US EPA ARCHIVE DOCUMENT

9.0 DISCUSSION OF FULL ATTAINMENT COSTS

9.1 RESULTS IN BRIEF

Bringing all areas of the country into attainment of the 0.08 4th Max ozone standard by the year 2010 is estimated to cost $9.6 billion annually in 2010. This cost is incremental to the costs associated with full attainment of the current hourly ozone standard, and includes the costs outlined in Chapter 7.0 associated with bringing a portion of the projected ozone nonattainment areas into attainment with the 0.08 4th Max standard. The costs beyond the partial attainment costs would be associated primarily with a relatively few areas of the country that suffer from the worst air pollution and are in need of additional emission reductions to reach attainment.

Bringing all areas of the country into attainment with the $PM_{2.5}$ 15/65 standard by the year 2010 is estimated to cost $37 billion annually in 2010. This cost is incremental to the cost associated with full attainment of the current PM_{10} standard, and includes the costs outlined in Chapter 6.0 associated with bringing a portion of the projected $PM_{2.5}$ nonattainment counties into attainment. As in the case of ozone, the costs beyond the partial attainment costs would be associated primarily with a relatively few areas of the country that suffer from the worst air pollution and are in need of additional emission reductions to reach attainment.

This regulatory impact analysis (RIA) is a snapshot of potential annualized costs for 2010, estimating both partial and full attainment. The partial attainment cost analyses presented in Chapters 6.0 - 8.0 do not include potential costs associated with arbitrarily forcing all areas into attainment prior to the maximum statutory deadlines. The full attainment analysis discussed in this chapter brings all areas into attainment by 2010, slightly before the deadlines currently in the Clean Air Act (CAA) for some areas.

US EPA ARCHIVE DOCUMENT

9.2 INTRODUCTION

This chapter presents a full attainment scenario for both the $PM_{2.5}$ and ozone standards. The costs and emission reductions associated with the partial attainment analysis of $PM_{2.5}$ outlined in Chapter 6.0 and partial attainment analysis of ozone in Chapter 7.0 are incorporated into this chapter's analysis. This full attainment analysis brings all areas into attainment by 2010, slightly before deadlines currently in the Clean Air Act (CAA) for some areas.

In reviewing these full attainment cost estimates, it is useful to keep several factors in mind. First, no analyses can accurately predict costs of control strategies for attainment goals 10 to 15 years in the future. In the case of new air quality standards, full attainment will not be finally required for 10-12 years after area designations (2012 for ozone, 2014 for PM). For a number of reasons, this is simply too long a time over which to assume accurate information related to implementation of the CAA. Historically, compliance costs over long time periods have consistently been overestimated.

The history of implementation of the CAA provides some context for this statement. Since 1970, the CAA has in many ways been a "technology-forcing" law. The obligation to meet the national air quality standards has created pressures and market opportunities for technology breakthroughs and continuous improvements. The result has been continued, affordable improvements in air quality across the country, even in the face of continued growth in the number of air pollution sources. This history, as well as a review of currently developing technologies, provides a sound basis for anticipating that technological progress will continue in response to new standards. Perhaps the most notable example of technological improvement that made past air quality improvements affordable was the introduction of catalytic technology for automobiles in the early 1970s. Predictions of economic chaos accompanied the setting of tailpipe emissions standards in the 1970 CAA, yet inexpensive catalytic technology made those standards achievable and affordable within a few years. However, for some of the areas with the most difficult air quality challenges, substantial technological advance is needed. Given EPA's

US EPA ARCHIVE DOCUMENT

modeling capabilities and assumptions of reductions required for attainment, these areas achieve approximately one third of the reductions needed to attain the new standards in 2010.

It is very difficult to predict technological improvements and their associated effects on cost because we have insufficient knowledge of which new technologies will be successful enough to have a meaningful impact on costs over the next ten to fifteen years--though history tells us such innovations will occur. One catalyst for such innovations will be the investments made to control greenhouse gases for climate change which will create a more energy efficient and less polluting economy.

Another factor which may have a significant downward influence upon actual costs relative to predicted costs is the likely replacement of many command and control pollution control systems with market-based pollution control systems. Since 1990, we have seen dramatic cost reductions associated with market-based programs. Examples of market-based air pollution control and their costs are included later in this chapter. The success of efforts such as the acid rain program under Title III of the CAA have led EPA and others to place primary reliance for implementing revised standards on new or expanded market-based programs. As a result, these approaches will likely be incorporated into new and existing control strategies at the local, regional, and national levels. Again, however, there are no clear means of incorporating the likely cost savings from these programs into current cost estimates.

A third factor which makes long-term estimates difficult, is the nature of implementation as laid out in the CAA. Under the Act, the primary responsibility for achieving national ambient air quality standards (NAAQS) falls to the states. Upon the setting of a new standard, the states begin a multi-year, sequenced process of monitoring and planning; the results of which are ultimately found in State Implementation Plans (SIPs). These SIPs are the blueprint of control strategies through which states meet their responsibility. While the federal government maintains primary responsibility for certain sources which are best controlled nationally (e.g., motor vehicles), and the CAA does provide some additional requirements, most decisions about which control strategies to utilize fall primarily to the states. This approach allows control

US EPA ARCHIVE DOCUMENT

decisions, including costs associated with those decisions, to be appropriately considered at the state and local level. But the variety of control strategies that may then be utilized in the hundreds of air quality districts across the country becomes quite difficult to incorporate into national cost estimates.

Because of the difficulty in knowing the true costs of control strategies to be implemented 10 to 15 years in the future, policy makers seeking guidance from this RIA must weigh the potential significance of predictions that, although estimates of quantified partial benefits (through 2010) clearly exceed estimates of partial costs for both pollutants, a full attainment benefit-cost comparison carries less certainty.

Looking out 10-15 years, technological breakthroughs are hard to predict. The presence of health-based air quality standards have in the past and likely will in the future accelerate the introduction of new technologies. These standards also motivate greater reliance on innovative regulatory/non-regulatory approaches as well, such as market-based strategies, pollution prevention, environmental management systems and energy-efficiency. These approaches also have the benefits of reducing greenhouse gases. In short, the analysis contained herein provides a basis for believing that during the next decade benefits resulting from efforts to meet both new air quality standards are likely to exceed costs.

In order to more fully inform policy makers and the public about cost and benefit implications, EPA intends to periodically update the analysis contained herein, both as monitoring and redesignation information becomes more complete, and as the 5-year cycle of review is completed again in 2002.

US EPA ARCHIVE DOCUMENT

9.3 METHODOLOGY AND RESULTS

To provide policymakers with as much information as possible to aid implementation planning, a full attainment analysis of both standards (0.08 4th Max and $PM_{2.5}$ 15/65) is carried out. To estimate full-attainment of the ozone standard, additional specified and unspecified control measures are assumed for areas still needing further reductions after the initial set of measures outlined in Chapters 5.0 - 7.0 are applied. The specified measures consist primarily of controls already in use, and are intended as illustrations of additional measures that could be chosen by states or local areas.

