Health Impact Assessment of Coal and Clean Energy Options in Kentucky

A Report from Kentucky Environmental Foundation

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KENTUCKY Environmental FOUNDATION

Acknowledgements

The authors thankfully acknowledge the following experts for reviews and comments on drafts of this report:

Carla Baumann, MSN, RN
Philip Curd, M.D., MSPH
Richard Futrell, PhD
Michael Hendryx, PhD
David Mannino, MD
John Patterson, MD, MSPH
Monica Unseld, PhD

Any remaining errors are entirely our own.

The authors also thank contributions of interviews carried out by students of Berea College's Health in Appalachia course (HEA/APS 210), Fall 2010 and 2011.

About Kentucky Environmental Foundation:

The Kentucky Environmental Foundation (KEF) is a non-profit organization dedicated to securing solutions to environmental problems in a manner, which safeguards human health, promotes environmental justice, preserves ecological systems and encourages sustainability.

Design and layout: Rob Gorstein Graphic Design, Inc.

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Executive Summary

Introduction

If we Kentuckians value our health, and if Kentucky legislators are concerned with improving public health, it is imperative that community and state leaders examine the role of energy policy in determining health outcomes. Governments and institutions are increasingly using Health Impact Assessments (HIA) as tools to help make policy decisions in the best interest of public health. Using both quantitative and qualitative data, an HIA can arrive at policy recommendations or propose a specific course of action to create the best health outcome possible.

Energy policy in Kentucky has typically been designed to maintain the use of coal, a resource that currently provides roughly 93-94% of Kentucky's electricity. Kentucky legislators have given less attention to the specific health benefits and consequences of our energy options. This HIA provides a health-based screening of coal, and of the energy efficiency and renewable energy options proposed in the Clean Energy Opportunity Act as introduced in the 2011 and 2012 Kentucky legislative sessions.

Findings. Coal has provided reliable electricity to Kentuckians for decades and has provided many Kentuckians with the benefits of employment, but at a substantial cost to the health of people in the Commonwealth. Public health is affected throughout the coal cycle from mining to waste disposal:

- Mountaintop mining exposes people to air pollution, contamination of groundwater and drinking water, flooding, structural damage to homes, and accidents.
- Miners working in deep coal mines are exposed to high levels of dust, noise, and toxic gasses, leading to respiratory damage and hearing damage.
- After coal is extracted, it is cleaned with a chemical wash. Any hazardous chemicals remaining from the wash are stored in ponds or injected into abandoned mines, both of which may leak into streams, rivers, and groundwater. Spills may involve millions of gallons, leading to flooding of toxic chemicals.
- Coal is transported by rail or trucks, which has led to accidents and respiratory disease from coal dust and diesel combustion.
- Impacts from coal power plants can be measured up to hundreds of miles from the source. Gaseous emissions and particulate matter can affect the heart, lungs, and nervous system, as well as damage prenatal development. Coal-fired power plants also emit mercury, a toxicant that can have significant negative effects on the nervous system, especially in fetuses, infants, and children. Individuals can experience loss of intelligence that can last a lifetime, in addition to other nervous system disabilities.
- Coal extraction and burning processes release greenhouse gases like carbon dioxide and methane, which are linked to climate change. Climate change impacts public health through heat strokes, flooding, loss of crops, and increased spread of diseases.
- Remaining coal ash contains toxic metals such as arsenic and cadmium. This is stored in impoundment ponds and landfills across Kentucky. These toxic metals can leak into water supplies or blow into the air, causing cancer and other health problems.

Electricity can also be generated from renewable sources such as solar, wind, hydro and biomass, and these sources may also have some health impacts. For example, solar panel manufacturing involves use of many heavy metals and chemicals (as in other electronics manufacturing) and as such poses occupational exposure risks. Low-frequency noise and vibrations from wind turbines have been reported to cause disturbances to some people living close by. Biomass can involve combustion of fuel sources like wood and switchgrass or other materials, which result in air emissions that may be harmful depending on the fuel used.

Energy efficiency is not an electricity source, rather refers to methods of using electricity from any source more efficiently. Home weatherization, energy efficient appliances and lighting are common examples of energy efficiency. Health impacts from energy efficiency activities may come from exposure to chemicals in construction or building materials, as would be the case generally with any new building construction or retrofit.

Scientific and health research clearly show that the beneficial impacts of energy efficiency and renewable energy are often realized in the avoidance of additional pollution from coal. Displacement of pollution at each step in the coal cycle means lower rates of worker illness or injury. Lower levels of soot, heavy metals, greenhouse gases and other harmful emissions can directly reduce the number of heart attacks and asthma attacks. In addition to the health

benefits of pollution prevention, tangible benefits from energy efficiency can be observed. Benefits include those from home weatherization, which results in fewer incidences of general illnesses, and reduction in eye-strain and headaches when energy efficient lighting is used.

Research also shows that avoiding the use of less- or non-toxic chemicals and materials can mitigate some of the potential health impacts associated with energy efficiency. Renewable energy health impacts can be addressed at the manufacturing or installation phase or in the case of biomass, by choosing non-toxic renewable fuels.

The HIA authors and reviewers intend for this document to serve as a tool primarily for Kentucky legislators to consider health outcomes of energy policy such as the Clean Energy Opportunity Act and other future proposed policies, and make decisions as though we value public health: because we should.

Recommendations

Based on these findings, we recommend:

1. Kentucky legislators should support diversification of Kentucky's energy portfolio to include renewable energy from sources such as solar, wind or hydro, and provide incentives for Kentuckians to use energy more efficiently. These portfolio standards would displace pollution from coal and provide additional direct health benefits to Kentucky residents. Policy proposals like the Clean Energy Opportunity Act (HB 167) of 2012 could help shift toward a healthier energy portfolio.
2. Kentucky legislators and environmental regulatory agencies should consider the health impacts of our state's current and future energy policy and consider requiring that HIAs be utilized as a part of any future electricity generation policy process. The HIA methodology and findings will help ensure that public health improvements are a priority policy outcome.

Introduction

Do we Kentuckians value our health? It is not always easy to tell. Kentucky is ranked among the worst in the nation for preventable illnesses including heart disease, lung disease, obesity, certain cancers and other chronic diseases. At the same time, results from a poll recently conducted by the Foundation for a Healthy Kentucky shows that 83% of Kentuckians felt protection of our health was extremely or very important.

The Commonwealth spends a considerable amount of money treating these illnesses, and state health agency and non-governmental groups undertake numerous programs to prevent illness through behavioral changes like smoking cessation, nutrition and exercise. However, little emphasis is placed on the prevention of environmental causes of the health problems we face—the ways in which harmful contaminants in our air, water, land or food can impact our health.

We as individuals have limited control over these environmental impacts, yet the price we pay for them is not cheap: Kentuckians face high rates of heart and respiratory diseases resulting in debilitating or deadly heart attacks or asthma attacks; one of the primary causes of these attacks is air pollution from burning fossil fuels like coal. Many Kentucky legislators, who have the authority to set energy priorities and policies affecting air pollution, frequently assert that their primary energy goal is to maintain or strengthen the coal industry and coal related jobs. The health impacts of proposed legislation or agency action are rarely discussed, though this pollution results in a heavy burden of illness.

If we Kentuckians value our health, how then could Kentucky's citizens and state legislators make decisions in a manner that could avoid chronic illnesses and premature death, and perhaps directly improve public health?

Health impact assessments (HIA) enable us to answer that question. The World Health Organization defines an HIA as "a combination of procedures, methods and tools by which a policy, programme, or project may be judged as to its potential effects on the health of a population, and the distribution of those effects within the population." HIAs have been used for decades in Europe to help use health data to define policy decisions made outside of the health sector. Governments and institutions in the United States are increasingly looking to HIAs to provide perspectives on public policy. The U.S. Centers for Disease Control and the non-governmental organization Human Impact Partners promote HIA methodology, which involves the following steps:

- Screening (identify projects or policies for which an HIA would be useful);
- Scoping (identify which health effects to consider);
- Assessing risks and benefits (identify which people may be affected and how they may be affected);
- Developing recommendations (suggest changes to proposals to promote positive or mitigate adverse health effects);
- Reporting (present the results to decision-makers); and
- Evaluating (determine the effect of the HIA on the decision).

Even with those common steps, each HIA is unique according to the geographic or screening scope, and the level of detail of options and recommendations.

The purpose of the Health Impact Assessment on Coal and Clean Energy Options in Kentucky is to provide a health perspective to state legislators, state agencies, health professionals and citizens on Kentucky's energy policy options based on our current primary energy source – coal – and on a recent policy proposal calling for energy efficiency and renewable energy portfolio standards.

That proposal was initially introduced in 2010, and then in 2011 and 2012 as the Clean Energy Opportunity Act. The 2012 Act would set a Renewable and Efficiency Portfolio Standard requiring utilities, through gradually increasing incremental goals, to ramp up to a renewable energy retail sales level of 12.5% by 2022, and offset 10.25% of annual retail sales with energy efficiency programs, over the same time period. The Act would also establish a "feed in tariff" for renewable energy production from wind, solar, hydro or low-impact biomass. A feed-in-tariff, also referred to as a Clean Local Energy Accessible Now (CLEAN) contract, means utilities purchase electricity at a fixed rate from customers who

provide renewable energy (such as from rooftop solar panels), to the electricity grid. Currently 40 U.S. states have set some type of renewable energy or efficiency goals.

This HIA uses both quantitative (facts, statistics that can be measured) and qualitative (how one feels, what we observe) data to provide a more comprehensive view of the health costs and benefits of our state's energy composition. The study addresses health impacts from each stage of the coal cycle: extraction, processing, transportation, burning and byproducts. It also examines health impacts presented by energy efficiency and renewable energy.

The quantitative information in this HIA was obtained from independent health and scientific sources, based as much as possible in Kentucky. However, a large percentage of existing data on the impacts of coal, energy efficiency or renewable energies has been gathered on a national level or outside of Kentucky. In those cases, we have searched for research from states or communities nearest to, or with similar characteristics as Kentucky (e.g., West Virginia). HIA methodology also allows for extrapolation of national data to gauge potential state or local impacts.

What may seem to be a bias or imbalance in reporting positive or negative health impacts is more accurately a reflection of the level of health data available. For example, there are far fewer studies on the health impacts of biomass emissions than there are of the impacts of coal burning, and the occupational hazards associated with coal mining are on a very different scale from the occupational hazards associated with solar panel manufacturing, although both are necessary precursors to energy production. Additionally, when considering the positive impacts of energy production options, often the most pronounced health benefits are in avoidance of less healthy options. The National Research Council addressed this issue when it chose to measure the benefits of wind energy by the degree to which it avoids air emissions like greenhouse gases from other electricity generation.

> *The environmental benefits of wind energy accrue through its displacement of electricity generation that uses other energy sources, thereby displacing the adverse environmental effects of those generators. Because the use of wind energy has some adverse impacts, the conclusion that a wind-energy installation has net environmental benefits requires the conclusion that all of its adverse effects are less than the adverse effects of the generation that it displaces… This focus on benefits accruing through reduction of atmospheric emissions, especially of greenhouse-gas emissions, was adopted because those emissions are well characterized and the information is readily available. (page 4)*

Qualitative data is useful to provide examples of personal experiences with health impacts linked to coal, energy efficiency and renewable energies. HIA researchers invited and requested stories and perspectives from a wide range of Kentuckians in the energy, utility and health fields and at the community level, however the stories included here do not assume to represent the full spectrum of beliefs of Kentuckians.

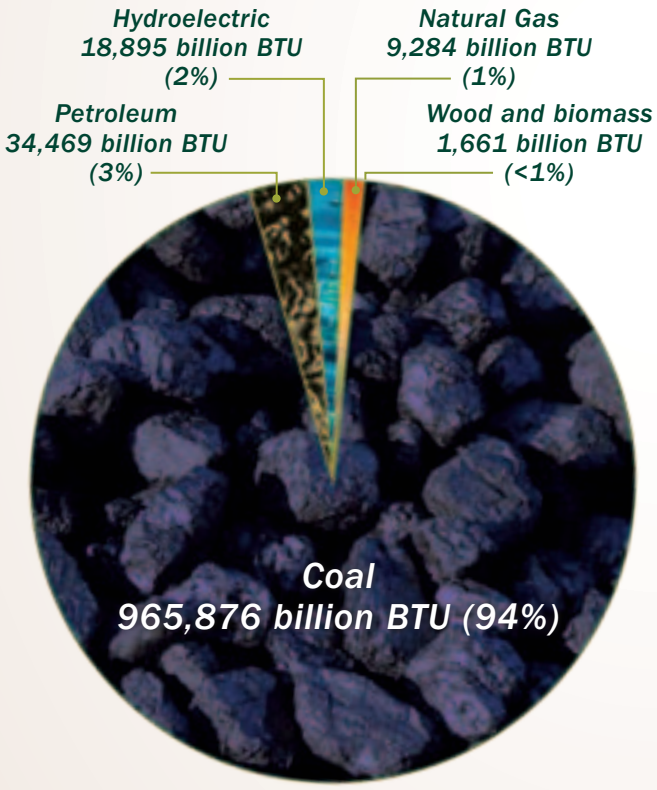
The HIA authors and reviewers intend for this document to serve as a tool for Kentucky legislators to weigh our energy policy options now and in the future, and for all Kentuckians to consider the impacts of energy decisions as if our health matters: because it does.

