil and Gas Act (YOGA)* which will provide the legislative authority to administer the development of its oil and gas resources.

Environmental Issues

Every aspect of petroleum production and use, from initial exploration, to final consumption, affects the environment. Some of the effects are temporary and reversible: others are longer lasting. Natural gas is the cleanest-burning widely-available fuel; sulphur removed from natural gas is used to manufacture fertilizers. In many cases, petrochemicals can meet human needs with fewer environmental impacts than substitute products: steel, aluminum, paper, glass, wood, or cement. Oil products are concentrated energy forms, tailored to specific tasks, easily transportable and efficient to use.

However, petroleum use is a factor in many environmental concerns: acid rain, urban smog, marine pollution, ecosystem degradation, and global climate change. All aspects of the industry are subject to government regulations, many relating to environmental protection. Both government and industry are sensitive to public opinion. Acceptable past practices continue to become outdated as new knowledge and technologies emerge. The benefits of change are constantly balanced against society's investment in the status quo, and are implemented over time.

Environmental Impacts of Oil and Gas Exploration and Development

Local impacts

Local negative environmental impacts of oil and gas exploration and development include spills, fires, odours, and land disturbance. The industry has endorsed the principle of sustainable development, and has adopted environmental codes of practice to minimize its impacts. Mitigation is addressed in all development proposals and applications for land use and other permits, such as for the transport of hazardous substances.

Government regulations and corporate policies and procedures are intended to protect people and the environment in the immediate vicinity of operations and facilities. Measures have been developed to recover oil and reclaim land after blowouts, and more important, better procedures have been developed to virtually make blowouts a thing of the past.

Regulations and procedures have also been improved to reduce the impact of exploration and production activities on forests, wildlife, and communities. This affects the design of access roads, seismic surveys, worker training, drilling procedures, and pipeline routing.

Visual impacts

Considering the importance of tourism to the economy, and the sensitivities of many Yukoners, the visual impact of seismic cuts cannot be overlooked. Changes in technology have allowed seismic lines to be much smaller than several years ago, down from nearly ten metres to as few as four metres or less, and they do not necessarily have to follow straight lines. Thanks to miniaturization and improved hydraulics, some shothole drilling units (for placing explosives) are now less than two metres wide.

Given that wells are often drilled to a depth of several hundred metres, and are tapping into reserves of several hundred metres in horizontal extent, the industry has considerable leeway in locating wells and collection facilities, so can normally avoid making equipment visible from major roads and highways.

Other impacts

In many cases, the growing awareness of and concern over environmental impacts has altered the practice of the petroleum industry and created new business opportunities: a large increase in helicopter portable equipment in sensitive areas, non-toxic muds and closed loop systems to reduce fresh water requirements, and reduced energy consumption in rigs through more efficient engines and improved muds and drilling bits.

Marine oil spills have differing impacts, depending on the environment and the product and quantity spilled. Leasing practices involve intense scrutiny of vessels and staff. New tankers may incorporate safety features such as double hulls. A network of regional spill response centres has been established. Four centres in Canada are equipped to handle spills of up to 10,000 barrels, although 99% of the spills are smaller than 100 barrels.

Environmental Impacts of Oil and Gas Refining and Marketing

Environmental and economic considerations have greatly altered the operations of the 284,000 kilometres of Canadian pipelines that transport oil and gas from production sites to distant consumers. Gas pipelines use their own clean-burning fuel to compress and transmit natural gas. The efficiency of natural gas turbines continues to improve, and large turbines are designed to reduce emissions of nitrogen oxides, another of the causes of acid emissions.

Refinery emissions

Refinery emissions have been reduced substantially from recent decades. The release of sulphur dioxide from natural gas processing has been cut in half in the last 20 years. Currently, about 98% of sulphur is recovered as elemental sulphur in all western Canadian gas production, turning a nuisance into a valuable byproduct which is used in the production of fertilizer. Large plants today can recover up to 99.8% of the sulphur from the gas stream. Because sulphur dioxide is a component of acid precipitation, industry and government are continuing efforts to reduce these emissions. Most of the soil in western Canada is alkaline, which neutralizes acid emissions. Although local impacts of acid precipitation have not been demonstrated in western Canada, the long range transport of acid emissions is not well understood and continues to be a concern.

Particulate emissions from refineries were reduced 97% in the 1970s and 80s, and the energy efficiency of refining processes improved by about 30%. Refineries have also greatly reduced odour and noise, and have all but eliminated contaminants in their waste water.

Most oil & gas activities are carried out in winter when the ground is frozen; sites are more easily accessed and environmental impacts are minimized. (Yukon Government photo)

Environmental Impacts of Oil and Gas Use

When they were introduced at the end of the previous century, oil products replacing coal and wood were hailed as clean fuels. Today we recognize that every energy form has its unique advantages and its short and long term environmental impacts and risks.

