The Health Impacts of the Coal Life Cycle

A Healthy Energy Initiative Fact Sheet

Introduction

Formed from dead organic matter hundreds of millions of years ago, coal has been one of the most commonly used energy fuels for centuries. Despite the recent rapid growth in renewable energy, coal continues to fuel approximately 40% of the global electricity supply.[1]

While not all types of coal are created equal in terms of their age, composition, and properties, they share a key attribute: the various stages in its life cycle—from extraction to waste disposal—result in widespread and long-term harm to the environmental quality and climate stability needed to protect and support human health.

- **Coal pollutes the air**
  The coal life cycle releases many harmful pollutants into the air, affecting workers, residents in the immediate vicinity, and even populations hundreds of kilometers away.

- **Coal strains water supplies**
  The coal life cycle uses vast quantities of water and leaks toxic waste products, threatening water sources on which humans depend.

- **Coal disturbs the land**
  Large areas of land—often with ecological, economic, or cultural significance—are often cleared for coal mines and later become unusable after mines close.

- **Coal fuels climate change**
  Coal plants are the world's largest source of carbon dioxide emissions,[2] and coal mines are a significant source of methane emissions.

> *"Coal is the world's most polluting fossil fuel, and coal combustion is an important cause of both pollution and climate change."*
>
> – The Lancet Commission on Pollution and Health, 2017[3]

The health impacts of the coal life cycle:

From mines to ash ponds

Coal has a wide range of adverse effects—summarized below for each step in the coal life cycle—on the health of the following groups:

Workers exposed to unhealthy or dangerous conditions

Communities exposed to pollution and other impacts on air, water, and land

Populations around the world that are vulnerable to, or already suffering from, the effects of climate change

Mining

Coal is extracted from the earth through either surface mining—including strip mining, open-pit mining, and mountaintop removal mining—or underground mining.

- Underground coal mining threatens worker health in many ways. Exposure to coal dust puts miners at risk for potentially fatal pneumoconiosis (black lung disease), silicosis, and lung cancer, as well as for chronic bronchitis and accelerated loss of lung function.[4,5] Coal dust and methane can cause explosions.[6,7] Methane, carbon monoxide, and carbon dioxide can also cause asphyxiation.[8,9]

- All coal miners are exposed to injury risk and can face dangerous levels of heat and noise.[10]

- Small-scale mines, more commonly found in developing countries, often have higher rates of accidents and injuries.[11]

- Large areas of forest and other productive lands are often cleared for coal mines, displacing communities, threatening livelihoods, and straining mental well-being. After mining activities cease, the land often remains barren and contaminated due to the high cost of rehabilitation.[12]

- There is evidence of elevated rates of cardiovascular, pulmonary, and kidney diseases, and of blood inflammation, near coal-mining operations.[13,14]

- Local air quality is affected by pollutants including particulate matter and coal seam gas (methane). Dust levels in mining communities can be significant, covering skin and surfaces in homes.[15]

- When coal mixes with water, the resulting chemical contamination and acid mine drainage can cause long-term contamination of drinking water supplies.[16]

- Coal mines are a significant source of anthropogenic emissions of methane, a potent greenhouse gas.[17]

- Deforestation and landscape changes associated with coal mining also release greenhouse gases.[18]

Processing

After it is mined, coal is often crushed, washed, and dried to remove impurities, making the product cheaper to ship and cleaner to burn. The large amounts of liquid waste (coal sludge) are disposed of near the coal processing plants, either contained by dams constructed from the solid mining waste, or injected into abandoned underground mines. Coal sludge contains toxic substances, including heavy metals and known carcinogens.

- Workers are exposed to dust, noise, ergonomic and injury hazards, and carcinogens.[19]

- Coal sludge can leak from impoundments and cause long-term contamination of drinking water supplies.[20]

- Catastrophic impoundment failures have led to deaths, injuries, and displacement.[21]

Transportation and Storage

After mining and processing, coal can be transported by various means, including by conveyors or trucks over short distances, by trains and barges over longer distances, or through pipelines after being mixed with water. As the coal is transported or stored, coal dust can be blown into the air, exposing nearby communities to dust inhalation.