Health Impacts of Coal Mining

Coal based energy production has long been integrated into the economics, culture and history of Kentucky. With 94% of the state's energy generated by coal, families have depended on coal mining jobs for sources of income to feed, house and support families. Energy derived from coal has aided in the growth and development of Kentucky and the U.S. The process of extracting coal from the Appalachian mountains and western coalfields, while financially beneficial to some, has had a direct impact on the health of Kentuckians, not only surface and deep miners, but also community members living in proximity to mining activities.

Kentucky Electric Power Sector Energy Consumption 2008[1]

TOTAL: 1,030,185 billion BTU (100%)



Research conducted within the Appalachian region indicates that people who merely live near mining activities face increased rates of illness and death.[2] Health outcomes include lung cancer,[3] heart, respiratory and kidney disease,[4] heart attacks,[5] cancer,[6] chronic obstructive pulmonary disease (COPD), high blood pressure,[7] low birth weight[8] and poorer health related quality of life.[9] Disease rates can also increase in direct correlation to tons of coal extracted from the region. A study found the odds for a hospitalization caused by COPD increased by 1% for every 1,462 tons of coal extracted and for hypertension increased 1% for every 1873 tons of coal extracted from a community.[10]

The cost of increased mortality from mining is high. One study revealed that, after controlling for other risks, 2,347 to 2,889 yearly excess deaths are associated with living in a coal mining area in Appalachia. Through calculations of the value of statistical life lost (a value that society places on an abstract human life) an estimated $10-13.4 billion is lost to society to these deaths annually.[11]

Mining communities face poorer health related quality of life (HRQOL), a measure designed to address the overall well being of a person beyond morbidity and mortality. Indices can include health risks and conditions, functional status, psychological health, social support, and socioeconomic status.[12] In addition, mining communities can experience a loss of social capital. One study associated this loss with a combination of depopulation as well as community-wide conflict that arose when an anti-union coal company bought out the union coal mine at which many in the community worked, challenging the union identity so engrained in the region.[13]

Education, an index of health related quality of life, also appears to be affected by the presence of coal mining activities. Children in counties with mining face poorer pass rates on standardized tests compared to non-coal mining counties. While rates in the study were associated with socioeconomic disadvantage, scores remained low after controlling for county high school education rates, percent of low-income students, percent of highly qualified teachers, number of students tested and county smoking rates.[14]

Surface and deep coal mining activities affect health through different exposure routes. Examining the specific health impacts of both types of mining processes is essential for mitigating the resulting effects.


(Photo credit: KFTC)

Health Impacts of Surface Mining

Kentuckians living near mountaintop mining (MTM) sites are exposed to a wide range of health risks. The mining process, which utilizes heavy explosives, creates large quantities of dust, a known respiratory irritant. Explosives including ammonium nitrate and fuel oil form toxic gasses including carbon monoxide (CO) and oxides of nitrogen (NOx). Carbon monoxide, an odorless, colorless gas that can cause asphyxiation and death, has been known to travel underground and poison area residents.[15] Explosives can also fracture water tables leading to the contamination of drinking water by heavy metals, acid mine drainage and methane gas. Area watersheds are also contaminated when "over burden," a byproduct from the explosions, is pushed into valleys and the headwaters of streams.[16] Exposed coal seams are harvested with heavy machinery and hauled away by dump trucks carrying up to 120,000 tons. While regulations require trucks to cover the coal, many do not, thus releasing dust and rocks along roadways farther from the mining site.[17]

Though state and federal regulations are established to minimize the impact of mining on surrounding communities, not all contaminants are contained on site. Contamination of air and water from mining activities may therefore serve as routes of exposure for a range of toxins leading to the poorer health observed in surface mining areas.

Studies on mountaintop mining communities have indicated increased poverty and mortality disparities,[18] birth defects,[19] chronic cardiovascular disease mortality,[20] higher rates of cancer[21] and poorer HRQOL.[22] Other health concerns include increased risk of flooding resulting from land being stripped of trees and vegetation.[23] Some communities have self-reported high numbers of gall bladder failure and tumors in eastern Kentucky[24, 25, 26] and cancer clusters have been observed where water quality has been degraded by mining.[27] Mining explosions have fractured foundations on homes and fly rock and boulders have crashed into homes causing structural damage and loss of life.[28] Such threats can also have a strong impact on psychological health inducing anxiety and fear.[29]

As of 2009, there were 249 licensed surface mines in operation in Kentucky,[30] with approximately 61,721 acres of valley fills covering over 1400 miles of streams.[31] Significant environmental degradation can impact the economic health of the region, an additional index of HRQOL. This may reduce opportunities for alternative industries including tourism which could boost economics and result in higher HRQOL indexes.

Heavy metals and acid mine drainage: concerns around water contamination

Surface mining contaminates watersheds through multiple routes. In the process of coal extraction, vast new surfaces of rocks are exposed to the sun and rain. Acid mine drainage (AMD) forms through the biological oxidation of metal sulfides in mines or mining waste heaps. When rain washes over the acidified exposed rocks, toxic elements can be released into the streams, groundwater and drinking water including arsenic, lead, aluminum, cadmium, selenium, manganese and copper. While some elements are essential for health in very small doses, all are toxic at a large dosage. The pH in streams directly impacted by mountaintop mining can reach as low as 3 (the acidity of a lemon) turning water orange or brown and eliminating aquatic life. Coal ash is sometimes used to neutralize the acid. This acidic environment can release the heavy metals bound within the ash causing them to leach out into the environment.[32]

Research by Lindberg and colleagues measured concentrations of major and trace elements within a watershed catchment covering 100 mining discharge outlets and approximately 28km of active and reclaimed surface coal mines on the Upper Mud River of West Virginia. A linear relationship was observed between contributions of run off from surface mining sites and increases in conductivity and the concentrations of selenium, sulfate, magnesium and other inorganic solutes. The results of the study reveal the cumulative impacts of multiple surface mining sites on the region's watersheds.[33]

Beverly May displays contaminated drinking water from her house in Wilson Creek, KY

Many rural communities in Kentucky's mining regions are not connected to public water supplies and therefore depend on groundwater for basic water needs. Local residents have found, however, that when wells near mining sites are contaminated with heavy metals or gases, coal companies are resistant to provide compensation or remediation for this contamination.[34] Reasons include the limited capacity to determine direction of water flow within aquifers.

Erica Urias lives in a valley in Pike County, KY surrounded by mountaintop mining. Her husband's family had lived on the land for many years and had always had clean well water. As surface mining started above their home they started to observe a change in the water. When tested, one well contained levels of arsenic 130 times the EPA's maximum contamination level and another has turned orange from high levels of iron. "I bathed my daughter in the water with high levels of arsenic for the first three years of her life and I worry what effect it may have had on her. We've stopped using

(Photo credit: KFTC)

The wells of four residents in Pike County, KY have been contaminated by mining activities with high levels of methane gas, sulfur and iron. Residents reported to local authorities in May of 2011 that the water would turn to black or orange, and burn the skin upon contact. Due to the high methane content the wells have been left to burn indefinitely. The families have received compensation through a settlement with the mining company but have continued to rely on bottled water for their source of clean drinking water.[37] Along with the psychological stress of the sounds of explosions beneath their homes, health concerns related to the contaminated water have included vomiting and hair falling out.[38]

that well and now depend completely on the well with orange water. It's all we have."

Poor water quality, including bad taste or color, can reduce an individuals desire to consume water. While research is limited in this area, concerns have been raised that decreased water consumption may lead to increased consumption of other liquids including high calorie soda, which in turn may contribute to Kentucky's growing obesity epidemic.[35] Bottled water consumption is slowly increasing in the U.S. The major driving factor of this increase is a concern over the safety of water. Purchasing bottled water adds an additional economic strain on household economies and adds to the municipal waste stream.[36]

Heavy metals potentially found in drinking water contaminated by coal mining practices and potential health effects from long-term exposure above the maximum contamination level (MCL) (unless specified as short-term) (EPA 2011)[39]

ANTIMONY	Potentially causes high blood cholesterol
ARSENIC	Potentially causes damage to the skin and circulatory system and an increased risk of cancer
BARIUM	Potentially causes increase in blood pressure
BERYLLIUM	Potentially causes intestinal lesions
CADMIUM	Kidney damage
COPPER	**Short term exposure:** Gastrointestinal distress **Long term exposure:** Liver or kidney damage
CHROMIUM	Allergic dermatitis
SELENIUM	Hair or fingernail loss; numbness in fingers or toes; circulatory problems
LEAD	Infants and children: Delays in physical or mental development; children could show slight deficits in attention span and learning abilities Adults: Kidney problems; high blood pressure
MERCURY (INORGANIC)	Kidney damage

Mountaintop Mining and Birth Defects

Increased rates of birth defects have been observed in Appalachian communities where mountain top removal mining methods are used. After controlling for socio-economic risks, smoking, level of education and other factors, mothers had a 26% higher risk of having a child with a birth defect than a mother living outside a mountain top mining community. Using National Center for Health Statistics natality files, the study evaluated live births in four Central Appalachian states between 1996 and 2003. Types of birth defects observed included circulatory/ respiratory, central nervous system, musculoskeletal, urogenital, gastrointestinal and 'other.' These defects became more pronounced in the latter time frame 2000-2003 suggesting that rates of birth defects will continue to increase as mountain top mining continues. Birth defect rates also increased the closer an individual lived to a mountain top mining site.[40]

Dust: a West Virginia Case Study

Dust and particulates produced by mining operations increase rates of respiratory problems. Studies exploring the link between mining dust and the health of children living or going to school near a mining site found that increased dust exposure can agitate asthma[41] and can lead to more trips to the doctor for respiratory consultations.[42] Marsh Fork Elementary in Raleigh County, West Virginia was formerly located 150 feet from a coal silo that loaded powdered coal onto trains. The school was also adjacent to a 1,849-acre surface mining site and 400 yards below a coal slurry impoundment.[43] Results from a health survey conducted by the organization Coal River Mountain Watch at the school revealed that:

- *"53 of the 60 households with children attending the school were found to have children with health problems. (88%)"*
- *"48 of these 53 households were found to have children with respiratory problems such as asthma and chronic bronchitis. (91%)"*
- *"43 of these 48 households that were found to have respiratory problems also complained of headaches, nausea, or just not feeling well at school, but better after being home for a while. (81%)"*
- *"22 of the 53 households with children found to have health problems also complained of conditions at the school that included either dust, coal dust, unusual smells, noise, or blasting from the coal mining site located behind and above the school. (41%)"[44]*

Concerns over the health of the children led to the engagement of the West Virginia Department of Education and Region III EPA. Tests by each institution produced varying results for the presence and toxicity of coal dust in the school, indicating a need for further research on the health impacts of mining operations. Funding was ultimately secured for the relocation of the school.

Flooding and accidents

Surface mining destroys forests and groundcover essential for rainwater absorption. With land stripped, water quickly washes off the mountainside carrying soil and causing destructive floods. These floods have been associated with damaged homes and roadways, caused injuries, deaths and contamination of water.[45] Research has shown a clear risk of increased flooding following mountain top mining and valley fill activity. Research by Phillips also discerned that flash flood activity in Eastern Kentucky previously blamed for large-scale variations in storm precipitation is likely not the main cause of the regions increased rates of flash flooding.[46]

(Photo credit: Shutterstock Images)

Home of the Pomeroy family hit by fly rock in Pike County, KY

(Photo credit: KFTC)

As mountain top mining sites are often developed alongside homes, the risk of mining accidents is not isolated to the mine. In August 2004, 3 year-old Jeremy Davidson was killed in his bed when a half-ton boulder, dislodged from a surface mining site in southwestern Virginia, rolled down a mountain and through the wall of his house. The boulder came to rest at the foot of his brother's bed. A bulldozer operator on Black Mountain had unknowingly dislodged the rock as he worked to widen a road.[47] In August 2009 explosions produced by the Austin Powder Company at the Frasier Creek Mine in Floyd County, KY released a large boulder that crashed into the bedroom of the Tussey family. While the Tusseys were not home, occurrence of such accidents indicate a threat to human life even in the presence of state and federal legislation.[48]

Psychological effects of mountaintop mining

Mountaintop mining activities can have negative psychological impacts on communities leading to poor HRQOL. People living near mountaintop mining sites are exposed to repeated loud explosions that come at irregular intervals. Heavy rains induce concerns of flooding or breaks in slurry impoundments.

