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# Coal in a Changing Climate

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## About NRDC

The Natural Resources Defense Council is a national nonprofit environmental organization with more than 1.2 million members and online activists. Since 1970, our lawyers, scientists, and other environmental specialists have worked to protect the world's natural resources, public health, and the environment. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, and Beijing. Visit us at www.nrdc.org.

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# Introduction

Coal is abundant and superficially cheap compared with the soaring price of oil and natural gas. But the true costs of conventional coal extraction and use are very dear. From underground accidents, mountain top removal and strip mining, to collisions at coal train crossings, to air emissions of acidic, toxic, and heat-trapping pollution from coal combustion, to water pollution from coal mining and combustion wastes, the conventional coal fuel cycle is among the most environmentally destructive activities on earth.

This NRDC analysis examines the changing climate for coal production and use in the United States and China, the world's two largest producers and consumers of coal. Together they are responsible for half of world coal production. In 2004, the use of coal resulted in 2.6 billion metric tons of heat-trapping carbon dioxide ($CO_2$) emissions in China and 3.9 billion metric tons of $CO_2$ in the United States, adding up to more than 20 percent of global $CO_2$ emissions from fossil fuel combustion. By 2030, China's $CO_2$ emissions from coal could grow to more than 8 billion metric tons ($GtCO_2$) and U.S. emissions to almost 3 $GtCO_2$ based on business-as-usual forecasts. Emissions from both countries are far higher than from any other country and will together constitute more than 60 percent of global $CO_2$ emissions from coal. NRDC is working in both the United States and China to reduce fossil fuel dependence and minimize damage to human health and the environment from coal production and use.[1]

To solve global warming and prevent the environmental harms from coal production, processing, transportation, and use the world must transition to an energy future based on efficient use of renewable resources. Energy efficiency is the cheapest, cleanest, and fastest way to meet our energy and environmental challenges, and renewable energy is the fastest growing supply option. Increasing energy efficiency and expanding renewable energy supplies will continue to be the top priority for NRDC's energy advocacy. At the same time, we recognize that the United States and China will continue for some time to rely heavily on coal to produce electricity, even though it is a poor choice considering its full economic, social, and environmental costs. In fact, China is building the equivalent of two large coal-fired power plants a week, and U.S. developers are proposing to build some 150 coal-fired power plants in the near future. If the coal-fired power plants currently under development are built as planned they will lock us in to a future of devastated landscapes, damaged public health, and dangerous global warming. Many of these proposed coal plants will be avoided with more attention to efficiency and greater use of renewable energy. But it is also essential to insist that the best available emission control technology is applied, including systems that capture and safely dispose of carbon dioxide, whenever and wherever coal is used.

There is no such thing as "clean coal." However, as far as the air pollution and global warming effects of coal are concerned, technologies ready for widespread commercial application can dramatically reduce emissions of carbon dioxide, mercury, sulfur, and nitrogen oxides from coal conversion. Although the other challenges remain, we must employ these technologies now to prevent even greater damage from coal use. The race for a better energy future is on.

# Background

Coal is the most abundant fossil fuel in the United States and throughout the world. Estimated recoverable coal accounts for more than 80 percent of global conventional fossil fuel resources. Even including unconventional oil and gas resources, coal still accounts for two-thirds of the fossil fuel resource base.[3]

## Coal Production

The largest coal resources are held by the United States, followed by Russia, China, India, and Australia. U.S. recoverable coal resources of 270 billion tons are about 250 times current annual production, while China's recoverable resources of 190 billion tons are about 80 times its current annual production.[4]

### Coal Production in the United States

The United States produces more than 1 billion tons of coal each year, with just over half of this total coming from mines in the West. Wyoming alone produces more than 400 million tons, more than two and a half times as much as any other state. Almost 90 percent of western coal production is from surface mining, which accounts for nearly all of Wyoming's production.[5]

Other western states currently produce only one-tenth or less of Wyoming's output, led by Montana and Colorado (40 million tons each in 2005), followed by North Dakota (30 million tons), New Mexico (28 million tons), and Utah (24 million tons).[6] In Colorado and Utah, underground mining is the dominant method.[7]

More than 40 percent of U.S. coal production comes from federal public lands, primarily in the West, and this production has increased by 20 percent in the last five years. In 2005 more than 453,000 acres of federal land were under coal leases, and the U.S. Bureau of Land Management (BLM) sold the rights to mine 1 billion tons of coal on this land.[8]

Appalachia is the second largest coal-producing region in the United States, with total production close to 400 million tons in 2005. West Virginia is the leading Appalachian producer (153 million tons in 2005), followed by Kentucky (119 million tons), Pennsylvania (67 million tons), Virginia (27 million tons), Ohio (24 million tons), and Alabama (21 million tons). Outside of Appalachia and the West, remaining U.S. coal production is classified as Interior, with Texas (46 million tons), Indiana (35 million tons), and Illinois (32 million tons) accounting for most of this production. About 65 percent of Appalachian production is from underground mining, whereas about 60 percent of Interior production is from surface mining. [9]

While 15 states produce more than 20 million tons of coal per year, the value of coal production represents more than 1.5 percent of gross state product in only three: Wyoming, West Virginia, and Kentucky (see Table 1). Pennsylvania, for example, is the fourth-largest coal producer, but the state has an expansive and diverse economy, so the value of Pennsylvania coal production represents less than 0.5 percent of the state's gross product. In Colorado the economic activity generated by the ski industry has been estimated at $2.0 billion to $2.5 billion per year, or roughly two and a half times the value of coal production. [10] But the political influence of coal producers far outstrips their economic importance, and a number of states seem eager to increase their coal production.

Coal prices on the spot market increased substantially during 2005 due to strong demand and the rising cost of competing fuels, particularly natural gas. Most coal is sold under long-term contracts, however, and the average price of coal delivered to electric utilities increased by only 13 percent between 2004 and 2005. [11]

**Table 1: 2005 Value of Coal Production**

| State | Production (thousand tons) | Average open-market price (dollars per ton) | Value (in thousands of dollars ) | Gross state product (in millions of dollars) | Value of coal produced share of gross state product |
|---|---|---|---|---|---|
| Wyoming | 404,310 | $7.71 | $3,117,230 | $27,269 | 11.43% |
| West Virginia | 153,650 | $42.14 | $6,474,811 | $53,050 | 12.21% |
| Kentucky | 119,734 | $39.68 | $4,751,045 | $140,501 | 3.38% |
| Pennsylvania | 67,494 | $36.39 | $2,456,107 | $489,025 | 0.50% |
| Texas | 45,939 | $17.39 | $798,879 | $989,443 | 0.08% |
| Montana | 40,354 | $9.74 | $393,048 | $29,885 | 1.32% |
| Colorado | 38,510 | $21.63 | $832,971 | $216,537 | 0.38% |
| Indiana | 34,457 | $25.31 | $872,107 | $238,568 | 0.37% |
| Illinois | 32,014 | $29.67 | $949,855 | $560,032 | 0.17% |
| North Dakota | 29,956 | $10.45 | $313,040 | $24,397 | 1.28% |
| New Mexico | 28,519 | $25.82 | $736,361 | $68,870 | 1.07% |
| Virginia | 27,743 | $47.97 | $1,330,832 | $351,903 | 0.38% |
| Ohio | 24,718 | $26.88 | $664,420 | $440,923 | 0.15% |
| Utah | 24,521 | $21.45 | $525,975 | $90,778 | 0.58% |
| Alabama | 21,339 | $53.63 | $1,144,411 | $151,610 | 0.75% |

Sources: http://www.eia.doe.gov/cneaf/coal/page/acr/table1.html; http://www.eia.doe.gov/cneaf/coal/page/acr/table28.html; http://www.bea.gov/bea/regional/gsp/; Energy Information Administration Form EIA-7A, "Coal Production Report"; U.S. Department of Labor, Mine Safety and Health Administration, Form 7000-2, "Quarterly Mine Employment and Coal Production Report."

### Coal Production in China

China produced more than 2.3 billion tons of coal in 2006, nearly 40 percent of the world's total and more than the United States, Russia, and India combined. Global annual coal production is on the rise as well, with projected increases of around 60 percent between 2004 and 2030. This rate of ramp-up will add 100 million tons of coal production worldwide each year, with the growth in coal production in China expected to account for 60 percent of this increase.[12]

More than 95 percent of China's coal comes from underground mines, often with a high sulfur and ash content. China's coal mining industry employs more than 7.8 million people in around 25,000 mines; 2,000 of these mines produce more than 100,000 tons per year.[13, 14] Many of the remaining small mines are illegal, inefficient, highly polluting, and have appalling safety records.

## Coal Use

More than 90 percent of the U.S. coal supply is used to generate electricity in some 600 coal-fired power plants scattered around the country, with the remainder used for process heat in steel manufacturing and other heavy industrial production. Coal is used for power production in all regions of the country, with the Southeast, Midwest, and Mountain states most reliant on coal-fired power. Texas uses more coal than any other state, followed by Indiana, Illinois, Ohio, and Pennsylvania.[15]

About half of the U.S. electricity supply is generated using coal-fired power plants. This share varies considerably from state to state, but even California, which uses very little coal to generate electricity within its borders, obtains nearly 20 percent of its total electricity from coal generated in neighboring Arizona and Nevada.[16] National coal-fired capacity totals 330 billion watts (GW), with individual plants ranging in size from a few million watts (MW) to in excess of 3,000 MW. More than one-third of this capacity was built before 1970, and more than 400 units built in the 1950s—with capacity equivalent to roughly 160 modern plants (48 GW)—are still operating today.

In China, more than half of the coal supply is used to generate electricity, with the rest used primarily for production of steel, cement, and chemicals, as well as for domestic heating and cooking. The country's total power generation capacity topped 600 billion watts (GW) in 2006, an increase of 20 percent from 2005.[17] Given China's skyrocketing economic growth, which exceeded 10 percent in 2006, this figure is expected to reach more than 800 GW by 2010, making China the fastest-growing power sector in the world.[18] Seventy-eight percent of China's current power generation capacity—484 GW—comes from coal-fired plants, which range in size from a few MW to 1,000 MW. There are more than 2,000 power plants in China today with a capacity of greater than 12 MW.[19]

# The Toll from Coal

The way coal is currently produced and used damages the land, water, and air, severely harming public health and the environment. Environmental insults begin with coal mining and transportation, continue with combustion, and leave behind a legacy of waste. This section summarizes these effects in this fuel-cycle order (which is not meant to imply an order of priority).

## Environmental Effects of Coal Production

### Health and Safety Risks

Recent high-profile accidents in Pennsylvania and West Virginia refocused the nation's attention on the hazards of coal mining, which remains one of the United States' most dangerous professions. The yearly fatality rate in the industry is 0.23 per thousand workers, making the industry about five times as hazardous as the average private workplace. [20] The industry had 22 fatalities in 2005, an all-time low, but 2006 was much more deadly, with 47 fatalities. [21] Eighteen of these deaths occurred during a one-month period. These high fatality rates nonetheless reflect significant reductions since the early part of last century. In 1925 there were 2,518 fatalities; since then, the coal industry workforce has shrunk due to automation, while output has grown. [22] Coal miners also suffer many nonfatal injuries and are vulnerable to serious diseases, most notably black lung disease (pneumoconiosis) caused by inhaling coal dust. Although the 1969 Coal Mine Health and Safety Act seeks to eliminate black lung disease, the United Mine Workers estimate that 1,500 former miners die of black lung each year. [23]

China's coal mining industry is the most dangerous in the world. Although it produced nearly 40 percent of the world's coal in 2005, it reported 80 percent of the total deaths in coal mine accidents. With soaring demand for coal in China, mine operators often ignore safety standards in search of quick profits. Other factors include inadequate safety equipment and a lack of safety education among miners. In 2006, 4,746 coal mining deaths were reported, occurring due to coal mine floods, cave-ins, fires, and explosions, resulting in an average of 13 coal miner deaths a day.[24] Using these official figures, it can be said that a Chinese miner is more than 100 times more likely to die on the job than a miner in the United States; however, this could be a great understatement as some scholars indicate that, including unreported deaths, coal mining in China could result in closer to 20,000 deaths a year.[25] In addition, about 300,000 coal miners suffer from black lung disease in China, with 5,000 to 8,000 new cases arising each year.[26]

### Destruction of Terrestrial Habitats

Coal mining—and particularly surface or strip mining—poses one of the most significant threats to terrestrial habitats in the United States. The Appalachian region, for example, which produces more than 35 percent of our nation's coal, is one of the most biologically diverse forested regions in the country.[27,28] But surface mining activity clearcuts trees and fragments habitat, destroying natural areas that were home to hundreds of unique species of plants, invertebrates, salamanders, mussels, and fish. Even where forests are left standing, fragmentation is of significant concern because a decrease in patch size is correlated with a decrease in biodiversity as the ratio of interior habitat to edge habitat decreases. This is of particular concern to certain bird species that require large tracts of interior forest habitat, such as the black-and-white warbler and the black-throated blue warbler. While underground mining generally results in less surface disturbance, land subsidence, particularly from longwall mining, can also destroy habitat.