- Handling and transportation of large amounts of coal exposes workers to injuries, noise, and ergonomic hazards.[22]

- Communities living near coal storage yards and transport corridors are exposed to coal dust and noise.[23] The health costs of coal dust from transportation and storage are approximately $203 and $183 per ton in the US, respectively, which dwarf the average $48 per ton that US coal-fired power plants pay for the coal itself. This burden is primarily borne by economically disadvantaged communities living near coal-fired power plants and railroad tracks.[24]

- Together, coal dust and diesel exhaust along transport corridors increase local concentrations of $PM_{2.5}$.[25]

- Railroad accidents and other incidents can cause injuries and deaths.[26]

- Diesel combustion required to transport coal is a major source of emissions of black carbon, a short-lived but powerful climate pollutant.[27]

? How does coal dust harm our health?

Coal dust is a fine powdered form of coal, created by crushing, grinding, or pulverizing coal. Coal dust ranges in size and composition, containing particles as small as $PM_{2.5}$ and hazardous substances including lead, mercury, arsenic, cadmium, silica, and sulfur compounds. Coal dust exposure can result in respiratory and cardiovascular disease, cancer, birth defects, neurological damage, and skin conditions. It is also highly explosive.

Combustion

Once coal is delivered to the power plant, it is typically stored temporarily, then pulverized into a fine powder that is burned to make steam, which drives a turbine to generate electricity. The combustion process emits large quantities of carbon dioxide as well as particulate matter, sulfur dioxide, oxides of nitrogen, mercury, and heavy metals. Some of these emissions react in the atmosphere to form secondary pollutants—including ozone and particulate matter—which can be carried through air currents to affect wide geographic areas. As a result, the combustion of coal for electricity generation carries the largest health burden in the coal life cycle.

- Workers may be exposed to coal, coal ash, all the components of the dust collection system, and asbestos.

- Particulate matter, sulfur dioxide, and nitrogen oxides are of particular concern because of their wide-ranging health effects.

- Coal combustion is the largest source of anthropogenic emissions of mercury—a potent neurotoxin that is especially dangerous for developing fetuses and young children. Mercury can be inhaled directly or ingested as methylmercury through seafood from contaminated waterways.[28]

- Persistent organic pollutants, including dioxins and PAHs (see sidebar), can also be either inhaled directly or ingested through food and water, resulting in carcinogenic, reproductive, endocrine, and immune system effects.[29]

- Sulfates and nitrates are precursors of acid rain, which damages streams, forests, crops, and soils, potentially threatening food security and livelihoods.[30]

- Coal plants consume large amounts of water for cooling, which can threaten water availability.[31]

- Coal combustion is one of the top sources of greenhouse gases—including CO_2, nitrous oxide, and black carbon—emitted through human activities.[32] It is responsible for 72% of CO_2 emissions from electricity and heat generation, and for 45% of CO_2 emissions from fuel combustion.[33]

? How do PM, SO_2, and NO_x harm our health?

Particulate matter (PM) refers to airborne particles that are either emitted directly from the coal life cycle (primary PM) or formed through atmospheric reactions of other pollutants emitted during coal combustion (secondary PM). PM originating from coal combustion contains toxic substances such as heavy metals and polycyclic aromatic hydrocarbons (PAHs). Both coarser PM_{10} and finer $PM_{2.5}$* are associated with premature death, hospitalizations and respiratory symptoms, and decreased lung function.[34] $PM_{2.5}$ is of particular health concern because it can travel deep into the airways, causing inflammation and passing into the blood stream. PM is a known carcinogen[35] and is associated with cardiovascular and respiratory disease, lung cancer, stroke, heart attacks, asthma attacks, adverse birth outcomes, autism spectrum disorder, reduced productivity, and other outcomes. There is no safe level of PM exposure.[36]

Sulfur dioxide (SO_2) is emitted when the naturally-occurring sulfur in coal is burned. Coal combustion is responsible for around 60% of global combustion-related SO_2 emissions.[37] Exposure to SO_2 can decrease lung function and cause inflammation and hyper-responsiveness of the airways; it thereby increases the incidence and severity of respiratory illnesses, including asthma and bronchitis, and it may raise the risk of death from heart and lung conditions.[38] SO_2 also reacts in the atmosphere to form secondary PM.

Nitrogen oxides (NO_x) are by-products of coal combustion that react in the atmosphere to form harmful pollutants including ground-level ozone and secondary PM. **Ozone** exposure damages the respiratory system and is associated with exacerbation of asthma, reduced lung capacity, increased rates of respiratory infections, and various cardiovascular effects.[39] **NO_2** is a nitrogen oxide that is itself a lung irritant and can increase the chance of respiratory illness by lowering resistance to infection.[40]

* PM10 and PM2.5 refer to particles with diameters less than 10 micrometers and 2.5 micrometers, respectively. For comparison, the diameter of a single human hair is typically 60-100 micrometers.