After application of the initial set of control measures analyzed in Chapter 7.0, seventeen areas are estimated to need further NO_x or VOC emission reductions to reach full attainment of the 0.08 4th Max ozone standard. Table 9.1 shows the estimated additional ozone season daily and annual emission reductions associated with full attainment of the 0.08 4th Max ozone standard. To reach full attainment, these areas are estimated to need approximately 1,000 tons per day of additional VOC emission reductions and 1,700 tons of additional NO_x emission reductions per day. Additional specified control measures would reduce this inventory by approximately 60 tons per day of VOC and 580 tons per day of NO_x. The average incremental cost effectiveness of the additional control measures included in this part of the analysis is approximately \$3,200/ton of NO_x reduced and \$4,000/ ton of VOC controlled. Emission reductions for the remaining tons (those not attributable to a specified control measure) are assumed to cost an average of \$10,000/ton for both NO_x and VOC emissions.

The estimated full attainment annual cost of the 0.08 4th Max ozone standard is \$9.6 billion (1990\$) in the year 2010. This includes the \$1.1 billion partial attainment cost estimate outlined in Chapter 7.0, and approximately \$800 million of additional specified reduction costs and \$7.7 billion of unspecified reduction costs. Characterization of full attainment costs should be considered more uncertain than cost estimates associated with the partial attainment analysis. Inclusion of control measures and their associated costs in this full attainment analysis does not

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

Table 9.1 Ozone 0.08 4th Max Estimated Full Attainment Emission Reductions

Pollutant/ Emissions Sector	Ozone Season Daily Tons					Annual Tons				
	2010 CAA Baseline Emission Level	Partial Attainment Emission Level[b]	Full Attainment Emission Level	Emission Reductions from Additional Measures[c]	Emission Reductions from Unspecified Measures	2010 CAA Baseline Emission Level	Partial Attainment Emission Level[b]	Full Attainment Emission Level	Emission Reductions from Additional Measures[c,d]	Emission Reductions from Unspecified Measures[d]
VOC										
Area	4,754	3,656		10		1,591,566	1,292,961		3,281	
Mobile	1,412	1,161		0		481,942	389,007		136	
Nonroad	1,403	1,400		9		452,781	452,426		2,890	
Point	900	884		40		328,637	322,760		13,651	
Utility	19	19		0		6,347	6,347		0	
TOTAL[e]	8,489	7,121	6,087	59	975	2,861,273	2,463,501	2,111,924	19,958	331,619
Shortfall[f]			1,034	975	0			351,577	331,619	0
NOx										
Area	1,158	1,085		0		499,705	447,274		0	
Mobile	2,699	2,441		8		969,975	882,104		3,061	
Nonroad	1,644	1,644		294		551,373	551,373		113,313	
Point	912	636		60		326,871	226,520		23,273	
Utility	554	554		218		350,786	350,539		83,795	
TOTAL[e]	6,967	6,359	4,657	580	1,122	2,698,710	2,457,811	1,802,556	223,442	431,812
Shortfall[f]			1,702	1,122	0			655,255	431,812	0

a Emissions and projected reductions needed for 17 areas projected to be residual nonattainment after application of control measures modeled in Chapter 7.0. Characterization of full attainment emission reductions and how such emission reductions would be achieved should be considered more uncertain than emission reduction estimates associated with the partial attainment analysis. Inclusion of control measures in this full attainment analysis does not represent selection of such control measures in future implementation strategies. Measures are included for illustrative purposes only. All emission reductions and shortfalls are estimated incremental to attainment of the current ozone standard.

b Emission level after application of control measures modeled in Chapter 7.0 and presented in Appendix B.

c Emission reductions from control measures discussed in Chapter 9.0 and presented in Appendix F.

d Annual tons estimated from ozone season daily tons by multiplying by 340 for VOC, and 385 for NOx. These conversion factors are derived from the average ratio of annual tons to ozone season daily tons identified in the 2010 CAA baseline and partial attainment analyses.

e Totals may not agree due to rounding.

f Shortfall represents emission reductions still needed to achieve the established target levels (see Chapter 4 for a more information on emission targets).

represent selection of such control measures in future implementation strategies. Measures are included for illustrative purposes only. All costs are estimated incremental to attainment of the current ozone standard.

A rough full attainment annual cost estimate for the selected $PM_{2.5}$ 15/65 standard is \$36.7 billion (1990\$). This cost estimate is incremental to full attainment of the current PM_{10} standard and is obtained by using the information from the partial attainment analysis to derive an estimate of additional reductions needed in each control region to reduce $PM_{2.5}$ concentrations to the level of the selected standard. The full attainment analysis assumes that these additional emission reductions are obtained at \$10,000/ton (as is assumed in the ozone full-attainment cost analysis). Tables 9.2 shows the estimate of additional emission reductions needed to fully attain the PM standard. The cost estimate was derived by the following steps:

<u>Step 1</u>: For each control region, the total NOx, SO_2, VOC, and direct PM_{10} emission reductions achieved by control measures employed in the partial attainment analysis (excluding the National PM2.5 Strategy) and the average annual $\mu g/m^3$ improvement realized in the 67 counties still violating the $PM_{2.5}$ standard after application of the National $PM_{2.5}$ Strategy were calculated.

<u>Step 2</u>: Using the information from Step 1, the $\mu g/m^3$/ton reduced in each region was calculated.

<u>Step 3</u>: The average annual average $\mu g/m^3$ shortfall in each region for the 30 residual nonattainment counties was calculated and each region's $\mu g/m^3$/ton reduced estimate (from Step 2) was multiplied by the average annual average $\mu g/m^3$ shortfall in each region to obtain an estimate of the additional emission reduction needed to eliminate the shortfall.

<u>Step 4</u>: This additional emission reduction estimate (from Step 3) was multiplied by \$10,000 per ton to obtain a cost estimate incremental to a 2010 CAA baseline cost estimate of \$38.5 billion (1990\$).

US EPA ARCHIVE DOCUMENT

Step 5: Eleven of 30 residual nonattainment areas for the $PM_{2.5}$ 15/65 standard are also projected to be in residual nonattainment for the current PM_{10} standard. The potential costs associated with the PM_{10} standard, $10.4 billion, was subtracted from the $38.5 billion estimate. The estimated annual cost of partial attainment of the $PM_{2.5}$ standard, $8.6 billion (outlined in Chapter 6.0), was added to this result. The final result is a $36.7 billion (1990$) full attainment annual cost estimate of the $PM_{2.5}$ 15/65 standard incremental to the current PM_{10} standard.

This approach assumes that additional control measures will be identified that will achieve a similar ambient reduction in particle species across a given modeling region as is achieved in the partial attainment cost analysis. The emissions inventory and control measure set used in the partial attainment cost analysis are not intended to represent the complete inventory or the complete set of potential control strategies. Therefore, using the linear relationship between control measure effectiveness and air quality improvement modeled in the partial attainment analysis may over- or under-estimate the additional air quality improvement achieved by actual additional reductions beyond partial attainment.

