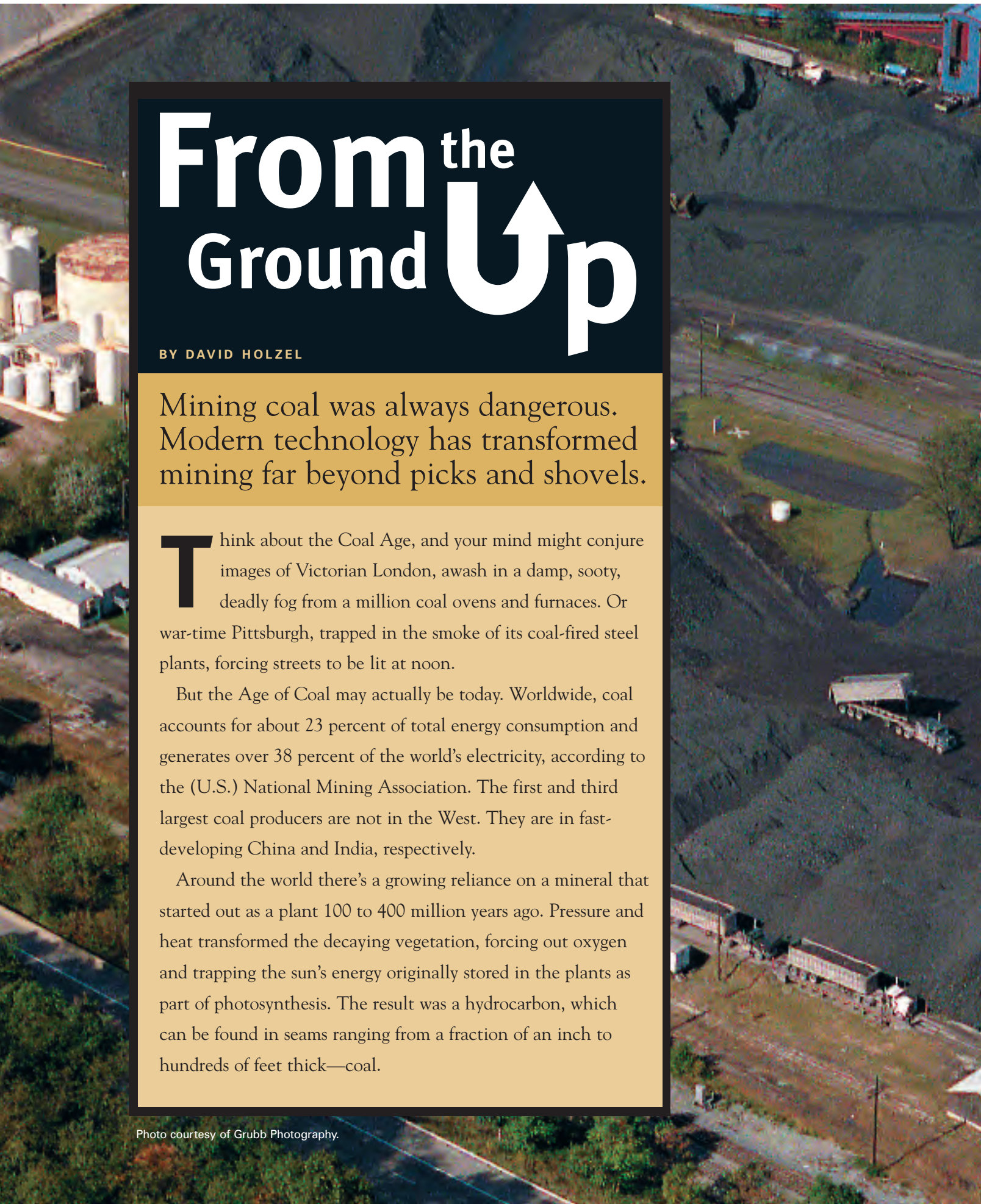

From the Ground Up

BY DAVID HOLZEL

Mining coal was always dangerous. Modern technology has transformed mining far beyond picks and shovels.

Think about the Coal Age, and your mind might conjure images of Victorian London, awash in a damp, sooty, deadly fog from a million coal ovens and furnaces. Or war-time Pittsburgh, trapped in the smoke of its coal-fired steel plants, forcing streets to be lit at noon.

But the Age of Coal may actually be today. Worldwide, coal accounts for about 23 percent of total energy consumption and generates over 38 percent of the world's electricity, according to the (U.S.) National Mining Association. The first and third largest coal producers are not in the West. They are in fast-developing China and India, respectively.

