The Clean Power Act of 2003: A Policy Analysis

"Clean Power: It's Not an Oxymoron"

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New York, New York

Summer 2004

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With special thanks to Professor Andrea Schmitz and Google.com

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Executive Summary

The Clean Power Act of 2003 amends the Clean Air Act of 1970 (CAA), which uses regulations to reduce and mitigate the effects of pollution on human health and the environment. Despite the CAA's initial success in reducing air pollution through emissions limits in the United States, several harmful pollutants are still being emitted in quantities dangerous to human health and the environment. The intent of the CPA is to further curb harmful air pollution by placing emissions limits on large-capacity commercial power plants.

The Clean Power Act strengthens standards on two criteria pollutants— nitrogen oxides (NO_x) and sulfur dioxide (SO_2)—and also regulates carbon dioxide (CO_2) and mercury (Hg) emissions, with reduction targets set for 2009 (2008 for Hg). The Act authorizes the Environmental Protection Agency (EPA) to use a system of emissions allowances to achieve a reasonable cap on these emissions while allowing individual facilities flexibility. It also encourages energy conservation, the use of renewable and clean energy technologies, and pollution reduction as long-term strategies.

The following analysis examines the electricity generation process at power plants and the emissions targeted to reduce the impact of each on human health and the environment. It also reviews the technology currently available to help meet target emissions standards and existing alternative solutions such as renewable energy and nuclear power. This report concludes with measurements that will determine the success of the Act by 2009 as well as the benefits of successful implementation.

The Clean Power Act focuses on regulating the emissions from power plants because electricity generation has inordinately increased the concentration of NO_x, SO_2, CO_2 and Hg in Earth's atmosphere, with significant implications for human health and the environment. Coal, the most pollution-intense and widely used fuel in the U.S., accounts for 51% of total electricity production. Coal-fired power plants are responsible for 80% of $NO_{x,}$ 98% of SO_2, and 73% of CO_2, and 90% of Hg emissions from all national power plants. In the following analysis, we will review the power generation process, detailing the source of combustion by-products.

The impact of NO_x, SO_2, CO_2, and Hg emissions have local and global consequences that are potentially deleterious to human health and the environment, including smog, acid rain, global climate change, and the bioaccumulation of mercury.

Although the impacts of power plant emissions are far-reaching, the culprit emissions may be reduced by a variety of techniques that can be implemented before, during and/or after the combustion process. Several emissions reduction approaches are currently viable and can be implemented before 2009 to achieve compliance with the Clean Power Act. In addition, there are alternative solutions to fossil fuel power generation that power plants can implement to reduce target emissions, including cleaner technologies, renewable energy and energy conservation actions.

Well-defined measurements of success are vital to assessing the effectiveness of the Act at reducing ambient levels of pollution and improving human health and the environment. In this analysis, three variables will be considered when measuring the success of this Act: the achievement of pollution reductions specified by the Act, implementation of the emissions allowance system, and the development of a clean and renewable energy infrastructure. Benefits achieved as a result of this act include improvements to human health and the environment.

The following analysis provides a general overview of the Clean Power Act of 2003, including the reasoning behind its development, methods of implementation, impacts on human health and the environment and how to measure its success.

The Clean Power Team
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August 20, 2004

Introduction

The Clean Power Act of 2003 (CPA) was introduced as an amendment to the existing Clean Air Act (CAA) and defines explicit national power plant emissions reduction targets for nitrogen oxides (NO_x), sulfur dioxide (SO_2), mercury (Hg), and carbon dioxide (CO_2) to reduce damage to human health and the environment. In order to evaluate the scientific feasibility of achieving these emissions reductions before 2008 and 2009, it is vital to understand how power plants produce electricity and how pollution is formed during electricity generation. Pollutants are released from power plants as fuel is combusted. These pollutants adversely affect human health and the environment. In most cases, proven technologies are available today to meet the emissions limits specified in the Act. In other cases, promising technologies are being developed and will be available in time to meet the goals established by this Act. In the future, it is hoped that such emissions can be dramatically reduced or avoided altogether through the use of new or improved power generation methods. Effective monitoring of actual emissions will gauge the effectiveness of the CPA and may be used to develop future legislation. Benefits of the Clean Power Act include reduction of smog, acid rain, mercury contamination and the potential of global climate change.

Clean Air Act History

Congress passed the Clean Air Act in 1963 to improve air quality in the United States. This legislation allocated funds to state and local regulatory agencies in the form of grants to implement pollution control efforts. Over the course of the next three decades, Congress passed amendments to strengthen the CAA, including the pivotal amendments of 1970, 1977, and 1990.

The 1970 Clean Air Act amendments coincided with increased national environmental awareness and activism. They represented a landmark in federal involvement in air quality control by establishing the National Ambient Air Quality Standards (NAAQS), targeting vehicle emissions, and enabling citizens to pursue legal recourse when NAAQS standards are not met.

The 1977 amendments took additional steps to protect air quality by strengthening pollution standards, including the designation of carcinogenic emissions as hazardous air pollutants. The 1990 Amendments set additional strict standards on individual pollutants and enforced the use of maximum achievable control technology (MACT) on designated emissions sources.

The Clean Air Act has been continually reviewed and amended to incrementally improve air quality control on a national level.

Clean Power Act Legislative Summary

The Reason for the Clean Power Act

The Clean Air Act (CAA) has been successful in reducing air pollution through incremental federal controls. However, several harmful pollutants are still being emitted in quantities dangerous to human health and the environment. In particular, harmful emissions from the electric power industry are not sufficiently regulated due to the sheer volume of emissions from these facilities and a "grandfather" clause in the current CAA, which exempts older facilities from adopting modern emissions controls. Innovations in air emissions policies, typified by the 1990 Acid Rain program (see case study below: EPA Acid Rain Program), and advances in pollution abatement technologies now make it possible to quickly and economically reduce emissions from all electricity generating facilities.

The Clean Power Act of 2003 amends the Clean Air Act to establish firm emissions caps on three air pollutants—nitrogen oxides, sulfur dioxide, and carbon dioxide—and one toxin, mercury. The CPA establishes a 2009 deadline to meet these emission caps for the three air pollutants and a 2008 deadline for mercury. It authorizes the Environmental Protection Agency (EPA) to use a system of tradable emissions allowances to achieve these emissions limits. Tradable allowances provide for dramatic emissions reductions at a decreased cost compared to traditional command-and-control regulations. The Act also encourages energy conservation, the use of renewable and clean energy technologies, and pollution reduction as long-term strategies.

Emissions Limits

The Clean Power Act explicitly defines national pollution limits which the electricity generating industry, as a whole, cannot exceed during a year. The limit for sulfur dioxide is 2.25 million tons per year, which must be divided between an eastern and western region of the country.

Due to the large numbers of coal-fired facilities, sulfur dioxide emissions from the Midwest, Northeast, and Southeast are considerably greater than emissions in the West. (EPA, 1999) Establishing eastern and western regions over which sulfur dioxide allowances may not be traded prevents high-emission facilities in the East from purchasing extra allowances from low-emission facilities in the West.

In the western region, the emission limit is 275,000 tons for all facilities, while in the eastern region the emission limit is 1.975 million tons. Combined, these sulfur dioxide emission limits represent an 80% reduction from year 2000 levels.

Emissions of nitrogen oxides must be reduced nationwide to 1.51 million tons. This emissions limit represents a 71% reduction from year 2000 levels. Emissions of carbon dioxide will be capped at 2.05 billion tons, a 21% reduction from year 2000 levels. Mercury emissions will be limited to 5 tons per year, a 90% reduction from year 2000 levels. While emissions of nitrogen oxides and sulfur dioxide have been regulated for many years under the National Ambient Air Quality Standards, the Clean Power Act will be one of the first laws in the U.S. to require mercury reductions from power plants, and it will be the first law to require carbon dioxide reductions from any source.

Modernization

Currently, all power plants constructed before the 1977 CAAA are exempted, or "grandfathered," from compliance with Best Available Control Technology (BACT) standards. Current BACT standards require all major polluting sources to install state-of-the-art air pollution control technology when constructing a new facility or making major modifications to an existing facility. In 1999, the U.S. Department of Justice asserted that these grandfathered facilities alone produced over three million tons of sulfur dioxide and nitrogen oxide pollution each year, leading to the emission of tens of millions of tons of additional air pollution in the almost three decades since the grandfather clause went into effect. The CPA will close this loophole by requiring that all facilities in the U.S. adopt the BACT standards either by the year 2014 or the facility's fortieth year of operation, whichever comes second.

Emission Allowances

Ideally, an emission allowance system allows for maximum pollution reduction at the lowest cost to the affected industry by allowing companies to reduce emissions at the facilities for which it is most economically advantageous to do so. Under the Clean Power Act, one allowance is equivalent to one ton of emissions for nitrogen oxides, sulfur dioxide, and carbon dioxide. (There are no tradable allowances for mercury emissions.) At the end of each year, facilities must submit one emission allowance to EPA for every ton of pollution they emit. Facilities that emit more pollution than they have allowances will be found in violation of the Clean Power Act. In order to meet emissions caps at individual facilities, the limits of which will be determined through forthcoming EPA deliberation, facilities may purchase unused allowances from other plants or may emit fewer emissions than allocated. Since the sum of all emissions allowances equals the yearly quota for the pollutants, when a given facility emits more than its limit and purchases allowances to make up the difference, the aggregate level of pollution does not increase. The emissions allowance system gives individual power plants the flexibility to comply with standards while maintaining adherence to strict regulatory standards. The allowance system also creates a financial incentive for facilities to shift toward conservation, the use of clean and renewable technologies, and pollution prevention.

Each year, the total amount of available emissions allowances is reduced by the total amount of pollution generated from small (<15 megawatt capacity) generators. Allowances can also be reduced further by the EPA Administrator in order to reduce "adverse local impacts [that] result from emission allowance trading," according to Section 705 of the Clean Power Act. This continual reduction in overall emissions allowances will prevent certain areas of the country from becoming pollution repositories where allowances are sold and pollution rights are purchased. Importantly, the Clean Power Act does not confer any property right with emission allowances, meaning they can be altered or revoked by EPA at any time.

Emissions allowances are the recommended option because, as gases, nitrogen oxides, sulfur dioxide, and carbon dioxide can travel hundreds or thousands of miles from their point of release, so local emissions do not necessarily produce local pollution. Because they can adsorb, or stick to, airborne particles and fall from the atmosphere onto the Earth's surface relatively close to their point of release and are highly toxic at low levels; therefore (Barnhart, 2003), mercury emissions do not receive allowances and cannot be traded.

The Clean Power Act of 2003 requires the EPA Administrator to establish an emission allowance trading system by which electric companies will be able to buy and sell allowances on the open market. It is most likely that the initial trading system established for SO_2 by the Acid Rain Program of 1990 will be used for the 2003 model.

