2 Coal

Coal is a mixture of organic mineral material produced by a natural process of growth and decay, or an accumulation of debris both vegetal and mineral with some sorting and stratification. The process is accomplished by chemical, biological, bacteriological and metamorphic action.[1]

Forms of Coal

Coal is a hydrocarbon that is classified according to the amount of heat it produces. Heat content depends upon the amount of fixed carbon it contains. Rank is the degree of progressive alteration in the transformation from lignite to anthracite. There are four primary ranks of coal:

- Anthracite (semi-anthracite, anthracite, and meta-anthracite)
- Bituminous (high-volatile, medium-volatile, and low-volatile)
- Subbituminous
- Lignite (brown coal and lignite)

The transformation of vegetal matter contained in wood and peat then to lignite and, finally, to anthracite results in a reduction of volatile matter and oxygen content with a simultaneous increase in carbon content. The following description lists coals by rank and gives some of their physical characteristics.

[1] Combustion Engineering, *Combustion-Fossil Power*, Chapter 2-7, 1991.

Anthracite - Hard and very brittle, anthracite is dense, shiny black, and homogeneous with no marks or layers. Unlike the lower rank coals, it has a high percentage of fixed carbon and a low percentage of volatile matter. Anthracites include a variety of slow-burning fuels merging into graphite at one end and into bituminous coal at the other. They are the hardest coals on the market, consisting almost entirely of fixed carbon. The little volatile matter present is chiefly methane, CH_4. Anthracite is used principally for heating homes and in the production of natural gas.

Some semi-anthracites are dense, but softer than anthracite, shiny gray, and somewhat granular in structure. The grains have a tendency to break off during handling and produce a coarse, sand-like slack. Other semi-anthracites are dark gray and distinctively granular. The grains break off easily in handling and produce coarse slack.

Bituminous - Bituminous coals are soft coals and are by far the most abundant group. When heated, they are reduced to a cohesive, binding, sticky mass. Their carbon content is less than that of anthracites, but with more volatile matter. The character of their volatile matter is more complex than that of anthracites and the volatiles are higher in calorific value. They burn easily, especially in pulverized form, and their high volatile content makes them good for producing gas. Their binding nature enables them to be used in the manufacturing of coke, while the nitrogen in them is utilized in processing ammonia. Bituminous coals are chiefly used to generate electricity but is also used to produce aluminum, cement, food, paper and textiles.

Low-volatile bituminous coals are grayish black and distinctly granular in structure. The grain breaks off very easily and handling reduces the coal to slack.

Medium-volatile bituminous coals are the transition from high-volatile to low-volatile coal and have the characteristics of both. Many are soft and granular in structure as well as easy to crumble. Some are homogeneous with very faint indications of grains or layers. Others are of more distinct laminar structure, hard, and withstand handling.

High-volatile bituminous coals are mostly homogenous with no indication of grains, but some show distinct layers. They are hard and withstand handling with little breakage.

High-volatile B bituminous coals have a distinct laminar structure; thin layers of black, shiny coal alternating with dull, charcoal-like layers. They are hard and withstand handling well.

High-volatile C bituminous coals have a distinct laminar structure and withstand handling well.

Subbituminous - Subbituminous coals are very soft coals. They are brownish black or black. Most are homogeneous and have smooth surfaces with no indication of layers. They have high moisture content, although they appear dry. When exposed to air they lose part of the moisture and crack with an audible noise. After long exposure to air, they disintegrate. They are non-coking coals. They burn readily and can be used for household heating as well as for industrial plants.

Lignite - Lignites are brown and of a laminar structure. They are comprised of remnants of woody fibers. Lignite gets its name from the Latin word *lignum*, which means wood. Freshly mined lignite is tough, although not hard, and requires a heavy impact with a hammer to break up the large lumps. When exposed to air, they lose moisture rapidly and disintegrates. Due to the high moisture and low heating value, they are not economical to transport it long distances.

Unconsolidated lignites, also known as "brown coals," are generally found close to the surface. Brown coals are readily recovered by strip mining.

2.1 Process Overview

2.1.1 Coal Mining

The first step in the mining process is to explore and evaluate the coal deposit. These activities are generally explained in more detail in the opening chapter of this report. After exploration, if an economical deposit is determined, the extraction process begins.

Coal is extracted principally in two ways:

- Surface mining
- Underground mining

The mining method used depends primarily on the depth of the coal bed from the surface and the surrounding terrain. Coal beds deeper than 100 to 200 feet or on hilly terrain are usually mined by underground methods, while those at lesser depths are surface mined.[2]

Surface mining accounts for about 60 percent of the total U.S. coal production of 1 billion tons/year. A large surface mine can be three miles long and a mile wide. Underground mining accounted for 430.5 million short tons in 1998, about 40 percent of total U.S. coal production that year.[3]

Coal fields in the eastern U.S. are characterized by relatively thin seams of deeply buried coal. Eastern coal generally has a high heating value. Conversely, relatively thick seams of shallow reserves characterize the coalfields in the western U.S. Western coal generally has a low heating value.

These deposit characteristics also greatly influence the mining method used. Underground mining is more frequently used on the thinner seams of the eastern coalfields. However, surface

[2] Kennecott Energy, *The Mining of Coal*, 1995 - www.kenergy.com/coalinfo/mining/mining.html
[3] National Mining Association, *Facts About Coal*, p. 18, 1999-2000.

mining is most frequently used in the West. These deposits require relatively low-volume, shallow digging to expose thick coal seams for recovery.

2.1.1.1 Surface Mining

In general, where favorable coal seam conditions exist, surface mining is the least expensive and most productive method of taking coal from the ground. Used when the coal seam is relatively close to the surface, it can result in the removal of as much as 95 percent of the total coal from a particular deposit.

The four types of surface mine construction are:

- Area
- Contour
- Mountain Top
- Auger

Area - Area surface mining is done on relatively flat land under which the coal is buried at roughly uniform depth. In this method, the overburden from a 100- to 200-foot-wide cut is used to fill the mined-out area of the preceding cut.[4]

Contour - Contour surface mining follows coal beds lying in hillsides. Excavation begins at a location where coal and surface elevations are the same. It proceeds towards the center of the hill or mountain until the overburden becomes too thick to remove economically.

Mountain Top - Mountain top removal mining is used to recover coal buried at or near the summit of a large hill or mountain by entirely removing the elevated area.

Auger - Less common in recent years, auger mining is sometimes employed to recover any additional coal left in deep overburden areas that cannot be reached economically by further contour or area mining. An auger functions much like a wood drill, to bore into the seam and discharge coal out of the spiral onto a waiting conveyor belt. The auger may bore holes as wide as 84 inches across and 200 feet deep.[5]

General Steps in Surface Mining

Most surface mines follow the same basic steps to produce coal. Bulldozers clear and level the mining area; topsoil is removed and stored for later use in the reclamation process; holes are drilled through the overburden, loaded with explosives and discharged, shattering the rock in the overburden; power shovels or draglines clear away the overburden until the coal is exposed. The dragline has a large bucket suspended from the end of a boom, which may be as long as 300 feet. The bucket, which is suspended by cables, is able to scoop up to 250 tons of overburden as it is dragged across the excavation area. The dragline is one of the largest land-based machines in the

[4] National Mining Association, *Facts About Coal*, p.26, 1999-2000.
[5] Kennecott Energy, *The Mining of Coal*, 1995 - www.kenergy.com/coalinfo/mining/mining.html

world. Smaller shovels then scoop up the coal and load it onto trucks, which carry the coal to the preparation plant.[6]

In addition to the excavation area, most surface mines have a number of structures as part of their operations, including headquarters, preparation plants, storage silos, and maintenance shops for equipment.

