COAL TECHNOLOGY

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TECHNOLOGY

TECHNOLOGIES HELP COAL MEET MODERN NEEDS

Coal has contributed to our quality of life for over 4,000 years. Archeologists believe coal was first used as a fuel to provide heat for cooking in 2,000 BCE*. Since then, technologies have been developed that use coal for a variety of other purposes.

Today's technologies range from sophisticated mining methods to techniques that allow coal to be burned cleaner and more efficiently. Specialized technologies have improved coal transportation systems, coal cleaning and coal processing methods. Because of technology, coal can be transformed into dozens of useful products. For example, coal is used to make coke*, an important component in the manufacture of steel. Coal is also used in the cement and pulp and paper industries to create the process heat required in the making of these products. And coal can be used to produce a variety of industrial products that are currently made from oil and natural gas feedstock*. Research continues to focus on new uses, more efficient processes and cleaner burning of coal.

For pinpoint accuracy, Global Positioning Systems (GPS) satellite technology is used to survey lands slated for development.

FROM LOW KEY TO HIGH TECH

70 YEARS OF INNOVATION

Modern technology, coupled with the need to be cost-effective, has completely reshaped how Canada's coal industry operates. What began as a labour-intensive, small-scale activity has evolved into a highly efficient, large-scale mining industry.

The work that used to be done by men with picks and shovels is now performed by trained workers operating sophisticated machines. Kilometres of electricity-driven conveyor systems have replaced horse-drawn trolleys and handcarts. Huge trucks and some of the largest earth-moving machines in the world—draglines*, shovels and loaders—move mountains of material.

Working conditions and environmental responsibilities have changed too. Today, industry programs and strict government regulations have dramatically improved worker safety and environmental protection.

The scale of modern coal operations is awesome. For example, at just one open-pit mine site in southeastern British Columbia, over 40 million cubic metres of rock and coal are handled every year. That's over 100,000 cubic metres a day, enough material to fill the Pengrowth Saddledome arena in Calgary, Alberta, one and a quarter times every day.

* See Glossary

Saddledome photograph by Brian Harder

TECHNOLOGY LINKS GEOLOGY WITH PRODUCTIVITY

TWO MINING METHODS, SEVERAL TECHNOLOGIES

Coal is mined by two main methods: underground mining and surface mining. The choice of method is determined by a number of factors such as geological characteristics, the quality of the coal, and the cost to extract the coal. In general, deeper lying coals will be mined using an underground process. If the deposit lies close to the surface, or if it is economically accessible by a surface technique, it will be mined in a surface mining operation.

UNDERGROUND MINING

Underground mining has become a highly technical and mechanized process. It involves three steps: cutting the coal from the seam, gathering and moving it to the surface and supporting the roof of the mine. There are two ways of completing these steps: room and pillar mining and longwall mining.

Though most of the world's coal is mined underground, very little of Canada's coal is mined this way.

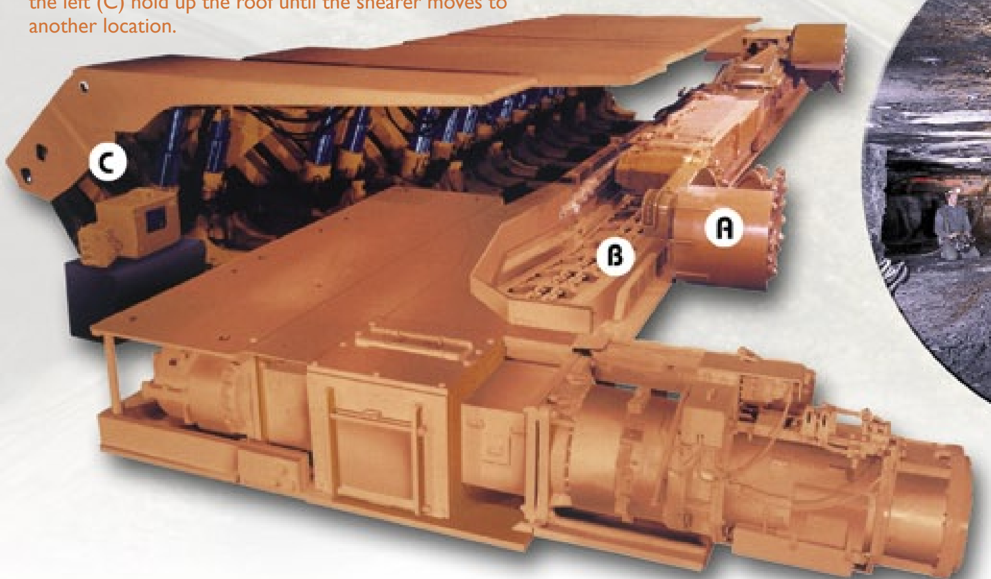
Longwall mining involves the use of a mechanized shearer to cut and remove the coal from the face, making a wall from 100 to 250 metres long. While the coal is being extracted, automatic, hydraulic-powered supports temporarily hold up the roof. The cut coal is plowed onto a chain conveyor below the shearer. The coal is then dumped onto a conveyor belt at the end of the long wall, which carries the coal out of the mine in a continuous stream.

