A Primer on Smog Control

Kenneth Chilton and Anne Sholtz

Amendments to the Clean Air Act appear likely to be passed by the 101st Congress and signed into law by President Bush. Much of the public discussion of Clean Air Act proposals has focused on specific control measures to attain the ozone standard prescribed in the act.

For the most part, the public debate is uninformed. Few citizens know the health risks associated with ozone, their exposure to "unhealthful" levels of the pollutant, or the benefits and costs of the current approach to reducing smog.

What is needed is a broader perspective that answers the basic questions:

- What does it mean to be a nonattainment area?
- What are the health effects of ozone pollution?
- What causes ozone buildup?
- What are the benefits and costs of reaching the air quality standard?
- How can the Clean Air Act be changed to protect public health and welfare in a more economical way?

What Does It Mean to Be a Nonattainment Area?

Nonattainment has a very precise meaning as defined in the Clean Air Act. If the fourth highest daily one-hour reading taken on any monitor during the most recent three-year period registers an ozone concentration above 0.12 parts per million (ppm), an area is not in attainment with the air quality standard. (The fourth highest daily maximum reading is referred to as the design value.) The definition is cut-and-dried and does not account for other monitor readings in a city that may be far lower than the highest reading.

According to the most recent Environmental Protection Agency figures, 88.6 million Americans live in counties that exceeded the ozone standard in 1987. Table 1 lists some of the areas that are classified as nonattainment. (The table uses the design value to order the severity of the ozone problem.)

The final column of Table 1 indicates how much the emissions of volatile organic compounds (VOCs) —reactive hydrocarbons from gasoline, solvents, paints, and decaying vegetation that are prime precursors of ozone—must be reduced for a particular area to reach the 0.12 parts per million standard. One point is abundantly clear: many cities must make large reductions in emissions to reach this standard for attainment. More than 63 million Americans live in areas where VOCs will need to be reduced by 40 percent or more to meet the standard.

The simple designation as a nonattainment area is misleading, however. This definition focuses on a one-hour peak concentration figure to provide an adequate margin of safety against *any* adverse health effects, but this is not necessarily the best measure of overall air quality. For example, Los Angeles undoubtedly suffers from the worst smog problem in the United States. Los Angeles' design value is 0.34 ppm—nearly three times the air quality standard. Area ozone levels at the highest monitor readings exceeded 0.12 ppm for one hour or more

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for an average of 145 days a year from 1986 through 1988.

But a different picture of the Los Angeles ozone problem forms when one considers an alternative set of facts. When all monitors are considered, readings were above the standard less than 3 percent of the total hours monitored from 1981 through 1985. The readings at all monitors were above 0.24 ppm less than one-half of one percent of the total hours monitored during this five-year period. And Los Angeles is not an isolated example. The average monitor readings in Chicago, Atlanta, Portsmouth, and most other nonattainment areas exceed the standard less than one percent of the total hours monitored.

Therefore, a nonattainment area may not be an unhealthy one. Without knowing how ozone affects health and without having a more realistic perspective of how many individuals are exposed to elevated ozone levels and how often and how long they are exposed, the general public has a distorted view of America's smog difficulties.

Table 1: Nonattainment Areas More Than 25 Percent above Standard

Area	Population (millions)	1986–1988 Design Value	Percent above Standard	Required VOC Reductions (%)
Los Angeles, CA	8.3	.34	183	80
New York, NY	8.5	.22	83	67
Chicago, IL	6.2	.20	67	53
Houston, TX	3.2	.19	58	60
Baltimore, MD	2.9	.18	50	42
Hartford, CT	0.7	.18	50	53
Milwaukee, WI	1.4	.18	50	53
Muskegon, MI	0.2	.18	50	61
Philadelphia, PA	4.5	.18	50	43
Portsmouth, NH–Dover, ME	0.2	.18	50	38
San Diego, CA	2.4	.18	50	44
Atlanta, GA	2.6	.17	42	36
Boston, MA	2.8	.17	42	34
El Paso, TX	0.6	.17	42	46
Fresno, CA	0.6	.17	42	55
Huntington, WV–Ashland, KY	0.3	.17	42	58
Louisville, KY	1.0	.17	42	58
Parkersburg, WV–Marietta, OH	0.2	.17	42	58
Sheboygan, WI	0.1	.17	42	58
Worcester, MA	0.4	.17	42	58
Bakersfield, CA	0.5	.16	33	49
Baton Rouge, LA	0.5	.16	33	60
Beaumont and Port Arthur, TX	0.4	.16	33	72
Cincinnati, OH	1.4	.16	33	44
Dallas-Ft. Worth, TX	2.4	.16	33	44
Portland, ME	0.2	.16	33	52
Providence, RI	0.6	.16	33	54
Sacramento, CA	1.3	.16	33	45
Springfield, MA	0.2	.16	33	53
St. Louis, MO	2.4	.16	33	50
Washington, DC	3.6	.16	33	45