? How does CO_2 harm our health?

Carbon dioxide (CO_2) is the most influential driver of climate change among several heat-trapping (or "greenhouse") gases, making it one of the most significant pollutants in coal's life cycle. With its global and potentially irreversible consequences, climate change is one of the greatest challenges to global health, affecting patterns of disease, water and food insecurity, vulnerable shelter and human settlements, extreme climatic events, and population growth and migration.[41] Tackling climate change—by reducing coal use and transitioning to low-carbon, renewable energy sources—could be the greatest global health opportunity of the 21st century.[42]

Waste Disposal

The combustion of coal creates large amounts of waste product called coal ash. Coal ash is disposed of in wet ash ponds, in dry landfills, or in abandoned and active mines as fill; it can also be "recycled", for example, as an agricultural soil additive. Coal ash contains a range of toxic materials that are known to leach, leak, or spill out of disposal sites, or to leach from recycled uses.

- Workers are exposed to the toxic effects of coal ash when transporting and depositing the large amounts of it produced in power stations, and when cleaning up coal ash spills.[43]

- The most common public health threat is the slow leakage of coal ash from disposal sites when it comes into contact with water, which carries it into above-ground and underground waterways, contaminating drinking water supplies.[44]

- While rarer, coal ash spills have severe consequences for nearby residents as well as the drinking water supply of communities within the watershed.[45]

? How does coal ash harm our health?

Coal ash is the waste product left over from coal combustion. While the composition of coal ash varies depending on where the coal is mined, it typically includes lead, arsenic, mercury, cadmium, chromium, selenium, and other toxic metals, which have the potential to damage all major organ systems. Especially with prolonged exposure, coal ash toxics can cause several types of cancer, heart damage, lung disease, respiratory distress, kidney disease, reproductive problems, gastrointestinal illness, birth defects, impaired bone growth in children, nervous system impacts, cognitive deficits, developmental delays, and behavioral problems.[46]

The myth of "clean coal"

The coal industry uses the term "clean coal" to refer to technologies that burn coal more efficiently, control air pollution, or capture carbon dioxide emissions—all of which are to be deployed in new coal plants that replace older ones. However, these technologies make only incremental improvements, are costly to implement, and may carry health risks themselves.

High-efficiency plants require less coal to generate a unit of electricity, thus emitting less CO_2 and harmful pollutants. Today, nearly 75% of operating coal plants are 'subcritical,' with efficiencies between 33 – 37%. This can be improved to 42 – 43% with supercritical plants, 45% with ultra-supercritical plants (USC), and 50% with integrated gasification combined cycle (IGCC) plants. These technologies are costly and still allow coal plants to emit dramatically more CO_2 and harmful pollutants than any other electricity source.[47]

Air pollution control technologies control the release of hazardous air pollutants (including $PM_{2.5}$, sulfur dioxide, nitrogen oxides, and mercury) by capturing and storing them in waste ponds or ash dumps which can break or leak, thus effectively transferring air pollutants into water supplies. Expensive to install and operate, these measures make coal plants less efficient and still do not eliminate some of the most hazardous pollutants such as dioxins. Some technologies, such as flue gas desulfurization (scrubbing), increase the plant's water needs.[48]

Carbon capture and storage (CCS) involves capturing CO_2 emissions, compressing them into a liquid, and permanently disposing of them underground. Depending on the capturing process, CCS may lead to a reduction in sulfur oxides and particulate matter. However, a major tradeoff to CCS is with coal plant efficiency, requiring 20 – 30% more coal, which leads to higher emissions of nitrogen oxides and may negate the reduction in sulfur oxides.[49] Additionally, the underground storage of CO_2 may contaminate groundwater with toxic metals and organic pollutants, and CO_2 leaks during transport or storage could cause headaches and unconsciousness.[50]

Ultimately, "clean coal" technologies do not significantly reduce the myriad health, social, and environmental costs of the coal life cycle. The immense investment they require can be much better utilized to develop truly clean, renewable energy projects.

For more information

To find all references listed in this fact sheet, view supporting materials, and learn more about the health impacts of the coal life cycle, visit www.healthyenergyinitiative.org/coal-and-health.

To learn about the Healthy Energy Initiative, visit www.healthyenergyinitiative.org, follow @healthyenergyi on Twitter, or email healthyenergy@hcwh.org

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