Surface Mining Reclamation

Reclamation involves restoring natural vegetation and drainage in order to return the mine site to a useful area such as farmland, wildlife areas, parklands, or housing developments. The reclamation process actually begins before the first ton of coal is removed. To fulfill mining permit requirements, the coal company must document how sedimentation from the temporarily disturbed areas will be controlled; how ground and surface waters will be protected; how archaeological artifacts that may be encountered will be handled; how wildlife disturbances will be minimized; and how restoration of the soil and vegetation will be achieved.

2.1.1.2 Underground Mining

The majority of the world's coal reserves are recovered though underground mining. Currently, almost two-thirds of hard coal production worldwide comes from underground mines, but in certain important coal producing countries, such as the U.S. and Australia, this proportion is significantly lower.

Underground mines are used for extracting coal deposits deeper than 100 to 200 feet.[7] Most underground mines are less than 1000 feet underground. However, some can reach depths of up to 2000 feet.[8] Passageways and underground workrooms are dug to enable the miners and machines to reach the deposits. Equipment in the various passages include water pumps or other drainage systems to remove seepage water. There are additional requirements that exist in underground mining that do not exist in surface mining. They include: roof support, ventilation, lighting, drainage, methane control, equipment access, and coal conveyance, among others.

Types of Underground Mines

Underground, or deep, mines are classified by the type of entrance used to reach the coal bed. There are three basic categories of underground mines:

- Drift mines
- Slope mines
- Shaft mines

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[6] Ibid.
[7] Yale-New Haven Teachers Institute*, Coal as a Source of Energy*, p. 5 - www.cis.yal.edu/ynhti/curriculum/units/1986/6/86.06.01.x.html
[8] Energetics, *Mining in the U.S.*,

Drift Mines - These are used to reach coal beds in hillsides. The entrance is located where the coal is exposed on the hillside. The tunnel is dug through the coal bed.

Slope Mines - These are used to reach coal beds in hilly areas. Miners open a sloping tunnel through the ground to the coal bed level. Miners and their machines are moved in and out of the mine on shuttle cars. The coal may also be taken out of the mine by shuttle car or by conveyor belt.

Shaft Mines - These are used to reach coal beds that generally lie deeper below the Earth's surface than those reached by slope mines. A hole or shaft is dug straight down to the coal. The miners then dig horizontal entries through the seams of coal. Miners, equipment and coal are carried between the coal seam and the surface by an elevator system. At the bottom of the shaft, personnel carriers carry miners to the work area. Separate shafts are often dug to provide ventilation for underground mines.

Table 2-1. Underground Coal Production by Mining Method – 2000 (Thousand short tons)

Method	Coal Produced
Continuous	178,617
Conventional	2,353
Longwall	188,972
Shortwall & Other	3,171
Total	**373,659**

Sources: U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual 2000*, Table 5, Page 11

The drift entry is a preferred choice because it is generally the most economic overall. However, it is limited to those seams that outcrop.

Underground Mining Systems

Once the coal bed has been accessed, one of three underground mining systems can be used to mine coal:

- Room-and-pillar mines using conventional or continuous mining
- Longwall
- Shortwall

Table 2-1 shows the amount of coal produced by mining method. Room and pillar systems account for over half of the coal mined in the U.S. However, longwall mining started to see large application in 1997.

Room-and-pillar - The room-and-pillar system is the most prevalent in the U.S. This system involves extracting the coal by carving a series of rooms 20 to 30 feet wide while leaving pillars of coal 20 to 90 feet wide and as high as the coal bed to support the mine roof. When mining reaches the end of a section of coal called a panel, the direction of mining is generally reversed (called the “retreat”) in an attempt to recover as much of the coal from the pillars as possible. Pillars are mined until the roof caves; that section of the mine is then abandoned. Generally, 50 to 60 percent of the minable coal is recovered using this system, although higher amounts are possible.[9] Roof bolting is also an important part of the operation since it maintains the structural integrity of the roof. A bolting machine drills holes in the roof and inserts anchor bolts, which firmly attach to the roof to create a stronger overlying layers of rock. Bolts are generally required on a 4- by 4-foot array.

Room-and-pillar: Conventional - Although, the method is still used in certain situations where geology is favorable, this method of coal mining has all but vanished. Conventional mining is a method of breaking down and removing coal in a room-and-pillar system. Conventional mining involves undercutting, drilling, shooting or blasting, and loading. Undercutting is accomplished by very large chain saws protruding from the bottom of self-propelled vehicles. These saws cut a slot or *kerf* about 6 inches high and 10 feet deep into the coal and 20 feet across the face. This machine moves to the next face while the drilling machine takes its place. The coal drill is a self-propelled vehicle with a long auger attached to a movable boom. It drills holes above and as deep as the cut. One hole is required for a face area 3 to 4 feet high and 4 to 5 feet wide. The presence of rock in the coal may mandate more holes. Blasting is done with chemical explosives or compressed gas. A machine slides the coal onto a conveyor belt and dumps it into a shuttle car. The shuttle cars take the coal either to a change point, where it is transferred to a conveyor belt or mine car, or directly out of the mine. Exposed areas are rock dusted (dusted with limestone powder) to dilute the coal dust and therefore prevents coal dust explosions. In all seams, frequent methane testing is required on the face.

Room-and-pillar: Continuous Mining - The "continuous miner" is another method of breaking down and removing coal in a room-and-pillar system. Continuous mining uses a machine called the "continuous miner" that combines cutting, drilling, and loading coal into one operation and requires no blasting. A large steel drum equipped with tungsten carbide steel “teeth” tears the coal from a seam. The continuous miner also has moving arms that load coal onto a short conveyor, which leads to a nearby shuttle car. A miner drives the shuttle car to a longer conveyor, which carries the coal to the surface. Every few minutes the continuous miner is moved to a new area. Miners use a roof bolting machine to secure the roof.

The role of continuous mining is changing due to the rapid development of technology for use with the other common method of underground mining, longwall mining. Although still used alone, continuous miners are being increasingly used for main mine entry and longwall panel development. Some mines are “hybrid” operations that combine continuous and longwall techniques.

Longwall - In longwall mining, a rotating cutting machine called a shearer moves back and forth across a wide panel of coal that averages about 800 feet in width and 7,000 feet in length.[10] The broken coal falls to a conveyor for removal. Longwall systems have their own hydraulic roof supports that advance with mining progress.

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[9] National Mining Association, *Facts about Coal*, p.20, 1999-2000.
[10] U.S. Department of Energy, Energy Information Administration, *Longwall Mining*, p. 3, March 1995

Longwall mining can increase the average coal recovery rate of an underground mine to 80 percent, significantly higher than what was achievable in the past.[11] However, longwall mining does have limitations. A longwall is not suitable if the coal bed thickness varies widely or if geographic faults break the coal bed. The mine roof and floor must also be sturdy enough to support the hydraulic roof supports. High capital costs for equipment and mine development also hinder the use of longwall mining techniques.

Longwall mining has helped to revolutionize underground coal production, in part, because it is feasible at greater depths than continuous mining. In the past 20 years, longwall's share of U.S. production has risen from less than 10 percent to just over 45 percent. In 1994, the tonnage extracted by longwall was greater than that of continuous for the first time.[12]

Shortwall - Another mining technique used in underground mines is shortwall mining. This currently accounts for less than 1 percent of annual underground mine production. Shortwall, like longwall, uses a continuous mining machine and movable roof supports. However, as its name implies, the panels sheared by the continuous miner with shortwall are only 150 to 200 feet wide and half a mile long.[13] Productivity is also lower with shortwall than longwall because coal is removed by cars rather than by conveyor.