Case Study: EPA Acid Rain Program

Under the previous program, the EPA Administrator allocated allowances at an emission rate of 1.2 pounds of SO_2/mmBtu (million British thermal units) of heat input, multiplied by the unit's baseline mmBtu (the average fossil fuel consumed from 1985 through 1987). Reserves allowances were set aside for utilities that installed clean technology in order to encourage that practice as a means for reducing SO_2 emissions. In addition, the EPA Administrator held under its own account 2.8% of the total annual allowance in order to ensure the economic efficiency of the market and avoid potential unhealthy imbalances between demand and supply. The special reserve also allowed for the addition of new electrical generation capacity. Once the allowances are allocated, utilities and other market participants can buy and sell according to need or strategy on the Chicago Climate Exchange. The value of an allowance is quickly determined by these open market trades. The price of SO_2 allowances generally ranged between $100 and $200 per ton between 1998 and 2003. However, beginning in 2004, the price of an allowance has steadily increased to the current price of $360.

Enforcement

Penalties for violating the Clean Power Act are described in the Act. The penalty for having emitted pollutants in excess of emissions allowances results in a fine of three times the market value of each allowance exceeded; for example, if a facility emits 5,000 tons of sulfur dioxide beyond the number of allowances it holds, would have to pay $3,000,000 if the market value of an SO_2 allowance that year were $200.

Special Provisions

The Clean Power Act provides multiple provisions designed to offset any economic harm resulting from implementation of the Act, promote efficient and renewable technologies, and fund research on carbon sequestration. For each of these provisions, the EPA can distribute additional allowances, which may be sold to provide additional funding. Each year the EPA Administrator may distribute a portion of the emissions allowances to provide transition assistance to displaced workers and communities economically impacted by this act, as well as to producers of electricity-intensive products. Up to 6% of the total allowances may be distributed to these groups starting in 2009; this percentage decreases by 0.5% each year thereafter until expiration at 2018.

The CPA also supplies transitional assistance to individual electricity generating facilities, based on their output to help defray the capital costs of pollution abatement technology. Up to 10% of the total allowances may be distributed to these facilities in 2009; this percentage decreases by 1% per year until expiration in 2018. Similarly, producers of renewable energy, energy efficient sources, and clean energy sources are also eligible for additional allowances, based on the amount of electricity generated by renewable sources or the electricity saved through the use of more efficient sources. In order to promote research in the sequestration of carbon dioxide, up to 0.075% of the allowances for this pollutant will be used to develop permanent and environmentally-benign sequestration methods.

In order to evaluate the scientific feasibility of obtaining these emissions reductions before 2008 and 2009, it is critical to understand how power plants produce electricity and how pollution is formed during electricity generation. Pollutants are released from power plants as fuel is combusted. Through chemical interactions in the atmosphere, these pollutants cause adverse effects in human health and the environment. In most cases, proven technology is available today to meet the emissions limits specified in the CPA. In other cases, promising technologies are being developed and will be available in time to meet goals established by the Act. In the future, it is hoped that such emissions can be dramatically reduced or avoided altogether through the use of new or improved power generation methods. Lastly, effective monitoring of actual emissions, as well as environmental and human health indicators, will gauge the effectiveness of this Act at protecting health and welfare and can be used to develop future legislation.

Power Plants

The Clean Power Act of 2003 explicitly targets electric power generating plants and their contribution to air pollution emissions. These facilities contribute a significant proportion of the pollution addressed in the Clean Air Act, and this chapter will briefly outline the fuels used by power plants, the way power plants operate, and the emissions that are produced during electricity generation.

Power Plant Operations

There are more than 1,110 power generating facilities in the United States, which provide electricity to homes and businesses. These facilities, or power plants, produce electricity using a variety of sources. Most commonly used are fossil fuels including coal, petroleum (oil), and natural gas. Power plants also utilize nuclear energy, hydropower, and renewable energy sources such as wind power, solar energy, geothermal energy, and biomass fuel. Figure 1 illustrates the amount of energy produced annually by fuel source.

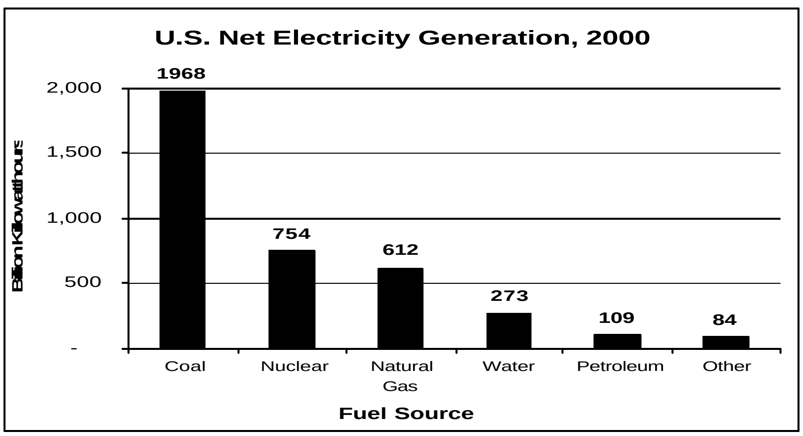


Figure 1. (Energy Information Administration)

This report focuses on fossil fuel-powered facilities, with primary attention paid to coal-fired power plants.

Fossil Fuels used for Electricity Production

Coal is a naturally occurring and abundant resource in the United States which been used for electricity generation since the late 1800s. In electricity generation, coal is crushed into a fine powder, which is then used as a combustion fuel. Coal provides an inexpensive and readily available fuel source; however, it is less efficient than other fuel sources and contains comparatively high amounts of other materials such as mercury and sulfur. According to the U.S. Department of Energy, the three largest coal-producing states are Wyoming, West Virginia, and Kentucky. As noted previously, coal-fired power plants comprise the majority of electricity generation in the United States, and, as such, contribute the greatest amount of harmful emissions.

Natural gas is a blanket term used to describe various naturally occurring gases deep in the earth. The vast majority of natural gas occurs as methane, but other forms include ethane, propane, and butane. Most of the natural gas extracted domestically comes from Texas, New Mexico, Oklahoma, and Wyoming. Natural gas is utilized in gas-fired, combined-cycle, and cogeneration electricity production, discussed below. This fuel source is both cleaner and more efficient than coal, and comprises 16% of fuel used for U.S. electricity production.

Petroleum, or oil, is the third fossil fuel used to generate electricity and is used in power generation similarly to natural gas. Oil, however, is used primarily as a fuel source for transportation and contributes less than 3% of total electric power generation.

Fuel Use

Combustion of fossil fuels is the most prevalent means of electricity production in the United States. The following schematic depicts a coal-fired power plant and illustrates the commonly used process of steam-powered electricity production. In its most basic interpretation, the fuel source (A) is inserted into the power plant. The fuel is burned in the boiler (B) where the heat generated creates steam (C). Steam pressure turns a turbine (D) which powers an electrical generator (E) and produces electricity (F). The water used in the boiler condenses, assisted by cooling water piped in from a river or reservoir (G), and returns to the boiler. Excess hot gases and particulates created in the power generation process escape as exhaust through the emissions stack (H).

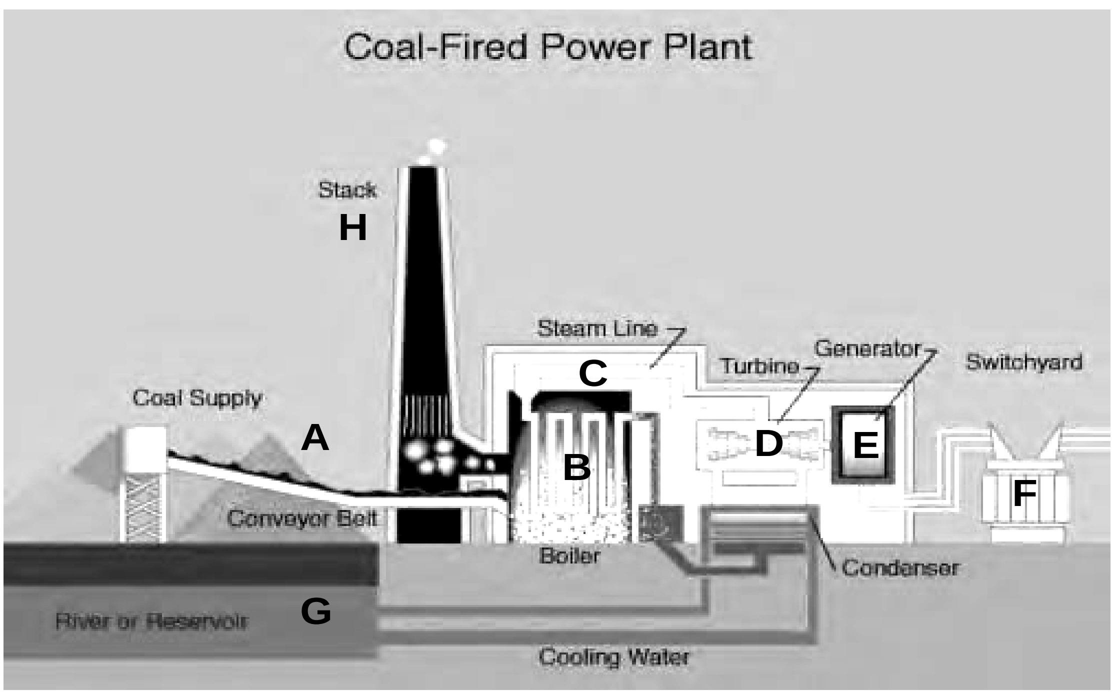
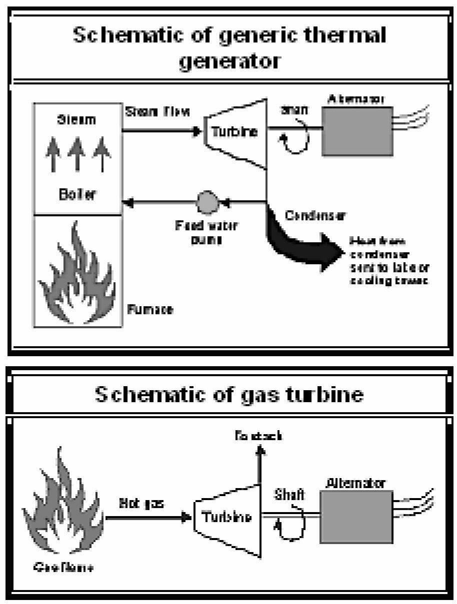


Figure 2. (http://www.fi.edu/guide/hughes/powerplants.html)

Power Plant Cycles

Four main power generation cycles utilize some form of the electricity production procedure described above. Steam generation is a process by which steam alone turns a turbine and produces electricity through the electrical generator. Gas generation uses the hot gases created by combustion of the fuel in the boiler to turn a gas turbine; in this case, the gas turbine powers the generator to produce electricity. According to industry expert Steve Kellogg, Utilities and Energy Planner, Exxon Mobil Corporation, these two processes are between 25% and 32% efficient. In both cases, hot gases are released as waste through the stack.