Ozone's Health Effects

During the past two decades researchers have extensively studied the health effects of ozone. They have examined both short-term (acute) effects and long-term (chronic) effects, but have focused primarily on acute responses to elevated levels of ozone. Medical research has used two basic types of studies—epidemiological and clinical. The former usually examine hospitals' and doctors' records to determine whether there is a relationship between a given health effect and an environmental factor, such as elevated ozone levels. But a variety of confounding variables and lack of information on individuals' exposures to ozone have typically made it difficult to obtain strong results from these studies. Clinical studies, on the other hand, are conducted in settings where the researcher controls the environment experienced by the subject. But these studies have been criticized because they typically use small numbers of subjects who have not been randomly selected.

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Not all clinical studies are small-scale, however. For example, McDonnell, Horstman, Abdul-Salaam, and House studied 135 subjects—healthy, young adult men who lived in low-pollution areas. The test group was segmented into six subgroups, and each subgroup was exposed to one of six concentrations of ozone (0.12, 0.18, 0.24, 0.30, and 0.40 ppm) while exercising very heavily, but intermittently, for two hours. Small changes in breathing capacity were observed at 0.12 and 0.18 ppm. Only at the higher levels were average lung function losses greater than 10 percent. Although average lung function losses were mild even at the 0.18 level, individual responses varied greatly. Some subjects experienced severe decreases in lung function, while others experienced no decreases whatsoever.

It would be impossible, however, to summarize the results of the myriad of clinical studies that have been conducted. While the studies generally show adverse health effects at unusually high ozone concentrations, a few points seem to have been underreported.

"Walter's solution is to pump a lot of fresh air into the atmosphere."

Ozone's effects on pulmonary function appear to involve an attenuation response, albeit a *temporary* one. Results from clinical studies show that, with repeated exposure to ozone, reductions in pulmonary function are greatest on the second day. On each succeeding day, the reductions are less than the day before. (Attenuation of a symptomatic response at a given ozone concentration does not reduce response to higher levels, however.) Following a sequence of repeated daily exposures, pulmonary function apparently returns to that experienced before exposure within three to seven days.

Many of the concerns about ozone's effects on persons suffering from lung disease also lack substantiation. According to the available evidence, people with preexisting lung disease and normal healthy subjects respond similarly to ozone exposure at moderate concentrations and exercise levels. This does not imply, however, that persons with already reduced lung function are not more at risk when experiencing the same *incremental* loss of breathing capacity as healthy subjects.

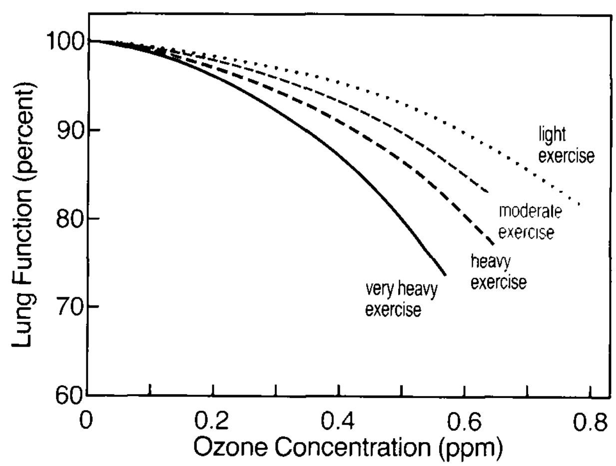
Short-term changes in lung function and increased respiratory symptoms are especially affected by the frequency and depth of breathing, which increase as the exercise work load increases. The EPA has pooled a variety of controlled human exposure and field studies to estimate the relationship of exercise levels and ozone concentations to reduced breathing capacity. Figure 1 illustrates the EPA's findings for healthy adult subjects (18 to 45 years old) after one to three hours of exposure.

These overall results show less than a 10 percent loss in lung function at ozone levels more than four times the current ozone standard during light exercise. Even during very heavy exercise, pulmonary function is typically reduced by less than 10 percent at concentrations twice the 0.12 ppm standard.