After mining is complete, these once-forested regions in the Southeast are typically reclaimed as grasslands, although grasslands are not a naturally occurring habitat type in this region. Reclamation practices limit the overall ecological health of sites, and it has been estimated that the natural return of forests to reclaimed sites may take hundreds of years.[29] Grasslands that replace the original ecosystems in areas that were surface mined are generally characterized by less-developed soil structure and lower species diversity compared with natural forests in the region.[30,31] Reclaimed grasslands also show a high degree of soil compaction, which tends to limit the ability of native tree and plant species to take root. According to the USEPA, the loss of vegetation and alteration of topography associated with surface mining can lead to increased soil erosion and may lead to an increased probability of flooding after rainstorms.[32]

The destruction of forested habitat not only degrades the quality of the natural environment but also destroys the aesthetic values that make the Appalachian region such a popular tourist destination. About 1 million acres of West Virginia mountains have been permitted for strip mining and mountaintop removal mining since 1977.[33] Many of these mines have yet to be reclaimed; where there were once forested mountains, there now stand crippled mounds of sand and gravel.

A tremendous amount of strip mining for coal also occurs in the Western United States.[34] As of 2005, surface mining had been permitted on 750,000 acres in just five western states: Wyoming, Colorado, New Mexico, Montana, and North Dakota.[35] Unlike the East, much of the West—including much of the region's principal coal areas—is arid and predominantly unforested. In the West, as in the East, surface mining activities cause severe environmental damage as huge machines strip, rip apart, and scrape aside vegetation, soils, and wildlife habitat as they drastically—and permanently—reshape existing land forms and the affected area's ecology to reach the subsurface coal. Strip mining replaces precious open space with invasive industrialization that displaces wildlife, increases soil erosion, takes away recreational opportunities, degrades the wilderness, and destroys the region's scenic beauty.[36] Forty-six western national parks are located within 10 miles of an identified coal basin, and these parks could be significantly damaged by future surface mining in the region.[37]

Land reclamation in the West after destructive mining tears through an area can be problematic because of climate and soil quality conditions. And as in the East, reclamation of surface mined areas does not necessarily restore pre-mining wildlife habitat and may require that scarce water resources be used for irrigation—a significant threat in a part of the country plagued by drought. [38]

**Water Pollution**

Coal production causes negative physical and chemical changes to nearby waters. In all types of coal mining in both the United States and China, the "overburden" (earth layers above the coal seams) is removed and deposited on the surface as waste rock, which often ends up in nearby streams and rivers.

The most significant physical effect on water occurs from valley fills, the depositing of waste rock associated with mountaintop removal (MTR) mining. Valley fills commonly bury the headwaters of streams, which in the southeastern United States support diverse and unique habitats and regulate nutrients, water quality, and flow quantity. The elimination of headwaters therefore has long-reaching impacts many miles downstream. [39] The government has estimated that valley fills buried more than 700 miles of streams from 1985 to 2001, and that roughly 1,200 miles of streams were affected by MTR, including valley fills, sedimentation, and chemistry alteration between 1992 and 2002. [40] Valley fills have done such extensive damage that the waterways harmed by them are nearly as long as the Mississippi River. Other types of mining activity also do damage to the water supply. Strip mining, particularly in the semi-arid West, and subsidence from underground mining can damage the underground aquifers that supply drinking water and water for households, agricultural purposes, and recharge surface waters.

Coal mining of all types can also lead to increased sedimentation, which affects water chemistry and stream flow and negatively impacts aquatic habitat. Valley fills in the eastern United States and waste rock from strip mines in the West add sediment to streams, as do the construction and use of roads in mining complexes. A final physical impact of mining on water involves the hydrology of aquifers. MTR and valley fills remove upper drainage basins and often connect two previously separate aquifers, altering the surrounding groundwater recharge scheme. [41]

Chemical pollution produced by coal mining operations comes most significantly in the form of acid mine drainage (AMD). In both underground and surface mining, sulfur-bearing minerals common in coal mining areas are brought up to the surface in waste rock. This problem could be exacerbated to the extent that advanced sulfur dioxide pollution controls allow increased use of high-sulfur coal. When these minerals come in contact with precipitation and groundwater, an acidic leachate is formed. This leachate picks up heavy metals and carries these toxins into streams or groundwater. Waters affected by AMD often exhibit increased levels of sulfate, total dissolved solids, calcium, selenium, magnesium, manganese, conductivity, acidity, sodium, and nitrate, reflecting drastic changes in stream and groundwater chemistry. [42] The degraded water becomes less habitable, non potable, and unfit for recreational purposes. The acidity and metals can also corrode structures such as culverts and bridges. [43] In the eastern United States, AMD has damaged an estimated 4,000 to 11,000 miles of streams. In the West, estimates are between 5,000 and 10,000 miles of streams polluted. [44]

The effects of AMD can be diminished through addition of alkaline substances to counteract the acid, but recent studies have found that the addition of alkaline material can increase the mobilization of both selenium and arsenic, causing these chemicals to reach the water even more rapidly. [45] AMD is costly to mitigate, requiring more than $40 million annually in Kentucky, Tennessee, Virginia, and West Virginia alone. [46]

## Air Pollution

There are two main sources of air pollution during the coal production process. The first is methane emissions from the mines. Methane is a powerful heat-trapping gas and is the second most significant contributor to global warming after carbon dioxide. According to the most recent official inventory of U.S. global warming emissions, coal mining results in the release of 3 million metric tons of methane per year, which is equivalent to 68 million metric tons of carbon dioxide. [47]

Methane emissions from coal mines make up between 10 and 15 percent of anthropogenic methane emissions in the United States. All coal contains methane, but the amount depends on the nature of the coal. Generally speaking, deeper coal seams have higher methane content. Underground mines therefore are by far the largest source of coal mine methane emissions, accounting for about 65 to 70 percent of the total. Most of the methane emitted from underground mines escapes through ventilation systems put in place for safety measures or through other shafts and portals. The remainder is released during the handling and processing of the coal after it has been mined.

The second significant form of air pollution from coal mining is particulate matter (PM) emissions. While methane emissions are largely from eastern underground mines, PM emissions are particularly serious at western surface mines. Mining operations in the arid, open, and frequently windy region creates a significant amount of particulate matter. These wind-driven dust emissions occur during nearly every phase of coal strip mining in the West, but the most significant sources are removal of the overburden through blasting and use of draglines, truck haulage of the overburden and mined coal, road grading, and wind erosion of reclaimed areas. The diesel trucks and equipment used in mining are also a source of PM emissions.

Particulate matter emissions are a serious health threat that can cause significant respiratory damage as well as premature death. [48] In 2002, one of Wyoming's coal producing counties, Campbell County, exceeded its ambient air quality threshold several times. Air pollution in Campbell County almost earned it nonattainment status, which would have prevented construction of two 90-megawatt power plants that have triggered a 7 percent increase in coal production. [49] Coal dust problems in the West are likely to get worse under EPA's recently finalized revisions to the national ambient air quality standards (NAAQS) for PM, which eliminate the annual standard for coarse PM ($PM_{10}$). [50]

## Coal Mine Waste

Coal mining leaves a legacy of wastes long after mining operations cease. One significant waste is the sludge that is produced from washing coal. There are currently more than 700 sludge impoundments strewn throughout mining regions, and this number continues to grow. These impoundment ponds pose a potential threat to the environment and human life. If an impoundment fails, the result is disastrous. In 1972 an impoundment break in West Virginia released a flood of coal sludge that killed 125 people. In 2000 another impoundment break covered an area in Kentucky with more than 300 million gallons of slurry (30 times the size of the *Exxon Valdez* spill), killing all aquatic life in 20 miles of stream, destroying homes, and contaminating much of the drinking water in the eastern part of the state. [51] Another waste from coal mining is the solid waste rock left behind from tunneling or blasting. This can set off a number of the environmental impacts previously discussed, including acid mine drainage (AMD). Adding to the coal mine waste problem is the legacy of mines no longer in use: If a mine is abandoned or a mining company goes out of business, the former owner is under no legal obligation to clean up and monitor the environmental wastes, leaving the responsibility in the hands of the state. [52]

### Damage to Surrounding Communities

Coal mining can also have serious impacts on nearby communities. Residents have reported that in addition to creating noise and dust, dynamite blasts can crack the foundations of homes, and many cases of subsidence due to the collapse of underground mines have been documented. [53] Subsidence can cause serious damage to houses, roads, bridges, and any other structures in the area. Blasting can also damage wells, and changes in the topography and structure of aquifers can cause these wells to run dry.

### Environmental Impacts of Coal Mining in China

Coal mining in China has destroyed 4 million hectares of land, a figure that increases by more than 46,000 hectares each year; only 12 percent of this land has been reclaimed.[54, 55] Land subsidence from mining covers 700,000 hectares, causing more than 50 billion RMB ($6.2 billion) in economic losses.[56] China also leads the world in overall coal mine methane (CMM) emissions, releasing 183 million metric tons of carbon dioxide equivalent from coal mining activities in 2004.[57] CMM emissions are projected to increase dramatically in the next several decades as a result of expected increases in coal production.

## Environmental Effects of Coal Transportation

Transporting coal from where it is mined to where it will be burned also produces significant quantities of air pollution and other environmental harms. Diesel-burning trucks, trains, and barges that transport coal release $NO_x$, $SO_x$, PM, VOCs (volatile organic chemicals), CO, and $CO_2$ into the earth's atmosphere. Trucks and trains transporting coal release more than 600,000 tons of $NO_x$ and over 50,000 tons of $PM_{10}$ into the air annually (barge pollution data are unavailable). [58, 59] In addition to the serious public health risks from these toxic emissions, black carbon from diesel combustion contributes to global warming. [60]

The trucks used to transport coal leave a trail of environmental hazards in their wake, from land disturbance caused by trucks entering and leaving the mine complex to coal dust particles released into the air along the transport route. [61] For example, a national magazine reported that in Sylvester, West Virginia, a Massey Energy coal processing plant and the trucks associated with it spread so much dust around the town that "Sylvester's residents had to clean their windows and porches and cars every day, and keep the windows shut."[62] Even after a lawsuit and a court victory, residents—who now call themselves "Dustbusters"—still "wipe down their windows and porches and cars." [63]

Local communities also have concerns about the size of the coal trucks that barrel through their neighborhoods. According to one report, in a Kentucky town coal trucks weighing 120 tons with their loads were common, and "the Department of Transportation signs stating a thirty-ton carrying capacity of each bridge had disappeared." [64] Although the coal company there has now adopted a different route for its trucks, community representatives in Appalachia believe that coal trucks should be limited to 40 tons. [65]

Almost 60 percent of coal in the United States is transported at least in part by train, with coal transportation accounting for 44 percent of rail freight ton-miles. [66] Coal trains some of which reach more than two miles in length, cause railroad-crossing collisions and pedestrian accidents (there are approximately 3,000 such collisions and 900 pedestrian accidents every year) and interruption in traffic flow (including disruption to emergency responders such as police, ambulance services, and fire departments).