"When we move, I don't want to live by a hill. I may be next."

— Zachary Davidson on fears of being crushed by a boulder similar to the one that killed his brother Jeremy.

"It's been horrible. The blasting caused so much shaking and rocking when I was standing in the bathroom the other day. If I hadn't been holding on to the basin, I believe I would have fallen over. I've been here 77 years, and I haven't seen anything like this. It ain't no fun living here anymore. It's a scary place."[47]

— Mary Crowe Pace of southwestern Virginia on living near a mountaintop mining site.

Tussey family home

(Photo credit: KFTC)

Communities observe a degraded environment and do not know what impact it will have on their health. Individuals observe high levels of black dust accumulating on their porches, their windshields and even inside their homes and are concerned about the black or brown water comes out of their faucets.

Scientific studies show that chronic stress, magnified by the random nature of the explosions, has numerous negative effects on health.[49, 50, 51] While limited scientific research has calculated the psychological impacts of these stressors in Kentucky, qualitative documentation indicates these issues impact citizens in mining communities of Appalachia.

Mountaintop Mining Health Impacts Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF HEALTH DETERMINANT'S IMPACT ON HEALTH
CONTAMINATED WATER	1. cancer 2. kidney disease 3. birth defects* 4. low birth weight* 5. tooth decay 6. increased mortality rates 7. gall bladder disease	Communities consuming well water near MTM sites	1. Hendryx (2010), Hitt (2010) 2. Hendryx (2009) 3. Ahern (2011) 4. Ahern (2010) 5. Loo (2003) 6. Hendryx (2008) 7. Neithercut (1989), Shukla (1998), Minton (2011)
CONTAMINATED AIR	1. respiratory disease 2. cardiovascular disease 3. birth defects* 4. low birth weight* 5. lung cancer	Communities living near MTM sites, children, elderly, individuals with asthma and COPD	1. Hendryx (2009), Knuth (2010), Brabin (1994) 2. Hendryx (2009), Esch (2011) 3. Ahern (2011) 4. Ahern (2010) 5. Hendryx (2008)
DEGRADED LIVING ENVIRONMENT	1. poorer quality of life 2. poorer test scores 3. increased health disparities	Communities living near MTM sites, school children	1. Zulig (2010, 2011) 2. Cain (2010) 3. Hendryx (2011)
FLOODING	1. loss of life 2. loss of property 3. injury	Communities living below MTM sites	1. Buchanan (2011) 2. Estep (2011) 3. Palmer (2010)
DETONATION OF EXPLOSIVES	1. psychological stress 2. loss of life 3. damage to housing 4. exposure to toxic gases 5. elimination of water sources through fracturing of water tables	Communities living near MTM sites	1. Nater (2011), Thoits (2010) 2. Morell (2005) 3. Cooper (2009) 4. Mainiero (2007) 5. Withrow (2011)

*potential cause

Health Impacts of Deep Coal mining

Kentucky has the greatest number of deep coal mines in the country accounting for 28% of those in operation. This mining process, which takes place at depths between 250 to 1000 feet underground, has the highest rates of injury and death compared to all other types of mining.[53] The confined nature of the mining process exposes miners to high levels of dust, noise, heat and gasses leading to both acute and chronic health problems. Heart and lung disease, hearing loss, and neck and back strain are common among deep coal miners. [54, 55, 56, 57, 58, 59, 60]

This occupation also carries a high risk of death.[61] As of 2008 the fatality rate for deep mining was 24.8 deaths per 100,000 workers, nearly six times higher than the total private industry rate of 4.3.[62] The U.S. coal industry experienced 365 deaths between 2000 and 2010; 91 of these fatalities occurred in Kentucky.[63]

Health Impacts on Miners

INJURY. In 2009 the Mine Safety and Health Administration recorded 3,885 reports of coal mining injuries nationally.[64] Mining injuries frequently stem from falling objects, roof collapse, mechanical equipment, electric currents, or falls from equipment or an extended height. Muscle and tendon inflammation are common. Back strain contributed to 58,975 of the 230,139 days lost from work across the US in 2003.[65] A total of 5,847 injuries resulted from the mining industry in Kentucky between 2000 and 2009.[66]

RESPIRATORY DAMAGE. A miner's exposure to high levels of dust puts them at risk for a range of respiratory health problems. Concerns can include chronic obstructive pulmonary disease (COPD) including emphysema, coal worker's pneumoconiosis (CWP) also known as black lung, silicosis and progressive massive fibrosis (PMF).[67, 68, 69] Both silica and coal dust can lead to advanced pneumoconiosis. Silica dust, however, is more toxic to lungs than coal mine dust exposure, causing more rapid development of progressive massive fibrosis (PMF) a debilitating disease that can eventually lead to death.[70]

The National Institute for Occupational Safety and Health (NIOSH) observed in a 2011 report that the prevalence of black lung is increasing. The highest rates of increase are taking place in the central Appalachian region including Kentucky, Virginia, and southern West Virginia. While many issues may affect this shift, contributing factors may include excessive exposure to dust combined with longer work hours. In addition, as thicker seams run out, a transition by the industry to thinner coal seams with more rock intrusions may increase exposure to silica dust.[71]

Occupational dust exposure in coal mines has effects similar to the link between smoking and emphysema. The severity of a miner's emphysema can be predicted by the amount of coal dust to which they are exposed over the course of their career. Different regions of a mine can also increase exposure to different types and quantities of dust. For example, roof bolters and drillers are exposed to higher levels of silica than are miners working only at the face of a seam. In contrast, miners working at the face of a seam may be exposed to chemical resins that may have a negative impact on respiratory health and lung function.[72]

Interestingly, small underground coal mines in the United States have higher rates of black lung and progressive massive fibrosis than other mines with more than 50 workers.[73] While this could indicate that smaller mines may have higher concentrations of dust, research is limited in this area.

HEARING DAMAGE. Coal mining operations utilize equipment with loud machinery in a confined space. Roof bolters can be exposed to excess of 95 dB for extensive periods of time. Hearing loss therefore accounts for 18% of all injuries reported to the National Institute for Occupational Safety and Health. NIOSH reports that approximately 50% of coal miners will experience some form of hearing loss by the age of 50 as opposed to only 9% of the general population.[74]

ACCIDENTS: FATALITIES AND INJURIES. Deep coal mining exposes workers to a range of life threatening circumstances. Mining releases methane, a gas that can cause asphyxiation through the displacement of oxygen. Methane, as well as suspended coal dust, can ignite and cause explosions leading to the collapse of a mine. Roof collapse is also a concern if bracing is insufficient.

Between 1900 and 2010, 104,722 coalmine workers were killed in over 500 U.S. underground coalmining disasters.[75] While the majority of these accidents took place in the early part of the 1900s, mining disasters continue to be a reality. Decline in the number of mining deaths may be associated with increased safety practices. However, other factors such as structural changes in the industry, mechanization, and decreased numbers of workers in the mine may also affect this number. Three disasters in 2006 led to the death of 19 miners including one killing

five people at the Darby Mine No. 1 in Holmes Mill, Kentucky. The 2010 disaster at the Upper Big Branch Mine in Montcoal, West Virginia lead to the death of 29 miners indicating that mining accidents remain a concern.[76]

Mining accidents involving multiple injuries or fatalities tend to receive more attention than individual accidents. However, within the last 30 years, most mining accidents have involved only one or two people. Kentucky had the second highest number of deaths in 2010 with seven (five underground, two surface mining) of the 48 deaths occurring in the nation. All of these accidents involved less than five people.[77]

Management of safety is determined by research, implementation of standards and surveillance. Breakdowns in this process lead to increased risk for miners. After three mining disasters in 2006 the National Mining Association identified a need for further research in rescue and escape training and communications, realistic training, professional emergency response and rescue capability, and development of a safety culture in mining organizations. A culture of disregard for safety measures such as the proper use of air monitors and curtains has lead to increased morbidity and mortality. While arguments against increased regulation include costs to the company, research indicates that improvements do not need to lead to a decline in productivity.[78]

Eddie Bostic began his career in coal in 1979 working for the Stump Coal Company while in his twenties. He got into the business because his father had worked in coal and he was always intrigued by the stories he told. Even though the work brought financial support, he also endured multiple injuries. He now has second stage black lung disease and joint problems. Several times he was involved in blowouts and collapses. "I witnessed several of my friends lose their lives and to this day have nightmares reliving all the tragic events. One of my fellow miners whose name was also Eddie perished due to electrocution. As he was leaving the mines to go on vacation with his family a coworker asked him to help repair some equipment. He walked back into the mine one last time and unfortunately did not walk back out."[79]

Coal miners have depended upon coal for sources of income to support families and maintain livelihoods. Eddie weighed the possibility of unemployment against resulting health impacts. "Despite all the things that have happened to me and all the things I have witnessed, when asked if I would do it all over again my answer is always a resounding yes."

Sam Buchanan, a former miner from Barbourville, Kentucky describes personal health impacts of working with coal:

"You always worried a little bit about breathing that dust and [about] rock falls. Quite a few get hurt. A couple get killed. Grandpa on my side of the family, he got busted up in a rock fall once or twice. He had black lung. Dad had black lung. On mom's side, her dad had black lung... I'd say it contributed to [his death]."

"It wears your joints...out all the time. The coal I worked you had to crawl. Seams [were] from seventeen to thirty inches. So you [were] all the time crawling a lot. You had to watch the roof belt, a piece of equipment that could tear you up, jerk you off it. Or getting crushed."[80]

Anonymous:

A Coal Miner's Daughter, Wife and Niece

"When my husband was injured, he had to be out of work. He had his neck broke, his chest broke, and his back broke... My husband's health is destroyed because of coal. My dad's health is destroyed because of coal. He and his family owns coal mines and has run coal mines all their life, but he is now sixty-two years old and has already had lung cancer and had half his lungs removed and is no longer able to work."

Numerous family members have been impacted by the coal mining industry including a number of uncles with black lung and emphysema. "My grandpa had the emphysema. He did not work in the coal mines, but they lived on the river bank and they burned coal their entire lives for heat. So the overall health effect of coal is damaging. But then in this area it is the only job that's available for most people to take care of their families. Without an education, it's all that is there for them. I am sure that if these men had the option to do something different they would do something different."

All Accidents with Five or More Fatalities, since 1970 in Kentucky Mine Safety and Health Administration.

YEAR	DAY	MINE	LOCATION	TYPE	DEATHS
2006	5/20	Darby Mine No. 1 Kentucky Darby LLC	Middlesboro, Harlan Co.	Explosion	5
1989	9/13	William Station No. 9 Mine Pyro Mining Co.	Wheatcroft, Union Co.	Explosion	10
1982	1/20	No. 1 Mine, RFH Coal Co.	Craynor, KY, Floyd Co.	Explosion	7
1981	12/07	No. 11 Mine, Adkins Coal Co.	Kite, KY, Knott Co.	Explosion	8
1970	12/30	Nos. 15 and 16 Mines, Finley Coal Co.	Hyden, KY, Leslie Co.	Explosion	38

TRENDS IN MINING SAFETY

Coal companies with high numbers of safety violations tend to have higher rates of injury and death. Metrics observing lost workdays can serve as indicators for levels of risk in a particular mine. Such trends should be observed by mine safety regulators in order to help reduce risk.[82]

Discrepancies exist in injury data collected from the Mining Safety and Health Administration (MSHA) database, the National Institute for Occupational Safety and Health (OSHA) and the Centers for Disease and Control (CDC) regarding disease and illness in U.S. mining. These inconsistencies may be related to a worker's fear of losing his or her job, health insurance, or other job related benefits contributing to under reporting.[83]

