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Coal: How We Achieved Our Dependency and Its True Cost

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Environmental Policy Thesis

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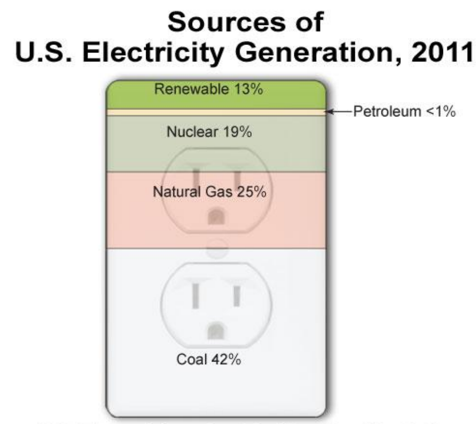
Introduction

In February 2011 Robert F. Kennedy Jr., a prominent environmental lawyer, came to Fordham University's Rose Hill campus and spoke to an auditorium full of students. During his lecture, Mr. Kennedy mentioned that very little research had been done on the true cost of coal and that it would make an excellent thesis paper for a student. Mr. Kennedy piqued my interest and I began to seriously consider taking his suggestion for my thesis.

As I began researching the true cost of coal I decided to use three primary disciplines to approach the problem: environmental history, environmental politics and law, and environmental economics. When looking at these three disciplines I found that coal is often advertised as the cheapest form of energy, but this low cost does not account for the negative externalities associated with mining and processing. Once these negative externalities are factored in, coal becomes an expensive, unrealistic and unsustainable form of energy.

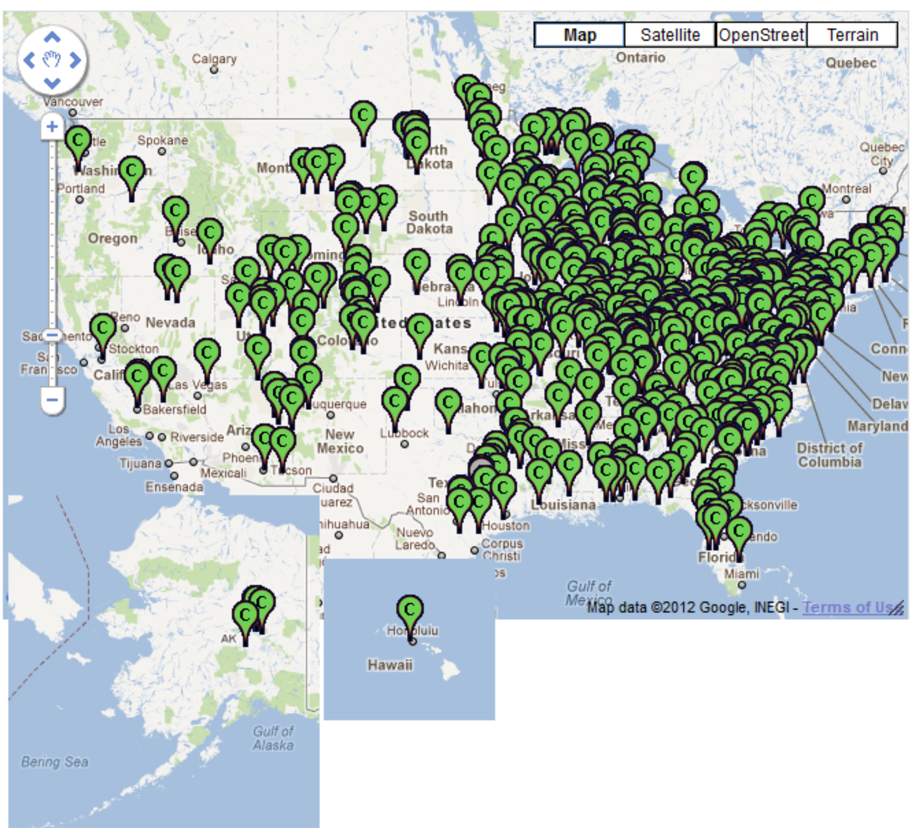
As I began to research "the true cost of coal" I realized that it was important to understand not only the externalities associated with coal, but to also understand the history of coal in the United States. Coal is one of America's most abundant non-renewable resources which has helped cause our coal dependency. Additionally, several key pieces of legislation have furthered the country's coal dependency.

In order to reduce America's dependency on coal and to promote the research and use of new alternative energy, it is critically important to understand how we achieved this dependency so that the mindset fostered by coal can be changed.



Source: U.S. Energy Information Administration, *Electric Power Monthly* (February 2012). Percentages based on Table 1.1, preliminary 2011 data.

Today, coal accounts for 42% of the electricity generated in the United States. ("Electricity Explained") In the United States there are 594 coal-powered power plants currently operating. Those 594 coal-powered power plants are producing energy at an approximate average of $0.032 per kwh (kilowatt hours). (Greenstone & Looney) The 594 coal-powered power plants, shown in the map below, are associated with numerous negative environmental impacts and negative public health impacts which will be outlined in the "Environmental Impacts" chapter. Along with the environmental impacts, I

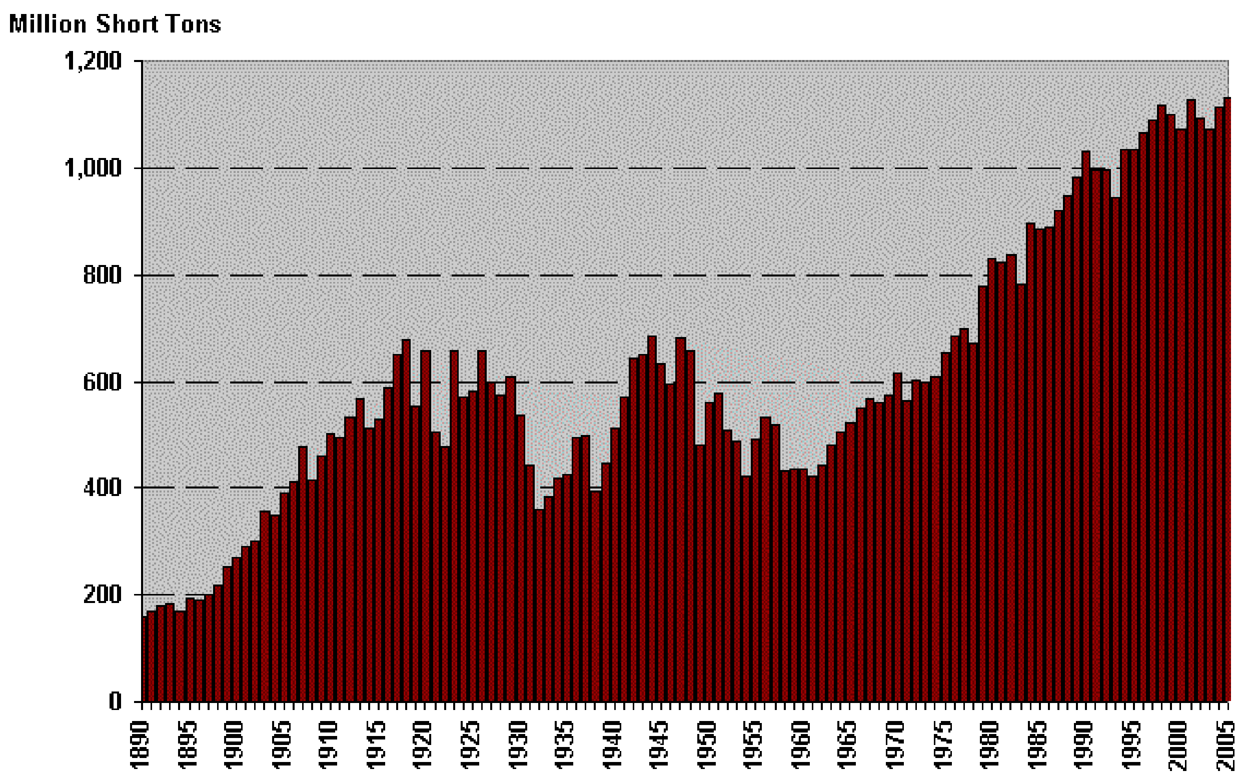


("National Map: Operating Coal Power Plants") will look at the history of coal mining, types of coal, methods of mining, important legislation and cases, and ultimately the true cost of coal once the negative externalities are factored into the cost.

