3. CONTROLLING EMISSIONS

Ozone is not emitted; rather it is produced in the atmosphere from reactions involving two "precursor" pollutants: volatile organic compounds (VOCs) and nitrogen oxides (NOX). Development of effective control strategies for ozone requires an understanding of the relationship between VOC and NO_x emissions levels and ozone concentrations. It also involves identifying measures to control VOC and NO_x emissions, and determining the levels of reductions that can be achieved and the control costs associated with each measure. In this chapter we discuss (1) the relationship between ozone and its precursors; (2) the sources of VOC emissions and estimates of future emissions levels; (3) the VOC emissions reductions that can be achieved using various control measures and how these compare with levels of reductions required to meet the ozone standard in current nonattainment areas; and (4) the costs of various VOC control measures.

3.1 Relationship of Emissions to Ozone Concentrations

Ozone is produced through chemical reactions of nitrogen oxides (NO_x) and volatile organic compounds (VOCs). Because the chemical reactions depend on both sunlight and temperature, ozone concentrations are highest on hot, sunny days. Nitrogen oxides are products of fossil fuel combustion. On a nationwide basis, approximately 45 percent of NO_x emissions are from motor vehicles and other mobile sources, 30 percent from utilities, and 12 percent from industrial fuel combustion.[1,2] VOCs are a broad class of organic gases such as vapors from solvents and gasoline. In urban areas, approximately 40 percent of VOCs are

[1] National Emissions Data System, Nationwide Emissions Report Summary, comPuter printout, U.S. Environmental Protection Agency, Research Triangle Park, NC, January, 1988.
[2] NO_x emissions from natural sources are negligible.

emitted from mobile sources, 30 percent from organic solvent use, and smaller fractions from other categories including gas station evaporation, solid waste disposal, chemical manufacturing and petroleum processing.[3][4]

The relationship between ozone and its precursors is complex. Reducing emissions of either VOCs or NO_x may or may not produce a decrease in ozone concentrations, depending on the mix of pollutants that is present. Reducing NO_x can even increase ozone concentrations, in some situations. The effect of emissions controls on ozone concentrations depends on meteorological conditions, the absolute and relative amounts of VOCs and NO_x emitted in a particular area, and the background concentrations of ozone and its precursors that are present. Every urban area has a different balance between VOCs and NO_x. Furthermore, day-to-day variability in emissions levels, background VOC and NO_x concentrations and wind patterns leads to day-to-day variations in the balance between VOCs and NO_x in each area. Thus the impact of controls on ozone concentrations will change from day-to-day in a given city, as well as differ across cities. Comparing two different pollution episodes leading to the same peak ozone concentration, the level of VOC emissions reductions required to attain the ozone standard will be highest for the episode that has the higher concentration of VOCs compared to NO_x (i.e. the higher "VOC-to-NO_x" ratio). The converse is true with respect to NO_x controls: the higher the VOC-to-NO_x ratio the higher the efficacy of NO_x reductions.

The impact of controls also depends on the distance between the area where the precursors are emitted and the location where the ozone concentration is monitored. In most areas, observed peak ozone concentrations occur during mid-to-late afternoon, about 30 miles downwind of the center of the city. However, concentrations of ozone that are two-to-three times higher than background levels[5] may be maintained well beyond that distance, affecting suburban and rural areas and also contributing to high concentrations in downwind cities. As the polluted air mass is transported, chemical and physical processes remove NO_x more rapidly than they remove VOCs. Thus in addition to differences in the balance between VOCs and NO_x across days and between different urban areas, for any given pollution episode there can be a substantial shift from relatively NO_x-rich conditions over the downtown area to VOC-rich conditions over downwind suburbs and rural areas. Reducing

[3] Ibid.

[4] In urban areas, VOC emissions from natural sources are also insignificant. During the summer, in areas which are far from heavy traffic and industrial sources of VOCs, vegetation can be the largest local source of VOC emissions. However, even at their highest levels (in some counties in the southeast during the summer), over equal land areas, estimated VOC emissions from vegetation are only about one-fifth of average urban VOC emissions. Moreover, unless NO_x is also present (from power plants or other industrial sources) ozone will not be produced.

[5] Background ozone concentrations are estimated to peak at about 0.04 PPm (one-hour average)"

VOC emissions is apt to be effective in reducing ozone at downtown locations. Reducing NO_x emissions generally becomes more effective in reducing ozone concentrations downwind from high emissions regions, over suburban and rural areas.

EPA has historically encouraged exclusive reliance on VOC emissions controls to ensure compliance with the ambient air quality standard for ozone. NO_x emissions controls have usually been used only to the extent necessary to comply with the standard for nitrogen dioxide. VOC controls have been emphasized for two reasons: (1) control technologies for VOCs have been assumed to be cheaper and more readily available than those for NO_x and (2) there has been concern that reducing NO_x emissions could increase ozone concentrations at some locations.[6] Recent measurements of VOC and NO_x concentrations in a number of areas and extension of modeling analyses to consider the build-up of pollutant concentrations over more than one day, distances further downwind of urban areas, and photochemical pollutants other than ozone, have suggested that in some areas, NO_x controls may be more effective in reducing photochemical pollution than previously thought.[7,8,9,10]

VOC Reductions Required to **Meet the** Standard

Figure 3-1 presents estimates of VOC emissions reductions needed to reduce local peak ozone concentrations or "design values" down to 0.12 ppm, the maximum concentration allowed under the ozone standard. For areas with design values up to 0.20 ppm, the control requirements shown were estimated using EPA's standard model (the Empirical Kinetic Modeling Approach or EKMA model), with a set of meteorological, emissions and transport conditions selected to approximate conditions in a typical urban area where transport from upwind cities is not the principal cause of nonattainment.[11] A moderate amount Of ozone is assumed to be transported from upwind. NO_x emissions are assumed to be unchanged from current levels. The range of estimates given for each design value corresponds to the range of VOC-to-NO_x ratios expected to prevail across different cities with the same design

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[6] Meyer, E.L. 'r"' "Review of Control Strategies for Ozone and their Effects on Other Environmental Issues," U.S. Environmental Protection Agency, Research Triangle Park, NC, August 1986.

[7] Bauges, K., "A Review of NMOC, NO_x and NMOC/NO_x Ratios Measured in 1984 and 1985, U.S. Environmental Protection Agency, Report Number EPA-450/4-86-015, Research Triangle Park, NC, September 1986.

[8] Milford J.B., "Photochemical Air pollution Control Strategy Development," ph. D. Thesis, Carnegie' Mellon University, Pittsburgh, PA, March 1988.

[9] Sillman, M. S., "Models for Regional-Scale Photochemical Production of ozone," Ph.D. Thesis, Harvard University, Cambridge, MA, November 1987.

[10] Trainer, M., Williams, E.J., Parrish, D. D., Buhr, M. P., Allwine, E.J., Westberg, H.H., Fehsenfeld, F. C., Liu, S. C., "Models and observations of the impact of natural hydrocarbons on rural ozone, " Nature, 329:705-707 (1987).

[11] Meyer, E.L., Jr., personal communication, September, 1987.

PERCENT VOC CONTROL REQUIRED TO MEET THE OZONE STANDARD

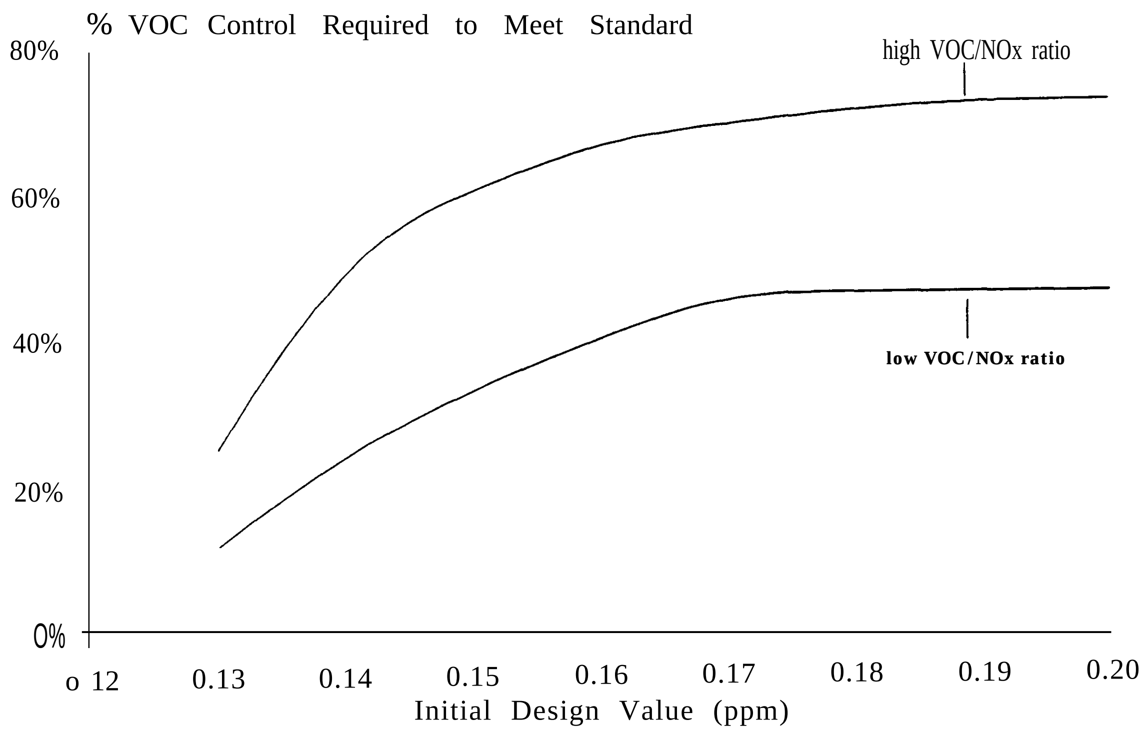

Figure 3-1. VOC emissions reductions estimated to be required to reduce ozone from the initial peak concentrations or "design values" shown down to 0.12 ppm. The control requirements were estimated using EPA's standard model, with meteorological, emissions and transport conditions set to approximate conditions in a typical area where transport from upwind cities is not the principal cause of nonattainment. The range of estimates shown for each design value corresponds to the range of VOC and NO_x ratios expected to prevail across different cities. The percentage reduction needed to meet the standard in an individual city will typically fall somewhere between the two curies shown.

value.[12] The estimates shown in Figure 3-1 are for reducing peak ozone concentrations at monitors that are about 30 miles downwind of an urban center. Situations involving transport to rural areas or other cities further than about 30 miles downwind will be discussed later.

To illustrate how to interpret Figure 3-1, the model predicts that for a typical city with a design value of 0.16 ppm, with no change in NO_x emissions levels, VOC reductions ranging from about 45 to 70 percent will be needed to meet the ozone standard. For areas where current conditions are usually NO_x-rich (e.g. an ambient VOC-to-NO_x ratio of about 8:1 or lower), the VOC reductions required to reduce local ozone concentrations are expected to be at the lower end of the ranges shown. Where conditions are predominantly VOC-rich (e.g. an ambient VOC-to-NO_x ratio of about 15:1 or higher), control requirements are expected to fall at the upper end of the range. Generally, the level of VOC control required to meet the standard locally will be highest for those areas with the highest design values and the most VOC-rich conditions.

Interim Reductions: The Effect of Lowering VOC Emissions by 35 Percent

As we will discuss later, if all of the controls we were able to analyze were to be imposed, the total reduction in VOC emissions estimated for most areas would be between 20 and 40 percent, falling short of the levels estimated to be required to attain the standard in many cities. Figure 3-2 shows the ozone concentrations predicted to result when VOC emissions are reduced by 35 percent (with NO_x emissions unchanged), plotted against initial design values. The three solid lines represent estimates of final ozone concentrations expected to result from a 35 percent reduction in VOC emissions with no change in NO_x emissions, if controls are applied in cities with low (8:1), medium (12:1) and high (15:1) VOC-to-NO_x ratios. The dashed line illustrates "no change" in ozone concentrations, i.e. the final concentration is the same as the initial concentration or design value. Note that the ozone standard, 0.12 ppm, is at the bottom of the graph, so that the relative position of a control scenario line between the "no change" diagonal and the bottom of the graph indicates what fraction of the reduction in ozone needed to obtain the standard is predicted to be achieved. For example, if a city has a medium VOC-to-NO_x ratio and a design value of 0.16 ppm, a 35 percent reduction in VOC emissions is predicted to yield a final ozone concentration of about 0.14 ppm, or about half of the reduction estimated to be required to meet the standard.

VOC reductions obtainable from the control measures we analyzed should be sufficient to enable most areas with design values of 0.13 ppm to meet the standard. Areas with design values of O. 14 ppm and low VOC-to-NO_x ratios should also be able to attain the standard.

[12] Bauges, op. cit., footnote 7.

EFFECT OF VOC CONTROL ON PEAK OZONE CONCENTRATIONS FOR A RANGE OF VOC–TO–NO_x RATIOS

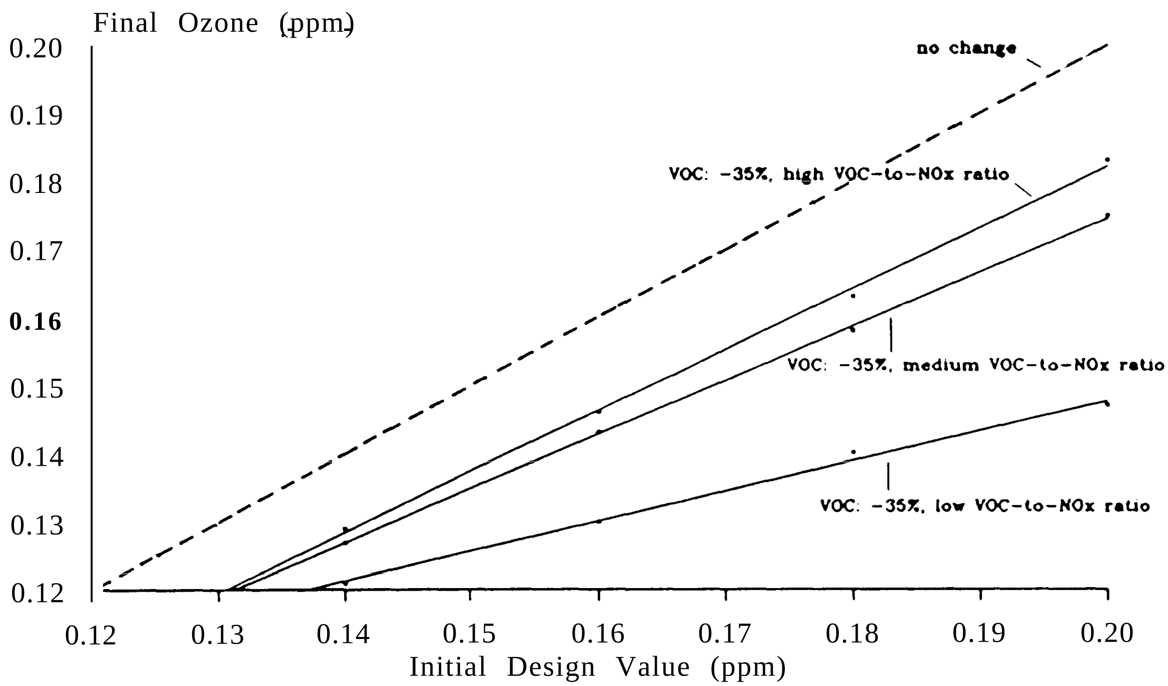

Figure 3-2. Ozone concentrations predicted to result when VOC emissions are reduced by 35 percent, with no change in NO_x emissions levels. The three solid lines indicate the ozone concentrations predicted *to* result in cities with low, medium and high VOC to NO_x ratios. The dashed line illustrates the "no control" case, i.e. the final ozone concentrations are the same as the initial design values.

The reductions we could quantify would be expected to get areas with higher design values and low VOC-to-NO_x ratios more than half way to the standard, in terms of the ozone reductions they need. Areas with medium to high VOC-to-NO_x ratios are predicted to get less than a third of the reductions they need.

Interim Reductions: The Effect of Adding NO Controls

Figure 3-3 shows the effect of reducing NO_x emissions as well as VOCs. Figure 3-3a shows the effect of adding NO_x controls to VOC controls in cities with medium VOC-to-NO_x ratios; Figure 3-3b in areas with low VOC-to-NO_x ratios; and Figure 3-3c in areas with high VOC-to-NO_x ratios. Each of these three figures provides reasonable estimates of the effect that reducing VOCs and NO_x would have on local peak ozone concentrations in roughly a third of the areas that are not meeting the ozone standard.

As shown in Figure 3-3, the model predicts that for most cities, 35 percent reductions in both NO_x and VOC emissions would reduce ozone concentrations more than 35 percent reductions in VOCs alone. In fact, the combination is predicted to result in attainment in some cities -- namely those with low design values and relatively high VOC to NO_x ratios, that would not be predicted to meet the standard if only VOC emissions were to be reduced.

In urban areas with low VOC-to-NO_x ratios and high design values, the model predicts that ozone concentrations would be higher if both VOC and NO_x emissions were reduced by 35 percent than if only VOC emissions were reduced (Figure 3-3 b). This result suggests that NO_x controls could be counterproductive for major urban areas that are characterized by low VOC-to-NO_x ratios and high design values -- such as Baltimore, Boston, Los Angeles, Philadelphia and Washington.[13] [14] However a complicating issue in Los Angeles is that No_x controls are expected to be needed to significantly reduce ozone concentrations at some locations within the air basin, whereas to reduce ozone at other sites VOC controls are predicted to be needed and NO_x controls to be counterproductive.[15] [16] No_x controls are a major thrust of strategies for reducing ozone in the Los Angeles basin. This same issue may be important in other places with high design values and low characteristic VOC-to-NO_x ratios where the ozone standard is exceeded over a large area (e.g. along the northeast corridor). However, for areas other than Los Angeles, we lack sufficient information to determine what combination of VOC and NO_x controls might be desirable.

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[13] Ibid.

[14] Bauges, K., personal communication, October 1987.

[15] Milford, op. cit., footnote **8.**

[16] South Coast Air Quality Management District, "Air Quality Management Plan, 1982 Revision, Appendix No. VI-A, Ozone Analysis for the South Coast Air Basin," El Monte, CA, October 1982.