US EPA ARCHIVE DOCUMENT

Table 9.2 Estimate of Additional Emission Reductions Needed to Fully Attain the $PM_{2.5}$ 15/65 Alternative

Control Region	Initial Nonattainment Counties[a]			Residual Nonattainment Counties[b]	
	Emission Reductions Achieved by Regionally Applied Control Measures[c] (tons/yr) [A]	Average Annual µg/m³ Reductions Achieved by Regionally Applied Control Measures [B]	Average Emission Reductions per µg/m³ Reduction [C = A ÷ B]	Average Annual µg/m³ Shortfall [D]	Estimated Emission Reductions Needed to Eliminate Shortfall[d] (tons/yr) [E = C × D]
Midwest/Northeast	3,176,259	3.1	1,024,600	1.6	1,588,129
Southeast	278,700	2.2	126,682	0.2	25,336
South Central	1,020,106	1.7	600,062	1.1	630,066
Rocky Mountain	923,841	2.0	461,920	1.7	762,169
Northwest	5,918	0.0	--	--	0
West	364,147	0.8	455,184	1.9	842,090

a Estimates in these columns are for 66 counties projected to be nonattainment after application of the National $PM_{2.5}$ Strategy.

b Estimates in these columns are for 30 counties projected to be nonattainment after application of control measures modeled in Chapter 6.0, and do not include reductions and air quality improvements achieved by the National $PM_{2.5}$ Strategy.

c Total NOx, SO_2, VOC, and direct PM_{10} emission reductions achieved by application of control measures modeled in Chapter 6.0, not including reductions achieved by the National $PM_{2.5}$ Strategy. Combining all precursor pollutants into a single total represents a gross simplification since different precursors have, among other distinctions, different marginal costs of control and different potential marginal contributions to progress toward attainment.

d The estimate of the additional reductions required to overcome shortfalls and attain the PM standards are highly uncertain. The estimates presented in this table represent gross oversimplifications of critical variables and are useful only for illustrative purposes. More definitive estimates of region- and source category-specific reduction requirements will not be available until emissions inventories, air quality modeling, and SIP planning processes are completed for individual nonattainment areas. The values in this column are extremely crude estimates which reflect gross oversimplification of the relationships between changes in emissions of various precursors and changes in ambient concentrations. In particular, these estimates embed the unrealistic assumptions that precursor emissions would be reduced in identical proportions and that ambient concentrations would change linearly in response to those proportional reductions in precursors. Neither of these two assumptions are likely to actually obtain. Furthermore, the actual reductions required to achieve attainment would be highly dependent on the sources of the reductions. This is because reductions achieved by different source categories would be distributed differently in terms of both release height and spatial dispersion. For example, mobile source reductions would be spatially dispersed but occur essentially at the bottom mixing layer, whereas utility emissions reductions would be more spatially concentrated but would occur at higher levels above the ground. Both of these factors influence ambient particulate matter formation and atmospheric transport; therefore tonnage reductions required to achieve full attainment in all areas may be different depending on the relative contributions of precursor reductions from different source categories. Totals may not agree due to rounding.

US EPA ARCHIVE DOCUMENT

The additional specified control measures analyzed in this chapter include conventional control approaches, pollution prevention techniques, cleaner fuels and combustion processes. The measures primarily address control of ozone precursors. Many of these measures are currently technically available to emission sources in most nonattainment areas. They are not included in the analyses in Chapters 6.0 - 8.0 because they are not needed in most areas except the most polluted ones, but represent a reasonable set of additional controls which are likely to be cost effective for certain areas. For some measures, technology is currently available to implement these controls. In the future, after improved $PM_{2.5}$ inventories and source-receptor relationships are developed, it should be possible to conduct similar analyses of specified control measures for fine particulates.

The control measures analyzed in this section are divided into three sectors: 1) stationary point sources; 2) stationary area sources; and 3) mobile sources (both on-road and off-road). The cost of each measure is generally determined by examining the change in costs for one unit of the controlled source (e.g., one engine for mobile source technology measures, one gallon of fuel for reformulated fuel measures) and the associated tons reduced from that unit. The level of emissions remaining from specific source categories in areas still needing further reductions after the application of the first tier of measures is determined. The potential emission reductions available from the application of a measure are determined by applying a control factor to that level of residual emissions. In some cases, potential further reductions from certain source categories are calculated by estimating the number of units (i.e., non-road heavy duty diesel engines) located in these areas. Control measures are then applied to those sources still needing reductions. For some source categories, there is more than one control strategy identified and choices are made as to the most appropriate. These choices may or may not reflect actual local control choices. Some of the control measures assessed in this part of the analysis include but are not limited to the following:

- repowering existing vehicles with natural gas;
- retrofitting existing engines with improved technology;

US EPA ARCHIVE DOCUMENT

- selective catalytic reduction for certain commercial marine engines and locomotives;
- electric-powered airport gate service equipment;
- lower-sulfur fuels for residential, industrial, commercial and mobile applications;more stringent leak, process vent and wastewater controls for refineries, chemical manufacturing plants, and treatment, storage and disposal (TSDF) facilities; and
- more stringent emission limits for utility boilers and internal combustion engines.

Additional information on the effectiveness and costs associated with these additional control measures can be found in Appendix F.1. The EPA recognizes that states and localities may consider some of this information as they undertake planning efforts to implement the NAAQS. In doing so, they should bear in mind caveats elsewhere in this RIA about the information and estimates presented. Second, it is important to note that the cost-effectiveness of a measure for a particular nonattainment area may vary from EPA's estimate of the cost-effectiveness estimates for nonattainment areas nationally. Third, EPA suggests avoiding comparisons of cost-effectiveness figures in this RIA between measures that control different pollutants, between measures that apply nationwide and those that apply only in non-attainment areas, and between year-round and seasonal measures. Such comparisons may be misleading. In the draft RIA accompanying the proposed revision to the ozone NAAQS, EPA asked for comment on the Agency's traditional calculation of cost effectiveness and two alternative methods of calculating cost effectiveness that have been suggested to the Agency. The traditional calculation compares total annual costs with total annual emissions reductions. The first alternative would compare total annual cost with emission reductions in nonattainment areas only. The second alternative would compare total annual cost with emissions reductions in nonattainment areas during peak ozone months of the year. Despite the request for comment, the Agency received no comments on this issue in the context of the RIA. Based on its own preliminary analysis and comments received in a separate rulemaking (National VOC Emission Standard for Consumer Products. Federal Register, 1996), EPA has concluded that each of the methods -- the traditional approach and both suggested alternatives -- raise issues requiring further consideration. As a result, EPA has not decided whether to recommend one or more of these cost-effectiveness measures as a valid way to compare control measures that are dissimilar

US EPA ARCHIVE DOCUMENT

in geographic scope (nationwide versus non-attainment areas) or period of applicability (year-round versus seasonal). EPA will continue to evaluate this issue in future rulemakings.