Coal is also sometimes transported in a coal slurry pipeline, such as the one used at the Black Mesa Mine in Arizona. In this process the coal is ground up and mixed with water in a roughly

50:50 ratio. The resulting slurry is transported to a power station through a pipeline. This requires large amounts of fresh groundwater. To transport coal from Black Mesa to the Mohave Generating Station in Nevada, Peabody Coal pumped more than 1 billion gallons of water from an aquifer near the mine each year. This water came from the same aquifer used for drinking water and irrigation by members of the Navajo and Hopi nations in the area. Water used for coal transport has led to a major depletion of the aquifer, causing water levels to drop more than 100 feet in some wells. In the West, coal transport through a slurry pipeline places additional stress on an already depleted water supply. Maintenance of the pipe requires washing, which uses still more fresh water. Not only does slurry-pipeline transport result in a loss of fresh water, but it can also lead to water pollution when the pipe fails and coal slurry is discharged into ground or surface water.[67] The Peabody pipe failed 12 times between 1994 and 1999. (The Black Mesa mine closed in January 2006 when its sole customer, the Mohave Generating Station, shut down because its emissions exceeded current air pollution standards.)

# Environmental Effects of Coal Use

Coal combustion produces enormous quantities of air pollutants that severely harm public health and the environment. Respiratory ailments, premature death, and cardiovascular illnesses are some of the serious health dangers associated with the air pollution caused by coal combustion. The combustion process generates heat-trapping carbon dioxide—the largest driver of global warming—and emissions of mercury and other toxic elements and compounds. Coal-fired power plants also use large quantities of water for cooling, directly affecting water quality, and produce more than 120 million tons of solid waste per year.

## Air Pollutants

There are five major conventional air pollutants from coal combustion:

- particulate matter (PM), in the form of both fine and coarse PM (PM measuring 2.5 micrometers or less in diameter [$PM_{2.5}$] or 10 micrometers or less in diameter [$PM_{10}$], respectively);
- oxides of nitrogen ($NO_x$), which produce smog;
- sulfur dioxide ($SO_2$), which causes acid rain ($NO_x$ and $SO_2$ also contribute to the formation of secondary PM in the ambient air, causing respiratory ailments and limiting visibility);
- mercury (Hg) and other toxic substances; and
- carbon dioxide ($CO_2$), the most important heat-trapping gas driving global warming.

The effects of each of these air pollutants are discussed in turn in the sections that follow.

### Particulate Matter (PM)

The Environmental Protection Agency (EPA) reports that coal-fired utilities in the United States were responsible for more than 219,000 tons of $PM_{10}$ emissions in 2002 and 114,000 tons of $PM_{2.5}$. Significantly, these emissions estimates do not include secondary PM, which forms in ambient air from precursors such as $SO_2$ and $NO_x$.[68] Some studies have estimated that secondary PM can account for as much as 60 percent of a facility's overall PM emissions.

The health effects from exposure to PM include premature deaths (primarily among the elderly and those with heart or lung disease); chronic bronchitis and heart attacks; aggravation of respiratory and cardiovascular illness, leading to more hospitalizations and emergency room visits (particularly for children, the elderly, and individuals with heart disease or respiratory conditions); changes to lung structure and natural defense mechanisms; decreased lung function and symptomatic effects such as those associated with acute bronchitis (particularly in children and people with asthma); lost work days; and an increase in school absences. Currently, nearly 70 million people in the United States live in areas with unhealthy levels of particulate matter pollution.

### Sulfur Dioxide ($SO_2$)

The EPA also reports that 10.3 million tons of $SO_2$ were released from U.S. power plants in 2004, 95 percent of these emissions coming from coal-fired plants.[69] $SO_2$ causes acid rain, which in turn acidifies lakes and streams, destroying aquatic habitat, damaging forest trees and plants (particularly trees at high elevations, such as red spruce above 2,000 feet), and impairing sensitive forest soils. In addition, acid rain accelerates the decay of building materials and paints, including the irreplaceable buildings, statues, and sculptures that are part of our nation's cultural heritage. Moreover, before they precipitate out of the ambient air, $SO_2$ and $NO_x$ (and their particulate matter derivatives, sulfates and nitrates) scatter light and create hazy conditions, decreasing visibility. This spoils scenic vistas across broad regions of the country, including in many national parks and wilderness areas as well as in urban regions. On the haziest days, visibility in some national parks is reduced as much as 80 percent, dropping visibility to 10 miles or less.

### Nitrogen Oxides ($NO_x$)

$NO_x$ emissions from power plants in the United States totaled about 3.9 million tons in 2004, with more than 90 percent of these emissions coming from coal-fired units.[70] $NO_x$ emissions contribute significantly to the formation of harmful ground-level ozone.[71] Ozone is the primary component of smog and is associated with numerous adverse impacts, including decreases in lung function that cause shortness of breath and other breathing problems; respiratory symptoms such as aggravated coughing and chest pain; an increase in asthma attacks, susceptibility to respiratory infection, and other respiratory problems; an increase in hospital admissions and emergency room visits; and reduced productivity for workers in outdoor jobs. Repeated exposure to ozone can result in chronic inflammation and irreversible structural changes in the lungs that can lead to premature aging of the lungs and other long-term respiratory illnesses. Additionally, ground-level ozone damages forest ecosystems, trees and ornamental plants, and crops. Currently, more than 110 million Americans live in areas with unhealthy levels of ozone.

### Mercury and Other Toxic Elements and Compounds

Coal-fired units are the largest U.S. source of human-made mercury pollution, emitting approximately 48 tons each year.[72] In addition, U.S. coal-burning plants annually emit 56 tons of arsenic, 62 tons of lead compounds, 62 tons of chromium compounds, 23,000 tons of hydrogen fluoride, and 134,000 tons of hydrochloric acid.[73]

The adverse public health and environmental effects of these toxic chemicals are both serious and long lasting. Mercury pollution from power plants, for example, is deposited on soil and in water, where it transforms chemically into a highly toxic form (methylmercury) that accumulates in the tissues of fish.[74] More than 13 million lake-acres and 750,000 river-miles in the United States are subject to fish consumption advisories due to elevated mercury.[75] Human exposure to mercury most commonly occurs through the consumption of contaminated fish, which can cause significant health effects. Mercury is particularly toxic to fetuses and young infants exposed during periods of rapid brain development. [76] Affected children are at risk of developmental and neurological harm, such as delayed developmental milestones, reduced neurological test scores, and, at high doses, cerebral palsy. [77] A July 2005 report from the federal Centers for Disease Control and Prevention (CDC) concluded that one in 17 women of childbearing age in the United States has mercury in her blood above 5.8 micrograms per liter—a level that could pose a risk to a fetus. This is an improvement from a prior report in 2003, which showed that one out of 12 women had mercury in her blood at this level. Newer science indicates, however, that mercury actually concentrates in the umbilical cord blood that goes to the fetus, so mercury levels as low as 3.4 micrograms per liter of a mother's blood are now a concern. Nearly one in 10 women of reproductive age in the United States has mercury in her blood at or above this level, according to the new CDC study. Significant evidence also links methylmercury exposure to cardiovascular disease. [78]

The other hazardous air pollutants (HAPs) emitted by power plants, which include arsenic, chromium, nickel, cadmium, dioxins, lead compounds, hydrochloric acid, and hydrogen fluoride, can also cause a wide variety of additional adverse health effects, including central nervous system damage, and cancer. [79, 80]

### Carbon Dioxide ($CO_2$)

Coal-fired power plants are the largest source of global warming pollution in the United States. These plants emitted 1.89 billion tons of carbon dioxide ($CO_2$) in 2004, accounting for more than 80 percent of the emissions from electric power production and more than 30 percent of total U.S. $CO_2$ emissions from all sources.

While technology exists to capture $CO_2$ from new coal-fired plants for safe disposal underground, only California has a law requiring plants to do so. It is very unlikely that conventional coal combustion plants will be retrofitted for $CO_2$ capture due to the high cost and large energy requirements of such add-on controls. Hence, the existing stock of coal-fired power plants as well as any new conventional plants that are built are not only a source of current emissions, but represent a commitment to an enormous stream of emissions over their lifetimes. Existing U.S. coal-fired power plants are expected to generate 90 billion tons of carbon dioxide over their expected remaining lifetimes. [81]

The carbon "shadow" from coal-fired power plants will grow enormously over the next 25 years if current business-as-usual forecasts are realized. More than 100 conventional coal-fired power plants are already in various stages of development in the United States, and the Department of Energy projects that more than 150 GW (the equivalent of 300 large plants) of new conventional coal-fired capacity will be built by 2030.[82] The carbon shadow from these plants would be an additional 62 billion tons of $CO_2$. Under this scenario, the committed emissions just from U.S. coal-fired power plants would be 150 billion tons of $CO_2$—half the total emissions the United States could produce from 2000 to 2050 within a global effort to prevent dangerous global warming.[83]

## Other Pollutants

### Water Damage

Coal-fired power plants not only pollute the air but also foul the water in the places they operate. In a detailed report titled "Wounded Waters," [84] the Clean Air Task Force summarized a number of insults that utilities inflict on the watersheds they use primarily for cooling water:

- entrainment and impingement of fish and shellfish species from cooling water intakes, with resultant damage to fish populations and economic fishing losses;

- alteration of water levels and flows in ways that can be damaging to plant and animal communities;
- discharge of water at temperatures as much as 60 degrees hotter than the water body from which it came, threatening aquatic ecosystems that cannot sustain such a temperature shock; and
- discharge of toxic chemicals used not only to keep cooling water usable but also to support boiler operation and as part of waste treatment

According to the report, the cumulative damage from intake and discharge from multiple plants along a river, in a coastal area, or near other important waters is poorly understood but can cause considerably more damage than would occur from any single plant. [85] In other words, power plants potentially can affect virtually every aspect of a water body's health and productivity.

**Coal Combustion Waste**

In addition to airborne pollutants such as carbon dioxide, sulfur dioxide, and mercury, coal combustion also yields more than 120 million tons of solid and liquid waste annually. These wastes are largely made up of the noncombustible constituents of coal, as well as particulate matter, sulfur, and other pollutants that have been captured by emissions control technologies. Along with large quantities of ash, coal combustion waste (CCW) can often contain significant amounts of toxic compounds and elements, especially heavy metals such as lead, cadmium, mercury, selenium, and arsenic. The primary environmental risk associated with the disposal of CCW is the possibility that the waste will come into contact with water and that the resulting leachate will infiltrate nearby drinking water supplies and aquatic habitats.

Coal combustion waste is typically handled in one of four ways: surface impoundment, landfilling, minefilling, and other "beneficial uses." Surface impoundments pose the greatest risk because they are left aboveground for extended periods of time in a liquid slurry state with a high potential for leaching into the surrounding environment. Due to these risks, the use of impoundments has declined in recent years from 25 percent of all CCW in 1996 to 19 percent in 2003.[86] Landfilling and minefilling are both safer alternatives because they present far fewer opportunities for contaminants to leach into surface water and groundwater. However, all three of these disposal strategies have the potential to cause significant harm to human health and the environment.

The EPA has recognized 24 instances in which CCW disposal has caused damage to nearby waters. [87] These instances are roughly split between landfills and surface impoundments, though landfilling has historically accounted for about twice as much disposal as impoundments. Minefilling is not currently a common practice, though it figures to become more prominent as an alternative to surface impoundment. Degradation from these activities is generally the result of toxic chemicals leaching into groundwater that is connected to nearby surface waters. This situation is more likely to occur where there is a permeable or otherwise insufficient barrier between CCW and nearby groundwater, where drinking water supplies and aquatic habitats are in close proximity to the disposal site, and where the water table is relatively shallow. When locating a site for CCW disposal, it is therefore necessary to consider the physical properties of the site in addition to the necessary preventive measures such as impermeable barriers.

Perhaps the best method of CCW disposal is to recycle it as raw material for certain construction and engineering products such as cement, wallboard, and roofing tiles. The use of coal combustion waste for these and similar purposes has increased in recent years, from 25 percent in 1995 to 38 percent in 2003.[88] The EPA recently found that the use of CCW in construction and engineering products does not pose a significant threat to human health and the environment. Rather than paying to dispose of these wastes, coal-fired power plants can sell them at a profit. The existence of these "beneficial uses" therefore serves as an economic incentive to improve water quality. These beneficial uses are particularly attractive with Integrated Gasification Combined Cycle (IGCC) power plants, whose elemental sulfur and sulfuric acid byproducts are generally in high demand.

Despite the advantages of these uses, it is best to be prudent in their application. While concrete and wallboard made from CCW will likely not leach toxic elements and compounds during their useful lifetime, it is also important to consider the environmental effects of their ultimate disposal.