EFFECT OF VOC AND NO_x CONTROL ON PEAK OZONE CONCENTRATIONS: MEDIUM VOC–TO–NO_x RATIO

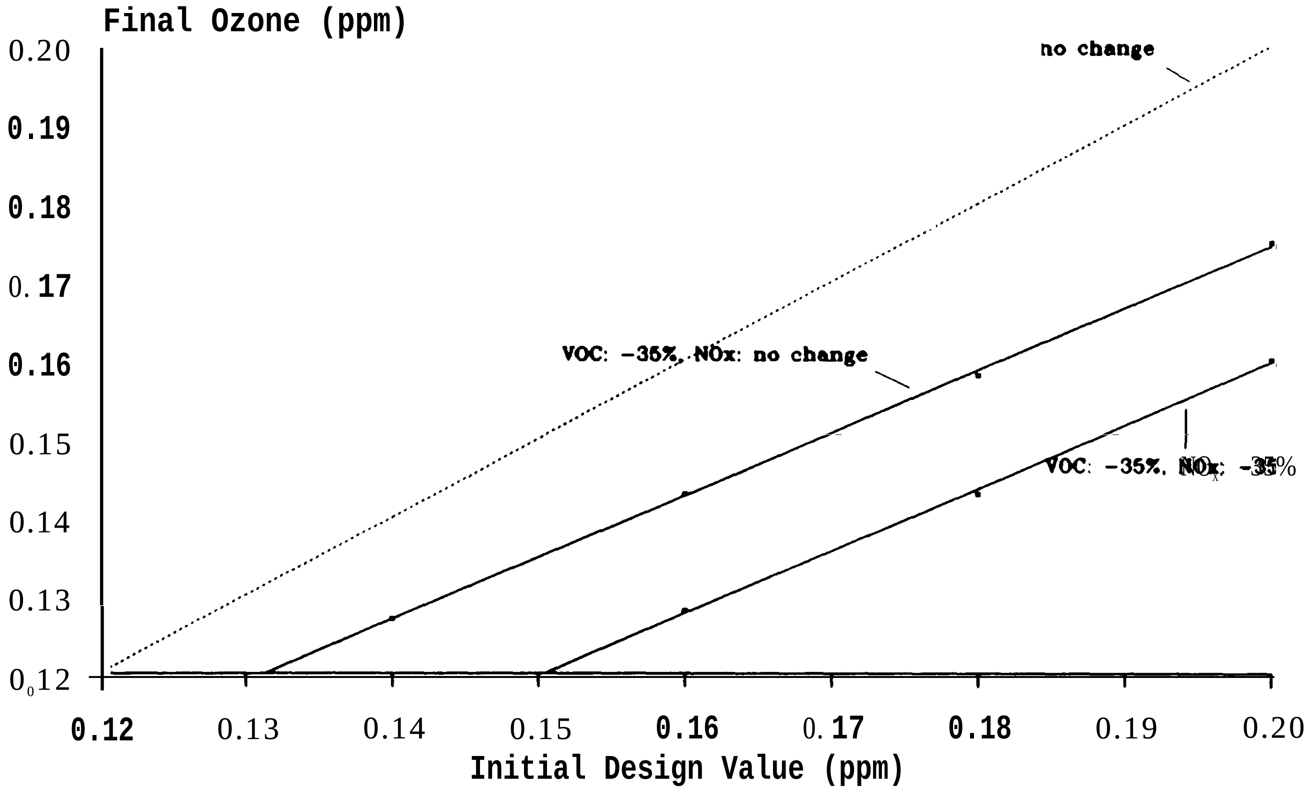

Figure 3-3. Ozone concentrations predicted to result when VOC emissions are reduced by 35 percent alone or in combination with 35 percent reductions in NO_x emissions. Figure 3-3a shows estimates for cities with medium VOC-to-NO_x ratios, Figure 3-3b cities with low VOC-to-NO_x ratios and Figure 3-3c cities with high ratios. Roughly one-third of the ozone nonattainment areas are thought to be represented by each figure. The dashed line in each figure illustrates the “no control” case, i.e. the final ozone concentrations are the same as the initial design values. The solid lines in each figure show results with 35 percent reductions in VOC emissions together with O and 35 percent reductions in NO_x. In areas with medium and high VOC-to-NO_x ratios (Figures 3-3a and 3-3c), ozone concentrations are predicted to be further reduced when NO_x controls are added to VOC emissions reductions. In areas with low VOC-to-NO_x ratios (Figure 3-3b), however, ozone concentrations are predicted to be reduced to the greatest extent by controlling VOC emissions alone, with NO_x emissions reductions of up to 35 percent predicted to be counterproductive.

EFFECT OF VOC AND NO_x CONTROL ON PEAK OZONE CONCENTRATIONS: LOW VOC-NO_x RATIO

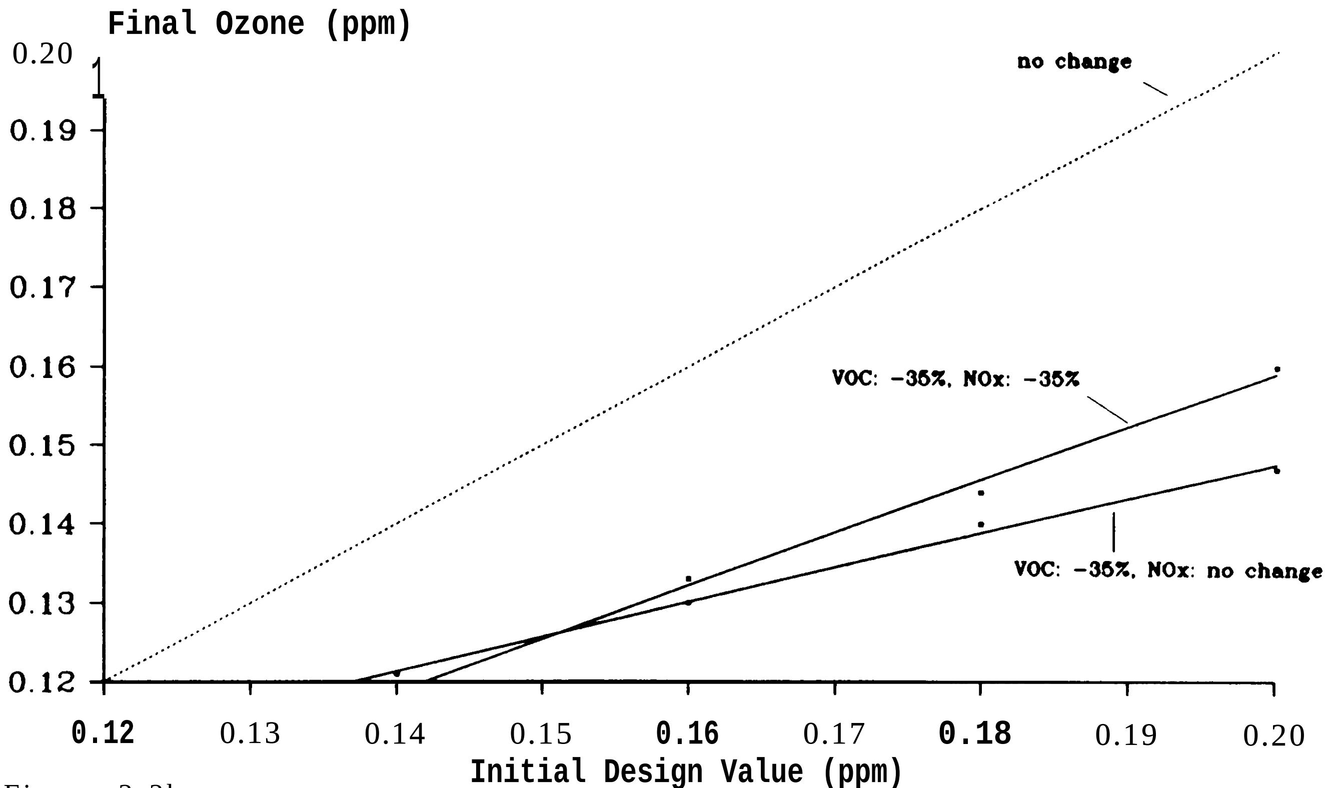

Figure 3-3b.

HIGH VOC-TO-NO_x RATIO

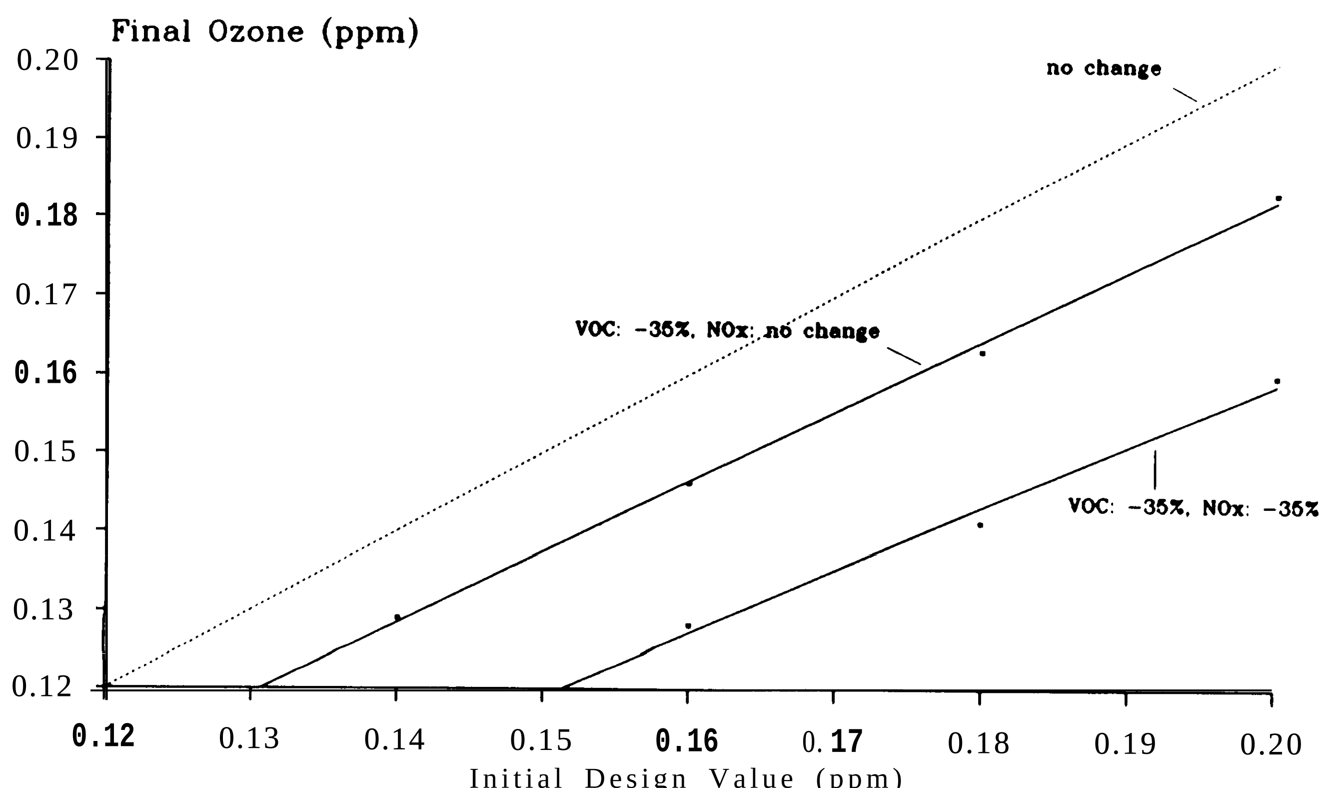

Figure 3-3c.

In general, where high ozone concentrations occur closer to the urban center than assumed for Figures 3-1 through 3-3, VOC controls are expected to be more effective, and NO_x controls less effective, than illustrated above.[17 18 19] Where high ozone concentrations occur further downwind than assumed for Figures 3-1 through 3-3, VOC controls are expected to be less effective, and NO_x controls more so, than shown.[20 21]

Situations Involving Transport of Ozone or its Precursors

Transport of ozone and precursors from upwind cities can complicate efforts to attain the ozone standard. Moreover, ozone concentrations in nonurban areas may approach or even exceed 0.12 ppm over an hour or more during the day due to transport from upwind cities. Elevated ozone concentrations in rural areas are of concern due to forest and crop damage that may result, in addition to potential health effects.

During the day, due to transport, elevated concentrations of ozone can occur over areas up to about a hundred miles downwind of urban areas, causing violations of the ozone standard in relatively sparsely populated, nonindustrial areas. At night, ozone and VOCs can be transported over distances of 200 miles or more.[22] Polluted air that has been carried at high altitudes over night mixes with air at the surface during the first few hours after sunrise (as ground-level temperatures increase).[23] Finally, in association with large-scale high pressure systems that maintain clear skies and elevated temperatures, pollution episodes can last for several days and cover multi-state regions.[24] During these episodes, which occur over the eastern United States several times each summer,[25 26] elevated ozone concentrations

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17 Meyer, Op. cit. ' footnote 6.

18 Milford, op. Cit., footnote 8..

19 Dodge, M.C., 'Chemistry of Oxidant Formation: Implications fOr Designing Effective Control Strategies," Proceedings, North American Oxidant Symposium, Quebec, Canada, February 1987,

20 Meyer, op. Cit., footnote 6.

21 Milford, op. cit., footnote 8.

** Spicer, Crew., Joseph, D. W., Sticksel, P. R., Ward, 'S'. > "Ozone sources and transport in the northeastern United States," Environmental Science and Technology, 13:975-985 (1979).

23 Note that due t. dilution and chemical reactions, the OZOne transported into an area 's not simply added to the concentration which would otherwise be produced (e.g. 0.10 ppm transported into an urban area in the morning might only contribute about 0.05 ppm to the peak ozone concentration observed that day.)

24 Vukovich, F. M., Bach, W.D. Jr., Crissman, B.W., King, W, J., "On the relationship between high ozone in the rural surface layer and high pressure systems," Atmospheric Environment, 11:967-983 (1977).

25 Samson, P.J , Ragland, K.W., "Ozone and visibility in the midwest: evidence for large-scale transport," J. "Applied Meteorology, 16:1101 -1106 (1977).

26 Vukovich et al., op. Cit., fOOtnOte 24.

over both urban and rural areas can arise from a combination of transport and fresh emissions that enter the system as it moves, and due to the maintenance of conditions ripe for ozone formation.

Transport of ozone and its precursors downwind of source areas on the same day the precursors were emitted is thought to be the most frequent cause of “rural” nonattainment. It can also compound ozone problems in urban areas downwind of the original source regions. Transport on this scale exacerbates nonattainment problems of cities along the northeast corridor from Virginia to Maine; along the Gulf Coast of Texas and Louisiana; and in California. Transport that occurs over night or during regional-scale episodes also exacerbates nonattainment problems in many cities. Although not typically leading to violations of the ozone standard in rural areas, overnight transport and regional-scale episodes are thought to account for a significant portion of the ozone measured at rural sites.

NO_x controls in upwind cities are generally expected to be more effective than VOC controls at lowering ozone concentrations in *rural* areas downwind.[27] Both VOC and NO_x controls in upwind areas may be effective for reducing the contribution of transport to ozone problems in downwind *urban* areas, because both transported ozone and transported VOCs can be important.

3.2 Volatile Organic Compounds: Characterization of Current and Future Emissions

This section describes the sources of volatile organic compound (VOC) emissions and presents our estimates of the changes in emissions over the next 15 years due to the offsetting influences of economic growth and State and federal regulations in place as of 1987. These estimates serve as a baseline for considering the effects of regulatory changes needed to attain the ozone standard.

Sources of Volatile Organic Compounds

Table 3-1 displays estimates of 1985 VOC emissions, number of cities, and population within each of five ozone design value categories. The EPA 1985 National Emissions Data System (NEDS) inventory is the source of our emissions data and serves as the base inventory for all future year projections presented in this report. Of the 19 million tons of VOCs

[27] NO_x controls are also expected to be required to reduce ozone produced locally in rural areas where VOCs from vegetation react with NO_x from power plants and other industrial sources [Trainer et al., 1987].

Table 3-1. SUMMARY OF 1985 VOC EMISSIONS IN NONATTAINMENT CITIES AND ATTAINMENT REGIONS

	Voc Emissions (1000 tons)[a]	Percent Stationary (%)	Percent Mobile (x)	No. of Cities	1985 Population (millions)
Nonattainment Cities by Design Value Category (in ppm O_3)					
0.13-0.14	2,200	62	38	37	30.2
0.15-0.17	3,600	61	39	40	55.3
0.18-0.26	1,100	63	37	14	20.2
> 0.26	770	56	44	3	11.9
Total (nonattainment)	7,700	61	39	94	117.7
Attainment Regions	11,000	62	38		118.8
TOTAL	19,000	61	39		236.5

Source: EPA 1985 National Emissions Data System emissions inventory, January 1988 printout; population data from Bureau of Census.

[a] Totals are rounded.

emitted per year, nationwide, approximately 40 percent were generated in 94 cities that exceeded the ozone standard during the 1983 to 1985 period[28]. These regions contain about half of the nation's population.

Figure 3-4 displays the percent contribution of various source categories to the total 1985 VOC emissions. About two-thirds of the emissions are generated from two main categories: mobile sources and organic solvent evaporation from stationary sources. About 30 percent of the 1985 emissions inventory is composed of highway vehicle emissions. A further breakdown of the data, shown in Figure 3-5, reveals that passenger cars are the largest contributors within the highway vehicle category, with almost 20 percent of the total 1985 VOC emissions, followed by light-duty gasoline trucks with eight percent.

Organic solvent evaporation from stationary sources contributed almost 30 percent of the total VOC emissions in 1985. The sources within this category are extremely varied and include such activities as decreasing of metal parts and products, dry cleaning, printing, and surface coating. The range of individual source sizes (as defined by their individual annual VOC emission rates) can also be quite wide, ranging from a small gas station decreasing tank that emits less than a ton per year, to large industrial operations that contain evaporation sources emitting several hundred tons per year. Figure 3-4 shows that solvent evaporation from small stationary sources emitting less than 50 tons per year contributes about 25 percent of total VOC emissions.

Figure 3-6 displays the breakdown of stationary source emissions by source size. About half of the total 1985 VOC emissions originated from stationary sources that emit less than 50 tons per year. Because of the way EPA constructs the NEDS emissions inventory, it is not possible to show, with much certainty, a more detailed breakdown of the "less-than-50 tons-per-year" size class.[29] However, we do know that at *least two* percent of the inventory comes from sources emitting between 25 and 100 tons per year, and that this contribution *could* be as high as 30 to 40 percent. We have chosen 18 percent as a "rough guess",

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[28]For our analysis, an area is considered in nonattainment if its design value is greater than 0.12 ppm ozone according to EPA-published 1983-1985 ozone monitoring data. EPA's actual determination of nonattainment is based on a slightly different method, but the resulting number of nonattainment cities are essentially the same. Our number of nonattainment areas differs from EPA's count of 61 because, in several cases, EPA has used Consolidated Metropolitan Statistical Areas (CMSAs), rather than cities. Several of these CMSAS include two or more cities that we have considered separately.

[29]EPA requires States t. report VOC emissions from individual sources that emit more than 50 tons per year. If a large "facility" (that contains more than one source) emits more than 100 tons per year of VOCS, each individual source emitting more than 25 tons per year *within* that *facility* must also be reported. EPA uses a "market-balance" approach to indirectly estimate the aggregate remaining emissions from small sources that are not required to report their em iss ions. Determination of individual *source sizes* is, therefore, not possible for these small size categories.