9.4 THE ROLE OF NEW AND EMERGING TECHNOLOGY IN NAAQS ATTAINMENT

During the course of implementing the CAA, many new technologies have been developed to control air pollution. Because of ongoing needs to offset growth in emissions sources, and because in some respects the CAA has been a technology forcing statute, air pollution control and prevention technologies are continuously under development and improvement. The result is a fairly rapid pace of innovation in the air pollution control sector. Ten years ago, technologies such as those listed below might not even have been contemplated. Today, they are successfully in use across the U.S. and throughout the world.

- Selective Catalytic Reduction (SCR) for NO_x emissions from power plants
- Gas reburn technology for NO_x
- Scrubbers which achieve 95 percent SO_2 control on utility boilers
- Reformulated gasoline
- Low-Emitting Vehicles (LEVs) that are far cleaner than had been believed possible in the late 1980s (an additional 95 percent reduction over the 1975 controls)
- Energy-efficiency improvements in industrial processes, commercial, residential and appliance applications
- Reformulated lower VOC paints and consumer products
- Sophisticated new valve seals and detection equipment to control leaks
- Water and powder-based coatings to replace solvent-based formulations
- Safer, cleaner burning, wood stoves
- Dry cleaning equipment which recycles perchloroethylene
- CFC-free air conditioners, refrigerators and solvents

US EPA ARCHIVE DOCUMENT

The air pollution control and prevention market is large and growing. The demand for cleaner products and cleaner production processes that lower overall costs, combined with the necessity for improved air quality, create strong incentives for technological innovation and a growing market for such innovations. As the demand for more innovative, cost-effective and cost-saving technologies increases, new technologies will move from the research and development or pilot program phase to commercial availability. Table 9.3 contains a sample of emerging technologies that could play a significant role in successful attainment strategies. A more comprehensive listing of technology examples can be found in Appendix F.2.

Table 9.3 Examples of Emerging Technologies for Lower Emissions and Cheaper Control of VOCs, NO_x, and PM

Example Source Categories	Technology Name(s)
Electricity Generation	Thin film photovoltaics: amorphous silicon, cadmium telluride, thin-layered crystalline-silicon
	Fuel cells: proton exchange membrane, molten carbonate, phosphoric acid, solid oxide
	Wind power: improved airfoil materials and manufacturing techniques
Small engines	Clean air 2-stroke engines, vaporizing carburetors, alternative fuels for commercial engines/vehicles
On-road and non-road vehicles	Exhaust aftertreatment technology : vacuum insulated catalyst, plasma treatment, non-thermal plasma reactor, oxygen enrichment membrane
	Alternative fuels: medium duty truck cng conversion kit, propane/butane fuel blends, LNG technology for locomotives;
	Electric vehicles & batteries: advanced inductive electric vehicle, advanced batteries and charging systems
	New vehicle designs: Partnership for New Generation Vehicle,
Industrial Adhesives	Water-based aerosol adhesive, dual cure photocatalyst technology, non-acrylate systems, electron beam-curable epoxy resins for composites
Surface Coating	Polyurethane reactive (PUR) technology, new applications of water and powder based coating, zero-VOC industrial maintenance metal coating, micro-emulsion technology, new photo initiator systems, advances in transfer efficiencies, supercritical CO2 as a paint solvent

US EPA ARCHIVE DOCUMENT

As referenced above, new and emerging technologies are expected to play a key role in future air quality management programs. In the 1990 Amendments to the CAA (CAA section 182(e)(5)), Congress expressly recognized that areas with the most serious air pollution problems can rely on new and developing technologies that are not available in the short term for purposes of demonstrating that they will attain the standards. This provision establishes interim milestones and relies on the existing attainment date as incentives to assure development and deployment of advanced technologies. Use of this provision has promoted investment in advanced technology research in the Los Angeles area. Some areas that will have the most difficulty attaining the new ozone and fine particulate matter standards may find a similar approach appealing. Before considering such an approach, a state should demonstrate that it will not attain the standard based on all reasonably available controls and needs to rely on innovative technologies as the basis for the remainder needed to reach attainment. EPA wishes to pursue an approach analogous to that established by Congress in section 182(e)(5), where states can provide appropriate assurances that such technologies will be available to be implemented in sufficient time for the area to attain the standard.

Beyond the control measures and associated emission reductions referenced in 9.3, some areas require further reductions. Air quality management areas and sources in these areas will seek these further reductions in a number of ways. Existing technology will play a key role for some sources, emerging technology for others. Innovations in both environmental policies, as well as commercial and industrial environmental management, will also play a major role.

Most of the emerging technologies that are highlighted in this section and in Appendix F-2 should be available for application at specific sources in locations needing further emissions reductions. Some of these measures, due to the specific economic characteristics of the industries involved, may make sense to implement on a national basis. The size of the eventual market for these emerging technologies will depend on their emission reduction potential, their ability to displace existing technology, and their potential to become part of an optimal regional or national air quality management strategy.

US EPA ARCHIVE DOCUMENT

This analysis assumes the average cost of reductions achieved through this variety of unspecified methods is $10,000/ton. This compares with an average control cost for specified measures in this full attainment scenario of approximately $3,200/ton for NO_x and $4,000/ton for VOC reductions. The relative high cost of the unspecified measures provides an ample margin to account for unknown analytical considerations associated with future projections and may tend to overestimate the actual final cost of full compliance.

The residual emission inventory present in areas after specified measures have been implemented will be comprised of a range of uncontrolled and controlled sources. Previously uncontrolled sources could be expected to utilize existing control strategies and technologies similar to those referenced in this analysis, among other solutions. Controlled sources may use emerging technologies designed to achieve even better environmental performance than the current level of technological control. Faced with a demand for lower emissions, industries often respond with more effective technological innovations like those outlined below. For example, the electric utility industry is considering moving from low-NOx burner designs to selective catalytic reduction of NOx emissions at potentially similar or reduced costs per ton and greater emissions reductions. The automotive industry employed a new generation of catalytic converter when required to reduce tailpipe emissions further.

This section provides a wealth of technological innovation examples actively being pursued for all types of sources of emissions. EPA believes that states and sources will utilize technologies that are the most cost effective and that act in synergy with the operations of the business or source itself. Although difficult to predict its eventual costs, future technologies will benefit from significant learning experience associated with present technological applications.

In addition to incremental innovations in the same type of pollution control technology (e.g., more efficient catalytic converters), many industries and sources seeking further improvements will implement altogether different types of solutions. A company or industry facing increasingly more stringent solvent emission limits, for example, is unlikely to seek ever more expensive add-on control devices. Instead they will seek substitutes such as non-volatile

US EPA ARCHIVE DOCUMENT

US EPA ARCHIVE DOCUMENT

material inputs or process changes. Redesign of both products and processes becomes a likely operative part of this industry's or company's environmental solution. The advent of low- and zero-solvent paints and coatings is a prime example. Powder and water-based coating systems are being introduced in many industries, including the automotive manufacturing sector. Other substitutions, such as cleaner fuels, are commonplace and can be expected in the future as industries seek optimal solutions. Many companies find that these changes save them material, as well as, pollution control costs.