Deep Mining Health Impacts Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF HEALTH DETERMINANT'S IMPACT ON HEALTH
Coal dust	1. Emphysema 2. Coal worker's pneumoconiosis (CWP) 3. Progressive massive fibrosis (PMF)	All miners	1. Kuempel (2009), 2. Bertrand (2007) 3. Attfield (2003) 4. Laney (2010)
Chemicals used in mining process: isocyanate, rueaformol, and formophenolic	1. Decreased lung function	Miners working at the face of the coal seam.	1. Bertrand (2007)
Roof drilling: noise	Hearing loss	Roof drillers	1. Peterson (2006) 2. Joy (2007)
Roof drilling: Production of silicate dust	1. Emphysema 2. Silicosis 3. Progressive massive fibrosis (PMF)	Roof drillers	1.Onder (2007)
Continuous mining machine: noise	Hearing loss	Miners working with continuous mining machines	1. Joy (2007)
Continuous mining machine: injury	Injury or death	Miners working with continuous mining machines	1. Solis (2009) 2. MSHA (2011)
Roof collapse	Injury or death	All miners	1. Solis (2009) 2. MSHA (2011)
Electric currents	Injury or death	Electricians, all miners	1. Solis (2009) 2. MSHA (2011)
Transport mining equipment	Injury or death	Equipment operators, all miners	1. Solis (2009) 2. MSHA (2011)
Trends of accidents associated with specific mines	Injury or death	All miners	1. Coleman (2007) 2. Laney (2010)
Major mining disasters	Injury or death	All miners	1. Attfield (2003) 2. Kowalski-Trakofler (2009)

Health Impacts of Coal Slurry

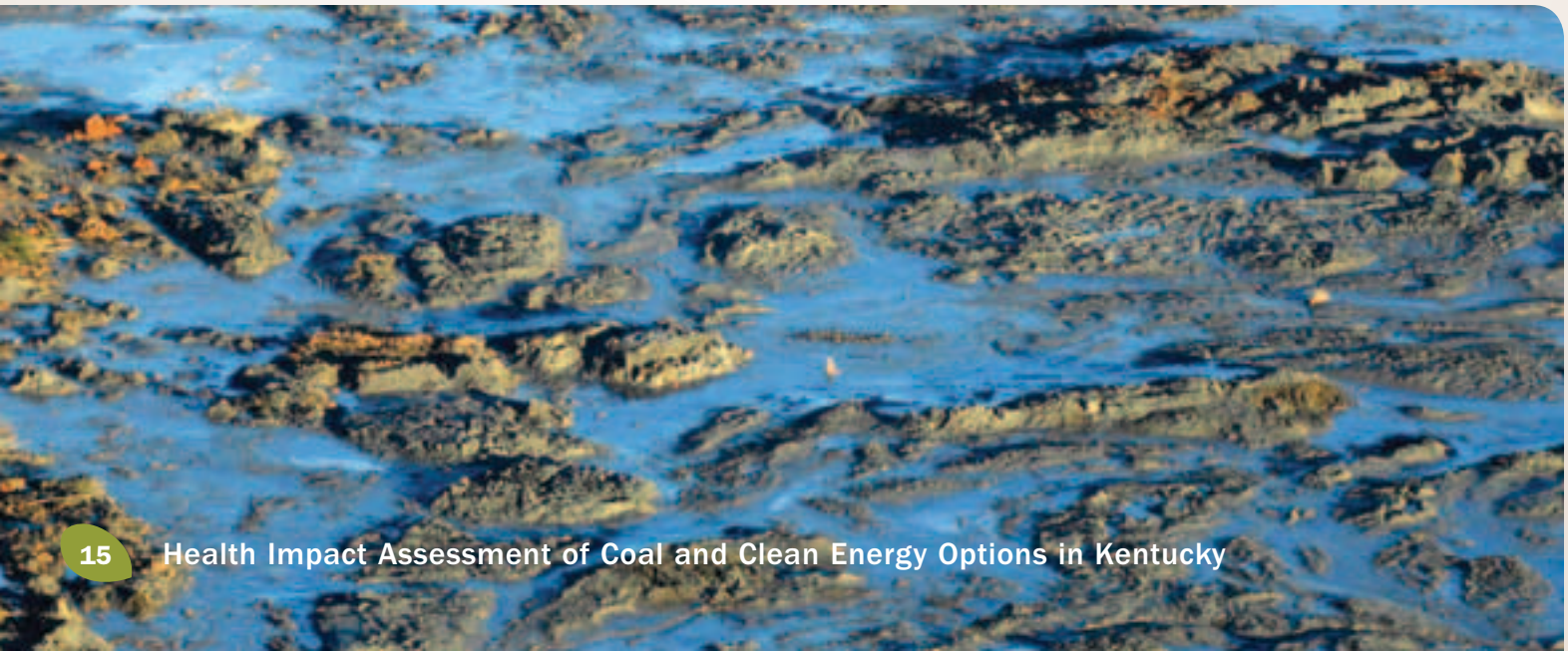
After coal is extracted, using either deep or surface mining, it is cleaned with a chemical wash (flocculent) to help waste particles coagulate. Waste material from this washing is called "slurry" and is made up of coal dust and mineral matter, as well as the washing materials. The composition of many flocculants is typically unknown due to companies' concealed trade secrets. While limited research has been carried out on public health effects, some versions of the flocculent may contain residual acrylamide monomers. These monomers may have side effects including nerve damage, effects on the blood, increased risk of cancer and reproductive or fertility problems.[84] While the wash reduces the amount of toxic chemicals in coal from being released into the air, the compound that is left behind when coal is burned remains toxic. The slurry is then stored in impoundment ponds or injected underground into an abandoned mine. There are currently 115 slurry impoundments in Kentucky.[85]

The Agency for Toxic Substances and Disease Registry has tested wells in proximity of coal slurry impoundments in Mingo County, West Virginia and determined that they were a risk to public health due to contamination by mining activities.[86] Studies by Stout have also observed contamination of well water by heavy metals at ratios comparable to that found in coal slurry.[87] Coal slurry has been shown to affect the viability of liver cells,[88] can cause deformities in fish due to high levels of selenium,[89] and can contain high levels of manganese.[90] Manganese in drinking water may attract bacteria causing increased numbers of oral cavities.[91] This could be one of the many factors related to high rates of tooth decay in central Appalachia.

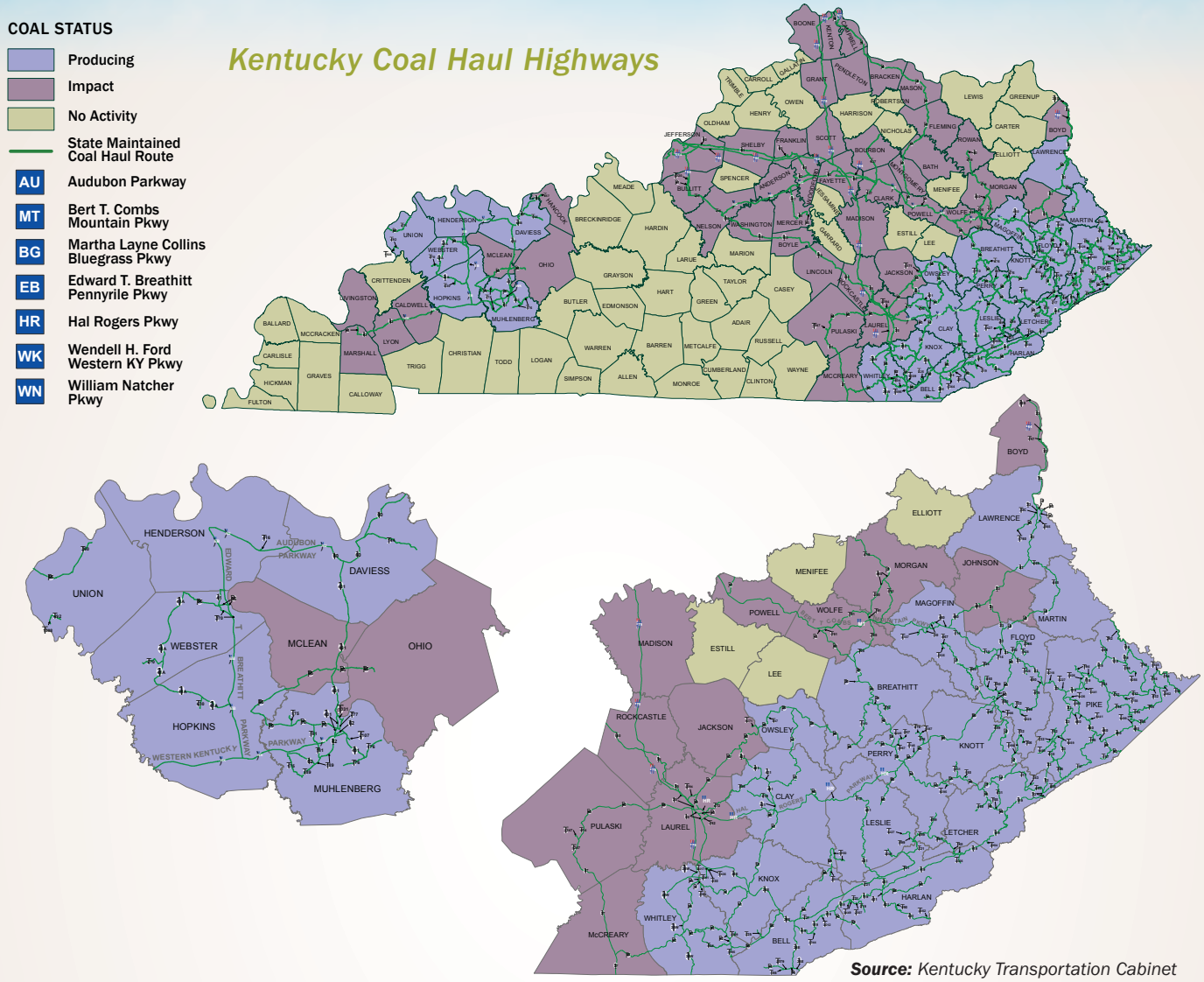
Health and life are at risk when impoundments are improperly maintained resulting in leaks or breaks. A major break at Buffalo Creek, WV in 1972, killed 125 people and injured hundreds more.[92] Over 300 million gallons of slurry were released into Kentucky's Tug Fork River in October 2000 after an impoundment, sitting on an old mine, broke through a mining shaft. The spill caused severe stream degradation and property damage. The Martin County spill covered over 75 miles of Kentucky waterways. Clean up costs exceeded 36 million dollars.[93, 94, 95] Risks of spills also include contamination of water sources with toxic metals and chemicals.

Coal Slurry Health Impacts Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF HEALTH DETERMINANT IMPACT OF HEALTH
Flocculants containing acrylamide	Nerve damage, effects on the blood, infertility, increased risk of cancer.	Workers handling slurry flocculent	EPA
Impoundment breakage/flooding	Risk of injury, death	Communities living below slurry impoundments	Martin County spill (2000)
Coal Slurry:Heavy metals, Chemical wash	1. Cancer, kidney disease 2. Liver disease	Community members consuming ground water near slurry impoundments	1. Stout (2004, 2009) 2. Bunnell (2008)



Health Impacts of Coal Processing and Transportation



Source: *Kentucky Transportation Cabinet*

After extraction and washing, coal is crushed to enable greater burning efficiency. It is then transported via truck, train and barge for use in power plants and other industrial operations. Each form of transport presents potential health impacts for both workers and the broader public including those caused by emissions, accidents and damage to infrastructure.

Approximately 3,700 miles of Kentucky's roads are used for transportation of coal by truck with just under one billion ton-miles reported moved in 2010.[96] Two thousand five hundred miles of railroad lines haul around 98 million tons of coal annually[97] and an additional 46 million tons of coal are transported by barge on Kentucky's 1,100 miles of navigable waterways.[98] Such extensive transportation produces high emissions of carbon dioxide, ozone and over 50,000 tons of PM10 (particulate matter greater than 10 microns).[99] Such quantities of pollution contribute to increased rates of asthma, lung cancer and concerns around cardiac health.[100], [101]

Rail transport of coal causes both occupational injuries and death. Between 2003 and 2009, 56 occupational deaths were associated specifically with the transportation of coal in the U.S.[102] In Kentucky, between 2001 and 2010, rail transport caused 137 fatalities and 1,175 nonfatal injuries.[103] With 47% of U.S. rail traffic tied to the transport of coal significant loss of life is associated with its movement across the country. This number does not include public fatalities and represents is only a fraction of lives impacted.[104] Epstein and colleagues estimated the cost of coal-based railroad accidents on the U.S. economy is $1.8 billion per year with approximately 246 U.S. lives lost annually.[105]

Truck transport of coal can result in significant community impacts. Overloading of coal trucks has led

to road and bridge damage from extreme truck weight, increasing potential for accidents.[106] In addition, trucks that fail to cover their coal can release cinders that break windshields of vehicles, reducing visibility and adding financial burden to the vehicle owner. Other community-based concerns include high levels of dust and noise. Rates of asthma in eastern Kentucky are high with an estimated 12 % of children and 10% of adults suffering from symptoms.[107] Increased exposures to dust can agitate the disease leading to asthma attacks.

