

# The SAGE Encyclopedia of Cancer and Society

## Coal Industry

Contributors: Emily Joy Haas & Steven E. Mischler

Editors: Graham A. Colditz

Book Title: The SAGE Encyclopedia of Cancer and Society

Chapter Title: "Coal Industry"

Pub. Date: 2015

Access Date: August 31, 2015

Publishing Company: SAGE Publications, Inc.

City: Thousand Oaks,

Print ISBN: 9781483345734

Online ISBN: 9781483345758

DOI: <http://dx.doi.org/10.4135/9781483345758.n146>

Print pages: 297-303

©2015 SAGE Publications, Inc. All Rights Reserved.

This PDF has been generated from SAGE knowledge. Please note that the pagination of the online version will vary from the pagination of the print book.

<http://dx.doi.org/10.4135/9781483345758.n146>

Coal is a brownish-black sedimentary rock that is the most abundant fossil fuel on earth. Coal is composed of carbon, oxygen, hydrogen, nitrogen, sulfur, and a mixture of minerals. The carbon [p. 297 ↓ ] and hydrocarbon content of the coal rock make it combustible and an accessible source of energy. Statistics from the World Coal Association indicate that, globally, coal provides around 30 percent of the world's primary energy needs and provides approximately 40 percent of the world's electricity.

Coal is found on every continent, with recoverable reserves that are economically extractable in about 70 countries. The largest coal reserves are found in the United States, Russia, China, India, and Australia. Approximately 25 percent of the world's coal content can be found in the United States. The majority of coal mined in the eastern United States is located in an area of largely rural and mountainous terrain that extends from southern New York to Mississippi, known as Appalachia. Specifically, eight states are considered the Appalachian coal mining region: Alabama, Kentucky, Maryland, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia. The majority of coal mined in the western United States is found in the Powder River Basin, which includes the states of Montana and Wyoming. However, several other states have active coal mines that perform underground and surface operations.

Estimates indicate that, at the current rates of production, there is up to 200 years of coal in reserves worldwide. However, with improvements in mining techniques and technology, reserves that are currently inaccessible may be able to be reached and extracted more easily in the future. Due to the abundance of recoverable coal reserves and the longevity of the coal mining industry, it is important to remain cognizant and responsive to the health and environmental impacts of coal mining and what risk-reduction methods can help minimize the occurrence of these associated health consequences. Therefore, after discussing types of coal and coal mining, this entry focuses on environmental and societal concerns of mining coal and control methods in place to alleviate these concerns.

# Types and Uses of Coal

Coal forms from years of intense physical and chemical pressures that act to transform the Earth's vegetation into peat and eventually coal, a process known as coalification. Coalification is classified by rank, the degree of transformation of the original plant material to carbon. There are four types of coal: lignite, subbituminous, bituminous, and anthracite. These four types of coal vary in rank from lowest percentage of carbon to the highest percentage of carbon, with the lower-rank coal having more hydrogen and oxygen.

Lignite coal is the least mature and softest of the coal types, having been exposed to the extreme temperature and pressure for the shortest amount of time. Lignite coal is more accessible because it is closer to the surface. However, lignite coal also has the highest sulfur content of all the coal ranks. So, when combusted, it results in the release of elevated amounts of pollutants such as sulfur dioxide (SO

2

). According to the Lignite Energy Council, about 79 percent of lignite coal is used to generate electricity, 13.5 percent to generate synthetic natural gas, and 7.5 percent to produce fertilizer.

Subbituminous coal, like lignite, is found closer to the surface and thus is cheaper to mine than higher-ranking coal. Similar to lignite, the main use of subbituminous coal is power generation. Both lignite and subbituminous coal are softer coals but subbituminous has been exposed to the extreme conditions for a longer period of time. Subbituminous coal generally has lower sulfur content and, as a result, burns cleaner than lignite. Further transformation, resulting from longer exposure to extreme temperature and pressure causes the lower-ranking coal rock to harden and become darker. As a result, the last two coal ranks are known as the hard coals.

Bituminous coal is the most plentiful type of coal, making up approximately 50 percent of the world's coal reserves. Bituminous coal consists of two different types: thermal and metallurgical. While thermal coal is used in power generation, metallurgical coal primarily is used in steel and iron production.