Once the coal has been removed, the roof over the area behind the face is allowed to collapse. The longwall mining method extracts over 75 per cent of the coal deposit.

Room and pillar mining involves cutting a network of "rooms" into the coal seam and leaving behind "pillars" of coal to support the roof. Machines cut coal from the face of the seam with cylinders or disks studded with carbide-tipped metal teeth. Behind the machine, the coal is transferred to shuttle cars or conveyors for transportation to the surface.

Initially, recovery may be only 50 to 60 per cent of the coal because of what is left in the pillars. The pillar coal is sometimes recovered at a later stage.

This longwall shearer has drum-like extensions (A) on the right to cut the coal on the nearest wall. The coal collects on the conveyor (B) that delivers the coal to other conveyors for eventual delivery to the surface. The hydraulic units to the left (C) hold up the roof until the shearer moves to another location.



This continuous mining machine is cutting coal from the seam in front of it to create a large, shallow room. For stability, pillars of coal are left in place to support the roof. You can see a pillar on the left, behind the machine operator.

SURFACE MINING

Surface mining is conducted on a highly efficient, large-scale basis. Using huge equipment and automated technology, surface mining involves three steps: separating the coal from the surrounding material, trucking it to nearby processing or power generating plants and preparing the coal for use. There are two ways of surface mining: strip mining and open-pit mining.

STRIP MINING

On the Prairies in western Canada, strip mining is the most common method of surface mining. Strip mining is used to mine thermal* coal, which is used to generate electricity. It gets its name from the fact that the mining occurs in narrow strips along the active mine cut.

In the prairie provinces, coal deposits are like expansive blankets lying under the flat surface of the land. The coal tends to be uniform in thickness and generally covers large areas. These characteristics are ideal for strip mining.

Strip mines are often surrounded by farmland. That's because the coal industry temporarily uses land for mining purposes and then restores it to its previous use—like farming, forestry, recreation or wildlife habitat.

This strip mine is surrounded by productive agricultural lands which were mined and reclaimed just a few years ago.

