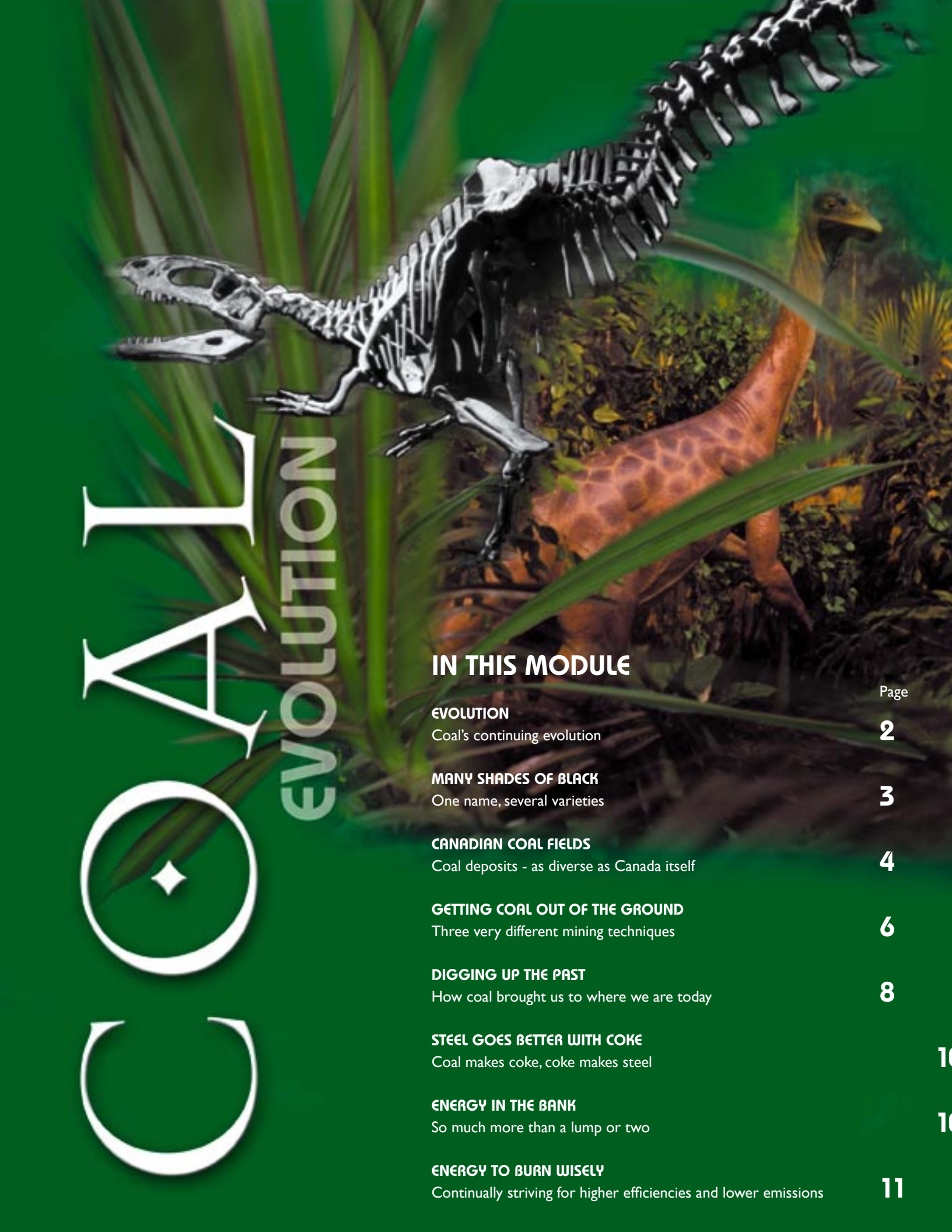


# COAL

## EVOLUTION

## IN THIS MODULE

# EVOLUTION

## COAL'S CONTINUING EVOLUTION

Coal is a valuable and plentiful natural resource found in Canada and around the world. Far more abundant than crude oil or natural gas, coal has been used by humans for over 4,000 years.

In the past, coal kept our ancestors warm and helped fuel our industrial development. Today, it generates much of our electricity, helps produce most of the world's steel and is used in other industrial processes like cement making. In the future, coal will continue to play a significant role in the energy mix for power generation.

## DATING BACK TO THE DAYS BEFORE THE DINOSAURS

Coal originated some 300 million years ago in the form of tropical and subtropical plants. When these plants died and decayed in swamps, they became layers of peat*. Inland seas, formed during the melting of the Ice Age, covered the peat with sediment. As this layer of sediment built up, it put pressure upon the peat. This pressure, in combination with high temperatures, transformed the peat into coal.

This transformation process took millions of years. It started just after the age of fishes and continued until dinosaurs became extinct, some 65 million years ago. That means that the steel for today's cars, bicycles, ships and buildings is produced using coal created from pre-historic plants. If you live where electricity is generated from coal, your computer could be powered by coal formed from decomposed grass once nibbled on by a Stegosaurus!

