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ABSTRACT

The environmental impact of air pollution on the earth can be described as grave. Air pollution, particularly acid rain, is devastating forests, crops, and lakes over wide areas of North America and Europe. In many cities, ancient buildings have eroded more in recent decades than they had over the previous thousand years. Indications are that Third World countries are starting to experience damage as well. This document discusses the state of the earth in relation to the air pollution problem. Specifically discussed are: (1) "The Global Threat;" (2) "The Environmental Toll;" (3) "Reducing Emissions;" (4) "A Political Progress Report;" and (5) "An Agenda for Clean Air." (CW)

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Clearing the Air: A Global Agenda

Hilary F. French

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> Coketown lay shrouded in a haze of its own, which appeared impervious to the sun's rays. You only knew the town was there because there could be no such sulky blotch upon the prospect without a town. A blur of soot and smoke, now confusedly tending this way, now that way . . . a dense formless jumble, with sheets of cross light in it, that showed nothing but masses of darkness.

The filthy air of industrial revolution England, memorialized in this passage from Charles Dickens's *Hard Times*, is generally perceived as a thing of the past. But in many parts of Eastern Europe, the Soviet Union, and the developing world, similar air pollution conditions persist today. Even in the West, where air pollution is now far less visible than it was in Dickens's time, poor air quality nevertheless contributes to hundreds of thousands of deaths and millions of ailments each year, dying forests and lakes, and corroding buildings and monuments.

Severe air pollution–related health problems span continents and levels of development. In the United States, some 150 million people live in areas where the Environmental Protection Agency (EPA) has declared that the air is unfit. In greater Athens, the number of deaths rises sixfold on heavily polluted days. In Hungary, a recent report by the National Institute of Public Health concluded that every 24th disability and every 17th death is caused by air pollution. In Bombay, breathing the air is equivalent to smoking 10 cigarettes a day. And in Mexico, the capital has been declared a hardship post for diplomats because of its unhealthy air; some governments advise women not to have children while posted there.[1]

I would like to thank Chris Calwell, Peter Sand, Debbie Sheiman, Michael Walsh, Fiona Weir, and several of my colleagues at the Worldwatch Institute for their insightful comments on preliminary drafts of this paper.

The environmental impact of air pollution is equally grave. Air pollution, particularly acid rain, is devastating forests, crops, and lakes over wide areas of Europe and North America. In many cities, ancient build-
6 ings have eroded more in recent decades than they had over the previous thousand years. Indications are that the Third World is starting to experience damage as well.

A century ago, air pollution was caused primarily by the coal that fueled the industrial revolution. Since then, the problem has grown increasingly complex and widespread. In parts of the world that continue to rely on highly polluting brown coal for the bulk of their energy, including much of Eastern Europe and China, coal is still the main source of air pollution. Elsewhere, however, automobiles and industries are now a primary cause.

Many areas that have had long-standing programs to abate pollution are finding their efforts overwhelmed as their populations and economies grow, bringing in ever more power plants, home furnaces, factories, and motor vehicles. Industrial activities are increasingly emitting pollutants of worrisome toxicity. Millions of tons of carcinogens, mutagens, and poisons are released into the air each year, damaging health and habitat near their sources and, via the winds, sometimes thousands of kilometers away.[2]

Even some of the solutions have become part of the problem: the tall smokestacks that were built in the sixties and seventies to disperse emissions became conduits to the upper atmosphere for the pollutants that form acid rain. Once a local phenomenon primarily affecting city dwellers and the immediate inhabitants of industrial plants, air pollution now reaches rural as well as urban dwellers and crosses international borders. Since one country's activities can damage another's citizens and ecosystems, emissions have become the subject of international negotiations and treaties. Though there have been some reductions in specific pollutants in specific areas, in general the problem has only gotten worse.

Meanwhile, global warming has arisen as a main focus of environmental concern, sometimes conveying the misleading impression that air

"Air pollution has proven so intractable that a book could be written about the history of efforts to combat it."

pollution is yesterday's problem. But traditional air pollutants and greenhouse gases stem largely from the burning of fossil fuels in energy, transportation, and industrial systems. Having common roots, air pollution and global warming can also have common solutions. Unfortunately, policymakers persist in tackling them in isolation, which runs the risk of lessening one set of problems while exacerbating the other.

Air pollution has proven so intractable a phenomenon that a book could be written about the history of efforts to combat it. The world's first clean air act may have been a 1306 proclamation by King Edward I of England banning the burning of "sea coles"—chunks of coal found along the seashore—by London craftsmen. Nearly six centuries later, the Coal Smoke Abatement Society, probably the world's first air pollution pressure group, was founded in London to combat that city's legendary soot. Nonetheless, thousands of Londoners died in the infamous "black fog" of 1952, leading to stricter emissions regulations. Today, the Coal Smoke group has a new name, the National Society for Clean Air, but its work remains unfinished. Though coal smoke is no longer the main problem, air quality is still unsatisfactory. Similarly, in the United States, Congress passed a landmark Clean Air Act in 1970, proclaiming that it would restore urban air quality. Twenty years later, 487 counties still are not in compliance, and Congress is back drafting a revised version.[3]

The reason efforts to clear the air have only been marginally successful at best is because they have focused on specific measures to combat individual pollutants rather than addressing the underlying societal structures that give rise to the problem in the first place. Winning the battle against air pollution will require moving beyond this myopic approach by reforming energy, transportation, and industrial systems.

The Global Health Threat

That air pollution could cause serious health problems first became evident during the industrial revolution, when many cities in Europe and the United States were covered with black shrouds of coal smoke.

On bad days, sickness was common, sometimes even leading to deaths.[4]

8 Incidents such as London's "black fog" prompted many governments to enact legislation to combat the primary pollutants of the day, sulfur dioxide (SO_2) and particulate emissions from stationary sources such as power plants, industries, and home furnaces. Both SO_2 and particulates—either alone or in combination—can raise the incidence of respiratory diseases such as coughs and colds, asthma, bronchitis, and emphysema. Particulate matter (an overall term for a complex and varying mixture of pollutants in minute solid form) can carry toxic metals deep into the lungs.[5]

With the aid of pollution control equipment and improvements in energy efficiency, many industrial countries have made major strides in reducing emissions of these pollutants. The United States, for example, cut sulfur oxides emissions by 28 percent between 1970 and 1987 and particulates by 62 percent. (See Figure 1.) In Japan, sulfur dioxide emissions fell by 39 percent from 1973 to 1984. Many Western European countries also significantly reduced their emissions in both categories from power plants, industries, and heating. In certain European cities, however, the widespread introduction of diesel-fueled vehicles, which emit large quantities of particulates and some SO_2, threatens to negate earlier gains.[6]

In Eastern Europe and the Soviet Union, hasty industrialization after World War II powered by the region's natural endowment of high-sulfur brown coal has led to air quality reminiscent of London at its Dickensian worst. The lack of market forces kept these countries from realizing the impressive gains in energy efficiency registered in the West after the oil shocks of the seventies, and their weak economies still preclude major investments in pollution control.[7]

Though emissions data for developing countries are scarce, air quality in many cities is known to be unhealthy. Plans to expand energy and industrial production and the lack of adequate pollution control regulations mean that air quality in many cities is likely to get even worse. China, for example, increased coal output more than twentyfold