Figures 3 & 4. (Baldick, 1999)

Combined cycle electricity generation typically uses a gas generation process, in addition to a steam generation process. In this case, the hot "waste" gases from gas generation are captured and reused to power an additional steam turbine and create additional electricity, increasing the efficiency of power generation. This process can increase the efficiency to over 40%.

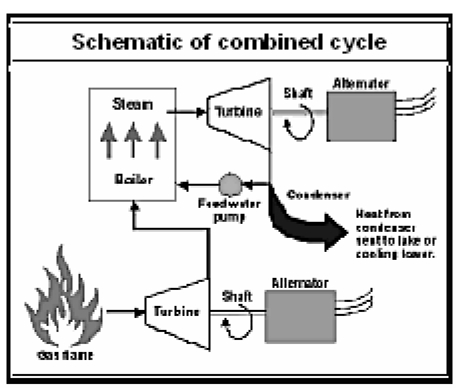


Figure 5. (Baldick, 1999)

Cogeneration can achieve up to 50% efficiency, as it uses the excess hot gases produced through gas-fired generation for other purposes such as manufacturing or central heating. Cogeneration plants are typically smaller in size and located adjacent to the recipient of the heat generated. The process eliminates the need to burn additional fossil fuels for heating purposes, and this increased efficiency reduces overall emissions. According to the Energy Information Administration, cogeneration accounts for more than half of all new power plant capacity built in North America in the last decade.

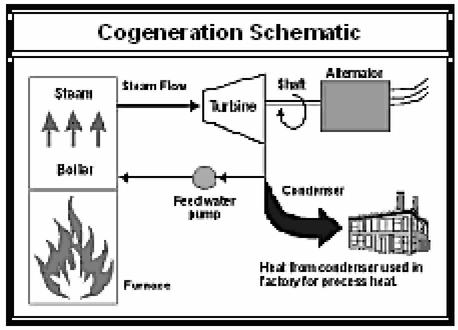


Figure 6. (Baldick, 1999)

Emissions

Emission levels are driven by the combination of fuel source and electricity generation cycle. Coal-fired power plants are the dirtiest because of constituents such as sulfur and mercury are naturally extant in the fuel source. Coal is the most pollution-intensive fuel source and is responsible for the majority of all emissions from power plants in the U.S. Natural gas and oil-fired power plants are typically much cleaner, as the fuels contain little to no sulfur or mercury. Natural gas is typically used in the more efficient power cycles and, therefore, uses less fuel to produce the same amount of electric power, thereby producing less nitrogen oxides and carbon dioxide than other combustion cycles. However, natural gas is nearly twice as expensive as coal as a fuel source, and is also subject to price fluctuations on the open market.

According to EPA, over 65% of sulfur dioxide released to the air, more than 13 million tons per year, comes from power plants that burn fossil fuels such as coal. Power plants are also the largest industrial source of the nitrogen oxide pollution that causes smog formation and are the largest source of the sulfur dioxide pollution that causes acid rain. Carbon dioxide is an inherent emission of the combustion process, and releases are mitigated only by implementing increasingly efficient combustion techniques. The following chart illustrates emission levels driven by each fuel source.

Fossil Fuel Emission Levels Pounds per Billion Btu of Energy Input			
Pollutant	**Natural Gas**	**Oil**	**Coal**
Carbon Dioxide	117,000	164,000	208,000
Carbon Monoxide	40	33	208
Nitrogen Oxides	92	448	457
Sulfur Dioxide	1	1,122	2,591
Particulates	7	84	2,744
Mercury	-	0.007	0.016

Figure 7. (Energy Information Administration)

Due to the significant contribution of coal-fired power plants to pollution, these facilities will be responsible for most emissions reductions specified by the Clean Power Act.

Targeted Emissions and their Impact on Human Health and the Environment

Carbon (C), nitrogen (N), sulfur (S), and mercury (Hg) are elemental constituents of fossil fuels and the atmosphere. The combustion reaction that occurs during power generation creates harmful gaseous compounds of the elements and releases both these compounds and elemental mercury into the atmosphere. The four specific atmospheric contaminants addressed by the Act, nitrogen oxides (NO_x), sulfur dioxide (SO_2), mercury (Hg), and carbon dioxide (CO_2), result from the combustion of fossil fuels. While some of these pollutants are naturally created in the environment, human activity, in particular power generation, has increased their concentrations in the atmosphere. Individually, and in some cases combined, these emissions have an adverse impact on both human health and the environment.

Nitrogen Oxides

Nitrogen comprises 78% of Earth's atmosphere in the molecule N_2. Extremely high temperatures caused naturally by ultraviolet (UV) radiation or anthropogenically through combustion splits the N_2 molecule and leads to the formation of the nitrogen-oxygen compounds Nitrous Oxide (NO) and Nitrogen Dioxide (NO_2). These two compounds have very similar effects and are often combined and generically termed "NO_x".

In the presence of sunlight, NO_x reacts with volatile organic compounds (VOCs), such as benezene, in the atmosphere to form ground-level ozone. It is important to distinguish ground-level ozone from atmospheric ozone. Atmospheric ozone occurs in the stratosphere, a layer of Earth's atmosphere several kilometers above the surface. Atmospheric ozone is formed naturally and creates a protective shield over the Earth which blocks harmful ultraviolet radiation. Ozone at ground-level, however, commonly known as "smog," causes severe environmental problems which will be discussed below.

The amount of ground-level ozone formed in an area is highly dependent both on environmental and weather conditions. Urban areas that contain high amounts of VOCs and also receive significant UV radiation from the sun have much higher rates of ozone formation than non-urban areas or regions that do not receive significant sunlight. Moreover, urban areas generally have much higher rates of ozone formation in the summer months because of the increased intensity and duration of solar radiation. Ozone pollution is not restricted to urban areas, however. NO_x and the pollutants formed from NO_x can be transported over long distances and create environmental problems in areas far from the pollution source. Some geographic locations have a higher propensity for ozone formation, especially those adjacent to mountains or oceans. These geographic conditions make the local regions susceptible to ozone because they trap air through atmospheric inversions, during which pollution is not readily dispersed by wind or atmospheric circulation.

Ozone is a significant human health concern, as it has been proven that even small doses throughout the span of a day can exacerbate existing respiratory and cardiac conditions. Ozone reacts with moisture and other compounds to form nitric acid vapor and other harmful particles that are inhaled deep into the lungs. These contaminants inflame and damage the pulmonary lining. Acute exposure to ozone can result in difficulty breathing; long-term exposure to ozone can have lasting adverse effects including damage to lung tissue, reduction of pulmonary function, worsening of respiratory diseases such as asthma, emphysema, and bronchitis, and aggravation of existing heart disease. High ozone exposure can yield permanent lung damage, chronic respiratory disease, and even premature death. Children, the elderly, people with pre-existing lung diseases, and people who work or exercise outside are most susceptible.

Ozone also has an aesthetic environmental impact. As NO_x particles absorb or scatter light they create a dirty haze which is the major cause of reduced visibility in the United States. The effect is present both in densely populated cities and in natural environments. This is particularly evident in National Parks and in the "brown clouds" of western cities such as Houston, Texas and Los Angeles, California.

EPA has tracked the emissions of the six principal air pollutants—carbon monoxide, lead, nitrogen oxides, particulate matter, sulfur dioxide, and volatile organic compounds—since 1970. Emissions of all of these pollutants have decreased significantly except for NO_x, which has increased by 3.5 million tons between 1970 and 1998, a 17% rise since the Clean Air Act was adopted.

Sulfur Dioxide

Sulfur dioxide (SO_2) belongs to the family of sulfur oxide gases (SO_x) formed when fuel containing sulfur, such as coal or oil, is burned, when gasoline is extracted from oil, or when metals are extracted from ore. The burning of fossil fuels by power-production companies and industries releases sulfur into the air, which combines with oxygen to form sulfur dioxide (SO_2). From these gases, airborne sulfuric acid (H_2SO_4) can form and dissolve in the water vapor in the air. Once airborne, SO_2 acids often travel far from the source, where they adsorb onto water vapor and fall to the ground as rain, sleet, or snow.

Acid precipitation damages forests and other vegetation, changes soil composition, and contaminates lakes and the biota they support. Continued exposure over a long period of time alters the natural variety of plants and animals in an ecosystem and causes millions of dollars in damage to agricultural production each year. Certain geologic regions have a decreased ability to neutralize acid rain based on the geology of the bedrock in lakes and streams. For this reason, acid rain is frequently a regional problem. For instance, pollution from Midwestern power plants travels downwind, bringing disproportionate amounts of acid rain to the northeastern United States and Canada.

Acid precipitation also impacts human structures causing dissolution and alteration of buildings, monuments, and sculptures. Sulfurous and sulfuric acids in polluted precipitation dissolve the calcite in marble and limestone, causing the decay of these structures. Acid rain causes roughened surfaces, removal of material, and loss of carved details in exposed areas of buildings and statues. Many of the structures affected by acid rain, such as irreplaceable monuments, statues and sculptures, are important to our nation's heritage.

Nationally, ambient SO_2 concentrations have decreased 54% from 1983 to 2002. Reductions in SO_2 concentrations and emissions since 1990 are due, in large part, to controls implemented under EPA's Acid Rain Program (see Case Study 1), which has been cited as one of the most successful pollution reduction programs in the United States to date. The Clean Power Act builds on this program's success and takes another step toward further pollution reduction.

Mercury

Mercury (Hg) is a naturally occurring heavy metal found in soils and fossil fuels and is toxic to living organisms when ingested in significant amounts. Airborne emissions of Hg are a by-product of electricity generation, causing contamination of water and soil.

When mercury-containing coal is burned during the combustion phase of electricity generation, the mercury is emitted through the smokestack with other chemicals. Half of the emitted mercury sticks to organic particles and drops from the emission plume quickly and accumulates locally.

Through direct deposition, leaching, runoff, and rain events, mercury enters aquatic systems such as lakes and streams near the power plant. When mercury contaminates aquatic systems, it is transformed by microorganisms (biota) into a toxic form called methyl mercury (MeHg). The mercury-laden biota is then eaten by fish or birds, and the MeHg accumulates in the fat tissue of the hosts' bodies. As fish and other aquatic species consume organisms containing the highly toxic MeHg, the mercury begins to bioaccumulate. Bioaccumulation is a process by which the contaminant becomes increasingly more concentrated at each successive level in the food chain.

Humans are most susceptible to mercury poisoning through eating contaminated fish. As humans continually ingest mercury-contaminated food, it accumulates in fatty tissues faster than the body can process and discard it. The human body easily absorbs methyl mercury. MeHg that is ingested is lipid soluble and readily crosses the blood-brain barrier and placenta. It also appears in breast milk, and concentrates in the kidneys and central nervous system. MeHg is processed in the liver, excreted in bile, reabsorbed, and then excreted in urine. For humans, about half the body burden of mercury can be eliminated in 70 days if no mercury is ingested during that time. Best estimates to date suggest that human activities have doubled or tripled the amount of mercury in the atmosphere and that the atmospheric burden is increasing by 1.5% per year.

