YUKON ENERGY RESOURCES

Canadian Pacific Railway coal unit train in British Columbia. (Courtesy of CP Rail)

This article is part of a series of publications on the Yukon's energy resources. It provides an overview of the extent of the Yukon's coal resource and the factors affecting its development. It is intended to encourage investment and to stimulate informed discussion among representatives of industry, government, and members of the community. Appendices of a more technical nature are available separately for 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.

Coal

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;*
- *fosters growth of local energy industries; and*
- *lower the cost of energy to consumers.*

Coal is a local energy resource which has potential for supplying both local needs and export markets.

Some debate has taken place regarding the use of coal to generate electricity for anticipated new mines and other industrial developments in the Yukon. The long-term electrical requirements of the customers on the Yukon's power grid will have a significant influence on the cost of the power produced by any power plant.

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Most of the discussion to date has focused on a plant of approximately 20 MW. This scale of plant is the most likely to be able to supply reasonably priced power under a steady load. The most significant barrier to the development of new electricity generation is the risk of stranded investment that would result from the loss of electrical load due to a mine shut-down. This is an issue for capital intensive projects such as hydro dams or coal-fired power plants.

Environmental impacts from both a coal mine and a power plant can be managed within the limits considered acceptable in Canada by employing commercially available technologies. Once the need for additional power has been established, it takes approximately three to five years for environmental studies, permiting, plant selection, design, construction, and final commissioning of a thermal power plant.

The Resource

The *Yukon Coal Inventory* lists over a hundred known occurrences of coal in the Yukon. Coal has been used off and on, on a small scale, for the last century, to meet some local requirements. Significant efforts to develop the resource have taken place in the four areas listed in this section.

Division Mountain

The Division Mountain coal deposit is located 90 km northwest of Whitehorse, approximately 20 km west of the Klondike Highway and the 138 kV Southern Yukon electrical transmission grid. Cash Resources has identified a deposit of 45 million tonnes of coal, or enough to supply a power plant of 50 MW for more than a century.

Ridley Island Coal Terminal at Prince Rupert, British Columbia. (Courtesy of Ridley Island Coal Terminal)

Origins of Coal in the Whitehorse Trough

In the late Mesozoic a seaway known as the Whitehorse Trough was uplifted. As the sea regressed a series of fresh water lakes was formed, which became coal swamps during the late Jurassic and early Cretaceous periods. Coal developed within a formation that is mainly conglomerate and sandstone, with the partings in the coal itself normally of mudstone and shale.

The deposition environment and subsequent tectonic activity have produced great variations in seam width over short distances. This situation occurs throughout the cordillera.

The coal is characterized as high ash, low sulphur, high volatile bituminous B. It occurs in seams of mineable thickness, and there is probable continuity along the strike for at least 15 km. Furthermore, there is considerable potential in the area to discover more coal. Unfortunately the coal seams are lenticular and discontinuous, dipping at steep angles, making them difficult to find and costly to mine.

Additional work can improve understanding of the geology of the deposit, and determine reserves, washability, mining costs and economics, and establish environmental base lines.

Whitehorse Coal

Whitehorse Coal is located approximately 30 km southwest of Whitehorse, close to transportation routes and domestic markets. Seams of mineable thickness, 0.6 to 13 m, have been identified extending discontinuously for 12 km. The coal is a low sulphur, moderate to high ash anthracite. Coal near the surface is highly oxidized.

Bonnet Plume

The Bonnet Plume Basin is located in the Northern Yukon approximately 100 km to the east of

Yukon Coal Properties

Ash Content	*Sulphur*	*Energy*	*Reserves*	*Other characteristics*
Division Mountain 8.59%	0.43%	5,205 kCal/kg 9,301 BTU/lb	45 Mt geological resource: high ash, low sulphur, high volatile bituminous B	Volatile matter - 25.85% Fixed carbon - 43.01% Residual Moisture - 2.38%
Whitehorse Coal 16.66% - 25.96%[1]	0.42% - 0.68%	5,814 - 6,679 kCal/kg 10,450 - 12,005 BTU/lb	26 Mt potential in situ, moderate to high ash anthracite coal resources; 200 kt drill indicated	Volatile matter 5.85% - 9.61%; Fixed carbon 66.99% - 77.06%
Bonnet Plume Can be cleaned and blended to produce a product of 15% ash content	0.33%[2]	Can be blended to maintain 9,700 BTU/lb (5,430 kCal/kg)	A total of 660 Mt high volatile bituminous C coal in seven coal areas	Ash fushion generally >1,200C, average at 1,340C Nitrogen < 0.8%
Rock River 18%	1.1%	3,719 kCal/kg (6,645 BTU/lb)	60 million tonnes lignite A to sub-bituminious C coal, with geo-physically indicated potential for up to 1.5 billion tonnes	Equilibrium moisture 26%

[1] Coal taken near the surface is consistently higher in ash than those samples taken at depth. A 14 tonne bulk sample taken in 1987 from the main coal pit had an ash content of 46.28% (dry basis) - JHP Coal-Ex Consulting, 1987

[2] Occasionally sulphur exceeds 1% in narrow intervals within the seams

the Dempster Highway. It contains the Yukon's largest reserves of coal, 660 million tonnes of high volatile bituminous C, in seams of mineable thickness. The coal is of low sulphur content and is potentially clean-burning. The quantities identified are suitable for power generation to support plants up to 2,000 MW in size. The coal is potentially suitable for conversion to clean gaseous or liquid fuels. The major drawback is its remote location, which leads to high costs for development work and transportation to markets.

Rock River

In the early 1980s Sulpetro Minerals Limited conducted mapping, geophysical (gravity) surveys, coal analyses, and diamond drilling of coal showings in the Rock River area, located in the southeast corner of the Yukon. There is no record of earlier coal exploration in that area. Coal is confined to an area approximately 10 by 50 km, and is mostly concealed in a mantle of clay, gravel and sand, locally up to 30 m thick. Based on five drill holes totaling 720 m, there appears to be approximately 60 million tonnes of coal within 80 m of the surface. It is classified lignite A to sub-bituminous C, with a thermal content of 3,720 kCal/kg. The gravity survey outlined anomalous areas indicating a potential for up to 1.5 billion tonnes.

The coal is amenable to surface mining at a ratio of approximately 2 to 1, waste to coal by volume. It is suitable for electrical power generation, and chemical uses, including the production of synthetic fuels.

Reclamation area at the Luscar Mine, Hinton, Alberta. (Courtesy of Gordon Ulrich, President of Luscar)

Secondary Power Sales

If a coal-fired power plant were built, there could be surplus power available during extended periods. This surplus electricity might be sold on an interruptible basis to be used for space heating at a price competitive with burning heating oil, i.e. approximately 3 to 5 cents per kilowatt hour.

Utilities have other pricing mechanisms available to manage loads. Time of use metering encourages customers to defer certain tasks until off-peak hours. Power rates can be seasonally adjusted to more accurately reflect the cost of generating power at different times of the year.