A History of Coal Mining in the U.S.

Coal has been used since the time of the cave man as a source of heat. Some of the earliest evidence of coal use in the North America came from the Hopi Indians in the 1300s. The Hopi's used coal for cooking, heating, and baking clay pottery. As more European settlers arrived in the 1600s coal use began to increase. However, commercial coal mining did not begin until the 1740s in what is now Virginia ("Fossil Energy: A Brief History of Coal Use in the United States").

Although coal use steadily increased from the 1600s, it wasn't until the Industrial Revolution that coal use began to boom. The following chart demonstrates the rapid growth in the use of coal between 1890 and 2005.



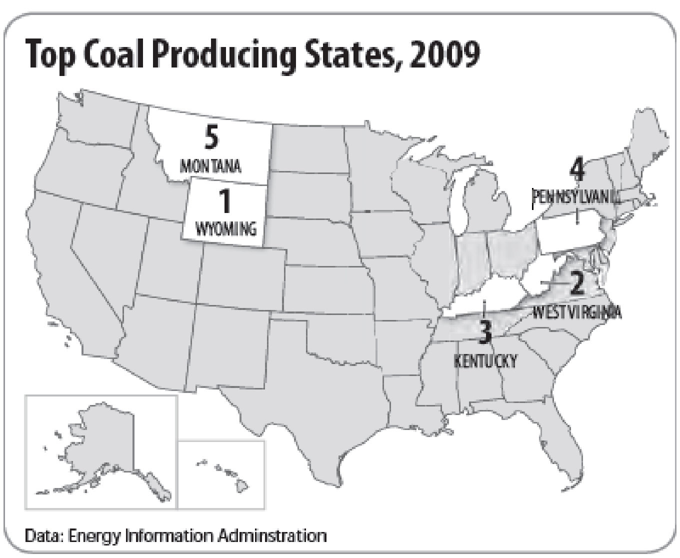
("Coal Production in the United States - An Historical Overview" 2)

From the colonial period through the end of the First World War coal production grew relatively steadily. During the Great Depression coal production dramatically declined until the United States entered into World War II at which time coal production soared to support the war effort. “Around 1950, coal consumption was distributed among the consuming sectors – industrial, residential and commercial, metallurgical coke ovens, electric power, and transportation – with each sector accounting for 5 to 25 percent of total consumption.” (“Coal Production in the United States – An Historical Overview” 1)

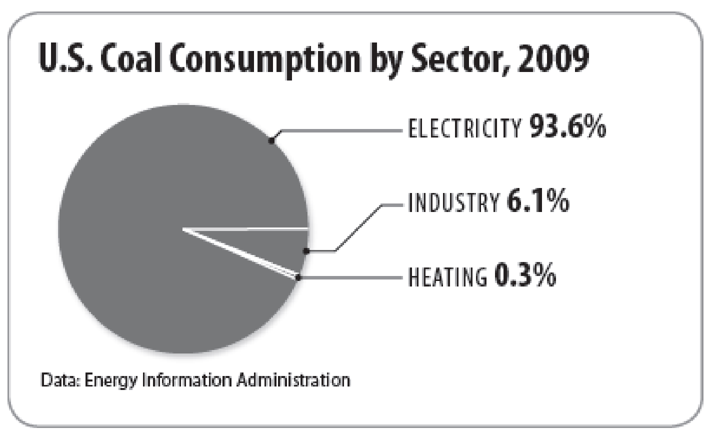
Since World War II, coal production has generally increased with the exception of a slight dip in production immediately after World War II until the early 1960s. This temporary decline in production was the result of a decrease in coal use for space heating, and water and rail transportation. In 1973 the Oil Embargo caused a renewed interest in the coal reserves located in the United States. As a result of the 1973 Oil Embargo the U.S sought to achieve energy independence.

Today, the U.S. has the world’s largest known coal reserves which have been estimated to last approximately 200 years (Epstein, Buonocore, and et al 74). From 1973 to 1976 the United States truly recognized the reserves available and coal production increased by 14.4 percent. In 1978 most oil-burning power plants were mandated to convert to coal or natural gas under the Power Plant and Industrial Fuel Use Act. This piece of legislation played a large part in the steady rise of coal production. Although there were years where coal production declined from the previous year, excluding the years affected by major unionized coal strikes, the number of annual increases in coal production outnumbered the number of annual decreases by almost two to one from 1950 to 2003 ("Coal Production in the United States – An Historical Overview").

"The shift of coal production from traditional eastern coalfields to the western United States is the most important development affecting coal markets in the last 30 years." ("Coal Production in the United States – An Historical Overview") Today, coal accounts for 42% of America's energy needs with 93% of the coal mined used for the production of electricity ("Coal"). This is a dramatic increase from the 19% of coal productions in 1950 used for electricity ("Coal Production in the United States – An Historical Overview"). Coal is currently mined in 25 states; the top producing states are Wyoming, West Virginia, Kentucky, Pennsylvania, and Montana. The largest coal mining facility in the United States is located in Wyoming: The North Antelope Rochelle Complex, produced over 80 million short tons (MMst) in a single year.



("Coal" 2)



("Coal" 2)

Types of Coal

Coal is broken down into four types based on the age and the amount of heat the coal can produce. The four types are lignite, subbituminous, bituminous, and anthracite.

Lignite, the youngest and lowest level of coal, makes up the majority of the coal reserves in the world. Lignite can be classified by its soft nature and brownish-black color ("Coal: Our Most Abundant Fuel"). Of the four types of coal, Lignite has the lowest carbon content, 25% to 35%, and produces the least amount of heat when burned. Lignite is primarily used for producing electricity and, in the United States, is found primarily west of the Mississippi River ("Types of Coal").

The third level of coal is called Subbituminous and is dull black in color. Subbituminous coal produces more heat than Lignite and is comprised of 35% to 45% of carbon ("Types of Coal"). Subbituminous coal is mined in the United States primarily in Montana and Wyoming. Compared to Lignite, Bituminous, and Anthracite, Subbituminous coal is the lowest in sulfur content which makes it very attractive for burning. The lower sulfur content allows companies burning coal to comply with regulations that limit the amount of pollutants that can be released without making as many major changes to their existing facilities ("Coal: Our Most Abundant Fuel").

Bituminous is the second level of coal and is primarily found east of the Mississippi River in Ohio, Illinois, and the Appalachian Mountain range ("Coal: Our

Most Abundant Fuel”). Bituminous coal produces the second most heat with a carbon content of 45% to 86%. Additionally, Bituminous is the most abundant type of coal in the United States (“Types of Coal”).