1985 VOC EMISSIONS BY SOURCE CATEGORY

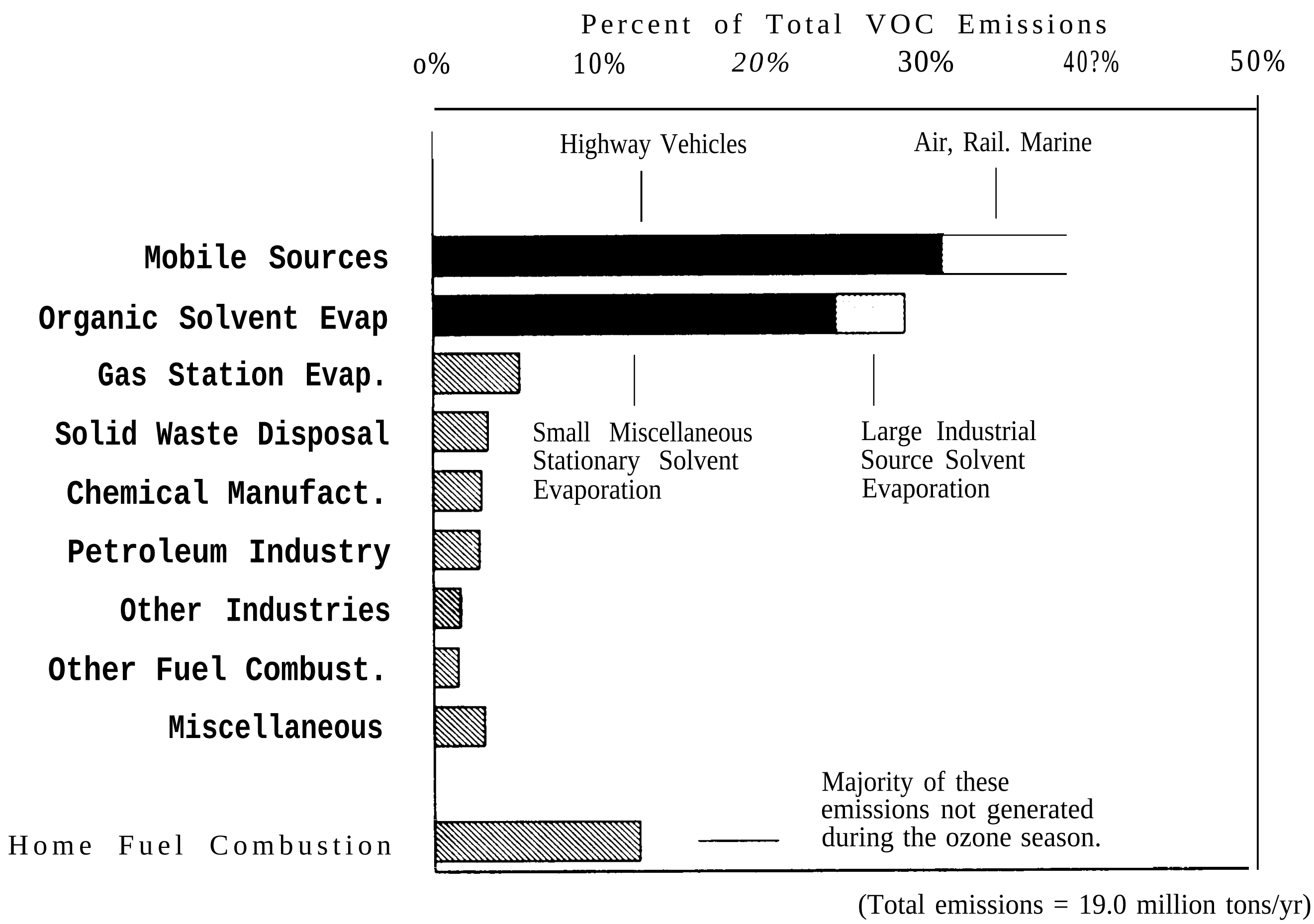

Figure 3-4. Volatile Organic Compound (VOC) Emissions by Source Category in 1985. Source: OTA, from EPA's National Emissions Data System (NEDS)

Note: Under the category "Organic Solvent Evaporation, " the subcategory "Small Miscellaneous Stationary. . . " includes only sources that individually emit less than 50 tons per year of VOC.

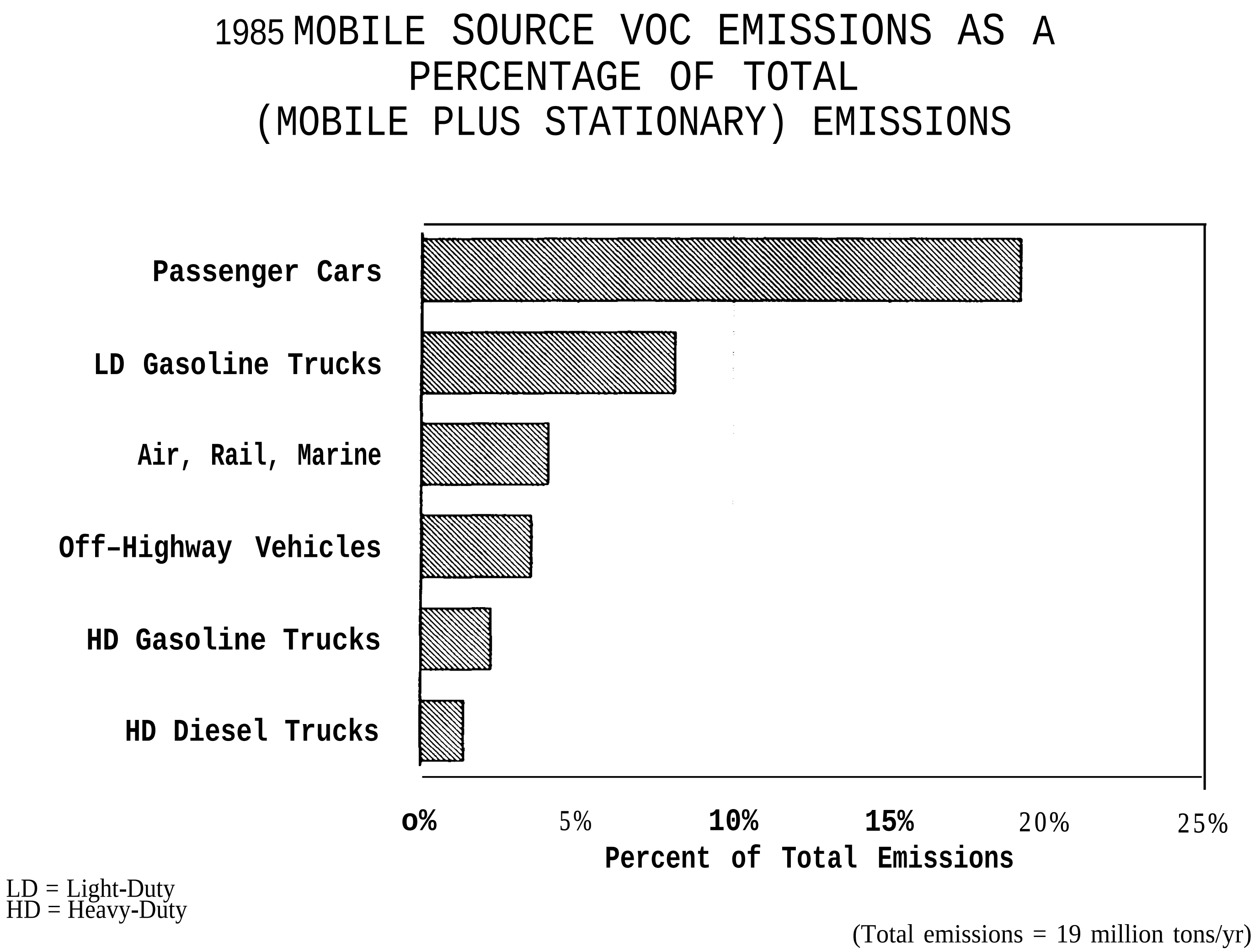

Figure 3-5. Volatile Organic Compound Emissions from Mobile Sources as a Percentage of Total (Mobile plus Stationary) Emissions in 1985.

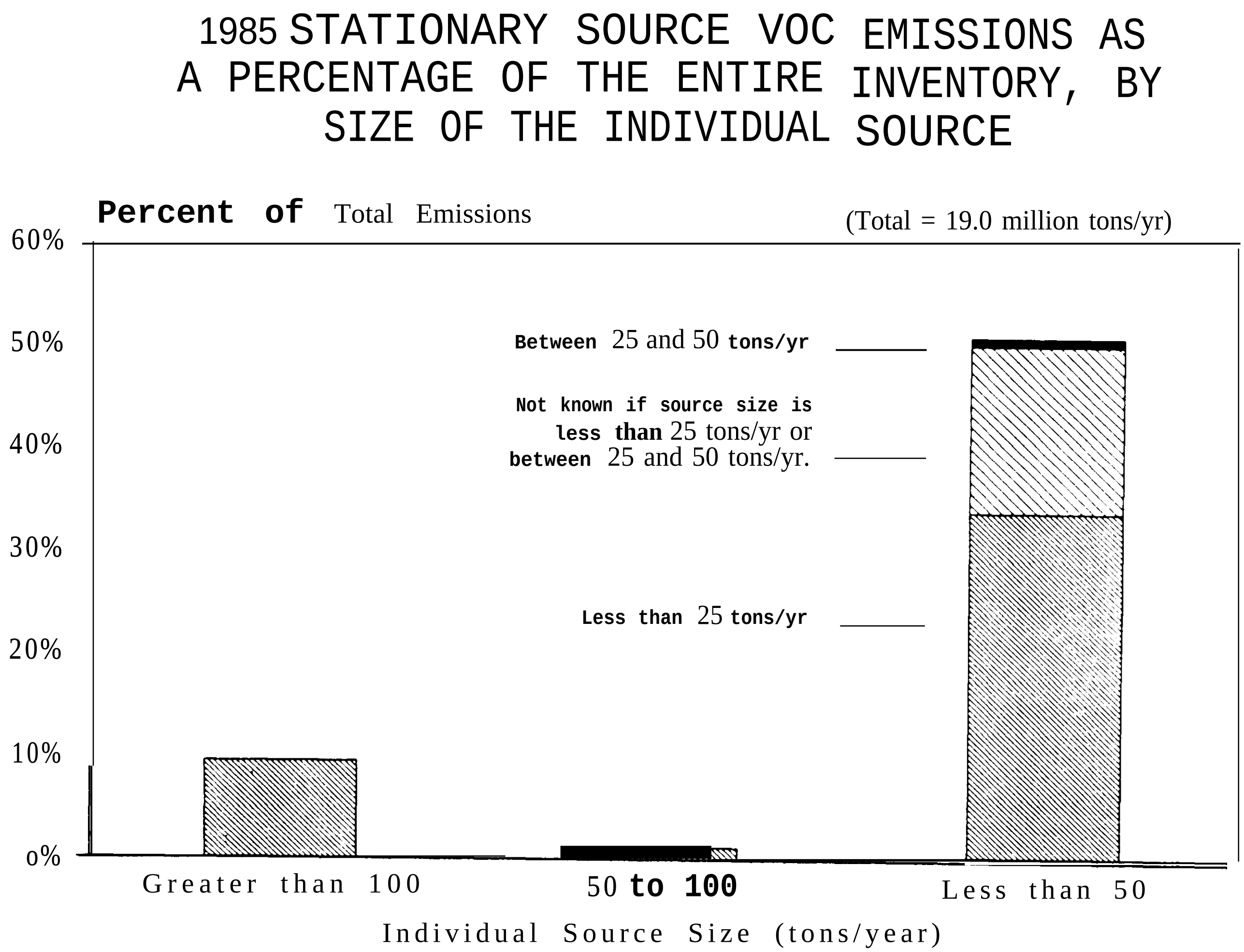

Figure 3-6. Stationary Source Emissions of Volatile Organic Compounds (VOCs) as a Percentage of the Total Emissions Inventory, By Size of the Individual Source.

Each bar displays the percentage of total VOC emissions that are contributed by each source-size class. For example, about 50 percent of total emissions come from sources that emit less than 50 tons per year. Because of the way the 1985 emissions inventory is constructed, we are unable to give a more precise detailed breakdown within the "Less-than-50 tons-per-year" category. We have assumed that sources that emit between 25 and 100 tons per year account for about 18 percent of the total VOC emzssions; this percentage could be as high as 30 to 40 percent.

assuming that about a third of (he small aggregated **VOC** stationary sources in the inventory (for which no source size can be identified) may, individually, emit more than 25 tons per year.[30] The uncertainty about the actual sizes Of the less-than-50-ton sources does not diminish the significant contribution they make to total VOC emissions.

It is important to highlight potentially significant sources of VOC that do *not* appear in the 1985 NEDS emissions inventory. Treatment, storage, and disposal facilities (TSDF's) are now considered important sources, and will very likely appear in future VOC inventories. Biogenic sources (e.g., trees and other vegetation) have also been recognized as a potentially important VOC source category. However, biogenic sources are generally considered to have little influence on local generation of *urban* ozone.

Finally, it is important to recognize that all emission inventories have an inherent, unquantified, level of uncertainty. Given this drawback, any interpretation of emissions inventory data, including those presented in this report, must be made with caution.

Future VOC Emissions

Tables 3-2 through 3-4 display our projections of VOC emissions in 1993, 1998, and 2003, assuming that existing State and EPA regulations do not change. These projections serve as a baseline from which to gauge the effectiveness of future regulations; for example, the changes proposed in recent Congressional bills or EPA's proposed post- 1987 ozone policy. Under current regulations, total VOC emissions would decline by approximately five percent from 1985 levels by 1993, and three percent from 1985 levels by 1998. However, total emissions are expected to start increasing again sometime after 1998, showing a net increase of two percent in 2003 from 1985 levels.

The net decrease in VOC emissions between 1985 and 1998 is due to lower emission rates from cars and trucks.[31] Although the number of vehicle-miles travelled is forecast to increase in many areas over this period, the gradual replacement of current vehicles with newer, cleaner ones will result in an overall decline in highway vehicle emissions. Figure 3-7 shows mobile and stationary source VOC emissions through time. VOC emissions from highway vehicles are projected to decline by about 44 percent between 1985 and 1998.

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[30]The 25-ton-per-year size cutoff was chosen so that we could analyze (in a later section) the emissions reduction potential from stationary sources greater than 25 tons per year. The Clean Air Act currently requires that, at a minimum, all stationary VOC sources that emit more than 100 tons per year in nonattainment areas must adopt "reasonably available" control methods, though this cutoff is lower for some categories.

[31]Future highway vehicle emissions were projected using EPA eStimates of future highway vehicle VOC emission rates, combined with estimates of average yearly miles -travelled per person, and Census Bureau population projections,

Table 3-2. SUMMARY OF 1993 VOC EMISSIONS IN NONATTAINMENT CITIES AND ATTAINMENT REGIONS (Emissions in 1000 tons per year)[a]

	VOC Emissions			Change from 1985 Emissions		
	Total	Stationary	Mobile	Total	Stationary	Mobile
Nonattainment Cities by Design Value Category (in ppm O_3)						
0.13-0.14	2,100	1,500	570	-7%	8%	-32%
0.15-0.17	3,400	2,400	980	-6%	10%	-31%
0.18-0.26	1,100	800	300	-3%	12%	-28%
> 0.26	720	490	230	-6%	14%	-31%
Total (nonattain.)	7,300	5,200	2,100	-6%	10%	-31%
Attainment Regions	11,000	7,600	3,200	-4%	9%	-27%
TOTAL	18,000	13,000	5,300	-5%	9%	-28%

[a] Totals are rounded.

Table 3-3. SUMMARY OF 1998 VOC EMISSIONS IN NONATTAINMENT CITIES AND ATTAINMENT REGIONS (Emissions in 1000 tons per year)[a]

	VOC Emissions			Change from 1985 Emissions		
	Total	Stationary	Mobile	Total	Stationary	Mobile
Nonattainment Cities by Design Value Category (in ppm O_3)						
0.13-0.14	2,100	1,500	530	-6%	13%	-38%
0.15-0.17	3,500	2,600	920	-4%	16%	-35%
0.18-0.26	1,100	850	280	0%	19%	-32%
> 0.26	750	530	220	-2%	23%	-35%
Total (nonattain.)	7,400	5,500	1,900	-4%	16%	-36%
Attainment Regions	11,000	8,000	3,000	-2%	15%	-30%
TOTAL	18,000	13,000	5,000	-3%	15%	-32%

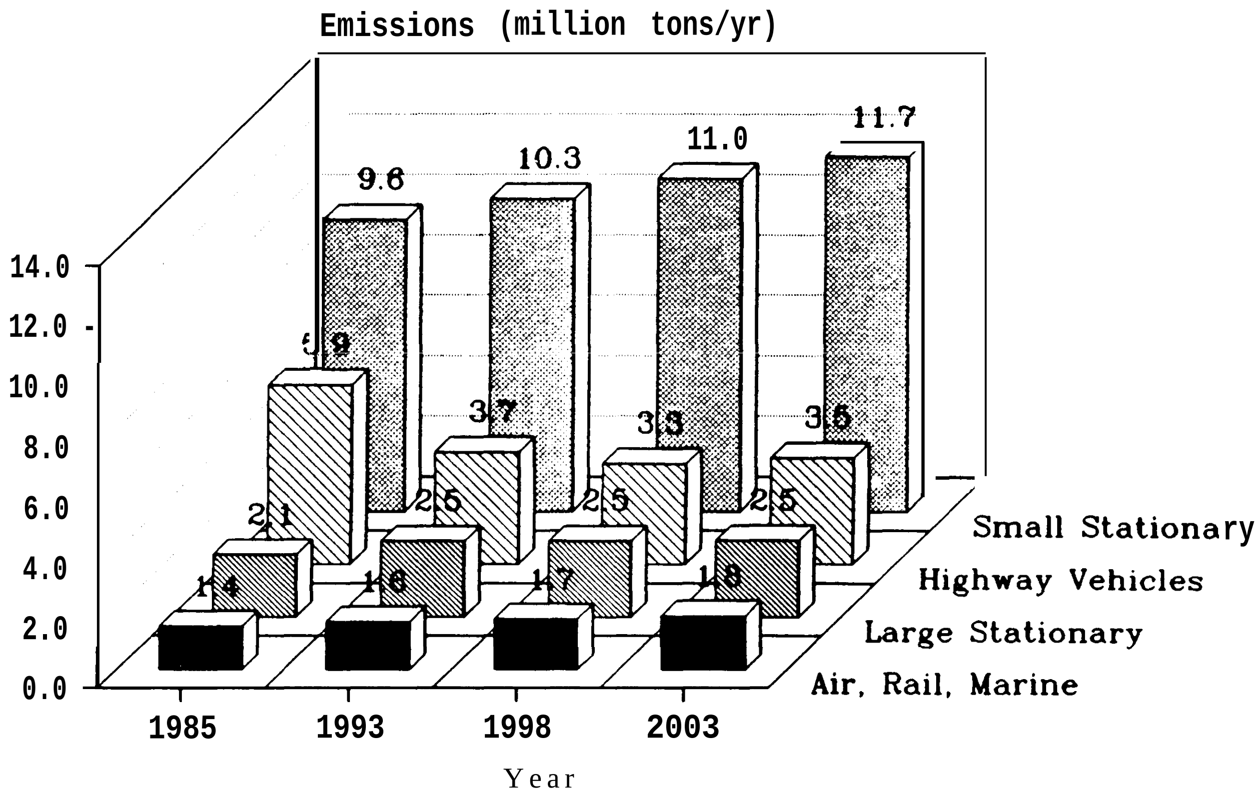
[a]Totals are rounded.

Table 3-4. SUMMARY OF 2003 VOC EMISSIONS IN NONATTAINMENT CITIES AND ATTAINMENT REGIONS (Emissions in 1000 tons per year)[a]

	VOC Emissions			Change from 1985 Emissions		
	Total	Stationary	Mobile	Total	Stationary	Mobile
Nonattainment Cities by Design Value Category (in ppm O_3)						
0.13-0.14	2,200	1,600	550	-22	18%	-35%
0.15-0.17	3,700	2,700	970	2%	23%	-32%
0.18-0.26	1,200	900	300	7%	27%	-30%
> 0.26	800	570	230	5 %	34%	-32%
Total (nonattain.)	7,900	5,800	2,000	2%	23%	-32%
Attainment Regions	12,000	8,400	3,200	3%	21%	-25%
TOTAL	19,000	14,000	5,300	2%	21%	-28%

[a]Totals are rounded.

SUMMARY OF ESTIMATED NATIONWIDE VOC
EMISSIONS BY SOURCE CATEGORY, BY YEAR



Note:
"Small Stationary" = sources less than 50 tons/yr.

Figure 3-7. Summary of Estimated Nationwide Volatile Organic Compound Emissions by Source Category, by Year.

The numbers directly above the boxes are the total emissions within the source category. For example, emissions from Highway Vehicles in 1993 are 3.7 million tons per year.

Stationary source emissions, on the other hand, are forecast to increase steadily between 1985 and 2003, showing a nine percent increase by 1993 and a 21 percent increase by 2003, over 1985 levels.[32] Small (less than 50 ton-per-year) stationary VOC source growth is one of the most important reasons why overall VOC emissions are not expected to decline more rapidly in the earlier years and why total emissions may show a net *increase* by 2003. This source category effectively offsets much of the emissions reductions realized from highway vehicles.