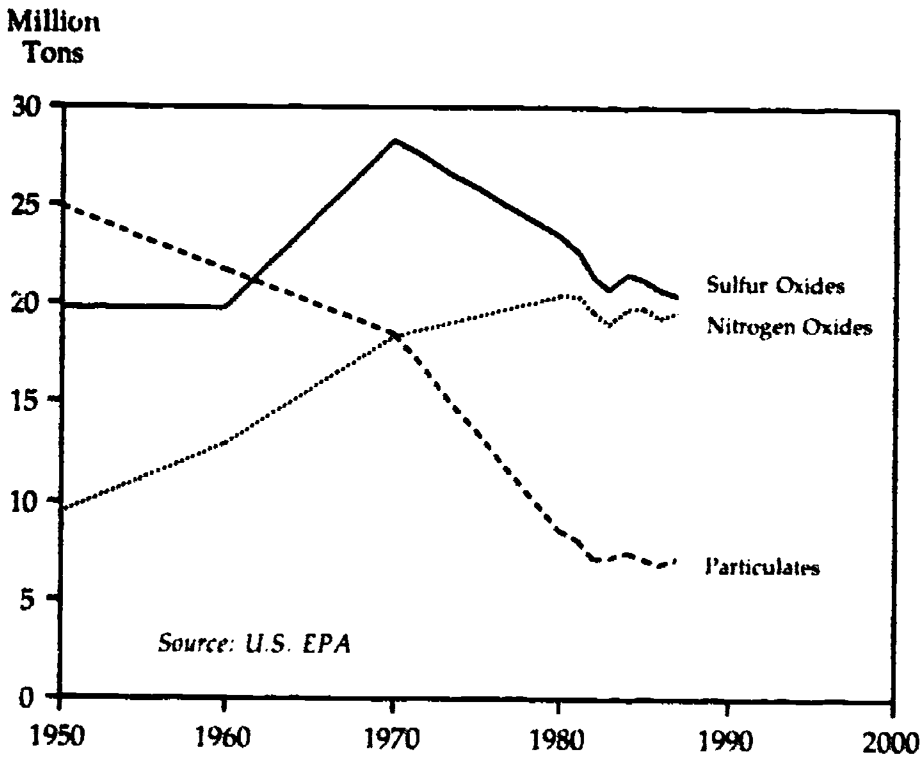

Figure 1: Emissions of Selected Pollutants in the United States, 1950–87

between 1949 and 1982 and plans to double consumption by the end of the century. In India, SO_2 emissions from coal and oil nearly tripled between the early sixties and the late seventies. Growing urbanization in much of the Third World means that ever increasing numbers of people are being exposed to polluted city air.[8]

A recent report by the United Nations Environment Program (UNEP) and the World Health Organization (WHO) gives the best picture to date of the global spread of SO_2 and particulate pollution. (See Tables 1 and 2.) In terms of average annual concentrations, 27 of the 54 cities with data available on sulfur dioxide for 1980–84 were on the borderline or in excess of the WHO health standard. High on the list were

Table 1: Ten Cities in the GEMS Network with the Highest Sulfur Dioxide Concentrations, Mid-eighties[1]

City	Annual Mean[2] (micrograms per cubic meter)	Days above Standard[3] (per year)
Milan	185	66
Shenyang	152	146
Tehran	132	104
Seoul	115	87
Rio de Janeiro	106	NA
São Paulo	92	12
Xian	83	71
Paris	83	46
Beijing	81	68
Madrid	72	35

[1] Figures are the averages of readings at a variety of monitoring sites over the period 1980–84.
[2] WHO annual-mean standard is 40–60 micrograms per cubic meter.
[3] WHO daily standard is 150 micrograms per cubic meter. Cities are in violation of the standard when they exceed it more than seven days per year.

Source: Worldwatch Institute, based on data supplied by the Global Environment Monitoring System and data published in U.N. Environment Program and World Health Organization, *Assessment of Urban Air Quality* (Nairobi: Global Environment Monitoring System, 1988).

Shenyang, Tehran, and Seoul, as well as Milan, Paris, and Madrid, indicating that SO_2 problems are by no means over for industrial countries. Indeed, Milan topped the list of average annual concentrations, with a reading more than three times the WHO norm. Though conditions are gradually improving in most of the cities surveyed, several in the Third World reported a worsening trend.[9]

Suspended particulate matter poses an even more pervasive threat,

Table 2: Suspended Particulate Matter Levels, Various Cities, Mid-eighties[1]

City	Annual Mean[2]	Days above Standard[3]
	(micrograms per cubic meter)	(per year)
Kuwait	603	NA
New Delhi	405	294
Beijing	399	272
Tehran	245	174
Jakarta	231	173
Bangkok	197	97
Kuala Lumpur	130	37
Zagreb	127	34
Rio de Janeiro	114	11
Lisbon	104	12

[1] Figures are the averages of readings at a variety of monitoring sites over the period 1980–84.
[2] WHO annual-mean standard is 60–90 micrograms per cubic meter.
[3] WHO daily standard is 230 micrograms per cubic meter. Cities are in violation of the standard when they exceed it more than seven days per year.

Source: Worldwatch Institute, based on data supplied by the Global Environment Monitoring System and on data published in U.N. Environment Program and World Health Organization, *Assessment of Urban Air Quality* (Nairobi: Global Environment Monitoring System, 1988).

especially in the developing world. Fully 37 of the 41 cities monitored for particulates averaged either borderline or excessive levels. Annual average concentrations were as much as five times the WHO standard in Kuwait, New Delhi, and Beijing. The extraordinary levels noted in some Third World cities can be partially explained by natural dust; other culprits include the black, particulate-laden smoke spewed out by diesel-fueled vehicles lacking even rudimentary pollution controls, and emissions from motor scooters equipped with highly polluting two-cycle engines. WHO and UNEP concluded that nearly 625 million people around the world are exposed to unhealthy levels of sulfur dioxide and more than a billion—one in five people—to excessive levels of particulates.[10]

Nations that built tall stacks to improve local air quality may have simply sent their health problems elsewhere. Though acid deposition—formed in the atmosphere by chemical reactions involving sulfur dioxide or nitrogen oxides (NO_x), and more commonly called acid rain or precipitation—is best known as an ecological threat, it is also suspected of having grave health repercussions. Sulfur dioxide can be chemically transformed into fine sulfate particles that mix with water in the air, liquefy, and become aerosols that are easily breathed deep into the lungs, bringing toxic metals and gases along with them. Some researchers believe this combination may be responsible for as many as 50,000 deaths in the United States every year—2 percent of total annual mortality.[11]

Acid deposition threatens human health indirectly as well. It can make several dangerous metals—including aluminum, cadmium, lead, and mercury—more soluble than usual. The metals can then leach from soils and lake sediments into aquifers, streams, and reservoirs, contaminating water supplies and edible fish. Acidic water can also dissolve toxic metals from the conduits and pipes of municipal and home water systems, poisoning drinking supplies. In portions of both the United States and Sweden, elevated levels of certain metals have been found in the water of several areas receiving acid precipitation.[12]

Pollutants that stem predominantly from cars have been fought around the world even less successfully than sulfur dioxide and particulates. One of the worst of these is ozone, the principal ingredient in urban smog. Ozone is a gas formed when energy from sunlight causes hydrocarbons (a by-product of many industrial processes and engines) to react with nitrogen oxides (produced by both cars and power plants). Recent U.S. research suggests that this ground-level ozone causes temporary breathing difficulty and long-term lung damage in lower concentrations than previously believed. Other dangerous pollutants emitted by automobiles include carbon monoxide, nitrogen dioxide, "Nations that built tall stacks to improve local air quality may have simply sent their health problems elsewhere."

lead, and toxic hydrocarbons such as benzene, toluene, xylene, and ethylene dibromide. (See Table 3.)[13]

Ozone has become a seemingly intractable health problem in many parts of the world. In the United States, 1988—one of the hottest and sunniest years on record—was also the worst year for ground-level ozone in more than a decade. According to the Natural Resources Defense Council, the air in New York City violated the federal health standard on 34 days—two to three times a week, all summer long. In Washington, D.C., the standard was topped every third day, on average, during the summer months. And in Los Angeles, ozone levels surged above the federal standard on 172 days. All told, 382 counties, home to more than half of all Americans, are currently out of compliance with the EPA ozone standard.[14]

Western Europe had its turn in 1989, when unusually sunny conditions in some countries during the summer led to high ozone readings. In the normally cloudy United Kingdom, for example, readings above WHO standards on several days prompted calls for a "smog alert" system. In the rest of Europe, monitoring by the Organization for Economic Cooperation and Development (a group of countries comprising all of Western Europe along with the United States, Canada, and Japan) indicates that ozone levels in excess of WHO-suggested levels occur at least occasionally over much of the continent.[15]

Information is scarce on ozone conditions in Eastern Europe, the Soviet Union, and the developing world. Rapidly growing fleets of vehicles lacking emissions controls, however, portend worsening conditions in many areas. Latin America appears to have a grave problem, due both to weather conducive to ozone formation and to rapid growth in automobile ownership rates. In Mexico City, the relatively lenient government standard of a one-hour ozone peak of 0.11 parts per million not to be exceeded more than once daily is topped more than 300 days a year—over twice as often as Los Angeles violates its much stricter standard.[16]

Even though the addition of catalytic converters to automobiles has greatly reduced emissions of carbon monoxide and nitrogen oxides

Table 3: Health Effects of Pollutants from Automobiles[1]

Pollutant	Health Effects
Carbon Monoxide	Interferes with blood's ability to absorb oxygen, which impairs perception and thinking, slows reflexes, causes drowsiness, and can cause unconsciousness and death; if inhaled by pregnant women, may threaten growth and mental development of fetus.
Lead	Affects circulatory, reproductive, nervous, and kidney systems; suspected of causing hyperactivity and lowered learning ability in children; accumulates in bone and other tissues, so hazardous even after exposure ends.
Nitrogen Dioxide	Can increase susceptibility to viral infections such as influenza, irritate the lungs, and cause bronchitis and pneumonia.
Ozone	Irritates mucous membranes of respiratory system; causes coughing, choking, impaired lung function; reduces resistance to colds and pneumonia; can aggravate chronic heart disease, asthma, bronchitis, and emphysema.
Toxic Emissions	A broad category including many different compounds that are suspected or known to cause cancer, reproductive problems, and birth defects.