The EPA is quick to point out, however, that some healthy adults can suffer losses in lung function when they engage in heavy exercise at 0.15 to 0.16 parts per million. In fact, adverse effects have been shown for some healthy adults at levels as low as 0.12 ppm. Children may also show decreases in lung function at ozone levels as low at 0.12 ppm with heavy exercise. Approximately 5 to 20 percent of the populations studied in these clinical tests have been dubbed "responders" because they show a greater responsiveness than average subjects to the same conditions.

Despite the extensive epidemiological and clinical studies done thus far, the book on the health effects of ozone is far from closed. Studies of ozone's chronic effects on animals, for example, continue to raise concerns among medical researchers. Some animal research suggests that ozone may affect the lungs' ability to resist bacterial and viral infections and accelerate the lungs' aging process. Extrapolating these findings to humans is highly problematic, however.

Figure 1: Lung Function Decrements for Varying Ozone and Exercise Levels



In summary, unusually high concentrations of ozone clearly produce adverse health effects. These effects are greatly influenced by increased levels of exercise, which suggests that significant numbers of at-risk individuals may be able to reduce the effects of smog by altering their behavior. Further, demonstrated effects have largely been short-term (acute) effects of a relatively mild and reversible nature. On the other hand, there is a clear need for further medical research on the possible chronic effects of ozone.

Causes of Ozone Pollution

Scientists also have been studying extensively the causes of ozone formation. This major component of photochemical smog is not emitted directly into the air, but is formed through complex chemical reactions between emissions of volatile organic compounds (VOCs)—primarily hydrocarbons—and nitrogen oxides (NO_x) in the presence of sunlight and oxygen. Both hydrocarbons and nitrogen oxides are emitted by transportation and industrial sources.

Ozone production follows several distinct patterns. Since the formation of ozone at the Earth's surface requires sunlight, concentrations are minimal around sunrise (near zero in most urban areas), rise to maximum levels in the early afternoon, and fall to minimal levels again at night. Ozone also follows a seasonal pattern. During the late spring and summer, more intense sunlight and stagnant air flows increase the level of ozone produced from any level of VOC emissions.

Many factors contributing to elevated ozone levels are beyond human control. One component of ozone formation occurs naturally as emissions from trees and plants. Some investigators believe that these naturally occurring sources are the dominant contributors of VOCs. Other researchers contend that at least two-thirds of these emissions result from manmade sources.

Because ozone moves with air masses, ozone levels can be higher in suburban or rural areas than in urban areas. Moreover, elevated levels of ozone can persist longer in outlying areas because of the absence of nitrogen oxide for chemical "scavenging" —chemically breaking down smog. Under some circumstances, reductions in nitrogen oxide concentrations can reduce its scavenger role and actually increase the formation of smog. The role of NO_x as both a precursor and a scavenger of ozone is one of the factors that makes it so difficult to deal with ozone problems.

In summary, the variability of weather conditions and natural and manmade emissions of pollutants that form ozone make the reduction of peak ozone levels most difficult. A regulatory approach that does not take specific local circumstances into account is likely to produce disappointing results.

The Benefits and Costs of Reducing Ozone Levels

There are no "silver bullets" that can bring into compliance all of the 83 urban areas that did not meet the 0.12 ppm ozone standard during the 1986–1988 period. Several methods required by current law can reduce 1987 VOC emission levels by a total of 18 percent by 2005. By 1995, these measures alone should reduce the noncomplying areas to 58; however, without added controls, population growth and increased automobile usage could increase that number to 72 by 2005.

The Clean Air Act does not require that decisions relating to control measures be based on a benefit-cost standard. As a result, there are only a few careful estimates of the benefits or costs of achieving improvements in reducing urban smog.

President Bush's clean air proposal identified ten new measures that could reduce VOCs by an additional 27 to 30 percent. The administration projected that these added measures would bring all but 20 cities into compliance by 2005. These 20 areas have a current population of 36 million.

Benefit Estimates. The Clean Air Act does not require that decisions relating to control measures be based on a benefit-cost standard. As a result, there are only a few careful estimates of the benefits or costs of reducing urban smog. Nonetheless, recent reports do provide some rough but useful estimates of aggregate benefits and costs.

One comprehensive, but preliminary, study of acute human health and agricultural benefits (completed for the Office of Technology Assessment by Alan Krupnick and Raymond Kopp of Resources for the Future) provides benefit estimates associated with various decreases in ambient ozone concentrations. Their study uses a willingness-to-pay method of benefit estimation and focuses upon reductions in acute health effects. The willingness-to-pay method of estimating benefits asks people how much they would be "willing to pay" to avoid experiencing a day (or part of a day) of a health effect or group of effects.