Our projections for large stationary source emissions may be somewhat high because we are unable to explicitly model all of the control requirements in the Clean Air Act pertaining to new and modified large VOC emission sources in nonattainment areas.[33] However, the effect on our overall emissions estimates is small because, as illustrated in Figure 3-7, small stationary source growth will have a much more significant impact on future estimates of total VOC emissions than large stationary sources. In most States, these more stringent new source regulations do not apply to small sources.

As discussed in the next section, changes in VOC emissions due to the source-specific regulations currently in place are not sufficient to attain the standard in most nonattainment cities. In a following section, we discuss the reductions necessary to attain the ozone standard, as required under the Clean Air Act, and the reduction potential of additional source-specific controls.

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[32] Future large stationary source (greater than 50 tons per year) emissions were estimated using projections of industrial employment growth within various industrial categories, while small source growth was based either on industrial employment, estimates of population growth, or growth in the Gross National Product per capita. References used included:

David South, et all Argonne National Laboratory, "Industrial VOC Model: Regionalized Forecasts of Uncontrolled Emissions by Source Category, Draft Discussion Paper No. 19 for Task Group B of the Interagency Task Force on Acid Precipitation," prepared for U.S. Department of Energy, Office of Planning and Environment, Washington, D. C., June 1985.

U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: U.S. Government Printing Office, October 1985), pp. 32-36 .,U.S. Department of Commerce, Bureau of the Census, *Statistical Abstracts of the United States, 1981* (Washington, DC: U.S. Government Printing Office, 1987), p. 14.

U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business* (Washington, DC: U.S. Government Printing Office, July 1987), pp. 78.

[33] These regulations require that new stationary sources with the Potential to emit more than 100 tons per year install the most stringent emission controls possible and that VOC emissions from other existing sources in the area be reduced so that there will be a net *decline* in emissions after new operations commence. These same control requirements apply to major modifications of existing sources that result in a VOC emissions increase of more than 40 tons per year.

3.3 Potential Emissions Reductions From Control Strategies Analyzed by OTA

In this section we analyze the VOC emissions reductions from, and costs of, source-specific control strategies currently being considered by the Congress and EPA. We also show how these potential emissions reductions compare with estimates of the overall emissions reductions needed to attain the ozone standard in each nonattainment city. Discussion of the costs of these control strategies appears in Section 3.5.

We are able to analyze the following source-specific control strategies:

- o "Reasonably Available Control Technology" (RACT) on all existing stationary sources;
- o Adoption of new "Control Technique Guidelines" (CTG's) for several existing stationary sources of VOC;
- o Establishment of new federally-regulated controls on selected stationary VOC sources;
- o "Onboard" technology on motor vehicles to capture gasoline vapor during refueling;
- o "Stage II" control devices on gas pumps to capture gasoline vapor during motor vehicle refueling;
- o Inspection and maintenance (1/M) programs for highway vehicles;
- o More stringent exhaust emission standards for gasoline highway vehicles;
- o New federal restrictions on fuel volatility; and
- o The use of methanol instead of gasoline as a fuel for vehicles in centrally-owned fleets.

Transportation control measures that limit motor vehicle use are potentially important control strategies that we are unable to analyze at this time.

Throughout the analysis, emissions reductions reported apply to the change occurring between 1985 and the relevant future year. The emissions reductions reported in our analysis result from currently available control methods that we know can be applied in the near-term. We were able to analyze the emissions reduction potential and associated control costs for strategies applicable to about three-quarters of current VOC emissions. The remaining one-quarter[34] of VOC emissions primarily come from stationary sources for which we either could not find applicable control technologies 01 that we could not analyze because of a lack of suitable information. We believe that the large majority of emission reductions possible with currently available control methods are accounted for in our analysis. This does not imply that additional VOC reductions beyond those analyzed here are not possible, but that they should not be counted on within the next five to 10 years.

All control strategies listed above apply to nonattainment cities. Strategies including federal controls on selected small VOC stationary sources, Onboard controls, more stringent highway vehicle standards and fuel volatility limitations apply nationwide, not just in nonattainment cities. It should be noted that both S.1894 and H. R.3054 require *some* VOC control in selected attainment areas in States designated as ozone transport regions. However, because each Congressional proposal sets up slightly different transport regions, we have chosen to exclude these areas from our analysis.

Tables 3-5 through 3-7 present estimates of emissions reductions achieved in 1993, 1998, and 2003, respectively, if the various control strategies listed above are applied. We estimate that VOC emissions in nonattainment cities can be reduced by 1.7 million tons per year in 1993, about 21 percent below 1985 levels. Because some measures are not restricted to nonattainment areas, approximately 2.7 million tons per year would be eliminated nationwide. By 2003, total emissions reductions from these control measures in nonattainment areas increase only slightly to about 1.9 million tons per year.[35]

Again, we must stress that these estimates are for emissions reductions from the additional controls that we are able to analyze. The remaining one-quarter of the inventory that we were unable to analyze may contain emissions that could have been reduced by applying some of these strategies. Therefore, actual emissions reduction potential available from these additional controls may be greater than represented here. Other potential control strategies, such as transportation control measures, are not included in our analysis.

Figures 3-8 and 3-9 display our estimates of emissions reductions resulting from each control strategy in 1993 and 2003, as a percentage reduction below total 1985 emissions in nonattainment cities. The largest reductions come from instituting RACT on stationary sources and limiting fuel volatility. The percentage reductions are about the same for most

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[34]Emissions from treatment, storage, and disposal facilities are not included in this fraction since they were not included in EPA's 1985 National Emissions Data System (NEDS) emissions inventory.

[35]Note that the total reductions are slightly lower than the SUm Of the component categories. This is because the emissions reductions achieved by (a) lowering fuel volatility in combination with an I/M program, and (b) combining a Stage 11 and Onboard control program, are slightly less than instituting each one alone.

Table 3-5. Potential Emissions Reductions in 1993 Compared to 1985 Emissions From Source-Specific Control Strategies (Emissions in 1000 tons per year)[a]

	RACT	New CTG's	Federal Controls	Onboard	Stage II	Combined Stage II & Onboard	Fuel Volatility Control[b]	Enhanced I/M	New Highway Vehicle Emis. Stds	Methanol Fuels	ALL CONTROLS[c]
Nonattainment Cities by Design Value Category (in ppm O_3)											
0.13-0.14	120	17	61	22	62	63	150	78	7	0	470
0.15-0.17	240	26	110	38	100	110	230	110	12	0	820
0.18-0.26	77	5	37	12	30	35	59	33	4	12	250
> 0.26	21	6	28	8	0	24	0	28	3	10	120
Total (nonattain.)	460	54	240	81	190	230	440	250	27	22	1,700
Attainment Areas	0	0	220	87	0	87	710	0	36	0	1,000
TOTAL	460	54	460	170	190	320	1,200	250	63	22	2,700

[a] Totals are rounded.

[b] Estimates are equivalent annual reductions. Actual reductions are required only five months out of the year.

[c] "All Controls" include RACT, new CTG's, federal controls, combined Stage II and Onboard, gasoline volatility controls, enhanced I/M, and new mobile emission standards. Note that total reductions are slightly lower than the sum of each component category. This is because the reductions achieved by lowering gasoline volatility in combination with an enhanced I/M program, and a combining Stage II and Onboard program, are slightly lower than instituting each one alone.

<u>Strategy Descriptions:</u>

RACT - "Reasonable Available Control Technology" on all existing stationary sources that emit more than 25 tons per year of VOC.

New Ctg's = Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

Federal Controls on selected small Stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Onboard controls on motor vehicles to capture gasoline vapor during refueling.

Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.

Fuel volatility control which limit the rate of gasoline evaporation.

Enhanced inspection and maintenance (1/H) programs for cars and light-duty trucks.

New highway-vehicle essission stadards for passenger cars and light-duty gasoline trucks.

Methanol fuels as a substitute for gasollne as a motor vehicle fuel.

Table 3-6. Potential Emissions Reductions in 1998 Compared to 1985 Emissions From Source-Specific Control Strategies (Emissions in 1000 tons per year)[a]

	RACT	New CTG's	Federal Controls	Onboard	Stage II	Combined Stage II & Onboard	Fuel Volatility Control[b]	Enhanced I/M	New Highway Vehicle Emis. Stds	Methanol Fuels	ALL CONTROLS[c]
Nonattainment Cities by Design Value Category (in ppm O_3)											
0.13-0.14	120	17	62	51	69	72	140	67	20	0	480
0.15-0.17	260	27	120	90	110	130	230	94	34	0	860
0.18-0.26	82	5	39	29	35	42	59	29	11	11	270
> 0.26	24	6	30	20	0	28	0	25	9	9	130
Total (nonattain.)	490	55	250	190	220	270	430	210	73	20	1,700
Attainment Areas	0	0	230	200	0	200	710	0	99	0	1,200
TOTAL	490	55	480	390	220	480	1,100	210	170	20	3,000

[a]Totals are rounded.

[b]Estimates are equivalent annual reductions. Actual reductions are required *only* five months out of the year.

[c]"All Controls" include RACT, new CTG's, federal controls, combined Stage II and Onboard, gasoline volatility controls, enhanced I/M, and new mobile emission standards. Note that total reductions are slightly lower than the sum of each component category. This is because the reductions achieved by lowering gasoline volatility in combination with an enhanced I/M program, and a combining Stage II and Onboard program, are slightly lower than instituting each one alone.

Strategy Descriptions:

RACT = "Reasonable Available Control Technology" on all existing stationary sources that emit more than 25 tons per year of VOC.

New CTG's = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Onboard controls on motor vehicles to capture gasoline vapor during refueling.

Stage II control devices *on* gas pumps to capture gasoline vapor during motor vehicle refueling.

Fuel volatility controls which limit the rate of gasoline evaporation.

Enhanced inspection and maintenance (I/M) programs for cars and light-duty trucks.

New highway-vehicle emissions standards for passenger cars and light-duty gasoline trucks.

Methanol fuels as a substitute for gasoline as a motor vehicle fuel.

Table 3-7. Potential Emissions Reductions in 2003 Compared to 1985 Emissions From Source-specific Control Strategies (Emissions in 1000 tons per year)[a]

	RACT	New CTG's	Federal Controls	Onboard	Stage II	Combined Stage II & Onboard	Fuel Volatility Control[b]	Enhanced I/M	New Highway Vehicle Emis. Stds	Methanol Fuels	ALL CONTROLS[c]
Nonattainment Cities by Design Value Category (in PPM O_3)											
0.13-0.14	130	17	64	74	77	80	140	69	28	0	510
0.15-0.17	280	27	120	130	130	140	230	97	49	0	920
0.18-0.26	86	5	41	44	40	48	62	30	16	11	290
> 0.26	27	6	32	30	0	32	0	26	13	9	150
Total (nonattain.)	520	56	260	280	240	300	440	220	110	21	1,900
Attainment Areas	0	0	240	310	0	310	750	0	150	0	1,400
TOTAL	520	56	500	580	240	610	1,200	220	250	21	3,300

[a] Totals are rounded.

[b] Estimates are equivalent annual reductions. Actual reductions are required only five months out of the year.

[c] "All Controls" include RACT, new CTG's, federal controls, combined Stage II and Onboard, gasoline volatility controls, enhanced I/M, and new mobile emission standards. Note that total reductions are slightly lower than the sum of each component category. This is because the reductions achieved by lowering gasoline volatility in combination with an enhanced I/M program, and a combining Stage II and Onboard program, are slightly lower than instituting each one alone.

<u>Strategy Descriptions:</u>

RACT = "Reasonable Available Control Technology" on all existing stationary sources that emit more than 25 tons per year of VOC.

New CTG's = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Onboard control on motor vehicles to capture gasoline vapor during refueling.

Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.

Fuel volatility controls which limit the rate of gasoline evaporation.

Enhancad inspection and maintenance (1/M) programs for cars and light-duty trucks.

New highway-vehicle emission standards for passenger cars and light-duty gasoline trucks.

Methanol fuels as a substitute for gasoline as a motor vehicle fuel.

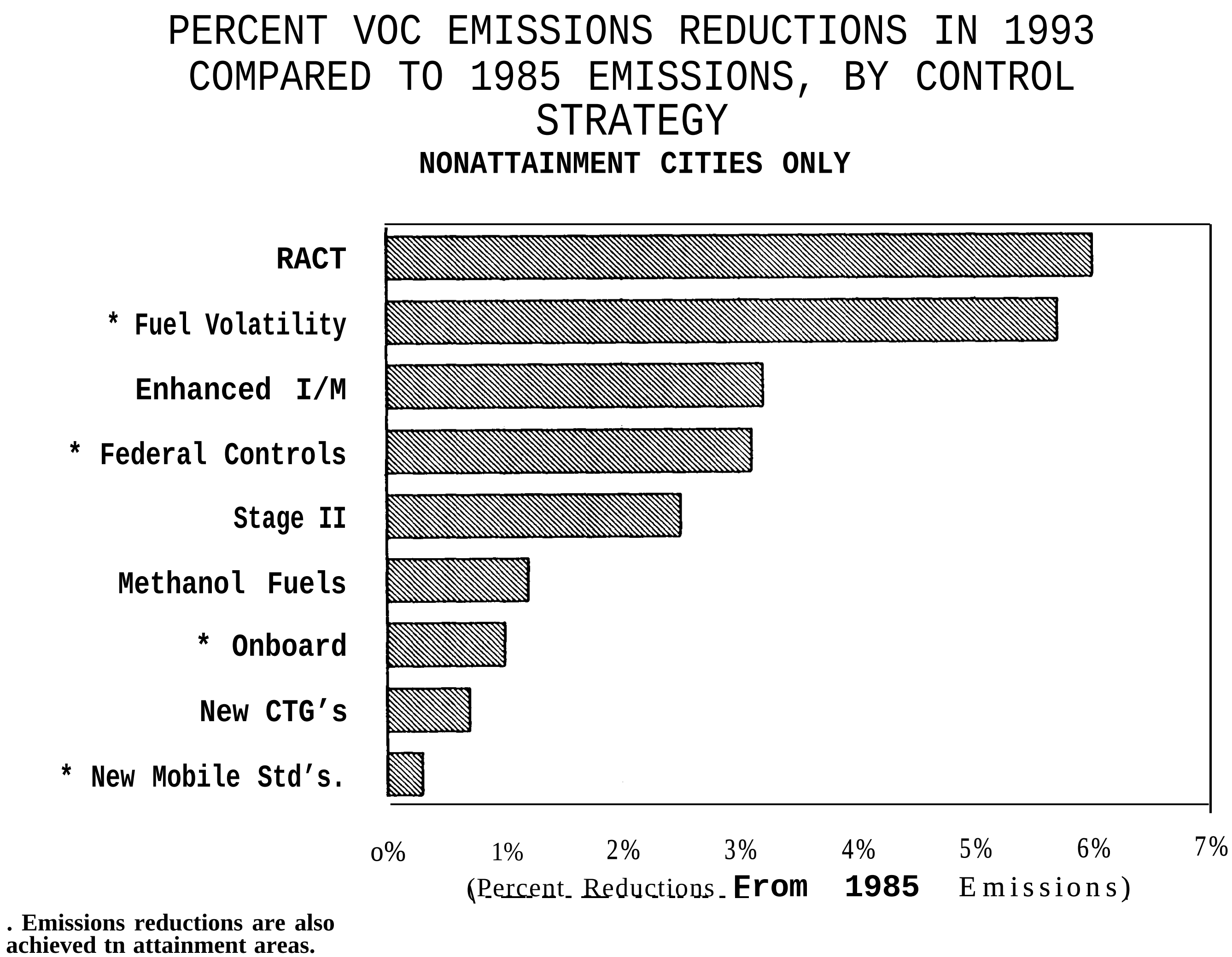


Figure 3-8. Percent Volatile Organic Compound (VOC) Emissions Reductions in 1993 Compared to 1985 Emissions, by Control Strategy

Strategy Descriptions

RACT= "Reasonably Available Control Technology" on all existing sources that emit more than 25 tons per year of VOC.

Fuel Volatility standards that limit the rate of gasoline evaporation.

Enhanced Inspection and Maintenance (I/M) programs for passenger cars and light-duty trucks.

Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.

Methanol Fuels as a substitute for gasoline as a motor vehicle fuel.

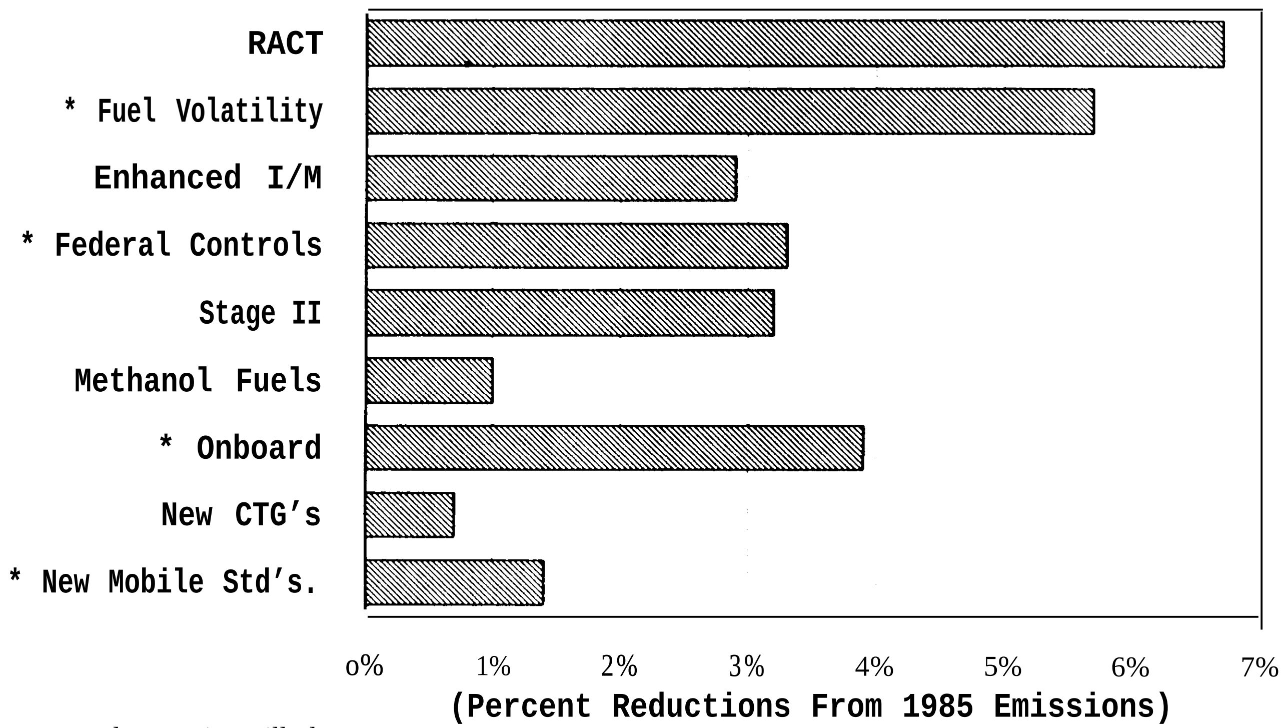
Onboard controls on motor vehicles to capture gasoline vapor during refueling.

New CTG's = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

New Mobile Standards = more stringent tailpipe emission standards for passenger cars and light-duty gasoline trucks.

PERCENT VOC EMISSIONS REDUCTIONS IN 2003 COMPARED TO 1985 EMISSIONS, BY CONTROL STRATEGY

NONATTAINMENT CITIES ONLY



. These control strategies will also create emissions reductions in attainment areas as well.

Figure 3-9. Percent Volatile Organic Compound (VOC) Emissions Reductions in 2003 Compared to 1985 Emissions, by Control Strategy.

Stratexy Descriptions

RACT "Reasonably Available Control Technology" on all existing sources that emit more than 25 tons per year of VCC.