Marginal generation costs refer to the cost of generating extra kilowatt hours from a plant that is already operating. In the case of a coal plant, marginal costs include a portion of the maintenance costs, and the extra fuel requirements, but need not include any allowance for the capital cost of the equipment or for its operation. If a utility could purchase coal at a (marginal) cost of $30 per tonne, it may be possible to recover the incremental costs of fuel, maintenance, transmission losses, distribution, and billing, by selling surplus electricity for heating at a price competitive with fuel oil.

Others

The *Yukon Coal Inventory* provides information on over 100 coal showings in the Yukon. Currently there is little information available for most of the showings. There is data on coal quality for fewer than half of them, and only preliminary information on reserves in the Whitehorse, Braeburn, Carmacks, Ross River, Watson Lake, Rock River, and Bonnet Plume areas.

Economic Issues

Markets

Potential local markets for coal include power generation and industrial heating. A recent study of a 20 MW thermal power plant indicated a potential for that scale of development, assuming that coal could be mined at a reasonable price, and that there was a market for the power. Operating a 20 MW power plant requires approximately 100 thousand tonnes of coal per year. Thus a deposit of approximately 3 million tonnes could ensure a supply of coal for the life of the power plant.

Yukon markets for heat energy include mines and other industrial developments. In the 1970s and 1980s, the mine at Faro, under the management of Cyprus Anvil and Curragh, used approximately 20,000 tonnes of coal per year for plant heating and concentrate drying.

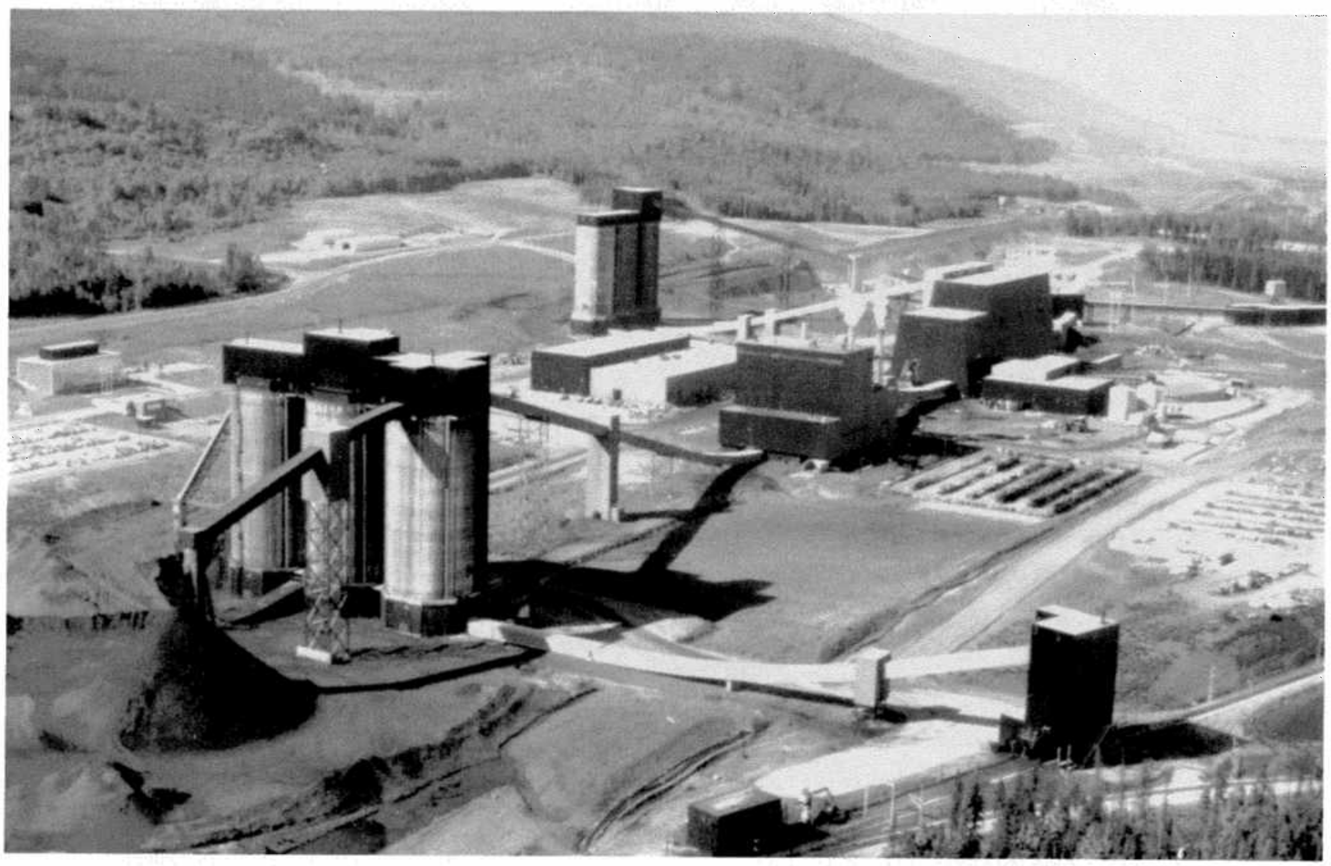
The projected power requirements for advanced mineral properties in the Yukon are shown in the publication on Hydro in this series, available from the Department of Economic Development.

Local Markets

Load Growth

It is expected that new mines will increase future electrical requirements, and cause associated growth in the residential and commercial sectors.

Whether certain mines use electricity from the grid or generate their own power will be a function of the will and ability of the government and the industrial sector to invest in developing energy infrastructure. Some new mines will be too far from the grid to tie in, and will generate their own power, normally from diesel.



The wash plant at Teck's Quintette Mine, Tumbler Ridge, British Columbia (Courtesy of Russ Hallbauer)

Coal-Fired Power Generation

Many technologies are available for converting coal to electricity. Each combustion technology has its advantages and disadvantages. The suitability of one technology over the others depends on the scale of the power plant, coal quality, location, environmental constraints, and other economic factors. As new coal use technologies become commercially available, new coal markets can be explored. A summary of the commonly employed technologies and of those showing promise for future development is contained in Appendix A.

Employment

On average, Canadian producers directly employ 110 workers per million tonnes of coal that they mine each year. At this level of productivity, mining enough coal for a 20 MW power plant to supply the Yukon's new electricity requirements would create 10 full-time jobs. A power plant of this size would require an additional 15 to 20 workers.

Accompanying Benefits and Impacts

The development of a coal mine, either for export or to supply local power needs, would make available a low-priced supply of fuel. This coal could also be used for space heating and industrial process heat. Some mines have used coal for space and process heating in the past. However, the lack of a reliable supply of low-priced coal has led them to convert to other more costly fossil fuels: oil and propane.

The open pit Luscar Mine at Hinton Alberta produces 2.7 million tonnes per year of clean metallurgical medium volatile bituminous coal. (Courtesy of Gordon Ulrich, President of Luscar)

Metallurgical or Thermal Coal?

Some bituminous coals are suitable for metallurgical purposes: smelting iron and steel. Their suitability for this purpose depends on a property known as fusibility and a complex combination of other factors including a high fixed carbon content, low ash (<5%), low sulphur, and low calcite ($CaCO_3$) content.

Guidelines for metallurgical coal change according to industrial demand. Some smelters are using soft coking coal in a pulverized coal injection (PCI) process, which allows them to use higher volatile bituminous coals than would otherwise be suitable for metallurgical purposes. Metallurgical coal is worth $50 US or more per tonne, or 15 to 50% more than thermal coal.