People living along or near coal transportation roadways expressed concern about high levels of traffic and pedestrian safety where roadways do not have sidewalks. Parents may not permit children to play in areas that are risky therefore reducing outdoor activity time.[108] Decreases in physical activity can contribute to obesity, a significant health concern that affects 31% of the entire population in Kentucky.[109]

William Minton from Manchester KY, lives next to a coal processing plant. He feels "hammered" every day by the plant and the trucks that pass back and forth in front of his house. "In the end we sit covered in coal dust. My whole family has respiratory problems but I'm most concerned about my child. She's seven and is on eight medications. She can't be placed on any more medications. No part of the [coal] process is clean."

Minton says care for his daughter is expensive and often requires long drives to the doctor, up to 110 miles if they have to go to Louisville. "If my child was not covered by a medical card there is no way I could afford the medicines that she's on. To be honest I don't know how much money that the government is out just on my child alone. Because if she wasn't being smothered to death and been put in the position to be on all these medicines that's one less bill that the government would have to foot."

Coal Processing and Transportation Health Impacts Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF IMPACTS EFFECT ON HEALTH DETERMINANT
Processing of coal: Crushing	Asthma, respiratory irritation	Asthmatics, children,	Minton (2011)
Coal Transport by Truck: Accidents	Risk of injury or death	Truck drivers and community members	KFTC
Diesel emissions	1. Cancer 2. Cardiac death 3. Artherosclerosis (blood clots), 4. Constricted blood vessels 5. High blood pressure 6. Heart attacks 7. Stroke 8. Asthma 9. improper immune development in infants 10. Reduced birth weight neonatal mortality	Truck drivers and community members	1. Bhatia (1998) 2. Dockery (1993) 3. Brook (2010) 4. Brook (2002) 5. Brook (2009) 6. Peters (2001) Epstein (2011) 7. Wellenius (2005) 8. Khatri (2009) 9. Herr (2011) 10. Slama (2007), Lin (2004) Lacasaña (2005)
Dust	Asthma and other breathing concerns	Truck drivers and community members	Minton (2011), Nunn (2009)
Road damage	Risk of accidents and death	Truck drivers and community members	KFTC
Reduced pedestrian transport	Increased obesity	Kentuckians living in coal mining communities	Minton (2011)
Coal Transport by train: Accidents	Risk of injury and death	Train engineers, Kentuckians living along tracks	1. Bureau of Labor Statistics (2009) 2. Federal Railroad Administration (2011) 3. Epstein (2011)
Emissions	As above in coal truck emissions	Kentuckians living along train transport routes for coal	As above in coal truck emissions
Coal Transport by barge: Emissions	As above in coal truck emissions	Kentuckians living along water transport routes for coal	As above in coal truck emissions

Health impacts of Coal Power Plant Emissions

Once coal has been transported to an energy plant, it is pulverized into a fine powder and burned. This pulverized coal combustion (PCC) system burns coal to heat water in tubes around a furnace, creating steam. The steam turns turbines, which then turn electrical generators. Gasses and particulates from the burning coal are released through smoke stacks into the air. While PCC systems have been the standard in coal fired power plants, newer more efficient technologies include fluidized bed combustion, supercritical and ultrasupercritical technology, and integrated gasification combined cycle (IGCC). Kentucky has 56 operating coal-fired generating units at 21 locations totaling 16,510 megawatts (MW). Most of these still use the PCC system.[110]

Particulates

Gases and particulates released by burning coal can distribute up to hundreds of miles from the source. Emissions can affect the heart, lungs and nervous system, as well as damage prenatal development. According to research by ABT associates for the Clean Air Task Force, Kentucky experiences approximately 412 deaths, 286 hospitalizations and 539 heart attacks annually due to power plant pollution. Of the 350,000 sudden cardiac deaths in the US per year, 60,000 are related to particulate air pollution from coal-based electricity production.[111]

Pollutants with the greatest potential to harm human health include particulate matter smaller than 2.5 micrometers (PM2.5), nitrogen oxides (NOx), sulfur dioxide (SO2) and ozone (O3). Particulates damage the respiratory and circulatory systems and nitrogen oxides decrease lung function.[112] Ozone can irritate the respiratory system, inducing asthma attacks, and causing wheezing and shortness of breath.[113] Health impacts of SO2 include nasal inflammation, shortness of breath, wheezing, coughing, destabilized heart rhythms, asthma, low birth weight and increased risk of infant death. Sulfur oxides can also react with sunlight causing acid rain.[114, 115]

Eighty percent of US green house gas emissions are caused by energy-related carbon dioxide emissions.[116] In addition, 18% of the nation's NOx and 66% of SO2 came from the US power sector in 2008. Of the pollutants within this sector the majority of SO2 emissions (99%) and NOx (93%) emissions came from coal combusting electricity generators.[117]

CARDIOVASCULAR DISEASE. Particulate matter (PM) is the leading source of health concerns in coal based air pollution. PM in the form of dust or pollen is typically greater than 10 microns and can be expelled from our lungs through coughing. Particles produced through combustion are much smaller, at 2.5 microns or less (PM2.5) and can travel hundreds of miles before being inhaled deep into the lungs. Such particles can then enter the circulatory system causing damage through inflammation and oxidation.[118] This inflammatory process can constrict blood vessels[119] increasing blood pressure and lead to heart attacks, arrhythmia, stroke or even death.[120, 121, 122, 123] Long term exposure to PM can lead to the development of atherosclerosis, the build up of plaques in the arteries.[124]

Exposure to PM2.5 can trigger heart disease and arrhythmias in as little as a few hours to a few days. Cases such as Donora, Pennsylvania (October 27-30, 1948), and the "London Fog" (December 5-9, 1952) provide clear examples of the health impacts of coal-based air pollution. Mortality rates reached 6 and 9 times higher than normal respectively during the episodes when air pollution from coal burning stoves in homes, and zinc, iron, steel and electrical industries built up in the local atmosphere. Further research has found that those most at risk to short-term high levels of PM2.5 include elderly, those with existing heart disease and possibly diabetics.[125] Additional studies have found that for each 10 mg/m3 increase in long-term average PM2.5 there is an associated 6% risk of cardiopulmonary mortality.[126]

The EPA believes there is no safe level of PM2.5. It is, however, considered a modifiable factor that contributes to cardiovascular morbidity and mortality. Increased exposure leads to higher rates of mortality and morbidity while decreased levels of exposure lead to reductions in mortality and morbidity.[127]

ASTHMA. Approximately one in 10 Kentuckians suffer from asthma.[128] Power plant emissions including PM, SO2, NOx and the associated ozone produced by exposure to sunlight can all contribute to increased rates of asthma attacks.[129] Currently 3,331,201 individuals in Kentucky live within 30 miles of a power plant. This includes 811,993 children, 44,158 of whom are asthmatic.[130] Kentucky's children, particularly those of color, experience the highest rates of asthma. Asthma rates reach as high as 22% for African American high school students.[131]

Health care for asthmatics is expensive. In 2002 Kentucky hospitals saw over 7,150 asthma patients with expenses averaging $6053.[132] In 2007, 6,235 Kentuckians were hospitalized for asthma costing $62,231,688.33 in health care. Of the 883,525 people enrolled in Kentucky's Medicaid program, 81,431 (9.2%) received asthma related services in 2006. An average of 50 deaths (1.2 per 100,000) occur annually in Kentucky with asthma listed as the primary cause.[133] A decrease in levels of particulate matter can help prevent asthma attacks and the amount of money spent on treatment.

PRENATAL DEVELOPMENT. Air pollution, including PM2.5 can affect the health and development of a fetus. Mothers exposed to elevated levels of air pollution can incur increased risk of preterm birth and the fetus may experience improper immune development[134] and reduced birth weight.[135, 136] For example, a study in the Utah valley found that mothers delivering babies during the time a coal-burning steel plant was closed had fewer preterm births. When the steel plant restarted operation, preterm births increased.[137] Research in Tongliang, China determined through cord blood testing for polycyclic aromatic hydrocarbons, lead, and mercury that exposure to pollutants from the local power plant adversely affected the development of children in motor, adaptive, language and social areas.[138] A meta-analysis, culminating research from multiple studies, concluded that for each 10 ug/m3 increase in PM10 was associated with a 22% increase in respiratory post-neonatal mortality.[139] As Kentucky experiences high rates of air pollution from power plants, such evidence warrants concern for the health of Kentucky's unborn children.

Annual benefit estimates of Title IV 1990 Clean Air Act Amendments for 2010

AVOIDED HEALTH EFFECTS	# OF CASES AVOIDED	MONETARY VALUE (MILLIONS)
Mortality (adults)	17,000	$100,169
Chronic bronchitis (adults)	10,400	$4056
Nonfatal heart attacks (adults)	22,800	$1917
Respiratory hospital admissions (all ages)	8,300	$123
Emergency room visits for asthma (children)	14,100	$4

Reductions in air pollution caused by legislation

Quality legislation can help reduce the impacts of coal-based air pollution. Title IV of the Clean Air Act Amendments (CAAA), also known as the Acid Rain Program, was established in 1990 to reduce power plant emissions of sulfur dioxide (SO2) and nitrogen oxides (NOx), precursors to acid rain. A review determined that ultimately costs were less than predicted with financial benefits associated with protection of human health and the environment far exceeding those planned. The cap and trade method proposed a cap of 8.95 million tons of SO2 , half the amount emitted by power plants in 1980.

The highest concentrations of ozone from coal combustion energy plants in the US lie across Kentucky and Tennessee. Nationally, estimated total value of health benefits for reductions in ozone due to Title IV for 2010 was about $4 billion. Ninety percent of this was associated with reductions in mortality. This included $59 million saved on potentially lost school days, $22 million to lost work days, $14 million on respiratory hospital admissions under the age of 2 and $27 million for admissions over the age of 65. [140] In its Transport Rule the U.S. EPA proposal estimates that reductions in power plant air pollution will prevent the deaths of 14,000 to 36,000 people annually starting in 2014. [141]

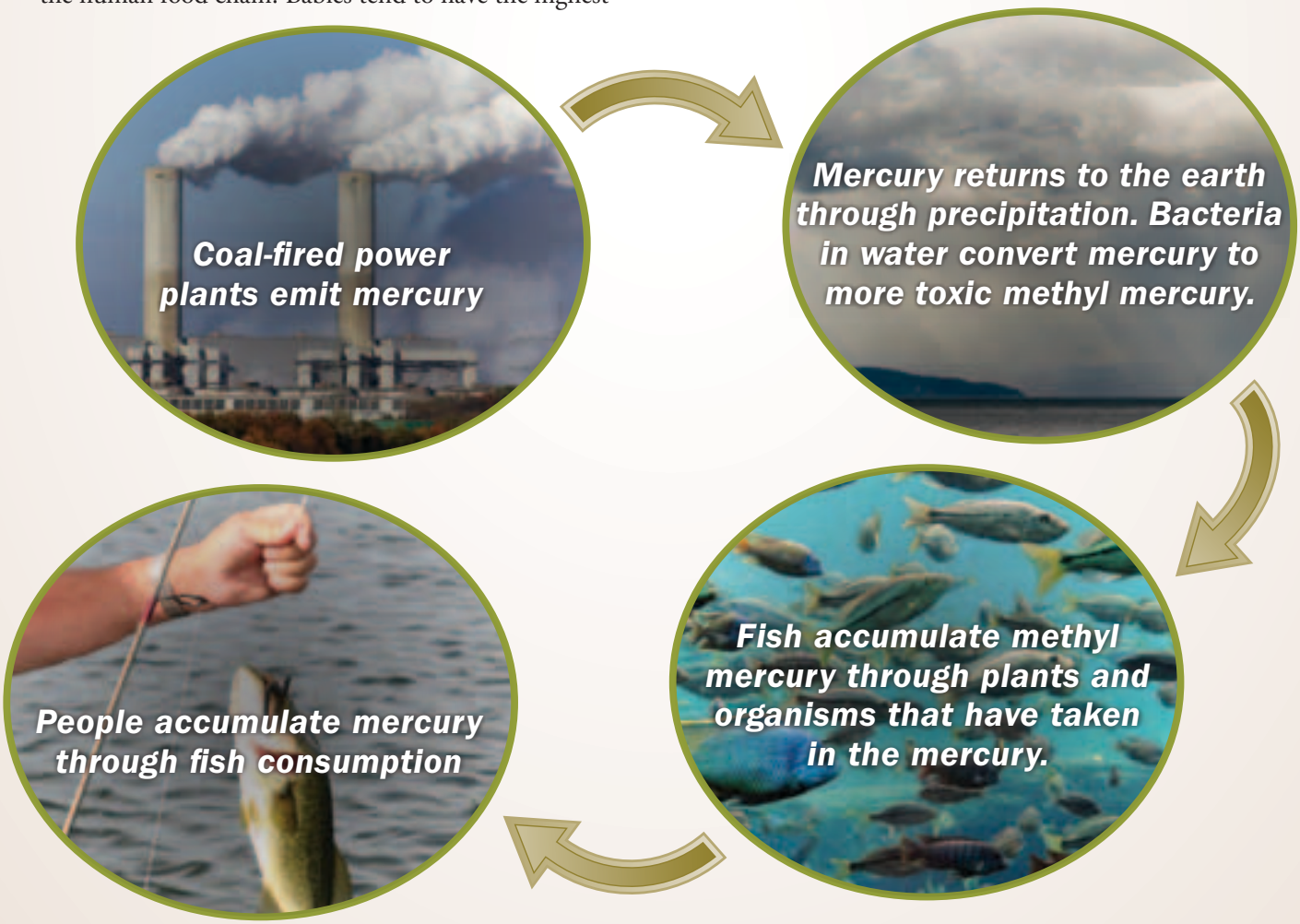
Studies indicate that creating good policy around air pollution can save lives and protect public health. Research by Rayens and colleagues observed reductions in asthma related emergency department visits after the implementation of a smoke free law in public places in Lexington, KY.[142] A study by Khudar and colleagues also found positive health outcomes through the smoking ban with reductions in hospital admissions for coronary heart disease.[143] Just as the smoking ban reduced indoor air pollution, policies for reductions in emissions of coal-based energy would create healthier air for Kentuckians.