Fuel Volatility standards that limlt the rate of gasoline evaporation.

Enhaocad Inspection and Maintenance (I/M) programs for passenger cars and light-duty trucks.

Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.

Methanol Fuels as a substitute for gasoline as a motor vehicle fuel.

Onboard controls on motor vehicles to capture gasoline vapor during refueling.

New CTGs = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

New Mobile Standards = more stringent tailpipe emission standards for passenger cars and light-duty gasoline trucks.

categories in 1993 and 2003, except that the reductions from Onboard controls and new highway-vehicle standards increase because more of the older vehicles will have been replaced by newer ones equipped with additional controls. Table 3-8 presents a more detailed breakdown of percent emissions reductions in 1993. By 1993, total reductions average about 21 percent in nonattainment cities.

Figure 3-10 displays potential emissions reductions and the percentage of emissions that remain after all of the reductions have been accounted for. In 1993, after all controls are applied, emissions are approximately 70 percent of the 1985 total. Most of the remaining emissions are from small stationary sources that emit less than 25 tons of VOCs per year. As stated earlier, we are unable to identify controls for approximately one-quarter of the emissions inventory. About 80 percent of this one-quarter (or about 20 percent of the entire inventory) are emissions from small stationary sources.

The following subsections summarize the emissions reduction potential of each individual control strategy.

Reasonably Available Control Technology (RACT) on All Stationary Sources

The Clean Air Act requires that each State adopt, as part of its State Implementation Plan (SIP), "reasonably available control technology" (RACT) regulations for existing stationary sources of VOC in nonattainment cities. In our analysis, we have applied RACT-level controls on 39 stationary source categories including petroleum refining, certain types of chemical manufacturing, paper surface coating, automobile surface coating, gasoline terminals, service stations, and dry cleaning.

The source of our estimates of the percentage reduction in VOC emissions from RACT and of the data we used to calculate the cost of these controls, is a recent draft report prepared for EPA by Alliance Technologies Corporation[36]. EPA made available to us a series of memos detailing the methods used, technical references, and economic assumptions used by Alliance, from which our estimates are drawn. A complete list of our control cost assumptions, including control efficiencies and associated costs for each source type, is included in Appendix A.

[36]William H Battye, Mark G. Smith, and Mark Deese, Alliance Technologies Corporation, "Cost Assessment of Alternative National Ambient Air Quality Standards For Ozone, Draft Report," prepared for the U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Contract No, 68-02-4317, October 1987.

Table 3-8. Percent Emissions Reductions in 1993 Compared to 1985 Emissions From Source-Specific Control Strategies[a]

	RACT	New CTG's	Federal Controls	Onboard	Stage II	Combined Stage II & Onboard	Fuel Volatility Control[b]	Enhanced I/M	New Highway Vehicle Emis. Stds	Methanol Fuels	ALL CONTROLS[c]
Nonattainment Cities by Design Value Category (in ppm O_3)											
0.13-0.14	5	1	3	1	3	3	7	4	<1	0	
0.15-0.17	7	1	3	1	3	3	7	3	<1	0	
0.18-0.26	7	<1[d]	3	1	3	3	5	3	<1	1	
> 0.26	3	1	4	1	0	3	0	4	<1	1	
Total (nonattain.)	6	1	3	1	3	3	6	3	<1	1	
Attainment. Areas	0	0	2	1	0	1	6	0	<1	0	9

[a] Totals are rounded.

[b] Estimates are equivalent annual reductions. Actual reductions are required only five months out of the year.

[c] "All Controls" include RACT, new CTG's, federal controls, combined Stage II and Onboard, gasoline volatility controls, enhanced I/M, and new mobil emission standards. Note that total reductions are slightly lower than the sum of each component category. This is because the reductions achieve lowering gasoline volatility in combination with an enhanced I/M program, and a combining Stage II and Onboard program, are slightly lower than inst each one alone.

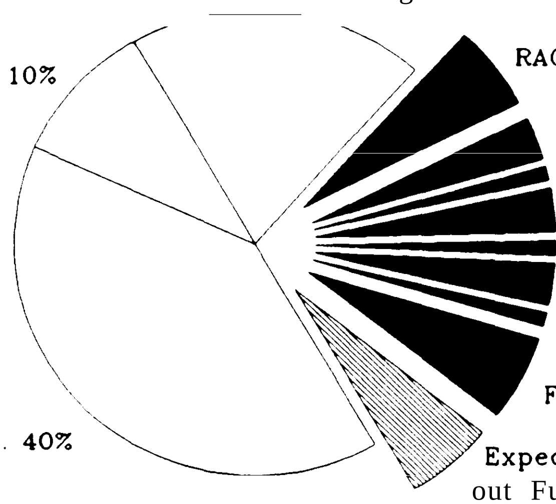
[d] "<1" means less than 1 percent.

Strategy Descriptions:

RACT = "Reasonable Available Control Technology" on all existing stationary sources that emit more than 25 tons per year of VOC.
New CTG's = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.
Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).
Onboard controls on motor vehicles to capture gasoline vapor during refueling.
Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.
Fuel volatility controls which limit the rate of gasoline evaporation.
Enhanced inspection and maintenance (Ire) programs for cars and light-duty trucks.
New highway-vehicle emission standards for passenger cars and light-duty gasoline trucks.
Methanol fuels as a substitute for gasoline as a motor vehicle fuel.

POTENTIAL VOC EMISSIONS REDUCTIONS AND REMAINING EMISSIONS IN 1993 AS A PERCENTAGE OF 1985 EMISSIONS

Nonattainment Cities Only



Notes:
•In a combined Stage 11 + On board control program, Stage 11 contributes about 70 percent of the reductions in 1993

Figure 3-10. Potential Volatile Organic Compound (VOC) Emissions Reductions and Remaining Emissions in 1993 as a Percentage of 1985 Emissions in Nonattainment Cities

The pulled-out slices represent emissions that can be eliminated by each control strategy. The three connected slices represent emissions in 1993 that remain after all control strategies are applied. The category "Expected Reductions without Further Control" represents reductions achieved from existing State and EPA VOC regulations as of 1985. "Remaining Small Stationary" represents emissions from stationary sources that emit Less than 25 tons per year of VOC.

Strategy Descriptions

RACT = "Reasonably Available Control Technology" on all existing sources that emit more than 25 tons per year of VOC.

Fuel Volatility standards that limit the rate of gasoline evaporation.

Enhanced Inspection and Maintenance (I/M) programs for passenger cars and light-duty trucks.

Federal. Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.

Methanol FueLs as a substitute for gasoline as a motor vehicle fuel.

Onboard controls on motor vehicles to capture gasoline vapor during refueling.

New CTGs = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

New Mobile Standards= more stringent tailpipe emission standards for passenger cars and light-duty gasoline trucks.

We estimate the emissions reductions achievable through RACT-level regulations by simulating controls on all existing stationary sources that emit more than 25 tons of VOCs per year;[37] in those cities that did not have an existing RACT regulation for a particular source category in their SIP as of 1985. For this analysis, additional RACT controls are applied only in nonattainment cities (although some bills also apply controls in selected attainment areas in States designated as ozone transport regions).

We estimate that applying RACT to all sources in nonattainment cities would lower VOC emissions by approximately 460 thousand tons per year in 1993, representing a six percent decline based on 1985 levels. Reductions continue to increase over time, with total reductions in nonattainment cities in 2003 estimated to be about 520 thousand tons per year, from 1985 levels.

Adoption of New "Control Technique Guidelines" (CTG's)

In the previous subsection, we analyzed the emissions reduction potential of applying all *currently* available RACT-level controls on all existing stationary VOC sources. Several additional stationary source categories are now being considered as candidates for development of new RACT regulations by EPA. These would be issued as "Control Technique Guidelines" (CTGs). Like the RACT controls analyzed in the previous section, nonattainment cities would be required to adopt these "new" RACT regulations on all *existing* stationary VOC sources that emit more than 25 tons of VOCs per year.

We are able to analyze the emission reduction potential from controls on (1) wood furniture coating, (2) autobody refinishing, (3) plastic parts coating, and (4) coke oven by-product plants. These four categories represent about one percent of the entire VOC inventory. Appendix A lists the control efficiency assumptions we used for these sources. We are unable to analyze the emissions reduction potential from other proposed new-CTG categories, and at least one of these--treatment, storage, and disposal facilities--might be quite large.

Emissions reductions from applying new CTG controls that we were able to analyze are estimated to be about 54 thousand tons per year in 1993, or about a one percent reduction based on 1985 emissions. This annual total is expected to increase by a few thousand tons in 2003.

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[37] Since a large fraction of small stationary sources (i.e., area sources) are reported as aggregate county-level totals in the 1985 NEDS emissions inventory, we have no way of knowing what fraction of those aggregate totals are contributed by individual sources greater than 25 tons per year. *Therefore,* for our analysis, we have assumed that one-third of the emissions from this aggregate total are from sources greater than 25 tons per year.

Federal Controls on Small VOC Sources

Many small sources of VOCs do not lend themselves to traditional forms of regulation (e.g., application of an add-on control device to reduce emissions). These sources individually emit, small amounts of VOCs, but when aggregated over a region, they collectively contribute a significant portion of the VOC inventory. Such sources include consumer and commercial solvents, architectural surface coatings, agricultural pesticides, adhesives, and others.

Although several categories have been proposed as candidates for new federal controls in recent bills, we are only able to analyze commercial and consumer solvents, and architectural surface coatings. These two categories represent about nine percent of the entire emissions inventory. We believe, however, that emissions from these two categories represent most of the emissions that would fall under proposed federal controls.

EPA control efficiency estimates range between 23 percent[38] and 65 percent[39] for architectural surface coatings, and about 20 percent[40] for commercial and consumer solvents. For our analysis, we assume a 25 percent control efficiency for both categories. Since these would be federally-regulated, emissions reductions would occur nationwide (in nonattainment and attainment areas).

In 1993, federally-regulated controls on commercial and consumer solvents and on architectural surface coatings are estimated to reduce VOC emissions by 240 thousand tons per year in nonattainment cities, and about 220 thousand tons year in attainment areas. By 2003 in nonattainment cities, emissions reductions will reach about 260 thousand tons per year.

Controls on Gasoline Emissions From Vehicle Refueling

Gasoline vapors that escape from vehicle fuel tanks during refilling can be controlled by two fundamentally different methods. One method involves installation of a vapor recovery system on service station gasoline pumps, commonly referred to as "Stage II" vapor recovery. The other method relies on a control device installed on each vehicle as part of the emission control system (commonly referred to as "Onboard" controls). Stage II programs

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[38] U.S. Environmental Protection Agency, Office of Air, Noise, and Radiation/Office of Air Quality Planning and Standards, "Control of Organic Emissions from Architectural Surface Coating," preliminary draft, March 1981, p. 3-11.
[39] U.S. Environmental protection Agency, Office of Air Quality Planning and Standards, "Implications of Federal Implementation Plans (FIP's) for Post- 1987 Ozone Nonattainment Areas," March 1987, p. V-78.
[40] Ibid., p. v-83.

can become fully effective within a few years. The emissions reduction benefits of an Onboard control program gradually increase over time and achieve full potential after about 10 years, when most older, non-equipped vehicles have been replaced. In the following subsections, we describe the emissions reduction potential of each program individually, and in combination.

"Onboard" refueling controls on motor vehicles

For this analysis, we assume that Onboard controls are required on all *new* gasoline vehicles starting in 1991 and that by 2003, *all* gasoline vehicles on the road will be equipped with Onboard controls due to fleet turnover. Assumptions regarding fleet turnover and control efficiencies are obtained from EPA's recent gas-marketing regulatory impact analysis.[41] [42] Because these controls apply to all new gasoline vehicles, emissions reductions will occur nationwide (in both nonattainment and attainment areas).

We estimate that in 1993, Onboard controls will eliminate about 81 thousand tons per year of VOC emissions in nonattainment cities, and 170 thousand tons per year nationwide, representing about a one percent reduction, compared to 1985 emissions. In 2003, total nationwide VOC reductions increase to about 580 thousand tons per year, or about a three percent reduction based on 1985 levels. These results reflect only Onboard controls for vehicle refueling and do not include reductions from additional Stage II controls. An analysis of a combined Onboard and Stage 11 vapor recovery program is presented later,

"Stage II" refueling vapor recovery

Unlike Onboard controls, which are applied nationwide, we assume Stage 11 controls are only installed in nonattainment cities. Congressional proposals have generally limited the Stage II requirement to these areas. Emissions reductions in 1993 and 2003 are estimated to be about 190 thousand and 240 thousand tons per year, respectively, which amounts to about a three percent reduction in both 1993 and 2003, relative to 1985 emissions. We assume a control efficiency of 86 percent, which represents EPA's average estimate for a Stage 11 program with annual enforcement. Note that the percent emissions reductions ultimately achievable with Stage II and Onboard controls are roughly comparable. However, in 1993, Onboard is less effective than Stage II, because fleet turnover will have only just begun.

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[41] U.S. Environmental Protection Agency, Office of Air and Radiation, "Draft Regulatory Impact Analysis: Proposed Refueling Emission Regulations for Gasoline-Fueled Motcr Vehicles--Volume I, Analysis of Gasoline Marketing Regulatory Strategies," EPA-450/3-87-00 la, July 1987, p. 2-33, 3-18.

[42] We assume that the percent reduction in refueling emissions from use of Onboard controls, as derived from EPA's gas marketing analysis (Ibid., p. 3- 18), is 28 percent, 58 percent, and 76 percent in 1993, 1998, and 2003, respectively.

Combined Stage II and Onboard controls

If both Stage II and Onboard controls are adopted, the percent emissions reductions in nonattainment cities in 1993 and 2003 are estimated to be about three and four percent, respectively, relative to 1985 emissions. As the reduction benefits from Onboard controls increase through time (due to fleet turnover), the benefits from the combined strategy is only slightly greater than either method above. We assume a combined control efficiency of about 83 percent based on EPA-derived data.[43]

Enhanced Motor Vehicle Inspection and Maintenance (1/M) Programs

For this analysis, we define an enhanced motor vehicle inspection and maintenance (1/M) program as one including all requirements of the existing California I/M program (among the most stringent in the nation), plus the following improvements: annual testing for all pollutants (VOC, NO_x, carbon monoxide, and particulate) on all vehicles, improved visual inspection of the emissions control system to detect tampering and other functional defects, and a repair cost ceiling of $200 per year. We have assumed that enhanced I/M programs are instituted in all nonattainment areas. Recent bills also require I/M in selected attainment cities within States designated as ozone transport regions. However, since the selection of attainment cities differs between these proposals, we have chosen to limit our analysis to nonattainment cities.

For cities without an existing I/M program as of 1987, the full emission reduction benefit of an enhanced I/M program is applied. If a city already had an I/M program as of 1987, then an incremental emission reduction benefit, representing the reductions achieved by going from an existing to an enhanced program, is applied. Emissions reduction benefit assumptions are taken from Sierra Research, Inc. (1988).44 We assume that the VOC emission reduction potential of existing I/M programs is about 12 percent. The full benefit of enhanced programs is about 30 percent, while the incremental benefit gained by switching from an existing to an enhanced program is about 17 percent.

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43 U.S. Environmental Protection Agency, Op. cit., footnote 41, p. 3-18.

44 Sierra Research, Inc., "The Feasibility and Costs of More Stringent Mobile Source Emission Controls," contractor report prepared for the Office of Technology Assessment, January 20, 1988. p. 9-23.

We estimate that enhanced I/M programs in nonattainment cities will reduce VOC emissions by about 250 thousand tons per year in 1993 and by 220 thousand tons per year in 2003.[45] This represents about a three percent reduction in both 1993 and 2003, based on 1985 emissions. Enhanced I/M programs become slightly less effective over time because a larger percentage of the vehicle fleet will be newer, lower-emitting vehicles.

More Stringent Hiqhway-Vehicle Emission Standards

This analysis includes the VOC emissions reduction potential of instituting more stringent tailpipe controls on new passenger cars and light-duty gasoline-fueled trucks. The standards we analyzed were determined to be the most stringent technologically feasible, given currently “available” control technology, according to Sierra Research (1988).46 47 Sierra Research assumes that these standards can be met after 50,000 miles of *controlled test* driving for passenger cars, and 120,000 miles for light-duty trucks; however, VOC emission rates after 50,000 miles (for cars) and 120,000 miles (for trucks) of *actual* use by vehicle owners would likely exceed these standards. We assume that new standards go into effect in 1990 for passenger cars, and 1992 for light-duty trucks.

We estimate that new highway vehicle standards reduce VOC emissions by less than one percent nationwide, in 1993. By 2003, reductions increase to just over one percent nationwide, compared to 1985 emissions. The increase in emissions reductions during this period is due to the gradual replacement of older vehicles with newer, cleaner ones.

Limits on Fuel Volatility

Lowering gasoline volatility (i.e., lowering the rate of evaporation) reduces emissions during refueling at the gas pump and during refilling of underground gasoline storage tanks, and reduces evaporative emissions from vehicle fuel systems. For this analysis, we assume that fuel volatility is reduced to nine pounds per square inch during the five-month summertime period when most ozone concentrations most often exceed the standard.

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[45] Nitrogen oxides, carbon monoxide, and particulate emissions reduction benefits are also gained by I/M programs, but are not calculated in this analysis.
46 Sierra Research, Inc., Op. Cit., fOOtnOte 44, p.‘‘3”
[47] The new emission standards used in our analysis are as follows:
(in “grams of pollutant emitted per mile traveled”, g/mile)
Passenger cars -- VOC: 0.25 g/mile; NO_x: 0.4 g/mile
Light-duty gasoline trucks (by truck weight) --
(less than 3,750 pounds) VOC: 0.34 g/mile; NO_x: 0.46 g/mile
(3,751 to 6,000 pounds) VOC: 0.43 g/mile; NO_x: 0.80 g/mile
(6,000 to 8,500 pounds) VOC: 0.55 g/mile; NO_x: 1.15 g/mile

However, for purposes of comparing total annual emissions reductions, we have scaled up the annual emissions reductions as though the volatility limits would be in effect year-round. Data for the analysis comes from EPA[48].

We estimate that limiting gasoline volatility would lower VOC emissions by about six percent in both nonattainment and attainment areas in 1993. Actual emissions reductions, in 1993, are estimated to be about 1.2 million tons per year, nationwide, of which about 440 thousand tons per year are achieved in nonattainment cities (actual VOC emissions reductions would be about 500 thousand tons nationwide, and 180 thousand tons in nonattainment areas, during the five-month ozone season). Total reductions stay relatively constant between 1993 and 2003.

Alternative Motor Vehicle Fuels: Methanol

H.R.3054 and S.1894 both mandate the use of ‘alternative” motor vehicle fuels for some ozone nonattainment areas. The “alternative” fuel which is most commonly considered for reducing ozone is methanol (either 100 percent or “neat” methanol, or a blend of at least 85 percent methanol and up to 15 percent gasoline). Current U.S. production of methanol totals about one billion gallons per year, mostly from natural gas. About 300 million gallons are currently used in oxygenated fuel blends.’[8]

Methanol is a VOC that reacts more slowly in the atmosphere and consequently produces less ozone than VOCs emitted from combustion and evaporation of gasoline. Per mile travelled, substituting methanol for gasoline as motor vehicle fuel is roughly estimated to be between 30 to 90 percent as effective in reducing ozone concentrations as completely eliminating the emissions from the gasoline-fueled vehicles.[50] Based on these estimates, substituting methanol for gasoline for 10 percent of the vehicle miles travelled (VMT) in an area would yield the same ozone benefits as simply reducing VMT by three to nine percent. The relative ozone-producing potential of gasoline and methanol-fueled vehicles depends on assumptions about the volatility limits imposed for gasoline, exhaust and evaporative emissions limits imposed on both gasoline and methanol-fueled vehicles (including limits on

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[48]U S Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, “Draft Regulatory Impact Analysis: Control of Gasoline Volatility and Evaporative Hydrocarbon Emissions from Motor Vehicles,” July 1987.