## Environmental Effects of Coal Use in China

China's coal sector is not only the world's largest, but also the most dangerous and most polluting. Pulmonary disease, closely related to air pollution from coal burning, is the second largest single cause of adult deaths in China (13.9 percent of the total).[89] An estimated 400,000 people die each year in China from $SO_2$ emission–related illnesses.[90] The Chinese government has estimated that the health costs of air pollution account for up to 2 percent of China's gross domestic product (GDP).[91]

Most of China's coal is either burned directly or burned in power plants with limited pollutant controls, resulting in significant emissions of $SO_2$, particulates, mercury, and $NO_x$. China leads the world in sulfur dioxide emissions, with more than 25 million tons of total $SO_2$ emissions in 2005.[92] About 90 percent of the total, more than 20 million tons, was attributable to coal combustion.[93] Acid rain falls on an estimated 30 percent of China's land mass, causing at least 110 billion RMB (US$ 13.3 billion) of damage each year.[94,95] Coal burning in China was responsible for about 10 million tons of particulate matter emissions, about 70 percent of total emissions.[96] The World Bank calculates the costs of exposure to fossil fuel particulates for urban residents in China, under an emissions-as-usual scenario, will rise to nearly $400 billion in 2020, equivalent to 13 percent of GDP.[97]

China also emits almost 700 tons of mercury into the world's atmosphere each year, accounting for nearly a quarter of the world's industrial emissions.[98,99] And mercury is a toxic substance that knows no boundaries; some scientists estimate that 30 percent or more of the mercury settling into U.S. soil and waterways comes from other countries—particularly China.[100]

China emitted 4.77 billion tons of carbon dioxide in 2004 and more than 183 million tons $CO_2$ equivalent in coal-mine methane.[101,102] Most analysts estimate that China's emissions of $CO_2$ more than doubled from 1990 to 2004, accounted for more than 18 percent of global carbon dioxide emissions in 2004.[103] While China's per capita emissions remain far lower than those in the United States, its emissions are continuing to grow by as much as 4.5 percent per year, the fastest increase of any major nation.[104] Due to rapid economic growth and increasing reliance on coal, China is expected to overtake the United States as the world's leading carbon emitter by 2010.[105]

# What Is the Future for Coal?

The pervasive environmental effects of coal production and use belie the "clean coal" rhetoric of industry promoters. Reducing the harms from coal requires a multi-pronged approach. Our first priority is to minimize dependence on coal and other fossil fuels through more efficient use of energy and greater development of renewable energy resources. Indeed, these resources have the technical capability fully to meet both the U.S. and China's demands for energy services. Nonetheless, it appears inevitable that both countries will continue to rely heavily on coal to generate electricity for many years. Thus, every effort also must be made to minimize the environmental harm from coal production, processing and transportation and to require that power companies use the best available technology for coal conversion to dramatically reduce emissions of $NO_x$, $SO_x$, Hg, and $CO_2$ from coal use.

## Reducing Fossil Fuel Dependence

There is enormous potential to reduce the demand for fossil fuels by aggressively promoting more efficient use of electricity and electricity production from renewable resources. Increasing energy efficiency is by far the most cost-effective way to avoid emitting carbon dioxide and has been the hallmark of NRDC's energy advocacy for 30 years. Technologies range from efficient lighting, including emerging LED lamps, to advanced selective membranes that reduce industrial process energy needs. Critical national and state policies include appliance efficiency standards, performance-based tax incentives, utility-administered deployment programs, and innovative market transformation strategies that make more efficient designs standard industry practice.

The potential is even greater in China. At a growth rate of 5 percent annually under business-as-usual assumptions, China's total electricity demand will rise by more than 2,600 gigawatts (GW) by

2050.[106] This is the equivalent of building almost four 300 MW power plants every week for the next 45 years.[107] NRDC's analysis shows that energy efficiency incentive programs have the potential to reduce China's growth in electricity demand by almost 950 GW by 2050. Efficiency investments could therefore make unnecessary the construction of more than 3,000 power plants, which would likely be coal-fired, preventing emissions of more than 4 billion metric tons of carbon dioxide per year by 2050. Application and enforcement of strong efficiency codes and standards could double those savings.

China is determined to improve its energy efficiency because for every dollar of economic output, China uses five times more energy than the United States and 12 times more than Japan.[108] China's Eleventh Five-Year Plan, which went into effect in January 2006, calls for a 20 percent reduction in energy use per unit of GDP by 2010.[109] Achieving this target while doubling its economy, China's other major goal, could do more than any other current initiative to reduce China's growth in GHG emissions.

Electricity generation by renewable resources is also expanding rapidly; recent decreases in the price of wind and biomass technologies indicate that these areas offer some of the most cost-effective renewable power generation options in both countries.[110] Some 20 U.S. states have adopted renewable portfolio standards requiring electricity providers to obtain a minimum portion of their portfolio from renewable resources. Federal tax incentives have also played an important role, particularly for wind, although uncertainty about when tax credits will expire has limited their effectiveness at spurring new investment. China's renewables sector is the world's fastest growing, at more than 25 percent annually.[111] China has enacted a new Renewable Energy Law and vowed to meet 15 percent of its energy needs with renewable energy by 2020.[112] A recent report by the China Renewable Energy Industries Association and Greenpeace International finds that China could double its current wind energy plan and deliver 40 GW of wind power within 15 years, rising to 10 times that amount by 2050.[113] This would put China on track to become the world's largest wind energy market by 2020.[114] The report also concludes that there is enough viable wind resource in China to completely power the whole country.[115]

The ability of effective energy efficiency and renewable energy policies to avoid fossil-fuel power generation has been demonstrated in practice in California. Per capita electricity use in California has remained essentially constant since 1975 and is now 40 percent lower than the average for other states. Nonetheless, California energy policymakers recognize the potential for enhanced efficiency gains and have committed to new programs that will continue the trend of flat or declining per capita electricity consumption through at least 2013 (see http://www.nrdc.org/air/energy/fcagoals.asp). Renewable energy sources other than hydropower supply 10 percent of the electricity consumed in California, and nonfossil resources overall generate almost 40 percent of California's supply, compared with national averages of 2 percent and 29 percent, respectively.[116]

The national potential for energy efficiency and renewable energy to satisfy a substantial portion of United States' electricity service needs has been examined recently in the Clean Energy Blueprint developed by the Union of Concerned Scientists (UCS). Based on aggressive national standards and other policies to promote energy efficiency, renewable energy, and combined heat and power, UCS projects that one-third of the expected electricity demand in 2020 could be avoided through energy efficiency and that nonhydro renewable energy could supply 20 percent of the electricity needs not supplied by combined heat and power. If this scenario were realized, the United States would not need to build any new coal-fired power plants. (New plants with carbon capture could still help reduce emissions if they replaced existing plants.)[117]

## Reducing the Impacts of Coal Production

Environmental damage from coal production, processing, and transportation must be reduced. In both the United States and China significant progress could be made simply by enforcing laws already on the books. Unfortunately, the U.S. coal industry has used its political clout to carve systematic loopholes in the way these laws are implemented. As long as the Bush Administration is in office, there is little chance that better enforcement will occur, let alone that its improper and often illegal interpretations of existing statutes will be voluntarily reversed, and requirements for protection and restoration of the landscape affected by mining activities strengthened. In the United States, there is an urgent need for congressional oversight of the implementation of the laws and programs governing coal mining and use. In China, booming demand and high prices for coal mean regulations are often ignored, production is pushed beyond safe limits, and mines that have been shut down reopen illegally. In both nations, stronger enforcement measures are desperately needed.

### Enforce the Clean Water Act

As discussed below, mountaintop removal mining and the related practice of destroying mountain streams by filling them with mining wastes are fundamentally inconsistent with the Clean Water Act. NRDC believes that these unsustainable approaches to coal mining must be abolished. Congress must ensure that the Clean Water Act's protections against fouling America's rivers and streams are properly enforced by the administration. This will force mining companies to internalize some of the costs of their destructive mining practices. Unfortunately, in recent years, the Army Corps of Engineers has taken a pair of regulatory actions to minimize coal producers' Clean Water Act obligations, to the detriment of communities and ecosystems in Appalachia that are threatened by mountaintop removal mining.

First, the Corps redefined coal mining waste as "fill" so that it would be subject to the dredge and fill permitting program administered by the Corps rather than the pollutant discharge program run by EPA. [118] Second, the Corps issued a general permit, authorizing surface mines to dump such "fill" (including excess mining-related material from mountaintop removal) into rivers and streams with few preconditions to actually protect the resource. Ending the lenient treatment that mountaintop removal enjoys under the Corps' rules is crucially important to Appalachia, as "an estimated 724 stream miles in West Virginia, Kentucky, and parts of Virginia and Tennessee were covered by valley fills and 1,200 miles of headwater streams were directly impacted by mountaintop mining activities" between 1985 and 2001. [119]

Fixing the "fill" rule redefinition is important, but will not be easy—at least while the Bush Administration is in office. Until May 2002, the Corps regulations defined "fill material" as any material used for the primary purpose of replacing an aquatic area with dry land or of changing the bottom elevation of an [sic] water body. The term does not include any pollutant discharged into the water primarily to dispose of waste, as that activity is regulated under" the National Pollutant Discharge Elimination System (NPDES) administered by the EPA. [120]

Under this definition, mountaintop removal "overburden" plainly should have been subject to EPA permitting, as mining companies destroy streams in Appalachia to get rid of their mining wastes, not to change the depth of the streams. Indeed, a Federal court held exactly that in 1999.[121] Unfortunately, instead of complying, the Corps then redefined "fill material" to include mining overburden, [122] an action that one court found would violate the Clean Water Act and would "allow the waters of the United States to be filled, polluted, and unavoidably destroyed, for any purpose, including waste disposal." [123] Under the new definition, the Corps is the lead permitting agency, and historically it has been more than willing to authorize stream destruction as part of mountaintop removal mining.

Restoring the prior definition's exclusion for waste material and insisting on EPA permitting would ensure that our nation's rivers and streams—particularly those in Appalachia—do not become dumping grounds for mining waste. In fact, because the NPDES permitting process requires the proposed discharge to comply with applicable effluent guidelines and with state water quality standards, and because valley fills often bury streams entirely, valley fills are effectively prohibited by the Clean Water Act. Fixing the fill rule would require coal companies to either find waste disposal methods that do not destroy waters in the process, or preferably, to abandon mountaintop removal mining altogether. [124]

It is unlikely, however, that the Corps will give up its current authority to permit valley fills. It is equally unlikely that the agency will revoke the general permit—Nationwide Permit 21 (NWP 21) —that it issued in 2002 (and has proposed to re-issue). NWP 21 gives mining companies a blanket Clean Water Act fill authorization and, despite a legal requirement to ensure that permitted activities "will cause only minimal adverse environmental effects when performed separately, and will have only [a] minimal cumulative adverse effect on the environment," lacks the mechanisms to guarantee that fills will not be harmful. For instance, NWP 21 lacks any limit on the number of acres or stream miles that can be affected by a valley fill, and it does not specify how mining companies must mitigate the impacts. Since 2002, under NWP 21, coal mining companies have buried numerous streams with rock and other waste from surface coal mining activities. And this practice will continue; the Corps intends to permit valley fills that, together with recent fills (since 1992), are expected to affect nearly 7 percent of a 12-million-acre Appalachian region that spans four states and includes roughly 59,000 miles of streams. [125] It will likely take a new administration or a successful court challenge to make the Corps revoke NWP 21 and require mining companies to obtain individual permits before they can destroy any streams with mining waste.

**Enforce the Clean Air Act**

Coal mines themselves are significant sources of air emissions, especially particulate matter and diesel exhaust from mining equipment and other sources at the mine site. Most U.S. mines have on-site equipment for processing, and moving coal, and loading it onto rail cars, all of which can contribute to air emissions. Coal preparation plants (which process coal by breaking, crushing, screening, wet or dry cleaning, and thermal drying) are subject to New Source Performance Standards (under 40 CFR 60 Subpart Y) and Clean Air Act (CAA) Title V permitting requirements. Moreover, if these sources emit pollutants in sufficient quantities, they are subject to the CAA's prevention of significant deterioration (PSD) requirements for NAAQS attainment areas—which impose an obligation to install best available control technology (BACT) on any new units or on any facility that undertakes a major modification.