2.1.1.3 Breaking Down Coal

Within each of the underground mining systems described above, there are many methods of breaking coal from the mine face in lumps suitable for hauling to the surface of the mine. They include:

- Undercutting
- Shooting-off-the-solid
- Cracking the coal wall
- Continuous mining
- Shearer
- Hydraulic Mining

Undercutting - Before the coal wall is cracked, the miners usually cut out the mine face at the bottom of the coal bed so explosives can shatter the coal more easily. This undercutting is done with cutting machines equipped with sharp, powerful blades. The machine resembles a large mobile chain saw. The cutting machine tears out the coal in a wide groove or *kerf*. Some cutting machines are built to cut into the coal not only at the bottom, but also at the top and sides of the face.

Shooting-off-the-Solid - Another simple method of breaking down coal is called shooting-off-the-solid. The coal is blasted off the bed without any undercutting to help break

[11] The National Mining Association, *Facts about Coal*, p.22, 1999-2000.
[12] Ibid.
[13] Kennecott Energy, *The Mining of Coal*, 1995 - www.kenergy.com/coalinfo/mining/mining.html

it down. The drawback is that a dangerously large explosive charge is needed in this method. Dust and fine coal are produced.

Cracking the Coal Wall - If explosives are to be used in breaking down the coal, shot holes are drilled at intervals along the face of the coal bed. The explosives are inserted in these holes or shots. When the explosion occurs, the coal wall cracks into pieces. Coal mines use cylinders of compressed air or liquid carbon dioxide or chemical explosives.

Continuous Mining - Continuous mining accounts for roughly 45 percent of coal taken from underground mines.[14] The continuous mining technique utilizes a specialized cutting machine, the "continuous miner." A large steel drum equipped with tungsten carbide steel "teeth" tears the coal from a seam and automatically removes it from the area using chain conveyors.

Shearer - A shearer is used in longwall mining. A shearer is a rotating cutting machine that moves back and forth across a wide panel of coal to break it down.

Hydraulic Mining – An emerging coal mining technique is hydraulic mining. As the name suggests, this method uses high-powered water jets to extract coal from the mine. The method has been used in limited tests in underground coal mines, although it is possible to use the technique in a surface mine. There are four main types of hydraulic mining that are defined by coal-breaking techniques.

- The first method does not actually use water to break the coal, but it is used indirectly, often to transport the coal to the surface. The coal may be pre-loosened by water infusion-hydraulic fracturing. Water may also be used to flush broken coal that has been excavated by either drilling and blasting or by mechanical cutting. In other mines, a mechanical loader may load the coal directly into the hydraulic transport system without using water in the excavation process. This technique is primarily used with hard coal, such as anthracite.

- The second technique uses water to actually break the coal from the bed. Excavation is carried out by combined hydraulic/mechanical cutting. This method is primarily used in harder coal seams. Such mines are designed for either hydraulic flushing and transport to the surface or mechanical transport.

- The most common type of hydraulic mining involves cutting or breaking the coal, washing the coal into flumes, and transporting the coal to the surface - all with water.

- Complete hydraulic mining involves the use of water jets to cut and break the coal, transport the coal, supply energy to drive mine machinery, fans, lights, and other facilities. This method eliminates the need for an electrical generator if the water can be moved via gravity.

[14] National Mining Association, *Facts about Coal*, p.24, 1999-2000.

Another significant part of a hydraulic mine is the surface plant, which may consist of installations for coal dewatering, water clarification, and high-pressure pumping stations. It is likely that surface installations will place a limit on production, because the hydraulic mine excavation and transportation system is highly productive with few underground constraints.

2.1.1.4 Ventilation Operations

Adequate ventilation is needed to provide fresh air, keep harmful gases under control and to prevent health hazards. Ventilating fans are used to circulate air. Water sprays help control the coal dust that is raised as the working face is cut. Spraying machines blow limestone dust over the roof and floors of tunnels. Miners wear respirators or masks so as not to inhale dust. Extensive drainage systems are installed in mines to keep water out of the working area.

2.1.1.5 Removal Systems

Coal is removed from underground mines by four methods: belt conveyors, shuttle cars, and hydraulic and pneumatic loading and conveying systems. Belt conveyors are the most common method to transport coal to the surface. Shuttle cars take coal to a central loading area in the mine. In most underground mines, low, flat loading machines gather the loose coal onto shuttle cars. The shuttle cars carry the coal to mine cars or to a conveyor belt. In surface mining, the loose coal is gathered up by large power shovels and is loaded on trucks.

Pneumatic and hydraulic coal loading and conveying systems provide alternative methods for the safe and efficient mining of the thin high-grade coal seams found in the southern Appalachians. Broken coal is loaded directly into a negative-pressure vacuum conveying system from several faces to a common storage hopper. Pneumatic systems eliminate most of the health and safety hazards associated with the operation of conventional mining and haulage equipment in small low-coal mines by removing powered mobile equipment from the mine. Ventilation is also improved by the coincidental removal of gas and respirable dust from the mine by the operation of the pneumatic loading. Other significant advantages of pneumatic coal recovery systems are relative simplicity, operating flexibility, low capital cost, quiet operations, environmental benefits, and ease of automation.

2.1.2 Coal Beneficiation

Coal consumers require coal of a consistent quality. Coal as mined, known as run-of-mine coal, contains a mixture of different size fractions such as lump coal (>5").[15] Run-of-mine coal may also contain unwanted impurities such as rock, dirt, clay, iron sulfide, carbonates, and silica.

Coal beneficiation consists of sizing, handling and washing run-of-mine coal. Most coal requires some preparation before use. Preparation may range from simply crushing to provide a size suitable for certain types of boilers, to extensive size reduction and cleaning, to remove sulfur and ash-forming mineral matter.

[15] World Coal Institute, *Coal- Fuel for Thought*, www.wci-coal.com/

Coal preparation, also known as coal beneficiation, is the stage in coal production when the raw run-of-mine coal is processed into a range of clean, graded, and uniform coal products suitable for the commercial market. A common term for this process is coal 'washing' or 'cleaning'. The basic cleaning process consists of crushing, screening, cleaning, de-watering, and drying. Not all preparation plants employ the full scope of operations and only coals ranging from lignite through bituminous require cleaning. The number and type of steps included in a plant usually determine the level of preparation. There are six levels of preparation:

1. No preparation
2. Crushing only
3. Only clean the coarse size
4. Course and fine size are cleaned, but not the ultra-fine size
5. All sizes are cleaned
6. Most rigorous degree of cleaning

Effective preparation of coal prior to combustion improves the homogeneity of coal supplied, reduces transport costs, improves the utilization efficiency, produces less ash for disposal at the power plant, and may reduce the emissions of oxides of sulfur. Sometimes, a modular coal processing plant is used to process coal at the mine.

2.1.2.1 Crushing and Pulverizing

Increasing the coal's particle surface area and decreasing its moisture content greatly increases its heating capacity. Many mechanisms can be used to grind the coal and prepare it for firing. Pulverizers, cyclones, and stokers are all used to grind and dry the coal. Coal may be cleaned and prepared before being either crushed or pulverized. In addition, the coal may undergo secondary crushing in a hammer mill after it has been washed.