Anthracite coal is the hardest, has the highest rank, and contains the highest carbon content of the four coal types. This type of coal is mostly associated with domestic and industrial heating. The World Coal Association indicates that there is less than 1 percent of anthracite reserves in the world.

Although coal is primarily used for power generation, several industries benefit from coal, including alumina refineries, paper manufacturers, and chemical and pharmaceutical industries. For example, coal is necessary to produce cement and steel. In addition, thousands of products have coal or coal by-products included in their component makeups, such as soap, plastic, nylon, aspirin, and dye.

## Types of Coal Mining

The coal industry utilizes two methods to mine coal: surface mining and underground mining. Surface mining, also called opencast or open-pit mining, is used when the coal seam is near the surface and the coal can be recovered after the overlying soil and rock, referred to as overburden, is removed. Once the overburden is removed, large pieces of equipment including draglines, power shovels, and excavators are used to retrieve the coal. Large haul trucks and conveyors are then used to transport the coal to where it can be processed or used. Once all of the recoverable coal is removed, the area can be backfilled to promote land reclamation. In surface mining, lignite and subbituminous coal are most often mined.

Underground, or deep mining, is used when the coal is hundreds of feet below the ground. Two methods for underground coal mining include continuous or room and pillar mining and longwall mining. Longwall mining is the most productive underground mining method. In longwall mining, coal mine workers extract coal from a long section of the coal seam using mechanical shearers. Continuous mining machines are also used during development of the longwall sections. Underground mining requires detailed geological exploration and mapping to ensure that the geology is satisfactory to run shafts underground and that the roof can be securely supported to avoid collapsing while the mine is active. Common types of ground and roof support include steel ribs, concrete segments, steel and cable bolts, and wire mesh.

Both surface and underground coal mining result in the production of emissions that can pollute both the air and water. These environmental concerns are discussed next.

## Environmental Concerns

Coal mining consists of several phases from mining the coal to processing, storing, and transporting it for eventual use. Throughout these phases, environmental concerns are always present, including harmful emissions into the air and water, potential impacts on global warming, and changes in land surface characteristics.

Air emissions from coal mining mainly consist of fugitive dust, diesel emissions, and methane. Fugitive dust, including coal dust, rock dust, and crystalline silica, is generated during the mining process by breaking the rock and also results from piles of uncovered coal and overburden when wind action suspends the dust into the air. Diesel emissions, including diesel particulate matter and oxides of nitrogen, from the large diesel engines used in mining, are also emitted into the atmosphere. Finally, methane is a greenhouse gas created during the coalification process. The mining of a coal seam with entrapped methane results in methane release. The deeper the coal seam, the greater the methane content of the coal. The World Coal Association estimates that underground coal mining accounts for 90 percent of methane emissions from the coal mining industry. Although the air emissions already discussed are generally associated with occupational exposures, due to the rural and isolated locations of coal mines, once in the air, there is potential for these emissions to reach nearby populated areas, resulting in public exposure to these emissions.

Water emissions from coal mining mainly consist of sediment and acid mine drainage. Sediment can be created during the mining process as water runs through the mine or when rainwater washes over uncovered piles of coal or overburden. Acid mine drainage results from water reacting with minerals released from the rock during the mining process. It is common for water released from mine sites to contain a higher concentration of sulfates, calcium, magnesium, selenium, arsenic, and other metals than their nonaffected counter bodies of water. Additional water contamination occurs as a result of coal washing, a process that applies chemical formulas containing surfactants, flocculants, and other agents to prepare coal for use in combustion. The

result of this process is the formation of slurry that is stored in surface ponds that can leach into groundwater or is injected underground into old mining spaces.

In addition to air and water emissions, mining can also change the landscape of mined environments by a mining technique known as mountaintop mining or by land subsidence. Mountaintop mining is a surface mining technique where mountaintops are removed to expose coal. Not only does removing mountaintops change the topical terrain and destroy forests, but the overburden, once removed, may be placed in valleys or streams, creating additional sediment pollution and further disturbing the natural biodiversity in the environment. Subsidence, although rare, is the readjustment of [p. 299 ↓ ] the ground surface resulting from the collapse of underground mine workings. Subsidence results in the formation of a sinkhole or trough, which may result in major impacts on surface waterways and structures.