Thermal power generation makes a quantity of heat energy available that is approximately double the electric energy output of the plant. If this heat were available on a long-term basis, it could become economically attractive to distribute it in a district heating system for space and hot water heating, or for industrial processing. Each year a 20 MW power plant produces a quantity of waste heat equivalent to burning approximately 30 million litres of diesel fuel or 30 million cubic metres of natural gas. There are other advantages to locating a thermal power plant close to where electricity and heat are needed: reduced line losses, availability of municipal services, and an increased availability of labour.

Comparison of Electricity Generation Options

	Advantages	*Drawbacks*
Diesel	• Low capital cost • High salvage value - portable • No surprises - technology readily understood, parts and labour available • Waste heat available for space or industrialprocess heating • Simple to add incremental capacity	• Imported fuel • Moderate to high fuel cost • Risk of fuel price increase • Environmental considerations - greenhouse gas emissions, potential fuel spills • High maintenance costs
Natural Gas Turbine	• Low capital cost • High salvage value - portable • Technology readily understood, parts and labour available • Waste heat available for space or idustrial process heating • Simple to add incremental capacity • Indigenous resource • Relatively low fuel cost	• Greenhouse gas emissions • NO_x emissions • SO_x emissions • Moving parts, maintenance costs
Wind	• No fuel purchases required • Winter availability • Does not emit greenhouse gases • Indigenous resource • Simple to add incremental capacity • Potential to export expertise in developing this technology for use in similar climates	• Technical difficulties related to winter weather conditions • Storage or standby capacity required during calm periods • High capital cost • Risk of stranded investment
Coal	• Indigenous resource • Relatively low fuel cost • Waste heat available for space or industrial process heating	• High capital cost • High risk of stranded investment • Emission of greenhouse gases
Hydro	• Indigenous resource • No fuel purchases required • Plant longevity • Low maintenance • Potential to export expertise in developing this technology for use in similar climates	• Very high capital cost • High risk of stranded investment • Site specific • Habitat affected by changes in upstream and downstream water levels and flows • Winter availability poor

Export Markets

World Trade

Canada exported over 34 million tonnes of coal in 1995. Most of it was metallurgical coal used in the steelmaking process. About 70% of Canada's coal trade is with Japan and Korea. Metallurgical coal constitutes about 85% of Canada's international trade, while world trade is split approximately 40% metallurgical, 60% thermal.

In 1995, the total world demand for coal was approximately 4.5 billion tonnes. The international trade in coal, approximately 450 million tonnes, represents 10% of the total world demand for coal. Most thermal coal is used locally, within a few kilometres of where it is mined. For example, China produces approximately a third of the world's coal, but accounts for only about 6% of international trade. The International Energy Agency predicts that by 2010 the portion of total world demand supplied by imports will have grown to over 14%.

Markets for thermal coal are growing in Japan, and demand for coal is increasing dramatically in a number of other industrialized Asian countries, at rates as high as 15 to 20% per annum. Korea is currently enjoying an economic growth rate of nearly 15%, and the Korean Electric Power Corporation has planned thermal capacity increases averaging 1,400 MW per year for the next four years.

International thermal coal prices have fluctuated between $30 and $45 (US) per tonne since 1980, and show an overall slight upward trend. A cautious approach is to assume that prices will show little net increase in the near future.

Prices for thermal coal are rising but have not yet reached the highs that they achieved in the early 1990's. Thermal coal is currently worth approximately US$35-$40 per metric tonne, f.o.b.t. (freight on board trimmed). Prices vary depending on port location, calorific value, sulphur, and other factors of specific interest to the buyer, such as fixed carbon and moisture content. Other non-technical factors may be important to the buyer as well, such as social and political stability in the country of origin, which would affect the supplier's ability to deliver.

Approximately 80% of the world's coal is produced by six countries: China, USA, India, Russia, South Africa, and Australia.

Export potential

Export markets for coal remain highly competitive. The major international exporters of thermal coal are Australia, Colombia, Venezuela, Indonesia and South Africa. Most thermal coal exported from Canada is washed in order to reduce shipping costs and to meet customers' needs. Thermal coal export contracts are normally negotiated for a period of approximately three years with the price reviewed annually.

Factors that favour a viable export trade are:

- large deposits (50-100 Mt), of sufficient quality,
- transportation infrastructure: low cost rail with unit trains and port system capable of accommodating 60 kilotonne ships, and
- competitive fiscal environment.

Different Types Of Coal

All coals are derived from vegetable matter, deposited in fresh water swamps. Conditions favourable to coal formation are similar to those in the Florida Everglades. Plant matter is converted into coal in two steps, first the biological process of turning cellulose to peat, and secondly the physicochemical process of turning peat into coal.

Coals are ranked into three broad classes: anthracite, bituminous, and lignite, depending on the degree of physicochemical change, or coalification, as the process of turning plant carbohydrates to hydrocarbons continues.

	Fixed Carbon	*Heating value (kCal/kg)*	*Characteristics*
Peat	29%	5,100	Brown, easily crumbled, light
Lignite	56%	6,800	Brown to brownish-black, weathers rapidly, plant residues apparent
Subbituminous	60%	7,600	Brownish-black to black
Bituminous	65%	8,400	Black, dense, brittle, plant residues can be seen with microscope
Anthracite	97%	8,400	Black, hard, glossy lustre.

Upgrading Plants

Coal can be upgraded to remove waste material, thereby increasing its thermal characteristics and reducing shipping weight. The simplest form of upgrading involves simple crushing and screening out the rocks, which are more durable than the coal.

Before being burned, coal can be blended to provide a more or less even thermal content. The need for this level of fuel preparation depends on the combustion technology employed.

Washing can increase the thermal content of coal by removing excess ash. It is frequently required when ash handling costs are very high. Washing by heavy medium separation involves floating the crushed coal in a dense fluid. In principle, since coal is significantly lighter than most rock, it floats, and the rocks sink. In practice, the coal is integrally mixed with the rock, or ash material. By varying the density of the medium, a coal of sufficient quality might be obtained at an acceptable recovery rate. Division Mountain coal can be upgraded by washing in a fluid of specific gravity 1.5 (one and a half times the density of water), but the recovery rate is low. Washability tests were conducted on coal from the first proposed mine area, on behalf of Cash Resources by Chemex Labs Ltd. of North Vancouver on a 20 kg composite sample. Although the thermal content of the coal was upgraded 16%, the loss in yield of 48% is considered too high to justify washing. Using this method to obtain a tonne of coal with a thermal content of 6,883 kCal/kg requires the input of 1.9 tonnes of raw coal (5,205 kCal/kg). In other words, nearly half of the energy winds up on the tailings pile.