[1] Automobiles are a primary source, but not the only source, of these pollutants.

Source: Worldwatch Institute, based on National Clean Air Act Coalition, *The Clean Air Act: A Briefing Book for Members of Congress* (Washington, D.C.: 1985); and other sources.

from individual cars in countries where they are required (Austria, Canada, Japan, Norway, South Korea, Sweden, Switzerland, and the United States), the recent WHO/UNEP report estimates that 15–20 percent of urban residents in North America and Europe are exposed to

"In Mexico, an entire generation of children may be intellectually stunted by lead poisoning."

unacceptably high levels of nitrogen dioxide and 50 percent to unhealthy carbon monoxide concentrations.[17]

Fortuitously for human health, catalytic converters are damaged by leaded gasoline. Where converters are required, the mandated use of unleaded gasoline has resulted in steep declines in lead emissions. In the United States they fell by 96 percent between 1970 and 1987 as a result of both the switch to converters and, after 1985, legislation halving the amount of lead permitted in regular gasoline. The average lead level in Americans' blood dropped by more than one-third between 1976 and 1980.[18]

Most countries, however, mandate neither converters nor unleaded gas. The WHO/UNEP report estimated that a third of North American and European city dwellers are exposed to either marginal or unacceptable concentrations of lead in the air. Paris topped the list of a limited sample, with an annual average concentration far in excess of the WHO guideline. In a study in Mexico City, 7 out of 10 newborns were found to have lead levels in their blood in excess of WHO norms. "The implication to the Mexican society, that an entire generation of children will be intellectually stunted, is truly staggering," says Mexican chemist and environmental activist Manuel Guerra.[19]

Concern is growing in the United States over the health threat posed by less ubiquitous but extremely harmful airborne toxic chemicals produced primarily by various industrial processes. Such chemicals—which can cause cancer and birth and genetic defects—have often fallen through the holes in the regulatory net. The current wave of concern has been fueled by the EPA's recent announcement that 1.2 billion kilograms of hazardous pollutants were released into the air by industries in 1987, including 107 million kilograms of carcinogens. Even this number is an underestimate, as it omits sources such as waste dumps, dry cleaners, and cars, and chemical releases into soil or water that end up in the air through evaporation. The true number may be in excess of 2.2 billion kilograms annually, the EPA admits.[20]

In a 1987 report, the agency concludes that emissions of toxic materials into the air cause some 2,000 cancer deaths a year. Because the study tallied the effects of only a third of known carcinogens, this is likely an underestimate. If all the hundreds of chemicals emitted into the air had been included and their synergistic effects considered, the number woul robably be far higher. Other studies have found high cancer rates i communities near certain types of factories. For example, in West Virginia's Kanawha Valley—home to roughly 250,000 people and 13 major chemical plants—state health department records show that between 1968 and 1977 the incidence of respiratory cancer was more than 21 percent above the national average. According to EPA statistics, a lifetime of exposure to the airborne concentrations of butadiene, chloroform, and ethylene oxide in this valley could cause cancer in 1 resident in 1,000.[21]

Unfortunately, similar data are not available for other countries. Wherever uncontrolled polluting industries such as chemical plants, smelters, and paper mills exist, however, emissions levels are undoubtedly high. Measurements of lead and cadmium in the soil of the upper Silesian towns of Olkosz and Slawkow in Poland, for instance, are among the highest ever recorded anywhere in the world. The government is considering a ban on growing vegetables in several Silesian towns due to soil concentrations of cadmium, lead, mercury, and zinc that are 30–70 percent higher than WHO norms.[22]

Airborne toxic chemical emissions are likely to rise rapidly in developing countries as industrialization continues. The Third World's share of global iron and steel production rose from 3.6 percent in 1955 to 17.3 percent in 1984. In India, pesticide production increased from 1,460 tons in 1960 to 40,680 tons in 1980—nearly thirtyfold. Production of dyes and pigments grew at a comparable pace over the same period, reaching 30,850 tons by 1980. Most of these countries have few pollution controls and little environmental regulation.[23]

Recent evidence suggests that toxic chemicals emitted into the air can be carried great distances before falling to the ground, a phenomenon already well known in the case of acid rain. This explains in part why DDT, presumably blown in from Central America or Mexico, is being found in the Great Lakes years after the pesticide was banned in the United States and Canada. It also may explain why researchers at

"Fishless lakes, dying forests, and faceless ancient sculptures all provide sad testimony to the destruction industrialization has wrought."

McGill University in Montreal have found DDT and PCBs throughout the Eskimos' food chain, including in bears, fish, berries, and snow.[24]

Putting a dollar value on the health costs of air pollution is difficult, as it involves judgments about the worth of good health and human life. The few guesses made suggest a very high price. Thomas Crocker of the University of Wyoming, for one, estimates that air pollution costs the United States as much as $40 billion annually in health care and lost productivity. And a study conducted in conjunction with a proposed air quality plan for Los Angeles projected that the region would save $9.4 billion a year in health care expenses under the new plan—more than three times what it is expected to cost.[25]

The Environmental Toll

Though concern for human health was the motivating factor behind the world's first control laws, the last 20 years have demonstrated that air pollution poses an equally grave threat to the environment and to human constructions. Fishless lakes and streams, dying forests, and faceless ancient sculptures all provide sad testimony to the destruction that industrialization has wrought.

The first warning came in the late sixties, when scientists in Scandinavia began to suspect that SO_2 emissions from the more urban and industrialized countries of Europe, such as the United Kingdom and West Germany, might be responsible for declining fish stocks in their lakes. American scientists studying acidity at the Hubbard Brook Experimental Forest in New Hampshire soon found similarly ominous indications. Extensive investigations in the seventies revealed that acid deposition was indeed acidifying water and killing fish and other aquatic organisms in geologically susceptible areas of Scandinavia and North America. (See Table 4.)[26]

In recent years, large areas of the world have been found to fall into this worrisome category of "geologically susceptible." In the United States, much of the Great Lakes region, several southeastern states, and many of the mountainous areas of the West appear to be at risk, in addition to

Table 4: Evidence of Acidified Lakes, Selected Countries

Country	Evidence
Canada	More than 14,000 lakes strongly acidified, and 150,000 in the the East (one in seven) suffering biological damage.
Finland	Survey of 1,000 lakes indicates that those with a low acid-neutralizing capacity are distributed across the country; 8 percent of these lakes have no neutralizing capacity; most strongly acidified ones are located in southern Finland.
Norway	Fish eliminated in waters covering 13,000 square kilometers and otherwise affected in waters over a further 20,000 square kilometers.
Sweden	14,000 lakes unable to support sensitive aquatic life and 2,200 nearly lifeless.
United Kingdom	Some acidified lakes in southwestern Scotland, western Wales, and the Lake District.
United States	About 1,000 acidified lakes and 3,000 marginally acidic ones, according to the Environmental Defense Fund; a 1984 government study found 552 strongly acidic lakes and 964 marginally acidic ones.