Krupnick and Kopp present seven scenarios and calculate benefits for each of them in 1984 dollars. The two researchers found that their estimates of health benefits could differ among the scenarios by a factor of 100. Depending upon the assumption, the benefits of reaching the current ozone standard of 0.12 ppm range from $51 million to $4.7 billion a year. Under the scenario that only individuals who exercise heavily derive benefits, the annual benefits of reaching the 0.12 ppm standard range from $51 million to $360 million; if all exercising individuals receive benefits proportional to their exercise levels, however, the benefits range from $667 million to $4.7 billion a year.

Of greatest interest for comparing benefits and costs is Krupnick and Kopp's analysis of an across-the-board 35 percent reduction in VOCs. Under the assumption that all exercising individuals receive benefits, a 35 percent reduction in emissions would produce health benefits ranging from $248 million to $1.7 billion with a best estimate of $684 million. If we take the high end of this range and adjust benefits to 1988 dollars, acute health benefits would be $500 a ton of VOCs reduced.

Reducing ozone levels also benefits crops and forests. A good deal of research has been done on these effects, and benefit estimates are available for agricultural crops. But benefit estimates for human health and agricultural products are not calculated on a comparable basis. Furthermore, control strategies to reduce VOC emissions in urban areas may produce few crop benefits in rural areas; the reverse is also true.

Other benefits from reduced concentrations of ozone include the aesthetic value of clean air. But the primary benefits, and those of most concern, are improvements in public health.

White House and OTA Estimates of Aggregate Costs. Aggregate cost projections for meeting the national air quality standard for ozone are derived by adding up piecemeal, generally rough estimates of costs for the various proposed requirements. For example, President Bush's proposal, designed to bring all but 20 cities into ozone compliance by the year 2005, is purported to cost $3 billion to $4 billion a year. The ten new steps included in this plan are estimated to reduce emissions by 27 to 30 percent from 1987 levels.

One of the most comprehensive estimates of aggregate costs for new methods of reducing ozone levels is contained in a July 1989 Office of Technology Assessment report, "Catching Our Breath." OTA projects total reductions of about 34 percent by 1994 at a total cost for all nonattainment areas between $4.2 and $7.1 billion per year. Costs would rise to between $6.6 and $10 billion annually by 2004.

Our own estimates, based upon EPA and OTA data, indicate that it would be possible to reduce emissions by 40 percent by the year 2004 at an estimated national cost of approximately $8.5 billion a year (in 1986 dollars). Theoretically, the combination of control measures used to achieve these results would bring all but 38 metropolitan statistical areas into attainment by the year 2004.

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Comparisons of Benefits and Costs. Table 2 compares the benefits of VOC reductions under the most inclusive health benefit estimate from the Krupnick and Kopp study with White House, OTA, and our own projections of the costs of the proposed control techniques. These comparisons are very rough, however, and should be considered only as "indicators."

Table 2: Comparing Acute Health Benefits with Costs (in 1988 dollars)

Study	Health Benefits	VOCs Reduced in Nonattainment Areas	Average $ Benefit per Ton
Krupnick and Kopp	$1.9 billion	35% (3.8 million metric tons)	500
	Abatement Costs		**Average $ Cost per Ton**
White House Proposal	$3–4 billion	30% (2.6 mmt)	1,200–1,500
OTA	$6.6–10 billion	35% (3.8 mmt)	1,700–2,600
Center for the Study of American Business	$9 billion	40% (4.3 mmt)	2,100

	Benefit to Cost Ratio
Krupnick and Kopp/White House	.33–.42
Krupnick and Kopp/OTA	.19–.27
Krupnick and Kopp/CSAB	.24

The Bush cost estimates and effectiveness projections suggest that the average cost per ton of VOCs removed is in the $1,200 to $1,500 range. The ratio of health benefits to abatement costs using White House projections thus ranges from 0.3 to 0.4. The benefit to cost ratios are slightly worse using OTA estimates. Costs per ton range from $1,200 to $2,600 and the benefit to cost ratio ranges from 0.2 to 0.3. Our estimates yield average nationwide costs for reducing VOCs at $2,100 a ton, for a benefit to cost ratio of roughly 0.2.

Counting only the health benefits of lower ozone levels suggests that the regulatory standard for ozone levels is excessively tight and is likely to cost consumers and taxpayers more than the health benefits of cleaner air.