Greenhouse Gases

The issue of climate change was addressed by a convention and Declaration at Rio de Janeiro in 1992. Canada has established a Voluntary Climate Change Action Plan and Registry Program. The petroleum industry strongly supports this program.

Greenhouse gases are emitted when any fossil fuel is burned. They are also emitted during the stages of exploration, extraction, transport, refining and distribution.

Natural gas normally contains some CO_2 which is released into the atmosphere when natural gas is produced. Some companies have recently begun to use CO_2 for enhanced oil recovery; however only a few oilfields are amenable to enhancement by CO_2 injection.

The escape of natural gas through leaks contributes another greenhouse gas, methane. When natural gas is used, it contributes 65% of the greenhouse gases compared with burning oil to obtain the same energy. Over the life cycle of the fuel, natural gas contributes less to the greenhouse effect than any other fossil fuel. When natural gas is burned it is generally considered the cleanest of all the fossil fuels. Greenhouse gases emitted at the burner tip are lower for natural gas than for any other fuel.

While greenhouse gas emissions from diesel electric plants are substantial, the diesel remains the most practical means of generating power for many of the Yukon's small communities, and for providing increased winter generation requirements on the hydro grid.

The use of local crude oil in diesel engines as an alternative to refined, imported petroleum products can reduce greenhouse gas emissions by a small but significant portion, through a reduction in the greenhouse gases otherwise emitted when petroleum is refined and transported. This benefit would, however, be accompanied by an approximate doubling of local acid gas emissions.

Acid gas emissions

While 98% of sulphur in natural gas is recovered sold as a byproduct, flaring is sometimes practised to dispose of the portion of hydrogen sulphide (sour gas) that cannot practicably be recovered.

Local Ground Level Ozone Pollution

Urban smog caused largely by ground level ozone, which is produced by the action of sunlight on volatile organic compounds (VOCs) and other gases in the atmosphere. VOCs are largely unburned fuel from automobiles due to driving and fueling. To reduce the production of ground level ozone, the volatility of gasolines is reduced in summer to reduce these hydrocarbon emissions, and in California, the vapours displaced in the fuel tank as customers fill their cars are recovered. Because of the relatively small density of vehicles in the Yukon, and the limited solar radiation in winter when temperature inversions prevent free air exchange, urban smog is not a problem locally. It is a problem in larger southern centres.

Credits

Prepared for the Cabinet Commission on Energy

by the

Department of Economic Development

Automobiles are continually improving through increased efficiency and reduced emissions, but due to the proliferation of the automobile, overall emissions continue to rise. Automobile manufacturers and fuel producers will continue to make improvements, and to provide the energy service, i.e. transportation, with reduced emissions and fuel consumption, but ultimately, the answer may be that sometimes less is more: improving quality of life through community planning that meets and exceeds human needs for social, economic, and intellectual activity with reduced consumption of goods and energy services.

Glossary of Energy Terms

atmosphere	An atmosphere of pressure refers to the normal sea level pressure of approximately 100 kPa (kilopascals) or approximately 15 pounds per square inch.
Cracking	The cracking process refers to breaking long hydrocarbon molecules into shorter chains, usually involving catalysts, and adding hydrogen or removing carbon atoms. Cracking is done to obtain a higher output of products like gasoline from crude oil at a refinery.
Prebuild section	The prebuild section of the Alaska Highway natural gas pipeline refers to a portion of pipeline from southern Alberta to the United States which was built in anticipation of a pipeline from Prudhoe Bay, Alaska to Alberta. The southern section was built, the northern portion was approved but not constructed.
wellbore	Wellbore refers to the diameter of the hole drilled for oil and gas production.

Reader Survey

Please take a few minutes to answer the following questions so that we can better meet your needs for information about energy resources in the Yukon. Please return it to us at: Yukon Economic Development, Box 2703, Whitehorse, Yukon, Y1A 2C6

Where did you get your copy of this publication?

___ Cabinet Commission on Energy

___ Energy Branch

___ Yukon Government Inquiry Centre

___ Through the mail

Other ____________________

Have you read any other issues in the series?

___ Coal

___ Hydro

___ Wind

___ Wood

___ Alternative Technologies

Did you find the information useful?

Would you recommend this publication to your colleagues?

Are there any other topics you would like to see covered in later publications?

Appendices available with this issue are:

___ Memorandum of Agreement

___ *Yukon Oil & Gas Act (YOGA)*

___ Eagle Plain Oil & Gas resource assessment

___ Whitehorse Trough Oil & Gas Assessment

___ Liard Plateau Oil & Gas resource assessment

Please check the ones you would like us to send to you.

If you would like copies of the appendices available with this publication, or additional copies of this publication please write your mailing address below.

Name ____

P.O. Box/Street ____________________________ City ____________________

Province/Territory____________________________ Postal Code____________________

Canol pipeline welding crew at Mile 273 from Johnson's Crossing, January 15, 1944. (Yukon Archives/ Richard Finnie Collection, 81/21, #456)

Yukon
Economic Development

September 1997