Sources: Jim Ketcham-Colwill, "Acid Rain: Science and Control Issues," Environmental and Energy Study Institute Special Report, July 12, 1989; U.N. Economic Commission for Europe, "Current Geographical Extent of Acidification in Rivers, Lakes, and Reservoirs in the ECE Region" (draft), June 15, 1988.

the Northeast, where damage has been evident for some time. Half the 700,000 lakes in the six eastern provinces of Canada are extremely acid-sensitive, as are large areas in all its western provinces, the Yukon, the Northwest Territories, and Labrador. Similarly vulnerable parts of Belgium, Denmark, Ireland, Italy, the Netherlands, Switzerland, and West Germany have been added to the European list, which previously included only Scandinavia and the United Kingdom. Vast parts of Africa, Asia, and South America are also acid-sensitive.[27]

Canadian biologist David Schindler warns that the ecological consequences are great. Though concern initially focused on damage to fish, many other aquatic organisms can also be affected. To investigate the biological impact of this process, Schindler and his colleagues deliberately acidified two lakes in northwest Ontario. When the first lake went from a pH of 6.5 to 5.0 over eight years, approximately a third of the species studied were eliminated. Extrapolating from these findings, Schindler estimates that in the Adirondack and the Foconos-Catskill regions, more than half the sensitive species such as mollusks, leeches, and crustaceans have been wiped out.[28]

Recent evidence suggests that the threat to coastal waters may be of similar magnitude. A 1988 study by the Environmental Defense Fund concluded that acid deposition is a major contributor to the degradation of the Chesapeake Bay. In a process known as eutrophication, nitrogen from a variety of sources causes "algae blooms." When the algae decay, they choke off the oxygen and sunlight required by other aquatic plants and animals. The study found that airborne nitrates account for fully 25 percent of the total nitrogen load currently entering the Chesapeake. If emissions continue their upward climb, this share will rise to 42 percent by the year 2030. Other research has shown that 27 percent of the Baltic Sea's nitrogen load comes from the air.[29]

In the early eighties, concern about the possible effects of acid deposition spread from lakes and streams to forests. Signs of widespread damage attributable to acid deposition first arose in West Germany. The share of forests there showing signs of damage rose from 8 percent in 1982, the first year a survey was done, to 34 percent in 1983, to 50 percent by the following year. It peaked in 1986, at 54 percent, and has since declined slightly, to 52 percent in 1988. Because dead trees are not included in the surveys, however, slightly lower percentages do not necessarily mean an improvement.[30]

Wide public debate about the causes and consequences of this forest decline followed. Though the exact mechanisms are still not precisely

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understood, most scientists believe that a complex mixture of pollutants—including acid deposition, ozone, and toxic metals—renders forests susceptible to a range of natural stresses, such as droughts, extremes of heat and cold, and blights, that combine to cause the decline. Initial fears of massive forest death throughout the continent have not been borne out, but damage is widespread and has exacted a high economic toll.

Since the initial alarm in West Germany, concern about forest damage has spread throughout the world. In Europe, several countries have initiated annual surveys. The results are now brought together in a yearly assessment by the U.N. Economic Commission for Europe. The 1988 report found at least preliminary signs of damage in each of the 26 areas surveyed. Twenty-two of the surveys—most of them national—found 30 percent or more of their forests to be damaged; for eight, the figure was half or more. Across the continent, nearly 50 million hectares have been damaged, representing 35 percent of Europe's total forested area. (See Table 5.)

North America may be next in line. Though the damage documented to date has been mostly restricted to isolated, high-altitude environments, many fear it is only a matter of time before it spreads to other areas. In the United States, some declines, such as those of Jeffrey and ponderosa pines in California and of eastern white pines, have been conclusively linked to high concentrations of ground-level ozone. In others, such as those of the red spruce, Fraser fir, yellow pines, and sugar maple, researchers are less certain about the role of air pollution. Even with these species, however, high levels of recorded pollution often correspond to areas of extensive damage, suggesting a link.[31]

On the summit of Mount Mitchell in North Carolina—where virtually all the red spruce and Fraser fir trees are dead—ozone levels more than half the time exceed those at which tree damage has been proved to occur in controlled laboratory studies. Cloud samples taken on this mountain during 1986 showed a pH varying from 5.4 (slightly acidic) to as low as 2.2, with a mean of 3.4. "It's plain," says plant pathologist Robert Bruck, who has been studying damage in this area for years, "that no one has proved, or ever will, that air pollution is killing the

Table 5: Estimated Forest Damage in Europe, 1988

Country or Area	Total Forest Area[1]	Estimated Area Damaged	Share of Total
	(thousand hectares)		(percent)
Czechoslovakia	4,578	3,250	71
Greece	2,034	1,302	64
United Kingdom	2,200	1,408	64
Estonia, Soviet Union	1,795	933	52
West Germany	7,360	3,827	52
Tuscany, Italy	150	77	51
Liechtenstein	8	4	50
Norway[2]	5,925	2,963	50
Denmark	466	228	49
Poland	8,654	4,240	49
Netherlands	311	149	48
Flanders, Belgium	115	53	46
East Germany	2,955	1,300	44
Bulgaria	3,627	1,560	43
Switzerland	1,186	510	43
Luxembourg	88	37	42
Finland	20,059	7,823	39
Sweden	23,700	9,243	39
Wallonia, Belgium[2]	248	87	35
Yugoslavia	4,889	1,564	32
Spain	11,792	3,656	31
Ireland[2]	334	100	30
Austria	3,754	1,089	29
France	14,440	3,321	23
Hungary	1,637	360	22
Lithuania, Soviet Union	1,810	380	21
Bolzano, Italy	307	61	20
Portugal	3,060	122	4
Other[3]	13,474	NA	NA
TOTAL[4]	140,956	49,647	35

[1]For areas where only conifers were surveyed, "total forest area" means total forested area of conifers. For Yugoslavia, which conducted only a regional survey, "total forest area" means total area surveyed.
[2]Conifers only. In Ireland, only trees less than 60 years old were assessed.
[3]Includes unsurveyed portions of countries that have done regional and conifer-only surveys.
[4]Does not include Turkey or any of the Soviet Union except for Estonia and Lithuania.

Source: Worldwatch Institute, based on U.N. Environment Program and U.N. Economic Commission for Europe, "Forest Damage and Air Pollution: Report of the 1988 Forest Damage Survey in Europe," Global Environment Monitoring System, 1989.

trees up here. But far more quickly than we ever expected, we've ended up with a highly correlated bunch of data—high levels of air pollution correlated to a decline we're watching in progress."[32]

The economic toll to the forestry and tourism industries is potentially enormous. Environmental scientists in Poland predict that forest loss will cost the country \$1.5 billion by 1992. Economists Werner Schulz and Lutz Wicke estimate that forest damage will cost West Germany between 5.5 and 8.8 billion deutsche marks (\$2.98–4.77 billion) annually over the next 70 years, depending on how strictly emissions are controlled. The losses are not only monetary: Fichtelberg, a mountain along the East German and Czechoslovakian border, once attracted many visitors who scaled it to marvel at the view. Now the panorama consists only of a vast expanse of dead trees.[33]

In addition to forests, air pollution also threatens crops. Ozone is the primary concern, although SO_2, nitrogen oxides, and sulfates and nitrates are also thought to be potentially harmful. The most comprehensive studies on this problem have been conducted in the United States. A 1987 government report by the National Acid Precipitation Assessment Program concluded that current levels of ozone were reducing crop yields by 1 percent or less for sorghum and corn, by about 7 percent for cotton and soybeans, and by more than 30 percent for alfalfa. Total crop losses were estimated to be in the range of 5–10 percent of production. According to one estimate, this represents an economic loss of some \$5.4 billion.[34]

Reports of similar damage to Third World forests and crops are starting to be heard. Damage in China's southwest forests is being increasingly linked by scientists to air pollution and acid rain caused by a heavy reliance on high-sulfur coal. In Sichuan's Maocaoba pine forest, more than 90 percent of the trees have died. On Nanshan hill in Chongqing (Chungking), the biggest city in southwest China, a 1,800-hectare forest of dense masson pine has been reduced by almost half. Both these regions have highly acidic rain and elevated levels of sulfur dioxide. China's *Science and Technology Daily* reported in May 1989 that acid rain is causing serious damage in Hunan Province as well, including crop losses worth about 1 billion yuan annually (\$260 million at 1989 official