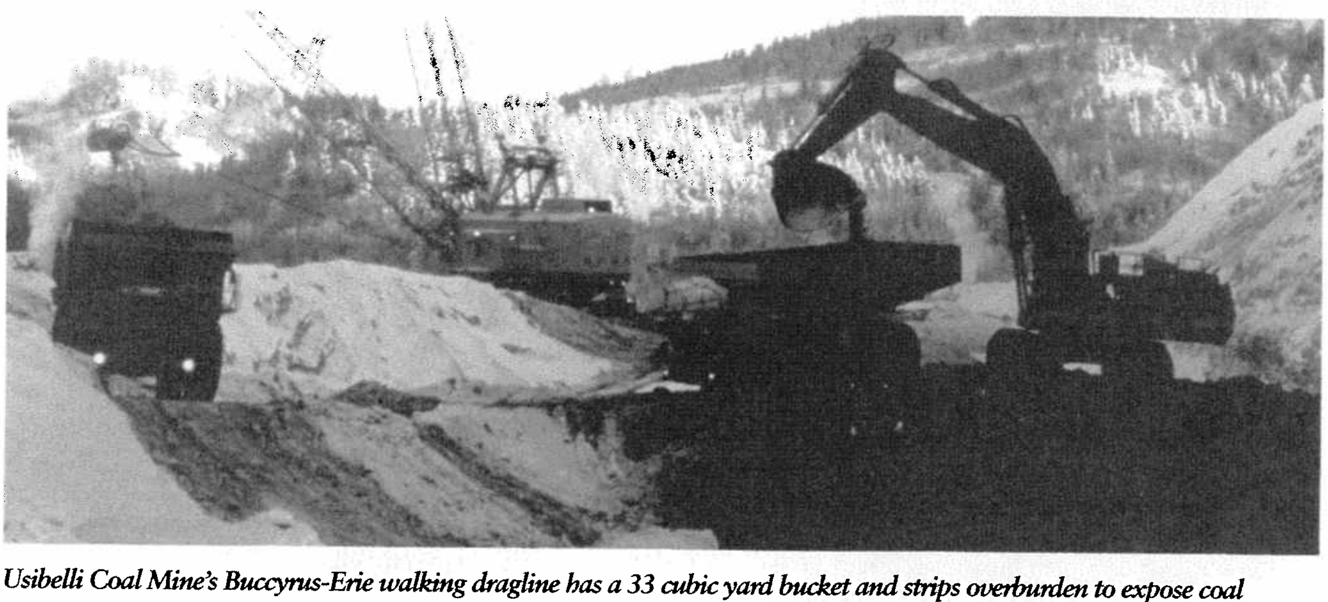
It is noteworthy that if Division Mountain coal were washed, the tailings would have a significant calorific value. If Division Mountain coal were washed as in tests conducted by Chemex, the tailings from the wash plant would have a thermal content of approximately 3,400 kCal/kg, or 6,000 BTU/lb. Power plants can be designed to operate using coal of very low thermal content. A 31.8 MW power plant operated by Tampella Power in Pennsylvania uses waste coal from the tailings of a coal upgrading plant, with a thermal content that varies from 5,000 to 8,000 BTU per pound. Given the reserves identified by Cash Resources the tailings from a washing plant would have sufficient energy to operate a 20 MW power plant for over 100 years.

Pulverized Coal Injection Technology

In recent years new processes for smelting steel have been developed that allow the use of thermal coal. Global demand is growing for thermal coal in iron blast furnaces that can employ pulverized coal injection (PCI) technology. Some Yukon coals appear to be suitable for this purpose.

Safety

Mine safety is regulated under the Occupational Health and Safety Act and Regulations, and is administered by the Yukon Workers' Compensation Health and Safety Board.



Usibelli Coal Mine's Buccyrus-Erie walking dragline has a 33 cubic yard bucket and strips overburden to expose coal seams. Here the dragline is working behind the backhoe and truck coal-loading operation at the Poker Flats Pit. (Courtesy of Usibelli Coal Mine)

Competing Resources

Electricity can be produced in many ways, each of which has its advantages and disadvantages. The best choice depends on many factors, including:

- scale of development;
- seasonal variations in the load;
- seasonal variations in energy supply;
- duration of the load, i.e. how many years, and what is the risk that the load will be terminated;
- load location, i.e. is it on the grid;
- environmental constraints;
- stakeholder preferences; and
- other factors, for example, markets for waste heat.

Factors Required For Viable Coal-Fired Generation

The factors required for viable coal-fired generation include:

- defined resource (30 to 50 year supply);
- large capital investment;
- a market for power which will allow the plant to operate at near capacity;
- market for waste heat;
- skilled work force;
- clear regulatory framework; and
- fair royalty/tax system.

Coal can also be used to supply thermal loads. However, it must compete with the convenience, flexibility and ready availability of oil and propane, with the convenience and low cost of natural gas when it is available, and with firewood as a residential heating source.

Mining Costs & Factors That Affect Costs

Infrastructure

In the Yukon, the cost of conducting business is high compared to other parts of Canada, due to the lack of road and power development. To participate in providing a competitive infrastructure base, the Yukon Government is prepared to make investments in infrastructure, such as in energy and transportation, to support specific projects that contribute to its socioeconomic goals. For more information contact the Department of Economic Development.

Appropriate Scale Of Development

The scale of development for a coal mine would affect the unit cost of coal production, and would be determined by domestic and foreign markets.

The appropriate scale for a coal-fired power plant is determined by an analysis of the expected loads, and of the mix of plants that can supply these loads. Typically, coal-fired power plants supply base loads. They are normally designed to take several hours to bring from a cold start to full load, and are not adept at following a load, although fluidized bed systems are more easily kept on standby and can more easily vary their power output than can most fixed bed plants.

Hydro plants can achieve full load in less than a minute. Diesel plants require approximately two minutes to achieve full load.

If the power output of a coal-fired plant is required to fluctuate with electrical system loads, this capability must be included in the original design. Typically, fluidized bed plants are better at operating at a standby mode than stoker type plants.