Finally, the oldest and hardest coal is Anthracite. Anthracite, which is the highest level of coal, is primarily found in the northeastern counties of Pennsylvania and makes up the smallest percentage of the world’s coal reserves. Anthracite has the highest carbon content of all the types of coal with 86% to 98% and produces the most heat (“Coal: Our Most Abundant Fuel”).

While each type of coal has its own unique qualities, each can be mined using the same methods depending on location and degree of difficulty to reach.

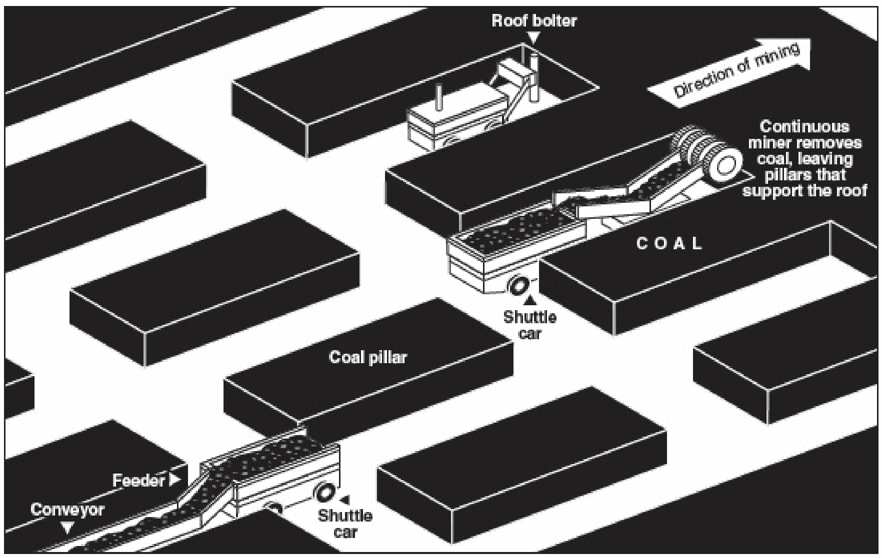
Methods of Coal Mining

Since the early use of coal there have been various methods of extracting it from the earth. Methods have ranged from simply picking up a piece of coal from the ground to digging elaborate mines. Today various methods of mining are used, however, all mining techniques fall into one of two categories: underground mining or surface mining. Approximately 70% of all coal mined in the United States comes from surface mining ("Coal").

Underground mining, also known as deep mining, is the extraction of coal from enclosed rock strata by tunneling below the surface. There are three types of underground mines which are based on the method of access. Drift mines are the easiest to open and tunnel directly into the coal seams. Shaft mines are created with a vertical shaft to the coal. Finally, slope mines feature a shaft that descends on a gradient which is primarily used in hilly terrain ("Coal Production in the United States – An Historical Overview").

Underground mining has three principal technologies used; these methods are conventional mining, continuous mining, and longwall mining. Conventional mining is a traditional method that uses the "room and pillar" method. This method leaves giant pillars of undisturbed coal in order to support the rock overhead. The exposed coal is undercut then a series of drilling and blasting occurs which utilizes either explosives or high-pressure air. Once the coal has been broken loose it is loaded into shuttle cars and carted out of the mine. As the mine grows larger additional roof supports are added.

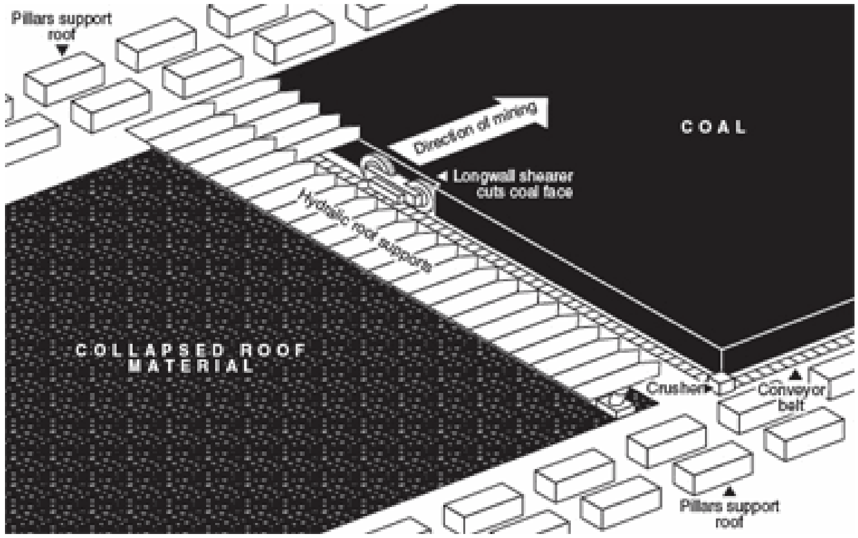
Continuous mining is relatively straightforward. A machine with toothed cylinders that rotate scrapes the coal off the face. The crushed coal falls into a pan and is transported along a conveyor belt that then dumps the coal into shuttle cars.



("Coal InfoMine")

The above graphic illustrates conventional mining and continuous mining being used in tandem ("Coal InfoMine").

The final method of underground mining, longwall mining, is an automated system that is distinguished by high recovery and extraction rates. This method of mining is only possible in a relatively flat, thick, and uniform coal bed. Longwall mining is started with continuous mining where a panel of coal approximately 1,000 feet by 10,000 feet is isolated by tunnels on all four sides. The longwall machinery is put in place along the 1,000 foot wall and is gradually sheared away from ceiling to floor. The coal is then removed from the mine on a floor-level conveyor. As the



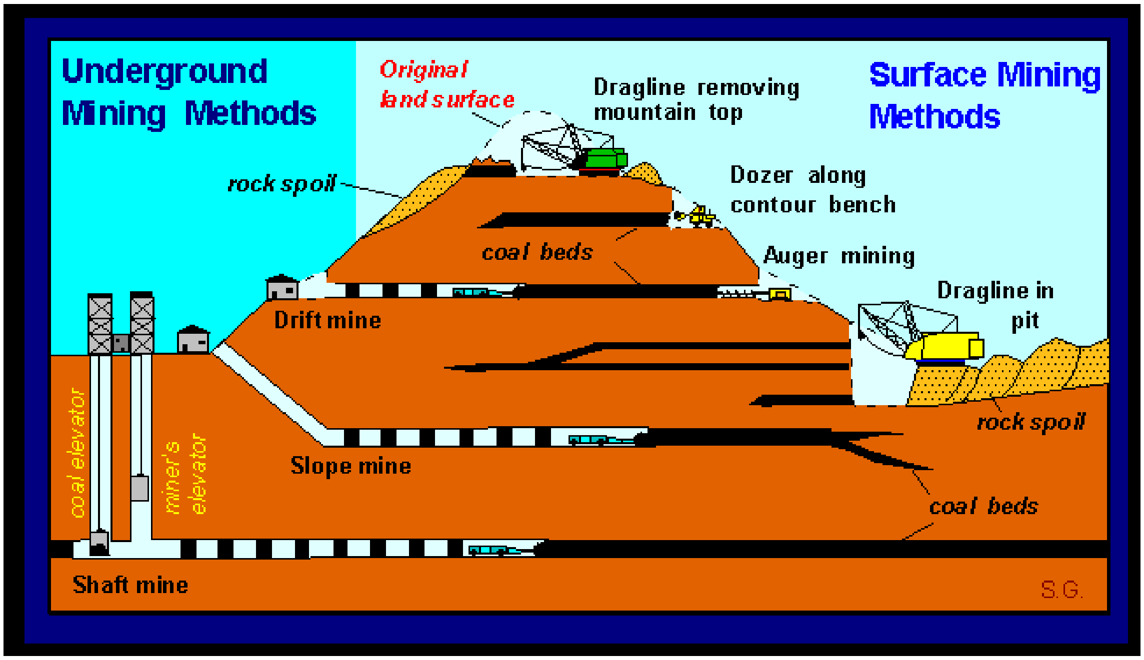
("Coal InfoMine")

longwall machinery progresses, temporary roof supports are used within the 1,000 feet by 10,000 feet block. Eventually the roof is allowed to evenly collapse behind the supports. The above graphic illustrates how the longwall mining process works ("Coal InfoMine").