* See Glossary

OPEN-PIT MINING

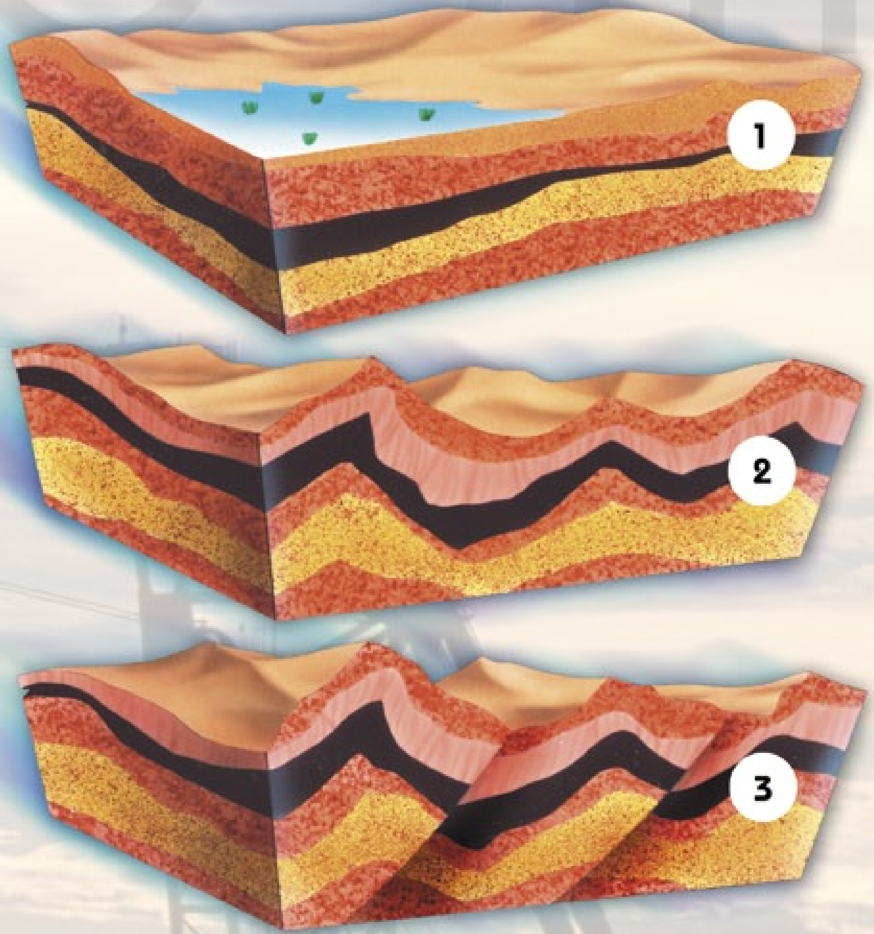
Most open-pit mines in Canada produce metallurgical* coal that is either exported to steelmakers around the world or used domestically. Open-pit mining is often used in the Rocky Mountains, where coal seams have been pushed up to the surface.

1. Like the coal of the Prairies, the coal in the mountains was originally formed in reasonably level deposits. However, the tectonic forces* that created the Rocky Mountains shifted the land.

2. The layers of rock and coal were pulled apart and then shifted back on top of each other.

3. In some places, the coal deposits were pushed up near the surface in seams, ranging in thickness from one to 15 metres. These sites are best suited for open-pit mining operations because experience has proven that open-pit operations recover more of the coal resource and are more economical than underground mining operations.

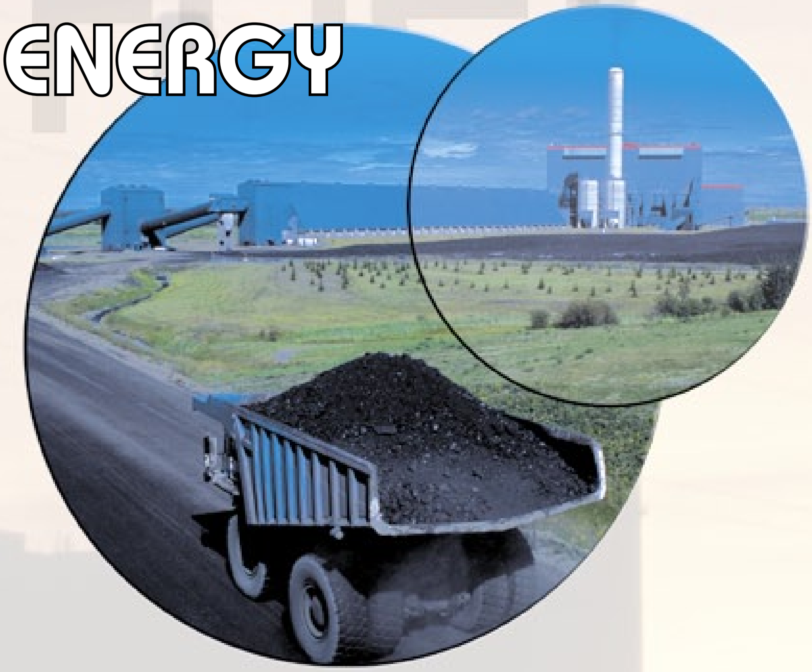
HOW COAL WAS FORMED IN THE ROCKIES



This plant prepares the coal for processing as described and illustrated on page 7. The coal hopper, where the trucks dump the coal, is on the far right.

