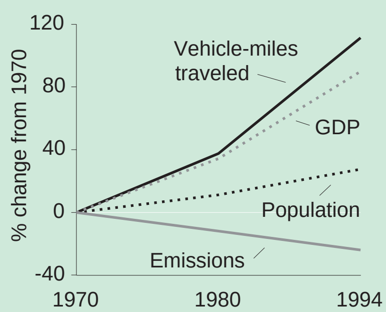
CHAPTER TEN

Air Quality

The use of regulatory approaches to manage air quality has been remarkably successful in the United States. From 1970 to 1994, total U.S. population grew by 27 percent, vehicle-miles traveled grew by 111 percent, and gross domestic product (GDP) grew by 90 percent. Yet in this same period the combined emissions of the six principal air pollutants dropped by 24 percent (Figure 10.1).

This is in stark contrast to past experience. Air pollution typically has followed economic and demographic trends. For example, during the Great Depression of the 1930s, emissions of air pollutants declined dramatically. During World War II, increased industrial production raised emissions to levels higher than those of the pre-Depression era. It has been estimated that, between 1900 and 1970, emissions of nitrogen oxides increased about 700 percent, volatile organic compound emissions increased about 250 percent, and sulfur oxides increased about 200 percent. Without the Clean Air Act, emissions of these and other pollutants would have continued to rise (see also Figure 10.2).

Figure 10.1 U.S. Emissions, Demographic, and Economic Trends, 1970-1994



Source: U.S. Environmental Protection Agency, *Air Quality Trends* (EPA, Research Triangle Park, NC, 1995).
Note: GDP=gross domestic product.

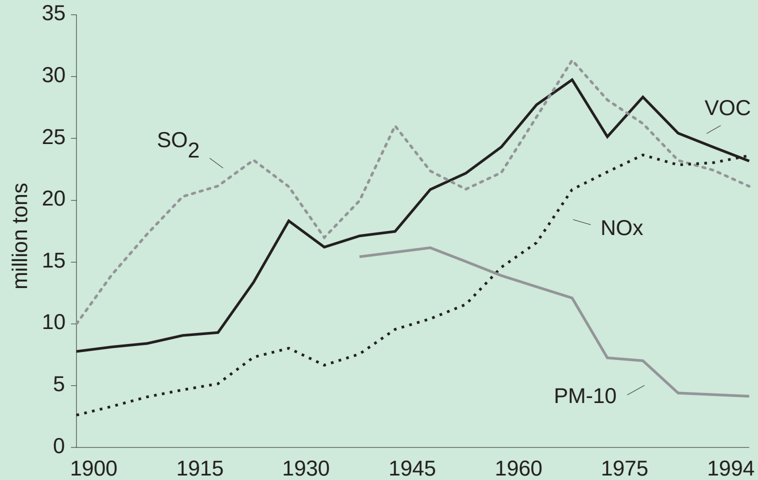
BACKGROUND

The Clean Air Act was signed into law in 1963, but it was the enactment of amendments to the law in 1970 that proved to mark a turning point in progress on air pollution control.

The basic objective of the law is to protect people and natural resources from airborne pollutants that could endanger public health and welfare or destroy the nation's natural resources.

The 1970 Clean Air Act amendments gave EPA three major tasks: (1) to set national ambient air quality standards (NAAQS); (2) to set new source performance standards (NSPS), and (3) to develop motor vehicle emission standards.

Figure 10.2 U.S. Emissions by Type, 1900-1994



Source: See Part III, Table 27.

Note: NO_x=nitrogen oxides. PM-10=particulate matter with a diameter of 10 microns or less. SO_2=sulfur dioxide. VOC=volatile organic compounds.

National ambient air quality standards set maximum allowable ambient concentrations for each pollutant. There are two kinds of standards: *primary* standards, which are designed to protect public health, and *secondary* standards, which are designed to protect public welfare (e.g., to protect against decreased visibility and damage to animals, crops, vegetation, and buildings). Primary standards are to be attained within prescribed deadlines; secondary standards are to be attained as expeditiously as possible. NAAQS have been developed for six common air pollutants, designated "criteria" pollutants: carbon monoxide (CO), lead, nitrogen dioxide (NO_2), ground-level ozone, particulate matter with a diameter of 10 micrometers or less (PM-10), and sulfur dioxide (SO_2).