Unlike underground mining, surface mining is typically more productive for coal production. Surface mining in its simplest form is achieved by removing coal from outcroppings or by removing the ground, rock, and soil, or "overburden," to expose the coal beneath. Surface mining is achieved through one of six methods: strip mining, contour mining, area mining, auger mining, highwall mining, or mountaintop removal mining ("Coal Production in the United States – An Historical Overview").

Strip mining is the most basic form of surface mining where parallel and adjacent rectangular blocks, called pits or strips, of overburden are removed. As the coal is mined from the strips, the overburden of new strips is dumped into old strips. The filling of empty strips with overburden is crucial to the process in order to enable mined-land reclamation (Schissler).

Contour mining produces coal from outcrops that are exposed when the overburden is removed. Contour mining is used on sloping terrain ("Coal Production in the United States – An Historical Overview"). While contour mining is used on sloping terrain, area mining is used on flat terrain. In area mining long pits, or box cuts, are made in succession. The overhead from the box cuts is removed, coal is mined, and the overhead is dumped into previous box cuts.



(Methods of Mining)

There comes a point in contour and area mining where it is no longer economical to remove the overburden from standing exposed rock. When this happens, auger mining and highwall mining are used. Auger mining uses a large diameter drill to bore holes into the coal bed. The drilled coal is collected and removed from the mine. Highwall mining is achieved through one of two methods. The first method uses a remote-controlled machine, known as a highwall miner, to cut the coal away. The second method uses an underground mining machine, known as a thin-seam miner, to remove wide channels of coal ("Coal Production in the United States – An Historical Overview"). This graphic illustrates various forms of underground and surface mining.

The final method, and perhaps one of the most controversial, is mountaintop removal mining. Mountaintop removal is practiced primarily in Kentucky, West Virginia, and other parts of the Appalachian Mountains and provides an estimated five percent of the nation's coal needs for electricity. Mountaintop removal is a form of strip mining where the summit or summit ridge of a mountain is blasted off with explosives in order to mine the coal seams. Prior to blasting, the area is deforested and cleared of all vegetation and topsoil. Once the mining has been completed the overburden that was removed is either replaced on top of the mountain to mimic the original shape, or dumped into nearby valleys. Regardless of whether or not the overhead is placed back on the mountain, some of it will end up in valleys due to the broken up nature of the overhead. "Some opponents argue that overburden dumped into valleys disrupts and pollutes natural water systems. 'Coal companies have buried a staggering 2,000 miles of freshwater streams in Appalachia in order to mine coal,' contends Appalachian Voices, a nonprofit activist group" (Espejo, 101).

Important Legislation and Cases

Prior to the 1970s the environment wasn't a high priority in the United States. However, in 1970 the environment became a much higher priority with the creation of the first federal environmental statute, the National Environmental Policy Act, or NEPA. After the creation of NEPA many more statutes were established. Four of these federal statutes have had a significant impact on the coal mining industry. The most important of these was the Surface Mining Control and Reclamation Act of 1977, or SMCRA. NEPA, the Clean Air Act, and the Clean Water Act also played a significant role on the development of coal mines ("Strict Regulations Govern Coal Mining").

In 1977 the Surface Mining Control and Reclamation Act was signed into law to provide strict guidance for coal mines. The Office of Surface Mining Reclamation and Enforcement, housed under the U.S. Department of the Interior, was tasked with the enforcement and oversight of SMCRA. The Office of Surface Mining Reclamation and Enforcement states that SMCRA, "balances the need to protect the environment from the adverse effects of surface coal mining with the Nation's need for coal as an essential energy source. It ensures that coal mining operations are conducted in an environmentally responsible manner and that the land is adequately reclaimed during and following the mining process." ("Regulating Coal Mines") SMCRA addresses issues like the abandoned mine reclamation fund, surface mining operations, special bituminous coal mines, and anthracite coal mines

("Surface Mining Control and Reclamation Act of 1977"). While SMCRA was the first major piece of legislation to specifically address coal mining, like all other environmental legislation, it derives much of its power from the National Environmental Policy Act.

The National Environmental Policy Act was significant for several reasons. NEPA was the first modern federal environmental statute that helped to pave the way for future statutes, like SMCRA, the Clean Air Act, and the Clean Water Act. NEPA also established the President's Council on Environmental Quality which works to ensure that all environmental policies created have a strong foundation in science (Gaba NEPA). However, the most important aspect of NEPA, which relates directly to SMCRA, is section 102(2)(C). Section 102(2)(C) requires that agencies must:

> include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement by the responsible official on (i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which

> would be involved in the proposed action should it be implemented. ("National Environmental Policy Act of 1969")

This is known as an Environmental Impact Statement, or EIS.

Section 102(2)(C) of NEPA specifically says agencies must file an EIS, however the Department of Interior is responsible for issuing permits for mines. The Department of Interior has to justify the issuing of permits with an EIS. One monumental case that dealt with Environmental Impact Statements was *Kleppe v. Sierra Club*. *Kleppe v. Sierra Club* focused on whether or not the Department of Interior was required under NEPA to create a regional EIS for multiple coal mining proposals within a region rather than individual Environmental Impact Statements for each project. Although this was the original issue the Supreme Court looked at, *Kleppe v. Sierra Club* established that an EIS needs to be prepared when an action, like creating a coal mine, is actually proposed.

The Clean Water Act, officially the Federal Water Pollution Control Act Amendments of 1972, is the primary federal statute that concerns water pollution. The Clean Water Act, or CWA, established many different programs to deal with water pollution, these programs include: direct dischargers – National Pollutant Discharge Elimination System (NPDES) point source program, indirect dischargers – pretreatment program, non-point sources – area-wide controls, dredge and fill program, and oil spill program. The two programs that primarily relate to coal mining are the NPDES point source program and the dredge and fill program.