Around the world there's a growing reliance on a mineral that started out as a plant 100 to 400 million years ago. Pressure and heat transformed the decaying vegetation, forcing out oxygen and trapping the sun's energy originally stored in the plants as part of photosynthesis. The result was a hydrocarbon, which can be found in seams ranging from a fraction of an inch to hundreds of feet thick—coal.

Photo courtesy of Grubb Photography.

Mining for coal can be as basic as using a pick and shovel. But today's coal mining more closely resembles a factory process. Increasingly it relies on computers and automation, and there is a growing focus on worker safety. So how does the modern coal mining process work?

To begin, there is not a single type of coal. Four basic kinds of coal are determined by their carbon content. The higher the carbon content, the more heat the coal produces. According to the Appalachian Blacksmiths Association (ABA), "The carbon content of coal supplies most of its heating value, but other factors also influence the amount of energy it contains per unit of weight."

Anthracite has the highest carbon content—between 86 and 98 percent. A pound of this hard coal can produce nearly 15,000 BTUs of heat, according to the ABA. BTU (British Thermal Unit) is the amount of heat required to change the temperature of one pound of water one degree Fahrenheit at sea level.

Bituminous coal "is used primarily to generate electricity and make coke for the steel industry," according to the ABA. It has a carbon content ranging from 45 to 86 percent and a heat value of 10,500 to 15,500 BTUs per pound.

Sub-bituminous coal has a 35 to 45 percent carbon content and a heat value between 8,300 and 13,000 BTUs per

Long walls of coal, typically 1,000 feet wide and one mile long, allow mining to continue without having to move equipment, resulting in higher production and lower operating costs.

Left: A continuous miner cutting coal
Above: A long-wall miner shearing coal

pound. Because it has a lower sulfur content than other kinds of coal, it is cleaner burning.

Lignite is a "geologically young coal which has the lowest carbon content, 25 to 35 percent, and a heat value ranging between 4,000 and 8,300 BTUs per pound," the ABA says. "Sometimes called brown coal, it is mainly used for electric power generation."

Mining Methods

Coal is mined both on the surface and underground.

Surface mining: Also called "strip mining," this method involves removing the rock and earth covering a coal seam or coal bed. The coal is then extracted. When the overlay proves difficult to remove, drilling and blasting are employed to break up the rocks. This method is called "open pit mining."

The amount of material removed from surface mining may total 10 percent coal to 90 percent rock and soil, according to Joseph W. Leonard, a professor of mining engineering and author of *Anthracite Roots: Generations of Coal Mining in Schuylkill County, Pennsylvania*. When that ration is uneconomical, the alternative is underground mining. "Deep mining removal may range from zero to 50 percent rock and soil," Leonard says.

Underground mining: Entry to an underground mine may be through either a horizontal or vertical tunnel. The ore is mined in rooms (stopes), either with mechanical equipment or with drilling and explosives to break the coal into pieces suitable to haul. Columns of coal help support the rooms. This system of support is called "room and pillar."

Long-wall mining is an increasingly popular method of underground mining because of its high productivity and economic benefits.

Long-wall mining involves two steps and two sets of equipment, according to Don Shillingberg, a consulting engineer who has worked in the U.S. coal mining industry for 30 years.

First, continuous mining machinery is brought in. This

Photo courtesy of Grubb Photography.

equipment has a large, rotating, drum-shaped cutting head studded with carbide-tipped teeth, which break up the seam of coal. In a long-wall operation, the continuous miner carves out the work area where the coal will be mined, as well as space for a conveyer belt, ventilation and supply entrances.

The long wall itself can be various widths and lengths. A typical long-wall block of coal could be 1,000 feet wide and one mile long. "The basic idea is to get the highest production you can," Shillingburg says. "You want as long a block of coal as you can so you can keep mining without having to move the long-wall equipment to another block of coal. This keeps your operating costs lower and increases profit."

In the second step of the process, the long-wall machinery is brought in and put to work. The computerized equipment requires three or four workers at a time to operate it around the clock, Shillingburg says.

A rotating shear sits on a conveyer that runs the length of the wall. Long-wall mining doesn't rely on the room-and-pillar system of support. "The long-wall miner itself has a hydraulically operated steel canopy [or shield] which holds up the roof and protects miners working at the face," according to the American Coal Foundation.

As the process begins, the shear begins to travel the length of the wall. "The cut coal falls into the conveyer belt and is moved out," Shillingburg says. "It gets dumped into a hopper and moved to a processing plant via conveyor belts."