Mercury causes damage to the human nervous system, brain, and spinal cord. Toxic levels differ by body weight and the body's ability to remove the mercury; the most susceptible humans are fetuses and young children. Effects are seen in delays or damage to their neurological development. Exposure to high levels of MeHg can also lead to kidney damage.

According to EPA, coal-fired power plants are the primary source of mercury emissions in the United States. While mercury has been linked to many pollution-related illnesses, it is still not regulated under the Clean Air Act.

Carbon Dioxide

Carbon Dioxide (CO_2) is a gaseous compound uniformly distributed over the earth's surface, and is produced both naturally and anthropogenically. Its presence in the Earth's atmosphere accounts for 0.035% of the total atmospheric composition, see Figure 8. Although this figure seems small, it is sufficient to trap outgoing solar radiation, which would otherwise escape into space and yield average surface temperatures on Earth well below 0ºC. CO_2 and other "greenhouse gases" (comprising a total of 1% of the Earth's atmosphere) are vital to maintaining an average global temperature of about 15ºC, a temperature warm enough to sustain life on the planet.

Composition of Dry Air at Ground Level in Remote Continental Areas		
Consituent	*Formula*	*Concentrations (%)*
Nitrogen	N_2	78.1
Oxygen	O_2	20.9
Argon	Ar	0.93
Carbon Dioxide	CO_2	0.035
Neon	Ne	0.0018
Helium	He	0.0005
Methane	CH_4	0.00017
Krypton	Kr	0.00011
Hydrogen	H_2	0.00005
Ozone	O_3	0.000001-0.000004

Figure 8. (Philander, 1998)

The chief concern of scientists and policymakers is that the amount of CO_2 released during anthropogenic activities such as electricity generation is causing a dangerous excess of CO_2 in the atmosphere. (See "The Science Behind Carbon Dioxide" below for details.) Any increase in the concentration of atmospheric CO_2 poses the threat of disruption to the balance of life-sustaining functions it provides. Scientific evidence shows a correlation between the rising concentration of CO_2 in the atmosphere and departure from the long-term mean temperature. According to the National Academy of Sciences, the Earth's surface temperature has risen by about 1ºF in the past century, with most of the warming attributed to human activities.

According to EPA, atmospheric concentrations of CO_2 have increased nearly 30% in the last century. Figure 8 illustrates the rise in concentration of atmospheric CO_2 since the time of the industrial revolution:

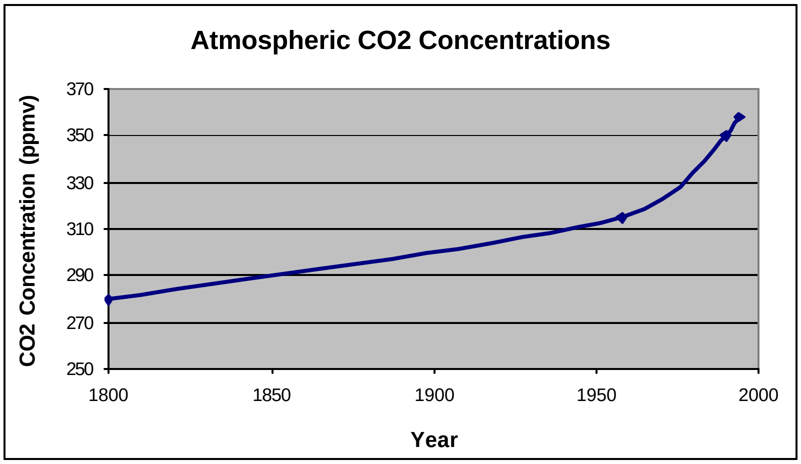


Figure 8. (Adapted from Schloerer, 1996)

Currently, atmospheric CO_2 concentrations are increasing steadily at a rate of about 0.3-0.4% per year. Carbon dioxide itself does not pose an inherent environmental threat, as it is a crucial component of the Earth's atmosphere. However, an overabundance of CO_2 strengthens the greenhouse effect, and climatologists maintain that the continued accumulation of CO_2 (and other greenhouse gases) will cause an increase in the average temperature of the Earth's surface resulting in various environmental problems. At increasing levels, CO_2 traps additional heat and prevents emission of radiation from the Earth. Many researchers predict significant environmental consequences due to the disruption of climate and weather patterns, including extreme weather events such as intense storms, hurricanes and floods, heat waves, and drought. Long-term regional temperature shifts may alter ecosystems and increase desertification, leading to a disruption in agriculture and ecosystems by permanently altering the boundaries of vegetation zones. Ultimately, even subtle alterations in climate patterns can destroy natural habitats and lead to the wide-spread extinction of sensitive animal and plant species.

Not only are there environmental implications to global climate change, there are significant human impacts as well. Problems include heat-related mortality and disease. Warming temperatures may extend the ranges and seasons of some disease-transmitting organisms such as insects and rodents. This could accelerate the spread of certain infectious parasites and increase the prevalence of vector-borne diseases such as malaria and West Nile Virus, as well as non-vector-borne infectious diseases like typhoid and cholera.

An increase in extreme weather events resulting in increased precipitation can induce not only flood damage, but also damage by introducing chemical pollutants into water supplies (through excessive runoff) and result in deaths, injuries, and psychological disorders. Such events can also alter agricultural regions in the short-term causing food shortages. Warmer temperatures are also associated with glacial melting, which may raise sea levels and inundate coastal urban centers worldwide. Regions like Manhattan and Bangladesh could easily be flooded by rising sea levels associated with global climate change.

Despite the overwhelming evidence of human-induced climate change, there is some controversy surrounding the issue of ambient carbon dioxide and the impact of increased levels of greenhouse gases. Some scientists argue that the rise in CO_2 is a natural occurrence and cite CO_2

fluctuations in the atmosphere over geologic time as evidence. Others recognize the anthropogenic role in CO_2 increases, but postulate that increasing global temperatures will be more beneficial than harmful, as additional regions become suitable for agricultural production and colder regions attain more comfortable temperatures. Scientists promoting these impacts comprise a small, but vocal, constituent and often weigh in on decisions regarding the importance of reducing CO_2 emissions. For example, MIT professor Richard S. Lindzen testified before the Environment and Public Works Committee stating, "In all likelihood, [Global Climate Change] will turn out to be something trivial and without policy implications except to those who bizarrely subscribe to the so-called precautionary principle." For this reason, carbon dioxide has been difficult to regulate, and the Clean Power Act of 2003 is the first law of its kind attempting to regulate these emissions.

The Science Behind Carbon Dioxide

Carbon dioxide is important not only for sustaining warm temperatures on earth, but also because it is an essential component of life. Naturally, CO_2 occurs as part of the carbon cycle, incorporating photosynthesis and metabolism into the cycle of life of plants and animals. Through the process of respiration, animals (including humans) release CO_2 as they exhale:

$$\textbf{glucose + oxygen} \rightarrow CO_2 + H_2O$$

Plants then utilize CO_2 for photosynthesis, the process by which plants manufacture carbohydrates and oxygen. According to the Carbon Dioxide Information Analysis Center, "photosynthesis is dependent on favorable temperature and moisture conditions as well as on the atmospheric carbon dioxide concentration. Increased levels of carbon dioxide can increase net photosynthesis in many plants" (1990). This process is represented by the following equation:

$$CO_2 + H_2O + \textbf{sunlight} \rightarrow \textbf{glucose (sugar) + oxygen,}$$

Industrially, CO_2 is a natural by-product of combustion and is inherent in the fossil-fuel based electricity production process. In the combustion process, a fossil fuel source combines with oxygen to produce energy (heat) as well as carbon dioxide and water:

$$\textbf{fuel} + O_2 \rightarrow CO_2 + H_2O$$

Available Technologies

Because, coal power produces a disproportionate amount of the pollutants addressed by the Clean Power Act, technology that targets coal electricity production provides the greatest potential to reach the reductions of pollutants listed in the Clean Power Act by 2009.

Pollution Reduction Technologies for NO_x

Both nitrogen (N_2) and oxygen (O_2) molecules from the air are present in the combustion chamber. When temperatures exceed 3,000°C during the combustion process, the high temperature causes both the N_2 and O_2 molecules to split and combine to form the nitrogen-oxygen compounds nitrous oxide (NO) and nitrogen dioxide (NO_2). Strategies to reduce the formation of NO_x gas include reducing the temperature of the combustion chamber and starving the combustion process of air. One pollution reduction strategy is to install low NO_x burners, which utilize multiple stages of combustion and employ both strategies to yield over 50% less NO_x formation. Another strategy, called selective non-catalytic reduction, involves injecting ammonia into the combustion chamber to reduce NO_x formation. Finally, selective catalytic reduction combines ammonia with the flue gas emissions after combustion to neutralize the NO_x and create the benign emissions of N_2 and water. This technology reduces NO_x emissions by over 80%.

Pollution Reduction Technologies for SO_2

Coal is the main source of sulfur in the formation of SO_2 emissions from power plants. Prior to combustion, coal can be washed to remove any inorganic sulfur present in the fuel. Once the coal is pulverized to prepare for combustion, it can be combined with lime or limestone, which reacts with the sulfur in the boiler forming gypsum, commonly known as drywall. Fluidized bed coal combustion technology utilizes the previous approach but makes the process more efficient by elevating the pulverized coal on air drafts while the limestone is injected. This process promotes good mixing and more complete combustion and can result in up to 90% reduction in the production of SO_2. Another technology is called flue gas desulfurization or “scrubbing,” a process in which limestone is injected into the flue gases and sticks to the sulfur, forming calcium sulfate ($CaSO_4$) particles that drop out of the emitted gases. Filters within the scrubbers then trap about 95% of emitted particles. This technology has also proven effective in reducing NO_x emissions as well

Pollution Reduction Technologies for Mercury

Mercury is another element found in coal. By washing coal with water and mixing it with magnetite, mercury can precipitate out of the coal and can be recycled for other purposes. Fuel treatment can be 37% effective at reducing mercury content. Mercury is highly unstable at combustion temperatures and is therefore difficult to separate from the emission stream after combustion. However, a technology called injected activated carbon can be employed to remove mercury from the flue gas. In this process, carbon is introduced into the emission stream which sorbs to mercury, creating larger mercury particles that can be more easily filtered. This technology is 55%-90% effective at filtering out mercury.