Eight will get you one. **Scientists estimate that it took about eight metres of compacted vegetation to produce one metre of coal. To put that in perspective, if you filled a room in your home to the ceiling with vegetation, compacted it, added heat and waited for a couple million years, you would get about 30 centimetres of coal.**

* See Glossary

# MANY SHADES OF BLACK

## ONE NAME, SEVERAL VARIETIES

All coal is not created equal. In fact, coal is composed of such a complex mixture of materials, it can be quite different from one deposit to another. Some deposits of coal, called metallurgical* or coking coal, are essential for use in steelmaking. Other deposits, called thermal* or steam coal, are used to generate electrical power and make cement.

**Metallurgical or coking coal is used in the steelmaking process. Thermal coal is used to generate electricity.**

Differences in coal deposits came from variations in the original plant materials that formed the deposit and in the process that creates coal. Different kinds of vegetation and variations in the amount of minerals influenced the composition of coal. Higher pressures and temperatures also affected the coal deposit's quality, as did the length of time it spent being formed.

## THE HIGHER THE CARBON CONTENT, THE HIGHER THE RANK

In North America, coal is classified by rank. Higher ranked coal contains more carbon and produces more energy.

Higher ranked coal contains more carbon and produces more energy.

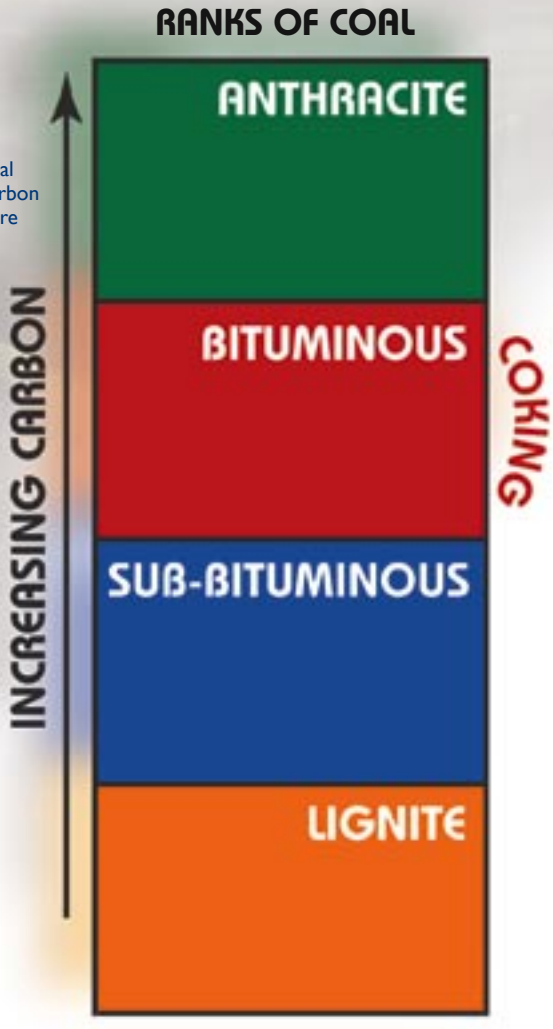
**ANTHRACITE*** is the top-ranked coal because it has the highest carbon content and, therefore, the most heat value. Anthracite is also the hardest of all coals. Although it is not currently being mined in Canada, anthracite deposits have been found in remote areas of northwestern British Columbia.

**BITUMINOUS*** coal is a step down from anthracite. It has a high carbon content, is generally low in moisture and has small amounts of hydrogen and oxygen. This composition makes bituminous coal ideal for both metallurgical and thermal uses. In 2001, bituminous coal accounted for over 48 per cent of Canada's total coal production. Of that, 84 per cent was mined for metallurgical use. There are bituminous coal deposits in British Columbia, Alberta and Atlantic Canada and minor amounts in Yukon, Northwest Territories and Nunavut.

Most of Canada's coal reserves are bituminous.

**SUB-BITUMINOUS*** coal is lower ranked and softer than bituminous coal and tends to have high moisture content. It is well suited for use in thermal electric power generation plants. Mined in Alberta, sub-bituminous coal accounted for 35 per cent of Canada's production in 2001.

**LIGNITE*** is the lowest ranked of all the coals. In comparison to other coals, lignite is quite soft. Its colour can range from a dark black to various shades of brown. Found in southern Saskatchewan and southeastern Alberta, lignite generates 65 per cent of Saskatchewan's electric power.