* See Glossary

OLD FUEL, NEW ENERGY



TRANSFORMING COAL INTO ELECTRICAL POWER

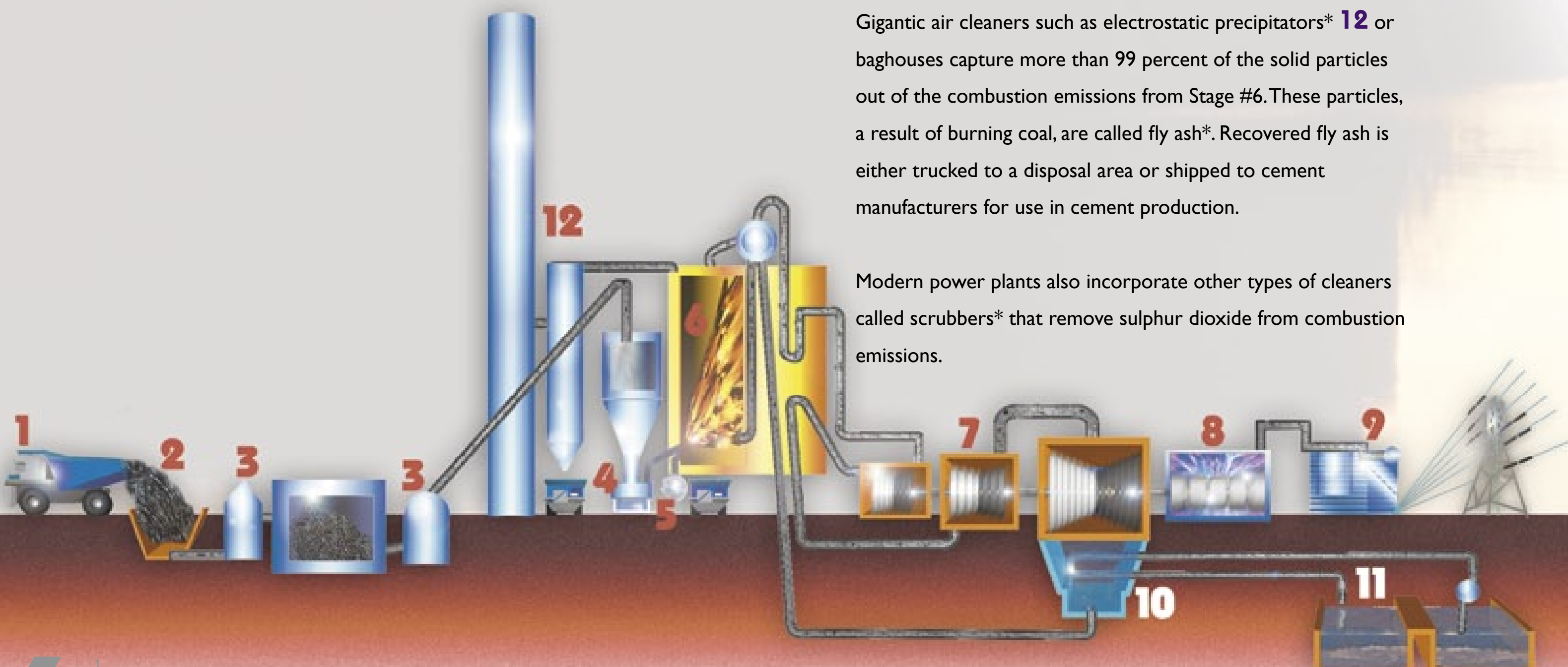
In western Canada, coal-fired power plants are located close to strip mining operations so the mined coal can be delivered economically by truck. They are often referred to as mine-mouth operations.