The NPDES point source program, which is outlined in section 402, requires that all industrial and municipal facilities need a NPDES permit if they directly discharge any pollutants into lakes, the ocean, or streams. The NPDES permit typically includes limits on the concentration or amount of the pollutants that can be discharged. The dredge and fill program, outlined in section 404, requires a "separate national permit program for construction that results in dredging or filling of 'wetlands.'" (Gaba CWA, 88) A significant court case, *National Mining Association v. Army Corps of Engineers 145 F.3d 1399 (D.C. Cir. 1998)*, involved the Clean Water Act and the dredge and fill program. *National Mining Association v. Army Corps of Engineers* looked at whether or not the "dredge and fill permit requirements apply to incidental fallback or de minimis redeposit of dredged materials back into the water." (Gaba CWA, 93) Fallback refers to soil or sediment that falls from any dredging equipment back into the water. This was significant because it determined that the dredge and fill requirements did not apply to fallback, the court said that if it did then virtually all "mechanized land clearing, ditching or excavation" would fall under this category. ("National Mining Association v. Army Corps of Engineers" 93)

Similarly to the Clean Water Act, the Clean Air Act is the primary federal statute that regulates air pollutants. The Clean Air Act, or CAA, establishes numerous programs to regulate these emissions. Some of the programs established include "the Mobile Source requirements, New Source Performance Standards, programs relating to attainment of National Ambient Air Quality

Standards…National Emission Standards for Hazardous Air Pollutants, and the Sulfur Allowance Trading Program." (Gaba CAA, 118) Potentially the most significant program with regards to coal mining and processing is the Sulfur Allowance Trading Program as sulfur is one of the pollutants that is typically released during the mining and purification process.

The Sulfur Allowance Trading Program is a way for the government to dispense "pollution rights" to various entities that allow them to emit a specified amount of sulfur. If an entity is able to reduce their sulfur emissions to below the amount issued to them by the government, they can sell the remainder of their allowances to companies that need more. This program encourages groups to reduce their sulfur emissions and rewards those that do with additional profit from the sale of allowances.

Although the Surface Mining Control and Reclamation Act of 1977, the National Environmental Policy Act of 1970, the Clean Air Act, and Clean Water Act are arguably the most important pieces of legislation that affect coal mining and processing, other legislation has impacted coal. One such piece of legislation was the Power Plant and Industrial Fuel Act of 1978.

Much like SMCRA, the Power Plant and Industrial Fuel Act of 1978 was enacted in response to the 1973 oil crisis. With the country looking to utilize natural resources located within the United States, the Power Plant and Industrial Fuel Act significantly limited the construction of new power plants that utilized natural gas and oil while encouraging the use of coal, nuclear energy, and other alternative fuel sources. Natural gas and oil use was also restricted in boilers for industry use (Kubiszewski).

As alternative fuels like coal and nuclear energy were used, the price of natural gas dropped drastically. With prices falling, Congress was motivated to repeal the sections of the Power Plant and Industrial Fuel Act that applied to natural gas use in 1987.

In addition to the Power Plant and Industrial Fuel Act, the Comprehensive Environmental Response, Compensation and Liability Act, or CERCLA, and the Resource Conservation and Recovery Act, or RCRA, also affect coal mining and processing. CERCLA and RCRA are both significant pieces of environmental legislation; however, they do not specifically apply to coal.

CERCLA was enacted in 1980 and created guidelines for the government to finance hazardous waste cleanups; this is often referred to as Superfund. Furthermore, CERCLA defines what can minimally be considered hazardous waste by referencing sections of other legislation like the Clean Water Act, the Clean Air Act, and RCRA. CERCLA also give the EPA the authority to classify other substances as hazardous (Gaba CERCLA).

The Resource Conservation and Recovery Act, adopted in 1976 as an amendment to the Solid Waste Disposal Act, is typically called RCRA. Major amendments to RCRA were adopted in 1984. RCRA is the primary piece of federal legislation that handles the disposal of solid and hazardous waste. Section 1004(5) RCRA states that:

> (5) The term 'hazardous waste' means a solid waste, or combination of solid wastes, which because of its quantity, concentration, or physical, chemical, or infectious characteristics may – (A) cause, or significantly contribute to an increase in mortality or an increase in serious irreversible, or incapacitating reversible, illness; or (B) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of, or otherwise managed. ("Resource Conservation and Recovery Act")

In the process of coal mining and processing various forms of waste are released. CERCLA and RCRA together provide direction on how to classify the waste and properly handle cleanup.

While each of these pieces of legislation and court cases is individually important, when viewed together they establish significant restrictions and guidelines for coal. Despite these restrictions and guidelines, coal still poses a threat to the environment.

Environmental Impacts

"Coal mining and processing generate the largest quantity of mine wastes." (Lottermoser, 51) From the initial mining process to the production of energy, the environmental impacts of coal can be found in the air, water, land, and the people. While researching the negative externalities associated with coal I tried to get as comprehensive a view as possible. To that end, I've identified the following as negative externalities associated with coal: land disturbance, including abandoned mine lands; greenhouse gases and other pollutant emissions; carcinogen contamination; and an increased public health burden. These negative externalities are meant to serve as categories that I will further break down in this chapter.

Land disturbance is a common problem associated with all forms of coal mining. "Mining…disturbs proportions of land and areas of existing vegetation and fauna. Mining activities may also cause distinct changes in topography, hydrology and stability of a landscape." (Lottermoser, 26) Of all the methods of coal mining, mountaintop removal causes a significant amount of land disturbance. Mountaintop removal deforests entire mountains and then blasts the tops off those mountains in order to gain access to coal seams. In addition to destroying the mountain itself, mountaintop removal affects the surrounding land when the excess overburden is used to fill in the nearby valleys. Mountaintop removal alone has completely altered 1.4 million acres of land, which is approximately the size of Delaware, and buried more than 2,000 miles of streams in Kentucky, Virginia, West Virginia, and Tennessee (Epstein, Buonocore, and et al 77).

Mountaintop removal and any mining process that requires deforestation not only impacts the natural landscape, but also impacts carbon storage capabilities and the water cycle. In the Appalachian region alone, an estimated 6 to 6.9 million tons of CO_2e (equivalent carbon dioxide) are emitted annually as a result of deforestation from mountaintop removal (Epstein, Buonocore, and et al 77). Globally, an estimated 6.1 billion tons of anthropogenic carbon dioxide are produced annually. The naturally occurring carbon cycle is only capable of absorbing 2.9 billion tons of the carbon dioxide produced which leaves 3.2 billion tons of carbon dioxide added to the atmosphere annually. ("Greenhouse Gases, Climate Change, and Energy") The deforestation that occurs with mining not only impacts the ability of the carbon cycle, it also increases the chances of mudslides, flash floods, and dislodged boulders. Additionally, "Blasting to clear mountain ridges adds an additional assault to surrounding communities. The blasts can damage houses, other buildings, and infrastructure…" (Epstein, Buonocore, and et al 77)

Both surface and underground mining can create dangerous, unstable conditions for the land, particularly when the mines are abandoned. Prior to the Surface Mining Control and Reclamation Act of 1977, mining operations were not required to facilitate the reclamation of land disturbed by the mining process. According to the Office of Surface Mining Reclamation and Enforcement:

> Abandoned mine lands are lands and waters adversely impacted by inadequately reclaimed surface coal mining operations on lands that were not subject to the…Surface Mining Law. Environmental problems associated with abandoned mine lands include surface and ground water pollution, entrances to open mines, water-filled pits, unreclaimed or inadequately reclaimed refuse piles and mine sites…sediment-clogged streams, damage from landslides, and fumes and surface instability resulting from mine fires and burning coal refuse. ("Reclaiming Abandoned Mine Lands")

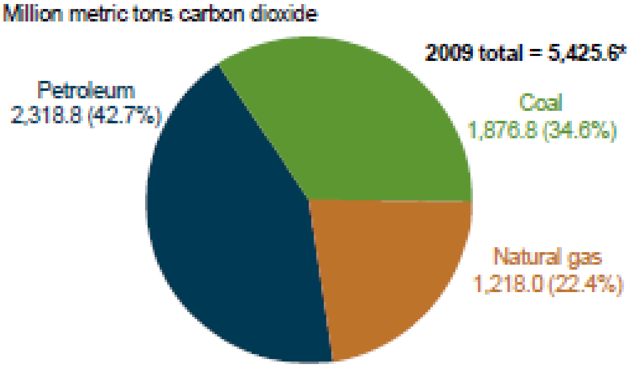
Since 1977, all active mining operations have been required to pay into the Abandoned Mines Reclamation Fund that was established by the Surface Mining Control and Reclamation Act.