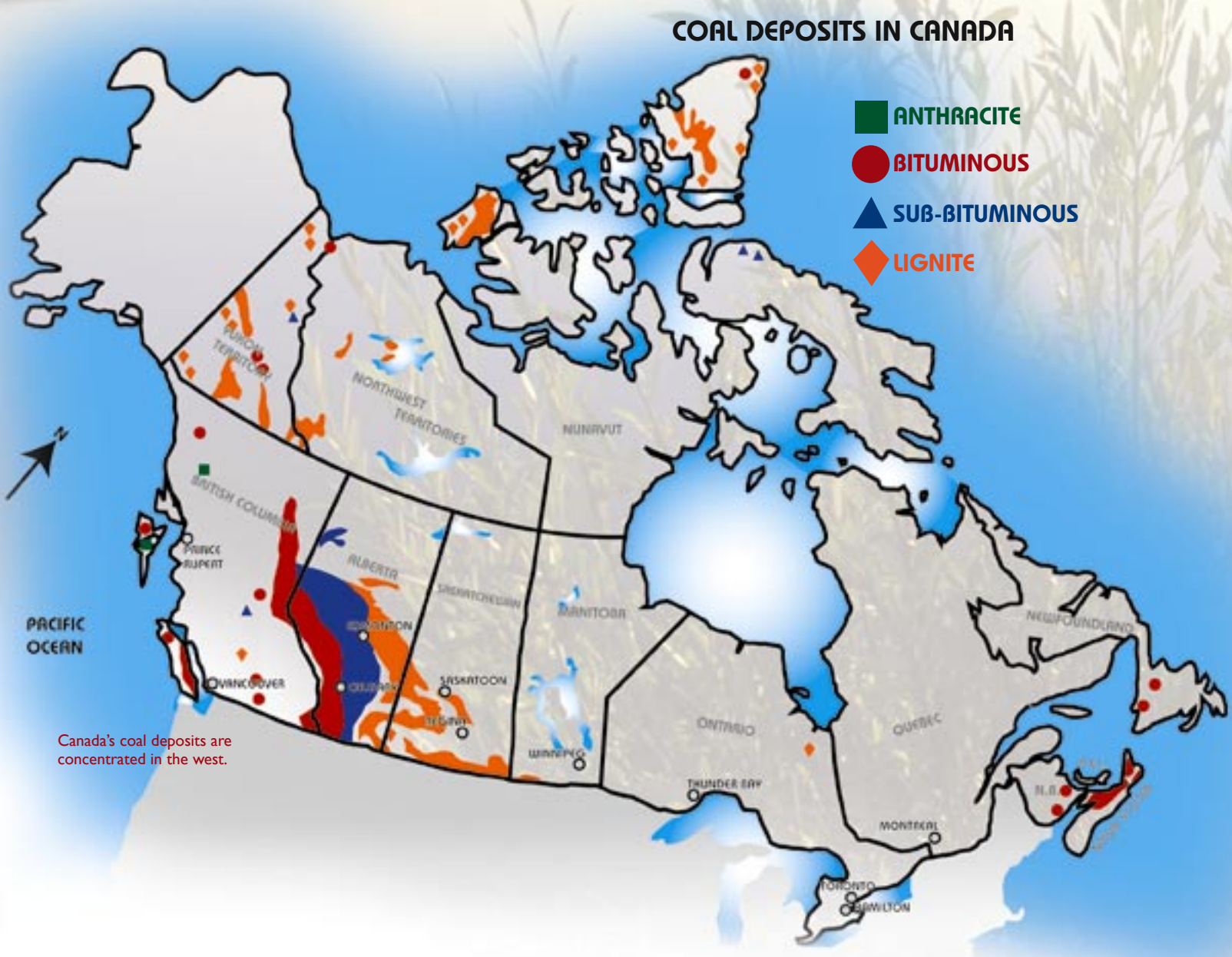



* See Glossary

# CANADIAN COAL FIELDS

## COAL DEPOSITS—AS DIVERSE AS CANADA ITSELF

Canada is a vast country, with landscapes that change dramatically with the geography, geology and climate. Canada's coal deposits are as big and varied as the country itself.




Canada's coal deposits are concentrated in the west.

## LIKE THE PRAIRIES—SMOOTH AND EVEN

In the Prairies of central and southern Alberta and southern Saskatchewan, coal lies in blankets spread under large tracts of land. Many kilometres in size, these gently dipping blankets of coal, known as coal seams, are usually the same thickness throughout. The coal is easily mined because it is near the surface under a shallow layer of glacial till*, soil or rock. Millions of years ago, these materials were the floor of an inland sea.

* See Glossary

Map Source: The Coal Association of Canada • 2003

## LIKE THE MOUNTAINS—STEEP, DEEP AND FOLDED

Extensive coal reserves also run through the foothills and mountains along the borders of Alberta and British Columbia. Coal seams up to 15 metres thick are not unusual! In contrast to the Prairies, however, these seams can be deeply buried and steeply inclined. The folds in the mountains cause breaks in the seams, so coal beds are heaved up, down or even to the side. The complexity of these seams generally makes open-pit mining the best way to get at the coal in the foothills and mountains. However, where the geology is less complex, underground mining is possible.

## LIKE THE OCEAN—VAST AND CHANGING

In eastern Canada, the Sydney Coalfield is the most significant deposit in Nova Scotia. Located mostly under the ocean, it features 11 major seams from 1.0 to 4.5 metres thick. Other coalfields in Nova Scotia include Springhill, Pictou, Roslin and Joggins-Chignecto. The cost to extract the coal in these fields made them uneconomical to mine and they were closed.

In New Brunswick, the Minto Coalfield covers about 400 square kilometres and runs between 0.3 and 0.7 metres in thickness. This single seam follows the contours of the land so it's easily surface mined.

## LIKE THE NORTH—DIFFICULT TO TAME

In northern Ontario, the Onakawana Coalfield is next to the Canadian Shield. This large deposit is 39 kilometres square, but due to its high moisture content and low heating value, it has not been developed.

In Northwest Territories, Nunavut and Yukon, coal deposits have been confirmed but their potential has yet to be determined. To date, no development is planned.