Geographic areas that meet or fall below the primary standards are called "attainment areas"; areas that do not meet the standards are "nonattainment areas." In attainment areas, new sources and major modifications to existing sources must use the best available technology to control emissions, although energy, economic, and environmental concerns are considered on a case-by-case basis. In some cases, where a specific existing source causes problems in the more pristine areas (parks and wilderness), the source must use the best available retrofit technology controls.

In nonattainment areas, new sources are required to achieve the lowest possible emissions rate regardless of economic considerations. Furthermore, emissions from new sources must be offset by emissions from existing sources in the same geographic area, resulting in a net improvement in ambient air quality.

Once air quality improves and meets the primary standards, nonattainment areas must develop a contingency plan of action to ensure continued attainment of the standards and are then formally redesignated. In September 1996, there was only one nonattainment area for NO_2. There were 10 nonattainment areas for lead, 31 for CO, 43 for SO_2, 68 for ozone, and 81 for PM-10 (Figure 10.3). Altogether, 171 areas were in nonattainment for one or more pollutants.

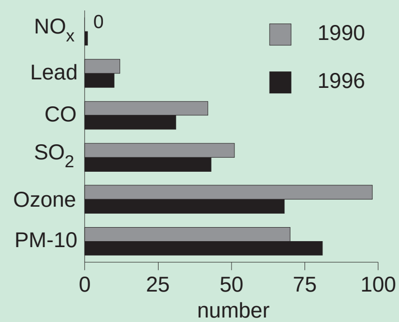
New source performance standards are nationally uniform standards based on the best demonstrated technology, taking cost into account, for a particular source category or process. These standards are designed to prevent new pollution caused by future growth and to improve air pollution as old facilities are replaced. Emissions limits have been set for about 60 source categories.

Motor vehicle emission standards control exhaust and evaporative emissions from cars, trucks, buses, and motorcycles. Emission standards were first established in the 1970s. Since then, they have become increasingly more stringent. They have accounted for much of the decline in CO, VOC, and NOx emissions: on average, a new car in 1990 is about 70 percent cleaner than a car built in 1970 without emission controls. The 1990 Clean Air Act amendments introduced a variety of new measures requiring even cleaner cars, cleaner fuels, enhanced inspection and maintenance programs, and—for the first time—emissions requirements for nonroad engines such as lawn mowers, boats, construction equipment, and farm equipment.

In addition to criteria air pollutants, the Clean Air Act also requires EPA to regulate hazardous air pollutants or "air toxics." Initially EPA regulated only seven hazardous air pollutants that caused serious health problems. The 1990 amendments expanded the list to 189 pollutants and required EPA to set technology-based control standards for 174 categories of sources.

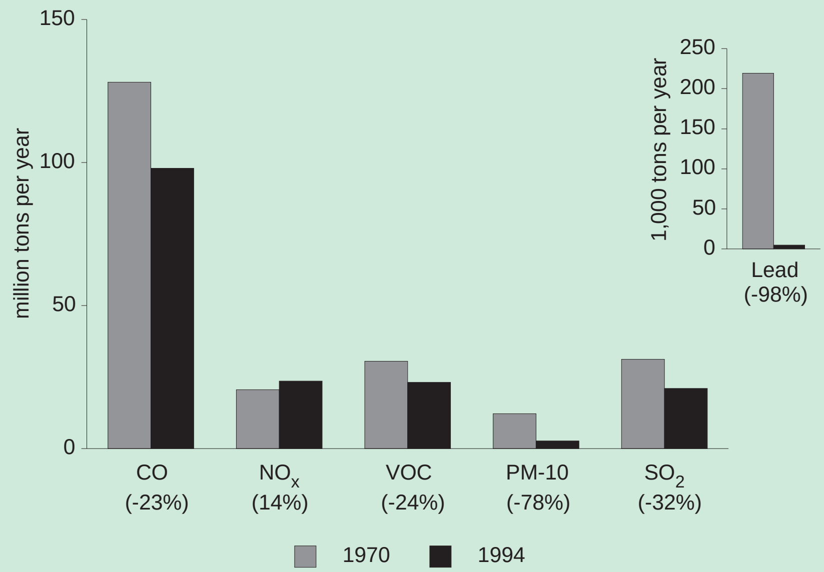
The 1990 amendments also created a national acid rain control program with reduction targets for SO_2 and nitrogen oxides (NO_x). For SO_2, the goal is to reduce annual emissions to a level 10 million tons below the 1980 level, a goal that will be largely reached by 2000. Another goal is to reach a permanent national limit, or annual cap, of 8.9 million tons for electric utility SO_2 emissions by 2000. A 1995 goal to reduce non-utility industrial SO2 emissions by 5.6 million tons has already been met.