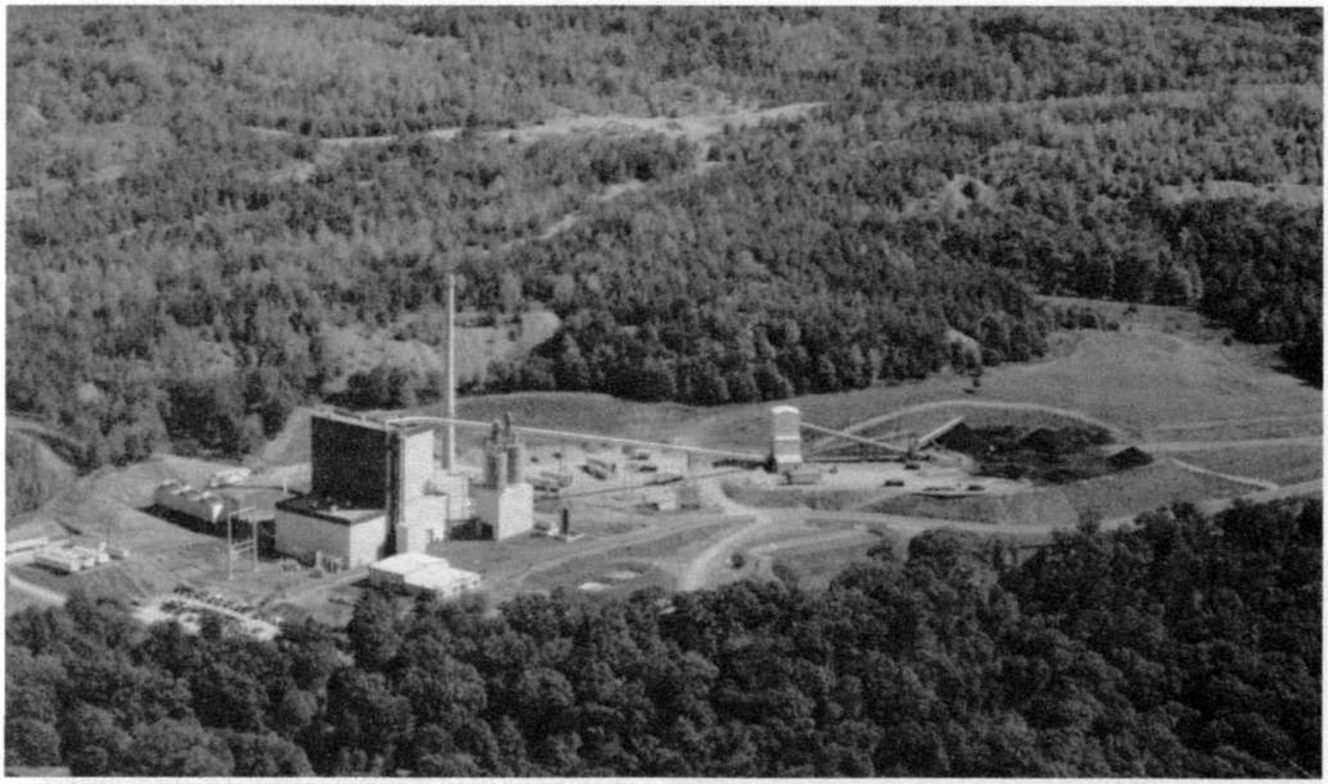
Transportation

Trucking coal a distance of 300 km would cost approximately $20 per tonne. Transportation costs could be reduced through the use of a railroad if volumes could justify its construction. Rail costs in

Infrastructure Support for Development Projects

The Yukon Government can work individually with industry in flexible and creative ways to address infrastructure needs. Projects that are environmentally sound and economically viable, and encourage economic development, may be eligible for funding assistance to develop energy, transportation or other infrastructure.

Proponents must submit their application before infrastructure work begins, and demonstrate a willingness to work with local communities and First Nations. For further information on support for infrastructure, contact the Department of Economic Development.



Tampella Power's 30 MW plant in Piney Creek, PA, burns waste coal in a fluidized bed. (Courtesy of Brian Martin)

Small Economic Coal-Fired Power Plants

Even though many power plants built today are large to take advantage of economies of scale, there is still a place for small, economically efficient plants designed to fill a specific niche.

Tampella Power operates a 31.8 MW coal-fired power plant at Piney Creek, Pennsylvania. The plant is a circulating fluid bed (CFB) type, built in 1992, that burns waste bituminous coal or gob (some stripped from mines, some of it rejects from cleaning plants). The fuel has a heating value of 5,000 to 8,000 BTU/lb and is blended to 7,200 BTU/lb. The fuel has a high sulphur content at 3.5% to 4.8%. Tampella pays only $4 per ton for its fuel.

The plant is operated by a staff of 30, including maintenance staff, operators, and supervisors. Total operating and maintenance costs for the Piney Creek plant average $0.026 per kWh.

The necessary water is drawn from a river. Discharge water is treated to ensure an acceptable pH. It is generally cooled for a day before being released. As a requirement of the air discharge permit, Tampella tests for SO_2, NO_x, CO, CO_2, hydrocarbons, opacity and particulates. If it is necessary to reduce the concentration of NO_x in the flue gas it is normally done using aqueous or anhydrous ammonia or urea, either of which reacts with the NO_x, and which is recovered on the fly ash. Fly ash is typically used as a fertilizer, to strengthen roadbeds or concrete, or for other purposes. The power plant is located about 6 km (normally downwind) from a university town of approximately 30,000.

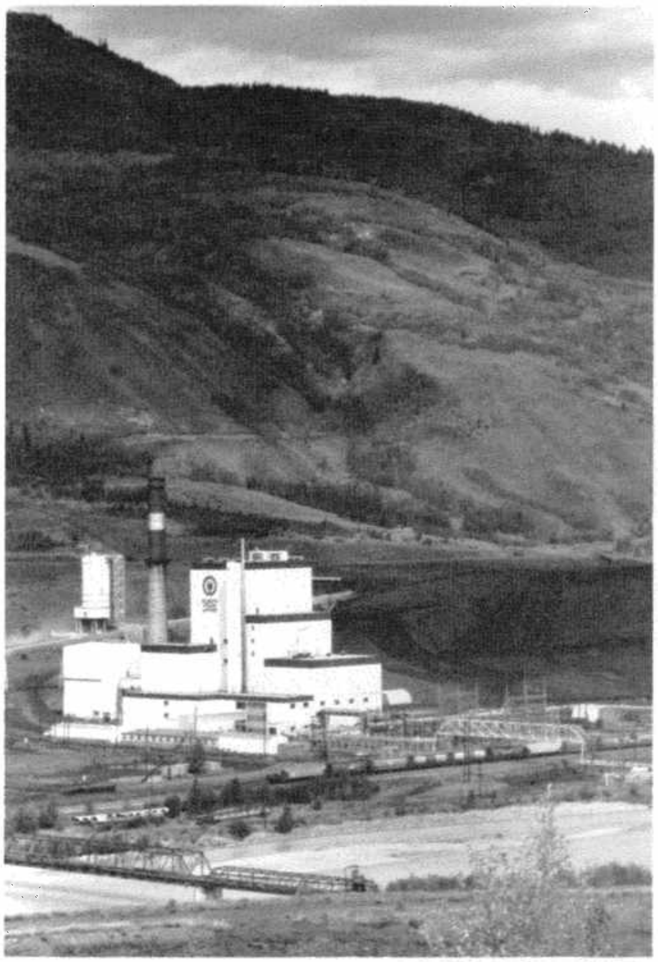
A fluidized bed plant was chosen because of its ability to utilize a broad range of fuels. This flexibility allows the operators to purchase fuel from several suppliers. Fluidized bed combustion is capable of using low BTU, high ash fuel.

The ash from the Piney Creek plant has a relatively high pH (about 10 to 11, depending on the limestone added to the boiler) and is normally disposed of in coal mines where the environment is more acidic.

other areas are typically about half that of trucking. Slurry pipelines have been studied but have not been used in Canada.

Facilities for ocean shipping in Southeast Alaska would have to be upgraded before coal export could be seriously considered. Current facilities in Skagway are now suitable for shipping mineral concentrates in ships of 30 to 40 kilotonnes capacity. Ocean shipping on the common "Panamax carriers" (approximately 60,000 tonnes) costs approximately $10 (US) per tonne, Vancouver to Japan. To accommodate this type of traffic would require a coal terminal and a greater draft in the harbour.

Loading coal onto a ship at a modern coal terminal costs approximately $4 per tonne. At Ridley Island near Prince Rupert, coal arrives in unit trains of 100 cars, which are dumped into a pile and bulk loaded onto a ship. This terminal has the capacity to unload a unit train (approximately 9,000 tonnes) within 3 hours.