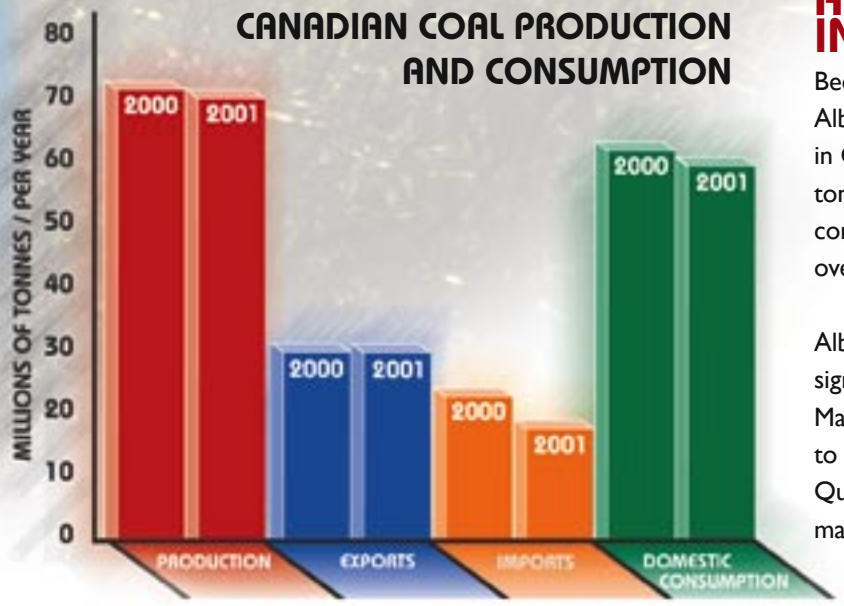



Chart Source: The Coal Association of Canada • Statistics Canada

## COAL PRODUCERS AND CONSUMERS IN CANADA

Because of their concentration of industry and people, Alberta and Ontario are the biggest consumers of coal in Canada. Every year, Alberta uses over 25 million tonnes of coal—that's over 40 per cent of all the coal consumed in Canada. Ontario uses 19 million tonnes—over 30 per cent of Canada's coal use.

Alberta and Saskatchewan use coal to generate a significant portion of their electricity. Ontario, Manitoba, Nova Scotia and New Brunswick use coal to generate some of their electric power. Ontario, Quebec and British Columbia also use coal to manufacture steel and cement.

Alberta and Ontario are Canada's biggest consumers of coal.

