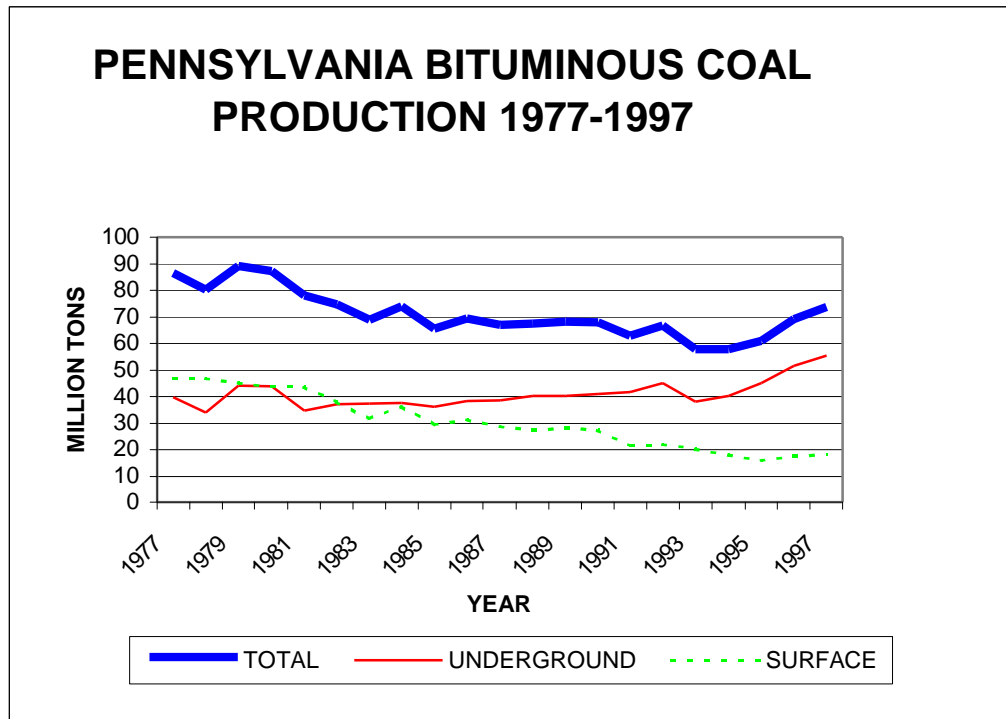


## VI. Underground Coal Mining in the Bituminous Coalfields

### Background

During 1997 over 73 million tons of bituminous coal was mined in Pennsylvania. More than 75% of the total production came from underground mines. The ratio of underground production versus total production has steadily increased over the past decade and is currently at levels not seen since the mid-1950s. The annual surface mining production has been generally declining since the late 1970s. In contrast, annual underground production was relatively constant during the 1980s and has experienced a marked upswing since 1993. Total bituminous coal production for the last 20 years is presented in Figure VI-1.