Pollution Reduction Technologies for CO_2

Carbon dioxide is a byproduct of the process of combusting any fossil fuel. Technologies to reduce the production of CO_2 aim to increase the amount of energy produced per unit of fuel. With higher fuel efficiency, power production yields more energy per pound of fuel. A pressurized, fluidized combustion system can achieve high efficiency by increasing the pressure of the gas and accelerating combustion. This process yields as much as a 50% increase in energy produced per fuel input. Coal gasification is another process which results in a decrease of CO_2 emissions. In this process, coal is combined at high temperatures with steam and oxygen, creating combustible gases such as carbon monoxide (CO), hydrogen (H), and other gaseous compounds. This process creates also highly concentrated CO_2 emissions which can potentially be captured and removed from the emission stream more effectively. According to the U.S. Department of Energy, coal gasification offers one of the most versatile ways to use coal cleanly and efficiently.

Aside from employing technologies which improve combustion efficiency, new methods called carbon sequestration techniques are being developed to capture CO_2 and remove it from the air. One type of carbon sequestration involves utilizing natural carbon sinks such as vegetation and oceans to absorb airborne CO_2. This can be achieved through planting trees (terrestrial sequestration), or injecting CO_2 deep into the ocean (oceanic sequestration). Another method of carbon sequestration is to store CO_2 in abandoned mines and empty aquifers (geologic sequestration). One of the greatest challenges of this method is to inexpensively separate carbon dioxide from ambient air. There is also some uncertainty as to the long-term viability of sequestering carbon in oceans, the wisdom of storing carbon dioxide in underground mines, and the impacts of introducing CO_2 into existing stable systems.

Alternative Technologies

The Clean Power Act provides incentives to sell emission allowances and the development of alternative energy sources such as wind power, solar power and fuel cells as well as biomass, landfill gas, geothermal and other energy sources. This provision is intended to increase the use of and research into alternative energy generation. The short timeframe set by the Act allows only limited implementation of current alternative energies, most feasibly the use of wind power and solar energy, and the possible integration of nuclear power.

Wind Power

Wind power is the world's fastest growing energy technology and has been used in rural communities for hundreds of years. Not until the late 1800s did refinements in equipment make its use more efficient. Since then, the creation of lighter, stronger materials and other advancements in technology have lead to the development of large-scale wind farms, which together generate enough electricity for five cities the size of Some estimates have indicated that the costs of wind power implementation will continue to drop as technology advances, leading to enough electricity to power 10 million homes by 2010. This could prevent the emission of millions of metric tons of CO_2, as well as NO_x, SO_2 and Hg. Moreover, in the case of this legislation, the increased cost of cleaning up the coal electricity power plants will mean that wind power would become more competitive compared to our current practices.

Reliance on wind power has some drawbacks. Wind power may be less reliable than traditional fossil fuel generation because of the unpredictable variation in wind velocity. In addition, wind farms require wide expanses of land, which is difficult to find near populated areas and is unpopular among landowners because the windmill structures are considered unsightly by some. If the wind farms are developed in uninhabited regions where sufficient space and wind exists, the transmission of wind power becomes problematic because extensive transmission lines would have to be constructed. Furthermore, wind power developments entail large capital expenses and depend on government tax credits to keep them competitive with coal.

Solar Power

The sun is another potential energy source that may be considered. Solar power technology harnesses the sun's radiative energy and converts it into electricity. Like wind power, solar power is an emissions-free technology. Solar power is dependent on silicon chips called photovoltaic (PV) cells which convert sunlight into electricity. The PV cells generate direct current (DC), which is then sold to electric utility companies using the electric grid. The cells then convert the DC into alternating current (AC) that can be used by consumers. PV cells can continue operating with little maintenance for up to 30 years. Drawbacks to the widespread use of solar energy include inconsistent sunlight, the large amount of flat surface area required and the capital cost of the PV equipment. Solar power is not currently used for large-scale electricity generation; however, due to its efficiency on a small-scale, many individuals have begun using solar power for a portion of their energy needs. As in the case of wind power, it is anticipated that additional research will lead to decreased costs which will help put more solar power equipment online.

Fuel Cells

Fuel cells are another potential source of energy that should be investigated as a viable alternative to fossil fuel electricity generation. They generate clean electricity by transforming stored energy into electricity and heat. Fuel cells have many applications and virtually no emissions. They are not yet used on a broad scale; less than wind, solar or nuclear power sources are used.

Because the use of wind power, solar photovoltaic cells and fuel cells is unlikely to significantly reduce our dependence on fossil fuels by 2009, we may become more dependent on nuclear energy in response to any decreased output from coal-fired power plants. Atomic fission creates energy and emits no greenhouse gases. Nuclear energy already comprises 20% of electricity production in the United States; however, the country does not currently have the infrastructural capacity to meet the potential needs. Moreover, the current political climate is unfavorable to the construction of new facilities, stemming from the potential human impact from nuclear waste and the environmental degradation it could cause if not handled properly. However, the efficiency of nuclear- powered electricity generation could be increased with plant upgrades. U.S. nuclear power plants have shown a steady improvement over the past 10 years and are highly efficient forms of power generation. With increased pressure to become even more efficient, the facilities may yield more electricity or be forced to make technological changes to meet the growing energy needs of the population.

Legislation such as the Clean Power Act of 2003 will likely spur innovation and research into alternative electricity technologies that will minimize emissions; however, the 2009 deadline may be approaching too rapidly to employ these technologies to a degree that meets our current energy needs. In the meantime, we may have to depend on our nuclear infrastructure to make up for losses of kilowatts generated by coal-fired power plants.

Although the list of these alternative energy sources is growing, they are expensive and fail to effectively compete with current electricity generating practices. Because these technologies are underutilized and the cost of coal remains low, they are not readily relied upon for electricity generation and development of new alternative energy sources has been stifled.

Measuring the Success of the Clean Power Act

Well-defined measurements of success are crucial to assessing the effectiveness of the Clean Power Act of 2003 at reducing ambient levels of pollution and improving human health and the environment. The Clean Power Act proposes dramatic reductions in the four pollutants outlined above and will affect each of the more than 1,110 electric generating facilities in the U.S. Like the Clean Air Act before it, this Act is likely to be in effect for decades, making effective implementation and monitoring vital to its success. Achievement of four goals will be considered when measuring the success of this act: achievement of the statutorily ordered pollution reductions; creation and implementation of the emission allowance trading system; increased energy conservation; and increased use of renewable and clean alternative energy technologies. Measuring success in these ways will ensure that the Act is being implemented while also providing environmental results that can be used to devise future regulations or laws.

Statutory Reductions

The goal of the Clean Power Act is to significantly reduce emission of nitrogen oxides, sulfur dioxide, mercury, and carbon dioxide. The amount of reduction and the timeframe to do so is specified in the Act. The Clean Power Act will have been successful if it meets these specific pollution reduction targets. By 2008, mercury emissions from facilities nationwide should be no more than 5 tons, a 90% decrease from year 2000 emissions levels. By 2009, nitrogen oxide levels nationwide should be no more than 1.51 million tons, a 63% decrease from year 2000 emissions levels. Additionally, sulfur dioxide emissions should be no more 2.25 million tons, with 275,000 tons in the western region and 1.975 million tons in the eastern region, a 79% decrease from 2000 emissions levels. Finally, carbon dioxide emissions should be no more than 2.05 billion tons, a 17% decrease from year 2000 emissions levels.

Achievement of these emissions limitations will be measured by Continuous Emissions Monitor (CEM) data from all facilities for NO_x, SO_2, CO_2, and Hg. Continuous emissions monitors, generally placed in the stack, electronically monitor released emissions at all times. These monitors have been required under the 1990 Acid rain program for SO_2 and NO_x and may also be used to monitor CO_2 and Hg emissions. Modernization of electricity generating facilities 40 years or older or by January 1, 2014, whichever is later, will be measured by the application of the best available control technology for the source, as measured by CEMs.

Creation and allocation of an emissions allowance system

Under the Clean Power Act, emissions allowances must be distributed to individual power plants according to standards developed by the EPA Administrator. Each allowance permits the emission of one ton of a pollutant. The second goal of the Clean Power Act is the successful creation and implementation of a robust and expanded emissions allowance program, which will come into effect at the Chicago Board of Trade, the current marketplace for emissions allowance trading under EPA's existing Acid Rain program.

Development of a Clean and Renewable Energy Infrastructure

The last goal of the Clean Power Act is the promotion of existing and the development of future clean and renewable power generating sources. Changes in renewable energy generation will be measured by the amount of electricity generated by renewable and clean coal sources per year after 2009, as a percentage of total electric generation. This information will be reported from electric-generating facilities to EPA on an annual basis. Increases in the development of future clean and renewable sources will be measured by the dollars generated by the sale of emissions allowances for this purpose during the years 2009-2018. This information will come from the results of each annual emissions allowance auction.

Benefits of the Clean Power Act

Ultimately, the purpose of Clean Power Act is to improve the environment, health, and quality of life for all Americans. Reductions in ambient pollution as specified by this Act should translate into reductions in negative environmental outcomes such as smog, acid rain, environmental mercury concentrations and global climate change. Smog reductions will reduce the number of ozone exceedances of the National Ambient Air Quality Standards and reduce smog-related respiratory diseases and deaths. Less smog will also result in reduced damage to vegetation and ecosystems, while also improving visibility in urban areas and National Parks. Reductions in acid rain will lead to improved air quality and protect public health through a decline in, chronic bronchitis, asthma attacks and premature deaths. These reductions will also help restore acidified lakes and streams so they may support aquatic life, especially in sensitive areas such as the Adirondack Lakes. Less acid rain will also repair damage to sensitive forests and coastal waters. Historic buildings and monuments will also be saved from further acid-induced degradation. The dramatic reductions in mercury called for in the Act should reduce measured mercury concentrations in fish, humans and the environment. Finally, carbon dioxide reductions specified in this act may reduce global emissions by up to 9.6%. While this decrease, in and of itself, will not be enough to halt climate change, the U.S., as the world's largest greenhouse gas emitter, has a responsibility to set global standards in emissions reductions. Decisive action by the U.S. to reduce greenhouse gases should result in stronger worldwide resolve to reverse climate change.

While current technologies do not allow for emissions-free electricity production on a large scale, the Clean Power Act provides support for their development. Funding the research and development of clean and renewable energy through the sale of emissions allowances allows a public good, clean air, to be paid for by the most polluting sources. As a result, the production of clean and renewable electricity should increase through time. In addition, promising technologies that are currently limited in use, such as wind and solar power, should become more economically viable and widely available to consumers. Once established as commercially successful, these technologies may allow the U.S. to increase its electricity production indefinitely without a subsequent increase in emissions.

Conclusion

Power plants emit nitrogen oxides (NO_X), sulfur dioxide (SO_2) and Mercury (Hg), and carbon dioxide (CO_2), pollutants that contribute to acid rain, smog, mercury contamination and global climate change. These environmental problems can lead to significant human health concerns, therefore the need for protective legislative is crucial.

In the more than 40 years since the inception of the Clean Air Act, Congress has passed several amendments; each an incremental step in improving national air quality standards. The proposed Clean Power Act of 2003 is another step forward, setting emissions reduction standards for U.S. power plants, since they are responsible for the majority of all industrial air emissions in the nation.