Alberta Power Limited's 150 MW H.R. Milner generating station, Grande Cache, AB. (Courtesy of Alberta Power)

Regulatory Issues

Territorial Coal Regulations

The development of coal resources in the Yukon is governed by the *Territorial Lands Act* and its Regulations (Federal Government). All permits are currently issued by the Department of Indian Affairs and Northern Development (DIAND); responsibility for issuing permits is due to be transferred to the Yukon Government April 1, 1998. The Regulations allow for three types of dispositions:

- Coal Exploration License – covers one quarter of a mineral claim staking sheet, approximately 190 square kilometres, and is valid for three years. Land that is in use for a variety of other purposes (parks, other mining activities, municipalities) is excluded;
- Coal Permit – allows individuals to mine a limited amount of coal for their own use for a one year period; and
- Coal Mining Lease – authorizes the holder to stake and mine coal on a property of approximately 1,600 hectares, for a period of 21 years.

Global Coal Supplies - What About Growth?

The world has a lot of coal, and there is little danger of running out for a long time. At the current rate of use, there is about a 3,500 year supply. However, imports by some Asian countries have grown at a rate of 17% in recent years. Even a small growth rate can have profound implications on the duration of the supply. A 3% growth causes the demand to double about every 23 years, and at that rate a 3,500 year supply would last 160 years.

Of course, in the final year before the coal ran out, we would be using it up over 100 times faster than we do today.

An environmental assessment is required under the *Canadian Environmental Assessment Act* before land and water use permits can be issued. DIAND conducts the review with the assistance of the Regional Environmental Review Committee, which is composed of representatives of the Federal, Yukon, and First Nations Governments.

Generic guidelines outlining the range of information required, available from the Environment Directorate of DIAND, and *Guidelines for Information Requirements for an IEE,* issued by Environment Canada, can assist proponents in preparing development proposals. Specific information requirements will be provided once the proposal is received. Normally the proponent must provide information relating to topographic and climatic conditions, geotechnical and geologic site conditions, methods and rates of mining, and baseline environmental and socio-economic information including air and water quality, wildlife, vegetation, land use, archaeological and historic resources, and an assessment of cumulative effects.

The environmental review process can take from six months to two years. Once the review process is completed the proponent may apply for the necessary regulatory permits, for example water license, land use, and coal permits. Regulatory licensing normally takes three months.

Development Assessment Process (DAP)

The Environmental Assessment and Review Process (EARP) was replaced in January 1995 by the *Canadian Environmental Assessment Act* (CEAA). The Development Assessment Process (DAP) will be the Yukon's new assessment process once legislation is in place, and will cover the same types of projects now addressed under CEAA, including land use, water, socio-economic, and environmental impacts of development projects, such as road upgrading and power line construction. DAP is specified by the Umbrella Final Agreement on Yukon First Nations' land claims.

Coal Production And Use In Neighbouring Areas:

Alaska

Alaska's only major coal mine is located at Healy, approximately 200 km south of Fairbanks. Since 1943 the mine has been owned and operated by Usibelli Coal Mine Inc. It produces approximately 1.5 million tons of coal per annum, by surface mining, using a dragline, shovel, and trucks. The coal is ranked subbituminous C with a heating value of 5,100 kCal/kg (7,800 BTU/lb). Sulphur at 0.17% is considered very low. Usibelli holds state coal leases totaling 18,000 acres and has identified reserves of 150-200 million tons. The State of Alaska estimates a potential coal resource of over 5 trillion tonnes.

Approximately half of Usibelli's coal is used domestically; the rest is transported by rail to tidewater and exported via the Seward Coal Terminal to Korea. Usibelli expects to sell 11 Mt during a 15 year contract period. Coal is sold from the mine mouth to domestic customers at approximately $38 per metric tonne ($53 CDN), and to overseas customers at approximately $25/tonne, f.o.b. Seward.

British Columbia

The majority of the coal mined in British Columbia is of metallurgical quality, and most is exported to Japan and Korea under long-term contracts. The coal is transported via rail in unit trains to tidewater at Roberts Bank near Vancouver, or at Ridley Island near Prince Rupert.

Quinsam Coal is located on Vancouver Island and exports raw thermal coal from a terminal on Texada Island. Most exported Canadian thermal coal is washed to increase the thermal content to approximately 6,700 kCal/kg.

History of Coal Development in the Yukon

Coal has been mined in the Dawson and Carmacks areas since the turn of the century, and used for domestic heating, to power riverboats, and to dry concentrate at the mines at Keno and Faro.

Coal exists in Mississipian, Jurassic, Cretaceous, and Tertiary non-marine sequences in seven coal areas in the Yukon:

- the Paleogene Amphitheatre Formation in the Kluane area
- the Whitehorse Basin (Carmacks, Braeburn, and Whitehorse)
- Tintina Trench (Dawson, Pelly River, Ross River, and Watson Lake)
- Indian River
- Rock River Basin
- Bonnet Plume Basin
- Kayak Formation (Northern Yukon)

In the Carmacks area, coal was discovered around 1888 when outcrops supplied fuel for gold prospectors. The first commercial mining took place near Five Finger Rapids, between 1900 and 1919. Five Finger Coal also opened the Tantalus mine just above Carmacks in 1905. Production of 9,000 tonnes was reported in 1907, but because of difficulty in transporting coal on the river for steamboats, this use was discontinued in favour of wood fuel, and after 1918 production dropped to a few hundred tonnes per year. The Tantalus Mine was closed in 1922 in favour of the Tantalus Butte Mine 5 km to the north, when the underground workings reached a fault and the coal could not be relocated. It is reported that the coal in the former Tantalus Mine was ignited by a forest fire in the 1950s and is still burning.