Appropriate application and rigorous enforcement of relevant standards are necessary to ensure adequate control of these emissions. It will take citizen action, congressional oversight, and perhaps a new administration before the EPA will require states to conduct meaningful and thorough review of Title V permit applications—and in particular, before the agency will demand an accurate accounting of the potential for these facilities to emit regulated pollutants. Most mine sources currently avoid future PSD requirements by adopting emission limitations in their Title V permits that are of questionable accuracy and effectiveness. Additionally, the EPA's interpretation of the statute allows enormous quantities of mining-related fugitive dust to go unaccounted for in the regulatory process.

As discussed above, PM emissions are among the most significant air contaminants from mining activities. One of the primary mechanisms for regulating PM is the implementation of National Ambient Air Quality Standards (NAAQS) through state implementation plans (SIPs). This regulatory mechanism, however, relies on the existence of a strong national standard. Amazingly, the EPA recently proposed new NAAQS for fine PM ($PM_{2.5}$) and coarse PM ($PM_{10}$) that would essentially give mining a free pass by regulating only "urban coarse" PM and entirely ignore rural and mining-related emission of coarse PM ($PM_{10}$).[126] While in its final rule the EPA ultimately did not entirely exclude mining-related $PM_{10}$ from regulation, it did revoke the annual $PM_{10}$ standard—leaving in place only the 24-hour standard. Thus, while there are national standards that target acute, short-term $PM_{10}$ exposure, there are no standards at all addressing long-term exposure to more moderate ambient levels of $PM_{10}$. Moreover, the EPA suggested in its final PM rule that it might revisit the idea of excluding rural and mining sources in the future. In order to protect the health of people living near coal mining activity, the EPA must reevaluate its decision on $PM_{10}$ and regulate these emissions on both a 24-hour and annual basis.

Additionally, the EPA should step up inspections and demand comprehensive monitoring of fugitive dust from mining and processing operations, but a new administration may have to take over before it does so. The agency has significant authority to demand such information, and only politically motivated unwillingness to obtain it is restraining the agency now.[127] According to personal reports from affected communities in Appalachia, dust levels are a significant nuisance, and quantifying the amount of pollution in their vicinity would be an important step forward.

Effective enforcement of the EPA's recent nonroad diesel rule, and expansion of that rule to regulate emission from diesel locomotives (an action that the EPA solicited advanced comment on in connection with the final nonroad diesel rule), will also help to address the emissions from sources at mine sites and from the trains used to transport coal once it is removed from the ground. These requirements apply only to new diesel engines, however, so it will take some time for fleets to turn over and the benefits of this rule to be fully realized.

If coal companies and transporters want to be better neighbors, they would take immediate action on their own initiative to reduce coal dust pollution. Adding moisture to coal to minimize dust would help the communities through which coal trucks and trains move.

### Enforce and Strengthen Surface Mining Laws

As the primary federal law governing surface- or strip-mining activities in the United States, the Surface Mining Control and Reclamation Act (SMCRA) has the potential to improve surface mining practices across the country. SMCRA was designed to ensure that coal mining practices are carried out in a way that minimizes impacts to the health and safety of local communities and the environment. Unfortunately, strip mining continues to exact a large toll, as blasting cracks foundations of nearby homes and runoff from mine sites pollutes nearby watersheds. Almost invariably, reclamation of a surface mine will proceed only until the point at which it meets the minimum requirements of SMCRA. Even worse, regulatory authorities sometimes do not insist that surface mining operations comply with SMCRA at all.[128]

While minimum compliance is not sufficient to protect the communities and ecosystems currently threatened by MTR, it is imperative that compliance not fall below minimum levels. Studies have shown that since the passage of SMCRA, water quality has improved with regard to pH, iron, and manganese. However, according to the EPA, streams still commonly exceed Maximum Contamination Level Guidelines (MCLG) for sulfate, iron, manganese, and aluminum.[129] Congress must ensure that the federal Office of Surface Mining Reclamation and Enforcement (OSM) has sufficient funding to provide thorough inspections of active surface mines and reclamation procedures. Proper inspections and enforcement could further improve issues relating to water quality, such as acid mine drainage. In order for a mine to be granted a permit under SMCRA, the applicant must first devise a reclamation plan and post a bond equal to the predicted reclamation costs for the proposed site. However, companies have been known to circumvent this requirement by setting up smaller, shell companies that post the bond, mine the area, declare bankruptcy, and forfeit the bond. [130] When this happens, the burden of reclamation falls to the state, and the amount of the bond is often not nearly enough to cover the cost of reclamation. Pennsylvania's Department of Environmental Protection, for example, projects an annual deficit of more than $1.2 million in its reclamation costs if its bond practices remain the same. [131] Procedures must be revised by the relevant state authorities so that bonds more accurately reflect the total cost of reclamation. [132]

Reclamation success and enforcement must also be improved. According to OSM, using the number of acres of land affected by surface coal mining operations that have been released from bonds as the measure of reclamation effectiveness, Wyoming—the nation's leading coal production state—"has not achieved a large amount of reclamation success." OSM also found that notwithstanding "the intent of SMCRA to assure that" mined areas are reclaimed "as contemporaneously as possible" to provide a balance between mined and reclaimed areas, "the gap between the acres disturbed [i.e., strip mined] versus reclaimed is widening…." [133] In FY 2005, the ratio of reclamation to net disturbance was 0.59, the lowest ratio in the last eight years. [134] In Montana more than 31,000 acres have been mined, but all four phases of land reclamation have been completed on only 216 acres, allowing release of their surety bonds. Three of the four phases—all that is required in many states—have been completed on only an additional 1,500 acres. [135]

The threats posed by coal waste sludge impoundments must also be addressed. Presently, regulations implementing SMCRA generally require that surface mining activities be conducted at least 500 feet away from any active or abandoned underground mining site, and ensure a stable foundation. [136, 137] In addition, these rules specify that waste disposal areas must "not create a public hazard. . . ." [138] Nevertheless, impoundment structures are capable of failure, and technology exists to process coal without creating large volumes of liquid and sludge that must be stored. For instance, in Kentucky, a Martin County Coal site had "a filter press system that removed the water from the coal slurry and buried the remainder on-site as a solid." [139] Unfortunately, "because it cost $1 more per ton of coal, Martin Coal abandoned it in the '90s and went back to filling up sludge ponds." [140] Liquid sludge storage has proven to be hazardous in the past: In 2000, one of these impoundment ponds failed, spilling more than 300 million gallons of sludge. [141]

If dry processing methods cost one dollar per ton more than using methods that create the need for large sludge dams, utilizing these technologies would raise the open-market cost of Appalachian coal by a few percent. In light of the significant risks to the local communities if there were to be an impoundment failure, these costs would appear more than justified. At a minimum, prohibiting new or expanded waste impoundments would be a significant step forward. West Virginia legislators considered, but did not take action on, a proposal to limit new and expanded impoundments. [142]

Recent years have also witnessed a series of notable attacks by the Bush Administration on the SMCRA regulations, as well as other environmental rules. One particularly powerful provision of the rules implementing SMCRA states that "no land within 100 feet of a perennial stream or an intermittent stream shall be disturbed by surface mining activities, unless the regulatory authority specifically authorizes surface mining activities closer to, or through, such a stream." [143] However, a recent Memorandum of Understanding "clarifying" the regulation negates the buffer zone regulation entirely and instead states that surface mining activities must comply only with a much weaker regulation under the Clean Water Act, which states that discharges to streams will not be permitted if they will result in "significant degradation." [144] This kind of backdoor rewriting of environmental legislation has been a hallmark of the Bush Administration, and, for at least the next two years, it will take the efforts of Congress, citizen groups, environmental organizations and the courts to ensure that the laws and regulations that protect our water and land are enforced according to their original purpose.

Unfortunately, SMCRA is full of loopholes on environmental issues, even without the assistance of the Bush administration. One section, for example, requires operators to "restore the land affected to a condition capable of supporting the uses which it was capable of supporting prior to any mining." However, the next clause states that the land can also be returned to a "higher or better use," a phrase so vague that it could mean anything from a landfill to a golf course. [145] Further, SMCRA addresses only aboveground damage and does not require restoration of underground aquifers, which have been damaged or destroyed across thousands of acres in the West. So while proper enforcement of SMCRA will yield benefits—as will efforts by citizen groups and environmental organizations along with others—surface mining will undoubtedly continue to be a major source of pollution and degradation for some time to come.

The federal coal leasing program, originally designed to ensure a fair return to the public for its resources and to mitigate impacts to wildlife, the environment, and affected communities and states, must also be reformed to effectively achieve its original mission.

**Protect Unique Places**

Fragile and unique ecosystems require additional protection to minimize the environmental effects of coal production in the future. Despite the growth in global conventions and agreements that have established protected areas (e.g., World Heritage sites and Biosphere Reserves), many of these unspoiled places are still severely threatened, and most remain officially unprotected and vulnerable to a variety of industrial activities, including coal mining. Since the establishment of Yellowstone National Park in the United States in 1872, often cited as the start of the modern era of protected park areas, the global loss of natural habitats and species has continued and recently has accelerated. Between 1970 and 2000, populations of terrestrial species declined by approximately 30 percent worldwide. [146] These declines occurred across ecosystem types, including forests, tundra, savanna deserts, and grasslands.

Many of the regions where these declines have occurred are characterized by extraordinary ecological attributes, such as plant diversity and endemism, or relatively intact predator-prey systems, and provide critical ecosystem services including 1) food for subsistence use and drinking water; 2) regulation of global carbon, floods, drought, land degradation, and disease; 3) supporting services such as soil formation and nutrient cycling; and 4) cultural services such as recreational, spiritual, religious, and other nonmaterial benefits.

Coal mining threatens to tear apart large tracts of habitat in many of these unique places, either through direct destruction or through secondary pollutants such as toxic runoff and coal deposits. For example, surface mining (mountaintop removal in particular) is severely disrupting the Appalachian/Blue Ridge Forests ecoregion—a globally outstanding area that has one of the most diverse assemblages of plants and animals found in any of the world's deciduous forests. [147] In the West, some of the most sensitive habitat on the Colorado Plateau is threatened by coal mining, despite the aridity of the region and its distance to markets. The Plateau includes the spectacular, wilderness-quality lands of Utah's Henry Mountains and the buffalo that inhabit them, and has been designated as one of five wilderness conservation priorities by Conservation International due to its high biodiversity and levels of endemism. [148]

It is essential that we protect these irreplaceable natural spaces on regional, national, and global scales. Unfortunately, the existing regulatory framework for the coal industry is inadequate: Mining is prohibited in only a limited number of places, and few of the protections are based on ecological principles. [149] Either as a result of regulation or voluntarily, mining companies must embrace the concept of land protection as an integral part of their operational planning in order to ensure the long-term viability of critical ecosystems and the valuable services these systems provide locally, regionally, and globally.

Some critical ecosystems that must be protected include but are not limited to: 1) designated protected areas such as World Heritage sites and Biosphere Reserves; 2) roadless areas and citizen-proposed wilderness areas; 3) sites containing significant archeological, historical, and/or cultural values (e.g., sacred sites); 4) ecosystems that are intact, rare, and contain high species richness, endemism, and/or endangered or threatened species; and 5) areas that provide critical ecological services (e.g., watershed protection and erosion control).

### Reducing Damage From Coal Production in China

In China, small mines account for one-third of the nation's total production of coal but contribute more than two-thirds of its death toll. [150] To improve its safety record, China has conducted many national campaigns to close dangerous mines, which have resulted in 850 fewer coal miner deaths in 2006 than the almost 6,000 deaths reported in 2005.[151] To build on these successes, the central government has called for the suspension of more than 4,800 more coal mines, primarily small mines that cannot meet basic safety standards, by mid-2008. [152] Yet many of these small coal mines have either refused to close or reopened illegally after the inspectors left. [153] In addition, although China has some mine safety laws and regulations on the books, they are rarely enforced. It is often cheaper for mine owners to pay bribes to local officials than to upgrade safety equipment.