Figure 10.3 U.S. Nonattainment Areas, 1990 and 1996



Source: U.S. Environmental Protection Agency.
Note: CO=carbon monoxide. Ozone refers to ground-level ozone.

Figure 10.4 Change in U.S. Emissions, 1970 to 1994



Source: See Part III, Table 27.

The 1990 amendments also call for a 10 percent reduction—or 2 million tons—in annual national NO_X emissions by 2000. The acid rain program is expected to account for a major part of the NO_X reductions.

Trends in Ambient Air Quality and Emissions

Except for NO_X, emissions contributing to criteria air pollutants decreased between 1970 and 1994. The most spectacular decline was for lead, for which annual emissions declined 98 percent (Figure 10.4). The declines in pollution-causing emissions have led to significant declines in concentrations of the criteria pollutants, improving air quality and yielding substantial human health, welfare, and ecological benefits.

Carbon Monoxide. Carbon monoxide is a colorless, odorless, poisonous gas formed when carbon in fuels is not burned completely. It enters the bloodstream and reduces oxygen delivery to the body's organs and tissues, representing a serious health threat for those who suffer from cardiovascular disease. Motor vehicle exhaust contributes more than two thirds of all CO emissions nationwide, and as much as 95 percent in cities. Other sources include industrial processes and fuel combustion in boilers and incinerators.

From 1970 to 1994, CO emissions declined from 128 million to 98 million tons per year, or 23 percent. During the 1985–94 period, CO emissions declined

Box 10.1
Indoor Air Pollutants

Recent evidence indicates that air in homes, schools, and workplaces can have higher levels of pollution than outdoor air, affecting health, comfort, and productivity. Common indoor air pollutants include radon; lead; environmental tobacco smoke (ETS); biological pollutants such as mold, dust mites, animal dander, bacteria, and viruses; and household chemicals and pesticides.

Potential long-term health effects include respiratory disease, damage to the brain and nervous system, cancer, and a variety of acute and chronic health problems, including asthma. The elderly and the young are particularly at risk from prolonged exposure.

Numerous federal agencies—including EPA, the Department of Labor's Occupational Safety and Health Administration (OSHA), the Department of Health and Human Services (including the Centers for Disease Control and Prevention), the Department of Energy, the Consumer Product Safety Commission, the Department of Housing and Urban Development, the General Services Administration, and others—are involved in efforts to reduce risk and improve the indoor air environment. States also have passed laws related to indoor environmental quality.

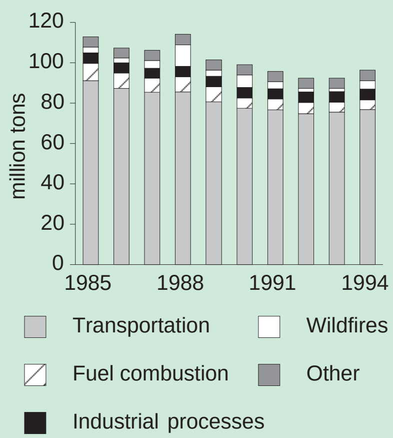
Radon, a naturally occurring gas, is the country's second leading cause of lung cancer, accounting for 7,000-30,000 deaths per year. Fortunately, radon can be managed with readily available technology. Between 1990 and 1994, the proportion of U.S. households that tested their homes for radon increased significantly. Federal goals for the next ten years include increasing the proportion of homes tested, increasing the number of jurisdictions in which testing is required as part of real estate transactions, increasing the number of jurisdictions with construction standards and techniques that minimize radon, and increasing the number of new homes built with radon-resistant features.

Although lead blood levels in children have declined significantly since the 1970s (primarily as a result of the switch to unleaded gasoline), ***lead*** continues to pose serious risks to children's health (see also Chapter 6, "Environmental Justice").

ETS is responsible for approximately 3,000 lung cancer deaths in nonsmokers annually, as well as 150,000 to 300,000 lower respiratory tract infections in infants, resulting in up to 15,000 hospitalizations per year. It exacerbates existing cases of childhood asthma and causes new ones. As public awareness of the dangers of "passive smoking" increase, children's exposure declines. Federal agencies and many private sector organizations are working toward the goal of reducing the proportion of children regularly exposed to tobacco smoke.