‘[8]’’ Oxygenated fuel blends” refers to gasoline to which either ethanol (grain alcohol), methanol plus ethanol, or methyl tertiary butyl ether (MTBE), a methanol derivative, has been added, resulting in a mixture which is about 90 percent gasoline by volume. S. 1894 and H. R.3054 mandate the use of oxygenated fuel blends during the colder months of the year in carbon monoxide nonattainment areas.

[50]U S.Environmental Protection Agency, "Guidance on Estimating Motor Vehicle Emission Reductions from the Use of Alternative Fuels and Fuel Blends,” EPA report number EPA-AA-TSS-PA-87-4, Research Triangle Park, NC, January 1988.

total VOCs, methanol, and formaldehyde -- a relatively reactive product of methanol combustion as well as gasoline combustion), and how vehicle design is optimized for methanol use.

Methanol substitution: centrally-owned fleets

S.1894 and H.R.3054 both include provisions for use of alternatively fueled vehicles in centrally owned vehicle fleets. In 1986, six million cars and two million light trucks in centrally owned fleets of 10 or more vehicles accounted for an estimated 15 percent of VMT nationwide.[51] For our analysis, we assume that all centrally owned fleets of 10 or more light duty vehicles in areas with design values of **0.18** ppm or higher will be required to operate strictly on neat methanol by 1993.[52] Further assuming that on a per mile basis, substituting methanol for gasoline is equivalent to reducing VOC emissions by half, a year-round requirement that methanol be substituted for gasoline would result in total VOC reductions in areas with design values of 0.18 ppm or higher of about 22,000 tons. Compared to 1985 VOC emissions, this is an average reduction of about 1.2 percent in each area.

3.4 Comparison of Potential Emissions Reductions and Reductions Needed to Attain the Ozone Standard

Without Additional Controls

Figure **3-11** shows variability among nonattainment cities in the changes in VOC emissions predicted to occur between 1985 and 1993, assuming that nothing is added to existing State and EPA regulations. For each city, at its design value, we have graphed the percentage change in emissions from the 1985 baseline expected to occur due to the regulations included in State Implementation Plans (SIP) as of 1985, the current Federal Motor Vehicle Control Program, and population and economic growth.

We have graphed cities by design value because it is a reasonable predictor of the emissions reductions needed to reach the standard. The graph also displays estimates of the reductions needed to reach the O. 12-ppm ozone standard, as a function of design value. The two curves arching across the graph represent high and low estimates of the percentage reduction in emissions that cities falling within a given design value range need attain the

[51] Automotive Fleet 1987 Fact Book, Volume 26 Supplement, p.9, Bobit publishing Co., 1987. Centrally owned fleet vehicles account for such a large fraction of VMT because each fleet vehicle is driven over two-and-a-half times as many miles in a year as is averaged by the general vehicle population.

[52] Centrally-owned fleets turn over in about three years (the total vehicle Population takes more than ten years to turn over), so we assume that fleet conversion would begin with all new vehicles registered in fleets in 1991.

VOC EMISSIONS REDUCTIONS BETWEEN
1985 AND 1993: NO ADDITIONAL CONTROLS

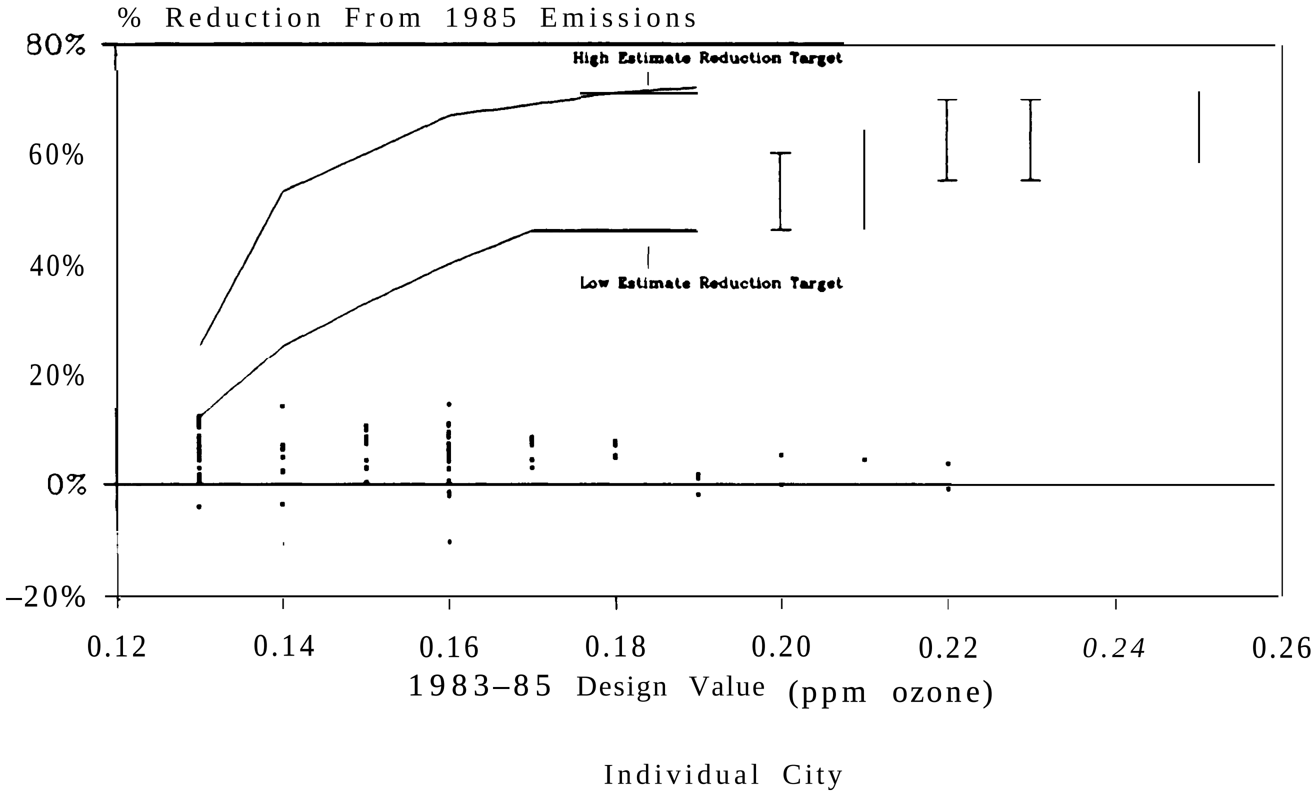

Figure 3-11. Volatile Organic Compound (VOC) Emissions Reductions Between 1985 and 1993, Assuming No Change from 1985 VOC Regulations.

Each square represents a nonattainment city. The location on the graph shows the VOC emissions reductions (as a percentage of 1985 levels) by 1993 given the State and EPA VOC regulations in place in 1985. Cities below the "0%" line experience a net increase in emissions between 1985 and 1993. The horizontal axis shows the "design value", a measure of peak ozone concentration used to determine the emissions reductions needed to attain the ozone standard. The two curves arching across the graph and vertical bars to the right of the curies show the upper and lower bounds of VOC reductions needed to attain the standard. The vertical bars show estimated control requirements explicitly for major urban areas with area-wide design values greater than 0.19 ppm.

standard. The area between these two curves represents a range of uncertainty in our estimates of required emissions reductions. The five vertical bars to the right of the two curves represent estimates of emissions reduction requirements for individual cities with design values above 0.19 ppm. Areas with design values above 0.19 ppm have been excluded from the graph because they are thought to be impacted significantly by transport from large cities upwind. We have also omitted three cities with design values greater than 0.26 ppm (all three are in southern California).

Summarizing how to read Figure 3-11, the *squares* show the change in VOC emission in each nonattainment city *projecled* for 1993 (assuming existing regulations) and the curves and vertical bars show the upper and lower bounds of the change ***needed,*** **in** each city, to attain the ozone standard by 1993.

As Figure 3-11 illustrates, the change in VOC emissions that would occur by 1993 without further control ranges from an increase of about 10 percent to a reduction of about 15 percent. Emissions in most cities are expected to decline, due to the replacement of today's cars with lower- emitting new cars. However, emissions may increase in some cities that are expected to experience high population growth.

Note that without additional controls only a few cities with design values of 0.13 ppm may be able to attain the ozone standard by 1993. Most nonattainment areas will not be much closer to meeting the standard than they are today.

With Additional Fuel Volatility Limitations and Onboard Controls

In the previous subsection, we analyzed the emissions reductions which would be expected in 1993 if only State and federal regulations existing in 1985 were to be applied; these estimates represent a "no-further-control" scenario from which we can gauge the effectiveness of additional control measures. Recently, EPA announced proposals requiring limits on fuel volatility[53] and Onboard controls on new motor vehicles.[54] Because these controls could become law in the near future, their exclusion from a baseline "no-further-control" scenario in a future year may not be appropriate. Therefore, the purpose of this subsection is to show how the addition of these two control strategies would affect future emissions reductions if they were added to the "no-further-control" baseline scenario.

Figures 3-12 and 3-13 illustrate the percent reductions which would be achieved in 1993 and 2003, respectively, from existing regulations plus fuel volatility and Onboard controls (assuming these regulations are adopted in the near future). On average, in 1993,

[53] 52 *Federal Register* 31274 (Aug. 19, 1987)

[54] Ibid., p. 31162.

VOC EMISSIONS REDUCTIONS BETWEEN 1985 AND 1993: WITH ONBOARD AND ADDITIONAL FUEL VOLATILITY CONTROLS

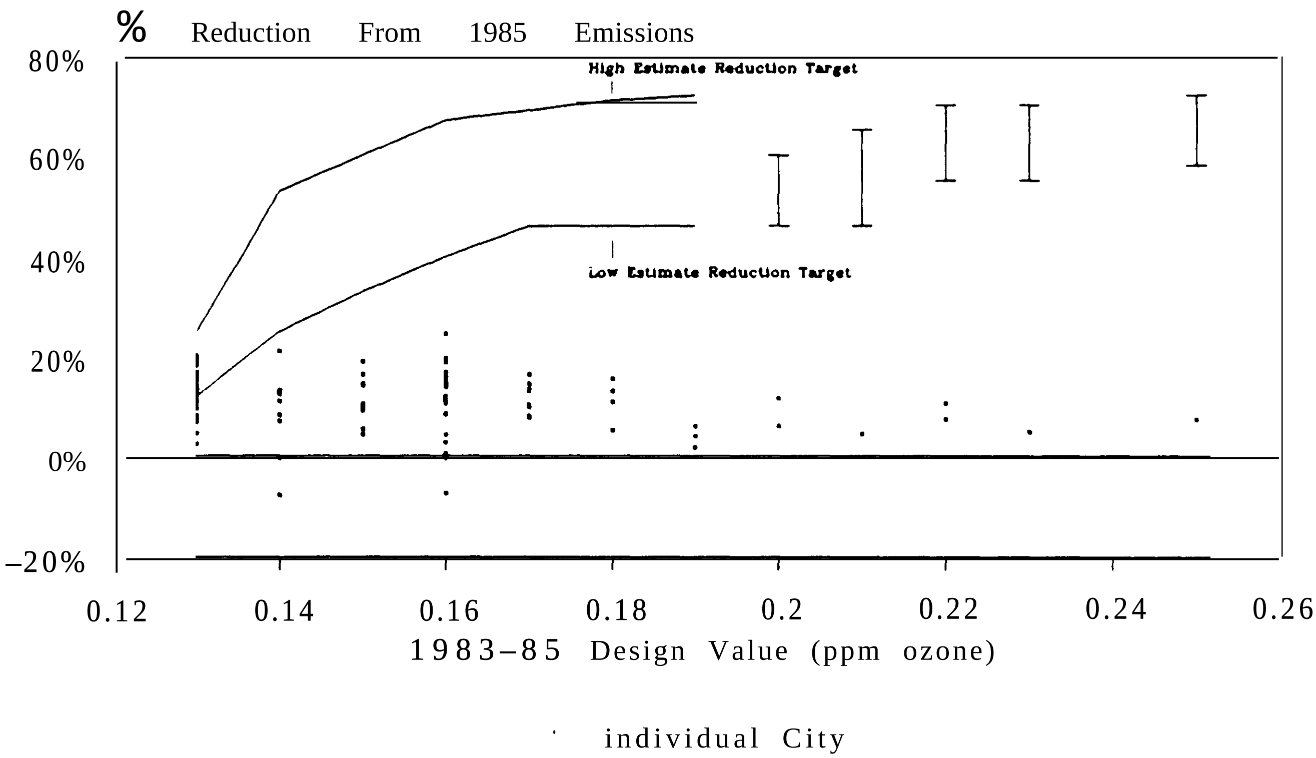

Figure 3-12. Volatile Organic Compound (VOC) Emissions Reductions Between 1985 and 1993, Including Onboard and Additional Fuel Volatility Controls.

Each square represents a nonattainment city. The location on the graph shows the projected VOC emissions reductions (as a percentage of 1985 levels) that each city can achieve by 1993 if Onboard technology (to control motor vehicle gasoline refueling emissions) and fuel volatility limits are adopted in addition to the State and EPA VOC regulations in place in 1985. Cities below the "0%" line experience a net increase in emissions between 1985 and 1993. The horizontal axis shows the "design value", a measure of peak ozone concentration used to determine the emissions reductions needed to attain the ozone standard. The two curves arching across the graph and vertical bars to the right of the curves show the upper and lower bounds of VOC reductions needed to attain the standard. The vertical bars show estimated control requirements explicitly for major urban areas with area-wide design values greater than 0.19 ppm.

VOC EMISSIONS REDUCTION BETWEEN 1985 AND 2003: EXISTING CONTROLS PLUS ONBOARD AND ADDIITIONAL FUEL VOLATILITY CONTROLS

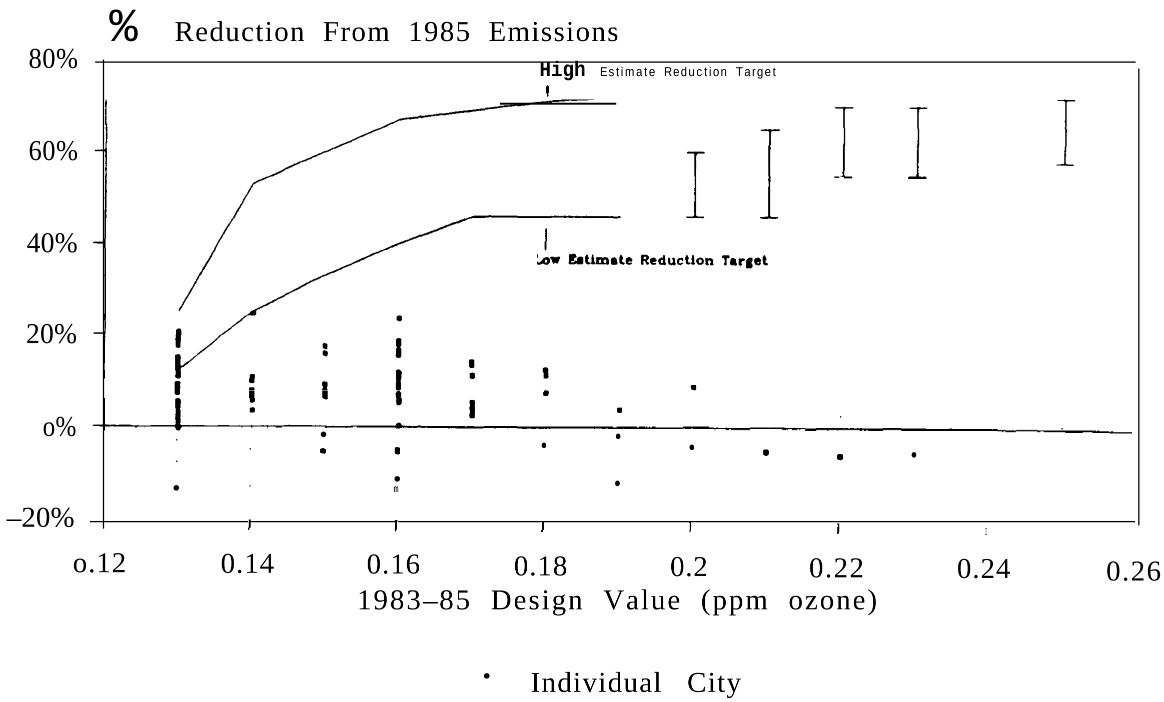

Figure 3-13. Volatile Organic Compound (VOC) Emissions Reductions Between 1985 and 2003, Including Onboard and Additional Fuel Volatility Controls.

Each square represents a nonattainment city. The location on the graph shows the projected VOC emissions reductions (as a percentage of 1985 levels) that each city can achieve by 2003 if Onboard technology (to control motor vehicle Gasoline refueling emissions) and fuel volatility limits are adopted in addition to the State and EPA VOC regulations in place in 1985. Cities below the "O%" line experience a net increase in emmissions between 1985 and 2003. The horizontal axis shows the "design value", a measure of peak ozone concentration used to determine the emissions reductions needed to attain the ozone standard. The two curves arching across the graph and vertical bars to the right of the curves show the upper and Lower bounds of VOC reductions needed to attain the standard. The vertical bars show estimated control requirements explicitly for major urban areas with area-wide design values greater than 0.19 ppm.

fuel volatility limits will lower emissions by about an additional six percent below 1985 levels; Onboard controls have only a minor effect in 1993 due to the small numbers of Onboard-equipped vehicles which would be on the road. As illustrated in Figure 3-12, when these control measures are added the percent reductions in many cities with design values of 0.13 ppm fall between the two curves. These cities may be able to attain the ozone standard in 1993. By 2003, most cars and trucks will be equipped with Onboard controls. Even so, Figure 3-13 shows that in 2003, the picture does not substantially improve compared to 1993, primarily because of the influence of additional emissions due to population and economic growth. Fuel volatility and Onboard controls, alone, are not expected to offset new emissions growth in 2003.

With All Control Strategies Analyzed by OTA

Figure 3-14 illustrates the percent reduction in VOC emissions that could be achieved by requiring all the control strategies listed in the beginning of this section. Emissions in 1993 would be lowered between about two and 40 percent, depending on the city. Figure 3-15 shows that emissions reductions do not substantially change between 1993 and 2003. This "flat" trend between 1993 and 2003 is due to the competing influences of population growth (which drives new emissions growth) and the effects of additional emissions control programs. The emissions reduction benefits from these programs act to cancel out new emissions growth due to rising populations.

For some cities, the VOC emissions reductions from all controls may be more than needed to attain the ozone standard. For other nonattainment cities with slightly higher design values, the reductions projected for 1993 fall within the range of reductions which might be needed. For most cities, however, projected reductions fall considerably below the amount needed to meet the standard. The issues of excess, or overcontrol, and reduction shortfalls (undercontrol) are discussed in the next subsection.

As stated earlier, the emissions reductions reported here represent control methods that we know can be applied in the near term. We are able to analyze the emissions reduction potential for about three-quarters of the VOC emissions inventory. The remaining one-quarter represents mostly emissions from stationary sources for which we either could not find applicable control methods or that we could not analyze because of a lack of suitable information.