When the coal trucks **1** arrive at the power plant, they dump the coal into a hopper* **2**. The coal is carried on a conveyor system through crushers **3** and a pulverizer **4** that grinds the coal into a fine powder. Powerful fans **5** blow the powdered coal through specialized burners* into the combustion chamber **6** of a boiler*. The fine coal particles are burned at very high temperatures (over 1,300°C), changing the water contained in tubes lining the boiler into steam. This steam blasts past thousands of turbine* blades **7** which causes the shaft of the turbine to rotate. The turbine spins the rotor in the generator **8** and an electrical current is produced. This electricity then passes through a transformer* **9** that boosts the voltage to a level that can be economically transmitted over long distances.

After passing through the turbine, the steam goes through a condenser **10** where pipes containing water from the cooling pond **11** convert the steam back to water so it can be used over again in the process.

Gigantic air cleaners such as electrostatic precipitators* **12** or baghouses capture more than 99 percent of the solid particles out of the combustion emissions from Stage #6. These particles, a result of burning coal, are called fly ash*. Recovered fly ash is either trucked to a disposal area or shipped to cement manufacturers for use in cement production.

Modern power plants also incorporate other types of cleaners called scrubbers* that remove sulphur dioxide from combustion emissions.



* See Glossary

PREPARING COAL FOR EXPORT

Metallurgical coal arriving at the processing plant is dumped into a coal hopper **1**.

From there, the coal enters a breaker* **2** where it's broken into small pieces and the larger hard rocks are removed. The coal is then conveyed to the wash plant **3** where fine impurities are removed. Washed coal is transported to the dryer **4** where moisture is removed in the form of steam.

Finally, the coal is moved to the load-out facility **5**. Sitting directly over the rail line, this facility allows unit trains to pass through and be efficiently loaded. At the same time, a thin coating of dust suppressant is sprayed on the top of the coal in the rail car. This coating minimizes dusting as the train travels to port facilities for final shipment to the customer.

Canadian coal producers employ unit trains to efficiently transport their coal products from minesites to port facilities for shipment worldwide. Unit trains are the the world's most advanced system for hauling coal over long distances.

* See Glossary

RESEARCH AND DEVELOPMENT ON THE MOVE

Working together, the coal industry, railways and shipping terminals have significantly increased the efficiency and safety of Canada's coal transportation processes.

INTEGRATED RAIL AND SEA TRANSPORTATION SYSTEMS INCREASE EFFICIENCY

The coal industry works continuously with the railways and shipping terminals to improve the efficiency of coal transportation systems. One important joint development was the unit train, proven to be one of the most efficient ways to transport bulk material on land. The most modern train cars are made of aluminum to reduce weight and increase capacity. Unit trains are up to 125 cars in length—that's two kilometres long!

A 125-car train can be loaded with 13,750 tonnes of coal in four hours. The cars are designed so trains can be loaded and unloaded without stopping. This enables the unit trains to travel from the coal mines in British Columbia and Alberta to the shipping ports on the West Coast in very short order. For example, trains from the Elk Valley in British Columbia make the 1,200-kilometre trip to the West Coast and back again in only four days.

The trains unload at Neptune Terminals in Vancouver, Westshore Terminals in Roberts Bank, south of Vancouver and Ridley Terminals in Prince Rupert. Westshore is one of the largest coal-handling ports in the world. As one of the most efficient and modern facilities in the industry, it can load over 26 million tonnes of coal a year.

All of the ports feature rotary dumpers, which unload coal from trains without disconnecting the cars. Each car in the unit train is simply rotated to empty it. This bit of smart technology enables a 125-car train to be unloaded in as little as 3 hours.

Canada's three major West Coast terminals handle approximately 30 million tonnes of export coal every year.

Unit trains also travel east to deliver coal to Thunder Bay Terminals at the port of Thunder Bay, Ontario. Located on the northwest shores of Lake Superior, the terminals are 2,300 kilometres from the nearest mine, but the coal trains can make the round trip in under six days.