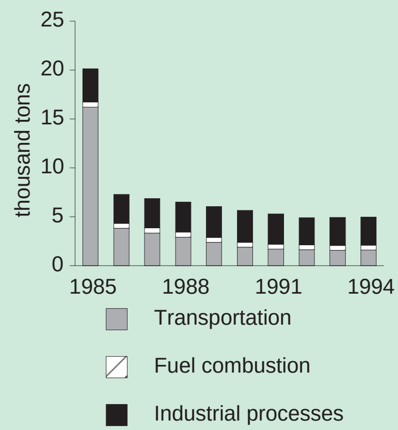
15 percent (Figure 10.5), and national average CO concentrations declined 28 percent (Figure 10.6). However, between 1993 and 1994, both emissions and concentrations increased (4 percent and 2 percent, respectively). This recent increase can be attributed to two sources: transportation emissions, which were up 2 percent, and wildfire emissions, up 160 percent.

Figure 10.5 U.S. CO Emissions, 1985-1994



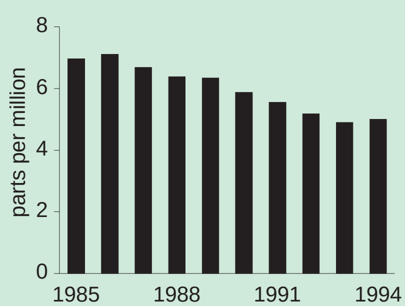
Source: See Part III, Table 27.
Note: Other includes structural and agricultural fires and slash/prescribed burning.

Figure 10.7 U.S. Lead Emissions, 1985-1994



Source: See Part III, Table 27.

Figure 10.6 U.S. CO Concentrations, 1985-1994



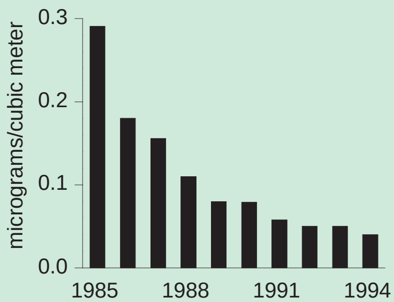
Source: See Part III, Table 30.

Lead. Lead is unquestionably a serious health hazard. Excessive exposure can cause anemia, kidney disease, reproductive disorders, and neurological impairments such as seizures, mental retardation, and behavioral disorders. Even at low doses, lead exposure can be harmful. Fetuses and children are especially susceptible.

The transition to unleaded gasoline in automobiles is responsible for most of the remarkable 98 percent decline in lead emissions between 1970 and 1994—from 219,500 tons to only 5,000 tons annually. Emissions decreased 75 percent in the 1985–94 period alone (Figure 10.7). Between 1993 and 1994, lead emissions remained unchanged while national average lead concentrations decreased 20 percent (Figure 10.8). Violations of the standard that still occur generally are in the vicinity of nonferrous smelters and other stationary sources.

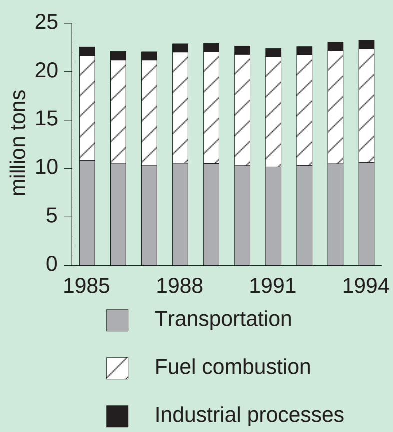
Nitrogen Dioxide. The pollutant NO_2 belongs to a family of highly reactive gases called nitrogen oxides (NO_X). These gases form when fuel is burned at high temperatures and come principally from motor vehicle exhaust and from stationary sources such as electric utilities

Figure 10.8 U.S. Lead Concentrations, 1985-1994



Source: See Part III, Table 30.

Figure 10.9 U.S. NO_x Emissions, 1985-1994



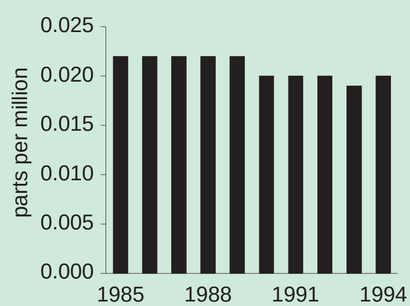
Source: See Part III, Table 27.

and industrial boilers. No human health effects of short-term exposure to typical levels of NO_2 have yet been demonstrated, but continued or frequent exposures to very high concentrations may cause increased incidence of acute respiratory illness in children. NO_x and the atmospheric nitrogen species formed from it contribute to the acid rain problem, and is now thought to be among the chemicals promoting the decline in aquatic ecosystems, especially along the Atlantic coast.