" 'Classic marble busts are being transmogrified into noseless and earless plaster grotesques.' "

exchange rates). Localized damage to trees and crops from air pollution, and possibly from acid deposition, has also been reported in Brazil, Chile, and Mexico.[35]

Elevated levels of acidity and ozone also have been found in tropical rain forests remote from industries and urban areas. In Latin America, the pollution is attributed to the enormous fires that rage as cattle ranchers and settlers clear land. In Africa, it stems from fires that burn for months across thousands of square kilometers of African savanna. They are set by fa mers and herders to clear shrubs and permit the growth of crops and grass. Tropical areas are thought to be especially vulnerable to acidification, because their soils are low in natural buffering agents.[36]

In contrast to damage to lakes and forests, that to the human-made environment is most frequently a local problem. Suifur dioxide and its acidic chemical derivatives are believed to be the chief culprits, though nitrogen oxides, ozone, and other pollutants also contribute.[37]

Corrosion of historical monuments is particularly evident in Europe—from the Acropolis, to the Royal Palace in Amsterdam, to the medieval buildings and monuments of Krakow, Poland. Although some decay is to be expected in structures dating to antiquity, pollution is greatly speeding the process. T.N. Skoulikidis, a Greek specialist on acid corrosion, has estimated that Athenian monuments have deteriorated more in the past 20–25 years from pollution than in the previous 2,400. Damage to historical artifacts and edifices is evident throughout Italy. "Classic marble busts," says *New York Times* correspondent Paul Hoffman, are being "transmogrified into noseless and earless plaster grotesques." In the Katowice region of southern Poland, trains must slow down in certain places because the railway tracks have corroded, apparently from acid rain.[38]

In the United States, air pollution may prevent the nation's historic monuments from ever reaching the ripe old age of Europe's. Already, Independence Hall in Philadelphia, where the Declaration of Independence was signed, is experiencing damage. At the Gettysburg Civil War battlefield, every statue or tablet made of bronze, limestone, or sandstone is being slowly but inexorably eaten away. Both the Statue of Liberty, made of copper, and the Washington Monument, a granite obelisk faced with marble, are also threatened.[39]

Again, the Third World is following the example of the First. The Taj Mahal appears to be endangered by emissions from an upwind oil refinery that are eroding its marble and sandstone surfaces, and recent research has found that acid rain falling on the Yucatan Peninsula and much of southern Mexico is destroying the temples, murals, and megaliths of the Mayans.[40]

Like the environmental damage caused by air pollution, the cost of corroding buildings and other materials can be high. Though quantifying the exact toll is difficult, given scientific uncertainties about the precise mechanisms of decay and difficulties in distinguishing between natural and acid-induced erosion, some rough attempts have been made. Researchers at the Swedish Corrosion Institute estimated in 1984 that corrosion to materials of all kind cost Sweden $2.5 billion per year. A 1980 report by the Dutch Ministry of Health and Environmental Protection estimated damage to monuments, libraries, and archives in the Netherlands at $10–15 million annually. Studies conducted in the United States have suggested a price tag in the billions. When these numbers are added to the other costs exacted by air pollution, reducing emissions begins to look cheap by comparison.[41]

Reducing Emissions

The tremendous damage to health and environment inflicted by air pollution has not been lost on the public or on policymakers. In the western, industrial world, the last 20 years has been a period of intensive political and scientific activity aimed at restoring clean air. The approaches to date, however, have tended to be technological Band-Aids prescribed by regulatory intervention rather than efforts to address the roots of the problem: the very nature of society's energy, transportation, and industrial systems.

The most widespread technological intervention has been the introduction of electrostatic precipitators and baghouse filters to control particulate emissions from power plants. Their use is now required in virtually all countries in the Organization for Economic Cooperation and Development (OECD). Though such technologies can reduce particulate emissions from smokestacks by as much as 99.5 percent, they do nothing to prevent gaseous emissions. These in turn can be converted in the air to acidic particles, such as sulfates and nitrates, harming both human health and the environment.[42]

The predominant technique used to reduce sulfur dioxide has been to put flue-gas desulfurization (FGD) devices, popularly known as scrubbers, on coal-burning power plants. Scrubbers can remove as much as 95 percent of SO_2 emissions. Among the members of the OECD, nearly 140,000 megawatts of power plant capacity were either equipped with FGD or had it under construction at the beginning of 1988. The United States led in total "scrubbed" capacity, with 62,000 megawatts, but this represented only about 20 percent of national U.S. coal-fired generating capacity, compared with roughly 40 percent in West Germany, 50 percent in Sweden, 60 percent in Austria, and 85 percent in Japan. By the end of the decade, the figures are expected to be 70 percent in Italy, 85 percent in West Germany, 100 percent in the Netherlands, but still only 30 percent in the United States.[43]

Though scrubbers have been rare elsewhere, this is slowly beginning to change. Czechoslovakia, for example, announced a major new environmental protection initiative in early 1989, including a $1.3-billion investment by the mid-nineties in desulfurization equipment at nine of the country's most heavily polluting power plants. China said in 1987 that it would, for the first time, equip a planned coal-fired plant with FGD.[44]

To control nitrogen oxides emissions from power plants, countries have pursued a variety of strategies, with mixed results. The most simple have been modifications in the combustion process, which yield reductions of some 30–50 percent. To date, the United States has invested heavily in this approach, and the United Kingdom and Portugal to a lesser degree. More expensive, but also more effective, is a process known as selective catalytic reduction (SCR). This can reduce emissions by 80–90 percent. Japan pioneered the technology in the seventies, primarily as an anti-smog measure. At the end of 1986, it had 91 units in operation, which was about 90 percent of total OECD-member installations and 54 percent of the country's fossil-fuel-fired generating capacity. West Germany and Austria have more recently embarked on ambitious SCR construction programs.[45]

Also under investigation are "clean coal" technologies, which lower emissions of both SO_2 and NO_x during combustion. Most prominent among them are various fluidized bed combustion technologies, whereby crushed coal is burned on a bed of limestone suspended by an upward injection of air, and a process known as integrated gasification–combined cycle, in which coal is transformed into a gas used to run a turbine (excess heat is tapped to produce steam, which powers a second turbine). These technologies offer deep cuts in SO_2 and moderate ones in NO_x while simultaneously burning more efficiently. Some of them are beginning to be commercialized, though others are still at the demonstration phase. Though an improvement over conventional power generation, "clean coal" is nevertheless something of an oxymoron: the technologies only marginally reduce carbon dioxide emissions and can produce problematic wastes.[46]

In general, new power plants are being fairly tightly controlled in most western countries. The problem comes in retrofitting existing facilities. This is becoming increasingly important, as construction of new power plants has slowed in the industrial world. To date, Denmark, Japan, the Netherlands, Sweden, the United Kingdom, and West Germany are the only OECD members to have undertaken significant retrofitting.[47]

Though the technologies just outlined provide necessary immediate reductions, they are not the ultimate solution. For one, they can create environmental problems of their own, such as the need to dispose of scrubber ash, a hazardous waste. Second, they do little if anything to reduce carbon dioxide emissions, so make no significant contribution to solving global warming. For these reasons, they are best viewed as a bridge to the day when energy-efficient societies are the norm and when pollution-free sources such as solar, wind, and water power provide the bulk of the world's electricity.