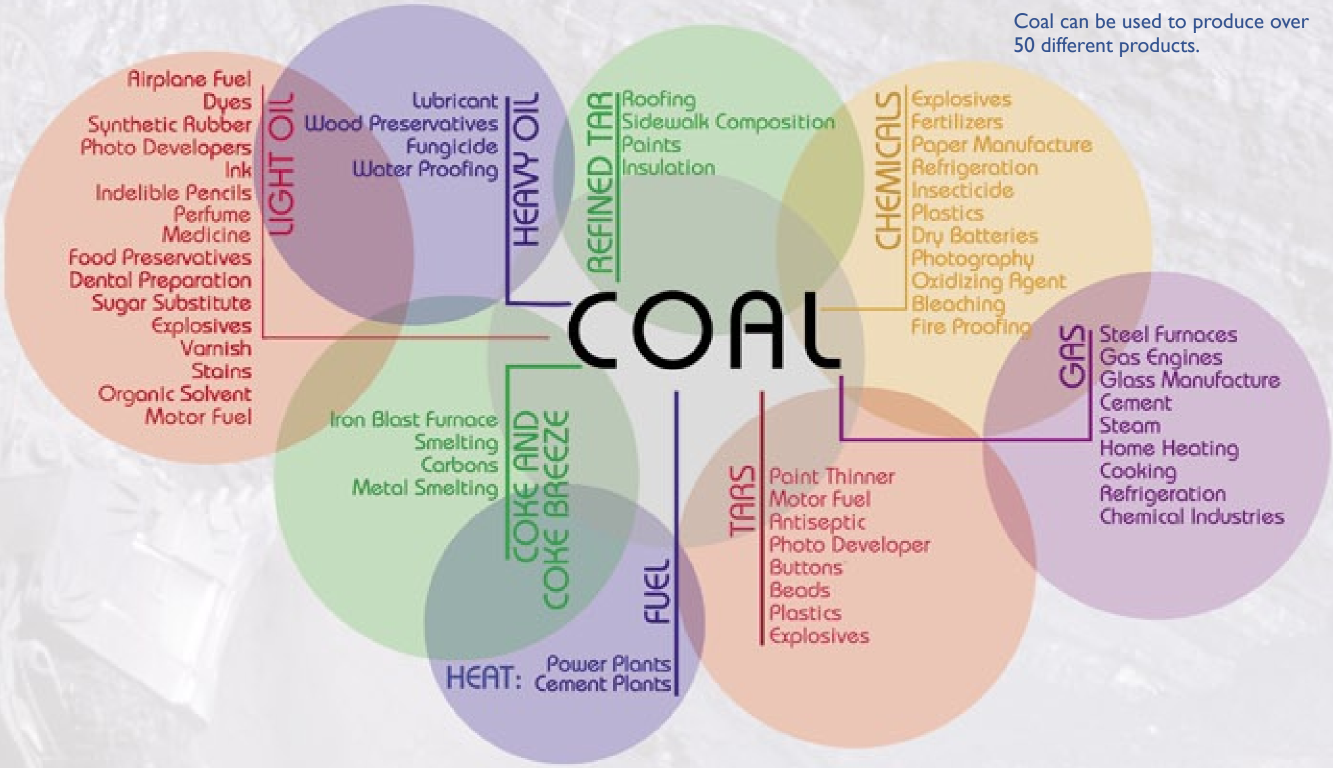
The technologies used at Canada's coal ports help the Canadian export coal industry be competitive in the international marketplace.

THINKING OUTSIDE THE BOX

TECHNOLOGY BRINGS OUT THE BEST IN COAL

There's a tendency to think of coal as just a fuel source for heating, generating electricity and manufacturing the coke used to produce steel. The fact is, coal can be processed into a wide range of products from bleach, fertilizer and perfume, to baking powder, medicine and gasoline.

Coal can be used to produce over 50 different products.



COKE AND COKING BY-PRODUCTS

In the 1600s, brewers converted coal into coke to dry their malt for beer making. In 1709, coke was first used for smelting iron ore. Shortly afterward, the process for converting coal into coke was used to extract coal by-products like liquid fuels, tars and gases.

The same basic technology is used today. Crushed coal is heated to temperatures as high as 700°C to force out moisture, gases, oils and coal tar. The remaining material, about 70 per cent of the coal, is called coke—a hard but porous substance composed mostly of carbon. Canada has coking plants in Ontario that produce coke for steelmaking in Hamilton and Sault Ste. Marie.