Estimates of Possible Excesses and Shortfalls in Emissions Reductions Required to Attain the Ozone Standard

In this section we estimate: 1) the extent of *overcontrol* in nonattainment cities with the lowest design values, and 2) the *shortfall* in nonattainment cities with higher design values, expected to occur after applying all of the VOC controls discussed earlier. Table 3-9

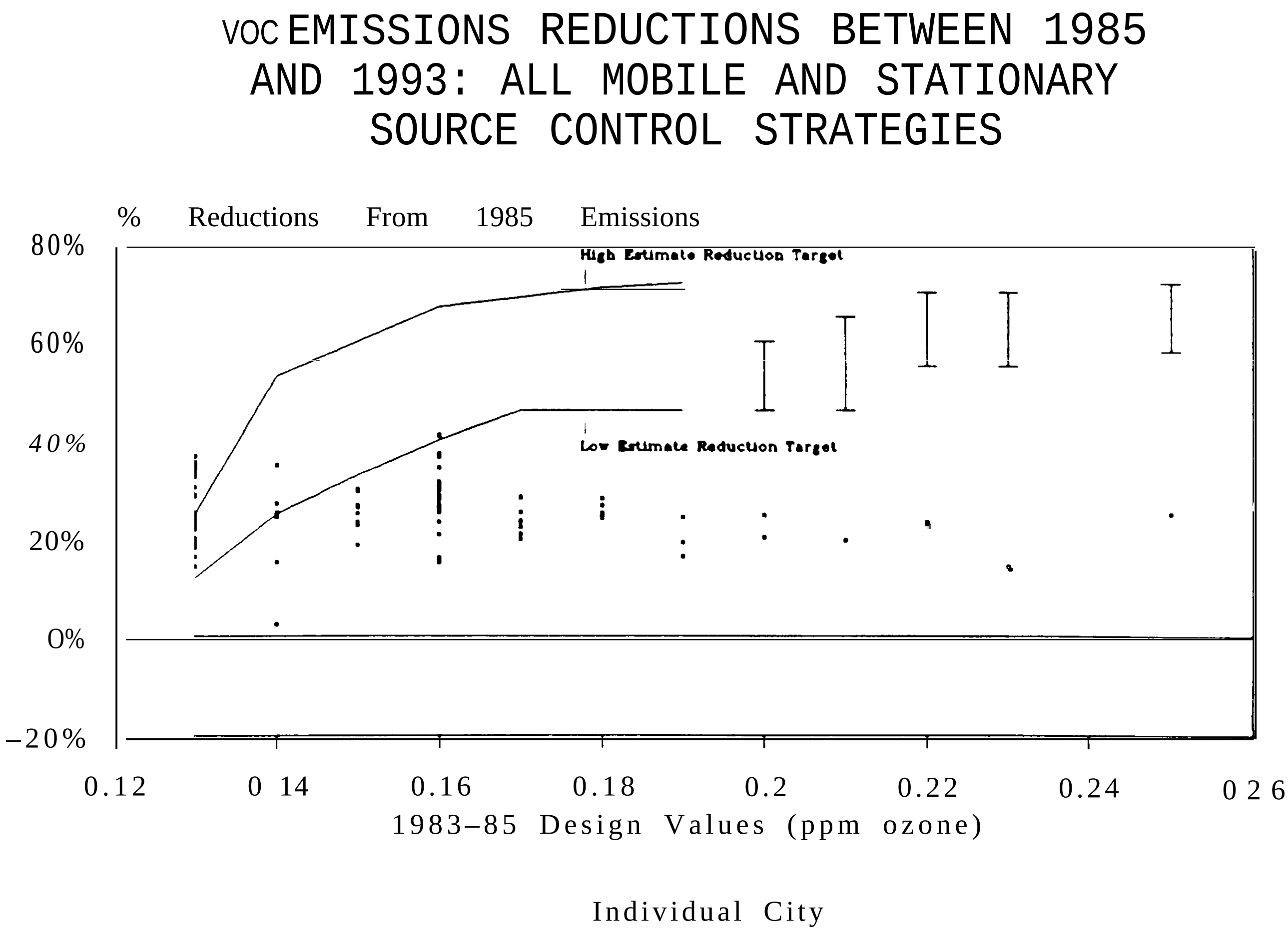

Figure 3-14. Volatile Organic Compound (VOC) Emissions Reductions Between 1985 and 1993, Including All Mobile and Stationary Source Control Strategies.

Each square represents a nonattalnment city. The location on the graph shows the projected VOC emissions reductions (as a percentage of 1985 levels) that each city can achieve by 1993 if all additional mobile and stationary source control strategies we analyzed are adopted in addition to the State and EPA VOC regulations in place in 1985. The horizontal axis shows the "design value", a measure of peak ozone concentration used to determine the emissions reductions needed to attain the ozone standard. The two curves arching across the graph and vertical bars to the right of the curves show the upper and lower bounds of VOC reductions needed to attain the standard. The vertical bars show estimated control requirements explicitly for major urban areas with area-wide design values greater than 0.19 ppm.

VOC EMISSIONS REDUCTIONS BETWEEN 1985 AND 2003: ALL MOBILE AND STATIONARY SOURCE CONTROL STRATEGIES

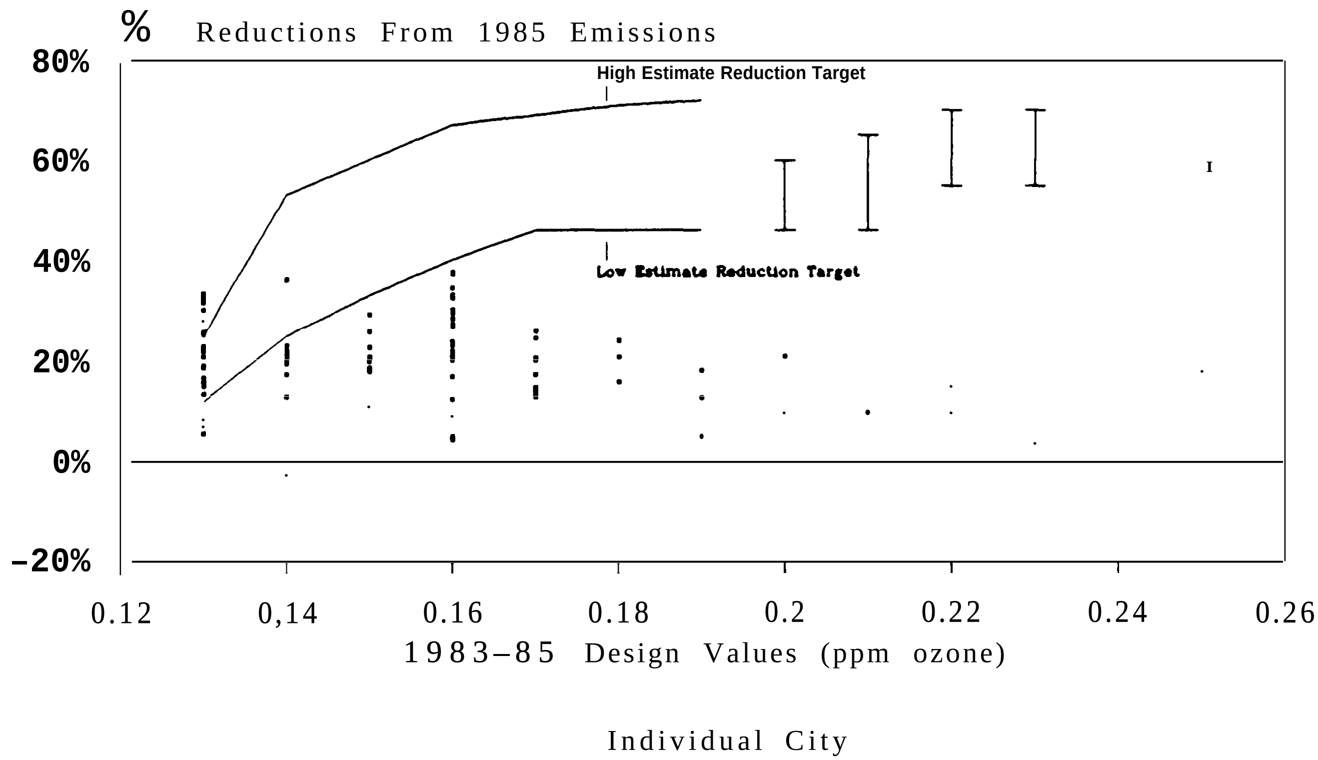

Figure 3-15. Volatile Organic Compound (VOC) Emissions Reductions Between 1985 and 2003, Including All Mobile and Stationary Source Control Strategies.

Each square represents a nonattainment city. The location on the graph shows the projected VOC emissions reductions (as a percentage of 1985 levels) that each city can achieve by 2003 if all additional mobile and stationary source control strategies we analyzed are adopted in addition to the State and EPA VOC regulations in place in 1985. The horizontal axis shows the "design value", a measure of peak ozone concentration used to determine the emissions reductions needed to attain the ozone standard. The two curves arching across the graph and vertical bars to the right of the curves show the upper and lower bounds of VOC reductions needed to attain the standard. The vertical bars show estimated control requirements explicitly for major urban areas with area-wide design values greater than 0.19 ppm.

Table 3-9. Estimates of Possible Overcontrol Resulting From All VOC Control Strategies, in 1993

Nonattainment Cities by Design Value Category (ppm O_3)	1985 Emissions (1000 tons/year)	Possible Overcontrol[a] 1000 Tons/Year		% of 1985 Emissions	
		Best Estimate	Range	Best Estimate	Range
0.13-0.14	2,200	99	1-290	4	0-13
0.15-0.17	3,600	0	0-1	0	0
0.18-0.26	1,100	0		0	
> 0.26	770	0		0	
Totals	7,700	99	1-290	1.3	0-3.7

[a] *Possible overcontrol* represents the VOC emissions reductions in excess of the total reductions needed to attain the ozone standard.

displays estimates of overcontrol from all VOC control strategies in 1993. We present a "best estimate" as well as an uncertainty range for the four design value categories. To obtain these estimates, we calculate the reductions in VOC emissions required to reach the ozone standard in each city, assuming both VOC- and NO_x-rich conditions. (An earlier subsection explains how the particular mix of pollutants in a city affects the reductions required to meet the standard.) Because we do not have data on the pollutant mix in each city, we feel it is important to present a range of uncertainty, in addition to the estimate one would expect if all cities had the nationwide average mix of VOCs and NO_x.

Our best estimate is that adoption of all controls might over control VOC emissions in low design-value nonattainment cities by about 100 thousand tons per year, or about four percent of their 1985 emissions. The overcontrol possible in these cities ranges from zero to 290 thousand tons per year.

VOC reductions in attainment areas are a potentially significant source of overcontrol in the sense that these areas do not need to reduce their emissions any further to meet the ozone standard locally. We know that there will be *some* benefit to nonattainment cities from controls in attainment areas, especially those in ozone transport regions, but we are not able to estimate how much. Moreover, even in cities that already meet the standard, lowering ozone concentrations even further will provide some benefit. Both S.1894 and H.R.3054 explicitly mandate VOC controls in attainment areas in regions of the country where transport of ozone and its precursors is a problem. Under S.1894, for example, VOC emissions reductions in attainment areas in ozone transport regions could be about 570 thousand tons per year in 1993 (about a 16 percent decrease based on 1985 emissions) after adoption of all applicable controls.[55] The total emissions reduction in all attainment areas from application of the <u>nationwide</u> control measures discussed above is about one million tons of VOCs per year, in 1993, or about nine percent, based on 1985 emissions. These reductions result from controls on small VOC sources, limits on fuel volatility, Onboard controls, and more stringent tailpipe standards for highway vehicles.

Table 3-10 presents our estimates of the additional VOC emissions reductions nonattainment cities must achieve to attain the ozone standard after all controls have been applied. Calculation procedures are similar to those discussed above. Our best estimate is

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[55] We assume that all VOC control strategies listed earlier, <u>except</u> Stage II and new CTG's, also apply in attainment areas in regions of the country where ozone transport is a problem. Of the 570 thousand tons per year of VOC reductions, about 270 thousand tons are from RACT and enhanced I/M programs; 300 thousand tons are from federal controls, fuel volatility limits, and Onboard more stringent highway vehicle standards.

Table 3-10. Estimates of Possible Undercontrol Resulting From All VOC Control Strategies, in 1993

Nonattainment Cities by Design Value Category (ppm O_3)	1985 Emissions (1000 tons/year)	Possible Undercontrol[a b]: 1000 Tons/Year — Best Estimate	1000 Tons/Year — Range	% of 1985 Emissions — Best Estimate	% of 1985 Emissions — Range
0.13-0.14	2,200	89	10-260	4	0-12
0.15-0.17	3,600	940	470-1,400	26	13-39
0.18-0.26	1,100	410	290-520	36	26-46
> 0.26	770	490	460-540	64	60-70
Totals	7,700	**1,900**	1,200-2,700	25	16-35

[a] *Possible undercontrol* represents the extra emissions reductions cities would need to attain the ozone standard.

[b] Emissions reductions from use of methanol as a motor vehicle fuel are not included in this analysis. Inclusion of this strategy in cities with design values greater than, or equal to, 0.18 ppm would decrease undercontrol (i.e., increase emissions reductions) by about one percent.

that the shortfall of emissions reductions will be about 1.9 million tons per year in 1993, or about 25 percent of 1985 emissions in these areas.[56] The shortfall in 1993 could be as low as 1.2 million or as high as 2.7 million tons per year.

3.5 Costs of Control Strategies Analyzed by OTA

This section summarizes the costs of the control strategies analyzed by OTA. Because we are unable to analyze the cost of *additional* emission controls required to make up the shortfall discussed above, we are not able to estimate the total costs of actually attaining the standard.

We estimate that the total cost of all controls analyzed by OTA in nonattainment cities will be about $5.8 billion to $6.8 billion per year, in 1993. By 2003, costs will increase to about $7.7 billion to $8.9 billion per year in nonattainment cities, primarily because of the higher percentage of highway vehicles with more stringent controls. Table 3-11 displays the costs in 1993, 1998, and 2003 by source category. Figure 3-16 displays the ranges of costs in nonattainment cities in 1993 and 2003.

Table 3-12 presents the “cost-effectiveness” (the cost per ton of VOC eliminated) of specific control measures for the three forecast years. Figure 3-17 illustrates the cost-effectiveness of control measures in nonattainment cities in 1993. The solid bars represent the average cost-effectiveness in all nonattainment cities. Uncertainty in the cost effectiveness estimates is denoted by the thin horizontal lines. Note the wide range in average cost-effectiveness across control measures, from about $500 per ton for limits on fuel volatility to about $39,000 per ton for methanol fuels.

We also analyzed the cost and emissions reduction impacts of limiting the application of controls on individual sources to those where the cost-effectiveness is equal to, or less than, $5,000 per ton of VOCs reduced. We estimate that in 1993, by not requiring controls that would cost more than $5,000 per ton, total costs in nonattainment cities would drop about $1.6 billion per year, lowering total costs by about 26 to 31 percent. About 200 thousand tons per year of VOC emissions reductions would be lost in nonattainment cities, lowering total reductions by about 12 percent. The declines occur entirely in the “RACT-on-all-sources” and “New-CTGs” categories.

A brief discussion of the costs and cost-effectiveness of each of the control strategies, including the data sources from which the estimates are calculated, follows.

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[56] It is interesting to note that the magnitude of this shortfall (25 percent) is roughly equivalent to the portion of the inventory that we are unable to analyze.

Table 3-11. Estimated Costs of Selected Control Strategies Analyzed by OTA
(costs in million dollars per year)[a]

	1993			1998			2003		
	Nonattainment Cities	Attainment Areas	Total	Nonattainment Cities	Attainment Areas	Total	Nonattainment Cities	Attainment Areas	Total
RACT	1,600	--[b]	1,600	1,700	--	1,700	1,900	--	1,900
New CTGs	300	.-	300	310	--	310	320	--	320
Federal Controls	420	390	810	440	400	840	460	420	880
Onboard	90	97	190	240	250	490	350	350	720
Stage II	190	---	190	220	--	220	240	--	240
Enhanced I/M (low)[c]	2,500	--	2,500	2,800	--	2,800	3,100	--	3,100
Fuel Volatility (low)[d]	94	150	240	91	150	240	93	160	250
New Highway Vehicle Standards[e]	250	330	580	680	920	1,600	980	1,300	2,300
Methanol Fuels	860	--	860	770	--	770	810	--	810
TOTAL (low estimate)	5,800	910	6,800	6,800	1,700	8,400	7,700	2,200	10,000
TOTAL (high estimate)	6,800	1,000	7,800	7,800	1,800	9,600	8,900	2,300	11,000

[a] Totals are rounded.
[b] "--" means control strategy applied only in nonattainment cities.
[c] Includes costs of VOC, NO_x, and carbon monoxide control.
[d] Estimates are equivalent annual costs. Controls required only five months out of the year.
[e] Includes costs of both VOC and NO_x control.

Strategy Descriptions

RACT = "Reasonable Available Control Technology" on all existing stationary sources that emit more than 25 tons per year of VOC.
New CTG's = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.
Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).
Onboard controls on motor vehicles to capture gasoline vapor during refueling.
Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.
Fuel volatility controls which limit the rate of gasoline evaporation.
Enhanced inspection and maintenance (I/M) programs for cars and light-duty trucks.
New highway-vehicle emission standards for passenger cars and light-duty gasoline trucks.
Methanol fuels as a substitute for gasoline as a motor vehicle fuel.

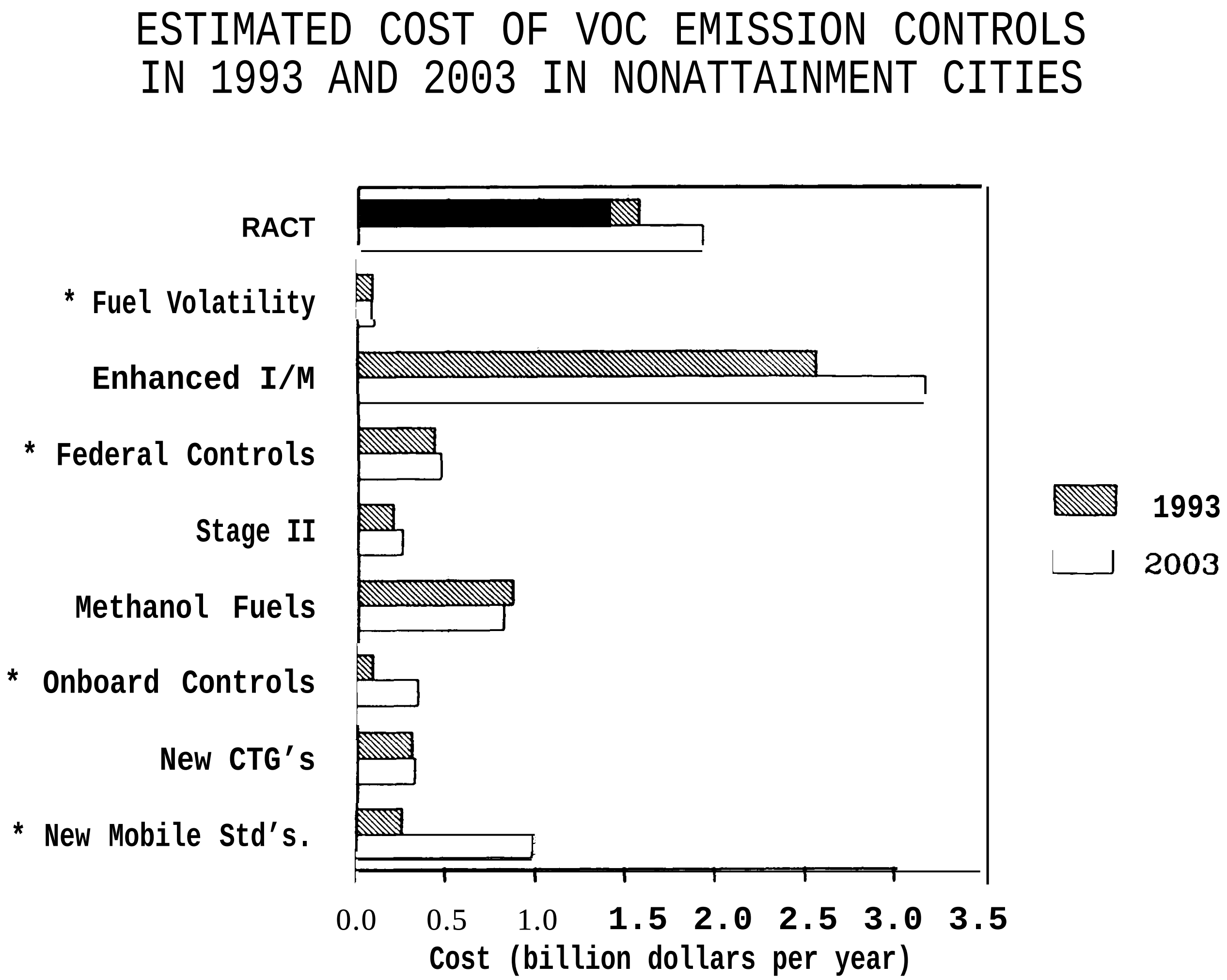
Table 3-12.Estimated Cost-Effectiveness of Selected Control Strategies Analyzed by OTA
(dollars per ton of VOC reduced)

	1993			1998			2003		
	Nonattainment Cities	Attainment Areas	Nationwide	Nonattainment Cities	Attainment Areas	Nationwide	Nonattainment Cities	Attainment Areas	Nationwide
RACT	2,900-7,200	--[a]	--	3,000-7,300	--	--	3,200-7,300	--	--
New CTGs	5,000-7,300	--	--	5,100-7,300	--	--	5,100-7,400	--	--
Federal Controls	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700	1,700
Onboard	1,100-1,300	1,100	1,100-1,300	1,200-1,400	1,200	1,200-1,400	1,200-1,400	1,200	1,200-1,400
Stage 11	1,000	--	--	1,000	--	--	1,000	--	--
Stage II & Onboard	1,200	1,100	1,200	1,700	1,200	1,500	1,900	1,200	1,600
Enhanced I/M[b]	2,500-5,100	--	--	3,200-6,400	--	--	3,400-6,800	--	--
Fuel Volatility[c]	320-700	320-700	320-700	320-700	320-700	320-700	320-700	320-700	320-700
New Highway Vehicle Std's[b]	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400	2,400
Methanol Fuels	39,000	--	--	39,000	--	--	39,000	--	--

a "--" Means control strategy is applied only in nonattainment cities.
b Estimates reflect costs associated with VOC control only. Enhanced I/M controls also applies to NO_x and carbon monoxide emissions; new highway vehicle standards also apply to NO_x emissions.
c Estimates reflect cost-effectiveness during the five-month summertime period when controls are required.