Such changes in environmental management practices are occurring today and will play a greater role in the future. Industrial environmental management strategies incorporate a broad spectrum of environmental solutions. Pollution prevention, material substitutions, cleaner process and product design, and improved material utilization are all acting to limit or eliminate the cost of pollution control. The demand for such innovations increases as the cost of traditional "add-on" solutions increases.

Environmental policy innovations are also being employed as efficient methods to provide cleaner air. Market-based policies, such as the acid rain emission trading system, are responsible for creating more efficient industry-wide environmental solutions. Localities, such as air quality management districts, are also implementing market-based emission reduction plans. Section 9.5.1 in this chapter describes how one such type of policy, "Clean Air Investment Funds," may contribute to a more efficient regional air quality management plan. EPA intends to strongly encourage these approaches as a means of minimizing compliance costs.

Given the breadth of environmental improvement solutions available, the significant number of emission control measures available for well under $10,000/ton of emissions reduced, and the wealth of active technological innovation underway, a $10,000/ton estimate for emission reductions beyond those specified in this analysis may be a conservative (i.e., high) estimate of future costs in some areas. EPA will encourage and facilitate flexible implementation approaches, such as emissions trading programs, to help areas eliminate barriers to utilizing the most cost-effective reductions.

US EPA ARCHIVE DOCUMENT

9.5 TRENDS AND FACTORS LEADING TO MORE COST-EFFECTIVE IMPLEMENTATION

9.5.1 Major Economic and Social Trends Affecting Future NAAQS Attainment Strategies

As illustrated in the preceding discussions, predicting the specific costs of meeting the new NAAQS in the year 2010 is, by its very nature, analytically difficult. Dynamic trends in the U.S. economy, in air quality modeling and in air pollution control strategies must all be taken into account. While the emission inventories contained within this analysis incorporate certain rates of economic growth, the analysis projects a “static” picture of the precise makeup of U.S. economic activity. Major trends currently reshaping the U.S. and world economy will continue to profoundly affect the makeup of our future economy and its resultant environmental impact. A majority of these trends will enhance a region’s ability to attain the new air quality standards.

Thirteen years from now, we could expect the U.S. economy to be more efficient in its production processes and use of materials. We could expect information technologies and high-value added sectors of the economy to grow at faster rates than traditional manufacturing and higher-polluting sectors of the economy. The fastest growing industries today and for the foreseeable future release less pollutants to the environment on an industry-wide basis than do the slowest or negative growing sectors of the economy.

Table 9.4 summarizes some of these major trends, their implications and the potential relative effect on attaining the new air quality standards. Following the table are brief descriptions of each trend or factor.

Table 9.4
Major Trends and Factors Leading to More Cost Effective Implementation

Trend	Implication	NAAQS Attainment Impact
Economic Trends		

Table 9.4 (continued)
Major Trends and Factors Leading to More Cost Effective Implementation

Trend	Implication	NAAQS Attainment Impact
1) Increasing knowledge-intensity of the U.S. economy	Shift towards less polluting manufacturing processes and services industries.	Enhance implementation & lower costs
2) Globalization of trade and investment	Growing market for high value U.S. business, financial and environmental services.	Enhance implementation & lower costs
3) Widespread adoption of advanced information technologies	Enhanced efficiency in manufacturing processes and growth of new, less polluting, technology and services industries.	Enhance implementation & lower costs
4) Geographic dispersion of business locations within the U.S.	Growth in mobile source pollution from increases in shipping and commuting distances.	Impede implementation & raise costs
Environmental Management & Policy Trends		
5) Increased use of market-based policies such as clean air funds & emission trading	Lower control costs, increased technology innovation and earlier compliance are all possible through economic incentive policies.	Enhance implementation & lower costs
6) Development and implementation of regional air pollution control strategies	Provides area-wide focus, leading to optimization of control strategies based on greater recognition of air emission transport and transformation. Fosters cooperation.	Enhance implementation & lower costs
7) Introduction of new regulatory mandates for international greenhouse gases and new categories and sources of toxic chemicals	Reduction in emissions of PM and ozone precursors as a side result of changes in industrial activities due to new mandates.	Enhance implementation & lower costs
8) Improved corporate environmental management strategies.	Pollution prevention programs, waste minimization schemes, environmentally-improved product and process design and ISO-14000 type programs	Enhance implementation & lower costs
Energy Trends		
9) Increased energy efficiency	Reduction of the energy intensity of the economy will reduce air pollution associated with energy generation and consumption.	Enhance implementation & lower costs
10) Deregulation of electric utility industry	Possible increase in energy demand and lower prices for electricity may increase demand for cleaner sources of power under regional agreements.	Enhance implementation
Societal Trends		

US EPA ARCHIVE DOCUMENT

Trend	Implication	NAAQS Attainment Impact
11) Increasing public concern with quality and preservation of the natural environment	Greater public willingness to support environmental protection efforts.	Enhance implementation
12) Development of local, state, national and international programs to monitor environmental quality	Increased integration of environmental protection concerns into economic development and other policy making processes.	Enhance implementation

US EPA ARCHIVE DOCUMENT

Economic Trends

1) Increasing Knowledge-Intensity of the U.S. Economy

Today's economy is becoming more "knowledge based" as high skill, information-intensive activities comprise a larger and increasingly important part of business and industrial activity. As a result, service and high-technology industries are growing and there is an increasing focus on higher value-added manufacturing activities. These changes have positive implications for NAAQS implementation because many of these growth sectors consist of low polluting industries.

As economic forces are leading to growth in higher value activities, there has been a related trend away from pollution intensive industries to cleaner, more energy efficient industries. Most of the fastest growing industries are in the services sector, particularly health care, transportation, and high value business services such as engineering and research. These industries are generally low emitters of SO_2 and NO_x have moderate VOC emissions. In comparison, many of the slowest growing industries are in heavy manufacturing and have relatively higher emissions of all three pollutants.

2) Globalization of Trade and Investment

Another key force behind the transformation of the U.S. economy is globalization. Globalization is manifested in a number of ways. New international production networks, for example, allow firms to increase efficiency by sourcing different stages of production in the most cost effective locations around the world, in effect, creating a new international division of labor in which the U.S. will continue to be the location for the most advanced business activities. Growth of foreign markets for environmental and other advanced technology products and services is another factor. Currently, environmental industries employ more than one million workers. The world environmental market is booming and is expected to grow at a 7.3 percent average annual rate according to studies released in April, 1995, by the National Commission for Employment Policy (NCEP).

Some of this growth in international trade is showing up as increased demand for products by relatively heavily polluting U.S. industries. However, broader trends towards concentration of high value business activities in the U.S. are positive for the reduction of pollution emissions.