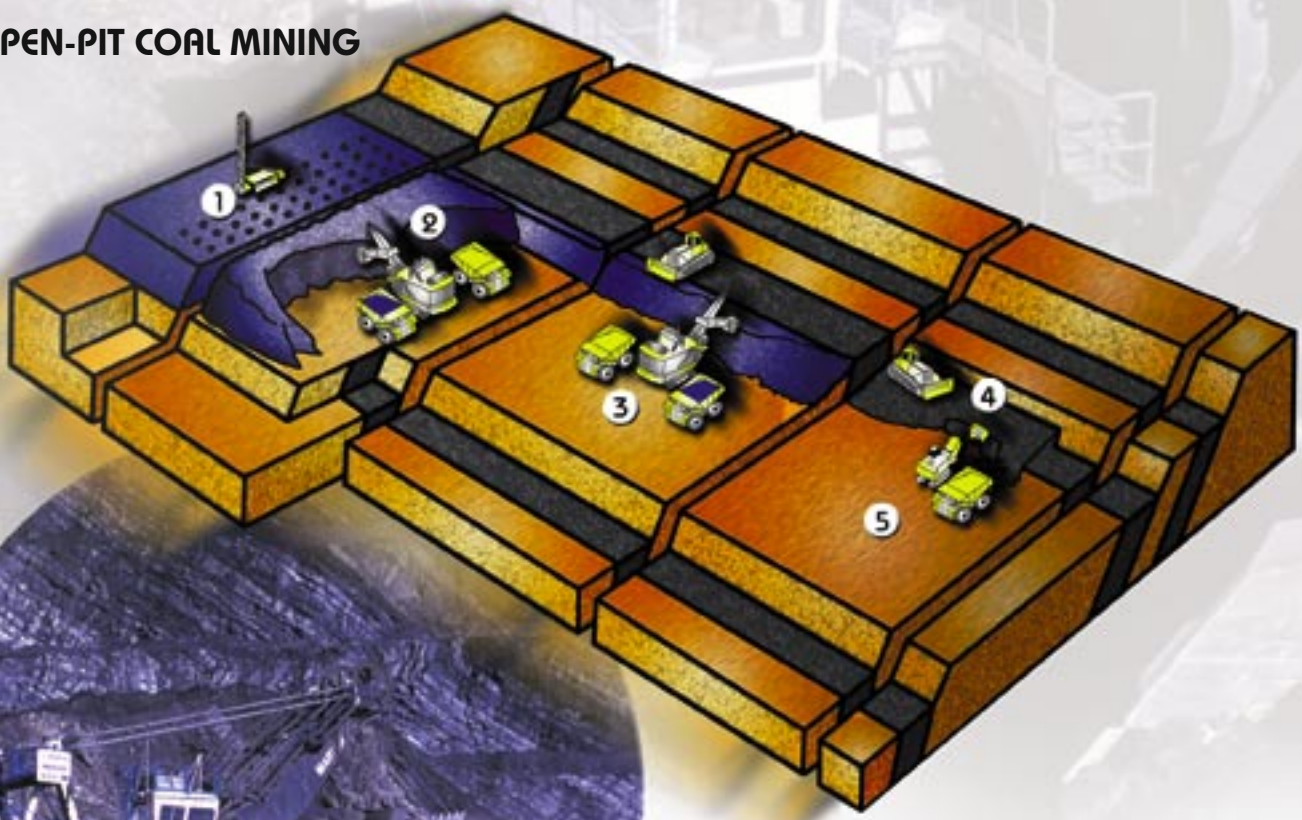
# GETTING COAL OUT OF THE GROUND

## THREE VERY DIFFERENT MINING TECHNIQUES

When someone mentions coal mining, an image of an underground coal miner usually comes to mind. Actually, that's old news. Today in Canada, virtually all our coal is mined from the surface in either open-pit or strip mines.

**OPEN-PIT MINING** is conducted in the foothills and mountains of Alberta and British Columbia. These large, open-pit excavations provide access to the coal that lies in dipping seams. As mining progresses, the pits are widened and deepened to follow the seams of coal. In a typical open-pit mining operation, a number of pits will be developed.

### OPEN-PIT COAL MINING




**1** Waste rock is drilled and blasted on each bench so it can be removed to expose the coal seam. **2** A large electric shovel and a smaller-capacity shovel **3** load the waste rock into haul trucks for removal to areas of the mine that do not contain coal. **4** While dozers and a backhoe "clean" the coal seam and push the exposed coal down to the bench floor, an excavator **5** places the coal into trucks equipped with specially designed coal boxes for transport to the rotary breaker. The mining sequence starts again as each bench level nears completion.

Illustrations Source: The Coal Association of Canada • 2003

**STRIP MINING** is the method used for extracting the coal that spreads out in blanket-like seams across the Prairies and in New Brunswick. Large draglines remove the rock and soil, called overburden*, to expose the coal so it can be removed. This process is called strip mining because the coal is mined in rows or strips.

**1** Soil is stripped ahead of mining and is salvaged for use in subsequent reclamation.

**2** A dragline removes the overburden to expose the coal seam.

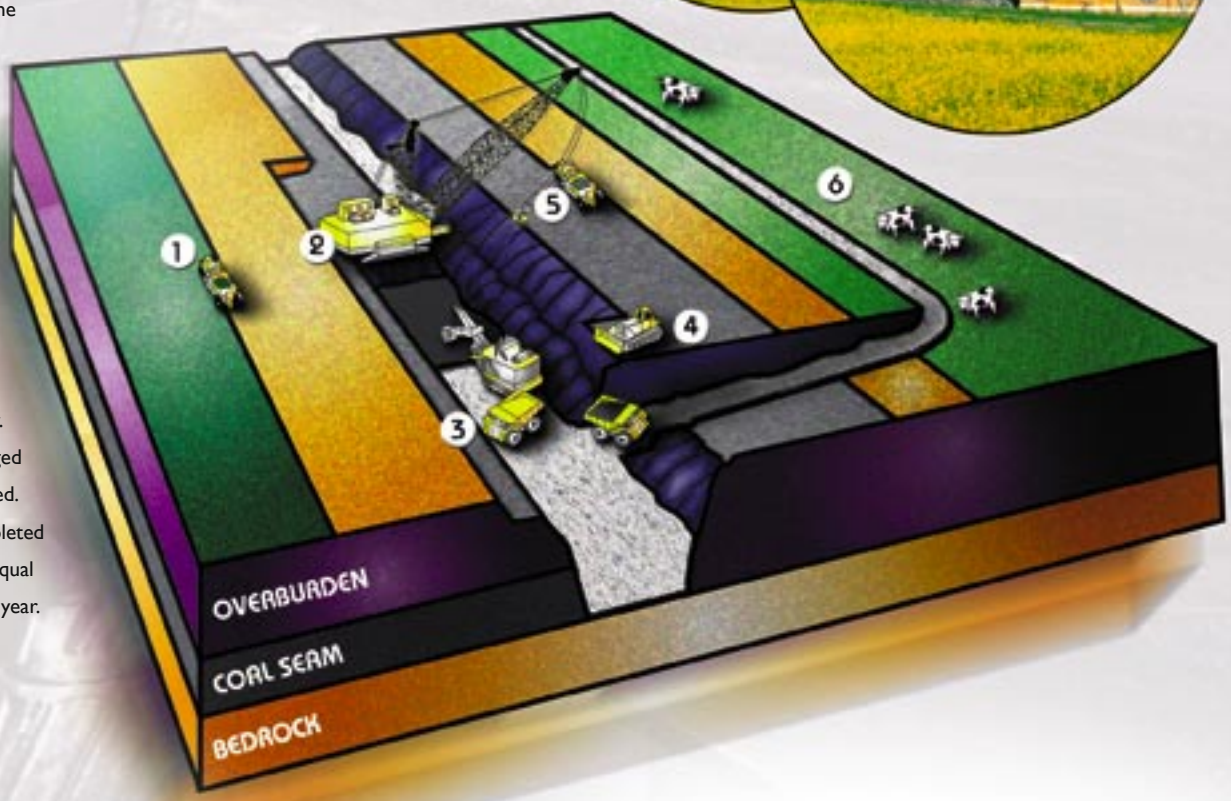
**3** Coal is loaded into large, off-road trucks for transport to the power plant.