The Clean Power Act establishes strict emissions caps for NO_x, SO_2, and $CO_{2,}$ which must be achieved by 2009, and an emissions cap for Hg which must be satisfied by 2008. Emissions reductions may be reached through an emissions allowance and trading system, outlined by the Act, and through the closure of a previous legislative loophole, requiring all plants to install the best available emissions control technology, regardless of their age.

The success of the Clean Power Act is contingent upon compliance with the emissions standards outlined in the Act. There are several new and existing technologies that will enable power plants to achieve these emissions reductions. Additionally, financial incentives built into the emissions trading system will help spur investment in research and the development of emissions-free and improved abatement technologies to increase the use of clean power generation. These incentives will also help reduce power plants' costs of compliance.

Successful implementation of the Act will be determined by emissions monitoring at power plants, an expansion of emissions trading, and an increase in the use of clean and renewable technologies. Ultimately, the reduction of $NO_{x,}$ SO_2, Hg and CO_2 will contribute to decreases in smog, acid rain, mercury contamination and global climate change and will lessen negative impacts to the environment and human health.

Building on more than 40 years of continued emission reductions legislation in the United States. the Clean Power Act of 2003 enables Congress to continue its commitment to improving air quality and human health throughout the United States.

Appendix

Clean Power Act of 2003 Summary & Status

S.366
Title: A bill to amend the Clean Air Act to reduce emissions from electric powerplants, and for other purposes.
Sponsor: Sen Jeffords, James M. [VT] (introduced 2/12/2003) Cosponsors (19)
Latest Major Action: 2/12/2003 Referred to Senate committee. Status: Read twice and referred to the Committee on Environment and Public Works.

TITLE(S): (*italics indicate a title for a portion of a bill*)

- SHORT TITLE(S) AS INTRODUCED:
  Clean Power Act of 2003
- OFFICIAL TITLE AS INTRODUCED:
  A bill to amend the Clean Air Act to reduce emissions from electric powerplants, and for other purposes.

STATUS: *(color indicates Senate actions)*
2/12/2003:
Introductory remarks on measure. (CR S2345-2346)
2/12/2003:
Read twice and referred to the Committee on Environment and Public Works. (text of measure as introduced: CR S2346-2351)
2/24/2004:
Introductory remarks on measure. (CR S1515-1517)

COMMITTEE(S):

Committee/Subcommittee:	**Activity:**
Senate Environment and Public Works	Referral, In Committee

RELATED BILL DETAILS:

NONE

AMENDMENT(S):

NONE

COSPONSORS(19), ALPHABETICAL [followed by Cosponsors withdrawn]: (Sort: by date)

Sen Biden Jr., Joseph R. [DE] - 2/12/2003
Sen Boxer, Barbara [CA] - 2/12/2003
Sen Clinton, Hillary Rodham [NY] - 2/12/2003
Sen Collins, Susan M. [ME] - 2/12/2003
Sen Corzine, Jon [NJ] - 2/12/2003
Sen Dodd, Christopher J. [CT] - 2/12/2003
Sen Edwards, John [NC] - 2/12/2003
Sen Feingold, Russell D. [WI] - 2/12/2003
Sen Feinstein, Dianne [CA] - 2/12/2003
Sen Kennedy, Edward M. [MA] - 2/12/2003
Sen Kerry, John F. [MA] - 2/12/2003
Sen Lautenberg, Frank R. [NJ] - 2/12/2003
Sen Leahy, Patrick J. [VT] - 2/12/2003
Sen Lieberman, Joseph I. [CT] - 2/12/2003
Sen Reed, John F. [RI] - 2/12/2003
Sen Sarbanes, Paul S. [MD] - 2/12/2003
Sen Schumer, Charles E. [NY] - 2/12/2003
Sen Snowe, Olympia J. [ME] - 2/12/2003
Sen Wyden, Ron [OR] - 2/12/2003

SUMMARY AS OF:
2/12/2003--Introduced.

Clean Power Act of 2003 - Amends the Clean Air Act to require the Administrator of the Environmental Protection Agency (EPA) to promulgate regulations to achieve specified reductions in emissions of sulfur dioxide, nitrogen oxide, carbon dioxide, and mercury from certain electric generation facilities by January 1, 2009. Directs the Administrator to establish an emission allowance tracking and transfer system. Makes a special rule for mercury emissions. Directs the Administrator to study the impact of emission allowance trading. Limits the trading of allowances with facilities other than electricity generating facilities to certain carbon dioxide emission control programs. Provides an allocation to: (1) dislocated workers; (2) disproportionately adversely impacted communities; (3) electricity generating facilities; (4) renewable electricity generating units; (5) efficiency projects; (6) cleaner energy sources; and (7) biological carbon sequestration activities. Directs the Administrator to establish and annually review emission limitations for mercury. Requires that captured or recovered emissions not be re-released into the environment. Requires the Administrator to request information from owners/operators about hazardous air pollutants other than mercury. Directs the Administrator to then propose and promulgate emission standards. Requires facilities to achieve specified emission standards should the regulations not be promulgated. Requires an assessment and identification of sensitive ecosystems and the objectives necessary for their protection, including the Adirondack, the mid-Appalachian, Rocky, and southern Blue Ridge Mountains. Includes as well the Great Lakes, Lake Champlain, Long Island Sound, and the Chesapeake Bay.

http://thomas.loc.gov/cgi-bin/bdquery/z?d108:SN00366:@@@L&summ2=m&

Glossary of Terms

Acid Rain – precipitation containing harmful amounts of nitric and sulfuric acids formed primarily by nitrogen oxides and sulfur oxides released into the atmosphere when fossil fuels are burned and has a pH below 5.6.

Allowances – a permit that grants power plants (or other buyers, including individuals or other entities) the right to emit (or retire) one ton of a pollutant.

Best Available Control Technology – emission controls that will achieve the lowest achievable emission rate for the source to which it is applied.

Bioaccumulation – the increase in concentration of a contaminant at each level of a food chain.

Birthday Clause – requires the modernization of electricity generating facilities by their fortieth year of operation or by January 1, 2014 (whichever is later) using the best available control technology for the source.

Carbon Dioxide – a gas that occurs naturally in the Earth's atmosphere and significant quantities are also emitted into the air by fossil fuel combustion and deforestation.

Carbon Sequestration – capturing carbon in carbon sinks such as the oceans, forests or soils to reduce the amount of carbon released into the atmosphere.

Coal gasification – process by which coal is converted into synthetic natural gas.

Clean Coal (Low Sulfur Coal/Anthracite) – formed in ancient fresh water river basins has low concentrations of inorganic sulfur.

Dirty Coal (High Sulfur Coal) – formed from plant material and deposited in marine settings has high organic sulfur concentrations.

Dry deposition – absorbed gaseous and particulate matter, aerosol particles or dust in the form of fallout from smokestacks without wind or water transport.

Fluidized Bed Coal Combustion – crushed coal particles are suspended in the boiler on upward-blowing jets of air. This allows the particles to move about dynamically in a fluidized state.

Gas Reburning – process of burning coal in a low oxygen environment, then injecting part of the fuel into a separate zone where fuel-rich conditions break apart NO_x and reburn at low temperatures.

Global warming – an increase in the average temperature of the Earth's surface, which occurs following an increase in greenhouse gases.

Grandfather clause – a 30-year loop-hole which enabled old power plants to continue to emit pollutants at levels far exceeding those of more modern plants.

Greenhouse gases – gases such as carbon dioxide, methane, water vapor, nitrous oxide, ozone and halocarbons in the atmosphere that trap heat from the sun and warm the earth.

Injected Activated Carbon – a process where activated carbon, along with sulfur or iodine, is injected into the flue gas of a spray dryer to form a stable mercury compound, causing 90% of Hg to precipitate out so it can be removed.

Low NOx Burners – limit the amount of oxygen available to react with nitrogen and lower combustion temperatures to nitrogen oxides.

Mercury – a heavy metal that can accumulate in the environment and is highly toxic if breathed or swallowed and has the potential to cause kidney or nervous system disorders.

National Ambient Air Quality Standards – standards established by the EPA to reduce the concentrations of six criteria pollutants: ozone, particulate matter, carbon monoxide, sulfur dioxide, nitrogen oxide and lead because they are considered harmful to public health and the environment.

Nitrogen oxides – compounds of nitric acid (NO), nitrogen dioxide (NO2), and other oxides of nitrogen typically created during combustion processes, and are major contributors to smog formation and acid deposition and may result in numerous adverse health effects and reduces visibility.

Radiative forcing – the change in the balance between the incoming and outgoing radiation; positive radiative forcing, which warms the Earth, occurs because greenhouse gases prevent some radiation from escaping back into space.

Renewable energy – can be used to create electricity without the release of emissions into the atmosphere includes wind, hydro, solar, fuel cell and biomass power.

Selective Catalytic Reduction (SCR) – Adds ammonia to the flue gas of a burner, which then passes through a catalyst, turning the NO_x into molecular nitrogen and water with reductions are as high as 90%.

Selective Non-Catalytic Reduction – Adds ammonia to the flue gas of a burner, which then passes through a catalyst, turning the NO_x into molecular nitrogen and water.

Scrubbing – a process requiring a mixture of limestone and water to be injected into the flue gas and reacts with SO_2 to form calcium sulfate also called “Flue Gas Desulfurization (FGD)."

Smog – pollution formed by the interaction of pollutants and sunlight in the lower atmosphere, restricting visibility, and potentially hazardous to health.

Sulfur Dioxide – a gas produced by burning coal, most notably in power plants and plays an important role in the production of acid rain.

Wet deposition – pollution that falls to the ground in the form of rain, snow, or fog.

Vector (as in vector-borne disease) – an organism, such as a mosquito or tick, that carries disease-causing microorganisms from one host to another of a different species.

Volatile Organic Compounds (VOCs) – compounds that have a high vapor pressure and low water solubility and react readily with NO_x to form ozone in the atmosphere.

Timeline for the Clean Air Act

The Federal Clean Air Act

The Federal Clean Air Act (CAA) is the core and driving force for all air pollution legislation in the United States. As it currently exists it is the framework for a wide ranging and coordinated federal/state scheme of regulation that that now pervades our social order and national economy. It affects nearly every corporate and private citizen in the country. The following sections summarize the structure and history of the Act, and demonstrate how it is currently applied.

History

The original CAA was passed in 1963, and since that time there have been five major amendment cycles. Prior amendments to the act have occurred in 1965, 1967, 1970, and 1977. The latest cycle was completed November 17, 1990, when President Bush I signed the latest Clean Air Act.

The original CAA

- Provided grants to state and local Air Pollution Control Districts.