Keep in mind, however, that this analysis does not include agricultural benefits or any additional costs to reduce rural ozone concentrations. In addition, other nonhealth benefits were not estimated.

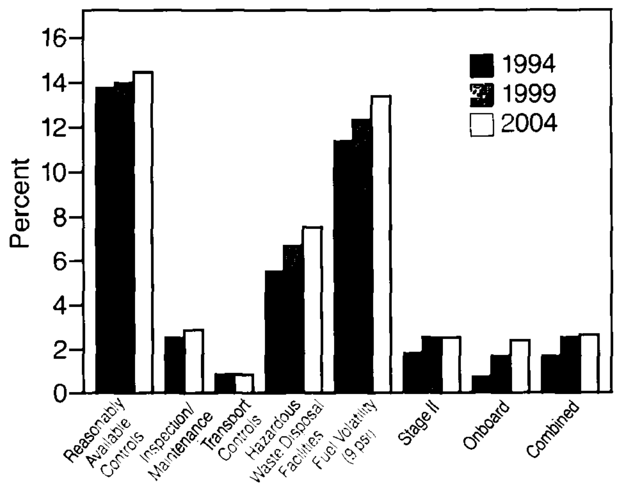
To be certain, no definitive conclusion should be drawn from such crude estimates, but benefit to cost ratios substantially less than 1.0 raise a warning flag. In general, optimum regulatory levels would occur where marginal benefits equal marginal costs—a point that typically occurs at a level of regulatory stringency where the total benefit to total cost ratio is greater than one. Counting only the health benefits of lower ozone levels, these very low benefit to cost ratios suggest that the regulatory standard is excessively tight. Thus, the standard is likely to cost consumers and taxpayers more than the health benefits of cleaner air.

Effectiveness of Control Measures. Aggregate cost figures do not provide sufficient information for making decisions about specific control measures, however. Proposals to reduce ozone levels need to be analyzed on an individual basis. A brief analysis of the cost for each ton of VOCs removed for several specific proposals follows.

Cost-effectiveness evaluations are not available for many of the control measures being proposed to reduce ozone levels. Nonetheless, the EPA and the Office of Technology Assessment have gathered cost-effectiveness estimates for a variety of control measures that apply on a nationwide basis. Using these data, we have analyzed the potential emission reductions, the cost per ton, and the total cost of reducing VOC emissions by: (1) applying reasonably available control technology to point and area sources; (2) requiring an enhanced inspection and maintenance program for vehicles; (3) instituting transportation control measures; (4) reducing fuel volatility; (5) requiring service stations to install Stage II fuel recovery systems; and (6) mandating onboard fuel recovery systems for autos.

Figure 2 illustrates the percentage of 1985 baseline VOC emissions potentially reduced by each of these control strategies in the years 1994, 1999, and 2004, according to our analysis. These estimates are nationwide averages for all nonattainment areas; actual reductions almost certainly vary across cities. The reductions in baseline emissions shown in Figure 2 are not net emissions, however. Population growth and increased automobile traffic will add to the emissions inventory and thus partially offset benefits derived from added controls.

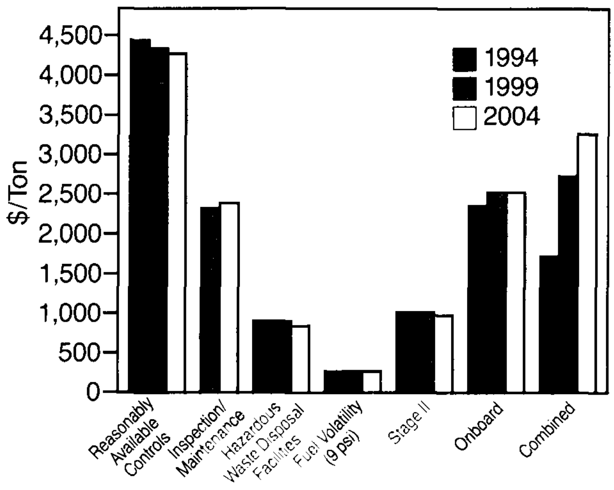
Figure 2: Emission Reductions Possible from New Control Measures (as a percentage of 1985 baseline emissions)



Reasonably Available Control Technologies. The category of controls producing the largest reduction in VOC emissions is called reasonably available control technologies. This category consists of a variety of control measures, each applicable to a particular source of VOCs (for example, dry cleaning, petroleum refining, chemical manufacturing, and paper coating). In all, the OTA and the EPA supplied information on control technologies for 40 specific source categories that together emit a substantial portion of controllable VOCs. Our analysis indicates that VOC emissions can be reduced by 14 percent (from 1985 baseline levels) by 1994 and by nearly 15 percent in 2004 by applying reasonably available control technologies.