Over the 1970–94 period, emissions of NO_x increased 14 percent, from 20.6 million to 23.6 million tons per year. Since 1985, emissions from highway vehicles decreased 7 percent while fuel combustion emissions increased 8 percent (Figure 10.9). Between 1993 and 1994, both NO_x emissions and NO_2 concentrations increased (Figure 10.10), largely as a result of increased emissions from off-highway vehicles and wildfires. Even with this increase, 1994 was the third year in a row that all monitoring stations across the country, including Los Angeles, met the NO_2 national air quality standard.

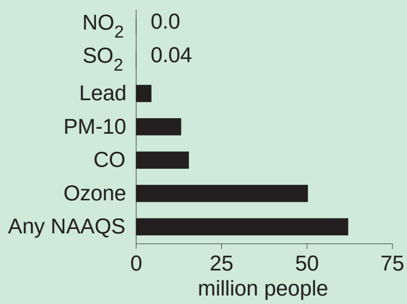
Ozone. Ground-level ozone (smog) remains the most complex, difficult to control, and pervasive of the six principal pollutants. Ozone is not emitted directly, but is created by sunlight acting on NO_x and volatile organic compounds (VOC)

Figure 10.10 U.S. NO_2 Concentrations, 1985-1994



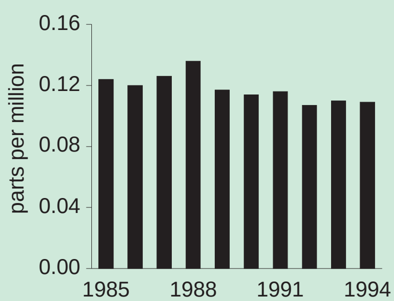
Source: See Part III, Table 30.
Note: NO_2=nitrogen dioxide.

Figure 10.11 U.S. Population in Counties with Air Quality Levels Above the NAAQS, 1994



Source: See Part III, Table 34.
Note: NAAQS=National Ambient Air Quality Standards.

Figure 10.12 U.S. Ozone Concentrations, 1985-1994



Source: See Part III, Table 30.
Note: Data refer to ground-level ozone.

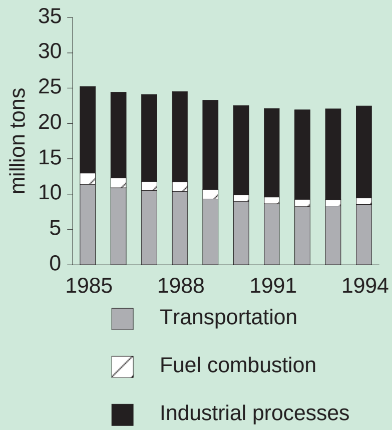
emissions. NO_X and VOC emissions are precursors of ozone formation. In addition to numerous nonanthropogenic sources, there are thousands of sources of VOC, including gasoline vapors, chemical solvents, combustion products of various fuels, and consumer products. They can originate from large industrial facilities, gas stations, and many other large and small businesses.

At high levels of activity, exposure to ozone near the current NAAQS level for six or seven hours can reduce lung function and produce symptoms such as chest pain, coughing, nausea, and pulmonary congestion. Results from animal studies indicate that repeated exposure at high levels for several months can produce permanent structural damage to the lungs, although there are limits to the extent to which these results can be extrapolated to humans. Ozone can also damage forest ecosystems and lower agricultural crop yields.

High levels of ozone persist in many heavily populated areas, including much of the Northeast, the Texas Gulf Coast, and Los Angeles. In 1994, about 50 million people were living in counties with ozone levels above the national standard (Figure 10.11). Average ambient ozone concentrations reported by monitoring networks were about 12 percent lower in 1994 than in 1985, even though meteorological conditions in 1994 were conducive to ozone formation (Figure 10.12 and Table 30). Recent control measures, including regulations to reduce evaporation of fuel and to limit NO_X and VOC emissions from tailpipe exhaust, may be responsible for the reduction. Emissions of anthropogenic VOC decreased 10 percent between 1985 and 1994 (Figure 10.13).