**4** "Spoil" piles left by the dragline are recontoured to produce suitable post-mining topography.

**5** Soil, which was salvaged before mining, is replaced.

**6** Revegetation is completed in increments roughly equal to the area mined each year.

## STRIP MINING




**UNDERGROUND MINING** methods are used where coal deposits are very deep. However, because of the high cost of operating underground mines, little of this type of mining occurs in Canada today. The only underground coal mine currently operating in Canada is located on Vancouver Island, British Columbia.

This remote-controlled, continuous mining machine is electrically powered for underground coal mining. The rotating drum at the front rips coal from the coal face. A built-in conveyor system carries the coal to the rear where it is loaded into shuttle cars.

## UNDERGROUND MINING

* See Glossary

# DIGGING UP THE PAST

## HOW COAL BROUGHT US TO WHERE WE ARE TODAY

Humans have a long relationship with coal. Archeologists tell us that people burned coal in Wales 4,000 years ago. We also know coal was commonly used in China and parts of the Roman Empire 2,000 years ago.

Coal was used for heat in Europe and North America in the 1200s. In the 1700s and 1800s, coal fueled the Industrial Revolution, producing steam for the engines that powered factories, trains and ships. Today, coal is used to generate a significant amount of the world's electric power.

Stamp of approval. **In 1973, the Government of Alberta named sub-bituminous coal as the "fuel of choice" for base-load electric power generation. Coal was chosen as the best fuel to make electricity in Alberta because coal is readily available.**

## BOTH SIDES TOWARDS THE MIDDLE

Coal mining began on Canada's east and west coasts. In 1639, the country's first producing coal mine opened in Grand Lake, New Brunswick. In 1720, coal mined in Port Morien, Cape Breton Island, Nova Scotia, was used as fuel to heat the fortress at Louisbourg. In the west, coal mining began in 1836 on Vancouver Island, British Columbia. Then, as the railroads moved west from central Canada in the late 1800s, mining spread to the Prairies and eastern British Columbia.

Coal heated homes, powered trains across Canada and helped fuel the country's industrial development. During the early 1900s, half of Canada's energy needs were supplied by coal. Coal was so economically important, it was called "King Coal" until the late 1940s, when huge reservoirs of crude oil and natural gas were discovered in Alberta.

Coal heated homes, powered trains across Canada and helped fuel Canada's industrial development.

## SWEPT ASIDE BY THE PETROLEUM REVOLUTION

In the 1950s, petroleum—crude oil and natural gas—replaced coal as the energy source of choice. The change happened so rapidly, coal-mining communities found themselves facing mine closures and job losses. Canada's once thriving coal industry struggled to find new customers and alternative markets for its products.

Things looked pretty bleak until the late 1960s, when Japan began importing Canadian coal for its steel industry. Then in the 1970s, Alberta and Saskatchewan began using their large coal reserves to generate electricity. Ontario followed suit by building coal-fired power plants to meet the rising demand for electricity in that province.

# CANADIAN COAL MAKES A DRAMATIC COMEBACK

By the late 1970s, the demand for coal was so high it exceeded the capacity of Canada's coal handling and transportation systems. Canadian railways responded by developing trains specifically designed for carrying coal. Canadian ports were also improved to speed up ship loading. New coal-handling systems were developed in seaports on both the east and west coasts, as well as in Thunder Bay, Ontario.


Using specially designed trains and efficient ports, Canada exports approximately 30 million tonnes of coal every year.

The continuing strength of the coal industry proves the long-term, beneficial effects of these high-volume systems. In 2001, Canada produced over 70 million tonnes of coal. Over 40 per cent of it—30 million tonnes—was exported to the Pacific Rim, Europe, the United States, Mexico and South America. Japan, Canada's largest coal customer, purchased 10 million tonnes of our export production. Over 90 per cent of Japan's coal purchases are metallurgical coal for steelmaking.

Why does Canada import coal? **Because of the cost of mining and transportation. The coal mines in the eastern United States are much closer to Ontario and Quebec than the mines in western Canada. Because of this proximity, it's much less expensive to send coal from the U.S. to central Canada than to ship it thousands of kilometres across the country.**