A preparation plant for bituminous coal is called a tipple. In the tipple, machines called breakers and crushers reduce the size of large bituminous lumps. The crushed coal is then screened to separate it into coarse and fine sizes for the washing operation.

A preparation plant for anthracite coal is called a breaker. The methods by which anthracite is prepared differ from those used to prepare bituminous coal. Before the raw anthracite is cleaned, it undergoes stage crushing during which it is broken into various sizes. The sizes are specified in the Anthracite Standards Law of 1947.

2.1.2.2 Cleaning

Anthracite coal may have a quantity of slate mixed with the coal as it leaves the mine. After being broken into smaller sizes, the slate is cleaned from the anthracite. Bituminous coal contains little or no slate, but may contain clay and other impurities that require cleaning. The usual procedure followed in the preparation of bituminous coal is to remove as much of the rock as possible by passing the coal over a scalping screen or a picking table.

The picking table is one of the oldest methods of cleaning coal. The picking table consists of a horizontal conveyor over which the coal moves slowly in thin layers. Workers on both sides of the conveyor pick the impurities from the coal. This is probably the best way to clean lump coal.

Mechanical cleaning is the preferred method of cleaning coal. Most mechanical cleaning processes depend on differences in specific gravity of coal and associated impurities to affect a separation. Other physical properties of coal and refuse utilized to a minor extent are shape, resiliency, coefficient of sliding friction, electrical conductivity, and froth-flotation differences. Magnetic separators are used widely to remove iron and thus prevent such material from getting into pulverizer mechanisms.

Widely used methods for separating coal and its impurities on the basis of particle density include both hydraulic and heavy-media processes. The major equipment of hydraulic cleaning are jigging, wet concentrating table, and hydrocyclone. The only widely used method, which does not separate particles on the basis of density, is froth flotation. Froth flotation separates particles on the basis of surface properties.

Coal-cleaning processes may be wet or dry, depending on whether water or air is used as the medium. In general, wet processes are more efficient than dry. Coal from wet-process cleaners must be dried by drainage, centrifuges, filters, or heat dryers to avoid excessive water in the final product. Most coal cleaning occurs at the mouth of the mine by using gravity concentration, flotation, or dewatering methods. The cleaning method used depends on the size of the coal pieces.

Larger material (10-150 mm lumps) is usually treated using “dense medium separation”. The coal is separated from other impurities by being floated across a tank containing a liquid of suitable specific gravity, usually a suspension of finely ground magnetite or sand. The coal, being lighter, floats and is separated off, while heavier rock and other impurities sink and are removed as waste. Any magnetite mixed with the coal is separated, using water sprays and is then recovered using magnetic drums, and recycled.

The smaller size fractions are treated in a variety of ways - usually based on gravity differentials (for example, in spiral chutes, or in dense medium centrifuges). Alternative methods use the different surface properties of coal and waste. In “froth flotation,” coal particles are removed in a froth produced by blowing air into a water bath containing chemical reagents. The bubbles attract the coal but not the waste and are skimmed off to recover the coal fines. After treatment, the various size fractions are screened and dewatered or dried and, then, recombined before going through final sampling and quality control procedures.

2.1.2.3 Sizing, Blending and Grading

In its natural state, coal is classified by rank, which depends on the following: carbon and ash content; the amount of volatile or gassy, matte, moisture content; and heat value. As sold in the market, coal is classified by grade, which depends on its rank and other characteristics such as the size of the lumps and on special treatment the coal has received.

Clean bituminous coal is classified or sized by passing it over a series of shaker and vibrating screens. These screens have perforations through which the particles fall according to size. The coal is then mixed and blended in mixing conveyors and delivered into a hopper.

2.1.2.4 Shipping

After the coal has been processed, it is loaded into railroad cars or coal barges. Approximately, two thirds of coal is transported to market by rail. Mines and preparation plants are also located on rivers because water transportation is more economical than shipping by rail. Barges also ship coal over inland waterways and along the Atlantic coast. Ships called colliers carry coal on the Great Lakes, along the coasts and for export. Trucks are moving a growing percentage of coal over short distances. Some utility companies burn coal in power-generating plants near a coal mine.

Coal may also be shipped in pipelines as slurry. Coal is transported over a pipeline by first crushing the coal into a powdery form, mixing it with water, and then pumping it through a pipeline. Coal slurry pipelines represent a proven technology for transporting high volumes of coal over long and short distances. A slurry pipeline can have economic and environmental advantages over other forms of transportation because of its lower cost, underground piping, and its ability to operate without having to haul empty rail cars or trucks back to the mine. The only drawback is that the slurry requires a large volume of water. The only operating coal slurry pipeline in the U.S. connects a mine in Arizona with a power plant in Nevada.

2.1.2.5 Storing

Most large consumers of coal try to keep several months supply on hand. Sometimes coal is stored in the open and sometimes in bins. Anthracite and bituminous coal may be stored for long periods of time without losing their heating or power values. Subbituminous coal must be stored or piled carefully to protect it from the weather. Lignite cannot be stored long because it dries out.

2.2 Summary of Inputs/Outputs

The following lists the inputs and outputs for coal mining and beneficiation. Key inputs and outputs are:

Inputs	**Outputs**
Electricity	Coal
Fuels	Waste Rock
Water	Methane
Chemicals	Acid Mine Water
	Dust and Fines
	Iron
	Magnetite