**Figure VI.1**  
**Bituminous Coal Production, 1977-1997**

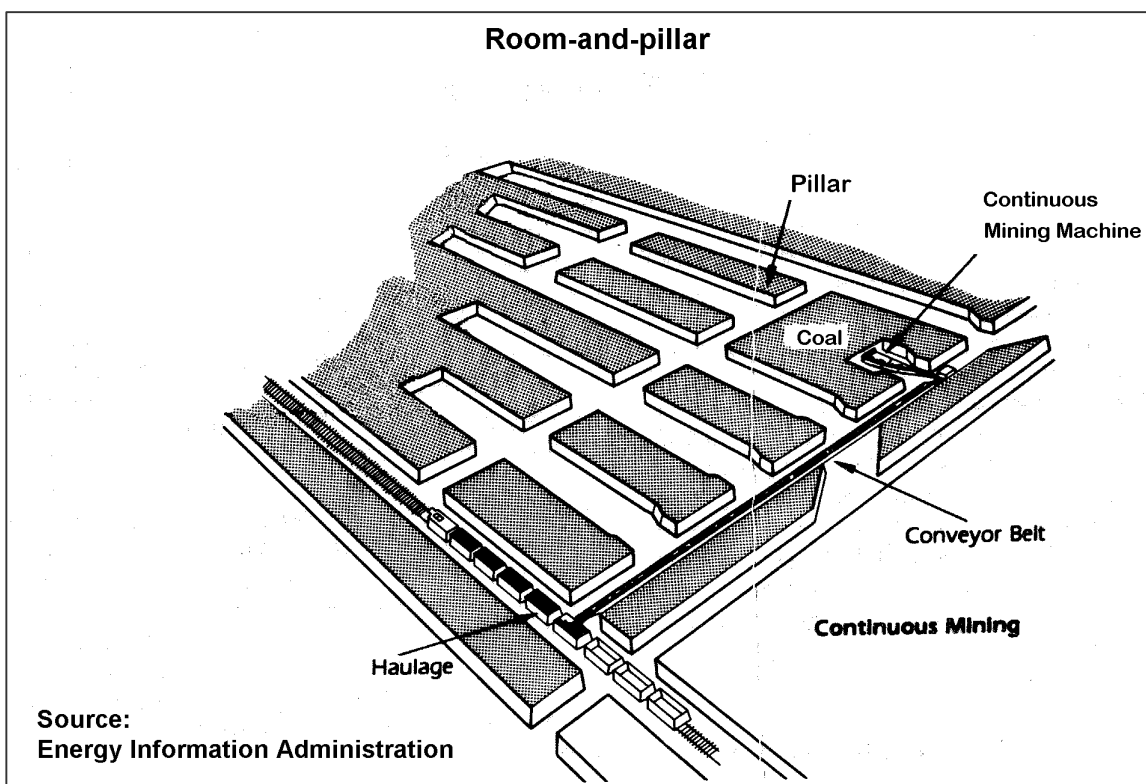


The major types of underground mining conducted in Pennsylvania's bituminous coalfields are room-and-pillar mining, room-and-pillar with retreat mining, and longwall mining. A brief description and historical information on each method are presented below.

## Room-and-pillar Mining

**Room-and-pillar** mining involves driving tunnel-like openings to divide the coal seam into rectangular or square blocks. These blocks of coal, or pillars, are sized to provide support for the overlying strata. The openings are referred to as rooms or entries. In older mines, entries normally ranged from 8 to 30 feet (2.4 to 9.1 meters) wide, while pillar sizes varied considerably. In modern-day room-and-pillar mines, the dimensions of the mining equipment (cut width and reach of the continuous miner) and the type of haulage system employed largely determine the pillar dimensions (see Figure VI.2). Coal recovery is relatively low using the room-and-pillar method, normally ranging between 35 and 70 percent. The highest coal recovery is normally achieved when retreat mining is combined with room-and-pillar mining. This method is often referred to as **room-and-pillar with retreat** mining. Retreat mining is a systematic removal of coal support pillars once a mining section has been developed using standard room-and-pillar mining. The retreat phase (also known as “second mining”) typically results in immediate or quick collapse of overburden into the unsupported opening. Room-and-pillar with retreat mining is a high-extraction mining method, generally recovering greater than 70% of the target coal seam.

**Figure VI.2**  
**Schematic Illustrating Room-and-pillar Mining**



## *History*

Room-and-pillar mines have been active in Pennsylvania's bituminous coalfields since the late-1700s. Bituminous coal was first mined in Pennsylvania at "Coal Hill" (Mount Washington), just across the Monongahela River from the city of Pittsburgh. The coal was extracted from drift mines in the Pittsburgh coal seam, which outcrops along the hillside, and transported by canoe to the nearby military garrison. By 1830, the city of Pittsburgh consumed more than 400 tons per day of bituminous coal for domestic and light industrial use. Development of the anthracite coalfields in eastern Pennsylvania had progressed to the point where "hard coal" had captured the eastern markets. Consequently, bituminous coal production in western Pennsylvania grew principally with western population growth, expansion and development of rail and river transportation facilities to the west, and the emergence of the steel industry. Towards the last half of the nineteenth century, the demand for steel generated by the explosive growth of the railroad industry and ship building concerns, began to further impact bituminous coal production in western Pennsylvania (Puglio, 1983). Until the maturation of modern longwall mining in the 1960s, Pennsylvania's underground bituminous coal production came almost exclusively from room-and-pillar mines.