Improving energy efficiency is an essential strategy for reducing emis-

"Improving energy efficiency is an essential strategy for reducing emissions from power plants."

sions from power plants. Such measures as the widespread use of more efficient refrigerators and lighting can significantly and cost-effectively reduce electricity consumption, which will in turn reduce emissions. The American Council for an Energy-Efficient Economy (ACEEE) has identified widely available conservation measures that could bring electricity demand 15 percent below utility forecasts in a region of the U.S. Midwest that is responsible for 33 percent of the nation's utility-generated sulfur dioxide. Implementing this program would cut SO_2 emissions by 7–11 percent between 1992 and 2002 and NO_x by an undetermined but significant amount.[48]

Equally important, the savings that result from not building power plants because demand has been lowered by efficiency can more than offset the cost of emissions controls at existing plants. This is a potent combination. Indeed, the ACEEE, using conservative assumptions, found that consumers in the Midwest could realize a savings of $4–8 billion if emissions controls and accelerated conservation were both pursued as part of a national effort to halve SO_2 emissions. Emissions controls in the absence of efficiency investments would instead cost billions of dollars.[49]

Similar rethinking can help reduce auto emissions. To date, modifying car engines and installing catalytic converters have been the primary strategies used to lower harmful emissions. However, even in countries that have mandated converters—which reduce hydrocarbon emissions by an average of 87 percent, carbon monoxide by an average of 85 percent, and nitrogen oxides by 62 percent over the life of a vehicle—rising auto fleets are overwhelming their efficacy. Though catalytic converters are sorely needed in countries that don't require them, they are not alone sufficient.[50]

Reducing air pollution in urban areas is likely to require a major shift away from automobiles as the cornerstone of urban transportation systems. As congestion worsens in most major cities, driving to work is becoming increasingly unattractive anyway. Convenient public transportation, car pooling, and measures that facilitate bicycle commuting are the cheapest, most effective, most sensible ways for metropolitan areas to proceed.[51]

Driving restrictions already exist in many cities around the world. In Florence, Italy, the heart of the city has been turned into a pedestrian mall during daylight hours. Portions of central Rome are off-limits to normal car traffic for seven hours a day, during the morning and evening rush hours. Budapest bans motor traffic from all but two streets in the downtown area during particularly polluted spells. In both Mexico City and Santiago, one-fifth of all vehicles are kept off the streets each weekday based on their license-plate numbers. Lagos has had a similar system in place since 1976, with odd and even numbers taking turns.[52]

One option under consideration in many countries is the introduction of vehicles powered by alternative fuels, such as methanol, ethanol, natural gas, hydrogen, and electricity. Although these fuels would reduce emissions of certain problematic pollutants, in some cases substantially, their widespread use runs the risk of solving one problem by substituting others.

For example, though most analysts agree that methanol would yield some reductions in ozone formation, vehicles powered by this fuel produce two to five times more formaldehyde, a probable human carcinogen, as do those run on gasoline. And if methanol is made from coal, as it might well be if it were relied on in a substantial way, emissions of the primary greenhouse gas, carbon dioxide, would be 20–160 percent higher than from gasoline. In addition, methanol is a highly poisonous, colorless, odorless, and tasteless liquid that could contaminate groundwater in the event of leaking storage tanks and seriously harm someone if splashed during refueling. When ingested or absorbed through the skin, methanol is at least twice as toxic as gasoline.[53]

Other alternatives are also by no means panaceas. Natural gas offers reductions of from 40–60 percent for hydrocarbons and 50–95 percent for carbon monoxide, but an increase of 25 percent in nitrogen oxides. In addition, its use poses distribution and design problems and would reduce greenhouse emissions only marginally.[54]

Ethanol, an alcohol distilled from biomass, emits substantial quantities of acetaldehyde, which can speed ozone formation. Its production is

"Reducing air pollution in urban areas is likely to require a major shift away from automobiles."

currently economical only with heavy government subsidies, and because it is often made from grain, its widespread adoption could result in a competition between food and fuel. The global warming implications of ethanol use depend upon the fossil fuel intensity of the agricultural production process. In the United States, total carbon dioxide emissions from ethanol production are estimated to be 63 percent less on an energy-unit basis than those from gasoline production and combustion.[55]

For the long run, electricity and hydrogen are probably the most promising of the alternative fuels. Cars that run on electricity generated by natural gas can reduce emissions of hydrocarbons by 99 percent, carbon monoxide by nearly 100 percent, and nitrogen oxides by 84 percent; vehicles run on hydrogen produced by electrolysis of water by a pollution-free power source such as solar energy would emit no hydrocarbons or carbon monoxide and significantly less nitrogen oxides. With both electricity and hydrogen, however, the key question is what fuel is used to produce it. Electricity generated from non-polluting, renewable sources is an appealing prospect, but not on the immediate horizon for widespread application. Similarly, hydrogen produced by photovoltaics—solar cells—would be an attractive option, but photovoltaic prices will have to drop five- to tenfold before this will be economically feasible.[56]

The problems posed by alternative fuels are not necessarily insurmountable. If such programs are to render real benefits, however, they must be implemented with great care as one component of a broader effort.

Less glamorous but perhaps more practical would be measures such as reducing the volatility of gasoline—which would lower emissions during refueling and from tanks—and introducing widespread inspection and maintenance programs to ensure that emissions control systems are functioning properly. Indeed, a recent U.S. Office of Technology Assessment (OTA) report concluded that reducing gasoline volatility would cost $120–760 per ton of hydrocarbons avoided, and implementing inspection and maintenance programs $2,100–5,800 per ton of reductions, whereas replacing gasoline with methanol would cost $8,700–51,000 per ton.[57]

A clear priority as society struggles with both air pollution and global warming is to encourage the manufacture and purchase of automobiles that are both low in emissions and high in fuel economy. There is a direct relationship between fuel economy improvements and carbon dioxide emissions reductions, but a far more ambiguous one between fuel economy and "conventional" pollutants. In the latter case, the relationship is complicated by variables such as combustion temperature and amount and type of catalysts.

Though the automobile industry has claimed over the years that the goals of reducing emissions and improving fuel economy are in direct conflict, both the EPA and the OTA maintain that they do not have to be. Indeed, most technologies employed to improve fuel economy reduce emissions. While some measures chosen to improve emissions may entail a fuel economy penalty, this can be avoided. An analysis of 781 car models by Chris Calwell of the Natural Resources Defense Council shows that the 50 most efficient emitted one-third less hydrocarbons than the average car and roughly half as much as the 50 least efficient ones.[58]

As with power plant and auto emissions, efforts to control airborne toxic chemicals will be most successful if they focus on waste minimization rather than simply on control. Such a strategy also helps prevent waste from just being shifted from one form to another. Many control technologies, such as scrubbers and filters, produce hazardous solid wastes that must then be disposed of on land. The OTA has concluded it is technically and economically feasible for U.S. industries to lower production of toxic wastes and pollutants by up to 50 percent within the next few years. Similar reduction possibilities exist in other countries.[59]

A Political Progress Report

The enormous health and environmental costs of air pollution would appear to present a compelling argument for controlling harmful emissions. Unfortunately, only a few policymakers are considering implementation of the comprehensive strategies that are necessary. Recent developments at the national and international levels—though steps forward—remain inadequate to the task.

"Because air pollution crosses borders with impunity, international cooperation on reducing emissions is essential."

In the United States, Congress is currently debating major amendments to the Clean Air Act of 1970. After years of deadlock in the legislature and inaction at the White House, President George Bush submitted a plan of his own for congressional consideration in July 1989. This active leadership, combined with strong public support for strengthened environmental regulations, has raised hopes that legislation will soon be in place that will halve the emissions that cause acid rain, tighten emissions standards for automobiles significantly, and require much stricter control of toxic air pollutants.[60]

Though any legislation is an improvement over the current impasse, the administration's proposal missed the opportunity to address the problem at a fundamental level by encouraging energy efficiency, waste reduction, and a revamping of transportation systems and urban designs. From this point of view, the acid rain provisions are probably the most promising, as they would give utilities their choice of control strategies, including energy efficiency. Positive incentives, however, could have helped make this the clear first choice for utilities rather than simply an option.

One controversial provision of Bush's plan would set up a market in reduction allowances of sulfur dioxide and nitrogen oxides, the precursors of acid rain. Under such a program, a company or power plant that had reduced its emissions below a certain threshold could sell the balance to another firm. The goal is to reduce the total cost of pollution control by ensuring that the polluters that can reduce emissions the most cheaply do so. Critics charge that recognizing a "right to pollute" is akin to recognizing a "right to assault." Others question whether an idea that sounds good in theory might not prove problematic in practice. Carefully designed emissions-trading schemes may have a role to play, but it is important that they not detract attention from the ultimately more important question of setting incentives that will spur pollution reductions rather than simply minimize costs.[61]

Because air pollution crosses borders with impunity, international cooperation on reducing emissions is essential. Europe, where many countries lie in close proximity, has a particular concern about transboundary pollution. For example, 96 percent of the sulfur deposited in Norway originates in other countries. The Norwegians can thus do little to save their lakes without the help of their upwind neighbors. (See Table 6.)