Figure 2-1. Coal Mining Flow Diagram

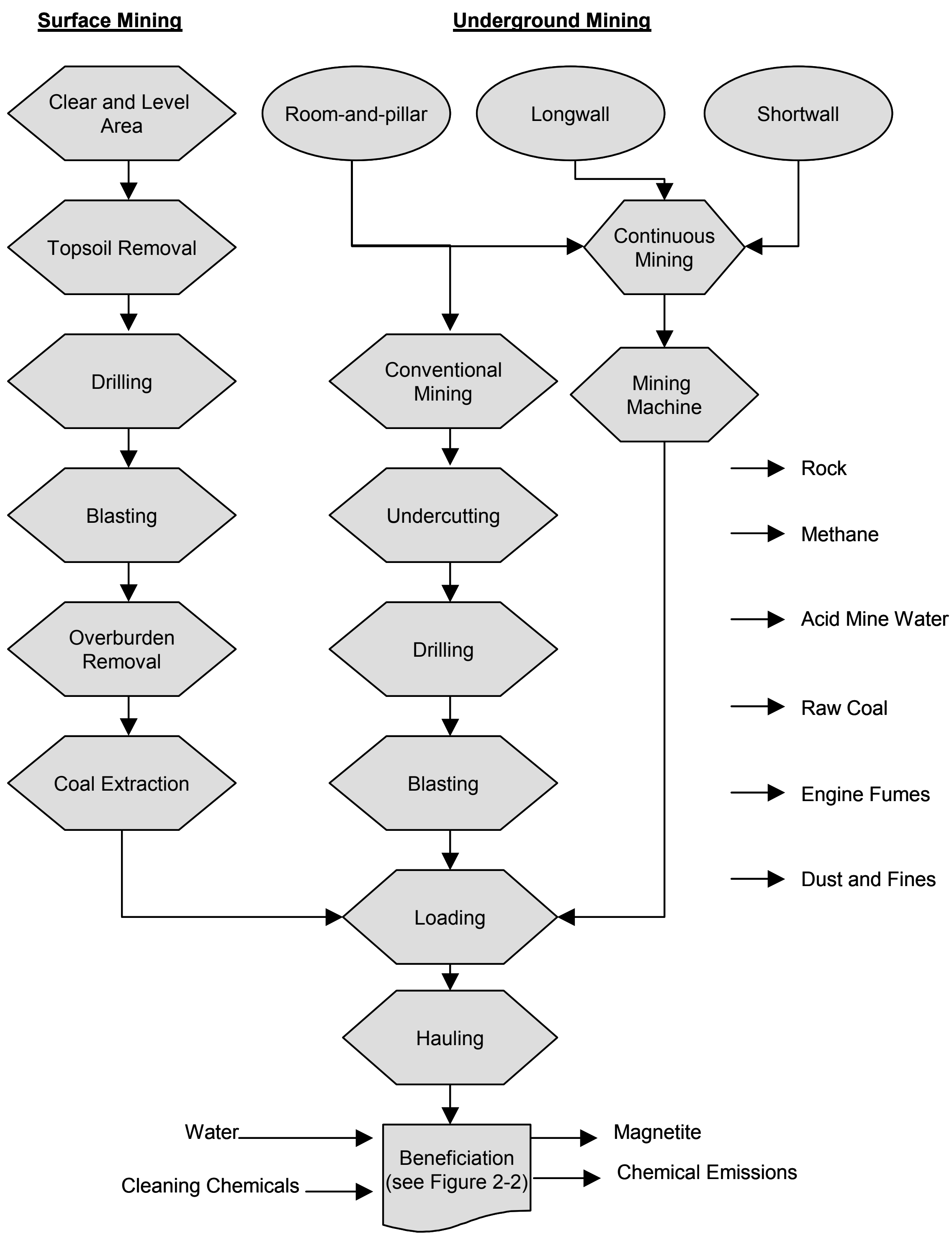
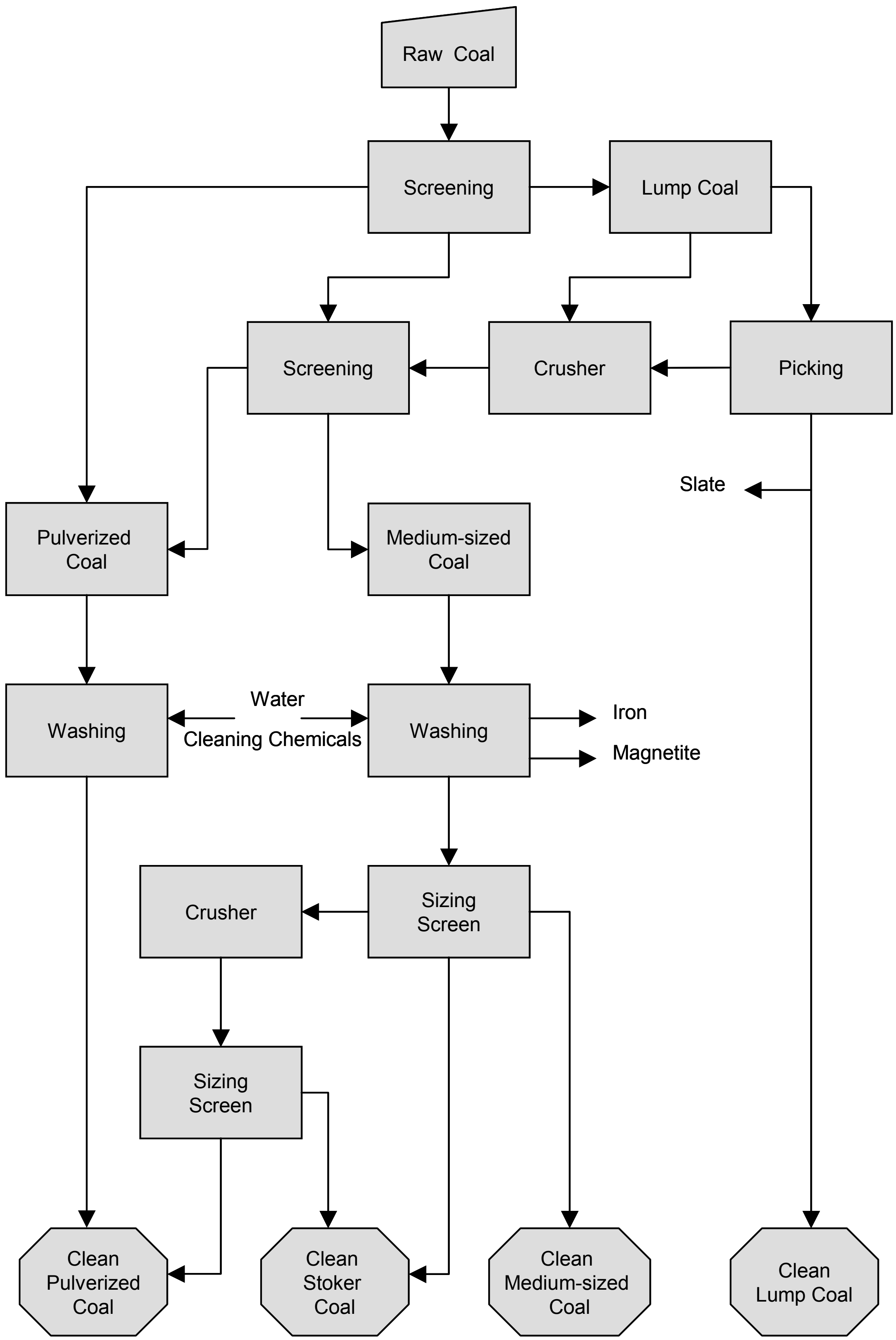


Figure 2-2. Coal Beneficiation Flow Diagram

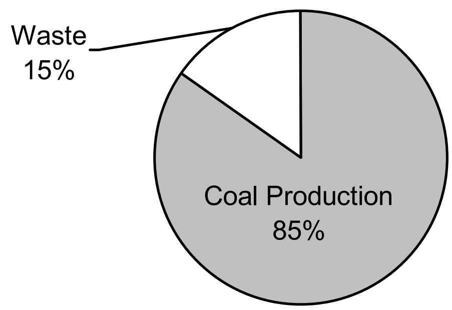


2.3 Energy Requirements

2.3.1 Materials Handled

Materials handled refers to the amount of ore and waste material that must be handled in mining. Figure 2-3 shows the amount of coal mined in relation to the amount of waste material produced in coal mining. The tonnage of materials that must be handled drives energy consumption in mining operations. For example, in 2000 the amount of coal produced was 1,073.6 million tons. With a national average recovery ratio of 82.05 percent, the amount of waste material produced was 234.8 million tons. This calculates to a total of 1,308.5 million tons of materials handled in coal mining.

Figure 2-3. Materials Handled for Coal Mining - 2000



Source: U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual 2000*

2.3.2 Energy Requirements for Coal Mining

The energy requirements for mining coal vary significantly from mine to mine due to the type of mining and type of coal being mined. Major energy sources include purchased electric energy as well as fuel oils. Table 2-2 shows the type and quantity of fuels consumed during coal extraction.