In addition to causing land disturbance and creating unsafe conditions with abandoned mines, coal mining, processing, and use produces several harmful pollutants. These pollutants include carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), sulfur dioxide (SO_2), coal combustion waste/fly ash and power plant waste, mercury, and carcinogens.

Carbon dioxide, nitrous oxide, and methane are all naturally occurring greenhouse gases. Greenhouse gases allow sunlight to enter the atmosphere

Figure 2. U.S. energy-related carbon dioxide emissions by major fuel, 2009

Million metric tons carbon dioxide



*Includes small amounts of CO_2 from non-biogenic municipal solid waste and geothermal energy (0.2 percent of total)

("Emissions of Greenhouse Gases in the United States 2009" 2) and reflect off the Earth's surface. The greenhouse gases then trap and absorb some of this heat in the atmosphere and the rest is released back into space. Although greenhouse gases are necessary in order to warm the planet, the higher the concentration of greenhouse gases in the atmosphere, the more heat is trapped. Coal mining, processing, and use significantly increases the amount of carbon dioxide, nitrous oxide, and methane present in the atmosphere. As of 2009, coal based energy accounted for 34.6% of the carbon dioxide released into the atmosphere. ("Emissions of Greenhouse Gases in the United States 2009" 2)

Carbon dioxide accounts for a large portion of the greenhouse gases being emitted into the atmosphere. "In the past 300 years, industrial, economic, and social

Table 3-7: CO_2, CH_4, and N_2O Emissions from Fossil Fuel Combustion by Sector (Tg CO_2 Eq.)

End-Use Sector	1990	2005	2006	2007	2008	2009	2010
Electricity Generation	**1,828.5**	**2,418.6**	**2,363.1**	**2,430.0**	**2,378.2**	**2,163.7**	**2,277.3**
CO_2	1,820.8	2,402.1	2,346.4	2,412.8	2,360.9	2,146.4	2,258.4
CH_4	0.3	0.5	0.5	0.5	0.5	0.4	0.5
N_2O	7.4	16.0	16.2	16.7	16.9	16.9	18.5
Transportation	**1,534.6**	**1,936.1**	**1,914.2**	**1,925.1**	**1,817.1**	**1,752.4**	**1,768.0**
CO_2	1,485.9	1,896.6	1,878.1	1,893.9	1,789.8	1,727.9	1,745.5
CH_4	4.7	2.5	2.4	2.2	2.1	2.0	1.9
N_2O	43.9	37.0	33.7	29.0	25.2	22.5	20.6
Industrial	**851.3**	**821.0**	**852.9**	**849.0**	**810.8**	**730.4**	**782.0**
CO_2	846.4	816.4	848.1	844.4	806.5	726.6	777.8
CH_4	1.6	1.5	1.5	1.5	1.4	1.2	1.4
N_2O	3.3	3.1	3.2	3.1	2.9	2.5	2.8
Residential	**344.1**	**362.5**	**325.6**	**346.2**	**354.0**	**343.5**	**344.7**
CO_2	338.3	357.9	321.5	341.6	349.3	339.0	340.2
CH_4	4.6	3.6	3.3	3.6	3.7	3.6	3.5
N_2O	1.1	1.0	0.9	0.9	1.0	0.9	0.9
Commercial	**220.2**	**224.8**	**209.8**	**220.1**	**226.4**	**225.9**	**225.5**
CO_2	219.0	223.5	208.6	218.9	225.1	224.6	224.2
CH_4	0.9	0.9	0.9	0.9	0.9	1.0	0.9
N_2O	0.4	0.4	0.3	0.3	0.3	0.3	0.3
U.S. Territories*	**28.0**	**50.2**	**50.5**	**46.3**	**40.0**	**41.8**	**41.8**
Total	**4,806.7**	**5,813.3**	**5,716.1**	**5,816.8**	**5,626.6**	**5,257.7**	**5,439.3**

Note: Totals may not sum due to independent rounding. Emissions from fossil fuel combustion by electricity generation are allocated based on aggregate national electricity consumption by each end-use sector.

* U.S. Territories are not apportioned by sector, and emissions are total greenhouse gas emissions from all fuel combustion sources.

("Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 - 2010" 3-7) activity has released more than 1.5 trillion tons of CO_2 and other greenhouse gases into the atmosphere." ("Clean Air Task Force") Even though there is a naturally occurring carbon cycle, we produce far too much carbon dioxide for the carbon cycle to process. Additionally, this process is relatively slow which means that even if all carbon dioxide emissions immediately stopped globally, it would take hundreds of years for the carbon cycle to remove the CO_2 that's remaining in the atmosphere. ("Clean Air Task Force")

While carbon dioxide is a very effective greenhouse gas on its own, nitrous oxide and methane significantly increase the heat trapping capabilities of the atmosphere. Nitrous oxide has an atmospheric lifespan of approximately 120 years and is 310 times more effective than carbon dioxide in trapping heat over a 100-year span. ("Nitrous Oxide") Methane is naturally occurring in coal and is released during both underground and surface mining. Methane has an atmospheric lifespan of approximately nine to 15 years and is 20 times more effective in trapping heat over a 100-year span than carbon dioxide. ("Methane") The chart above shows carbon dioxide, methane, and nitrous oxide emissions by sector. Electricity generation, of which coal accounts for 42%, releases more greenhouse gases than any other sector. The combined effects of the greenhouses gases in the atmosphere have resulted in 20 of the Earth's hottest years since 1880 in the last 27 years. "Scientists say that the Earth could warm by an additional 7.2˚F during the 21st century if we fail to reduce fossil fuel emissions." ("Clean Air Task Force") Additionally, "it is now well established in climate science that CO_2 emissions globally must stop, by the middle of this century, to avoid the worst cataclysms of global warming." ("Clean Air Task Force")