Figure 3 illustrates the average dollar cost per ton of VOCs removed (unit cost) for each of the selected emission control methods. Figures 2 and 3 present a dilemma: requiring added installation of reasonably available control technologies is quite expensive as a whole (about $4,500 a ton), but it

Figure 3: Unit Cost Estimates for Selected Controls (dollars per ton of VOCs removed)



can also reduce the largest percentage of emissions.

Not all "available technologies" can be considered "reasonable" when imposed on small sources. For instance, incineration of VOCs at every small surface coating plant is estimated to cost just over $7,700 a ton. Similarly, controls at small dry cleaners average $3,600 a ton while these same controls at large dry cleaners (at least 100 tons of VOC emissions a year) cost an average of only $230 for each ton of VOCs removed.

Unfortunately, the emissions reduced by these very expensive controls make up a significant portion of the expected VOC reductions obtainable by applying reasonably available control technologies more widely. If control of these small sources is not assumed, VOC reductions of approximately 8 percent of the 1985 baseline emissions can be achieved by 1999 as a result of applying the remaining technologies. Correspondingly, the cost to eliminate a ton of VOC emissions by using reasonably available control technologies is reduced by 36 percent from $4,400 a ton to $2,800 a ton.

Fuel Volatility and Vehicle Emissions Certification. Another method that can significantly reduce VOC emissions is lowering fuel volatility. The effects of this control measure are twofold. First, lowering fuel volatility significantly reduces "running losses" —evaporative emissions that occur while a vehicle is in operation. Second, lowering fuel volatility increases the effectiveness of auto emission control systems. Taking both of these effects into account, lowering fuel volatility to the current level used in testing pollution equipment—a vapor pressure of 9.0 pounds per square inch (psi)—would reduce VOC emissions by 11.5 percent in 1994 and by 13.5 percent in 2004.

When testing procedures and standards were set, most commercial fuels maintained volatilities near this prescribed testing level, but the volatility of fuel has been increasing since the 1970s. The actual average volatility of current commercial gasoline is near 11.5 psi. A February 1989 law requires a summertime fuel vapor pressure of 10.5 psi.

Energy firms indicate, however, that nationwide gasoline volatility cannot be reduced to a vapor pressure of 9.0 psi without substantial capital improvements at refineries. This problem might be avoided by initially requiring this low volatility only in the more serious nonattainment and transport areas.

Stage II and Onboard. Vapor recovery systems can be used to control refueling emissions. There are two different technologies available to remove most

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of these emissions: (1) new cars can be required to be equipped with "onboard" controls or (2) service stations can be required to install "Stage II" equipment on each of their gasoline pumps. Since only new cars would be equipped with the onboard device, *at least* ten years would pass before this option could become fully effective. (See Figure 2.) Further, because nationwide, rather than regional, implementation would be a more feasible strategy, *all* the driving public would bear the costs uniformly, but nonattainment areas would receive disproportionately large benefits.

Both strategies for controlling vehicle refueling emissions—Stage II and onboard—can attain basically the same VOC reductions in nonattainment areas by the year 2004, about 2.5 percent. But the Stage II controls achieve much larger immediate results and are more than twice as cost-effective as onboard controls with a cost of about $1,000 a ton versus $2,600 a ton of nonattainment VOCs removed.

Other Measures. Other control methods analyzed include transportation control measures (carpooling and alternative working hours), expanded vehicle inspection and maintenance, and controls on hazardous waste disposal facilities. Figure 3 shows that removing a ton of VOCs by using an expanded inspection and maintenance program is about nine times more costly than using fuel volatility controls. In addition, this approach only reduces emissions about one-fifth as much as does lowering fuel volatility. As Figure 2 shows, transportation control measures are not expected to greatly reduce ozone levels nationwide—less than one percent. But there are certain areas of the country where such controls may be more beneficial—specifically, the South Coast Basin in California, which includes Los Angeles.

Reducing peak ozone concentrations with temporal controls may produce greater health benefits than measures that reduce VOC emissions by a constant amount at all times.