Though the past few years have seen important incremental advances in international forums, there remains much room for improvement. Under the auspices of the U.N. Economic Commission for Europe, agreements to reduce emissions of sulfur dioxide and nitrogen oxides have been reached. The SO_2 protocol, adopted in July 1985, calls for a 30-percent reduction in emissions or their transboundary flows from 1980 levels by 1993. The nitrogen oxides accord, signed in November 1988, calls for a freeze on emissions at 1987 levels in 1994, as well as further discussions beginning in 1996 aimed at actual reductions.[62]

Most but not all major countries have signed these agreements; some have even made commitments to go beyond them. At least nine countries have pledged to bring sulfur dioxide levels down to less than half of 1980 levels by 1995; Austria, Liechtenstein, Sweden, and West Germany have committed to reducing them by two-thirds. On nitrogen oxides, 12 Western European nations have agreed to go beyond the freeze and reduce emissions by 30 percent by 1998. Work is now under way on a protocol aimed at reducing hydrocarbons, precursors of ozone.[63]

A November 1988 directive by the European Economic Community (EEC) represents a binding commitment by the members to reduce acid-rain-causing emissions significantly. The directive will lower community-wide emissions of SO_2 from existing power plants by a total of 57 percent from 1980 levels by 2003, and of nitrogen oxides by 30 percent by 1998. The amount each country will be required to cut is based on its contribution to long-range transboundary pollution, level of industrial development, dependence on domestic high-sulfur energy resources, and pollution control efforts before 1980. Belgium and West Germany, for example, would have to reduce SO_2 emissions by 70 percent by 2003, while Ireland could have 25 percent higher output and Portugal, 79 percent higher. (See Table 7.)[64]

These commitments, while far better than nothing, are not enough. For

Table 6: Sulfur Pollution in Selected European Countries, 1988[1]

Country	Total Emissions[2]	Total Deposition	Share of Emissions Exported[3]	Share of Deposition Imported
	(thousand tons)		(percent)	
Norway	37	210	76	96
Austria	62	181	74	91
Sweden	110	302	69	89
Switzerland	37	65	81	89
Netherlands	145	104	80	72
France	760	622	67	59
West Germany	750	628	63	56
Czechoslovakia	1,400	659	75	47
Poland	2,090	1,248	68	46
Soviet Union[4]	5,150	3,201	61	38
Italy	1,185	510	72	36
East Germany	2,425	787	75	22
Spain	1,625	590	72	22
United Kingdom	1,890	636	71	15

[1]Sulfur is generally emitted as sulfur dioxide but may fall to earth as a variety of its chemical derivatives, including sulfuric acid and sulfates.
[2]Unless otherwise noted, emissions figures are preliminary 1988 data. Data for Austria, Sweden, and France are for 1987; Italy, 1986; and Spain, 1983.
[3]May be deposited either in another country or over a body of water.
[4]Only the European part of the Soviet Union; thus, export figure includes exports to the Asian part of the Soviet Union.

Source: Worldwatch Institute, based on emissions data in Economic Commission for Europe, "Annual Review of Strategies and Policies for Air Pollution Abatement" (draft), September 26, 1989, and on data on transboundary flows supplied by the European Monitoring and Evaluation Program.

one, it is unclear whether all signatories to the SO_2 and NO_x protocols will meet their targets. Second, the reductions envisioned are too little and too late to protect the environment adequately. Ecologists who have

Table 7: Sulfur Dioxide Emissions Reductions Targets from Existing Plants, According to the EEC Directive

Country	1980 Baseline	1993 Target	1998 Target	2003 Target
	(1,000 tons)	(percent reduction relative to baseline)		
Belgium	530	–40	–60	–70
Denmark	323	–34	–56	–67
France	1,910	–40	–60	–70
Greece	303	+6	+6	+6
Ireland	99	+25	+25	+25
Italy	2,450	–27	–39	–63
Luxembourg	3	–40	–60	–70
Netherlands	299	–40	–60	–70
Portugal	115	+102	+135	+79
Spain	2,290	0	–24	–37
United Kingdom	3,883	–20	–40	–60
West Germany	2,225	–40	–60	–70
TOTAL	14,430	–23	–42	–57

Source: Nigel Haigh, "New Tools for European Air Pollution," *International Environmental Affairs*, Winter 1989, based on European Economic Community Directive 88-609, November 24, 1988.

looked carefully at the amount of pollution that various European ecosystems can withstand believe that cuts in emissions on the order of 90 percent in sulfur and nitrogen oxides and 75 percent in ozone levels are what is really needed. How individual countries will choose to meet their given targets remains an open question. Unfortunately, energy efficiency rarely appears at the top of their lists.[65]

Europe generally has been quicker than the United States to address acid rain, but slower to tackle urban air quality. Though non-EEC countries such as Austria, Norway, Sweden, and Switzerland have had

"Los Angeles is one of the first regions to realize that lasting change will not come by merely tinkering with the status quo."

strong auto emissions control legislation in place for several years, until recently the community had been unable to agree on stringent standards.

This finally changed in June 1989, when the EEC Council of Environmental Ministers ended a nearly four-year debate and approved new standards for small cars that will be as tough as those now in effect in the United States. To meet them, small cars will have to be equipped with catalytic converters. Standards for large cars were already in place, but the EEC environment commissioner is considering stricter ones. A community-wide speed limit is also being looked at as a pollution control measure, but West German fascination with high-speed driving may make this politically infeasible. Although clearly a step forward, it is somewhat ironic that Europe sees its adoption of U.S. standards as a major victory at the same time that the United States is realizing these regulations do not go far enough.[66]

Los Angeles—with the worst air quality in the United States—is one of the first regions in the world to really understand that lasting change will not come by merely tinkering with the status quo. Under a bold new air quality plan embracing the entire region, the government will discourage automobile use, boost public transportation, and control polluting household and industrial activities. For example, paints and solvents will have to be reformulated, gasoline-powered lawn mowers and barbecues and fuels that require lighter fluid will be banned, carpooling will be mandated, and the number of cars per family limited. Though the plan has been approved by all of the relevant state and federal agencies, implementing it at the local level will likely prove a challenge.[67]

In Eastern Europe and the Soviet Union, air pollution has only recently emerged as a pressing political issue. Fyodor Morgun, then head of the Soviet Union's State Committee on the Protection of Nature, reported to the Nineteenth Communist Party conference in 1988 that air pollution levels in 102 Soviet cities, affecting more than 50 million people, were often 10 times higher than the national standard. This official recognition of the problem was an important step. Similarly, when Solidarity sat down with the Polish leadership in March 1989 for the discussions that resulted in a Solidarity-led government, environmental issues in general and air pollution in particular figured prominently on the agenda.[68]

To make a dent in their pollution, Eastern Europe and the Soviet Union will need western technologies as well as domestic reform. Given current economic conditions in these countries, however, "environmental aid" from the West will be necessary for the purchase of pollution control, energy efficiency, renewable energy, and waste reduction technologies. Such aid can be in the best interests of the purveyor, as stemming pollution in Eastern Europe, where even rudimentary controls are still lacking, can yield a far greater return on the investment than taking further incremental steps at home. Sweden, for example, imports 89 percent of the sulfur that is contributing to the poisoning of its lakes and forests by acid rain. (See Table 6.) Because much of this total is of Eastern European origin, anything Sweden does to combat emissions there helps Sweden at home as well. Concern about global warming is an added impetus for the West to help the East with energy efficiency and renewable energy.