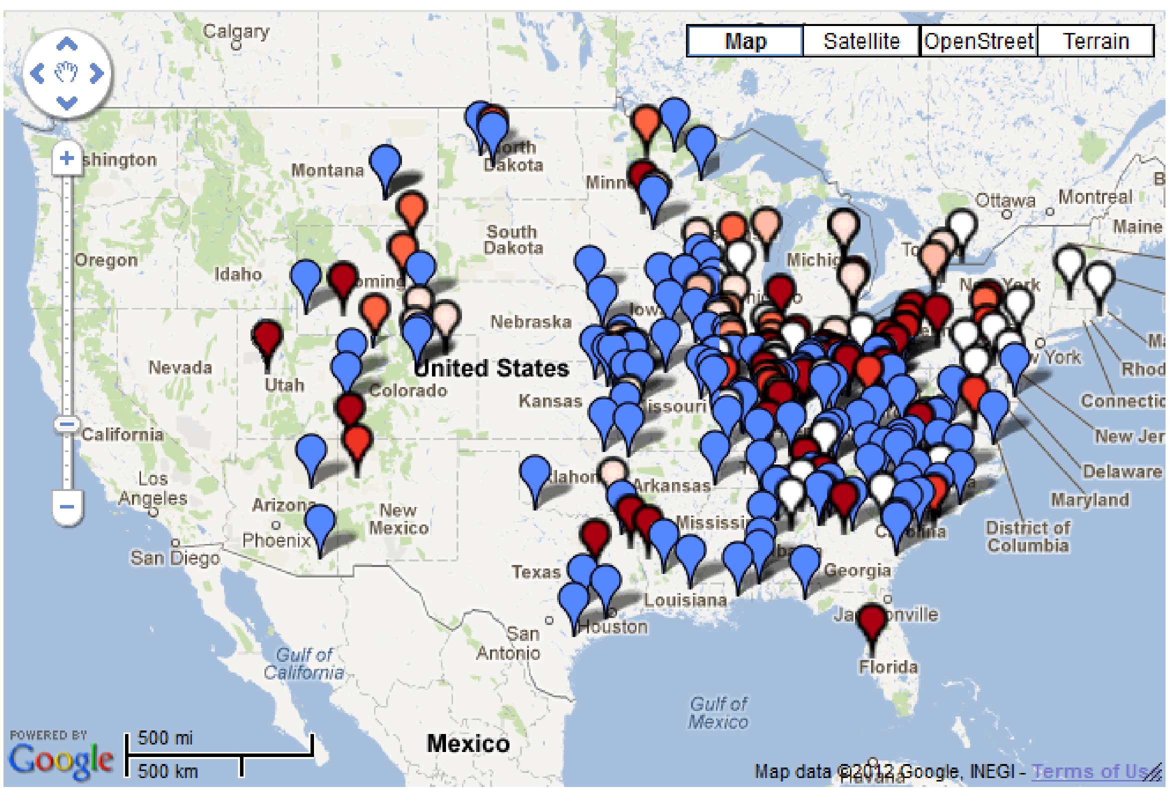
"Coal-burning to make electricity is a major source of sulfur dioxide." ("Clean Air Task Force") Sulfur dioxide has been linked to various respiratory problems including bronchoconstriction and increased asthma symptoms with only short-term exposure. Short-term exposure is defined as anywhere from five minutes to 24 hours. ("Sulfur Dioxide") Long-term exposure to sulfur dioxide can cause chronic bronchitis, emphysema, and respiratory illness while aggravating existing heart conditions. Additionally, industrial exposure can result in decreased fertility in men and women. ("Tox Town") Since the Clean Air Act of 1990 sulfur dioxide emissions have been reduced to 50% of the levels present in 1980, however, "…power plant-related particulate matter pollution, mostly from SO_2, will still result in more than 15,000 premature deaths…" ("Clean Air Task Force")

While the previous greenhouse gases and sulfur dioxide can be found in coal mining, processing, and use, mercury (Hg) is found primarily during coal use for electricity. Although mercury is a naturally occurring metal, "The electric power industry emits more than 65 air toxics, and coal-fired utilities are the single largest industrial emitter of mercury air pollution, responsible for more than one-third of U.S. Hg emissions." ("Clean Air Task Force") People are primarily exposed to mercury by breathing it in, eating fish and shellfish that have lived in mercury contaminated water, or by coming into physical contact with it. Mercury exposure is dangerous because it bioaccumulates in the body. High levels of mercury can cause death or permanent brain and kidney damage. The brain damage can cause: changes in vision or hearing, memory problems, tremors, psychosis, loss of appetite and weight, irritability, hallucinations. Additionally, pregnant women that have been exposed to mercury run the risk of causing damage to the fetus or even suffer a miscarriage. (“Tox Town”)

Another byproduct of coal use is power plant waste and coal combustion waste/fly ash. Power plant waste is a broader category that encompasses coal combustion waste and, in some cases, can include more than just coal combustion waste. Coal combustion waste, also known as fly ash, is composed of the products of coal combustion and other solid wastes generated through coal mining, processing, and use. This waste contains various toxic chemicals and heavy metals which have been shown to cause various health problems including reproductive disorders, neurological damage, learning disabilities, birth defects, cancer, diabetes, and kidney disease. (Epstein, Buonocore, and et al 81) This waste is typically dumped in giant impounds that are nothing more than valleys in the

("Earth Observatory")

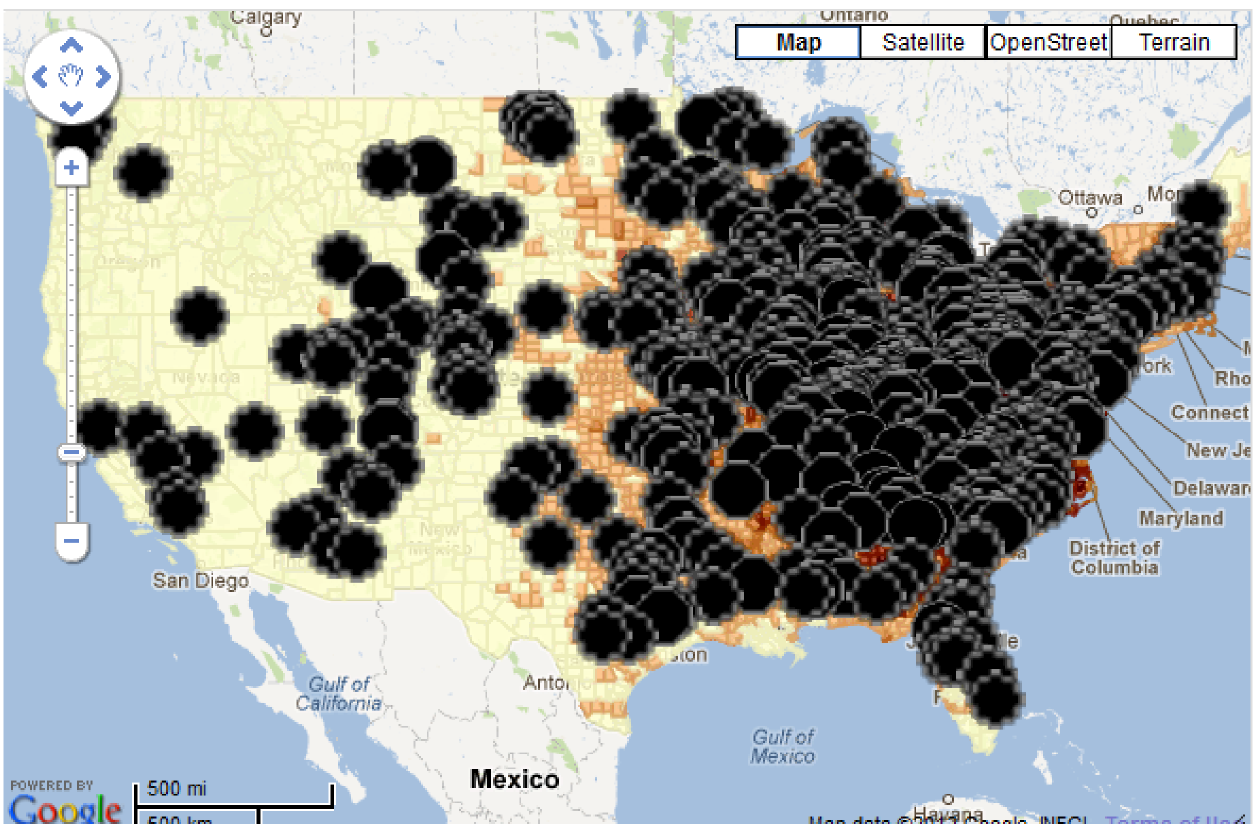
landscape which are supposed to have a liner to help prevent leaching. The older the impound the less likely it is to have a liner which means that harmful toxins can easily leach out into the groundwater. Even impounds that have liners will leach toxins. "Each year, coal-fired power plants generate 130 million tons of solid power plant waste (PPW) – enough to fill the Grand Canyon." ("Clean Air Task Force") In 2009, the EPA disclosed that there are currently 584 fly ash dump sites across 35 states. The above photo was taken over West Virginia in March 2006 by an orbiting satellite. The two giant black spots are actually dump sites for fly ash which were created by using the valleys between the mountains. It is estimated that in Kentucky alone, "up to 1 in 50 residents…including 1 in 100 children, living near one of the fly ash ponds are at risk of developing cancer as a result of water- and air-borne exposure to waste." (Epstein, Buonocore, and et al 82) The map below