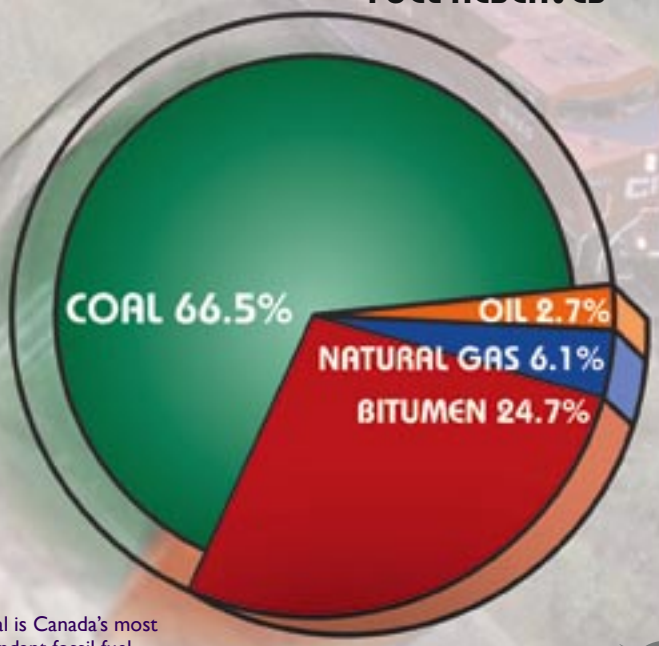
**For a similar reason, Atlantic Canada imports coal from Colombia and Venezuela. Transporting coal by ship is less costly than sending it across Canada by train. Lower South American mining costs make their products even more attractive.**

# STILL TOGETHER AFTER 4,000 YEARS

Humans have benefited from the use of coal for over 4,000 years. In all likelihood, we will continue to use coal for as long as we need steel and electricity. In Canada, approximately 12.5 per cent of our electricity is generated by coal-fueled power plants. In the process, we consume over 54 million tonnes of coal—a great deal of coal! And no doubt that volume will increase as demand for electric power continues to grow.

Luckily, Canada is well-stocked with coal. According to the Geological Survey of Canada, we have over eight billion tonnes of coal reserves. That's enough coal for over 120 years of mining at current rates of production. In spite of this abundance, eastern Canada still imports a vast amount of coal from nearby producers in the United States and South America. In 2001, over 17 million tonnes of coal were imported, primarily for the steel and cement industries in Ontario and Quebec and for coal-fired electric power plants in Ontario and Atlantic Canada.

## CANADIAN FOSSIL FUEL RESERVES




Coal is Canada's most abundant fossil fuel.

Chart Source: The Coal Association of Canada • 1999

# STEEL GOES BETTER WITH COKE

Coke from coal is an essential element in steelmaking.

## COAL MAKES COKE, COKE MAKES STEEL

Brewers were the first to use coke. To toast the grain used in their beer, brewers learned how to heat coal to very high temperatures in the absence of air. This process drove the unwanted by-products like tars, oils and gases out of the coal. The end product was a very hard, foam-like mass of almost pure carbon, named coke. Coke worked well for brewers, but more importantly, it became a key ingredient in making steel.

In steelmaking, coke and metal ores, like iron ore, are combined in blast furnaces. Coke provides the heat that chemically changes the rock-like ores into a molten metallic form. Coke also helps separate the gases from the molten metal. While the gases rise in the furnace, the molten metal sinks to the bottom where it is removed for further processing into steel.

**Multi-purpose coal. Coal can be transformed into a multitude of products we use every day. It can be processed into synthetic gas, which can then be refined into gasoline, diesel fuel and kerosene. In fact, coal can become a feedstock for making plastic, fertilizer, film and even perfume!**

# ENERGY IN THE BANK

## SO MUCH MORE THAN A LUMP OR TWO

In the 1800s, coal literally drove the industrialization of the world. Today, it generates over 35 per cent of the world's electricity and is used to produce 70 per cent of the world's steel. Coal's by-products can be used to make all kinds of things, from gasoline to perfume, mothballs to baking powder.

The best part about coal, however, is its low cost. Coal is—and will continue to be—a reliable, economical fuel. Here in Canada, we've traditionally used coal for electrical generation, heating, steelmaking and other industrial processes. Because of its affordability and abundance, new uses for coal are anticipated, especially as new technologies are developed and the costs to produce other energy sources rise.

## COAL FIRES UP CANADA'S ECONOMY

The economic importance of the coal industry is significant. Canada's annual coal exports are valued at $1.6 billion. And in an average year, the total value of coal production to the Canadian economy is $4.5 billion.

The coal industry directly employs 5,850 people across Canada, creating a wide variety of opportunities for geologists, engineers, environmental specialists, reclamation experts, skilled trades people and information management professionals. But there are thousands of other jobs linked to coal. In total, the Canadian coal industry directly and indirectly supports over 56,000 jobs! These include positions in the steelmaking, transportation, power generation and manufacturing industries, as well as jobs in the local businesses and services that support Canada's coal mines.

Besides providing employment, the coal industry makes significant economic contributions to governments, communities and other industries. Every year, coal companies pay approximately $220 million in taxes, licenses and permits. Coal employees pay an additional $167 million in personal income taxes. Approximately $660 million is paid to Canadian railways and ports to cover transportation costs and the loading of ocean-going vessels. And every year, the coal industry spends about $470 million on materials, fuel and electricity. Of that, 90 per cent is purchased in Canada.

# ENERGY TO BURN WISELY

## CONTINUALLY STRIVING FOR HIGHER EFFICIENCIES AND LOWER EMISSIONS

No story about the evolution of coal would be complete without discussing the evolution of environmental challenges, strategies and successes.