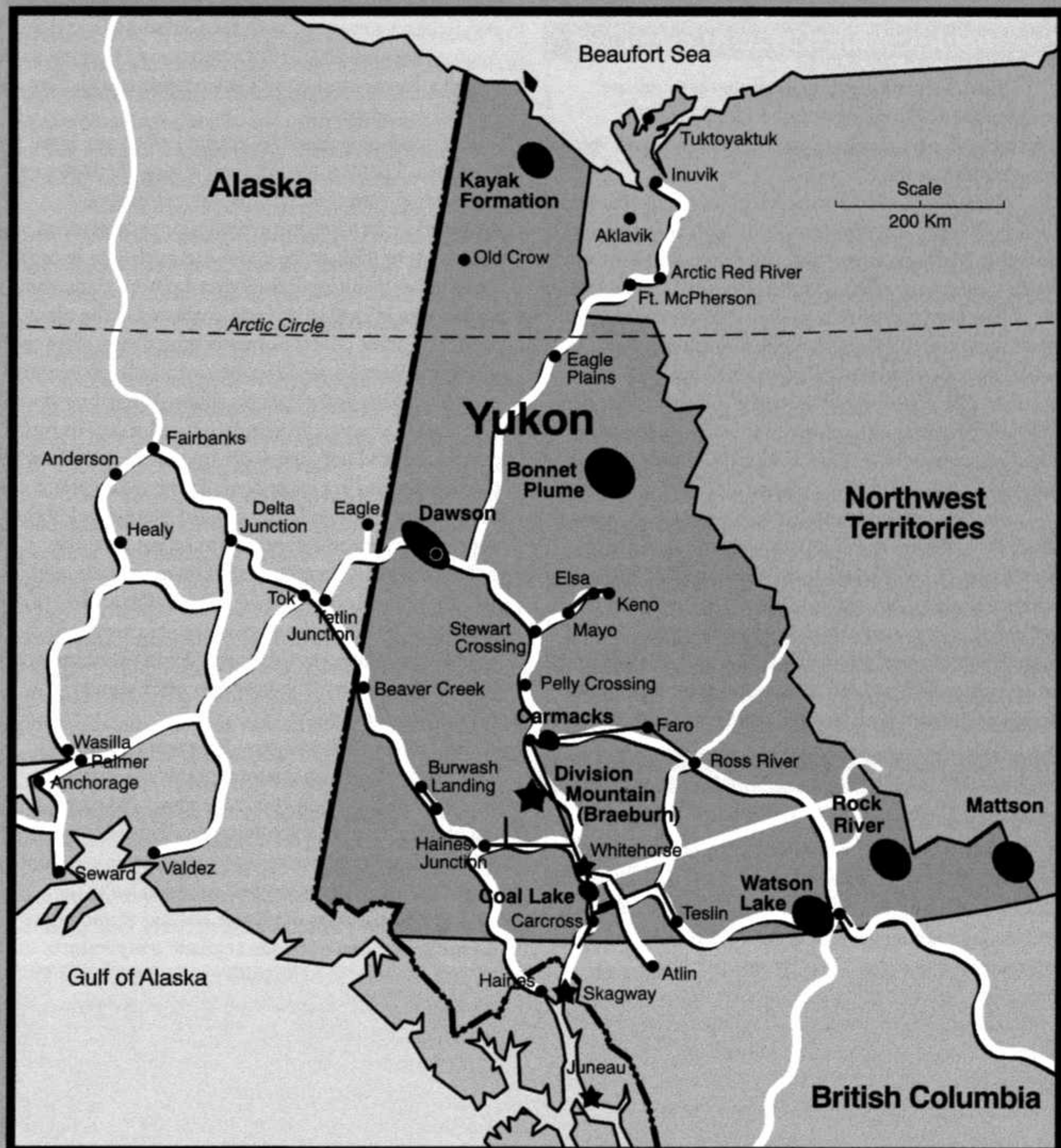
Low levels of production continued at the Tantalus Butte Mine until 1938 when the mine closed for 10 years. In 1948 the Yukon Coal Company, owned by Cassiar Asbestos, reopened the mine with a federal loan of $300,000. Production increased to nearly 13,000 tonnes by 1954, but then declined as demand by river steamers and United Keno Hill Mines decreased. The mine was reopened in 1969 by the Anvil Mining Corporation. Production increased to approximately 18,000 tonnes per year, where it was used at the lead/zinc mine at Faro for concentrate drying and plant heating. Cyprus Anvil calculated reserves of approximately 85,000 tonnes in 1976, most of which has been mined. Operations ceased in the early 1980s due to the closure of the Anvil mine and an underground fire in the shafts.

Coal was discovered on Division Mountain in 1903. Much interest has been expressed in this coal deposit in recent years, and because of its current economic importance and potential the property is featured in this publication.

Coal was used to generate electricity for the dredges in the Klondike from 1907 to about 1913 until the opening of the North Fork Hydro plant. Coal from the same deposit was also used in river boats and for domestic heating in Dawson City.

Coal was first reported in the Bonnet Plume basin in 1893. Economic interest in the area began during the Second World War when the Basin was mapped for Imperial Oil as part of the Canol project to identify possible sources of oil for the U.S. Military. In 1977 Pan Ocean acquired 21 coal leases covering an area of over 3,000 km^2 . Exploration reports indicated sufficient coal to supply an export business of 10 to 15 million tonnes per annum, in addition to power production of up to 270 MW. However, due to its remote location, development of the coal in the Bonnet Plume has not yet been considered economic. The Bonnet Plume coal area lies approximately 130 km to the east of the Dempster Highway. Geological mapping at a scale of 1:250,000 was published in 1975.

Coal Deposits in the Yukon (Yukon Economic Development)



Environmental Issues

Environmental Impacts of Mining Coal

Coal does not readily break down to release contaminants. However, waste rock can require treatment to prevent the release of contaminants into neighbouring waters.

Coal mines can be a source of methane emissions, especially when the coal contains a high percentage of volatiles. Methane is one of the gases that contributes to the greenhouse effect, discussed later in this section.

The licensing of new mines normally includes provisions at the design stage for minimizing dust, noise, nuisance and health effects, and occupational hazards. Reclamation of the land is a requirement of a land use permit. It is normally necessary to dispose of timber, recontour the land, and establish new ground cover.

A coal development would require a license under the Yukon Waters Act if it used water, diverted any watercourses, or affected surface drainage or ground water. Effluent discharge is normally a key factor addressed in most environmental assessments. The license would specify water quality standards including temperature, pH and the concentration of suspended solids and metals such as iron and manganese.

Environmental Impacts of Burning Coal

Greenhouse Gases

Coal is a fossil fuel created from plants that lived long ago, drawing carbon from an ancient atmosphere. When that coal is burned today the carbon is released into today's atmosphere. It is believed that the burning of fossil fuels is responsible for the increase in atmospheric levels of carbon dioxide (up approximately 25% since the turn of this century). This increase of carbon dioxide concentration may magnify the greenhouse effect and lead to climate change. Next to water vapour, carbon dioxide causes the greatest greenhouse effect.

As a greenhouse gas methane, or natural gas, is next in importance to CO_2. It is released naturally by volcanoes, through anaerobic decomposition in swamps, and by animals. Anthropogenic sources include landfills, sewage and manure processing, cattle, natural gas leaks from pipelines, and the methane released from coal mines. Methane can also constitute a safety hazard in underground coal mines.

The issue of climate change was addressed by a convention and Declaration at Rio in 1992. Canada has established a Voluntary Climate Change Action Plan and Registry Program. Both the Canadian Electricity Association and The Coal Association of Canada have signed a Memorandum of Understanding with Natural Resources Canada.

Greenhouse gases are emitted when any fossil fuel is burned. They are also emitted during the stages of exploration, extraction, transport, refining and distribution. In assessing greenhouse gas emissions, it is important to look at the entire fuel cycle. For example, when a coal plant replaces a diesel power plant, there is an increase in carbon dioxide produced at the plant itself. However, coal is normally mined very close to where it is burned, and requires very little preparation compared with petroleum products. The net production of greenhouse gases, resulting from all stages of fuel production and use, can differ by as little as 10% when the two options are compared. At the same time, a coal-fired power plant replacing a diesel plant would bring about a net decrease in other important airborne pollutants: nitrogen oxides, carbon monoxide, and volatile organic compounds (VOCs). Regardless of the method of producing energy, there are positive and negative economic, environmental and social impacts to consider (see insert "Comparison of Electricity Generation Options").

Water Use and Discharge — Thermal Pollution

Typically thermal power plants use water to condense the steam from the turbines, and then circulate it through a cooling tower before returning it to the plant. Supply water is required mainly to replace water lost to evaporation and to steam leaks.