Table 2-2. Coal Production and Energy Consumed by Type [a]

	Units	1987	1992	1997
Coal Production	Million Tons	918.8	997.5	1,089.9
Energy Consumption				
Coal	Thousand Tons	47.5	60.3	Withheld
Coal produced and used at site	Thousand Tons	276.7	258.3	252.9
Fuel oil [b]	Million bbl.	10.5	10.5	9.0
Natural Gas	Billion Cubic Feet	1.0	0.8	0.5
Gasoline	Million bbl.	0.8	0.6	0.1
Electricity Purchased	Million kWh	13,300	12,600	11,400
Electricity generated less sold	Million kWh	Withheld	Withheld	Withheld

a Coal is a summary of SIC Codes 1221, 1222, 1231 (1997 NAICS Codes 212111, 212112, 212113)
b Summation of distillate and residual fuel oil
Sources: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census, Census of Mineral Industries, *Industry Series*, Coal Mining
US Department of Energy, Energy Information Administration, *Coal Industry Annual 1997*
US Department of Energy, Energy Information Administration, *Coal Industry Annual 1996*

Due to a lack of current information on the energy requirements on mining and beneficiation, the "SHERPA Mine Cost Estimating Model" along with the "Mine and Mill Equipment Cost, An Estimators Guide" from Western Mine Engineering, Inc., were used to calculate the energy requirements on mining and beneficiation coal in the eastern, interior and western U.S.

Table 2-3 shows the energy requirements for a hypothetical underground room-and-pillar coal mine in the eastern U.S. This coal mine operates over a 20-year lifetime with a 20 million-ton output at the end of its life. The mine runs 301 days per year with two 9.00 hour shifts per day, which gives it a daily production rate of 3,322 tons per day. The deposit characteristics are a bedded deposit with an average dip of 18 degrees. It has an average maximum horizontal of 2,900 feet and a minimum of 20 feet. The average maximum vertical is 5.9 feet with a vertical distance to the surface of 1,000 feet.

Table 2-3. Energy Requirements for a 3,322 ton/day Hypothetical Eastern Underground Coal Mine					
		Energy Consumption			
Equipment (number of units)	Daily hours/unit	Single Unit (Btu/ton)	All Units (Btu/hour)	All Units (Btu/day)	All Units (Btu/ton)
Main Fan [b] (11)	18.00	11,900	24,300,000	437,000,000	132,000
LHD[b] (25)	18.00	2,340	10,800,000	195,000,000	58,600
Service Trucks [c](31)	18.00	1,840	10,500,000	189,000,000	57,000
Drills [b] (13)	18.00	317	761,000	13,700,000	4,120
Two Boom Jumbo [a, b] (20)	18.00	1,740	6,410,000	115,000,000	34,700
Continuous Mining Machine [b] (2)	18.00	8,740	3,220,000	58,000,000	17,500
Raise Borers (1)	18.00	4,690	866,000	16,600,000	4,690
ANFO Loaders [c] (6)	18.00	1,840	2,040,000	33,700,000	11,000
Crusher [b] (1)	18.00	1,760	325,000	5,840,000	1,760
Conveyor [b] (1)	18.00	2,370	437,000	7,860,000	2,360
Roof Bolter [c] (1)	18.00	1,280	237,000	4,270,000	1,280
Water Pumps [b] (2)	18.00	72	27,000	476,000	143
Diamond Drill [b] (1)	0.36	6	59,000	21,100	6
Total			**60,000,000**	**1,080,000,000**	**325,000**

a Drills not included
b Calculated at $0.049 per kWH: average for Rocky Mountain Region, 1999
c Calculated at $0.535 per gallon: average prices for sales to end-users in U.S. Petroleum Administration for Defense District No. IV, 1999

Note: Assumes a room and pillar coal mine operating over a 20-year lifetime with a 20 million-ton output at the end of its life. Mine runs 301 days per year with two 9.00 hour shifts per, giving it a daily production rate of 3,322 tons per day. Deposit characteristics are a bedded deposit with an average dip of 18 degrees; Average maximum horizontal is 2,900 feet and a minimum of 20 feet. Average maximum vertical is 5.9 feet with a vertical distance to the surface of 1000 feet.

Source: BCS, Incorporated estimates (September 2002) using the Western Mining Engineering, Inc., *SHERPA Mine Cost Software* and *Mine and Mill Equipment Cost, An Estimator's Guide*
US Department of Energy, Energy Information Administration, *Coal Industry Annual 1997*, December 1998

With a daily production rate of 3,322 tons per day, this mine operates at 325,000 Btu per ton of coal produced. The highest level of energy required is to operate the ventilation fan. The fan is run by electrical energy and is the most energy-intensive piece of equipment. Many of the major energy centers are in the transportation functions of mining, which accounts for 41 percent of total energy consumed. Generally, transportation equipment is not energy intensive on a per-unit basis because so many units are required. Transportation energy becomes a major energy center of the mine. For example, the 25 LHDs consume 195 million Btu per day; however, each unit only consumes 2,340 Btu per ton mined. Similar patterns exist for the service trucks. The LHD runs on electric energy whereas the service trucks run on diesel.

Table 2-4 shows the energy requirements for an underground longwall mining operation. This longwall unit produces 7,258,000 tons per year or 27,808 tons per day. The most energy-intensive machine used is the continuous mining machine. The two machines require 71 percent of the energy needed in longwall mining and are both run on electricity.

Table 2-4. Energy Requirements for a 27,808 ton/day Hypothetical Eastern Longwall Coal Mine

Equipment (number of units)	Daily hours/ unit	Equipment Energy Consumption			
		Single Unit (Btu/ton)	All Units (Btu/hour)	All Units (Btu/day)	All Units (Btu/ton)
Continuous Mining Machine [b] (2)	19.00	1,100	3,220,000	61,300,000	2,200
Longwall Mining Machine [b] (1)	19.00	592	866,000	16,400,000	592
Conveyor [b] (1)	19.00	298	435,000	8,300,000	298
Total			**4,530,000**	**86,000,000**	**3,100**

a Drills not included
b Calculated at $0.049 per kWH: average for Rocky Mountain Region, 1999
c Calculated at $0.535 per gallon: average prices for sales to end-users in U.S. Petroleum Administration for Defense District No. IV, 1999
Note: Assumes production of 7,258,000 tons per year or 27,808 tons per day.
Source: BCS, Incorporated estimates (September 2002) using the Western Mining Engineering, Inc., *Mine and Mill Equipment Cost, An Estimator's Guide*

Table 2-5 shows the energy requirements for a hypothetical surface coal mine in the interior U.S. This coal mine operates over a 20-year lifetime with a 60 million-ton output at the end of its life. The mine runs 301 days per year with one shift per day of 10.34 hours, which gives it a daily production rate of 9,967 tons per day and a daily waste production of 36,050.16 tons per day. The distance the ore must travel is 1,000 feet at a gradient of 8 percent and the distance the waste must travel is 70 feet with a gradient of 8 percent.

Table 2-5. Energy Requirements for a 9,967 ton/day Hypothetical Interior Surface Coal Mine

Unit	Daily hours/ unit	Energy Consumption			
		Single Unit (Btu/ton)	All Units (Btu/hour)	All Units (Btu/day)	All Units (Btu/ton)
Hydraulic Shovel [c] (1)	9.38	3,860	4,100,000	38,500,000	3,860
Rear Dump Trucks [c] (11)	14.00	2,330	18,200,000	255,000,000	25,630
Front-end Loaders [c] (5)	14.00	5,110	18,200,000	255,000,000	25,550
Bulldozer [c] (2)	14.00	7,190	10,200,000	143,000,000	14,400
Pick-up Trucks [c] (8)	14.00	291	1,660,000	23,200,000	2,330
Rotary Drills [c] (2)	14.00	1,130	1,610,000	22,600,000	2,260
Pumps [b] (2)	14.00	466	663,000	9,280,000	931
Service Trucks [c] (2)	14.00	477	679,000	9,500,000	953
Bulk Trucks [c] (2)	13.58	462	679,000	9,220,000	925
Water Tankers [c] (1)	2.94	443	1,500,000	4,420,000	443
Graders [c] (1)	0.56	35	619,000	347,000	35
Total			**58,200,000**	**770,000,000**	**77,300**

a Drills not included

b Calculated at $0.049 per kWH: average for Rocky Mountain Region, 1999

c Calculated at $0.535 per gallon: average prices for sales to end-users in U.S. Petroleum Administration for Defense District No. IV, 1999

Note: This coal mine operates over a 20-year lifetime with a 60 million-ton output at the end of its life. The mine runs 319 days per year with two 7.00 shifts per day which gives it a daily production rate of 9,967 tons per day and a daily waste production of 49.835 tons per day. The distance the ore must travel is 1000 feet at a gradient of 8 percent and the distance the waste must travel is 70 feet with a gradient of 8 percent.