In September 1988, the South Coast Air Quality Management District proposed a three-tier, twenty-year plan to achieve ozone attainment. The transportation control measures (including management of growth) in this plan provide a best-case scenario of possible VOC reductions from these controls. By the year 2010, the South Coast Basin expects cars, trucks, and other mobile sources to contribute 39 percent of total VOC emissions. Transportation control measures proposed include: (1) requirements to reduce work trips by at least 10 percent; (2) increases in carpooling and ridesharing resulting from preferential parking and financial incentives for participants, ride-matching services, park-and-go lots, high-occupancy-vehicle lanes, and a cap on the number of parking spaces available; (3) transit improvements such as increased bus fleet and express services; (4) truck rerouting; (5) traffic flow improvements including ramp metering and synchronized signals; (6) growth management; and (7) electrification of some vehicles and rail. All of these controls are predicted to result in a 12 percent decrease in 2010 baseline VOC levels for the South Coast Basin, almost a one-third reduction of emissions from mobile sources.

The cost of these emission reductions, however, is relatively unmeasurable as it requires cost estimates of lifestyle changes, particularly growth management measures that account for one-third of the anticipated reductions. Moreover, as the OTA cautioned in its July 1989 report, "involuntary transportation control measures have proven politically infeasible and voluntary ones difficult to sustain."

Temporal Controls. One group of control measures currently given short shrift is temporal controls—measures such as staggered work hours and reduced commuter traffic that alter individual and business behavior during critical time periods. The Clean Air Act prohibits including temporal controls in state implementation plans by requiring that all areas attempt to meet the standard by using controls that are continuous. As a result, the cost savings possible from using temporal controls to reduce ozone levels have not been adequately investigated. One study of continuous versus intermittent abatement techniques for controlling SO_2 in Tennessee found that the cost of meeting the SO_2 standard by using temporal measures would be one-fifth of the cost of constant controls.

Moreover, health benefits from time-varying controls can be substantial in cases where continuous controls are unable to prevent high ozone peaks. While there is much debate about possible threshold levels for ozone effects, it is clear that higher levels have pronounced incremental effects on larger numbers of individuals. Thus, flattening peak ozone concentrations with temporal controls may produce greater health benefits than measures that reduce VOC emissions by a constant amount at all times.

Revising the Clean Air Act

Legislative Action. Both the Senate and House environmental subcommittees were active throughout the fall marking up a clean air bill. Rep. Henry Waxman, chairman of the Health and Environment Subcommittee, began with President Bush's proposal (H.R. 3030, introduced by Rep. John Dingell and Rep. Norman Lent) as the base bill.

The Bush proposal is an omnibus approach, addressing ozone, carbon monoxide, particulates, toxic air pollutants, and acid rain. Like earlier bills proposed by Rep. Waxman (H.R. 2323) and by the so-called "Group of Nine" (nine moderate Democrats on the House Energy and Commerce Committee, who submitted H.R. 99), President Bush's proposal calls for different classes of ozone nonattainment and corresponding attainment deadlines. The proposal is most noteworthy for its emphasis on economic incentives and a relatively flexible approach. Nonattainment areas are required to demonstrate "reasonable further progress" and to make "reasonable efforts" to meet ozone standards to avoid the EPA's sanctions.

The House mark-up process in September focused primarily on mobile source provisions of the bill. A few of the results from that process may shed some light on how the administration's conciliatory proposal is being altered. Beginning with the already stricter auto requirements proposed by the administration, Waxman's subcommittee tightened controls in three significant ways. One provision essentially called for national tailpipe-emission standards to be the same as those required by the state of California. The EPA estimates that the subcommittee's decision will cost between $100 and $600 per auto. Part of these requirements involves a mandated 40 percent reduction in hydrocarbon emissions. The stricter standard is projected to reduce the nationwide release of this major component of smog by only 0.4 percent.

The other two auto provisions passed by the House environmental subcommittee were even less cost effective. They raised the costs to car buyers with virtually no benefit to the environment. In what appeared to be an example of regulation for regulation's sake, the lawmakers rejected the administration's proposal allowing auto manufacturers to meet *average* emissions standards for each year's production. The subcommittee insisted, instead, that each auto produced meet an identical standard.

To appreciate the folly of this decision, suppose that fleet averaging were allowed in meeting a requirement of 0.25 grams per mile (gpm) for hydrocarbon emissions. Suppose that a subcompact car can meet a tighter standard of 0.20 gpm for $50 or just equal 0.25 gpm for $45. Suppose also that it would cost $150 for a full-sized model to meet the 0.25 gpm standard but only $100 to meet a 0.30 gpm emission level. For the sake of simplicity, assume that a manufacturer only produces subcompact and full-sized cars and does so in equal numbers.