## Health and Safety Concerns

In addition to their environmental impacts, emissions resulting from both the mining and the combustion of coal have been linked to adverse health consequences on the human population, including certain types of cancer. Several pollutants released into the environment from coal mining are of particular concern including coal mine dust, crystalline silica, diesel particulate matter, and arsenic.

Arsenic in drinking water can increase risks for lung, bladder, or kidney cancer. Crystalline silica has been associated with increased risks of lung cancer and silicosis, a debilitating respiratory disease. Several U.S. studies conducted by Michael Hendryx and colleagues concluded that living in coal-mining locations, such as the Appalachian region, is an independent risk factor for developing lung cancer and other health-related problems including colon, bladder, leukemia, and kidney cancer. Specifically, studies conducted with adults in two West Virginia communities, one in a mining area and the other in a nonmining area, found significantly higher self-reported cancer rates in the mining area after controlling for age, sex, smoking, occupational history, and family cancer history. Also, in June 2012, diesel particulate matter was classified by the International Agency for Cancer Research as a known human carcinogen.

Coal mine workers are an especially vulnerable population who experience greater risks because they are exposed to occupational pollutants, including respirable coal mine dust, crystalline silica, and diesel emissions, daily and over an extended period of time. Globally, hundreds of thousands of individuals have careers as coal mine workers, indicating a large population being directly and consistently exposed to coal mine-related pollutants. The American Cancer Society noted that occupational exposure to cancer-causing substances, or carcinogens, accounts for about 4 percent of all cancers in the United States. Coal mine workers are thought to be at increased risk for diseases such as heart disease, chronic obstructive pulmonary disease, and lung cancer.

More specifically, Coal Workers' Pneumoconiosis (CWP), or black lung disease, is the leading cause of death due to occupational illness among underground coal mine workers. Silicosis, resulting from continued exposure to respirable crystalline silica, is more common for those who work on the surface of mine sites, although silica can be inhaled when coal seams are cut as well. With diagnoses of CWP or silicosis also come associated health problems such as lung cancer, autoimmune disorders, pulmonary tuberculosis, and chronic renal disease.

From the early 1980s to 2006, the underground coal mining industry experienced little change in levels of exposure to respirable coal mine dust. However, a chest X-ray surveillance program initiated by the National Institute for Occupational Safety and Health, which conducts preventative and diagnostic screenings of participating coal mine workers, found that, after many years of decline in the incidence of CWP, the prevalence of the disease is on the rise again. For example, between 2000 and 2005, data from the U.S. Department of Health and Human Services (HHS) indicated that CWP contributed to the deaths of close to 3,900 coal mine workers. This recent increase supports the need for additional risk reduction mechanisms to maintain the health of coal mine workers, specifically.

Because of the importance of coal energy to the world economy, it is necessary to continuously evaluate and create methods to help mitigate the exposure of coal miners and the public to hazardous emissions associated with coal mining as well as reducing the impact of coal mining on the environment.

# Risk Reduction Efforts for Environmental and Societal Health

The coal industry and pertinent regulatory agencies remain vigilant in researching and adopting methods to help reduce and control respirable dust and pollution levels to help protect the environment and the public. In response, emissions of many of the pollutants that put individual and environmental health at risk are regulated and controlled to some degree.

The Environmental Protection Agency (EPA) proposes and modifies regulations to minimize risks generated from coal power plants and producers. Under the Surface Mining Control and Reclamation Act of 1977, it is required for land impacted by mining to be reclaimed for other uses. This act requires that mine companies reclaim land where coal has been extracted already. Closed mines can become housing units, farmlands, forests, or even public parks. For instance, in the European Union, more than half of mining lands are reclaimed as forests or grasslands, whereas in China, a majority of reclaimed mining lands are used for agriculture purposes.