Strategy Descriptions

RACT = 'Reasonable Available Control Technology" on all existing stationary sources that emit *more* than 25 tons per year of VOC.
New CTG's = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.
Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).
Onboard controls on motor vehicles to capture gasoline vapor during refueling.
Stage II control devices on gas pumps to capture Baseline vapor during motor vehicle refueling.
Fuel volatility controls which limit the rate of gasoline evaporation.
Enhanced inspection and maintenance (I/M) programs for cars and light-duty trucks.
New highway-vehicle emission standards for passenger cars and light-duty gasoline trucks.
Methanol fuels as a substitute for gasoline as a motor vehicle fuel.



• Costs in **attainment areas** not shown.

Figure 3-16. Estimated Cost of Volatile Organic Compound (VOC) Emission Control Strategies in 1993 and 2003 in Nonattainment Cities,

The cost of Enhanced Inspection and Maintenance (1/M) programs includes nitrogen oxide and carbon monoxide control. The cost of New Mobile Standards includes nitrogen oxide control.

Strategy Descriptions

RACT = "Reasonably Available Control Technology" on all existing sources that emit more than 25 tons per year of VOC.

Fuel Volatility standards that limit the rate of gasoline evaporation.

Enhanced Inspection and Maintenance (I/M) programs for passenger cars and light-duty trucks.

Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Stage II control devices on gas pumps to capture gasoline vapor during motor vehicle refueling.

Methanol Fuels as a substitute for gasoline as a motor vehicle fuel.

Onboard controls on motor vehicles to capture gasoline vapor during refueling.

New CTGs = new Control Technique Guidelines for existing stationary *sources* that emit more than 25 tons per year of VOC.

New Mobil Standards = more stringent tailpipe emission standards for passenger cars and light-duty gasoline trucks.

ESTIMATED COST-EFFECTIVENESS OF VOC EMISSION CONTROL STRATEGIES IN 1993 IN NONATTAINMENT CITIES

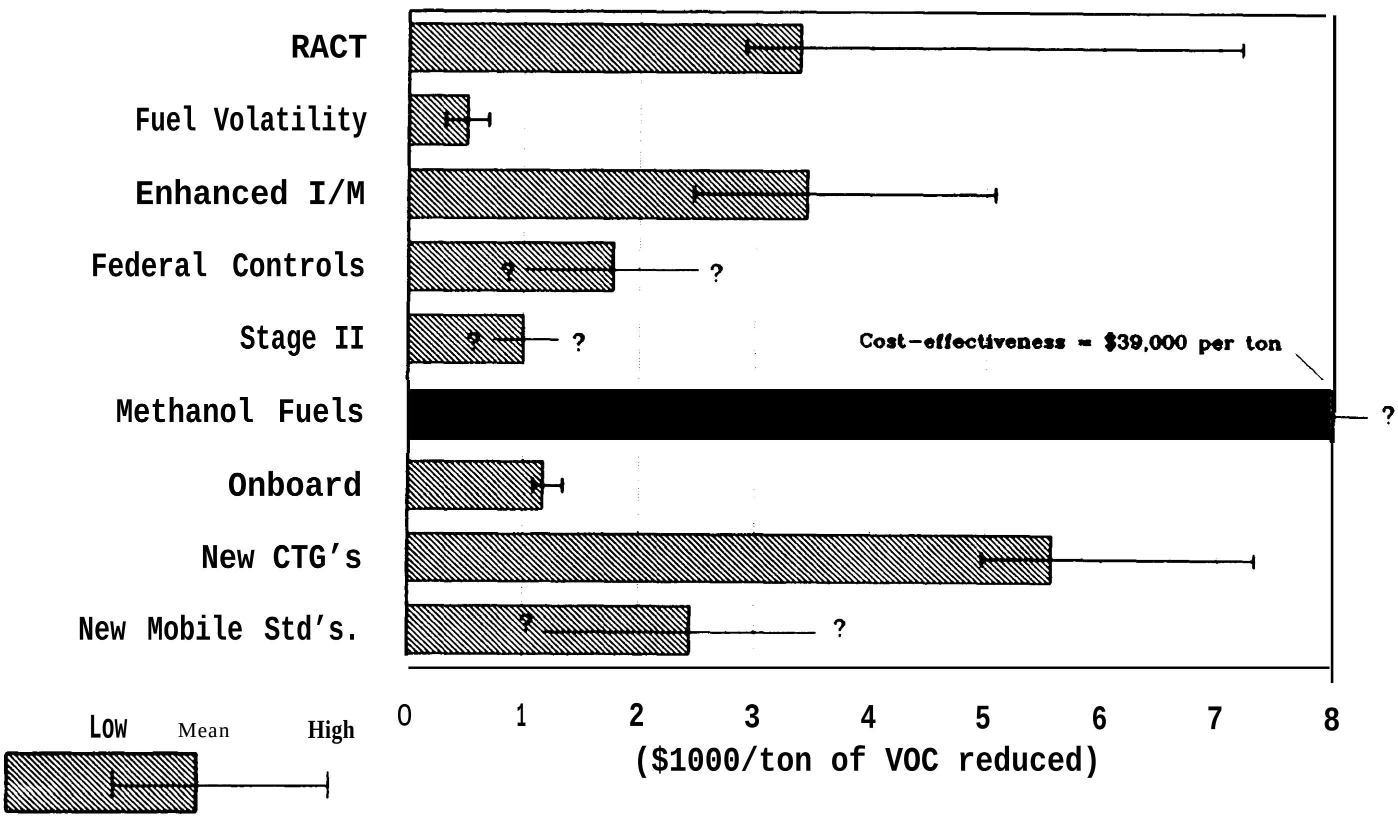


Figure 3-17. Estimated Cost-Effectiveness of Volatile Organic Compound (VOC) Emission Control Strategies in 1993 in Nonattainment Cities.

The cost-effectiveness of Enhanced Inspection and Maintenance (1/M) programs and New Mobile Standards include only the coat of VOC control. The thin horizontal lines represent ranges of uncertainty. The "?" attached to these lines means that calculation of uncertainty was not possible. The very large uncertainty associated with the Methanol Fuels is due to the uncertainty of methanol prices relative to gasoline prices.

Strategy Descriptions

RACT = "Reasonably Available Control Technology" on all existing sources that emit more than 25 tons per year of VOC.

Fuel Volatility standards that limit the rate of gasoline evaporation.

Enhanced Impection and Maintenance(I/M) programs for passenger cars and light-duty trucks.

Federal Controls on selected small stationary sources of VOC (consumer and commercial solvents, and architectural surface coatings).

Stage II control devices on gas pumps to capture Gasoline vapor during motor vehicle refueling.

Methanol Fuels as a substitute for gasoline as a motor vehicle fuel.

Onboard controls on motor vehicles to capture gasoline vapor during refueling.

New CTGs = new Control Technique Guidelines for existing stationary sources that emit more than 25 tons per year of VOC.

New Mobile Standards more stringent tailpipe emission standards for passenger cars and light-duty gasoline trucks.

Reasonably Available Control Technology (RACT) on All Stationary Sources

Total costs in nonattainment cities for this category are predicted to be about $1.6 billion per year, in 1993, averaging about $2,900 to $7,200 per ton of VOC removed.

As mentioned in an earlier subsection, this control strategy applies to about 39 broad source categories such as petroleum refining, certain types of chemical manufacturing, gas stations, etc. A complete list, with our assumptions about control efficiencies and cost-effectiveness for each source type, is included in Appendix A.

Adoption of New "Control Technique Guidelines" (CTG's)

As stated earlier, we analyzed four stationary source categories currently being considered as candidates for new CTG's: wood furniture coating, plastic parts coating, automobile refinishing, and coke-oven byproduct plants.

We estimate that new CTG's would cost about $300 million per year in 1993, all of which would be incurred in nonattainment cities. The cost-effectiveness averages about $5,600 per ton with a range of $5,000 to $7,300 per ton. Appendix A lists the cost assumptions used in our analysis.

Federal Controls **on Small VOC Sources**

The small amount of cost data available for architectural surface coatings revealed a wide range of estimates, from a net *savings* to default costs of $2,000 per ton of reduction. We assume that controls for this source cost about $1,000 per ton of VOC reduced. For commercial and consumer solvents we assume a default cost of **$2,000** per ton.

We estimate that, in 1993, federal controls on small VOC sources would cost about $810 million per year, nationwide, with about $420 million per year incurred in nonattainment cities. The average cost-effectiveness is estimated to be about $1,700 per ton of VOC removed.

Controls on Gasoline Emissions From Vehicle Refueling

"Onboard" refueling controls on motor vehicles

We estimate the cost of Onboard controls by 1993 to be about $190 million per year, nationwide, with about $90 million per year incurred in nonattainment cities. By 2003, costs would total $720 million per year, nationwide, because of the higher percentage of On board-equipped vehicles on the road. The average nationwide cost-effectiveness is estimated to be about $1,100 per ton in 1993.

For this analysis, we assume that all gasoline vehicles manufactured in 1991 and later will be equipped with Onboard controls to capture gasoline vapors during refueling. By 2003, all gasoline vehicles on the road will be equipped with these controls. We assume that Onboard controls cost about $25 per vehicle, which is close to EPA's upper bound estimates'. Note, however, that others conclude that the costs are higher. A study for the Motor Vehicle Manufacturers Association estimates average per-vehicle costs of $80 for model-year 1991 vehicles .58

"Stage II" refueling vapor recovery

We estimate the cost of Stage II controls to be about $190 million per year in 1993, all of which is incurred in nonattainment cities. This estimate is based on a cost-effectiveness of $1,000 per ton of VOC removed. This figure represents EPA's upper bound range as presented in the recent gas-marketing regulatory impact analysis.[59]

Combined Stage II and Onboard controls

We assume that the cost of a combined Stage II and Onboard program is the sum of the cost of each individual program. Therefore, in 1993, we estimate the cost to be about $380 million per year, nationwide, with approximately $280 million per year incurred in nonattainment cities. Nationwide costs increase to about $960 million per year in 2003. The nationwide combined cost-effectiveness in 1993 is estimated to be about $1,200 per ton of VOC removed and is expected to increase to about $1,600 per ton by 2003 because of fleet turnover.

Enhanced Motor Vehicle Inspection and Maintenance (1/M) Programs

We estimate that enhanced I/M programs in nonattainment cities cost between about $2.1 billion and $3.0 billion per year. In 2003, costs are expected to rise to between about $2.6 billion and $3.7 billion per year. Assuming that one-third of the total costs are for VOC reductions (the other two-thirds for NO_x and carbon monoxide), the cost-effectiveness in 1993 is estimated to be between $2,500 and $5,100 per ton of VOC reduced. In 2003, the cost-effectiveness will increase to between $3,400 to $6,800 per ton; this rise is due to the fact that cars and trucks will be cleaner in 2003, thus lowering the emission reduction potential of enhanced I/M programs.

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[57]U.S. Environmental Protection Agency, op.cit., footnote 41, p. 2-51

[58]Multinational Business Services, Inc., "Costs and Cost-Effectiveness of Stage II and Onboard Refueling Vapor Controls," prepared for the Motor Vehicle Manufacturers Association of the United States, Inc., and the Automobile Importers of America, Inc., April 1987, p. 4-14.

[59]U.S. Environmental Protection Agency, op.cit., footnote 41'

Our estimates of enhanced I/M program costs are based on an analysis of the California I/M program, prepared for the California Air Resources Board by Sierra Research, Inc.[60] We use Sierra Research's finding that an enhanced I/M Program costs about $50 Per vehicle. About $20 of this cost is for the inspection fee and program administration. The remainder is for repair costs, which we assume to range between $70 and $100 per vehicle for one-third of the vehicles inspected. Sierra Research's analysis concludes that an enhanced I/M program can reduce VOC emissions from cars and light-duty trucks by about 30 percent. This is about 17 percent higher than current I/M programs. For those cities that already have an I/M program in place, we credit $20 per vehicle as the cost of the existing program.

These costs are quite a bit higher than EPA estimates.[61] The major difference seems to be assumptions about whether repair costs drop after the program has been operating a few years.

<u>More stringent Highway-Vehicle Emission Standards</u>

We estimate that the total cost of tighter emission standards for highway vehicles in 1993 will be about !$580 million per year, nationwide, of which about $250 million per year will be incurred in nonattainment cities. By 2003, costs will total about $2.3 billion per year, nationwide, because a higher percentage of vehicles on the road will be equipped with new controls. These totals include the costs attributed to <u>both</u> VOC and NO_x control on new passengers cars and light-duty gasoline trucks. Costs are based on an OTA contractor report by Sierra Research, inc. (1988), that estimated new emission control costs of about $140 per vehicle for combined VOC and NO_x control.[62] Reductions of VOC are estimated to cost about $2,400 per ton of VOC reduced. (The cost-effectiveness of combined VOC and NO_x control is about $9,200 per ton of VOC and NO_x reduced.) As described earlier, we analyzed more stringent standards that can be met after 50,000 miles of driving under *controlled* conditions for cars, and 120,000 miles for light-duty trucks; tailpipe VOC emissions may exceed these standards after 50,000 miles (for cars) and 120,000 miles (for trucks) of *actual* use by individual vehicle owners.

<u>Limits on **Fuel Volatility**</u>

We estimate that reducing fuel volatility (i.e., the rate of evaporation) during the five-month summertime period costs between about $150 million and $340 million per year

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[60] Sierra Research, Inc., op. cit., footnote 44.
[61] Phil Lorang, US Environmental Protection Agency, Office of Mobile Sources, "Further OMS Reflections on the Cost of Mobile Source Provisions of the Mitchell Bill," September 10, 1987.
[62] Sierra Research, Inc., Op. cit., footnote 44.

nationwide. The cost-effectiveness, as estimated by EPA, ranges between about $320 to $700 per ton of VOC reduced.[63]

Alternative Motor Vehicle Fuels: Methanol

Because methanol is incompatible with some metals and polymers currently used in automotive fuel systems, straight methanol is not recommended for use in vehicles designed to run on gasoline. However, methanol-fueled vehicles have been built in limited runs and are currently being test driven in California. Automobile manufacturers estimate that in runs of less than about 150,000 vehicles, passenger vehicles designed to operate on methanol would cost $500 to $1,000 more per vehicle than gasoline-fueled vehicles.[64] Assuming that using methanol is equivalent to reducing total VOC emissions by 50 percent, compared to a new gasoline-fueled vehicle with refueling controls in place, and that methanol-fueled vehicles cost $500 to $1000 more than comparable gasoline-fueled vehicles, the costs associated with a methanol strategy would be roughly $10,000 to $20,000 per ton of VOC removed[65], not considering fuel costs. However, in large runs, others expect the costs of producing gasoline and methanol-fueled vehicles to be comparable, so that considering vehicle costs alone, the cost per ton of VOCs removed would be negligible.[66]

Based on estimates of the retail cost of methanol ($0.84 per gallon[67]) and the 1987 average retail price of gasoline ($0.96 per gallon[68]), and assuming that gasoline mileage is 1.8 times better than that of methanol, we estimate that fuel costs for operating motor vehicles on methanol would be about 50 percent higher than operating them on gasoline: 5.7 cents per mile for methanol versus 3.6 cents per mile for gasoline. Retail gasoline prices would have to rise above about $1.50 per gallon with no change from current prices for methanol in

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63 U.S. Environmental protection Agency, op. cit., footnote 48, pps. 6-26, 6-28.

64 "Cost and Cost Effectiveness of Alternative Fuels," prepared for the Vice President's Task Force, July 1987.

65 Assuming new gasoline-fueled vehicles emit 0.95 g/mi.

66 Ibid.

67 Based on current wholesale methanol costs of $0.60 per gallon (Alcohol Update, Information Resources, Inc., Washington DC, April 11, 1988), and $0.24 per gallon for taxes, distribution and markup.

68 Monthly Energy Review, U.S. Department of Energy, DOE/EIA-0035 (87/10), Washington DC, October, 1987, p. 96.

order for gasoline and methanol fuel costs to be equal.[69] Again assuming that methanol 'se is equivalent to reducing VOC emissions by 50 percent, the existing difference in fuel prices would result in emission reduction costs of about $39,000 per ton of VOC removed, above vehicle costs .'" Based on this cost effectiveness estimate, the total cost of a strategy in which centrally owned light-duty vehicles in areas with design values of 0.18 ppm or higher would be required to operate on methanol is estimated to be $860 million, in 1993. Finally, note that the cost effectiveness of methanol use is highly sensitive to the relative prices of methanol and gasoline. If retail methanol prices were ten cents lower than assumed above, for example, the estimated cost per ton of VOC removed would be reduced by one third, to about $26,000.

[69]The amount of methanol required to operate centrally owned fleets of 10 or more light duty vehicles year round in all areas with design values of 0.18 ppm or higher is estimated to be about 2.8 billion gallons per year. This level of methanol consumption is more than twice current U.S. production. Moreover, existing methanol production capacity worldwide is insufficient to meet this demand. Because new facilities for methanol production are unlikely to be profitable if methanol prices drop much below current levels, significantly lower methanol prices are not expected in the future.

[70]In estimating cost effectiveness it is assumed that a gasoline-fueled vehicle would get 27 miles per gallon, and emit a total of 0.95 grams VOC per mile.