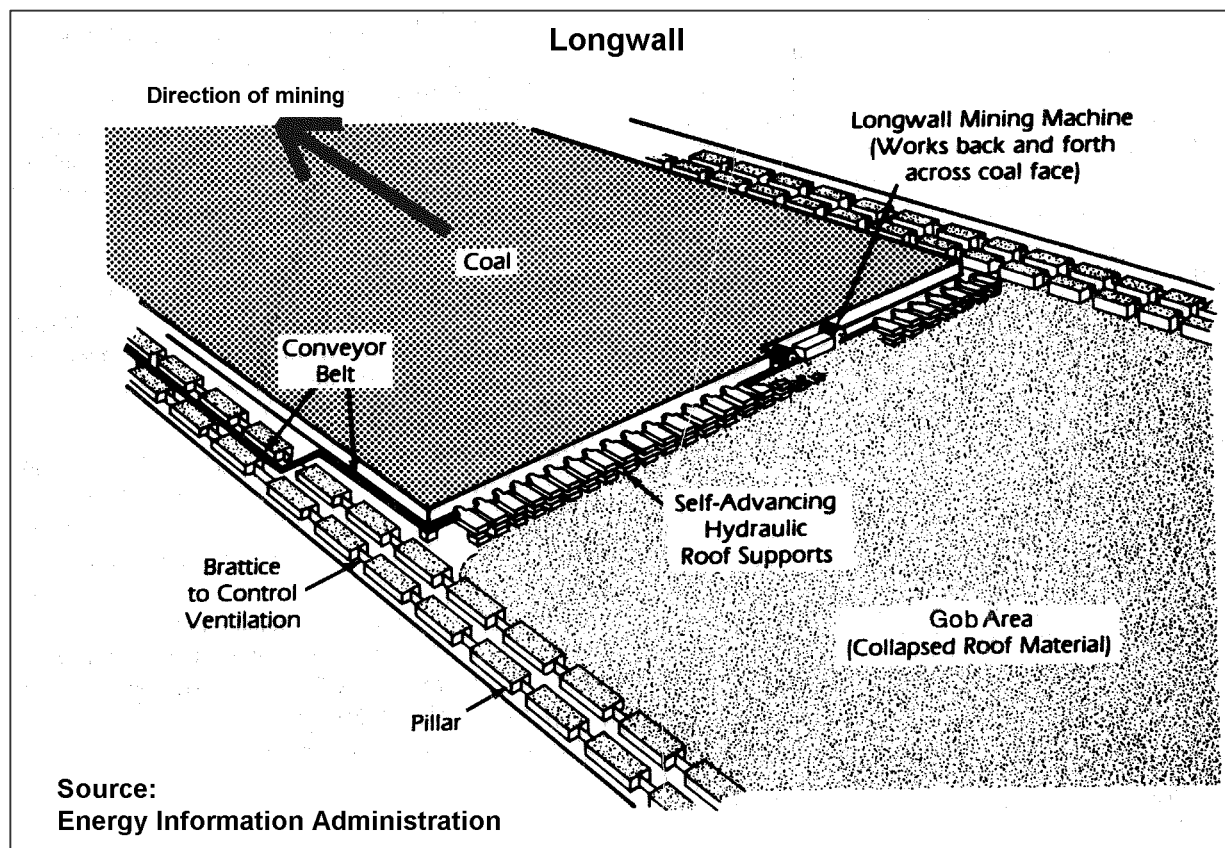
Early room-and-pillar mines did not include retreat mining; they relied on manual labor to cut the coal at the working face and the coal was hauled from the mine by horse and wagon. Today, many room-and-pillar mines use mechanized continuous mining machines to cut the coal and a network of conveyors that transports the coal from the working face to the surface (**continuous haulage**). The room-and-pillar mining method is used in all of Pennsylvania's underground bituminous coal mines including longwall mining operations, where it is used to develop the haulage and ventilation systems, and to delineate and support the longwall panels. Until the relatively recent advent of modern longwall mining, room-and-pillar mining had been the prime method for underground bituminous coal extraction in Pennsylvania. While room-and-pillar mining is still an important player in Pennsylvania, longwall mining continues to capture a growing portion of the Commonwealth's total underground production. Recent trends include a decline in the large high-extraction room-and-pillar mining operations, and some increase in small room-and-pillar operations that utilize continuous haulage. A complete list of all mines that produced coal during the study period is presented in Appendix C, Table C.1.