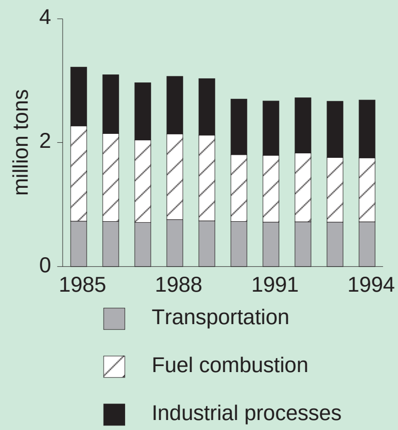
Particulate Matter. Particles are emitted from a variety of sources, including diesel trucks, wood stoves, and power plants. The PM-10 standard applies to small particles with a diameter of 10 micrometers or less. Such particles can damage respiratory systems and cause

Figure 10.13 U.S. VOC Emissions, 1985-1994



Source: See Part III, Table 27.

Figure 10.14 U.S. PM-10 Emissions, 1985-1994



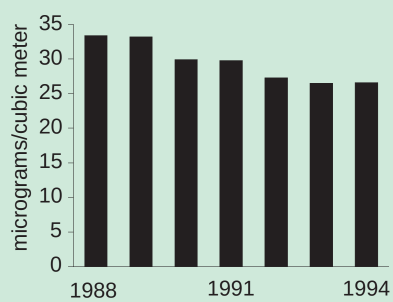
Source: See Part III, Table 27.

premature death. The smaller-sized particles (less than 2.5 micrometers in diameter) include many precursors to ozone and affect visibility.

Over the 1970–94 period, anthropogenic PM-10 emissions from sources such as fuel combustion, industrial processes, and transportation declined 78 percent. During the 1988–94 period, emissions declined 12 percent (Figure 10.14). Over the same 1988–94 period, average ambient concentrations declined about 20 percent, from 33.4 to 26.6 micrograms per cubic meter (Figure 10.15).

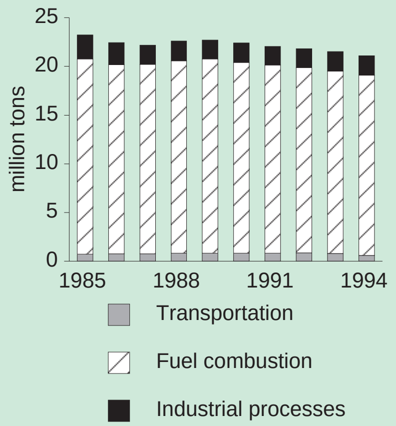
Sulfur Dioxide. Sulfur dioxide, which is part of the family of sulfur oxide gases (SO_X), is formed when fuel containing sulfur (mainly coal and oil) is burned. Health concerns related to high exposure levels include breathing difficulty, respiratory illness, alterations in pulmonary defenses, and aggravation of existing cardiovascular disease. Asthmatics or people with chronic lung disease or cardiovascular disease are particularly sensitive to high levels of SO_2. SO_2 emissions can damage the foliage of trees and agricultural crops, and SO_2 and NO_X are precursors to acid rain, which is associated with the acidification of lakes and streams. Sulfur compounds also con-

Figure 10.15 U.S. PM-10 Concentrations, 1988-1994



Source: See Part III, Table 30.

Figure 10.16 U.S. SO_2 Emissions, 1985-1994

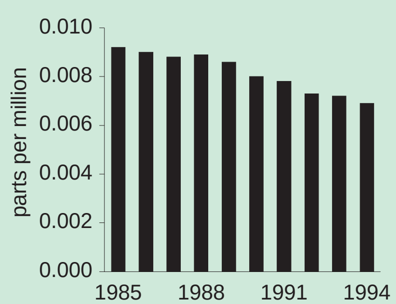


Source: See Part III, Table 27.

tribute to visibility degradation, depletion of nutrients in forest soils, and materials damage (e.g., buildings and monuments).

Over the 1970–94 period, emissions of SO_2 declined 32 percent. Between 1985 and 1994, emissions declined 9 percent (Figure 10.16) and concentrations declined 25 percent (Figure 10.17).

Figure 10.17 U.S. SO_2 Concentrations, 1985-1994



Source: See Part III, Table 30.