Several promising initiatives are already under way. To cite just a few of many examples, the U.S.-based Natural Resources Defense Council and Rocky Mountain Institute are advising the Soviet government on policies to improve energy efficiency. The U.S. Congress has passed legislation that will allocate $40 million in environmental assistance for Poland and Hungary, a token sum given the magnitude of the problems but symbolically important. And the Swedish government has announced that it plans to provide Poland with $45 million in aid over the next three years, mostly for environmental protection. East and West Germany recently initiated a three-year program to cooperate on pollution control. East Germany will contribute 120 million deutsche marks ($65 million) and West Germany, 300 million ($163 million) that will go toward the purchase of advanced coal-burning technology for power plants and other pollution control measures. The two countries will also standardize air pollution data in order to help forecast smogs that waft across the border.[69]

Air pollution is beginning to emerge on the political agenda in the Third World as well. In Cubatão, Brazil, a notoriously polluted industrial city known as "the Valley of Death," a five-year-old government cleanup campaign is starting to make a dent in the problem. Total emissions of particulates, for instance, were cut from 236,600 kilograms a day in 1984 to 70,782 in 1989. Mexico City, too, is embarking on an ambitious clean-up. With the support of the World Bank, West Germany, Japan, and the United States, the municipal government hopes to introduce a package of measures to cut automotive pollution dramatically over the next two to three years.[70]

Industrial countries are involved in a variety of efforts to assist developing countries with air pollution problems. The International Environmental Bureau in Switzerland and World Environment Center in New York help facilitate transfer of pollution control information and technology to the Third World. The World Bank is exploring ways to step up its air pollution activities. One proposed project involving the World Bank and the U.N. Development Program would help Asian governments confront urban environmental problems, including air pollution. Legislation recently passed by the U.S. Congress requires the U.S. Agency for International Development, in the interests of slowing global warming, to encourage energy efficiency and renewable energy through its programs. This will reduce air pollution at the same time.[71]

In attempting to help Eastern Europe, the Soviet Union, and the Third World with air pollution problems, western industrial countries must take care not to simply transfer wholesale their current pollution control strategies—strategies that clearly have not solved the problem over several decades. The ultimate solution to air pollution is not to control it but to act in ways that prevent it in the first place.

An Agenda for Clean Air

As we enter the nineties, air pollution policy around the world is in flux. Though numerous technologies and strategies are available to reduce emissions, their piecemeal adoption has led to overall failure in the battle for clean air. Efforts to improve air quality by focusing on one pollutant at a time have proven inadequate. To clear the air, it will be necessary to supplement traditional air pollution strategies with innovative policies that encourage energy efficiency and non-polluting, renewable energy sources, minimize dependence on the automobile, and reduce the production of toxic wastes.

Developing a more environmentally benign energy system depends critically on correcting market imperfections. The first step is to ensure that subsidies are removed so that the cost of energy reflects its true value, providing an incentive to use less. Centrally planned or controlled economies in Eastern Europe, the Soviet Union, and the developing world have the potential to make particularly rapid strides in this direction as they move toward market-based economies. In China, for example, energy efficiency has improved an average of 3.7 percent annually since the country's economic reform program began in 1979. As energy use per unit of gross national product declines, so does the amount of pollution.[72]

Incorporating the environmental costs of burning fossil fuels into the power planning process is a crucial second step. In the United States, the State of New York is pioneering this approach. Under an innovative program, a competitive market is being set up whereby independent power producers must bid against each other for power supply contracts. Suppliers planning to burn fossil fuels are required to add nearly one cent per kilowatt-hour to their bids to account for air pollution, and an additional half cent per kilowatt-hour to account for other environmental costs. This can give renewable sources or energy efficiency just the edge they need to be competitive.[73]

Such a program could be effectively supplemented by rewarding utilities that reduce emissions, and customers' bills, through efficiency programs with a slightly higher rate of return on investment. If aggressively implemented, these policies could eliminate the need to

"Developing a more environmentally benign energy system depends critically on correcting market imperfections."

build additional power plants in industrial countries and even make it possible to phase out today's most polluting plants.[74]

Taxing emissions also can serve as a strong disincentive to pollute. Swedish officials have drafted proposals that would tax sulfur, nitrogen oxides, and carbon dioxide emissions. The sulfur and carbon dioxide taxes would be levied on the purchase of fuels, while the nitrogen oxides tax would be levied directly on emissions from factories and power plants. If the proposed plan is approved, by the end of the decade it would reduce sulfur dioxide emissions by 7 percent from their 1987 level, nitrogen oxides by 8 percent, and carbon dioxide by from 9 to 17 percent. The Italian cabinet has recently approved a similar scheme as part of its 1990 budget, though it must still be passed by the parliament. France and Japan have experimented with this approach for several years. Though the charges imposed in these countries have succeeded in raising revenues for designated purposes, thay have not had a significant impact on emissions because the fees were set too low. To prevent such taxes from raising the national tax burden, they can be offset by reductions in other taxes.[75]

Though encouraging materials recycling has caught the public's attention as a way to save on scarce landfill space, its pollution prevention potential is equally important. Each ton of paper made from newsprint rather than wood lowers energy use by one-fourth to three-fifths and air pollutants by some 75 percent. Aluminum produced from recycled cans rather than ore cuts emissions of nitrogen oxides by 95 percent and of sulfur dioxide by 99 percent.[76]

New transportation policies can help lessen society's dependence on automobiles—especially the most polluting and fuel-inefficient varieties. In addition to restricting the entry of cars into downtown areas, municipal governments can invest more in efficient public transportation systems and help commuters organize car pools to keep vehicles off the road. Developing policies to ensure that drivers pay the full cost of using their cars could also curb automobile dependence. Taxing or eliminating free parking benefits, collecting tolls or fees for road use, and imposing hefty gasoline and automobile sales taxes are all means to this end.

A recent analysis by John Pucher of Rutgers University that compared gasoline and auto sales tax rates with average driving frequency in 12 North American and Western European countries concluded that high gas and auto sales taxes tend to deter driving. In the United States, where gas taxes are only 45 percent of the pre-tax price and auto sales taxes 5 percent, the citizenry drives an average of 7,700 kilometers per person per year; in Denmark, with gas taxes of 355 percent and an automobile sales tax of 186 percent, only 4,200 kilometers per person are driven annually. While varying tax rates are only one explanation for these large differences, the Rutgers study concludes that they are an important one.[77]

To encourage the manufacture and sale of less-polluting cars, governments could consider an emissions-pegged sales tax. Analysts at the Lawrence Berkeley Laboratory in Berkeley, California, have suggested a revolving fund that would tax new high-emission cars, and subsidize cleaner ones. Consumer demand would then spur the industry to produce less-polluting autos. Sweden has already successfully used such an approach to promote the purchase of cars equipped with catalytic converters.[78]

Beyond tax policies, dependence on the automobile can also be minimized through better land use. In the sprawling cities of Denver, Houston, and Los Angeles, roughly 90 percent of commuters drive to work. In Europe, by contrast, where extensive suburbs are less common and commuting distances generally half those in North America, only about 40 percent of urban residents commute by car. In the future, "satellite cities" may become the norm: self-contained communities for home and work connected to a central urban hub by convenient rail transport.[79]

Because emissions of toxic chemicals into the air are commonly less strongly regulated than those onto land or into water, stricter controls on them are sorely needed. Over the long term, this will serve as an incentive to reduce waste: as disposal becomes more difficult and expensive, waste reduction and recycling become increasingly attractive. Certain other economic incentives could also help. For example, a "deposit-refund" system might be implemented whereby industries are taxed on the purchase of hazardous inputs, but given a refund for wastes produced from them that are recovered or recycled.[80]

Freedom of information is an often neglected but crucially important element in an effective air pollution strategy. Experience in the United States has shown that public access to information about what chemicals a plant is emitting can be instrumental in spurring public response, and more responsible behavior by industries. Within weeks of its release of information on emissions mandated under right-to-know legislation, the Monsanto Company announced its intention to cut back its toxic air emissions by 90 percent by 1992.[81]

Most European countries have yet to provide for the release of information about emissions from industrial plants, although the EEC is considering a draft directive on freedom of information on environmental matters that would improve this somewhat. Glasnost is gradually improving the environmental data flow in some Eastern European countries and in the Soviet Union, though much progress in this area remains to be made. Grassroots groups in some developing countries are also beginning to break down the secrecy barriers.[82]

Now that air pollution and its damaging health and ecological effects have proliferated around the globe, crossing borders with the winds, international cooperation is critical. Nations that receive the bulk of their pollution from other countries have an obvious interest in sharing and financing the technical means to reduce that pollution. Just as essential is information sharing. International negotiations within the framework of both the Economic Commission for Europe and the European Community as well as the ongoing negotiations on global warming offer invaluable opportunities to trade insights and experiences.

While the means are available to clear the air, it will be a difficult task. In the West, powerful businesses with vested interests in the status quo will strongly resist measures that cost them money. In Eastern Europe, the Soviet Union, and the developing world, extreme economic problems coupled with shortages of hard currency mean that money for pollution prevention and control is scarce.

Around the world, however, the notion that "pollution is the price of progress" has become antiquated. Faced with ever mounting costs to human health and the environment, people on every continent are discovering that pollution prevention is a sound investment. This newfound consensus is an essential first step; the challenge now is to move beyond it to concrete action.

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