The main by-products of the coking process—hot gases—are used to fuel the blast furnaces. However, before the gases are sent to the furnaces, they're stripped of ammonia, light oils and coal tars. The ammonia is used in fertilizer, while the oils and tars are processed into a variety of organic solvents and chemicals.

RESEARCH

TECHNOLOGY LEADS TO SMARTER AND SAFER MINING

Nearly all of Canada's coal is produced from surface mines where large, specialized equipment is used to move earth and rock to recover the coal. To make these operations as safe as possible, coal companies, employees, unions and government agencies have worked together to develop solid safety guidelines, procedures and practices. Major advances have been made in mine engineering, training standards and operating practices. These efforts have earned coal mining one of the lowest worker-accident rates for major industries in the country.

Canada's coal industry stands as an example of the safety level that can be achieved with commitment from industry and workers, and the ongoing support of government.

Cold-climate technologies. **Canadian winters present special challenges for surface mining operations. Several technological advances have been developed to deal with these unique mining conditions. For example, cold-tolerant steels have been developed for heavy mining equipment and cold-weather resistant brakes have been installed in haul trucks.**

ENGINEERING TECHNOLOGY FOR SAFETY

Surface mining technologies use the information from studies of coal seams, local rock strata and groundwater conditions to fine tune the design and engineering of open-pit and strip mines. Using this information, potential hazards such as unstable ground and unpredictable earth movements can be minimized.

These and other technological advances, combined with the industry's emphasis on training and safe work practices, reflect a process of continuous improvement to ensure the safety of coal industry employees.

PROOF IN THE PERFORMANCE

CONTINUOUS IMPROVEMENT IS ESSENTIAL

For Canada's coal industry to remain viable and competitive both domestically and internationally, it has had to create and adopt innovative, efficient and sophisticated technologies.

Canada's coal industry is recognized worldwide for its proactive land reclamation practices.

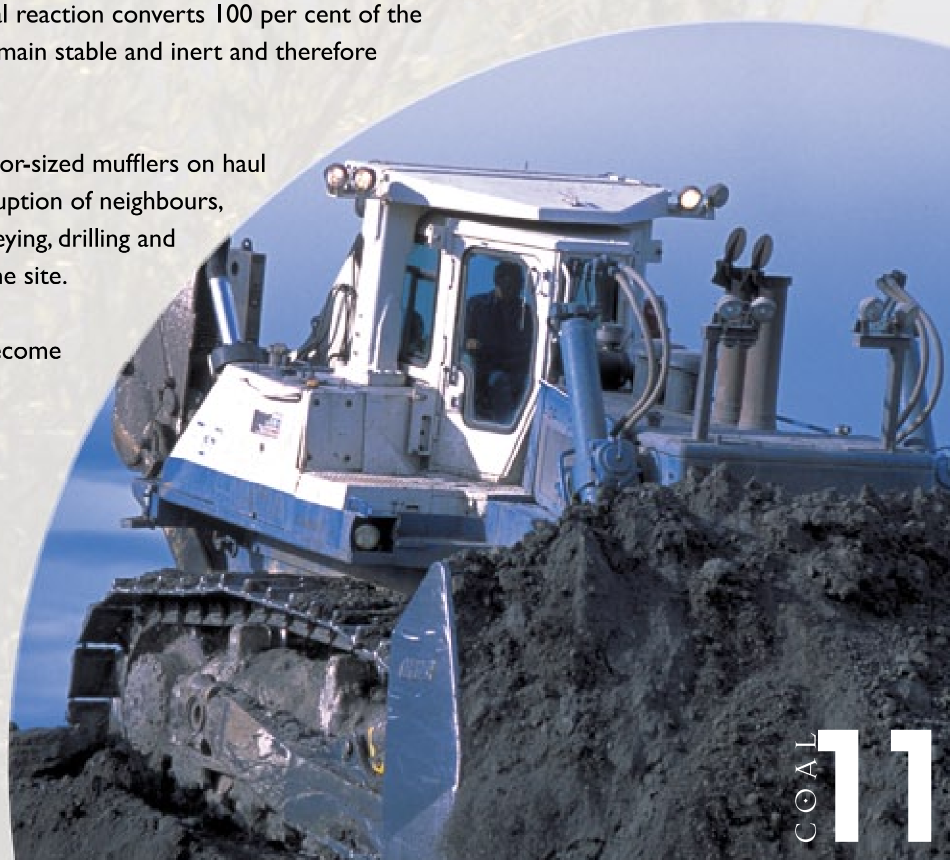
Given the great distances from mines to ports and then to end markets, Canadian export-coal producers face unique challenges in shipping to customers around the world. Innovations in Canadian mining and coal processing methods, combined with advanced unit train and ship loading systems, contribute significantly to the industry's success in export markets.