Mercury emissions

Coal-fired power plants contribute to one third of man-made sources of mercury in the environment.[144] Mercury, a mineral toxic even at low dosages, is a natural component of coal and is released into the air as coal is burned. As rain falls, the mercury ends up in streams, rivers, lakes and oceans, where bacteria convert the elemental mercury into methyl mercury, a form much more harmful to life. The mercury in this more dangerous form works its way up the food chain from the bacteria into water plants, through small invertebrates, to small and then bigger fish. At each step the mercury is concentrated in the organism, leading to much higher concentrations in larger fish. When humans consume the fish, their bodies again concentrate the mercury.

Mercury is most harmful to the developing nervous system. Pregnant women, breastfeeding women and children should limit consumption of fish with potentially high levels of mercury. Because the physiological processes of pregnancy and lactation concentrate levels of mercury, babies are at the top of the human food chain. Babies tend to have the highest levels of mercury in their bodies at a time when they are most vulnerable to its harmful effects. Due to these vulnerabilities, there is currently a fish consumption advisory on every body of water in Kentucky recommending pregnant women consume no more than one fish per week from Kentucky waters.[145]

Renzoni and colleagues report that additional effects of mercury on the nervous system include tremors, impaired vision and hearing, paralysis, insomnia, emotional stability, developmental deficits during fetal development and attention deficit and developmental delays during childhood.[146] Mercury contamination in infants, even in small doses can cause disabilities including blindness, deafness, cerebral palsy, speech problems and mental retardation.[147] High mercury levels in humans may also lead to increased rates of cardiovascular disease and cancer.[148] Research by Trasande and colleagues estimated that, in the U.S., between 316,588 and 631,233 children are born each year with blood mercury levels high enough to impair performance on neurodevelopmental tests.[149] This ultimately comes with a high economic impact on society.



Power Plant Emissions Health Impact Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF HEALTH DETERMINANT IMPACT ON HEALTH
PM2.5	1. Cardiac death 2. Damaged respiratory system 3. Artherosclerosis (blood clots), 4. Constricted blood vessels 5. High blood pressure 6. Heart attacks 7. Stroke 8. Asthma 9. Improper immune development in infants 10. Reduced birth weight 11. Neonatal mortality	Elderly, Those with existing heart problems, Pregnant mothers, Diabetics (Brook 2008), Asthmatics	1. CATF (2010), Dockery (1993) 2. Lockwood (2009) 3. Brook (2010) 4. Brook (2002) 5. Brook (2009) 6. Peters (2001) 7. Wellenius (2005) 8. Khatri (2009) 9. Herr (2011) 10. Slama (2007), Lin (2004) 11. Lacasaña (2005)
Ozone (O_3)	Asthma attacks, Wheezing, Shortness of breath	Children, elderly, people with asthma or other respiratory disease, people who exercise outdoors.	1. Lockwood (2009) 2. Ji (2011) 3. EPA
Nitrogen Oxides (NO_x)	Decreased lung function and Lung disease	Elderly, children, people with asthma	1. Lockwood (2009) 2. EPA
Sulfur Dioxide (SO_2)	Nasal inflammation, shortness of breath, wheezing, coughing, destabilized heart rhythms, asthma, low birth weight and increased risk of infant death	children, people with asthma	1. Lockwood (2009) 2. EPA
Mercury (Hg)	1. Tremors, impaired vision and hearing, paralysis, insomnia, emotionally stability, developmental deficits during fetal development, and attention deficit and developmental delays during childhood 2. Cerebral palsy, speech problems and mental retardation 3. Increased rates of cardiovascular disease and cancer 4. Impaired performance on neurodevelopmental tests		1. Renzoni (1998) 2. Davis (2002) 3. Risher (2002) 4. Trasande (2005), Tang (2008)

Health Impacts of Greenhouse Gas Emissions

Coal based energy, through mining and burning, produces carbon dioxide, methane and other "greenhouse gases," so named because these gases, in the atmosphere, trap in solar heat, creating greenhouse-like warming on the planet. The burning of coal is the largest current source of carbon dioxide, producing approximately one-third of current U.S. CO2 output.[150] About 6% of current methane emissions are the result of coal mining.[151]

As the planet continues to warm, greater fluctuations occur in weather patterns. Kentucky will not be exempt from more extreme temperatures, droughts and floods. Higher temperatures in the summer mean that outdoor workers and athletes may experience higher rates of heat stroke.[152] Globally, the planet is also experiencing melting glaciers, higher sea levels and loss of coastal land. All have direct effects on human health, including an increase in deaths from heat strokes, flooding, malnutrition and water- and insect-borne illness such as diarrhea, Lyme disease and malaria.[153, 154, 155] Drought can cause loss of crops and resulting hunger. Major U.S. storms in the past 10 years have caused significant injuries and loss of life. The World Health Organization has estimated that 160,000 people died and many more were made ill in the year 2000 as a direct result of climate change.[156] Knowlton and colleagues have accounted for about $14 billion in health care costs associated with six climate change events between 2000 and 2009. The majority (95%) of these costs are due to the value of lives lost prematurely.[157] This number may continue to grow as greenhouse gases increase each year.

Carbon sequestration, a process of capturing and storing CO2 emissions underground, has been considered as a measure to reduce this green house gas. Concerns, however, have been raised regarding the effectiveness of the method and the feasibility of long-term storage. If stored in saline environments, CO2 can acidify the water, killing aquatic life.[158] Other health concerns lie in the fact that concentrated carbon dioxide can itself be a health hazard if released suddenly.[159] Prevention of the need for CO2 capture is currently more affordable than construction of carbon capture systems.

Greenhouse Gas Emissions Health Impacts Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF HEALTH DETERMINANT IMPACT ON HEALTH
Shifts in weather patterns: Extreme heat	Heat stroke	The young, the elderly, those working out doors, atheletes, those without cooling systems, all Kentuckians	Patz (2005), Yard (2010), Knowlton (2011)
Increased flooding	Injury, loss of life, loss of property	Those living in flood zones	Patz (2005), Haines 2006, Knowlton (2011)
Increased drought	Loss of crops, decreased food security	Farmers, all Kentuckians	Patz (2005), Haines 2006, Knowlton (2011)
Increased global temperature: Flooding	Injury, loss of life, loss of property	Those living at sea level	Patz (2005), Haines 2006, Knowlton (2011)
Expansion of vector habitat	Increased cases of malaria, Lyme disease	Individuals in vector's expanded habitat.	Patz (2005), Haines 2006, Mohammed (2011), Brownstein (2005)

Health Impacts of Coal Combustion Waste

Coal ash, or coal combustion waste, is the byproduct of burning coal for electricity generation or industrial use. Types of ash include boiler slag, bottom ash and fly ash. Each contains varying levels of silicates, calcium and heavy metals. Individuals in the coal ash recycling industry believe that the substance is inert and does not pose a health risk.[160] However, because the presence of toxic metals such as arsenic, selenium and cadmium depend on the composition of the coal source, one cannot determine if a sample is toxic without individual testing.

Power plants in the U.S. produce about 130 million tons of coal ash annually much of which is stored in 431 wet impoundments. Kentucky's plants produce over nine million tons of coal combustion waste, ranking the state 5th highest in the nation for ash generation.[161] A significant portion of this waste is stored in 43 wet impoundment ponds or dry landfills across the state.[162]

As coal ash is currently not legislated as a toxic waste, monitoring of coal ash disposal sites has been limited. Monitoring near unlined ponds in Kentucky has not been mandated even when there has been evidence of toxic metals releases.[163] Within the U.S. the EPA has indentified 63 "proven and potential" damage cases where drinking water, wet-lands, creeks or rivers have been contaminated by coal ash toxins.[164] Earthjustice and the Environmental Integrity Project, through monitoring and available state data, have identified 90 cases of coal ash based contamination. Four of these sites are present in Kentucky including Louisville Gas & Electric's (LG&E) Mill Creek Plant owned by E.ON U.S., the Tennessee Valley Authority's (TVA) Shawnee Fossil Plant in Paducah and Eastern Kentucky Power Cooperative's Spurlock Station in Maysville[165] and the TVA's Paradise Fossil Plant near Paradise, KY.[166]

The Spurlock Station plant had samples with arsenic that exceeded the EPA's maximum contaminant level (MCL) for safe drinking water by 16 times, 3.5 times for the Secondary MCL (SMCL) for sulfate, 11 times the SMCL for iron, and total dissolved solids (TDS) 4 times the SMCL. The Mill Creek Plant, 15 miles south of Louisville had groundwater that had been contaminated with arsenic at 1.5 times the federal MCL. Contaminants in the alluvial aquifer of the Shawnee Fossil Plant included selenium at concentrations almost twice the federal Maximum Contaminant Level (MCL), arsenic slightly exceeding the MCL, boron up to 2.5 times higher than the EPA Lifetime Health Advisory Level, total dissolved solids up to 4 times the Secondary MCL(SMCL), and sulfate up to 5.6 times the SMCL. At the Paradise Fossil Plant manganese was 203 times the Lifetime Health Advisory Level.

Additional ground water monitoring data available for eight different coal ash storage sites in Kentucky taken by the state and retrieved by Quarles and colleagues revealed that all eight were contaminated.[167]

The toxic compositions of coal ash can have a range of health affects on Kentucky's citizens. Effects can include increased risk of cancer, delayed mental development, reduced cognition and focus, and intestinal irritation. Heavy metals can contaminate the communities surrounding coal ash impoundments by leaching out of unlined ponds into local water supplies or blowing through the air in the form of fine particles and dust.[168] Coal fly ash less than 2.5 microns has been shown to increase inflammation in the lungs of mice particularly with increased sulfur and trace element content.[169] Significant concern persists for those consuming water from sources near coal ash impoundments.

Storage of coal ash in poorly maintained impoundments also poses threats to human life. In December 2008, the embankment of a coal ash pond at Tennessee Valley Authority's Kingston Fossil plant broke spilling 5.4 million cubic yards of coal combustion waste and released high levels of lead and thallium that can cause birth defects and nervous and reproductive system disorders if consumed through untreated well water.[170]

(Photo credit: Thomas Pearce)

EPA Identified High Hazard Coal Ash Impoundments in Kentucky

COMPANY	FACILITY NAME	UNIT NAME	CITY
Kentucky Utilities	E W Brown	Auxiliary Pond	Harrodsburg, KY
Kentucky Utilities	E W Brown	Ash Pond	Harrodsburg, KY
Kentucky Utilities	Ghent	Gypsum Stacking Facility	Ghent, KY
Kentucky Utilities	Ghent	Ash Pond Basin 1	Ghent, KY
Kentucky Utilities	Ghent	Ash Pond Basin 2	Ghent, KY
Louisville Electric	Cane Run	Ash Pond	Louisville, KY

In Kentucky, six impoundments near the communities of Louisa, Harrodsburg, Ghent and Louisville are currently considered "high hazard" which means an accidental release could cause significant loss of life.[171]

Approximately 40% of the coal ash produced in the U.S. is used for secondary purposes. These include concrete, filler in asphalt, snow and ice control, roofing granules, drywall, and soil modification. Coal ash, an alkaline substance, is also used to neutralize acid mine drainage from abandoned mining sites.[172] Coal ash confined in products such as concrete may produce less risk to the general public than ash that is spread loosely into the environment as road grit. However, when coal ash is utilized in this way there is frequently no record kept of its location. Coal ash in products such as concrete and dry wall may still expose constructions workers to unknown levels of contaminants.