## BETTER PRACTICES FOR A BETTER WORLD

Along with the rest of society, mining companies have become much more environmentally responsible over the past 30 years. They operate according to comprehensive, provincially approved reclamation plans and follow stringent standards regarding air quality, ground water and surface water.

Mining companies regularly consult with local communities and area residents to find ways to minimize the disruptions and intrusions of mine operations. Companies have taken an active stewardship in the development of programs aimed at reducing mining's impact on the local flora and fauna. They have also shortened the time it takes to return mined land to a productive state equal to, or better than, that which existed before mining.

Land borrowed for coal mining can quickly be returned to its original use. This hay crop was harvested on land that was a strip mine just three years ago.

Together with government and the public, Canada's coal companies have developed some of the highest standards for protecting the environment. Our country is now a world leader in the reclamation of mine sites. Land which originally was used for agriculture or forestry purposes is now just temporarily "borrowed" for mining operations and then returned to its previous use.

**For over 4,000 years, coal has helped keep people warm, protected and comfortable. With responsible resource management and the use of smarter, cleaner-burning technologies, coal can continue contributing to our quality of life for a fifth millennium.**

## A BETTER WORLD MEANS REDUCED EMISSIONS

Canada's coal industry is concerned about the issues related to climate change. As a result, the industry is pressing ahead with the development and use of cleaner-burning and more efficient technologies that reduce emissions from burning coal. The emphasis is on energy efficiency and resource conservation*.

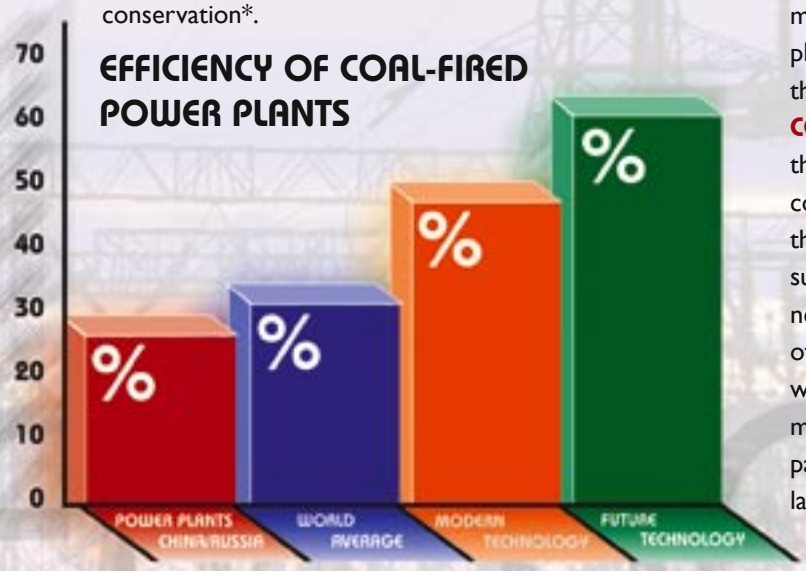



Chart Source: Future Technologies: U.S. Department of Energy (DOE/EIA) Vision 21

**ENERGY-EFFICIENCY** programs focus on deriving the greatest benefit from using the least amount of energy. The coal industry is working with government agencies and electrical utilities to develop new technologies to burn coal more cleanly and efficiently. In this area, the industry has made great strides. As indicated in the chart to the left, modern coal power plants are more efficient than older plants. Future technologies are expected to further improve the amount of electricity a tonne of coal will produce.

**CONSERVATION** is aimed at ensuring energy supplies for the future by reducing waste and discouraging unnecessary consumption. Coal consumption is expanding throughout the world. Developing nations, in particular, are experiencing substantial increases in consumption. This growth signals a need for global cooperation to maintain sustainable levels of resource use. In response to this need, Canada is working with other countries to encourage responsible mining and coal use practices around the world. A big part of Canada's conservation contribution is its proven land reclamation programs.

* See Glossary

# GLOSSARY

**ANTHRACITE** – the highest rank of coal because of its high carbon content.

**BITUMINOUS** – an intermediate ranked coal between anthracite and sub-bituminous coal. It has a high carbon content and is low in moisture content. Bituminous coal can be used for both steelmaking and power generation.

**CONSERVATION** – the wise and careful use, protection or management of natural resources.

**GLACIAL TILL** – rock material made up of clay, sand, gravel and boulders that are deposited directly from glacier ice.

**LIGNITE** – a low-rank coal with a relatively high moisture and low heat/energy content. Ranging in colour from black to brown, lignite is used in power generation.

**METALLURGICAL COAL** – a term used to describe varieties of bituminous coal that are converted into coke for use in the steelmaking process.

**OVERBURDEN** – layers of rock and soil covering a coal seam. In surface mining operations, overburden is removed using large equipment and is either used for reclaiming mined areas or hauled to designated dumping areas.

**PEAT** – partly decayed plant matter found in ancient bogs and swamps. Dark brown in colour and high in moisture content, it will burn when dry.

**SUB-BITUMINOUS** – a generally soft coal with a heating value between bituminous and lignite. It has low fixed carbon and high percentages of moisture and volatile material. Sub-bituminous coal is mainly used for generating electricity.

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

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MODULE 4: ENVIRONMENT
MODULE 5: SUSTAINABILITY