Canadian coal mines are also becoming less intrusive on the local environment. An increased understanding of natural processes is enabling mining companies to adapt their practices to minimize impact on air, water and land. Reclamation techniques are returning mined lands back into wildlife habitat, commercial forests and farmland. New environmentally friendly lubricants are replacing older varieties which contained harmful components like lead.

Coal-fired power plants are employing a variety of cleaner-burning systems to reduce emissions and increase efficiencies. When electrostatic precipitators and scrubbers are used in the exhaust system, emissions like fly ash and sulphur dioxide are removed. Other research programs are testing new emission technologies that could lead to even lower, and in some cases even zero emissions from burning coal. For example, one conceptual process exposes carbon dioxide to abundant, naturally occurring minerals like magnesium and calcium silicate. Theoretically, the chemical reaction converts 100 per cent of the carbon dioxide to mineral carbonates that remain stable and inert and therefore are not released to the atmosphere.

Other innovations include installing refrigerator-sized mufflers on haul trucks to reduce noise and minimize the disruption of neighbours, and using GPS navigating technology for surveying, drilling and dispatching shovels and haul trucks at the mine site.

Like other industries, the coal industry has become high-tech in order to increase efficiencies and compete in the global marketplace. Coal, one of the world's oldest fuels, is currently generating a significant portion of the electricity that powers the most advanced technologies in today's world. And as demand for coal-powered electricity increases, the Canadian coal industry continues to develop new ways to meet the world's coal needs.



GLOSSARY

BCE – in measuring time, it stands for "before the common era". Formerly BC ("before Christ").

BOILER – a tank in which water is turned to steam for heating or for power.

BREAKER – a machine that crushes and screens coal. It consists of a rotating drum in which coal is broken by gravity impact against the walls of the drum. During this process, large rocks are removed.

COKE – a hard, dry foam-like carbon substance produced by heating metallurgical coal to a very high temperature in the absence of air. Coke is used in making steel and iron.

DRAGLINE – an excavating machine that uses a bucket operated and suspended by cables. One set of cables lowers the bucket from the boom, while another set of cables allows the bucket to swing out from the machine or to be dragged toward the machine to remove overburden above a coal seam.

ELECTROSTATIC PRECIPITATOR – an electrical device for removing fly ash from flue gases before the gases are released from the power plant's stack.

FEEDSTOCK – raw material for industrial processing.

FLY ASH – the mineral residue produced as a by-product of burning coal. Fly ash is collected from flue gas before it exits the power plant's stack.

HOPPER – a funnel-shaped bin that loads from the top and discharges its contents through a door or chute at the bottom.

METALLURGICAL COAL – a term used to describe varieties of bituminous coal that are converted into coke for use in the steel making process. It is also referred to as coking coal.

SCRUBBERS – any of several forms of chemical/physical devices which operate to remove sulphur compounds formed as a result of fossil-fuel combustion.

SPECIALIZED BURNERS – modern burners (low nitrogen oxide burners) that include special controls to minimize the production of nitrogen oxide gases from the combustion of coal.

TECTONIC FORCES – forces pertaining to changes in the structure of the Earth's crust.

THERMAL COAL – a term used to describe coal which is used primarily to generate heat. It is also referred to as steam coal.

TURBINE – a machine for generating rotary mechanical power from the energy of a stream of fluid such as water, steam or hot gas.

TRANSFORMER – an electrical device for changing the voltage of alternating current.

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