1965 Amendments

- Added Title II - The Motor Vehicle Pollution Control Act, authorizing federal emissions standards for new vehicles. [40CFR89]

1967 Amendments

- Registration of fuel additives (Sec. 211) [40CFR79] - Coupled with the amendments of 1970 allowing citizen suits led to the lead phase-out regulations [40CFR80.20] and special nozzles with matching inlets for cars. The latest lead regulations were promulgated in 1985 [50 FR 9386 (3/7/85)].
- Aircraft engine emissions controls [40CFR87]
- New Source Performance Standards (NSPS) (Sec. 111) [40CFR60] - Among other things, sets test methods, and *requires states to regulate existing sources in any category for which EPA sets NSPSs.*

1970 Amendments

- Establishes air quality criteria pollutants (Sec. 108) [40CFR50].
- Requires EPA to set National Ambient Air Quality Standards (NAAQS) and goals with deadlines (Sec. 109) [40CFR50].
- Required establishment of air quality control regions (Sec. 107) -by default settled on county boundaries and formalized regions in 1977 amendments.
- Required preparation of State Implementation Plans (SIPs) to achieve NAAQS (Sec.

110) [40CFR51].

- Required that National Emissions Standards for Hazardous Air Pollutants (NESHAPs) be set (Sec. 112) [40CFR61]
- Required the preparation of Transportation Control Plans (TCPs) in ozone non-attainment areas.
- Mandated New Source Reviews in non-attainment areas (Sec. 110 (a) (2) (D)) including authorization of off-set rules (41 FR 5524-30 and 44 FR 3274).
- Set vehicle emissions limits with compliance schedule [40CFR86].
- Allowed citizen suits (Sec. 304) - Citizens suits led to the Prevention of Significant Deterioration (PSD) policy and amendments in 1977, a TCP for the Los Angeles basin, and a NAAQS for lead.
- Required public disclosure of emissions (Sec. 114) - A source could not claim company proprietary rights to prevent public disclosure of emissions data.

1977 Amendments

- Prevention of Significant Deterioration (PSD) of air quality (Sec. 163) (45 FR 52676 (8/7/80) and 48 FR 38745 (8/25/83)) [40CFR52.21].
- Ozone protection (Sec. 150-159).
- Forbids use of intermittent controls or dispersion to control air pollution (Sec. 123)
- Establishes Emissions 0ff-sets and "bubble" approach (51 FR 43814 (12/4/86)).
- Puts carcinogenic air pollutants into NESHAPs (Sec. 112)

1990 Amendments

The 1990 Federal CAA was a complete rewrite of the old clean air act. Revises the Titles and requires EPA to issue 175 new regulations, 30 guidance documents, and 22 reports. It also establishes 6 panels and initiates 53 research projects. Formalizes congressionally mandated regulations. Following are some of the items covered:

- Drops automotive emissions limits for HCs to 0.25 g/mi and for NOx to 0.4 g/mi from 0.41 and 1.0 g/mi respectively
- Mandates gasoline reformulation in "dirtiest cities".
- Mandates fleet clean fuels and lowers CAFE levels
- Sets diesel particulate standards.
- EPA may prohibit highway grants to states
- EPA must establish interstate air pollution transport regions.
- Mandates maximum achievable control technology (MACT) for 189 airborne toxics by 2003.
- Mandates reduction of SOx emissions by 8.9 million tons per year by 2000.
- EPA to establish an allowance trading and tracking system for SOx emissions.
- Mandates complete phase-out of CCl_4 and TCA by 2000 and 2002 respectively.

- Bans non-essential uses of ozone depleting chemicals
- Requires recycling of CFCs from air conditioners and refrigerators by 1992
- Mandates permit and emissions fee system for acid rain emissions
- Sets new SIP requirements
- By 1992 states must require owner/operators of >10 ton per year emitters to submit inventories of NOx and VOC emissions.

The 1990 Clean Air Act

The CAA is constructed of titles, each addressing a specific air pollution issue. The CAA currently has nine titles, covering National Ambient Air Quality Standards, Mobile Sources, Air Toxics, Acid Rain, Permitting, CFCs, Enforcement Issues, Miscellaneous Topics, and Research. An individual Title may require the appropriate agency (usually the EPA) to write certain regulations, prepare reports, issue guidance documents, or conduct studies. For example, under Title 1, Sec.176A(a), The EPA must by rule establish interstate transport regions whenever interstate transport of air pollutants contribute significantly to a violation of a national ambient air quality standard. The individual titles with their major requirements are listed below.

Title I - Attainment of National Ambient Air Quality Standards

Title II -Mobile Sources

Title III - Hazardous Air Pollutants (Air Toxics)

Title IV -Acid Rain

Title V - Permits

Title VI - CFCs Phaseout/Global Warming

Title VII - Enforcement

Title VIII - Miscellaneous Issues

Title IX - Research

(http://www.co.mendocino.ca.us/aqmd/pages/CAA%20history.html)

Q1. **What is the greenhouse effect?**

A1. *The greenhouse effect refers to the rise in the Earth's temperature as a result of certain gases in the atmosphere (including water vapor, carbon dioxide, nitrogen oxide, and methane) trapping energy from the Sun. Without these gases and the greenhouse effect, heat would escape back into space and Earth's average temperature would be about 58°F colder.*

Q2. **What is a carbon sink?**

A2. *Any reservoir that takes up carbon released from some other part of the carbon cycle may be referred to as a carbon sink; for example, vegetation, soils, the atmosphere, and oceans are major carbon sinks because much of the carbon dioxide produced elsewhere on the Earth ends up in these bodies. (See Figure A).*

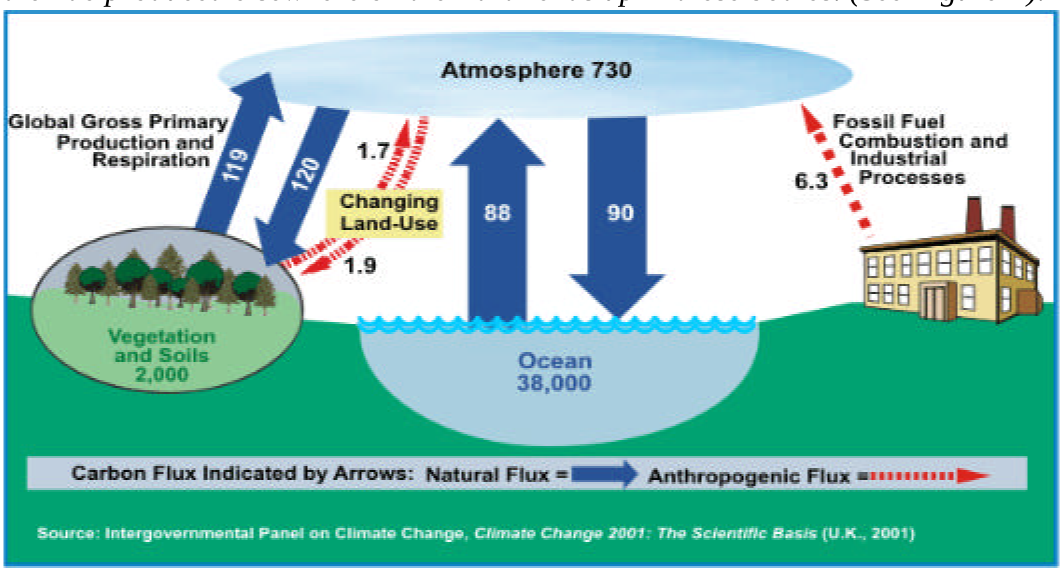


Figure A. Global Carbon Cycle (Billion Metric Tons Carbon) [IPCC 2001]

Q3. **How is smog formed?**

A3. *The formation of smog occurs as a result of a photochemical reaction between several distinct forms of pollutants. Two groups of chemical pollutants are involved: nitrogen oxides (NO_x), and volatile organic compounds (VOCs). When stagnant air masses linger over urban areas, the pollutants are held in place for long periods of time. Sunlight interacts with these pollutants, transforming them into ground-level ozone. The ozone remains in the lower atmosphere until weather systems flush out a given area and dissipate them. An `episode' of ground-level ozone can last from several hours to several days. Episodes are particularly severe in cities with high concentrations of NO_x and VOCs during periods of warm weather.*

Q4. **What are the specific measurable goals of the Act?**

A4. *I. By 2009, emissions from power plants should be reduced to specified levels:*

- *CO_2 to 2,050,000,000 tons (currently not regulated)*
- *SOx to 275,000 tons in the West and 1,975,000 tons in the East (75% reduction)*
- *NO_x to 1,510,000 tons (70% reduction)*
- *Hg to 5 tons. (by 2008) (90% reduction)*

II. All facilities will be required to adopt the Best Available Control Technology (BACT) "by the later of 2014, or 40 years after commencing operation."

III. A system of emission allowance trading will be established for SO_2, NO_x, and CO_2.

Q5. **Are the mandatory reductions of 70 to 90 percent realistic?**

A5. *The reductions were defined statutorily; the Act does not specify how it must be reduced. However, one way we can meet the standards of the law is by following the bill's requirement that all power plant facilities use the BACT to reduce their emissions. We have been controlling SO_2 and NO_x since the 1970s, but many power plants are exempted because of the grandfather clause. Much of the technology has been in use for a long time; this bill attempts to make sure that all facilities use it. In this way, the mandatory reductions appear realistic.*

Q6. **Why aren't VOCs addressed in this act?**

A6. *The Clean Power Act seeks to limit the deleterious emissions of power-generating facilities. These facilities emit negligible amounts of VOCs, thus the Act does not target these pollutants. (As a side note, regional conditions will dictate whether NO_x or VOCs will be the primary determinant of ground-level ozone production. VOC emissions have decreased by about 40% since the Clean Air Act was enacted.) See Figure B.*

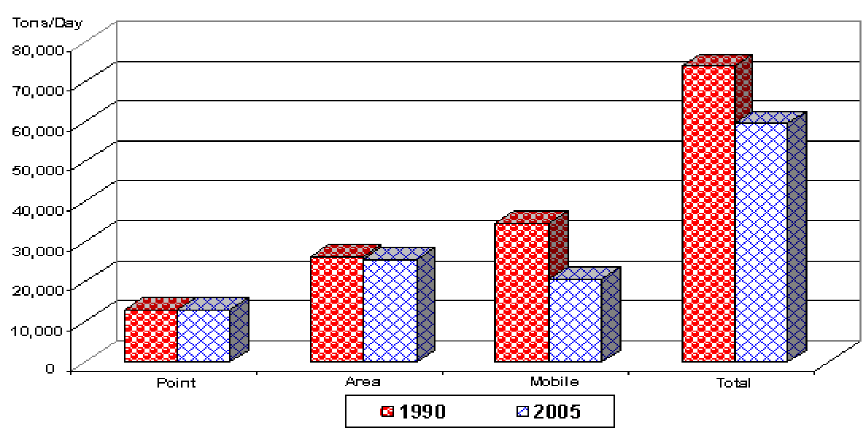


Figure B. VOC emissions by source, 1990 and est. 2005.
http://www.epa.gov/oar/oaqps/bluebook/vocsrc90.html.