Classification of coal ash is currently under consideration by the EPA. Subtitle C of the "Clean water Act" would classify coal ash as a toxic substance and would require stronger regulation and documentation by the state. A second option, Subtitle D would make recommendations to the state but not enforce regulations on the management of ash. While stronger regulations would require a greater investment from energy companies, there would be greater assurance of the protection of Kentucky's public health.

Coal Combustion Waste Health Impacts Summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	POPULATION AT RISK	EVIDENCE OF HEALTH DETERMINANT IMPACT ON HEALTH
Leaching of heavy metals from storage impoundments, land fills and secondary uses such as fill, road grit and acid mine drainage neutralization	Increased risk of cancer, delayed mental development, reduced cognition and focus, intestinal irritation, other illnesses related to heavy metal exposure	Communities consuming water near coal ash storage and disposal sites	Stant (2010), Quarles (2010), EPA
Coal ash particulates	Inflammation of the lungs (observed in mice)	Individuals living near coal ash landfills	Gilmore (2004)
Exposure to coal ash via construction materials such as dry wall board and concrete	Unknown	Construction workers	Unknown
Risk of flooding	Potential loss of life, damage to property, Psychological stress	Communities living below coal ash impoundments	T.V.A. coal ash spill, Tennessee (2008), We Energies coal ash spill, Wisconsin (2011)

Coal ash storage units like the ones found at LG&E's Cane Run plant near Louisville, Kentucky have raised concerns for neighboring communities when dust clouds blow off of the plant. The Metro Air Pollution Control District responded to these concerns in November 2011 with a notice of violation and a possible fine of $26,000 for repeatedly disregarding city regulations. The violations include 1) six incidents throughout June, July and August in which clouds of fly ash rose from its sludge processing plant, causing "nuisance and annoyance to the residents"; 2) three incidents in July where LG&E "failed to take precautions to prevent particulate matter from becoming airborne beyond the work site"; and 3) four incidents in August in which they failed to report "excess particulate emissions" from the plant. In August of 2011, newly washed homes tested positive for coal ash. These samples were not, however, mentioned in the notice of violation. [173]

Kathy Little lives in a subdivision near LG&E's Cane Run power plant near Louisville, KY. The plant currently stores its coal ash and scrubber sludge in a landfill that accumulates about 650,000 pounds of ash a year. Little is concerned about the health of citizens in her community due to fugitive dust that blows off the top of the ash pile. She estimates that about 300-400 individuals live near the plant, many of them renting in trailer parks. When it comes to addressing concerns around emissions and dust from the plant they've been told that they don't count because they don't own the property. "It's a human rights issue and nobody seems to care," Little says.

One mother near the plant took her son to an allergist for his persistent respiratory problems. The doctor told her she had to move. "You can't live over there with him." The mother is single with limited resources and had just purchased the trailer. "I can't move right now. I can't afford to move right now," she responded. "You don't know how bad that makes me feel to be a mother causing my child to be ill." [174]

Health Impacts of Energy Efficiency and Renewable Energies

Shifting Kentucky's energy portfolio to include diversified renewable sources and better utilization of energy efficiency measures may help alleviate Kentucky's health problems. However no energy source is completely benign.

Solar

Solar energy most commonly involves harvesting the power of the sun to generate electricity for general consumption or to heat water. As of Autumn 2011, there were roughly 3 to 5MW of installed solar generation in Kentucky, including commercial, residential and institution (schools, universities) systems. Solar energy systems can be stand-alone off the grid in which excess energy is stored in a battery, or tied to the electricity grid.

Raw materials required for solar panel manufacturing, similar to that of the microelectronics and steel industries, include silica and a range of metals. Silica mining carries hazards also associated with other mining processes. For example, production of silica dust has been associated with silicosis, a severe lung disease. Particulate matter from silicon dust during solar panel manufacturing can also pose a risk of respiratory irritation to workers. The U.S. Occupational Safety and Health Administration (OSHA) sets exposure standards for particulates and notes that dust mitigation practices and use of respirators or masks can reduce worker illness.[175] The manufacturing process uses various forms of crystallized silica and silane gas, an explosive gas,[176] and other emissions including acetone and ammonia,[177] which can pose a hazard to workers and communities living near manufacturing facilities. A wide range of chemicals, ubiquitous in manufacturing processes in the U.S. and overseas, is used in the solar panel industry. Chemicals include sodium hydroxide, hydrochloric acid, sulfuric acid, nitric acid, and hydrogen fluoride, which may pose occupational risks to workers. Heavy metals including lead, cadmium, tellurium, nickel, arsenic and selenium compounds are also used in solar cell processing. While some of these elements are well-established carcinogens,[178] health hazard data is not available for some other chemical compounds associated with solar devices.

Panels themselves are manufactured all over the world, and one company, Alternative Energies Kentucky LLC, has opened a solar panel facility in Danville, Kentucky. Transportation of solar panels within the U.S. typically takes place by freight trucks, which pose similar threats to those related to other forms of petroleum-based transport.

Other occupational hazards are low. Certified technicians with training in electrical systems install solar panels. Panels are typically mounted on building roofs though they can also be pole-mounted on the ground. Grid-tied systems involve the transfer of electricity from the panels through an inverter that is attached to a building's main electrical system. When the electricity grid is "down," so is the power to the home even though the solar panels themselves are still functioning. However this does not create a risk for utility line workers because the inverters are designed to shut down automatically upon loss of utility supply.

Once installed, most solar panels carry a manufacturers warranty and have a life of 25 years or more. The solar process of electricity generation produces no pollution.

Health impacts from the end-of-life of solar panels are similar to that of other electronics waste. Toxic chemicals used in the manufacturing process can be released into the air, water and soil through land filling or inadequate recycling. The principles of Extended Producer Responsibility (EPR) encourage electronics companies to use least-toxic substitutes in the manufacturing process and to develop "take back" policies that allow products to be safely recycled. To date, 15 states have adopted some type of EPR standards Electronics that can apply to the life cycle of solar panels.[179]

Non-governmental organizations offer specific recommendations that would prevent health harm from the solar panel industry, including reducing use of toxic chemicals in the production and waste stream; ensuring that manufacturers follow EPR principles; testing new chemicals and technologies for health hazards; and designing products for easy recycling.[180]

Wind

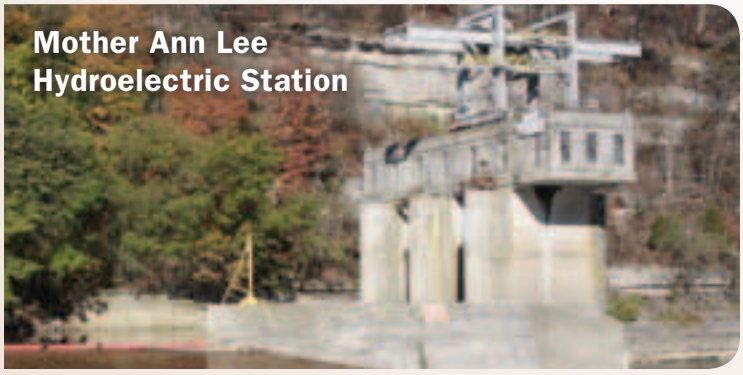
Wind energy potential is determined by wind speeds at specific geographic locations as well as by the height of the wind turbine, comprised of a tower, hub, blades, gearboxes and a generator. Earlier wind turbine heights topped at 80 meters, but utility-scale turbines can also have hub heights of 120 meters or more. The National Renewables Energy Laboratory and AWS Truewind determined in 2009 that wind energy potential in Kentucky could be nearly 50,000 megawatts for wind turbines with a 100-meter hub height.[181]

Turbine component parts are manufactured in the U.S. and overseas. Occupational health and safety impacts for wind turbines component parts are similar to that of other metals manufacturing processes. Once installed, wind turbines require occasional routine maintenance, and produce no pollution.

Wind turbines emit low frequency vibrations, low frequency noise from the gearbox and shadow flickers as the blade shadows move across the ground.[182] In a document called "Public Health Impacts of Wind Turbines," written to assess the impacts of proposed wind turbines in Minnesota, researchers examined variable human sensitivities to these low frequency disturbances and concluded that the health impacts are generally not a problem for businesses, public buildings or for people outdoors.[183] The National Research Council had in its 2007 study concluded that these disturbances are not a concern beyond a half-mile from the turbine site. Disturbances to nearby populations can be limited by attention to turbine siting.

Hydroelectricity

Kentucky rivers currently generate roughly 2,605 MWh of electricity through hydroelectric dams.[184] The National Renewables Energy Laboratory estimates that an additional 887 MW could be generated from existing small-scale hydro dams in Kentucky waterways.


Mother Ann Lee Hydroelectric Station

Hydroelectricity is the production of electrical power through the use of the gravitational force of falling or flowing water, through a hydraulic turbine that is connected to a generator. The water exits the turbine and is returned to a stream or riverbed below the dam. Once operating, occupational hazards are low as only routine mechanical maintenance is required.[185] Dams do not release pollution into the water or air and therefore have little to no impact on human health. Still, organizations such as the Low Impact Hydropower Institute offer voluntary certification of "low impact" hydro facilities, to encourage owners to minimize environmental impacts. In 2007 the Mother Ann Lee Hydroelectric Station on the Kentucky River received its Low Impact certification.[186]

Biomass

The Kentucky Governor's plan of 2008 pushes for tripled production of renewable energy by 2025.[187] While renewable sources in the proposal include hydro and solar, more than 50% would be comprised of bio-fuels such as wood and landfill gas. Like coal, burning biomass can produce particulates less than 2.5 microns, nitrogen oxides, and volatile organic compounds that increase smog and ozone. Health concerns are therefore similar to those produced by emissions of coal-based power plants.[188,189,190] National organizations such as the American Lung Association, American Cancer Society and the U.S. EPA's Clean Air Scientific advisory committee have articulated concern about the significant health impacts of fine particulate air pollution. Other concerns have been raised around the potential health effects of specific biomass sources. Wood products containing formaldehyde, chicken waste and switch grass may have varying levels of particulates and combusted by-products. Such concerns should be included with the development of Kentucky's energy portfolio.

Energy efficiency

Beyond production, Kentucky's energy use impacts the health of its citizens. Homes with poor efficiency are associated with a range of health concerns including higher rates of respiratory disease, lower HRQOL and more frequent trips to the doctor.[191,192] High energy use also has economic implications for many low income families. Costs of heating inefficient homes can exceed the cost of a mortgage or rent payment, creating tremendous financial burden.

Investments in energy efficiency and renewable energy can be healthy for Kentuckians. Studies indicate that insulating existing houses can lead to significantly warmer, drier indoor environments resulting in improved self-rated health, reduced wheezing, fewer days off school and work as well as fewer hospital admissions for respiratory conditions.[193,194] Energy efficient lighting in schools and workplaces improves safety, increases learning, and improves social interaction and physical health.[195] Weatherization programs also improve water and heating systems, which ultimately reduce the risk of fire.[196]

Energy efficient lighting

Utilizing natural lighting can offer physical and mental health benefits including less eye-strain. Energy efficient electric lighting also holds many health benefits including avoided unnecessary pollution from fossil fuels. Compact florescent lightbulbs (CFLs) can save as much as $6 a year in electricity costs and can save more than $40 over its lifetime.[197] In addition, research indicates that verbal-intellectual task performance and visual performance may be better under electronic ballasts than older, less efficient magnetic ballasts.[198]

CFLs contain a small amount of mercury that could be released into the environment if a bulb breaks. CFL manufacturers and the Environmental Protection Agency's Energy Star program offer guidelines for cleaning up and disposing of broken CFLs to limit the risk of human exposure to mercury. Overall, the health benefits of CFLs greatly outweigh the potential risks of mercury exposure. For example, the Environmental Protection Agency estimates that one 60 watt incandescent bulb results in 5.8 mg of mercury from electricity usage, while one 13 watt CFL results in only 1.6 mg of mercury.

Moreover, unbroken CFLs can be recycled. In Kentucky, many cities offer waste recycling services for CFLs and retail stories like Home Depot collect used bulbs for recycling regardless of where the bulbs were originally purchased.

Newer LED bulbs offer a step-up in energy efficiency and offer longer-term health benefits because they do not contain mercury. Currently LED bulbs carry a higher sticker price however the costs are dropping as demand increases.