Source: BCS, Incorporated estimates (September 2002) using the Western Mining Engineering, Inc., *SHERPA Mine Cost Software* and *Mine and Mill Equipment Cost, An Estimator's Guide*
U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual 1997*, December 1998

The bulldozers are the most energy intensive piece of equipment. The front-end loaders and rear-dump trucks, are the largest energy consumers. These pieces of equipment run on diesel fuel. The front-end loaders consume 33 percent of the total energy consumed per ton. Again, the other major energy consuming pieces of equipment are transportation equipment. Rear-dump trucks, front-end loaders, bulldozers, and trucks account for 88 percent of energy used.

Table 2-6 shows the energy requirements for a surface coal mine in the western U.S. This coal mine operates over a 20-year lifetime with a 200 million-ton output at the end of its life. The mine runs 360 days per year with two shifts per day of 10.00 hours which gives it a daily production rate of 27,778 tons per day and a daily waste production of 114,243 tons per day. The distance the ore must travel is 1000 feet at a gradient of 8 percent and the distance the waste must travel is 70 feet with a gradient of 8 percent.

The cable shovels are the most energy-intensive piece of equipment. They run on diesel fuel. The rear-dump trucks are the largest energy consumers and, alone, consume 47 percent of the total energy consumed per ton. Combined with the other transportation equipment, this equipment accounts for 75 percent of the total energy consumed per ton.

Energy Requirements for Coal Cleaning

Coals ranging from lignite through bituminous require cleaning. Electricity and a small amount of fuel oil or coal is used in running beneficiation equipment. Physical cleaning is the predominate method used and has been commercial for over 50 years. There are about 700 physical coal cleaning facilities currently operating in the U.S., with capacities that range from 200 to 20,000 tons/day.

The cost of capital equipment and installation ranges from $25,000 to $100,000 /metric ton/hr depending on the coal feedstock and the level of coal cleaning desired. There are four levels of physical coal beneficiation each with different operating and cost requirements. Generally, a coal beneficiation facility costs about 1-5 percent of the total cost of the generating plant that uses the cleaned coal. Non-fuel operating and maintenance cost about $1-15/metric ton of cleaned coal. Fuel varies with coal type and beneficiation process, but typically ranges from $.50-$2.00/metric ton of cleaned coal.[16]

Table 2-7 shows estimated energy requirements for the beneficiation coal in a hypothetical eastern underground coal mine. By far, the most energy-intensive step of coal beneficiation is grinding. It requires 310 million Btu per day or 93.2 thousand Btu per ton of coal produced. Grinding mills use electric power. They are energy intensive because of the inefficiency of a grinding mill.

To estimate the energy required to produce one ton of coal, the estimated energy requirements for both the mining stage and the beneficiation stage are combined. The total Btu per ton for all units operating is based on the total output of each mine site. An underground mine requires the most energy for beneficiation at 94,500 Btu per ton.

[16] www.greentie.org/class/ixa02.htm, 1992

Table 2-6. Energy Requirements for a 27,778 ton/day Hypothetical Western Surface Coal Mine					
Equipment (number of Units)	Daily hours/ unit	Energy Consumption			
		Single Unit (Btu/ton)	All Units (Btu/hour)	All Units (Btu/day)	All Units (Btu/ton)
Rear Dump Trucks [c] (11)	20.00	2,370	33,200,000	724,000,000	26,000
Bulldozer [c] (7)	20.00	1,680	16,300,000	327,000,000	11,800
Cable Shovels [b] (4)	20.00	2,490	13,900,000	277,000,000	9,980
Pick-up Trucks [c] (20)	20.00	149	4,140,000	82,800,000	2,980
Rotary Drills [b] (2)	20.00	813	2,260,000	45,200,000	1,630
Water Tankers [c] (1)	20.00	1,080	1,500,000	30,000,000	1,080
Pumps [c] (2)	20.00	332	923,000	18,500,000	665
Service Trucks [c] (2)	20.00	293	813,000	16,300,000	586
Bulk Trucks [c] (2)	20.00	293	813,000	16,300,000	586
Graders [c] (1)	1.20	52	1,220,000	1,460,000	52
Total			**78,000,000**	**1,540,000,000**	**55,400**

a Drills not included
b Calculated at $0.049 per kWH: average for Rocky Mountain Region, 1999
c Calculated at $0.535 per gallon: average prices for sales to end-users in U.S. Petroleum Administration for Defense District No. IV, 1999

Note: Assumes coal mine operation over a 20-year lifetime with a 200 million-ton output at the end of its life. Mine runs 360 days per year with two shifts per day of 10.00 hours which gives it a daily production rate of 27,778 tons per day and a daily waste production of 138,890 tons per day. Distance the ore must travel is 1000 feet at a gradient of 8 percent and the distance the waste must travel is 70 feet with a gradient of 8 percent.

Source: BCS, Incorporated estimates (September 2002) using the Western Mining Engineering, Inc., *SHERPA Mine Cost Software* and *Mine and Mill Equipment Cost, An Estimator's Guide*
U.S. Department of Energy, Energy Information Administration, *Coal Industry Annual 1997*, December 1998

When combining the mining and beneficiation energy requirements for single units, the underground eastern mine requires the most energy overall at 325,000 Btu per ton. The interior surface follows at 77,300 Btu per ton and the western surface mine requires 55,400 Btu per ton.

These values demonstrate that an underground operation is more intricate and extensive, therefore requiring more energy.

Table 2-7. Energy Requirements for Beneficiation (Eastern Mine)

Equipment (number of Units)	Daily hours/ unit	Equipment Energy Consumption			
		Single Unit (Btu/ton)	All Units (Btu/hour)	All Units (Btu/day)	All Units (Btu/ton)
Grinding Mill [b] (1)	18.00	93,200	17,200,000	310,000,000	93,200
Centrifuge [b] (1)	18.00	585	108,000	1,940,000	585
Flotation Machine [b] (1)	18.00	359	66,200	1,190,000	359
Screens [b] (1)	18.00	238	43,900	790,000	238
Magnetic Separator [b] (1)	18.00	121	22,300	401,000	121
Total			**17,400,000**	**314,000,000**	**94,500**

a Drills not included
b Calculated at $0.049 per kWH: average for Rocky Mountain Region, 1999
c Calculated at $0.535 per gallon: average prices for sales to end-users in U.S. Petroleum Administration for Defense District No. IV, 1999

Source: BCS, Incorporated estimates (May 2000) using the Western Mining Engineering, Inc., *SHERPA Mine Cost Software* and *Mine and Mill Equipment Cost, An Estimator's Guide*
Department of Energy, Energy Information Administration, *Coal Industry Annual 1997,* December 1998

2.4 Emissions

Major environmental emissions in coal mining are methane and carbon dioxide gas. The five major sources of greenhouse gas emissions on coal mine sites are[17]:

- Energy consumption during mining activities
- The coal seam gas liberated due to the extraction process (fugitive emissions)
- Oxidation of carbonaceous wastes
- Land use
- Embodied energy

[17] CSIRO, *Greenhouse Gas Emissions in the Coal Mining Industry*, 1998 - http://dcetsun.syd.dcet.csiro.au/nov98-b.html

Coal mines account for approximately 11 percent of national methane emissions. They are currently the fourth-largest source of methane emissions in the U.S. behind landfills, oil- and gas-related emissions, and domestic livestock. Methane emissions from coal mining have five sources: ventilation systems in underground mines, degasification systems in underground mines, surface mines, post-mining activities, and abandoned or closed mines. Only the first four sources are included in emissions estimates because data on emissions from abandoned mines are lacking.[18]

Methane is usually present in coal seams. It occurs in greater quantities with increasing coal rank. It has been long considered a major coal mining safety hazard because of its explosive nature. To address this problem, methods to monitor and reduce methane levels in mines have been developed. Recently, however, technological development has been focused in harnessing this methane for use as an energy source.