Q7. **Is CO_2 a type of VOC?**

A7. *No. CO_2 may function like VOCs at some times, but VOCs are regulated pollutants in the U.S., and have been for over 20 years, while CO_2 has remained* *unregulated (which is one of the reasons for this bill). If CO_2 was a VOC (and was defined as such in the law), EPA could issue regulations to reduce its emission levels based on the fact that it was contributing to the ozone problem.*

Q8. **How are allowances determined?**
A8. *The EPA administrator is responsible for determining allowances for each power plant.*

Q9. **What is the current status of the Act?**
A9. *The Act was shelved, but, for all intents and purposes here, we are assuming that it passed, and we are working on a plan for implementing and managing the program.*

Q10. **What are the estimated costs of compliance?**
A10. *This has not yet been determined, and we will look at this later. We will examine the costs when we begin to explore the implementation of the Act.*

Q11. **Why is coal cheaper than other types of fossil fuels?**
A11. *The short answer is that there is a lot of coal, and it is abundant domestically. It is also easier to transport, since it is a solid, and not a highly combustible gas or a liquid.*

Q12. **What is the difference between "clean" coal and "dirty" coal?**
A12. *Clean and dirty coal can mean two things:*
1) *It can refer to the grade of coal, as different kinds of coal have varying amounts of sulfur and other impurities. These are:*
- *Lignite—(softest coal-found in the TX, LA, ND, and MT)*
- *Sub-bituminous (MT, WY, CO, WA)*
- *Bituminous (Appalachia, Midwest)*
- *Anthracite (hardest) (Eastern PA only)*

The hardness of coal is a measure of its purity; harder coal has more carbon and less other stuff (like sulfur) per unit of mass. This is why harder coal burns cleaner. Anthracite is the cleanest coal, then. It is also occurs in a very limited area and is severely depleted, making it more expensive. Bituminous is the coal most commonly used for electricity generation. (Mineral Information Institute)

2) *Clean coal refers to treating coal in a way that results in less emitted pollution, either by a physical or chemical cleaning to remove impurities. These processes involve crushing the coal and sifting it through screens, and soaking it in water to extract impurities. For further information, please see:*
<http://www.epa.gov/ttn/chief/ap42/ch11/final/c11s10.pdf>

Q13. **What percentage of these pollutants comes from U.S. power plants versus other sources?**
A13. *U.S. fossil-fuel powered electricity generating units emit:*
- *67% of total U.S. SO_2 emissions*

- *23% of total U.S. NO_x emissions*
- *64% of total U.S. Hg emissions*
- *35% of total U.S. CO_2 emissions*

Q14. What is the total U.S. contribution to global emissions of CO_2?
A14. *The United States emits 24% of total worldwide CO_2 emissions.*

Q15. If climate change is a global problem, why is it addressed in this act?
A15. *It is vital to understand the political context surrounding this act. After coming into office in 2001, President Bush said that the U.S. would withdraw from the Kyoto Protocol on Climate Change. Under the Constitution, only the President may negotiate treaties with other countries. A senator like Jim Jeffords, the bill's sponsor, cannot initiate a global treaty, whether he wants to or not, but he can introduce a national act. Jim Jeffords probably knows that climate change is a global problem and can only be effectively addressed at a global level. But he also knows that the U.S. is not going to pursue global action anytime soon. So the next best step is to try for national CO_2 reductions. Since the U.S. is such a large producer of greenhouse gasses, this bill would have some effect. Also consider that Jeffords is from Vermont, which is seriously affected by power plant pollution. So whether this bill passes or not, he can say he's trying to protect his constituents by introducing this bill.*

Q16. Are emissions trading permits publicly available?
A16. *The Act says in Section 705(b)(3)(B)(i) and (ii) that: "the emission allowance tracking and transfer system established under subparagraph (A) shall…permit any entity to buy, sell or hold an emission allowance; and to permanently retire an emission allowance."*

Q17. Are property rights assigned?
A17. *No, the Clean Power Act specifically states that the emissions allowances are not property rights. This allows EPA to take them away from the facilities who have purchased allowances but whose emissions contribute to National Ambient Air Quality (NAAQs) violations in their local area.*

Q18. How is the number of permits per facility determined?
A18. *The method for distributing allowances is not specified in the legislation. EPA will distribute allowances to individual facilities based on a formula determined in regulations.*

Q19. How does mercury get into the water, on land, etc.?
A19. *Mercury travels naturally through the environment in small amounts. It leaches out of Earth's crust, and is found in soil, where it is taken up by plants (and animals who eat them) in trace amounts without help from humans burning coal. Mercury also ends up in water and on land through dry deposition from power plants. It is not transported far because of the weight of this heavy metal.*

Q20. **What is mercury and why is it in coal emissions?**

A20. *Mercury is an element that generally occurs in trace amounts. Plants take up mercury from the soil during their lifetimes. Coal is formed when plants die and settle under anaerobic conditions (like in a peat bog). Without oxygen, the plant matter cannot decompose. Under great pressure and millions of years, the dead plants are transformed into coal. Since the plants have not decomposed, coal is made up of the same elements as the original plants. Since some plants collect trace amounts of mercury, coal, too, contains mercury. Since mercury is an element, it is not consumed by combustion, but rather carried up out of the smokestack.*

Q21. **How is Methyl Mercury different from other types of mercury?**

A21. *Methyl Mercury (MeHg), is an organic form of Hg, which is apt to "accumulate up the food chain in aquatic systems and lead to high concentrations of MeHg in predatory fish, which, when consumed by humans, can result in an increased risk of adverse effects in highly exposed or sensitive populations."*

Q22. **How are humans exposed to mercury?**

A22. *Humans are exposed to mercury chiefly by eating contaminated fish.*

Q23. **How is mercury toxicity measured in humans?**

A24. *Mercury toxicity in humans may be measured through urinalysis or blood tests.*

Q24. **How is mercury passed from mother to a fetus?**

A24. *A mother can pass along mercury to a developing fetus or to her child through breast milk. Some of the effects that can be passed from the mother to the fetus include: brain damage, mental retardation, blindness, seizures, and inability to speak.*

Q25. **Has anyone died from mercury poisoning?**

A25. *Death and illness from mercury poisoning have long been recognized. The expression "mad as a hatter" came from the occupational hazard of hat makers in the 1800's who were poisoned by mercury salts used in the making of felt hats. Consumption of food contaminated with methyl mercury in the second half of the 20th century resulted in death or illness for thousands of people around Minimata Bay, Japan. (Mercury poisoning that was first described in the inhabitants of Minamata Bay and resulted from their eating fish contaminated with mercury industrial waste.)* (MedicineNet.com, 2004)

Q26. **If you keep eating fish, does mercury stay in your body? How much mercury can your body process?**

A26. *Mercury may stay in the human body for 70 to 140 days before being excreted.*

Q27. **How many older power plants are still in operation today?**

A27. *In 2000, approximately 57% of fossil fuel power plants in the U.S. (1,396 facilities) began operating before 1972. The older power plants emitted 59* *percent of the sulfur dioxide, 47 percent of the nitrogen, and 42 percent of the carbon dioxide from fossil-fuel units in 2000, while generating 42 percent of all electricity produced by fossil-fuel units. Units that began operating in or after 1972 were responsible for the remainder of the emissions and electricity production.*

Q28. **What percent of the energy currently produced in the U.S. is renewable energy?**

A28. *Currently renewable resources (solar, wind, geothermal, hydroelectric, biomass, and waste) provide almost 12 percent of the Nation's electricity supply. Hydroelectric resources provide about 10 of this 12 percent while biomass and municipal solid waste (MSW) together contribute more than 1 percent. All other renewable resources, including geothermal, wind, and solar, together provide less than 1 percent of the total. (DOE, 2004)*

Q29. **Wouldn't the cost of renewable energy go down if more people used it?**

A29. *Economically, it makes sense that after renewable energy becomes well-established it will be easier to produce the technologies to create economies of scale would result in lower costs; however, currently the technologies cannot be implemented at a competitive cost relative to coal-fired power.*

Q30. **Why are we further regulating SO_2 if previous legislation was so successful?**

A30. *The basic reason is that SO_2 remains a concern to human health and the environment, particularly through its contribution to acid rain. While SO_2regulation under the Clean Air Act has been hugely successful, it is felt that further gains can be made by eliminating the grandfather clause from the Act and provoking firms to install advanced SO_2 control technology.*

Q31. **Where did the statistic that power plants cut short the lives of nearly 24,000 Americans every year an average of 14 years come from?**

A31. *This data is from Clear the Air <http://cta.policy.net/dirtypower> and Final Report to Congress on Benefits and Costs of the Clean Air Act, 1970 to 1990", EPA 410-R-97-002 p. I-23.*

Q32. **How many grandfathered plants are there?**

A32. *Nationally, there are 540 grandfathered plants total* (Southern Alliance for Clean Energy, 2003).

Q33. **How does depriving emissions of air or saturating with oxygen reduce CO_2 and NO_x?**

A33. *The difference between saturating the combustion chamber with oxygen and starving it of air can be explained by the ratio of nitrogen to oxygen present in the chamber at the time of combustion. If ambient air is at a premium (low NO_x burner technology) then fuel combusts and prefers to form CO_2 thus yielding lower overall NO_x formation. Conversely, if the combustion chamber is saturated with O_2, combustion of fuel promotes CO_2 formation over the formation of NO_x*

and, consequently, also promotes more complete (efficient) combustion of the fuel.

Q34. Doesn't injecting CO_2 into the ocean run the risk of forming carbonic acid? What studies or tests have been done to prove the safety of this measure?

A34. *Injecting CO_2 into the ocean can run the risk of forming carbonic acid. Thus it is important to inject it around or below the thermocline (~1,000 meters down), where less aquatic life exists. There are methods being explored to get the CO_2 to react more quickly with compounds already present in seawater to form mineral deposits, which could then sink to the bottom of the ocean.*

Q35. What are some other ways power plants can reduce CO_2?

A35. *Beside carbon sequestration, power plants can reduce emissions through fuel switching (changing to cleaner energy source or increasing the proportion of energy derived from cleaner sources) or by increasing efficiency of the burning of current fuel sources (thereby reducing the amount of fuel needed, and the amount of carbon combusted).*

Q36. Who is funding the research and development efforts for new emissions control and alternative power technologies?

A36. *Funding for the research and development efforts for new emissions control and alternative power technologies comes from direct government research (especially by the Department of Energy), government subsidies for private research and development of new emissions-control technologies, and private funding by firms that anticipate more stringent standards and hope to take advantage of first-mover benefits.*

Q37. Are there any places that have come up with one system that satisfies all the regulations and goals set by the Clean Power Act?

A37. *The DOE is working on coal gasification, which can reduce sulfur dioxide, nitrogen oxide, and mercury emissions. Because technology leads to more efficient combustion, less carbon will be necessary to produce energy, so CO_2 emissions will, effectively, be reduced.*

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