## **Longwall Mining**

Longwall mining is a high-extraction mining method. Room-and-pillar mining methods are used to isolate a rectangular **panel** of coal which is then completely extracted by an automated cutting head (shearer) that moves along a track parallel to the working coal face. The shearer contains two rotating drums laced with bits that cut 2- to 3-foot swaths of coal on each successive pass. The cut coal falls onto a conveyor and is transported along the working face and eventually out of the mine. The coal within a longwall panel occupies a rectangular area which can approach 1,000 feet (305 meters) in width and be over 10,000 feet (3,048 meters) in length. Hydraulic roof supports are used to protect mine workers and equipment. As the shearing machine progresses through the panel, the roof supports are advanced. The unsupported mine roof and overlying rock then collapse into the void left behind the advancing

roof supports. Once the panel is mined, the longwall machine is moved to an adjacent panel and the process is repeated resulting in near-complete extraction of the target coal seam over large areas. (See Figure VI.3)

**Figure VI.3**  
**Schematic Illustrating Longwall Mining**



Modern longwall mining has been part of Pennsylvania's mining industry for over 30 years. In the late-1960s longwall mining was conducted on the Upper Freeport and the Upper and Lower Kittanning coal seams by Barnes & Tucker Coal Co. (No. 20 and No. 24 mines), Eastern Associated Coal Corp. (Delmont mine), Rochester & Pittsburgh Coal Co. (Lucerne No. 6 mine), and Bethlehem Steel Corp. (No. 32 & 33 mine). Technological improvements along with the gradual shift of longwall operations to the thick, expansive, flat-lying Pittsburgh coal seam (ideal for longwalling) have combined to make longwall mining the major method for underground bituminous coal extraction in Pennsylvania. Longwall mining was first conducted on the Pittsburgh seam in Pennsylvania in 1970 at Gateway Coal Company's Gateway Mine. Over the next two decades the Pittsburgh seam would become the prime longwalling seam in Pennsylvania.

Longwall mining presently accounts for approximately 75% of all underground bituminous coal production in the Commonwealth. The history of modern longwall mining in

Pennsylvania is illustrated by the list of all longwall mines, past and present that is presented in Table VI.1.

**Table VI.1**  
**Pennsylvania's Modern Longwall Mines**

Active Mines

Company	Mine	Coal Seam	1997 Production (thousand tons)	Operating Period	
				start	Close
Consol	Blacksville #2	Pittsburgh	W. Va. Tonnage*	1977	-
Consol	Bailey	Pittsburgh	7,517	1986	-
Consol	Dilworth	Pittsburgh	5,547	1984	-
Consol	Enlow Fork	Pittsburgh	8,376	1991	-
Consol	Eighty Four	Pittsburgh	4,784	1976	-
Cyprus	Emerald	Pittsburgh	4,728	1982	-
Cyprus	Cumberland	Pittsburgh	7,538	1981	-
Maple Creek	Maple Creek	Pittsburgh	2,850	1980	-

Mines that have closed

Company	Mine	Coal Seam	Operating Period	
			Start	Close
Barnes and Tucker	Lancashire 24-D	L. Freeport	1967	1985
Barnes and Tucker	Lancashire 24-B	L. Kittanning	1968	1971
Beth Energy	Cambria 33	L. Kittanning / U. Kittanning	1968	1994
Eastern Associated	Delmont	U. Freeport	1969	1977
Gateway	Gateway	Pittsburgh	1970	1990
Helvetia	Lucerne 6	U. Freeport	1970	1979
Barnes and Tucker	Lancashire 20	L. Kittanning	1971	1985
Florence	Florence #1	L. Kittanning	1972	1986
Consol	Blacksville #1	Pittsburgh	1972	1991
Keystone	Jane	L. Freeport	1972	1976
Vesta	Vesta	Pittsburgh	1973	1982
Keystone	Emilie 1 & 2	U. Freeport	1974	1980
Pennsylvania Mines	Greenwich	L. Freeport	1975	1989
Consol	Westland	Pittsburgh	1977	1981
Consol	Humphrey #7	Pittsburgh	1982	1997
Helen Mining Co.	Homer City	U. Freeport	1983	1992
Consol	Pursglove	Pittsburgh	1985	1989
Duquesne Light	Warwick #3	Sewickley	1992	1996

\* Tonnage for Blacksville #2 is credited to West Virginia, where the coal is removed from the mine.