The preliminary estimate of methane emissions from coal mines is 3.1 million metric tons. The estimate represent a decrease of 0.3 percent from 1997 and a decrease of 26 percent from the 1990 level of 4.26 million metric tons. The decline is attributed to three important trends: (1) methane recovery from active coal mines for use as an energy resource increased from 0.25 million metric tons in 1990 to about 1 million metric tons in 1998; (2) methane drainage from active mines decreased by some 0.1 million metric tons between 1990 and 1998; and (3) methane emissions from ventilation systems at gassy mines dropped by about 0.3 million metric tons between 1990 and 1998.[19]

The amount of methane released during coal mining depends on a number of factors. Coal rank, seam depth and mining methods are generally the most important factors. Table 2-8 shows estimations of methane emissions from coal mining.

Other emissions include carbon dioxide, carbon monoxide and coal dust. Carbon-dioxide gas is also emitted from coal-bearing strata as they are utilized. If enough carbon dioxide collects, it is a menace to breathing. The poisonous gas carbon monoxide sometimes occurs after an explosion or a mine fire. Coal dust is formed when coal is broken up at the working face. Coal dust is environmentally damaging and may ignite if combined with the right mixture of air.

Coal miners are also exposed to hazardous emissions from dust, and engine fumes in underground mining. The public exposure to engine fumes, storm water runoff and acid or alkaline drainage is limited. Engine fumes dissipate quickly and are produced in only small amounts. Storm water runoff and acid or alkaline drainage if untreated may affect a small number of people through drinking water. Health impacts from transporting coal would result mostly from vehicle emissions.

[18] EIA, *Emissions of greenhouse gases in the U.S.* 1998, p. 116.
[19] EIA, *Emissions of greenhouse gases in the U.S.* 1998, p. 28.

Table 2-8. CH4 Emissions from Coal Mining (1990-1998) (Million Metric Tons of Carbon Equivalent)									
Activity	1990	1991	1992	1993	1994	1995	1996	1997	1998
Underground mining	17.1	16.4	15.6	13.3	13.1	14.2	12.6	12.3	11.4
Liberated	18.8	18.1	17.8	16.0	16.3	17.7	16.5	16.8	16.1
Recovered and Used	(1.6)	(1.7)	(2.1)	(2.7)	(3.2)	(3.4)	(3.8)	(4.6)	(4.8)
Surface Mining	2.8	2.6	2.6	2.5	2.6	2.4	2.5	2.6	2.6
Post- Mining (Underground)	3.6	3.4	3.3	3.0	3.3	3.3	3.4	3.5	3.4
Post- Mining (Surface)	0.5	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Total	**24.0**	**22.8**	**22.0**	**19.2**	**19.4**	**20.3**	**18.9**	**18.8**	**17.8**

Sources: U.S Environmental Protection Agency, *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-1998*, April 1999, document # EPA 236-R-99-003
Note: Totals may not sum due to independent rounding

Coal cleaning and beneficiation can also create unwanted emissions. Coal cleaning generally takes place in the central and eastern United States, where high-sulfur coal is mined. Coal cleaning displaces land with gob piles and slurry lagoons. Windblown coal dust and acid drainage from these areas can adversely affect the environment.

2.5 Effluents

Mining activities can alter the topography and vegetative land cover affecting the volume and rate of surface water run-off. The run-off increases the variability in stream flows and can dramatically affect aquatic life, however, as required by SMCRA (see below), all runoff must be collected and treated before it can be discharged.

Underground mining generally has less impact on soil and vegetation than surface mining, but in some areas can cause greater quantities of acid or alkaline drainage. When coal beds containing high amounts of pyrite or other sulfur-bearing minerals are mined, these minerals are exposed to air and water. The chemical reaction between the sulfur, air and water produces sulfuric acid which, if discharged without treatment, would kill aquatic life and make the water unfit for use. Treating water before it is released into the environment controls acid drainage. In most cases, the treatment involves neutralization with lime and settling to reduce the concentration of iron.

Effects of coal beneficiation are similar to those of mining, although of lesser magnitude. Discharges from refuse piles and holding lagoons, if uncontrolled, can degrade the quality of both surface and ground waters. As with mining effects, waters affected by coal beneficiation operations may also exhibit altered pH and increased dissolved solids including contamination by heavy metals and hydrocarbons.

2.6 By-products and Solid Waste

Beneficiation creates wastes containing sulfur compounds, natural radioactive materials, and toxic trace metals. In areas with abundant rainfall, these materials could leach into nearby surface water if not properly managed.

Coal beneficiation creates coal refuse by-products. Coal refuse is composed primarily of coarse rock waste separated from coal by physical screening and flotation processes at a preparation plant. The rock waste is composed of carbonaceous shale, mudstone, sandstone and a minor amount of low-grade coal. Reclamation of coal refuse may be difficult due to acidity, toxicity, nutrient deficiency and poor physical properties of the coal refuse. Pyrites are frequently concentrated into coal refuse during coal preparation and most coal refuse is acid-forming to some extent.

2.7 SMACRA Requirements

All coal mining in the U.S. is regulated by the Surface Mining Control and Reclamation Act of 1977 (SMCRA). SMCRA was signed into law on August 3, 1977. It was the first federal law to regulated directly the unique environmental issues associated with coal mining, including postmining land use, hydrologic issues, restoration and revegetation of mined lands, and control of subsidence. SMCRA was also the first environmental statute to regulate a specific industry (coal mining) as opposed to a type of pollution such as air or water pollution. SMCRA has two major components. Title IV establishes a program to reclaim lands that were mined prior to the August 3, 1977, date of the Act and abandoned without reclamation. Title V establishes a regulatory and permitting program to require active coal mining operations to comply with detailed environmental performance standards and reclamation requirements. These performance standards include requirements that the land be restored to its approximate original contour, that it be revegetated, that acid mine drainage be prevented or treated, that subsided lands be restored, that "prime farmland" be restored to productivity, that disturbance to the "hydrologic balance" be minimized, that blasting be strictly controlled, that reclamation proceed as "contemporaneously as practicable" with mining operation, that highwalls be covered, that erosion be controlled, along with others.[20]

There are no hazardous wastes generated by coal mining and beneficiation. SMCRA equates to a RCRA Subtitle C permit for coal waste management.

[20] Environmental Law Institute, Environmental Regulation of Coal Mining, SMCRA's Second Decade, James M. McElfish, Jr. and Ann E. Beier, p. 282, 1990