China's efforts to end collusion between government officials and coal mine owners, another major reason for poor work safety standards in coal mines, have begun to show success. Due to pressure from the central government in 2005, more than 7,000 local government officials who had shares in coal mines have withdrawn their share. China has taken additional steps to strengthen enforcement, including elevating the State Administration of Work Safety to ministry level and renaming it the General Administration of Work Safety, punishing hundreds of officials for coal mining accidents, and drafting a new energy law aimed at improving mine safety. Yet much more aggressive enforcement measures are desperately needed.

Independent oversight by China's courts could help, but workers injured in accidents involving more than three people cannot bring claims through China's court system. Instead, they must seek redress administratively, making it even more difficult to obtain reasonable compensation. This dual system arose at a time when China's coal mines were all state-owned, but it is no longer appropriate now that most mines are under private ownership.

## Reducing Damage From Coal Use

Dramatic reductions in power plant emissions of criteria pollutants (pollutants subject to national air quality standards), toxic compounds, and heat-trapping gases are essential. Strategies to simultaneously reduce all of these emissions from coal-fired power plants would be among the most cost effective approaches to reducing environmental harms. Such reductions are achievable with technology available today, both by reducing reliance on coal and through advanced combustion systems that gasify coal and use the resulting synthesis gas in a highly efficient combined cycle generator. This integrated gasification combined cycle (IGCC) system enables cost-effective advanced pollution controls that can yield extremely low criteria pollutant and mercury emission rates and facilitates carbon dioxide capture and geologic disposal. These technologies will not be widely employed in either the U.S. or China, however, without a sustained market driver, which requires vigorous enforcement of clean air standards, new limits on carbon dioxide emissions, and market oriented incentives to deploy carbon dioxide capture and disposal systems.

| Table 2: Emissions Comparison (lbs/MWh) | | | |
|---|---|---|---|
| | Existing average | Median new PC permits | New integrated gasification combined cycle with CCD |
| $NO_x$ | 3.5 | 0.7 | 0.5 |
| $SO_x$ | 10.4 | 1.0 | 0.3 |
| Hg | 48 x 10-6 | $18 \times 10^{-6}$ | $1.7 \times 10^{-6}$ |
| PM | 0.2 | 0.14 | 0.06 |
| $CO_2$ | 2165 | 2100 | 250 |

Sources: Existing emissions average comes from Benchmarking Air Emissions 2004; median new PC permits derived from the EPA's RACT/BACT/LAER Clearinghouse website at http://cfpub1.epa.gov/rblc/htm/bl02.cfm; new IGCC with CCD is based on permits issued for new IGCC plants, except for $CO_2$, which is based on 85 percent emission reduction from CCD.

**Enforce Clean Air Standards at New and Existing Power Plants**

The single most important step toward reducing emission of criteria air pollutants from new coal-fired power plants in the United States is the appropriate interpretation and application of the Clean Air Act's Prevention of Significant Deterioration (PSD) permitting requirements. The PSD program requires preconstruction permits for any new facility (including power plants) located in clean air areas. These permits must contain emission limits—for, among other things, PM, $NO_x$, $SO_2$, and VOCs—that reflect the Best Available Control Technology (BACT).[154] The PSD program, and BACT in particular, are intended to ratchet emission limitations downward over time to ensure that the standards for new facilities reflect application of the best available control technologies and emission reduction techniques. In areas that don't meet air quality standards, a new source review accomplishes much the same goal by requiring the lowest achievable emission rate (LAER).

The EPA has recently sought to water down these requirements in several ways. For example, the EPA has taken the position that requiring coal-fired power plants to consider the use of lower sulfur coal or to consider the emissions benefits of using integrated gasification combined cycle as a part of its BACT or LAER analysis would constitute a "redefinition of the source" that the Clean Air Act does not require. This position is without merit, and it runs directly counter to both the language of the Act itself and the relevant legislative history. The EPA must interpret the Clean Air Act and apply the requirements of BACT and LAER in a manner that complies fully with the language and intent of the statute. By doing so, the EPA would ensure that any new coal-fired power plant would utilize the best emission control technology—currently IGCC—and therefore have dramatically lower emissions of dangerous criteria pollutants, as well as lower toxic emissions and the ability to capture and store $CO_2$ as discussed below.

The EPA is also continuing its long assault on the Clean Air Act's new source review (NSR) requirements for modifications at existing sources. The EPA has accomplished this in part by expanding the exemption for "routine maintenance" to include almost any changes at a facility, by limiting NSR to situations where a modification at a facility results in an increase in emissions measured on an hourly (rather than annual) basis, and by interpreting the NSR provisions as not encompassing "debottlenecking" activities (where the "modification" that increases emissions is made to ancillary equipment such as piping and not to a boiler unit itself).

One key to eliminating the worst emitters is to close down antiquated and poorly controlled coal plants (whose emissions can be many times higher than emissions from new plants). Appropriate interpretation and rigorous enforcement of the NSR requirements would create an incentive for the retirement of such old facilities, which have far outlived their expected useful lives, and would require those facilities that did remain to significantly improve their emissions performance.

As mentioned previously, the EPA has also recently issued new ambient air quality standards for particulate matter. While the $PM_{10}$ provisions of the new PM NAAQS will have potentially significant implications for coal mining emissions, the $PM_{2.5}$ component of that rulemaking has significant implications for the regulation of power plant emissions. By failing to adopt the stringent $PM_{2.5}$ standards recommended by the EPA's own Clean Air Science Advisory Committee (CASAC)—ignoring the relevant data on health effects—the EPA has walked away from its obligation to protect Americans from the profound health impacts associated with these emissions, including emissions from coal-fired power plants. The EPA must adopt a more stringent standard for $PM_{2.5}$ than it has included in its current NAAQS.

Finally, while EPA has adopted the Clean Air Interstate Rule (CAIR), which establishes a cap-and-trade program for electric utilities whose emissions contribute to poor air quality in neighboring states, this rule will not address the emissions from the worst-performing sources nor require new coal plants to use the best available emission control technologies. Indeed, under CAIR many old power plants will remain entirely uncontrolled. CAIR should be made more stringent and should not be used as a free pass to avoid appropriate regulation under other Clean Air Act programs, such as NSR and the NAAQS.

**Enforce Clean Air Standards to Reduce Toxic Emissions**

The EPA must also abandon its effort to give coal-fired power plants a virtual free pass to emit toxic pollution. The Clean Air Act required the EPA to study the hazardous pollutants emitted by power plants, report to Congress about their threats by November 1993, and determine whether to regulate utilities under the protective requirements applicable to other toxic polluters. The agency submitted its Report to Congress in February 1998, and then determined, in December 2000, that the study supported the conclusion that regulating power plants was both appropriate and necessary. In particular, the agency pointed to the widespread mercury contamination problem, noted that U.S. anthropogenic emissions contribute significantly to domestic mercury deposition, and estimated that power plants were the largest U.S. source of industrial mercury emissions. [155] The EPA concluded that "the available information indicates that mercury emissions from [power plants] comprise a substantial portion of the environmental loadings and are a threat to public health and the environment." [156]

After the regulatory determination, the EPA conducted an extensive fact-gathering and regulatory development process aimed at establishing protective "maximum achievable control technology" (MACT) standards for power plants, as the Act required. In late 2003, however, the agency abruptly reversed course and proposed three regulatory options: 1) a terribly weak MACT standard, which the EPA made clear was not its favored approach; 2) a pollution trading scheme, in which the level of the cap would be equivalent to the nationwide emission reductions that a source-by-source MACT standard would achieve; and 3) retracting its December 2000 determination to control power plants under the most protective requirements of the Act, and instead creating a two-phase trading program using a much weaker legal authority. [157, 158] Each of these options would have applied only to mercury from coal-fired power plants and nickel from oil-fired plants; EPA proposed to ignore all other HAPs. [159]

The EPA's final rule reneged on its pledge to require MACT controls and instead put forward a pollution trading scheme that fails to meet the Clean Air Act's requirements and falls short of its own weak promises:

- The EPA's pollution trading rule requires no mercury-specific pollution reductions until 2018, despite the availability of cost-effective controls and a MACT requirement to achieve roughly 90 percent reductions (from approximately 48 tons to 5 tons annually) by 2008.
- Instead, the rule would allow power plants to emit as much as 38 tons per year until 2018—a mere 21 percent cut. Even this reduction is simply the incidental result of a separate regulation governing the release of other kinds of pollution.
- With such a weak initial obligation, companies are expected to reduce their emissions slightly more than required from 2010 to 2018.This will allow them to build up a cache of pollution "credits."Then, when 2018 arrives, polluters will cash in their banked credits rather than reduce their emissions to the level of the second cap (15 tons, or a 69 percent reduction). In fact, the EPA has conceded that power plants will not have cut their mercury emissions to 15 tons even by 2025, and the agency does not know when emissions will fall to that level.

As noted, complying with the Clean Air Act would get far greater reductions, far sooner, in power plant mercury pollution. It also would require the EPA to set standards for toxins other than mercury, such as cadmium and arsenic, and dramatically cut utilities' emissions of those pollutants as well. A responsible coal policy would honor the commitment the EPA made in 2000 to require power plants to play by the same rules as other toxic polluters and would require existing plants to adopt MACT-level controls within three years (new plants would need to meet protective standards upon construction).

**Strengthen and Enforce Clean Air Standards in China**

A significant source of air pollution is China's use of relatively low-quality coal that is largely unwashed. [160] Very few power plants in China have installed flue gas desulfurization (FGD) equipment because of its cost. [161] Similarly, although a number of plants have installed continuous emission monitoring systems, only a few of them are in operation because of their cost to operate and the ambiguous role of monitoring in China's environmental regulatory system. Many of the plants built before 1980 have relatively low smokestacks and are located near cities, contributing greatly to local air pollution.[162] Newer plants often rely on tall smokestacks to meet $SO_2$ concentration limits, exacerbating regional and transboundary pollution problems that are difficult to address under China's existing system of environmental regulation.[163]

Since 1995, China has developed an integrated approach to the control of $SO_2$ and acid rain, including the demarcation of $SO_2$ emission and acid rain control zones, $SO_2$ emission limits, plant closures and relocations, limitations on the mining of high sulfur-coal, technology and monitoring requirements, and a variety of enforcement mechanisms and market-based instruments.[164] Many of these reforms are embodied in the 2000 Amendments to the Law on the Prevention and Control of Atmospheric Pollution.[165] Enforcing this existing regulatory scheme could result in significant reductions in $SO_2$ and other major pollutants.

Yet these reforms, even if fully implemented, are simply not sufficient to keep power-sector emissions under control in light of China's skyrocketing power demand. In 2006 alone, China brought on line new generation capability equal to almost double the entire generation capacity of California.[166] And rather than meeting its goal of reducing national $SO_2$ emissions by 20 percent from 2000 levels by 2005, China instead increased sulfer emissions by 25 percent to 25.5 million tons in 2005.[167] Reducing demand through market incentives, extensive energy efficiency programs, internalizing the environmental costs of coal, applying modern pollution controls, and increased focus on renewable energy are therefore essential.

## Global Warming and Coal

Carbon dioxide and most other heat-trapping gases stay in the atmosphere anywhere from decades to hundreds of years once emitted, locking us into centuries of environmental impacts from the coal burned today. Recent observations of trends in global temperature, arctic sea ice extent, and mountain snowpack leave no reasonable doubt that global warming is under way. Ocean data have confirmed that there is substantial additional warming "in the pipeline" and unavoidable. With current coal (and oil) consumption trends, we are headed for a doubling of $CO_2$ concentrations by midcentury if we don't redirect energy investments away from carbon-based fuels and toward new, climate-friendly energy technologies.

To avoid locking ourselves and future generations into a dangerously disrupted climate, we must accelerate the progress already under way and adopt policies now to turn the corner on emissions. Scientists are concerned that we are very near this threshold already. Many say we must keep global temperatures from rising another 2 degrees Fahrenheit to avoid risking severe environmental impacts. Global warming already is causing more severe storms, heat waves, droughts, and the spread of malaria and other diseases. An additional 2-degree global temperature increase could cause the extinction of many species, the death of coral reefs, and, eventually, a 20-foot rise in sea levels because of the irreversible melting of the Greenland ice sheet. To have a reasonable chance of limiting global warming to less than 2 degrees, the concentration of heat-trapping gases in the atmosphere must be stabilized at a level no higher than the equivalent of 450 parts per million of $CO_2$. With $CO_2$ concentrations now above 380 ppm and rising at a rate of 1.5 to 2.0 parts per million per year, we will pass the 450 ppm threshold within two or three decades unless we change course soon.