The wider the wall is, the more shields are needed to protect the work area. Arranged side by side, the shields find themselves a distance from the wall once the shear has cut a swath of coal. The computer now signals the hydraulic legs of the canopies to release pressure. "Each shield then pulls itself up, resets and pushes the conveyer belt closer to the wall," Shillingburg says. The legs are re-pressurized to support the roof. The shear operates in this manner back and forth across the face of the wall.

The process is repeated until the long wall has been mined. As the shields advance, the unsupported ceiling behind them collapses.

Once removed from the mine, the coal typically moves on a conveyer belt to an on-site preparation plant. There, dirt, rock and other impurities are removed. Trains and barges are the most economical vehicles to carry coal to its final destination. Utility

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A tug boat pushing a group of coal barges.

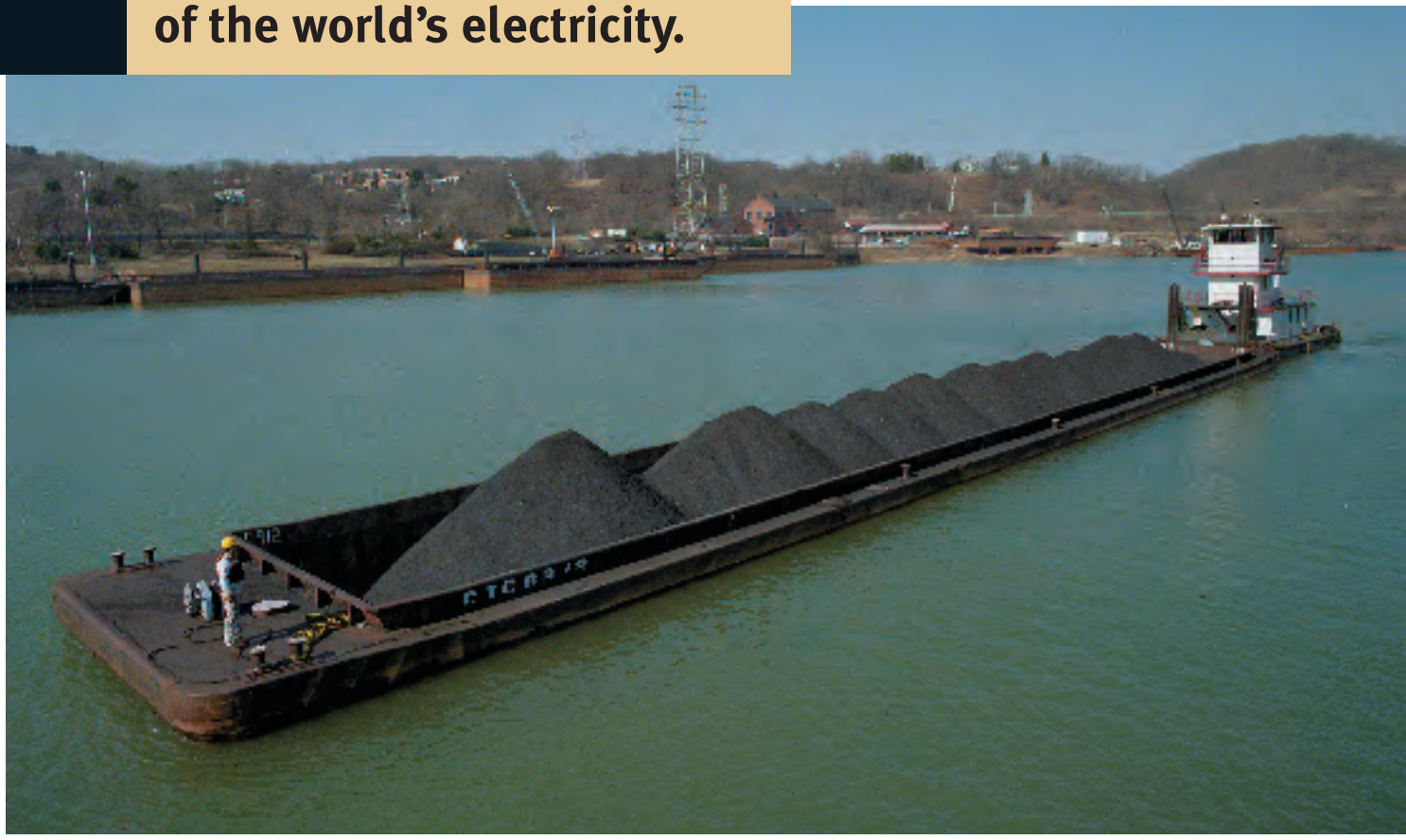

Photo courtesy of Grubb Photography.

plants, among the largest coal consumers, are often built near mines to minimize transportation costs.