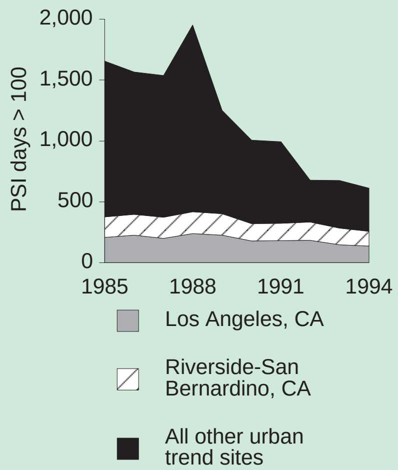
Overall Trends. The Pollutant Standards Index (PSI) is an overall assessment of air quality for a given day. These values are reported daily in all cities with populations over 200,000. A PSI value over 100 indicates that at least one criteria pollutant exceeded air quality standards on a given day. Between 1985 and 1994, the total number of reported days per year nationwide with a PSI value greater than 100 declined 72 percent (not including Los Angeles and Riverside, California). In Los Angeles, the number of days per year with a PSI value greater than 100 declined 35 percent during that time; in Riverside, the decline was 27 percent (Figure 10.18).

Hazardous Air Pollutants

The 1990 Clean Air Act amendments introduced important innovations for controlling air toxics—pollutants that are known or suspected to cause cancer, poisoning, nausea, and a variety of immunological, neurological, reproductive, developmental, and respiratory effects. These pollutants also contaminate soil, streams, and lakes, affecting ecological systems and further threatening human health through consumption of contaminated foods (especially freshwater fish).

Air toxics include benzene, dioxin, chromium, mercury, formaldehyde, and toluene. Prior to passage of the 1990 amendments, EPA had regulated only seven of the hundreds of hazardous air pollutants emitted from motor vehicles, factories, and other sources, reducing annual air toxics emissions by only 125,000 tons. The problem under the

Figure 10.18 U.S. Urban Air Quality, 1985-1994



Source: See Part III, Table 33.
Note: PSI=Pollutant Standards Index. PSI days > 100 are within the unhealthy range. See notes for Table 33.

1970 amendments was that EPA first had to establish that pollutants cause death or serious illness before regulating these air toxics to levels that protect public health "with an ample margin of safety." Under this risk-based approach, EPA could not clearly define a "safe" level of exposure to these cancer-causing pollutants, and it became almost impossible to issue regulations where there was no clear evidence of public harm.

The 1990 amendments called for a new approach. EPA must identify categories of "major" sources that emit any of the 189 toxic air pollutants listed specifically under the act. A major source is one that emits more than 10 tons per year of a single air toxic or 25 tons per year of any combination of air toxics. By the year 2000, EPA is required to develop technology-based emissions standards for these source categories that reflect the "maximum achievable control technology" for all of the toxic pollutants emitted by them. These standards must reflect some of the best control technologies that have already been demonstrated (they must be at least the average of the best performing 12 percent).

As of July 1996, EPA had issued regulations affecting 46 industrial categories that emit one or more hazardous pollutants. By 1999, these regulations will have reduced annual air toxics emissions by nearly 1 million tons.

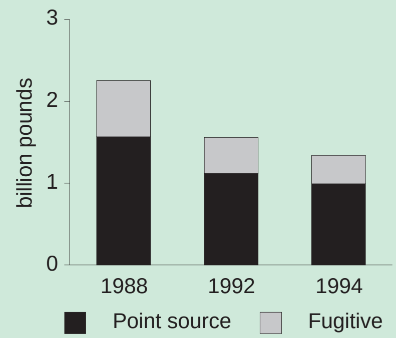
Data on air toxics have been collected since 1987 in the Toxics Release Inventory (TRI). This inventory covers 300 chemicals and is submitted annually by manufacturing facilities with 10 or more employees. The TRI does not provide a complete picture of air toxics emissions. For example, it does not include all toxic pollutants and does not include small companies and the mobile, commercial, and residential sectors, which can be significant sources of emissions. Nevertheless, it is useful to note that between 1988 and 1994, total TRI air emissions declined by 41 percent, from 2.3 billion pounds per year in 1988 to 1.3 billion pounds in 1994 (Figure 10.19). Of the 10 toxic air pollutants that together account for more than half of total TRI air emissions, all but hydrochloric acid have declined since 1988.

Benefits and Costs of the Clean Air Act, 1970 to 1990

In May 1996, EPA completed a draft study on benefits and costs of the Clean Air Act during the 1970–90 period. The draft analysis, which has been reviewed by the EPA Scientific Advisory Board and is undergoing revision, found that spending for Clean Air Act programs during this 20-year period yielded benefits that far outweighed the costs.