*Coal provides around 30 percent of the world's primary energy needs and provides approximately 40 percent of the world's electricity. Emissions resulting from both the mining and the combustion of coal have been linked to adverse health consequences on the human population, including certain types of cancer. (MorgueFile)*



Another environmental regulation is the 1976 Resource Conservation and Recovery Act (RCRA). This regulation indicates that any hazardous waste that results from mining be treated and stored properly and then disposed in a way that protects the environment

and surrounding individuals. For example, in 2010, the EPA proposed to regulate coal combustion residuals under the RCRA. Further, in 2012, under the Clean Air Act, the EPA proposed a new source performance standard to limit emissions of carbon dioxide from new, fossil fuel-fired, utility-generating units, which includes coal and natural-gas-fired units. Limiting these emissions is expected to reduce greenhouse gas pollution.

Although regulations require an increase in accurate environmental assessment and rigorous planning, these strategies ensure that mining companies remain in compliance regarding protecting the environment from air, water, and gas pollution, thus providing more protection for individuals who reside in mining areas as well.

Absent of regulations, however, the coal industry makes several efforts to minimize harmful environmental consequences of mining coal. New technology at power plants helps keep air clean during the cleaning and processing of coal. One example of such technology includes an integrated gasification combined cycle (IGCC), which is a coal gasification process that turns coal into a gas before burning it, resulting in cleaner air. In addition, the coal industry has been actively involved in researching methods to extract the methane from coal and preventing its release into the environment. The capture of methane before it is released both reduces emissions of greenhouse gases as well as improves the safety of underground coal mines. Explosions in **[p. 301 ↓ ]** underground mines result in loss of lives worldwide, and while any loss of life is too high, the number of explosions has been steadily declining as methane recovery technologies have been improved and deployed on a wider scale.

Due to the nature of their occupation, the environmental-based regulations and research do not fully protect coal mine workers, who are exposed to more respirable dust than the rest of the public. As a result, coal mine workers have a greater risk for various types of cancer and respiratory diseases than the general public. However, there are specific risk reduction efforts that target this at-risk group of individuals.

# Risk Reduction Efforts for Mine Worker Health

Because the process of mining coal results in the potential for increased occupational exposures to coal dust and other pollutants, risk reduction efforts are needed on regulatory, organizational, and individual levels to best protect coal mine workers. For instance, in the United States, the Mine Safety and Health Administration (MSHA) promulgated regulations that limit the exposure to respirable coal mine dust to an average of 2.0 milligrams of respirable dust per cubic meter of air ( $\text{mg}/\text{m}^3$ ) over a standard work shift. Mine operators are responsible for regularly collecting respirable dust samples in active, working mines. If the results exceed the allowable average dust level, the mine must take corrective action to reduce the average concentration of respirable dust to below the permissible concentration. In addition, the mine operators must continue sampling until they measure dust concentrations below the allowable limit on five sequential samples.

Internationally, respirable dust regulations vary. In Australia, different mining areas such as New South Wales, Queensland, and Western Australia have separate health and safety regulations. In New South Wales, mine operators at each mine must ensure that no mine worker is exposed to more than  $3.0 \text{ mg}/\text{m}^3$  of respirable dust or  $10.0 \text{ mg}/\text{m}^3$  of inhalable dust over an eight-hour sampling period.

In addition to regulating allowable airborne dust concentrations, new advances in mining technology can help to (1) minimize the creation of dust and (2) allow individuals to more accurately monitor their dust exposure on the job. The National Institute for Occupational Safety and Health (NIOSH) has completed numerous studies to recommend the best methods to control exposure to airborne dust in coal mining. These researchers have found that technology controls, water spray systems, and ventilation systems function as protective devices to help prevent the formation of dust, suppression of dust to prevent it from becoming airborne, and removal or dilution of the dust once it is airborne. For example, water spray systems can help suppress or redirect dust away from mine workers and walkways. In addition, scrubbers can be

mounted on existing mining machines to help move air and capture dust while mining coal. Improved ventilation systems can also dilute dust concentrations after becoming airborne.