A Rise in Safety

Coal mining historically has been an unsafe—and often fatal—occupation. Mine roof collapses and gas explosions took many lives. Chronic lung diseases, such as Black Lung, caused by breathing coal dust, shortened the lives of workers.

Advances in technology have reduced those dangers in the industrialized world. "Today [mining] is ranked among the safest industrial places to work. Forty or more years ago it was among the most dangerous," Leonard says. He points to improvements in safety, such as roof bolts, to prevent cave-ins. Roof bolts are long steel rods used to bind the exposed roof surface to the rock behind it. Mechanization has increased the speed of mining and, in doing so, lowered the chances of settlement and rock failure, he adds.

The last great coal mine disaster in the United States was in 1968. Seventy-eight miners were killed and another 21 escaped to the surface after an explosion at Consol's No. 9 mine in Farmington, West Virginia. The catastrophe prompted a national uproar and new safety legislation.

The following year, 203 coal miners died in the United States. In 1994, fatalities had dropped to 28.

"Coal mining today would best be described as a factory process," Leonard says. "Deep mine productivity went from a few tons to 30 to 1,000 tons per man per day." The wide range is due to a variety of factors at a particular site.

To gauge how far coal mining has come in the developed world, you just need to look at the news coming from China, the world's largest coal producer. In 2004, *The Washington Post* reported: "By the [Chinese] government's own reckoning, more than 6,700 miners died in accidents last year, about 18 per day—and experts say the real figure is probably twice that." The fatality rates in China's mines are as much as 350 times those in other parts of the world, according to *The Washington Post* article.

Those deaths came in explosions, roof collapses and floods, *USA Today* reported. Responding to water seepage is a high priority in mine safety. Water must be pumped out—as much as 18 tons of water per ton of coal mined, Leonard says—and visible fissures sealed.

Such scenarios were just as routine a generation ago in industrialized countries. Today, with computers, walking umbrellas and cutting shears that can travel for miles, coal can be mined without a pick and shovel in sight.

Photo courtesy of Grubb Photography.

Environmental Changes Through Gasification

Gasification has been in commercial use for more than 50 years as a process technology for the refining, chemical and power industries. The gasification of coal may play a key role in reducing countries' dependence on foreign oil.

The gasification process converts any carbon-containing material, such as coal, into a synthesis gas composed primarily of carbon monoxide and hydrogen, which can be used as a fuel to generate electricity or steam or used as a basic chemical building block for a large number of uses in the petrochemical and refining industries. Gasification adds value to low- or negative-value feedstocks by converting them to marketable fuels and products.

When linked with modern combined cycle turbines, gasification is one of the most efficient, environmentally effective means of producing electricity from solid or liquid feedstocks.

Air emissions from an Integrated Gasification Combined Cycle (IGCC) power plant are far below U.S. Clean Air Act standards, and sulfur removal efficiencies of more than 99 percent are achievable. As air emissions standards become more strict, the superior environmental performance of IGCC will take on added economic benefits because the technology can achieve greater emissions reductions at lower cost than less advanced technologies.

Information provided by the Gasification Technologies Council, www.gasification.org.

Top Coal Producing Countries

(2004 figures, in metric tons)
From the World Coal Institute

Major Producers of Hard Coal (2004e)

China	1,956 Mt
United States	933 Mt
India	373 Mt
Australia	285 Mt
South Africa	238 Mt
Russia	210 Mt
Indonesia	129 Mt
Poland	100 Mt
Kazakhstan	83 Mt
Ukraine	62 Mt

Metric ton
Approximately 2,200 pounds in the English system of measurements. In the international system of measurements, 1 metric ton = 1,000 kg.

Source: U.S. Nuclear Regulatory Commission

Global Hard Coal Consumption

	1984	1994	2004e
World	3,066 Mt	3,541 Mt	4,646 Mt
Selected Regional Aggregate Estimates			
Europe	17%	12%	8%
Former Soviet Union	18%	10%	6%
North America	22%	23%	21%
Asia-Pacific	38%	50%	60%

World Coal Production *(in millions of short tons)*

Source: U.S. Energy Information Agency

2004e	4,629 Mt*
2003	4,231 Mt
1980	2,805 Mt

**a 9.4% increase in production over the previous year & 65% growth over the past 25 years.*