US EPA ARCHIVE DOCUMENT

3) Widespread Adoption of Advanced Information Technologies

The widespread adoption of advanced information technologies is one of the main factors driving the creation of information-intensive, often low-polluting industries. It is also a main driver in helping manufacturing become more efficient and hence cleaner. Both of these trends enhance the ability of the economy to implement the NAAQS. Technologies such as computers, software, semiconductors, telecommunications services, and communications equipment have diffused throughout the economy. In 1984, less than 25 percent of the U.S. workforce used a computer on the job. By 1993, this number had nearly doubled, to 46 percent. Even in manufacturing, the numbers have risen to the point that by 1993, 42 percent of all workers in manufacturing industries used computers at work.

4) Geographic Dispersion of Business Locations within the U.S.

The shift of jobs to the service sector now occurring in the U.S. economy has reduced the role of central cities within most metropolitan areas. In addition, the decline of large, vertically-integrated factories means that the flow of materials from one processing stage to the next requires external freight transportation at the same time that the location of manufacturing industries has spread throughout the U.S. As a result, there is continuing growth of mobile source pollution despite technological improvements to reduce vehicle emissions. As the contemporary economy becomes more complex, transportation demand increases on a per capita basis. Vehicle Miles Traveled (VMT) for all road vehicles has more than doubled, on a per capita basis, since 1960. Although such VMT growth is accounted for in EPA's analysis and growing investment in transport planning measures is expected, continuation of this trend potentially impedes NAAQS attainment efforts.

US EPA ARCHIVE DOCUMENT

Environmental Management & Policy Trends

5) Increased Use of Market-Based Policies such as "Clean Air Investment Funds" and Emission Trading

In addition to changes in the level of environmental standards and the types of compounds and industries that are regulated, some sweeping changes are occurring in the way environmental standards are being implemented. Several efforts are underway to create new regulatory processes that afford greater flexibility with the goal of lowering the costs of meeting environmental protection goals. These efforts include a variety of market-based incentive systems. Market-based systems to reduce pollutant emissions have been promoted for many years as an alternative to fixed regulatory standards. Such systems are expected to reduce the costs of compliance and induce more technological innovation in methods of reducing pollution.

National and regional market-based programs such as emissions trading may achieve pollution control goals at dramatically less expense because they allow firms that face high costs to purchase "extra" reductions from firms facing below-average control costs. This RIA models a SO_2 cap and trade program, but due to data limitations, does not attempt to model other potentially cost saving market-based programs. However, the lead and chlorofluorocarbon (CFC) phase-out plans and the Acid Rain program are all examples of the ability of national market-based programs to provide environmental protection at lower cost. With pollution control efforts pegged to the going price of allowances, rather than to the highest cost source, these market-based programs can promote both cheaper and faster compliance.

Continued experience with market programs indicates that they do lead to greater cost savings. For example, the cost of reduction in the CFC phaseout program, which used an allowance system, was at least 30 percent less than predicted. EPA's 1988 RIA estimated a 50 percent CFC phase-out regulation would cost a total of $2.7 billion ($3.55 per kilogram). A subsequent analysis performed in a 1992 RIA estimated that a 100 percent phase-out by 2000 would cost a total of $3.8 billion ($2.20 per kilogram). The most recent analysis conducted by EPA in a 1993 RIA estimated a 100 percent phase-out by 1996 would cost $6.4 billion ($2.45

US EPA ARCHIVE DOCUMENT

per kilogram) for faster reductions and enhanced environmental benefits. The CFC example illustrates that, although phasing-out CFCs seemed a daunting challenge a decade ago, firms have eliminated CFCs faster and at lower cost.

In addition to EPA's experience, at least one nonattainment area has implemented a market-based program. In 1993, California's South Coast Air Quality Management District (SCAQMD) developed a market incentive approach known as the SCAQMD Regional Clean Air Incentives Market (RECLAIM) as an alternative to traditional command and control regulation - RECLAIM is perhaps the first very large-scale, multi-industry emissions trading program.

The goal of RECLAIM is two-fold: provide facilities with added flexibility in meeting emission reduction requirements, and lower the cost of compliance. RECLAIM covers emissions of both NO_x and SO_x, for at least 70 percent of the Los Angeles basin's stationary source emitters, by establishing facility mass emission limits. RECLAIM allows sources the flexibility to achieve prescribed emission reduction targets through process changes, installation of control equipment, emissions trading, or other methods (SCAQMD, 1993). The Second Annual Audit Report describes RECLAIM's successes including meeting its emission reduction goals, and developing an active trading market with "average prices of RECLAIM Trading Credits (RTCs)...well below the back-stop price of $15,000 per ton...$154 per ton for 1996 NO_x RTCs; $1,729 per ton for 2010 NO_x RTCs; $142 per ton for 1996 SO_x RTCs; and $2,117 per ton for 2010 SO_x RTCs." (SCAQMD, 1997).

EPA is actively pursuing and encouraging adoption of innovative approaches to air quality control, including use of economic incentive programs. Areas are expected to adopt market-based systems to meet their PM, ozone, and regional haze (RH) air quality goals because such systems allow emission reductions to be achieved using the most cost-effective controls. In addition, market-based programs provide continuous and powerful incentives to develop new technologies while achieving emission reductions which otherwise would not be available under the typical regulatory approach.

US EPA ARCHIVE DOCUMENT

EPA intends to place heavy reliance for implementing revised standards on new or expanded market-based programs. Market-based systems potentially in place 10 years from now include:

- Clean Air Investment Funds (see below);
- Cap-and-trade systems for NO_x in eastern (Ozone Transport Assessment Group (OTAG)) and western (Grand Canyon) regions;
- Cap-and-trade system for SO_2 to implement fine particles standard (building on the current acid rain program); and
- Cap-and-trade systems for volatile organic compounds (VOC) in major metropolitan areas (modeled on Chicago program now being adopted);
- "Open market" trading to bring in cost-reducing emission control opportunities from smaller or unconventional sources outside of the cap-and-trade programs.

As cited above, another example of a market-based strategy that could reduce control costs without sacrificing pollution control is an investment fund strategy. Through a "Clean Air Investment Fund," states or EPA could allow firms facing high costs to pay into a fund rather than control emissions themselves. Fund revenues may then be used to purchase additional emission reductions from lower cost sources. The net result of this approach would be to facilitate continued progress on reducing pollution while simplifying compliance for sources choosing to pay into the Fund.

Consider an area which, for example, after implementing a significant emission control program, is left short of the necessary emission reductions it needs for attainment. The residual emission inventory is dominated by two types of emission sources: (a) relatively well-controlled major sources where the next increment of emission control can only be obtained for a relatively high $/ton marginal cost (e.g., $15,000/ton) and (b) uncontrolled minor sources, where the cost per ton of emission control is relatively small ($2,000-$5,000/ton), but the sources are traditionally not subject to control because they are too small and numerous to incorporate or outside the scope of existing regulatory policies for other reasons. The high dollar-per-ton source, faced with a relatively high emission control cost, could make a contribution to the Clean

US EPA ARCHIVE DOCUMENT

Air Investment Fund at a predetermined price instead. The price or "deposit" would be less than the control cost they were facing, but greater or equal to the marginal control cost faced by sources regulated in earlier phases of the attainment strategy.