The control methods already discussed are applied to help reduce the concentrations of airborne dust that reach the inhalable breathing zones of coal mine workers. However, personal protective equipment (PPE), such as an airstream helmet or respirator, can be worn by coal mine workers to reduce the amount of dust actually inhaled. This PPE functions as a barrier between coal mine workers and respirable mine dust. Other equipment can be used to help mine workers monitor their exposure to dust throughout the workday. Specifically, a continuous personal dust monitor (CPDM) is available to the coal mining industry that can provide mine workers with near real-time feedback on their exposure to respirable coal mine dust. If mine workers and mine site safety personnel know how to properly use and communicate about the information provided by CPDMs, they may be able to make adjustments to the workplace and work procedures to try to reduce their exposure to respirable coal mine dust as they complete work tasks.

Even though risk reduction methods are in place, exposure can still occur through breaches in these regulations, accidents, or inability of individuals to recognize and mitigate these hazards in their surrounding environment. Therefore, a final area of prevention includes education that empowers mines and respective mine employees to take action to reduce their exposure to respirable coal mine dust on the job. Educational interventions that seek to motivate and persuade changes in mine workers' behaviors to lower their exposure to respirable coal mine dust can enhance methods used by mine [p. 302 ↓ ] workers to reduce personal dust exposure and, consequently, the incidence of CWP. For example, if mine workers are aware of the areas that produce more dust and can stand in different positions, or are trained in the use of technology to reduce the concentrations of dust, they immediately have more control over their dust intake on the job. These changes in work behaviors can ultimately lead to improvements in coal miners' longevity and quality of life.

## Conclusion

This entry discussed the positive uses of coal while acknowledging the negative impact coal mining can have on the environment and individual health. Because of the pros and cons that exist due to coal mining, a systematic approach is needed to address some of the drawbacks, so the nation can continue to benefit from coal and coal by-products. Risk reduction efforts were discussed on a policy, organizational, and individual level that are used to protect the environment, general public, and coal mine workers as much as possible. Specifically, participating in strategic planning before mining, including ways the land can be reclaimed, enforcing health and safety policies, leadership engaging in surveillance of mine worker behaviors, and mine worker education and empowerment are crucial to preventing the onset of cancer and other adverse health effects for individuals who experience consistent exposure to carcinogens emitted from coal.

**See Also:** [Lung Cancer, Small Cell](#); [Pollution, Air](#); [Pollution, Water](#).

Emily JoyHaasSteven E.Mischler

<http://dx.doi.org/10.4135/9781483345758.n146>

Further Readings

Ahern, Melissa and MichaelHendryx. " Cancer Mortality Rates in Appalachian Mountaintop Coal Mining Areas ." *Journal of Environmental and Occupational Science* , v.1/2 (2012).

"Code of Federal Regulations." Washington, DC: U.S. Government Printing Office, Office of the Federal Register.

Colinet, Jay F., James P.Rider, Jeffrey M.Listak, John A.Organiscak, and Anita L.Wolfe. " Best Practices for Dust Control in Coal Mining ." Publication No. 2010-110. Pittsburgh, PA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health, 2010.

Hendryx, Michael, Kathryn O'Donnell, and Kimberly Horn. "Lung Cancer Mortality Is Elevated in Coal-Mining Areas of Appalachia ." *Lung Cancer* , v.62 (2008).

U.S. Department of Health and Human Services. "Work-Related Lung Disease Surveillance Report, Volume 1, Coal Workers' Pneumoconiosis and Related Exposures ." Public Health Service, Centers for Disease Control and Prevention, 2008.

U.S. Department of Labor. "Division of Coal Mine Workers' Compensation, Black Lung Program Statistics, 2010 Statistics ." <http://www.dol.gov/owcp/dcmwc/statistics/statistics.htm> (Accessed June 2011).

U.S. Energy Information Administration. "Annual Coal Report, 2013 ." <http://www.eia.gov/coal/annual> (Accessed March 2014).

"Work Health and Safety Regulations 2012, Australia." <http://www.legislation.sa.gov.au/LZ/C/R/WORK%20HEALTH%20AND%20SAFETY%20REGULATIONS%202012.aspx> (Accessed March 2014).

World Coal Association. "Coal Statistics ." <http://www.worldcoal.org/resources/coal-statistics> (Accessed March 2014).

Zhengfu Bian, Hilary Inyang, John Daniels, Frank Otto, and Sue Struthers. "Environmental Issues From Coal Mining and Their Solutions ." *Mining Science and Technology* , v.20/2 (2010).