During 1997 underground mining in Greene and Washington Counties accounted for more than half of all the bituminous coal produced in Pennsylvania. The top three producing longwall mines, all located in Greene County, accounted for 32% of all the bituminous coal produced in Pennsylvania during 1997.

#### *Early History (1875 – 1950)*

Longwall mining is believed to have originated in Shropshire, England toward the end of the seventeenth century (Laird, 1973). Longwalling was not conducted in the United States until 1875 when newly arrived Welsh coal miners introduced the method. Mine layout in this early period was radial, typically incorporating two shafts sunk from the surface to the coal seam with perpendicular entries driven for a distance of 125 to 250 feet from the shafts. The ends of the entries were then connected by a series of perimeter entries and yield pillars forming a hexagon- or octagon-shaped panel. The delineated panel was then mined using a series of small advancing faces, with the roof being supported by timbers or jacks. The coal at the face was undercut, usually by hand, to a distance of 2 to 3 feet and supported by timbers on 4- to 6-foot centers. When undercutting was completed, the timbers were knocked out, allowing the immediate face coal to break free. In cases where the face coal did not break free under its own weight the coal had to be frequently wedged and sometimes blasted free. The loose coal was then hand loaded and removed from the mine, usually by horse and wagon.

Very few advances in longwall design or related technological improvements occurred between 1875 and 1950. The most significant improvement was the development of the steel jack, which was first introduced in 1912 for roof control at the working face. In 1924, a belt conveyor and partial chain conveyor were introduced. Maximum production ranged from 750 tons per day in 1915 for a wood-prop longwall to 850 tons per day by 1935 when steel jacks and conveyor haulage technology reached maturity. Longwall mining remained labor-intensive. The advancement of roof support and haulage equipment as mining progressed still required extensive manual effort and remained a significant production constraint. (Barczak, 1993)

#### *Modern Longwall Mining*

The years between 1950 and 1960 saw considerable changes in longwall technology. The most significant technological development during this period was the introduction of the mechanized cutting head known as the plow or coal plane. The plow replaced the labor-intensive method of undercutting practiced in the 1875-1950 period. As mechanized longwall equipment evolved, the profile of the panel changed from the small faces and radial geometry of the early mines to a single face developed across a large rectangular panel. **Modern longwall mining** began in the United States in 1952 at Eastern Associated Coal Corporation's Stotesbury Mine near Beckley, W. Va. It involved the mechanized extraction of a relatively large coal panel using a German-made coal plane. Three panels were successfully mined between 1952 and 1958, producing an average of 530 tons per shift. The primary constraint to increased production from longwall operations during this era was roof-support advance. Roof supports still needed to be advanced manually.

In 1954 the British developed a powered, self-advancing roof support. In the early 1960s the new self-advancing roof supports, along with a newly developed cutting head known as a shearing machine (shearer), were introduced into U.S. mines. The new shearers used a electrically powered rotating cutting head (drum) that was capable of cutting 24- to 28-inch deep “shavings” of coal on each pass. The number of U.S. longwall faces reached 18 by 1966. However only eight remained in continuous production throughout the 1960s and U.S. mining companies viewed longwall mining as having a mixed record of success. Longwall mining still accounted for only 0.4 percent of the total underground coal production (Barczak, 1993).

Between 1966 and 1975 high-capacity roof-support systems were developed which drastically improved safety and production in longwall mines. The introduction of the double-drum shearer helped set a production record of 6000 tons per day in a northern Appalachian longwall mine in 1969. In the mid-1970s the new double-drum shearer was widely employed in U.S. longwall mines. By 1975, 28 different coal companies operated 58 longwall faces and accounted for 3.1 percent of total U.S. underground coal production.

Continued technological improvements during the 1980s led to an increase in longwall production in recent years. Advancements included; (1) high-capacity hydraulic shields combined with electrohydraulic control systems allowing for fast roof-support advance with less labor; (2) increased shearer power; and (3) faster haulage speeds.

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