The Clean Air Investment Fund would then use these revenues to encourage other more cost-effective sources in the area to make reductions. Such inducements could come in many forms. The Fund could provide rebates for the purchase of cleaner products to replace older more polluting sources. Large-scale small engine (lawn mowers and other such equipment) buy back programs or funding the cost of mass transit vehicle engine retrofits are such other examples. Other investment opportunities for the Fund include: utility and industrial boiler SO_2 and NO_x reductions beyond the acid rain program levels for SO_2 and beyond the 0.15 lb/MMBTU limit for NO_x, use of more stringent leak detection programs to control fugitive emissions at chemical plants, refineries, and other large sources of ozone and PM precursors, and additional use of low- or no-VOC coatings.

A Fund would give states and localities the ability to achieve emissions reductions from sources not currently regulated (such as voluntary efforts, e.g., buy-back programs) and through reductions in energy consumption or vehicle miles traveled in exchange for economic incentives. Clean Air Investment Funds also provide powerful incentives to develop new technologies since the developers would know that the resulting emission reductions could be sold to the Fund.

Because Clean Air Investment Funds have an ability to reach out to otherwise unregulated sources, they could greatly increase a region's ability to pull cost-effective emission reductions from a diverse set of sources into a strategy. A Fund with the authority to arrange for emission reductions from its own choice of unregulated sources is much more likely to succeed because of the incremental and selective nature of the program.

In addition to its active role in seeking out emission reductions, Clean Air Investment Funds have the advantage of facilitating the operation of a market-based system. The transaction costs of economic-incentive programs, such as locating potential sources of emission reductions

US EPA ARCHIVE DOCUMENT

and negotiating mutually agreeable terms, can be (or appear to be) large enough to discourage the use of trading systems. However, many of the difficulties in setting up emission allowance or cap and trade systems can be mitigated by a Clean Air Investment Fund because it allows sources to limit their dealings to an agency or third-party entity that is competitively neutral. The existence of a Fund also provides a limited guarantee that emission reductions will be available if needed, generally at a predictable cost. Thus, states may also choose to adopt a Clean Air Investment Fund as either a supplement to or a substitute for a cap and trade program.

A Clean Air Investment Fund is one example of innovative clean air policies that can help even the most difficult nonattainment areas improve their compliance situation. Current and proposed Fund programs, such as those in Sacramento, Ventura County California, Connecticut, Illinois, and El Paso, Texas/Juarez, Mexico, will provide invaluable experience for future programs. Over the next decade, economic incentive programs like Clean Air Investment Funds will likely become more commonplace as emission inventories are improved, experience expands, and the benefits associated with such systems are realized.

6) Development and Implementation of Regional Air Pollution Control Strategies

While national and local control strategies continue to be important in reducing air pollution, there is a relatively new focus on regional control strategies. On an area-wide level, we have learned through the work of the Ozone Transport Commission (OTC), OTAG, and the Grand Canyon Visibility Transport Commission, that air quality problems in many areas are a result of emissions transport and transformation and not local emissions alone. For example, OTC and OTAG developed potentially more cost-effective strategies than had been thought to be available -- both regions will be using a cap on NO_x emissions that should lower the overall cost. Consequently, regional measures are likely to be a critical component of many attainment strategies. Cooperative planning among all states, tribes, and localities contributing to common air quality problems is necessary to develop effective regional control plans.

US EPA ARCHIVE DOCUMENT

In implementing the new PM and ozone NAAQS, EPA expects areas will develop regional control strategies unique to each area. These coordinated strategies should be carefully developed based on regional considerations. Thus, actual implementation strategies may be significantly more cost-effective than the local and broader-based strategies assessed in this RIA.

7) New Controls for International Greenhouse Gases and New Categories and Sources of Toxic Chemicals

Several new environmental policies, if implemented, would have an impact on future NAAQS implementation. These include:

- A potential new international agreement reducing greenhouse gas emissions would likely have significant impacts on ozone precursors and thus would further encourage types of emissions reductions related to the proposed new NAAQS. (See Trend 9 below).

- Introduction of new international regulatory regimes to govern Persistent Organic Pollutants (POPs) and Endocrine Disrupting Chemicals (EDCs). Actions on POPs and EDCs may affect plastics, manufacturing processes involving chlorine, agricultural pesticides containing cyclic organic substances, incineration of organic and chlorine compounds, and detergents. To some extent there is likely to be an interrelationship between control options for these substances and subsequent effects on PM and ozone.

- Expansion of reporting requirements under EPA's Toxic Releases Inventory System. Presently, seven more industries are being added to the TRIS: coal mining, metal mining, electric utilities, commercial hazardous waste treatment, petroleum bulk terminals, solvent recovery services, and chemical wholesalers. These industries are among some of the most significant producers of PM and ozone precursors. Based on previous TRI experience requiring these industries to report their toxics emissions will, by making the information public, lead to pollution reductions.

US EPA ARCHIVE DOCUMENT

8) Improved Corporate Environmental Management Strategies

Corporations and other organizations are making a number of important changes to voluntarily contribute to the lowering of emissions through improved environmental management. Environmental management in business today is quickly becoming a vital part of overall business management strategies. Businesses are striving to reduce operating costs through improved efficiency, productivity, and reduced material and waste management costs. ISO 14000 Environmental Management Systems are expected to be an integral part of business strategies in the near future. Pollution prevention programs emphasizing source reduction and waste minimization are proliferating. Environmental accounting practices are identifying hidden, but previously unaccounted for, environmental costs associated with certain products and practices. This awareness is leading to a reduction or elimination of such costs. And finally, manufacturing processes and products themselves are increasingly being designed with environmental impacts in mind.

Energy Trends

9) Increasing Energy Efficiency May Lower Costs

The preceding analyses of the costs presented in this RIA are generally based on business-as-usual assumptions concerning the future demand for energy. Yet, energy consumption can be a major source of air pollution, including ozone and $PM_{2.5}$ precursors. To the extent that the energy intensity of the American economy can be significantly reduced through cost-effective investments in energy efficient technology, meeting any new emissions limitations will be easier and cheaper. One recent study, for example, suggested that the nation could cut the growth of energy use by 15 percent in the year 2010 at a net savings of about $530 per household per year. (Alliance to Save Energy, et al., 1997). Combined with the use of cleaner energy resources, this study indicated that energy efficiency investments would also lower NO_x and SO_2 emissions signficantly below their 1990 levels. This suggests that there is

US EPA ARCHIVE DOCUMENT

ample scope to increase the nation's energy efficiency, which will simultaneously improve overall economic productivity and reduce energy-related pollution.