The United States, the world's leading carbon dioxide emitter, must immediately enact a national program to limit $CO_2$ emissions and create the market incentives necessary to shift investment into the least polluting energy technologies on the scale and timetable that is needed. There is growing agreement among business and policy experts that quantifiable and enforceable limits on global warming emissions are needed and inevitable. These limits can then be allocated in the form of emission allowances which can be traded between companies to ensure that the most cost-effective reductions are made, as is currently the practice with sulfur emissions that cause acid rain. A number of such cap-and-trade proposals have been introduced in Congress, and many states are moving forward with their own programs in the absence of federal action.

Targeted energy efficiency and renewable energy policies are critical to achieving $CO_2$ limits at the lowest possible cost, but they are no substitute for explicit caps on emissions. Most important, we need to set these caps now, because industry is already building and designing the power plants that the United States will rely on for the next 40 to 80 years. We need to redirect these investments to prevent them from locking us into a substantial increase in U.S. and global emissions.

Although China has ratified the Kyoto Protocol, as a developing (non-Annex I) country it is not bound by restrictions on global warming pollution during the first commitment period (2008–2012). But senior climate experts in China recognize that the country may face emission limits after 2012 and needs to begin making preparations now.[168] Enacting limits on carbon dioxide emissions could help China meet its national goals of diversifying its energy structure; ensuring a stable, economic, and clean energy supply; and increasing its energy efficiency.[169]

In the meantime, China is actively involved in developing carbon emission-reduction projects under the Kyoto Protocol's Clean Development Mechanism (CDM). Current CDM projects in

China, including those awaiting approval from the CDM executive board, will result in an estimated 250 million tons of certified carbon emission reductions (CERs).[170] Within the next five years, China expects to be involved in carbon trading of more than 200 million tons each year.[171] These efforts, while perhaps small in relation to total carbon emissions, have begun to convince many Chinese decision makers of the potential economic benefits of joining the emerging global carbon trading market.

**Capture and Safely Dispose of $CO_2$ From Any New Plants**

It is technologically feasible to avoid the construction of new coal-fired power plants and meet $CO_2$ emission limits in the United States and China through energy efficiency, renewable energy, and natural-gas-fired combined heat and power systems. Utilities should be required to use this order of preference in selecting new resources, as they are in California. Despite the best efforts of energy efficiency, renewable energy, and environmental advocates over the last 15 years, however, coal-fired electricity generation increased by 24 percent between 1990 and 2004.[172]

Increased recognition of the dangers of global warming and more robust advocacy certainly could increase the pace at which energy efficiency and renewable energy technologies are deployed, but it seems very likely as a matter of political and practical reality that the United States, and certainly China, will for many years continue to rely heavily on coal for electricity generation given the size of the resource, its low direct cost (excluding environmental externalities), and the political power of coal interests. We must therefore include emissions reduction within the coal industry as a part of any discussion of the future of coal. This includes accelerating the replacement of existing dirty coal-fired power plants with advanced technology units, rather than simply adding end-of-stack pollution control equipment to aging plants.

The critical technology for coal in both countries is $CO_2$ capture and geologic disposal. This is the only technology that will make continued coal use compatible with protection of the climate. Marginal improvements in coal plant efficiency will not deliver reductions on the scale needed to stabilize concentrations at reasonable levels.

The three required elements of a coal-based $CO_2$ capture and disposal system (CDS) have all been demonstrated at commercial scale in numerous projects around the world. But there is large potential for optimization of each element, and their integration, to bring down costs and improve efficiency. In addition, experience with large scale injection of $CO_2$ into geologic formations is still limited.

The first step is processing coal to make a gas stream with high $CO_2$ concentrations. Coal gasification is today's demonstrated method. Coal is reacted with oxygen under high pressure and temperature to produce synthesis gas consisting primarily of carbon monoxide (CO) and hydrogen ($H_2$). A steam shift reaction can then be carried out to produce additional hydrogen and $CO_2$ ($H_2O + CO \text{–>} H_2 + CO_2$). In contrast to conventional coal combustion using air, the result is a smaller gas stream with higher $CO_2$ concentrations. This approach significantly reduces the cost and energy required to capture $CO_2$. The hydrogen can be used as a chemical feedstock or burned in a combined cycle (gas turbine plus steam turbine) power plant to make electricity.

Coal gasification is in operation in dozens of installations around the world, including many fertilizer plants in China. A notable example in the United States is the Tennessee Eastman plant, which has been operating for more than 20 years using coal instead of natural gas to make chemicals and industrial feedstocks. It also achieves mercury reductions of more than 90 percent.

The electric power industry has been slow to take up gasification technology, but two commercial-scale units are operating in the United States, in Indiana and Florida. The Florida unit, owned by TECO, is reported by the company to be the most reliable and economic unit on its system. Two U.S. coal-based power companies, AEP and Cinergy, have announced their intention to build coal gasification units. And several of China's largest power companies, including the China Huaneng Group, announced in December 2005 that they have set up a new company in order to build China's first coal gasification power plant, complete with the technology to capture and store carbon.[173] In addition to enabling lower-cost $CO_2$ capture, gasification technology has very low emissions of most conventional pollutants and can achieve high levels of mercury control with low-cost carbon-bed systems.

Methods for capturing $CO_2$ from industrial gas streams have been in use for decades. In the United States, for example, they are used to separate $CO_2$ from "sour gas" at natural gas processing plants and are even in use at a few coal-fired power plants to produce $CO_2$ for sale to the food and beverage industries. In North Dakota, the Great Plains Gasification Plant, a legacy of the 1970s synfuels program, now captures $CO_2$ and ships it by pipeline to an oil field in Saskatchewan, where it is injected to produce additional oil. In Wyoming, a large gas processing plant captures $CO_2$ for sale to oil field operators in that state and in Colorado. Smaller plants in Texas do the same thing to serve oil fields in the Permian Basin.

Once captured, the $CO_2$ must be disposed of. The most viable approach currently is to transport the $CO_2$ by pipeline and inject it into deep geologic formations that are capable of permanently retaining it. Geologic injection of $CO_2$ has been under way in the United States for a couple of decades as a method for producing additional oil from declining fields. Today, oil companies inject about 35 million tons annually into fields in Texas's Permian Basin, Wyoming, Colorado, and other states. Because industrial sources can emit $CO_2$ without penalty under current U.S. policy, most of the injected $CO_2$ is supplied from natural $CO_2$ reservoirs, rather than captured from emission sources. Ironically, due to the lack of emission limits and the limited number of natural $CO_2$ fields, a $CO_2$ supply shortage is currently constraining enhanced oil recovery from existing fields. There is, of course, a massive supply of $CO_2$ from power plants and other sources that would become available to supply this market, but that will not happen as long as $CO_2$ can be emitted at no cost.

Such enhanced oil recovery (EOR) operations are regulated to prevent releases that might endanger public health or safety, but they are not monitored with any techniques that would be capable of detecting smaller leak rates. Small leak rates might pose no risk to the local surroundings but over time could undercut the effectiveness of geologic storage as a $CO_2$ control technique. Especially in EOR operations, the most likely pathways for leakage would be through existing wells penetrating the injection zone. Much of the injected $CO_2$ is also brought back to the surface with the oil produced by this technique. That $CO_2$ is typically reinjected to recover additional oil, but when oil operations are completed it may be necessary to inject the $CO_2$ into a deeper geologic formation to ensure permanent storage.

In addition to these EOR operations, $CO_2$ is being injected in large amounts in several other projects around the world. The oldest of these involves injection of about 1 million tons per year of $CO_2$ from a natural gas platform into a geologic formation beneath the seabed off the coast of Norway. The company decided to inject the $CO_2$ rather than vent it to avoid paying an emission charge adopted by the Norwegian government—a clear example of the ability of emission policies to produce the deployment of this technology. The Norwegian operation is intensively monitored and the results from more than six years of operation indicate the $CO_2$ is not migrating in a manner that would create a risk of leakage. Other large-scale, carefully monitored operations are under way at the Weyburn oil field in Saskatchewan and the In Salah natural gas field in Algeria.

The first project to combine all of these elements—gasification technology, carbon capture and storage, and enhanced oil recovery—was announced in February 2006 by British Petroleum and Edison Mission Group. The project, which is slated to be near Long Beach, California, will use petroleum coke, a byproduct from a local refinery, in a gasification combined-cycle power plant designed to generate 500 MW of power and capture more than 90 percent of the $CO_2$ produced in the process. The captured carbon dioxide will be piped to a nearby oil field and injected into the ground to enhance oil recovery.

While additional experience with large-scale injection in various geologic formations is needed, we know enough to expand these activities substantially under careful procedures for site selection, pipeline siting and safety, operating requirements, and monitoring programs. The imperative of avoiding further carbon lock-in due to construction of conventional coal-fired power plants and the capabilities of $CO_2$ capture and storage technologies today warrant policies in both the United States and China to deploy these methods at new coal plants without further delay.

**Replace Oil With Low-Carbon Fuels**

High oil and natural gas prices and the security risks posed by dependence on imported oil have led both the United States and China to express strong interest in producing liquid fuels from coal.

### Coal Procurement Guidelines

Stricter environmental requirements need to be applied to coal production nationwide. Meanwhile, power companies can help reduce the upstream impact of coal production by insisting that their coal suppliers adhere to strict environmental guidelines.

To qualify under the proposed low emissions coal generation obligation, a power plant would have to obtain all of its coal from sources that adhere to these guidelines as well as meet strict emission rate requirements for carbon dioxide and other pollutants.

Detailed procurement guidelines need to be developed, but qualifying coal must, at a minimum, be obtained from sources that:

- Comply with all local, state, and federal health, safety, and environmental regulations and guidelines;
- Do not include operations where mountain top removal and valley fills have occurred;
- Employ effective and ecologically appropriate land reclamation;
- Protect aquifers and surface waters;
- Protect ecologically significant and unique areas and wildlife;
- Avoid coal mine methane emissions;
- Protect coal field communities from structural damage or water contamination caused by mining activities;
- Avoid vulnerable sludge impoundments;
- Mitigate social and economic impacts of boom-bust development; and
- Ensure that the public obtains a fair return for its resources under the federal coal leasing program.

Coal-based liquid fuels, however, pose their own dangers: the greatly exacerbated environmental impacts of coal production and global warming pollution.

To avoid catastrophic global warming, the United States and other nations will need to deploy energy resources that result in much lower releases of $CO_2$ than today's use of oil, gas, and coal. The technologies we select to replace conventional transportation fuels must lead to greatly reduced $CO_2$ emissions. With the technology in hand today and on the horizon, it is difficult to see how a large liquid coal program can be compatible with the low-$CO_2$-emitting transportation system that must be designed if we are to prevent dangerous global warming.

**The Damage of Liquid Coal**

To assess the global warming implications of a large liquid coal program, we need to examine the total life cycle or "well-to-wheels" emissions of these new fuels. When coal is converted to liquid fuels, two streams of $CO_2$ are produced: one at the liquid coal production plant and the second from the exhausts of the vehicles that burn the fuel.

Today our system of refining crude oil to produce gasoline, diesel, jet fuel and other transportation fuels results in a total "well to wheels" emission rate of about 25 pounds of $CO_2$ per gallon of fuel. Based on available information about liquid coal plants being proposed, the total well to wheels $CO_2$ emissions from such plants would be about 50 pounds of $CO_2$ per gallon, roughly twice as much as using crude oil, assuming that the $CO_2$ from the liquid coal plant is released to the atmosphere. [174] Obviously, introducing a new fuel system with double the $CO_2$ emissions of today's crude oil system would conflict with the need to reduce global warming emissions. If the $CO_2$ from liquid coal plants is captured, then $CO_2$ emissions would be reduced but here one confronts the unavoidable fact that the liquid fuel from coal contains the same amount of carbon as gasoline or diesel made from crude. The result is that the well-to-wheels emissions would still be higher than emissions from today's crude oil system. [175]

Therefore, using coal to make liquid fuel for transportation needs flatly conflicts with our need to reduce global warming pollution. Creating a liquid coal industry would make much more difficult

**The Potential of Enhanced Oil Recovery**

There is great potential to produce additional oil from already developed fields using carbon dioxide captured from coal-fired power plants. When $CO_2$ is injected at high pressure into mature oil fields under the right conditions it increases reservoir pressure and the oil's mobility, promoting enhanced oil recovery (EOR). Standard primary and secondary production without $CO_2$-EOR recovers only about one-third of the original oil in typical reservoirs. Current state-of-the-art EOR techniques generally allow an additional 10 percent of the original oil in place to be recovered.