The authors stress that many uncertainties could broaden the range of outcomes, particularly regarding the human health, human welfare, and ecological benefits of emissions reduction, as well as the economic valuation of those benefits. On the other hand, inclusion of non-monetized and unquantified benefits would be likely to raise both the lower and upper bounds of the range, perhaps by significant amounts. The additional value of reductions in air toxics, protection of ecosystems, and a variety of other health and environmental effects could not be quantified or monetized. For example, the reduction in both criteria pollutants and air toxics probably yielded widespread improvements in the health and quality of terrestrial and aquatic ecosystems. In some cases, strong scientific evidence of a health effect existed, but data were still too limited to support quantitative estimates of incidence reduction (e.g., changes in lung function associated with long-term exposure to ozone). Similarly, the contribution of air pollution deposition to water quality problems was not well enough established to quantify costs and benefits.

Figure 10.19 U.S. Emissions of Air Toxics, 1988, 1992, and 1994



Source: See Part III, Table 72.

Not all clean air regulations yielded equally favorable comparisons of costs and benefits. A large proportion of the benefits are linked to the dramatic reduction in two pollutants in particular: lead and PM-10. However, PM-10 is caused by a wide variety of precursor emissions, such as SO_2 from utilities and NO_X from motor vehicles. Reductions in these emissions yield a variety of direct and indirect health, ecological, and visibility benefits, including reduced ambient particulate concentrations.

RECENT DEVELOPMENTS

In recent years, there have been several significant new developments in air pollution control. For example, market-oriented, economic incentive-based approaches increasingly are used as complements to traditional command-and-control regulation. The trend toward more flexible, performance-based implementation is growing, and there is increased recognition of the value of voluntary and cooperative initiatives.

Emissions Trading

Emissions trading among stationary sources is an increasingly important regulatory tool. Under emissions trading systems, a company that reduces emissions below the level required by law can receive credits usable against higher emissions elsewhere. Companies can trade emissions among sources within their own company and with other companies so long as combined emissions stay within an aggregate limit. Companies also can trade emission credits or store earned emission credits for future use.

The largest emissions trading program is the SO_2 allowance trading system established by the acid rain control program. This system uses market incentives to reduce pollution. Under this system, the highest-emitting utilities are allocated allowances based on their historic consumption and a specific emissions rate. Each allowance authorizes a utility to emit one ton of SO_2 during a specified year. Allowances can be bought, sold, or traded.

In 1995, because all 445 affected utility units met their compliance obligations, SO_2 emissions did not exceed allowances. In fact, these utilities together held 8.7 million SO_2 allowances, permitting up to 8.7 million tons of SO_2 emissions, but only emitted 5.3 million tons—39 percent less than allowed. The remaining allowances were banked to allow emissions in later years. The General Accounting Office has estimated that by 2010, the cost of compliance with SO_2 emissions reduction goals will be less than half what they would be without the allowance trading system.

A similar system of allowance trading is being developed for NO_X emissions in the northeastern United States by the Ozone Transport Commission (OTC). The OTC was established by the 1990 Clean Air Act amendments to coordinate state efforts to reduce ground-level ozone in 12 northeastern states and the District of Columbia. Other regions are also looking to allowance systems. The Southern California Air Quality Management District has started RECLAIM (Regional Clean Air Incentives Market) to limit new and existing sources of SO_X and No_X. Illinois has proposed an allowance system for VOC in the Chicago region.

A second major system of emissions trading is open-market trading. In August 1995, EPA proposed an open-market trading program for ozone-creating NO_X and VOC emissions. Under this program, a company that exceeds its required pollution reductions would have the opportunity to sell its "surplus" reductions (or "credits") to companies that find credits a cost-effective way to comply with the emissions reduction requirements. Once a state adopts and EPA approves an open-market trading plan, companies would be able to freely engage in trades without prior approval as long as reporting and public health standards are met.

Expanded use of market trading on local and regional levels will give companies broad flexibility to find lowest-cost approaches to emissions reductions. The system will encourage experimentation with new trading options.

Cutting Red Tape

In August 1995, EPA proposed ways to simplify the complex procedures under which air pollution permits are issued. Companies will be better able to keep their processes up-to-date without needing to meet burdensome procedural requirements.

In March 1996, EPA proposed reforms that will further simplify the process by combining multiple, overlapping Clean Air Act requirements into one permit. EPA also proposed significant revisions to streamline the permitting process for new sources of air pollution, making it easier for companies to certify compliance. These actions are expected to reduce paperwork burdens for businesses by as much as 10 million hours over the next 3 years, allowing companies to focus time and effort on productive activities and on avoiding violations of air pollution controls, and saving about $600 million.

Overall, the regulation of air pollution in the United States is going through a significant transition, with increased emphasis on cost-effectiveness, flexibility, community participation, and the use of market-based incentives.

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