("National Map: Coal Ash Waste in Place (Tons)") shows where the documented fly ash dump sites are located. The darker the color, the greater the amount of fly ash held there (from lowest to highest amount: white, light pink, peach, blue, red).

One of the other major negative externalities associated with coal is the carcinogens released throughout the mining, processing, and use of coal. Coal-fired power plants emit 84 of the 187 hazardous air pollutants that the Environmental Protection Agency has listed that pose a threat to the environment and human health. In addition to the previously discussed pollutants, coal-fired power plants have been found to release the following carcinogens: arsenic, benzene, cadmium, chromium compounds, dioxins, formaldehyde, and nickel. ("Tox Town") Benzene in particular has been linked to several types of leukemia. ("American Cancer Society")

Finally, all of these negative externalities ultimately can result in death. This



("National Map: Deaths from Coal")

map shows all of the deaths associated with coal in 2010. When compared to the map provided on page 4 it is easy to see that the deaths are concentrated around the same areas where coal mines are located. This map also shows the number of heart attacks, asthma attacks, hospital admissions, cases of chronic bronchitis, and asthma ER visits associated with coal. The darker and/or bigger the area, the greater the number of people affected. When all the information is totaled, the following is concluded: 13,200 deaths; 9,700 hospital admissions; 12,300 ER visits for Asthma; 20,400 heart attacks; 8,000 cases of chronic bronchitis; 217, 600 asthma attacks; and 1,627,800 lost work days. (Schneider and Banks 10) Ultimately all of these negative externalities will result in billions of additional dollars that need to be factored into the true cost of coal.

<u>The True Cost of Coal</u>

After taking into account the environmental impacts associated with coal I developed the following table. This table illustrates the amount of money spent annually on the negative externalities associated with coal. Currently, almost $250 billion is not factored into the cost of coal.

Mortality (Schneider and Banks)	$96,300,000,000
Hospital admissions (Schneider and Banks)	$230,000,000
ER visits for Asthma (Schneider and Banks)	$5,000,000
Heart attacks (Schneider and Banks)	$2,230,000,000
Chronic Bronchitis (Schneider and Banks)	$3,560,000,000
Asthma attacks (Schneider and Banks)	$11,000,000
Lost work days (Schneider and Banks)	$150,000,000
Abandoned Mine Lands ("Reclaiming Abandoned Mine Lands")	$8,775,282,692
Carbon dioxide (CO_2) emissions from coal-fired electricity	$18,067,200,000
Methane (CH_4) emissions from coal-fired electricity	$102,500,000
Nitrous oxide (N_2O) emissions from coal-fired electricity	$109,150,000,000
Lost productivity from mercury emissions (Trasande et al)	$1,625,000,000
Mercury emissions causing mental retardation (Trasande et al)	$289,000,000
Subsidies granted by the gov.'t (Adeyeye, Barrett, and et al)	$5,373,963,368
Land disturbance (Epstein et al)	$3,349,209,766
Total Amount	**$249,218,155,826**

While I was able to find many of these figures from other sources, some dollar amounts were calculated from existing data. Figures that I calculated were carbon dioxide emissions from coal-fired electricity, methane emissions from coal-fired electricity, and nitrous oxide emissions from coal-fired electricity.

Based off of the chart found on page 27, 2,258.4 Tg CO_2e of carbon dioxide, 0.5 Tg CO_2e of methane, and 18.5 Tg CO_2e of nitrous oxide was released in 2010. 2,258.4 Tg CO_2e of carbon dioxide is equal to 2,258,400,000 metric tons, 0.5 Tg CO_2e of methane is equal to 500,000 metric tons, and 18.5 Tg CO_2e of nitrous oxide is equal to 18,500,000 metric tons.

To convert these amounts into dollars they were multiplied by the social cost of each pollutant. The social cost is the marginal external costs that result from climate change. A 2011 report found that in 2010 the social costs of carbon dioxide, methane, and nitrous oxide were as follows: $8 per metric ton of carbon dioxide, $205 per metric ton of methane, and $5,900 per metric ton of nitrous oxide. (Waldhoff et al)

While this amount, $249,218,155,826, is not inclusive of every negative externality associated with coal, it does begin to give a better understanding how much is currently not being paid for by the coal industry.

Conclusions

"The electricity derived from coal is an integral part of our daily lives. However, coal carries a heavy burden. The yearly and cumulative costs stemming from…coal affect individuals, families, communities, ecological integrity, and the global climate. The economic implications go far beyond the prices we pay for electricity." (Epstein et al) With approximately 200 years worth of coal left in the United States it is irresponsible financially and environmentally to continuing using coal. In order to break the dependency on coal that has been fostered there are several different solutions that could help.

First, the $5,373,963,368 in annual subsidies needs to be immediately stopped. Currently, $72 billion in subsidies are offered for fossil fuels in general. Although the $29 billion in subsidies offered for alternative fuel sources far surpasses the $5.37 billion offered for coal, it pales in comparison to the $72 billion offered for all fossil fuels. (Adeyeye, Barrett, and et all) These massive government subsidies that favor coal only encourage its continued use. In addition to stopping the coal subsidies, the amount of subsidies for alternative fuel needs to be drastically increased.

A second solution would be to make the standards coal mines need to follow stricter. The more difficult and costly it becomes to mine coal; the more likely it is that consumers will be motivated to find alternative means of getting electricity. As the cost increases, and consumers find alternative sources of energy, the demand for coal will begin to decline.

A third, more drastic solution would be for congress to pass legislation similar to the Power Plant and Industrial Fuel Act of 1978. If congress mandates that power plants need to switch to alternative sources of energy the demand for coal would drastically fall. Some may argue that this would ultimately result in the loss of jobs; but, there are currently only 86,432 coal mining jobs in the country. ("Coal: Dangerous Power") This makes up less than half of one percent of the U.S. population. However, a job retraining program can be offered to those 86,432 coal workers, ideally job retraining that would enable them to work with alternative energy.

My final solution would be to add a severe tax to coal in order to compensate for the $249,218,155,826 that is not factored into the cost of coal currently. Again, with the cost of coal rising, consumers would be less inclined to continue using coal and more inclined to find alternative energy sources.

Realistically, some combination of these four solutions would likely produce the desired outcome, a decreased dependency on coal. No matter the solution, it is critically important that the United States break this dependency and begin to use alternative sources of energy. Continued coal use will not only continue to damage the environment severely, but it will continue to pose significant health risks to humans.

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