Energy efficient construction materials

Construction materials vary widely in their health and carbon footprint, and the toxicity of some materials used for energy efficient retrofits may impact public health. For example, some insulation contains formaldehyde, which may leach out into homes.[199] Vinyl-clad windows and doors, often used to replace older wooden models, carry a higher health impact due to the presence of highly toxic polyvinyl chlorides (PVC). Noting the health impacts of PVC exposure in buildings, on November 2, 2011 the American Public Health Association passed a resolution calling on "decision-makers...to consider phasing out the use and purchase of flexible PVC in building materials...and facilities with vulnerable populations when cost-effective alternatives are available."[200]

These health impacts are those faced in any building. However, some impacts can be mitigated or avoided with energy efficient new construction, or renovations, when builders themselves, homeowners or landlords are informed about and utilize healthier materials. Kentucky small businesses such as the Bluegrass Green Company in Louisville provide non-toxic building materials as do larger hardware retail stores. Organizations such as the Healthy Building Network, through its Pharos database, provide access to comprehensive health and pollution screening data on a wide range of construction materials.[201] In addition, proper ventilation of homes on a new or newly weatherized home is essential. The Department of Energy's Weatherization Assistance Program (WAP) provides guidelines and requirements that all homes weatherized after January 1, 2012, must meet the most recent minimum ventilation standards. WAP guidelines also outline health and safety standards for workers and materials in order to limit accidents or exposures. In Kentucky, WAP requirements are implemented by the Kentucky Housing Corporation.

Marshall Porter, 23, from Elizabethtown, Kentucky-

"Back in 2004 we replaced our existing single pane windows with double pane argon windows. The original windows were difficult to open and were drafty. After having the new energy efficient windows installed we instantly noticed the energy savings as well as a difference in temperature control. Before we got the windows, in the summer the electric bills were sometimes over $200 but now it is rare to pay even $100. Replacing the windows was absolutely worth the investment, we save money all year round. I think it would be wonderful for people to have government assistance in energy saving efforts not only for the sake of saving energy but also because it can help improve the value of their homes and give them a better quality of life."

Home energy efficiency improves respiratory health

Improving energy efficiency can reduce air pollution and the associated illnesses and deaths.[202] Researchers in California estimated in 2006 that a state energy efficiency program to add fiberglass attic insulation to electricity-heated homes would result in a four-fold reduction in disease burden – a net avoidance of premature deaths from exposure to power plant soot – over the life of the insulation, even considering occupational health concerns associated with manufacturing the insulation. [203]

One study by Levy and colleagues found that upgrading insulation for approximately 46 million single family homes in the U.S. with poor or adequate insulation would save 800 BTU (8 × 1014 British Thermal Units). This would result in 3,100 fewer tons of PM2.5, 100,000 fewer tons of NOx, and 190,000 fewer tons of SO2 per year. The emission reductions would be associated with outcomes including 240 fewer deaths, 6,500 fewer asthma attacks, and 110,000 fewer restricted activity days per year. Corresponding health benefits include $1.3 billion in externalities averted and $5.9 billion in economic savings annually. [204]

Nishioka and colleagues determined the reductions in risk of illness and death tied to electricity production by installing high quality insulation (International Energy Conservation Code) in all new home construction. Sufficient insulation would lead to a national reduction of over 1000 tons of PM2.5, 30,000 tons of NOx and 40,000 tons of SO2 and would lead to 60 fewer deaths over a ten year time period. Adoption of a more stringent code of insulation for new homes in Kentucky would also lead to reductions of PM2.5, NOx and SOx. Out of all 50 states, improvement in insulation standards for Kentucky and West Virginia would lead to the greatest reduction in air pollution. This is due to the fact that many Kentucky homes use electric space heating with electricity provided by higher emitting power plants. Kentucky ranked third in this study for its potential to reduce the risk of mortality caused by power plant emissions. [205]

Good, efficient air ventilation also improves health. Individuals living in new homes with heat recovery ventilators reported improvements in respiratory health including throat irritation, cough and fatigue, over the course of one year compared to occupants in new homes without the efficiency modification.[206]

The "heat or eat dilemma"

Families in Kentucky can spend over $300-400 a month to heat poorly insulated houses or trailers.[207] This often leads to the "heat or eat" dilemma to which families must decide between paying their heating bill and having money to buy groceries. The financial burden can impact the nutrition of children and has been associated with higher rates of anemia. [208, 209] Families that spend a significant portion of their budget on housing costs also have increased psychological stress[210] and reduced resources to spend on medical care. State investments in energy efficiency could reduce this financial disparity freeing up funds to spend on more nutritious food. Programs that help improve the efficiency of homes also lead to fewer cut-offs and reconnection fees for delinquency.[211]

Jerry Workman is familiar with the association between energy bills and struggling to get by. As coordinator of the Berea Food Bank and Bereans United for Utility and Rent Relief (BUURR), Workman helps alleviate the burden of energy bills and buying groceries by providing partial assistance with rent, utilities, and groceries to families in need. It makes sense that these two organization work closely together, because as Workman notes, "Most of the time when people are having trouble with their utilities, they're also having trouble with food. Food is energy. There is an intermarriage between the food bank and BUURR, because most of the time when people are talking about utilities, they're also talking about food." When families fall on hard times, they are forced to prioritize their spending, creating some difficult decisions. In 2011, Workman had seen 97 of those families come to BUURR for help with their bills and 536 of those families at the Food Bank. The average amount that BUURR distributed to a family was $97.32. He shared the hardships of his community through raw data, "There have been 750 visits, which means that many families have been here more than once. Of the families that have been in so far this year, 36% have never been to the food bank before. It's been a hard year."[212]

Building a healthy economy

Kentucky's lack of diversity in energy generation increases economic risk. Coal based electricity rates have increased as much as 30% from 2009 to 2011. While the U.S. Department of Energy estimates that Kentucky has approximately 14,480 million tons of estimated recoverable reserves,[213] the downward trend of coal production over the last 10 years may suggest that Kentucky has already peaked in financially viable coal.[214] The contribution of coal to the national energy mix is also expected to decline from 45 to 43%. In addition, coal mined from the Appalachian region is expected to increase in price leading to a decrease in production and a stronger dependence on coal from the Powder River Basin. Such trends suggest that diversifying Kentucky's energy economy would improve the economic health of the region.[215]

Projections made by the U.S. Energy Information Administration predict that the renewable electricity sector will expand from 10 to 14% by 2035.[216] This shift will utilize sources such as wind and solar and could improve the health of 700,000 US workers and potentially eliminate 1,300 worker deaths over the coming decade by reducing risk in the energy extraction phase.[217] A new report by Synapse Energy Economics estimates that the Clean Energy Opportunity Act (HB 167) introduced in the 2012 Kentucky legislative session could create over 28,000 jobs for the state over the next 10 years. This is over and above those that might be lost to fossil fuel extraction.[218] Transitioning from one primary source of energy to a diversified portfolio could strengthen the economy and improve the health concerns related to Kentucky's coal based electricity generation.[219]

Richardsville Elementary School in Warren County Kentucky was the first school in the country to operate with a net zero energy design. The school, which serves approximately 500 students, preschool through 5th grade, has a LEED Gold certification by the U.S. Green Building Council. Through the use of energy efficiency measures including insulated concrete form wall construction, a high performance building envelope, active day-lighting, and geothermal HVAC with CO2 monitoring and de-centralized pumping, the school has significantly cut down on heating, lighting and appliance costs. A thin film photovoltaic system adhered to the roof produces electricity for the school.[220] *After an energy audit the school also incorporated simple behavior change techniques to save energy such as turning off the lights when leaving the classroom. The school also set up "energy teams" with the students to further study and promote actions for saving energy.*

Work towards energy efficiency is not new to Kentucky schools. In 1990, Paint Lick elementary school installed the first geothermal system in the state. Since then more than 290 schools have added geothermal systems to help offset heating and cooling costs.[221] *Through projects such as the Green Schools Program more than 100 Kentucky schools now have ENERGY STAR certification.*[222] *Working towards energy efficient buildings can ultimately be good for both student's education and their environmental health.*

Jonita Horn, eastern KY resident

Some Kentuckians are concerned about a shift from coal based energy to other forms of renewable energy production. Members of Jonita Horn's family work in the coal industry and have depended on coal mining for their income. She feels that if energy policies change, alterative industries must move into Kentucky's mining regions to ensure employment within the region.

"I really like the idea of policies that support clean energy. There is no doubt that all this coal we burn is polluting us just as much as it is polluting our planet. However, I have some very real concerns [on what a shift from coal] might do to the people who rely on coal for their livelihood. We know that similar programs have created many jobs, but we do not know who ended up filling those jobs. Obviously, the counterpart to more clean energy is less dirty energy. The jobs that are created will also mean jobs that are lost. It is very important that the men and women that rely on coal for their living have first chance at these jobs...It would also be important for the jobs to pay at least as much as the coal so that people could maintain their standard of living."

(Photo credit: J.M. Hibberd)

Renewable and energy efficiency health impacts summary

HEALTH DETERMINANT	EFFECTS ON HEALTH	AFFECTED POPULATIONS	EVIDENCE OF HEALTH DETERMINANT IMPACT ON HEALTH
Wind turbines	Negligible affect on health	Those living near turbines	MN Dept. of Health, Env. Health Division, Natl. Resource Council
Wind Turbines: Zero emissions during energy production	Reduced lung and heart disease	All Kentuckians	All research pertaining to particulate matter
Solar Panels: Production (silica dust)	Silicosis	Silica miners	Fthenakis, Electric Power Research Institute
Solar Panels: Zero emissions during energy production	Reduced lung and heart disease	All Kentuckians	All research pertaining to particulate matter
Hydro electricity Plant operations:	Occupational safety hazards	Plant operators	Fairchild
Hydro electricity: Zero emissions during energy production	Reduced lung and heart disease	All Kentuckians	All research pertaining to particulate matter.
Biofuel	Heart attack Artherosclerosis ischemic and hemorrhagic stroke	All Kentuckians	Peters Brook Wellenius
Home energy efficiency	1. Improved comfort and quality of life 2. Improved respiratory health 3. Reduced deaths caused by air pollution	All Kentuckians	1. Leech, Howden-Chapman, Fisk 2. Howden-Chapman, Levy, Fisk, Leech 3. Nishioka, Levy, California Air Commission
Energy efficiency building materials: PVC	Risk of cancer	Individuals utilizing PVC based materials	EPA
Reduced spending on housing costs	1. Improved nutrition 2. Reduced Psychological Stress	Low income families	1. Harkness, Schweitzer, Frank, Meyers 2. Frank
Energy efficient lighting	Improved attention, learning, safety, and work efficiency	Children in schools and individuals in the work place	Veitch
Expansion of renewable energies industries	1. Reductions in injuries, disease, and fatalities associated with the extraction process of fossil fuels 2. Healthier, diversified economy	1. Energy industry workers 2. All Kentuckians	1. Sumner 2. Tracz
Policy: Clean Air Act Amendments	Reductions of mortality, chronic bronchitis, nonfatal and fatal heart attacks, respiratory hospital admissions, emergency room visits for children with asthma, preterm birth (expand list to include all from study)	Adults with heart and lung diseases, elderly, children living with asthma, pregnant mothers, all Kentuckians	Chestnut L.G.

Recommendations

Data reviewed for this health impact assessment clearly indicates that coal poses significant health risks to people working at or living near coal facilities at each phase of its cycle – mining, processing, transportation, combustion, and waste disposal. Accidents in underground mines, and at or near surface coal mines can injure or kill workers or people living nearby. Pollution including soot, smog-forming chemicals, greenhouse gases and heavy metals travels through the air or water and can impact the health of people living close to coal-related activities, and the general public living hundreds of miles from the pollution source.

In the case of energy efficiency measures, and electricity generated by solar, wind, hydro or biomass may have potential health impacts, but these impacts are similar to those experienced in general manufacturing processes or construction and can often be mitigated by use of less toxic materials, or by attention to the siting of a renewable energy generating system.

Based on these findings, we recommend:

1. Kentucky legislators should urgently focus on diversification of Kentucky's energy portfolio to include renewable energy from sources such as solar, wind or hydro, and provide incentives for Kentuckians to use energy more efficiently. These portfolio standards would displace harmful coal pollution and provide additional direct health benefits to Kentucky residents.

   Kentucky legislators should explore proposed policies like the Clean Energy Opportunity Act (HB 167) of 2012, which would require utilities to 1) increase, incrementally, their renewable energy generation to 12.5% of retail sales by 2022; and 2) offset 10.25% of annual retail sales through energy efficiency by 2022. The bill would also establish a feed-in-tariff for in-state production of renewable energy.

2. Kentucky legislators should consider utilizing health impact assessment methodologies in regard to specific energy and environmental policy options in order to ensure that protection and preservation of public health is a top priority. HIAs are being used more frequently in the United States and here in Kentucky, including this document as well from the Green River District Health Department in Owensboro, that is currently assessing a proposed coal-gasification project. They can allow a wide range of affected populations, community leaders and elected officials to engage in productive dialogue and reveal multiple solutions that had not previously been considered.

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