If fleet averaging is allowed, the overall emissions levels will be identical to those resulting from requiring each vehicle type to meet the 0.25 gpm standard. On the other hand, requiring the auto maker to meet the standard for each car model means that buyers of full-sized automobiles would pay $50 more and subcompact buyers $5 less than if an averaging of tailpipe emissions were allowed. Total costs for car buyers increase, but there is no improvement in air quality—a case of "getting nothing for something."

The third costly decision by the House panel was to require onboard devices to capture emissions when motorists are refueling their vehicles. As our earlier analysis of the benefits and costs of onboard controls versus Stage II equipment (controls at the gas pump) showed, both strategies can produce the same reductions in smog-related emissions due to refueling—about a 2.5 percent decrease in nonattainment area hydrocarbon emissions by the year 2004. Recall that the costs of decreasing hydrocarbon emissions in dirty air areas would be less than $1,000 a ton for Stage II deployment versus nearly $2,600 a ton for the onboard solution.

The big advantages of placing emission control devices at the pumps are that they produce immediate results and can be restricted to the nonattainment areas, whereas placing devices on new cars requires a complete turnover in the existing fleet of autos to achieve the same outcome.

But the big advantages of placing the controls at the pump are that they produce immediate results and can be restricted to the nonattainment areas, whereas placing devices on new cars requires a complete turnover in the existing fleet of autos to produce the same outcome. Requiring canisters on all new automobiles reduces the average cost per auto since fixed production costs are spread over a larger number of units. But this means that auto buyers in areas that do not have a smog problem are helping to pay the costs of reducing ozone levels in other communities.

The least cost-effective approach of all, however, is to require both Stage II and onboard equipment. The House subcommittee did place such a requirement on cities with severe ozone problems. Further, since some areas have already implemented Stage II controls, requiring onboard devices would result in a costly redundancy in those communities as well. The combined strategy produces virtually no added benefits, but increases costs significantly. The combined approach is akin to a man's wearing a belt and suspenders at the same time.

Recommendations. This analysis of urban smog problems suggests a number of possibilities for improving the Clean Air Act:

• Change the definition of nonattainment to be more consistent with the nature of the public health risk posed by ozone.

Instead of using the highest ozone reading recorded at a single monitor, an average should be taken of a representative set of monitors in a given area. Furthermore, nonattainment "classes" should be based on the average number of times the standard is exceeded annually *as well as* on some measure of peak ozone concentration. For example, nonattainment classifications could be based on the 90th or 95th percentile of daily peak one-hour readings.

Requiring the EPA to consider the cost-effectiveness of individual measures to improve air quality could reduce the number of federally mandated controls and substantially decrease the costs of compliance.

• Change the Clean Air Act language that requires primary air quality standards to be set at a level to provide an adequate margin of safety against any possible adverse health consequences. Primary air quality standards should be set to protect the public against the unreasonable risk of medically significant adverse health effects.

The EPA's Office of Air Quality Planning and Standards recently recommended that mild responses to ozone—those involving a 5- to 10-percent reduction in lung function—not be considered an "adverse" health effect. Allowing the EPA administrator to use discretion in defining "significant" adverse health effects seems no more problematic than the current difficulty of defining an "adverse" health effect. In addition, the EPA administrator's definition of "unreasonable risk" should be required to take into account the nature and extent of the risk, the number of people exposed, and the attainability of the standard while considering economic and other public interests.

• Require that the EPA administrator consider cost-effectiveness when promulgating regulations under the Clean Air Act.

Requiring the EPA to consider the cost-effectiveness of individual measures to improve air quality could reduce the number of federally mandated controls and substantially decrease the costs of compliance. This provision would speed the implementation of measures that pass the EPA's muster and would eliminate the practice of local officials' making ad hoc decisions to delay programs that are not cost effective.

• Reduce the federal role in specifying precise control measures to be used. Encourage states to use innovative approaches that fit local circumstances in their state implementation plans.

Because each nonattainment area is unique, there is a need for greater flexibility than can be achieved by federal mandates. The EPA's role should be one of evaluator of state implementation plans rather than monitor of state compliance with federal proscriptions. In this regard, VOC reductions resulting from temporal controls should be included in state implementation plans.

America's resources are vast but finite. Our analysis of atmospheric ozone—its health effects and its complex chemical nature—and of the Clean Air Act's provisions for dealing with urban smog makes it clear that these resources could be allocated much more effectively than at present. The foregoing recommendations for revisions to the Clean Air Act would not "trade lives for dollars"; on the contrary, in practice they could result in a higher level of environmental benefits for Americans but with less economic disruption.

Selected Readings

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