The U.S. Department of Energy has estimated that if EOR were widely available for $CO_2$, current techniques could recover more than 60 billion barrels of oil from domestic fields in the lower 48 states.[176] Advanced techniques have the potential to double the fraction of the original oil in place that could be recovered using $CO_2$-EOR to more than 120 billion barrels, or more than 18 times the amount of oil that is estimated to be economically recoverable from the Arctic National Wildlife Refuge, at a cost of $40 per barrel or less.[177] If power plant, pipeline, and power-line siting issues are properly addressed, capturing $CO_2$ from coal-fired power plants could therefore not only reduce global warming pollution, but also significantly contribute to meeting America's energy needs without sacrificing our few remaining wild places to oil exploration and development.

the task of achieving any given level of global warming emission reduction. Proceeding with liquid coal plants now could leave those investments stranded or impose unnecessarily high abatement costs on the economy if the plants continue to operate.

**Establish a Low-Emissions Coal Generation Obligation**

Given the dual need to avoid building new conventional coal-fired power plants and to rapidly expand the market for low-emissions electricity-generating technology, NRDC supports the development of a low-emissions obligation for coal generation, which would require U.S. and Chinese electricity suppliers to generate a growing portion of their coal-fired electricity using plants that capture and permanently dispose of their $CO_2$. This approach spreads the costs of deploying carbon capture and disposal technology across the entire fleet of coal-fired power plants, rather than concentrating these costs only on developers of new units.

The standard should be phased in at a rate corresponding to the expected construction of new coal plants plus the gradual replacement of existing obsolete plants over time. To qualify, plants would have to obtain their coal from sources that comply with strict environmental guidelines (see box) and would need to have a $CO_2$ emission rate less than 250 pounds/MWh (which represents an 85 percent to 90 percent reduction compared with a conventional coal plant) as well as state-of-the-art emissions performance for other pollutants. Implementation of the low-emissions coal generation obligation would include a credit trading program, which would allow suppliers that exceed their minimum requirements to bank their extra credits or sell them to suppliers who come up short.

# Conclusion

The current coal fuel cycle is among the most destructive activities on earth, placing an unacceptable burden on public health and the environment. There is no such thing as "clean coal." Our highest priorities must be to avoid increased reliance on coal and to accelerate the transition to an energy future based on efficient use of renewable resources. Energy efficiency and renewable energy resources are technically capable of meeting the demands for energy services in countries that rely on coal, including the world's two largest coal consumers—the United States and China.

However, more than 500 conventional coal-fired power plants are expected in China in the next eight years alone, and more than 100 are under development in the United States. Building these plants as planned would perpetuate emissions of harmful pollutants and foreclose the possibility of preventing dangerous global warming.

Because it is very likely that significant coal use will continue during the transition to renewables, it is important that we also take the necessary steps to minimize the destructive effects of coal use. That requires the U.S. and China to take steps now to end destructive mining practices and to apply state of the art pollution controls, including $CO_2$ control systems, to sources that use coal.

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[132] Office of Surface Mining Reclamation and Enforcement, Annual Evaluation Summary Report for the Coal Regulatory Program Administered by the Land Quality Division of the Wyoming Department of Environmental Quality [pursuant to the Surface Mining Control and Reclamation Act of 1977] for Evaluation Year 2005 (July 1, 2004, to June 30, 2005), August 24, 2005, at 7. Unfortunately, rather than fault Wyoming for this lack of success, OSM attempts to excuse it by pointing to the large number of surface mines operationg in the state (31 as compared to 2 underground mines), the large size of western mining operations and the policy of mining companies to delay applying for bond release—all but the last of which underscore the need for greater success. Id. at 6.

[133] Id. at 9.

[134] Id. at 13.

[135] Western Organization of Resource Councils, Memorandum to NRDC, March 10, 2006, citing Montana Department of Environmental Quality 2006 Annual Report.

[136] 30 C.F.R. § 816.79.

[137] Id. § 816.81(d).

[138] Id. § 816.81(a)(4).

[139] Reece, Erik, *Lost Mountain: A Year in the Vanishing Wilderness*, 131 (2006).

[140] Id.

[141] Id. at 124.

[142] W.Va. H.B 4583 (introduced Feb. 15, 2006), available at http://www.legis.state.wv.us/Bill_Text_HTML/2006_SESSIONS/RS/BILLS/hb4583%20intr.htm (visited April 18, 2006).

[143] 30 C.F.R § 816.57(a)

[144] 40 C.F.R 230 § 404

[145] Surface Mining Control and Reclamation Act, 1977. 30 U.S.C 1265 § 515(a)(2)

[146] Living Planet Report. World Wildlife Fund. 2004.

[147] Terrestrial Ecoregions of North America—A Conservation Assessment. World Wildlife Fund. 1999.

[148] Conservation Regions—Priority Areas, High Biodiversity Wilderness Areas. North American Deserts. Conservation International 2006.

[149] SMCRA prohibits mining within specific land systems such as national parks, forests, wildlife refuges, wild and scenic rivers, and designated wilderness areas; in areas which will adversely affect sites listed on the National Register of Historic Places; and within a restricted distance of specified buildings like homes, schools, and churches as well as cemeteries and roads, subject to certain exceptions. See, e.g., Office of Surface Mining, Lands Unsuitable for Mining/Petitions processed at http://www.osmre.gov/unsuitability.htm (last viewed February 4, 2006). SMCRA's petition process, by which additional specific lands can be declared unsuitable, has not proved to be useful for obtaining protection for western coal lands. See id. The regulations of the Bureau of Land Management, which manages leasing and development of federal coal, provide discretionary authority for declaring lands to be unsuitable for specific ecological reasons —e.g., bald and gold eagle nests and roosts, and "essential" habitat for resident species of fish, wildlife, and plants "of high interest to the state" subject to important exceptions. See 43 CFR § 3461.5, sub §§ (k)(1), (l)(1), and (o)(1) (10-1-03 Edition)

[150] Xu Huaqing, et al. *Report on China's Energy/Environment Development* (Zhongguo nengyuan huanjing fazhan baogao) (Beijing: China Environmental Sciences Press [Zhongguo huanjing kexue chuabanshe]: 2006), p. 25.

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[153] Shaoguang Wang. "Regulating Death at Coalmines: Changing Mode of Governance in China." *Journal of Contemporary China* 15 (46) (2006), p.18.

[154] The Clean Air Act defines BACT as "an emission limitation based on the maximum degree of reduction . . . which the permitting authority, . . . taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facilities through application of production processes and available methods, systems, and techniques, including fuel cleaning, clean fuels, or treatment or innovative fuel combustion techniques for control of each . . . pollutant." CAA § 169(3).

[155] See 65 Fed. Reg. 79,825, 79,827 (Dec. 20, 2000).

[156] See 65 Fed. Reg. 79,825, 79,827 (Dec. 20, 2000).

[157] EPA got to this result after disbanding a stakeholder work group advising the agency on the development of MACT standards. Tom Hamburger & Alan C. Miller, "Mercury Emissions Rule Geared to Benefit Industry, Staffers Say; Buffeted by complaints, EPA Administrator Michael Leavitt calls for additional analysis," *Los Angeles Times* at A1 (March 16, 2004). EPA also prohibited its professional staff from doing certain technical analyses. Id. ("EPA staffers say they were told not to undertake the normal scientific and economic studies called for under a standing executive order. At the same time, the proposal to regulate mercury emissions from coal-burning power plants was written using key language provided by utility lobbyists."). Finally, the agency underestimated the pollution reductions that MACT could achieve. U.S. EPA, Office of Inspector General, Additional Analyses of Mercury Emissions Needed Before EPA Finalizes Rules for Coal-Fired Electric Utilities, at 16 (Feb. 3, 2005) (finding it unlikely that "an unbiased calculation" would allow 34 tons of mercury emissions per year nationwide, as EPA's proposed "MACT" standard would have). The result was a weaker MACT standard than any stakeholder group participating in the MACT advisory committee had recommended. See Northeast States for Coordinated Air Use Management, Mercury Emissions from Coal-fired Power Plants: The Case for Regulatory Action, at p. ES-2 ("the stakeholder groups that participated in EPA's Utility MACT Working Group have recommended a range of standards that equate to annual national emissions from coal-fired utility boilers of between 2 and 28 tons.").

[158] See 69 Fed. Reg. 4,652 et seq. (Jan. 30, 2004).

[159] See 69 Fed. Reg. 4,652 et seq. (Jan. 30, 2004).

[160] Xu Huaqing, et al. *Report on China's Energy Environment Development* (Zhongguo nengyuan huanjing fazhan baogao) (Beijing: China Environmental Sciences Press [Zhongguo huanjing kexue chuabanshe], 2006), p. 26-27.

[161] Matt Pottinger, Steve Stecklow, and John J. Fialka. "Invisable Export—A Hidden Cost of China's Growth: Mercury Migration." *The Wall Street Journal* (December 20, 2004).

[162] World Bank. *Clear Water, Blue Skies: China's Environment in the New Century.* (Washington, D.C.: World Bank, 1997), p. 50.

[163] Jintian Yang and Jeremy Shreifels. "Implementing $SO_2$ emissions in China." In *OECD Global Forum on Sustainable Development: Emissions Trading.* (Paris: OECD, 2003), pp. 7-8.

[164] Jintian Yang, Dong Cao, Chazhong Ge, Shuting Gao, and Jeremy Schreifels. "Practice on $SO_2$ Emissions Trading in China." Presentation given at the PACE China's Environment and Natural Resources Symposium, Environment and Development Insitute, School of Environmental and Natural Resources, Renmin University, Beijing, China (October 23 and 24, 2003), pp. 39-40.

[165] For a copy of the amended law in English, please see: "Law of the People's Republic of China on the Prevention and Control of Atmospheric Pollution." http://www.enviroinfo.org.cn/LEGIS/Laws/la004_en.htm.

[166] Richard McGregor. "China's Power Capacity Soars." *Financial Times* (February 6, 2007). Available at http://www.ft.com/cms/s/e66cde98-b5fc-11db-9eea-0000779e2340,dwp_uuid=9c33700c-4c86-11da-89df-0000779e2340.html

[167] Xu Huaqing et al. *Report on China's Energy/Environment Development* (Zhongguo nengyuan huanjing fazhan baogao) (Beijing: China Environmental Sciences Press [Zhongguo huanjing kexue chuabanshe], 2006). p. 9.

[168] "Bid to Reduce GHG Emissions Stepped Up." *China Daily* (December 14, 2005). http://www.china.org.cn/english/environment/151716.htm .

[169] Id.

[170] Id.

[171] Id.

[172] http://www.eia.doe.gov/emeu/aer/txt/stb0802c.xls

[173] Interfax Information Services. "Huaneng Funds Green Coal Power Project, Aiming at Zero Carbon Dioxide Emission." *China Energy Report Weekly* 4 (49) (December 24, 2005).

[174] Calculated well-to-wheels $CO_2$ emissions for coal-based "Fischer-Tropsch" are about 1.8 times greater than producing and consuming gasoline or diesel fuel from crude oil. If the liquid coal plant makes electricity as well, the relative emissions from the liquid fuels depend on the amount of electricity produced and what is assumed about the emissions of an alternative source of electricity.

[175] Capturing 90 percent of the emissions from liquid coal plants reduces the emissions from the plant to levels close to those from petroleum production and refining, while emissions from the vehicle are equivalent to those from a gasoline vehicle. With such $CO_2$ capture, well-to-wheels emissions from liquid coal fuels would be 8 percent higher than for petroleum.

[176] http://www.fossil.energy.gov/programs/oilgas/eor/Six_Basin-Oriented_$CO_2$-EOR_Assessments.html

[177] See http://www.nrdc.org/land/wilderness/arcticrefuge/facts3.asp