For plants that discharge cooling water, water licensing agencies normally regulate temperatures in order to protect local ecosystems. The practice of discharging cooling water is no longer in common use in modern plants.

A thermal power plant is normally designed for zero cooling water discharge. The 31.8 MW plant of Tampella Power uses only 1.6 litres per second, barely a trickle, (approximately 0.2 L/kWh) to replace water lost to steam leaks. The plant requires another 40 L/s to replace water lost to evaporation in its cooling tower.

If a power plant used an air-cooled condenser, it is possible to obtain the necessary water from a well. An air-cooled condenser is not normally used, as it adds 1 to 2% to the capital costs and consumes about 2 to 3% of the energy produced. A water license would be required, regardless of the source.

Coal Ash

Coal ash can be thought of as either bottom ash (removed from the combustion chamber) or fly ash (removed from the stack). Fly ash is frequently used to strengthen concrete. Alberta Power's Battle River power plant obtains sufficient revenue from the sale of fly ash for this purpose to pay for all other ash disposal costs. Bottom ash can contain heavy metals, although it is not normally considered a hazardous waste, and can in fact find uses in the manufacture of cinder (concrete) blocks, as an agricultural additive, as road bed material, or for sanding roads in winter. In many cases ash is returned to the mine after the coal is removed. Coal ash in Alaska is normally disposed of in land fills.

Air Emission controls

Particulate emissions may be controlled either by an electrostatic precipitator (like a smoke eater in a lounge), or a bag house, which operates similar to the way a vacuum cleaner gathers dust.

There are currently no regulatory emission standards for coal-fired power plants that would operate in the Yukon. Air Emission Regulations are currently being developed under the Yukon Environment Act. These Regulations will apply on all lands controlled by the Yukon Government, and will be developed in consultation with stakeholder groups. It is desirable to develop regulations that are in harmony with regulations in other jurisdictions, in order to maximize investor confidence. A prudent investor might also assume that compliance monitoring would be a requirement of an air emissions permit, and budget accordingly. The current federal guidelines, *Thermal Power Generation Emissions - National Guideline for New Stationary Sources*, issued by Environment Canada, May 1993, may be cited as a requirement of a land use permit issued for projects on federal lands. These *Guidelines* specify desired maximum emissions as follows:

SO_2	258 nanograms per joule of heat input
NO_2	170 nanograms per joule of heat input
Particulate matter	maximum 160 milligrams per cubic metre, corrected to 3% oxygen in the flue gas
Opacity	20% maximum on a continuous basis; opacity may be 40% for less than 6 minutes per hour

The use of limestone in the bed can remove up to 90% of the sulphur. Because Yukon coals are low sulphur (some are less than 0.5%), sulphur dioxide emissions would be close to meeting the Canada *Guidelines* even without control technologies. If fluidized bed combustion were chosen, nitrogen oxide emissions would be well within the *Guidelines* without employing additional controls. Other combustion technologies would generate greater concentrations of nitrogen oxides, and if necessary, these emissions could be controlled.

Coal is also a source of heavy metals emissions. A protocol on the transboundary impacts of heavy metals emissions is currently being addressed by the United Nations Economic Commission for Europe.

The Cost of Coal-Fired Power

H.A. Simons Consulting estimated the capital and operating costs to build and operate a 20 MW thermal power plant in the Yukon. A plant of this size would produce approximately 140 GWh per year. If coal were available at a cost of $20 per tonne, it could produce power at a first year cost of approximately 6 cents per kilowatt hour, excluding transmission costs and losses. Each $16/tonne increase in the cost of coal would increase the cost of power by about one cent per kilowatt hour.

If electrical requirements changed and the power became surplus, it would still be necessary to carry the capital costs, approximately $6 million per year. If plant output were reduced to 35 GWh per year, power costs under this low-use scenario would increase to approximately twenty cents per kilowatt hour.

Operating a 20 MW plant would cost an estimated $1.7 million per annum for fixed expenses and $0.6 million for coal handling and ash disposal.

Acid Precipitation

Acid precipitation is caused largely by emissions of nitrogen oxides and sulphur oxides, which are emitted from power plants and internal combustion engines (cars). Nitrogen oxides (NO_x) may be either fuel derived or air-derived. NO_x emissions are a leading component of acid precipitation. The production of air-derived NO_x increases with flame temperature and operating pressure. NO_x emissions may be controlled by decreasing combustion temperatures, or captured in exhaust gases through the use of ammonia.

Sulphur oxides (SO_x), mainly sulphur dioxide, are formed in a power plant when sulphur in the fuel is burned. SO_x is an irritant and a prime ingredient in acid rain. SO_x may be controlled with limestone in the bed or through exhaust scrubbers.

Summary of factors affecting development of Yukon coal

The cost of transporting coal to tidewater and the lack of suitable port facilities at either Skagway or Haines are barriers to the export of coal from the southern Yukon. The limited transportation infrastructure and the size of the local coal market for thermal power generation constrain the scale at which coal can be mined, thereby increasing unit development costs. As these factors also conspire to limit the attractiveness of coal exploration, little is known about the extent, and in many cases the quality, of the identified Yukon coal deposits.

On the positive side, most Yukon coals have a relatively low sulphur content, and show potential for use in iron blast furnaces that can employ pulverized coal injection (PCI) technology. If the transportation infrastructure were developed, Yukon coal could better benefit from its proximity to markets in Asia.

If export is not a viable option, there are smaller but steady local markets for power and for heat which could be supplied by coal.

Summary of factors affecting the use of coal as a source of power

There are no serious technical or regulatory obstacles to using coal as a source of electrical power in the Yukon.

Coal can provide power at a lower cost than diesel if conditions are right. A new mine or other major industrial load is needed to create a demand for electricity that cannot be supplied by existing hydroelectric facilities.

A coal-fired power plant would have higher capital costs than a diesel plant. Consequently it carries a greater risk of increasing power rates if it were to become surplus to electricity system requirements due to a mine shutdown.

The economics of a coal-fired power plant can be improved through load management tools such as variable (time of use and seasonal) power rates to optimize the output of generating facilities.

In the absence of air emissions regulations, the standards of the Federal Government and neighbouring provinces can be used as a surrogate to develop concept designs. Clear guidelines reduce uncertainty for investors wishing to establish a thermal electric generating plant. These regulations are to be developed by the Department of Renewable Resources under the Yukon Environment Act.

The Yukon's industrial sector is growing, and with it the need for power. Coal is one of the options for providing that power. New and projected power needs, and the best mix of energy resources to supply those needs, are determined through the Yukon Energy Corporation's capital planning process. The interests of the Yukon Government in electricity supply planning are determined through consultative processes lead by the Cabinet Commission on Energy.

Financial assistance may be available for projects that develop the Yukon's energy infrastructure, enhance business opportunities in the resource development sector, and benefit Yukon communities and First Nations. For more information contact the Department of Economic Development.

Credits

Prepared for the Cabinet Commission on Energy

by Robert Collins,

Energy Resources Analyst

Department of Economic Development

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

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Has this issue improved your understanding of the Yukon's coal resource?

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:

___ Appendix A Power Plants

___ Appendix B Rio Convention

___ Appendix C Coal Analysis

___ Appendix D Glossary

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