The U.S. Climate Change Action Plan (CCAP) is an important step in an energy-related productivity strategy. The CCAP is designed to lower greenhouse gas (GHG) emissions which most scientists now believe contribute to global climate change. The majority of today's CCAP programs target end use energy demand in lighting, buildings, appliances, and industrial motors and processes. Current projections suggest that today's CCAP programs will reduce the expected growth of U.S. emissions that cause global climate change by 25 to 30 percent. The next stage of the U.S. national climate change mitigation policy will most likely continue to pursue a productivity-led investment strategy, but would do so in concert with policies that will unambiguously signal the need to avoid any increases in GHG emissions, and to even reduce emissions from current levels. In the international climate change negotiations, the U.S. is pursuing legally binding targets at a level considered to be "real and achievable." Such targets will help decrease not only GHG emissions, but also a variety of other air pollutants. Moreover, greater penetration of today's energy-efficiency technologies can also decrease American dependence on foreign oil, increase productivity of domestic industries, and promote U.S. leadership in the large and growing international market for advanced technologies. Perhaps most important, shifting capital from energy expenditures to new investments elsewhere in the economy would help drive economic growth, employment and consumer income.

10) Deregulation of Electric Utilities

The federal and state governments have taken steps to introduce deregulation into electric power markets. The Energy Policy Act of 1992 (EPAct) made several fundamental changes in the wholesale electricity markets, including: encouraging independent power producers to sell power in the wholesale market; allowing new market entrants such as power brokers and marketers to sell power; and ensuring open, non-discriminatory access to transmission services.

US EPA ARCHIVE DOCUMENT

Similar actions at the retail level have encouraged greater competition, including provisions to allow consumers to choose the generation source and the local retail supplier of their electricity, much like consumers now choose their long-distance supplier in telecommunications. Due to the significant nature of these changes on how electricity is supplied to consumers, there is the great potential that consumers will opt for cleaner sources of electricity and markets will respond accordingly.

Societal Trends

11) Increasing Public Concern with Quality and Preservation of the Natural Environment

Increased affluence and mobility are creating a greater demand for communities with cleaner, safer environmental conditions. Indeed, "quality of life" is cited as an increasingly important criterion in business location decisions as firms, particularly in high-growth, technology-intensive industries, position themselves to compete for the best talent. This shift in public attitudes can be expected to have positive impact on NAAQS implementation as citizens become more willing to apportion the attention and resources necessary to address environmental problems.

Evidence of this trend in societal, and particularly, business attitudes is provided by a 1995 study by Arthur Andersen conducted as part of Fortune Magazine's report on the "Best Cities for Business." In this study, a selection of worldwide business leaders was asked about key factors in making site selection decisions for different types of business operations. The executives said that high quality of life was especially important for headquarters and research and development operations, i.e., for attracting knowledge-workers. Similarly, when Money Magazine polled a sample of readers about the things most important to them in selecting a place to live for the magazine's annual survey of "The Best Places to Live Today," clean water and clean air ranked at the top of the list above such things as low taxes, good schools, health care or local employment conditions.

US EPA ARCHIVE DOCUMENT

12) Development of Local, State, National and International Programs to Monitor Environmental Quality

As the shift in public attitudes has become more pronounced, policy makers, economists, academics, and others have recognized a need to change economic and policy systems to incorporate new public attitudes and goals. As a result, there is increased integration of environmental protection concerns into economic development and other policy making processes. This change is reflected in the increasing inclusion of environmental data in measurement systems for ranking communities (e.g., the Well-Being Index published by American Demographics) and nations (e.g., the World Bank's sustainable wealth of nations measure). It is also reflected in the development of movements such as "sustainable communities" and EPA's Smart Growth Network. This shift in public attitudes and programs can be expected to have positive effects on the ability to implement new air quality standards as public interest in addressing environmental problems becomes more imbedded in customary decision making and planning processes.

9.5.2 Uncertainties in Estimating Compliance Costs Often Lead to Overestimates

Major environmental regulations, like other types of social regulation, entail social costs as well as benefits. However, under Congress' direction, some environmental regulations -- like the NAAQS -- must be based only on health considerations. The Agency believes that while it is inappropriate to consider costs in setting health based standards like the NAAQS, it is appropriate to consider the expected costs of implementation alternatives to guide states and localities as they make the difficult choices in deciding how to implement the standards. Developing accurate, unbiased estimates of the social costs of complying with or implementing a regulation is, thus, a key component in analyzing its likely impacts on society.

Many factors, however, such as the "static" nature of this analysis may lead to the overestimation of costs. For example, a firm's initial response to a new regulatory demand may be

US EPA ARCHIVE DOCUMENT

far less efficient than its later response to the same challenge. Analyses of this sort do not capture this learning curve effect and tend to overestimate costs. Similarly, technologies themselves change and become more optimal and efficient over time. These improvements and the effect they may have on lowering costs between early and mature stages of technology development are difficult to capture.

Concerning technology change, regulations themselves affect the rate and direction of technical innovation. As firms invest in new plants and equipment, they will take into account any regulatory changes that have occurred since the previous generation of investments was put in place. Less pollution intensive technologies or processes will become more attractive. Besides technological advances, another phenomenon affecting long-run compliance costs is the ability of the regulated community to learn over time to comply more cost-effectively with the requirements of the regulation. While in practice this effect is difficult to quantify separately from the effects of technological change, the combined effects on pollution abatement and control costs can be incorporated into regulatory compliance cost forecasts by applying an assumed rate of "learning" arising from both sources. This analysis does not incorporate such an assumption. The following discussion of the use of progress ratios for estimating future technology and compliance costs evaluates these notions further.

9.5.3 Use of Progress Ratios to Deflate Cost Estimates for Existing Technologies

As discussed in the preceding section, a more accurate cost estimate would account for technological advancement and learning curve effects. In fact, hundreds of studies confirm that new products and technologies decline in cost as they become accepted and widely adopted throughout the economy. The rate of decline varies among the different technologies. However, a common rule of thumb -- often referred to as a "Progress Ratio" -- is that each new doubling of output for a given technology will deflate the unit cost of that technology to about 80 percent of its previous value.

US EPA ARCHIVE DOCUMENT

The fall in unit cost is the result of a variety of factors: (a) new knowledge that is continuously flowing into the production process; (b) economies of both scale and scope that can be achieved with increasing levels of output; (c) costs that fall with "learning by doing" even without any visible change in the physical capital used for production; and, finally, (d) the proliferation of service and distribution networks that reduce the cost to consumers using the new technologies. Thus, future estimates of energy and pollution control technology forecasts should anticipate some decline in the cost of these technologies over time; or more specifically, as a function of continued production and increased market share.

Estimates of Progress Ratios

Examples of progress ratios for various past and future technologies, either calculated or taken from the literature, are shown in the Table 9.5 below. Based upon the examples in this table, the progress ratios range from 67 to 98 percent. The example of a so-called "mature" technology such as the magnetic ballast shows a 98 percent progress ratio which means that costs are not falling very quickly at all. On the other hand, a more advanced technology for the same end use, in this case the more efficient electronic ballast, suggests a 90 percent progress ratio. The pollution control technologies in the above table -- including CFC substitutes and scrubbers -- appear to hover close to the 90 percent benchmark.

US EPA ARCHIVE DOCUMENT

Table 9.5 Examples of Progress Ratios

Technology	Period	Cumulative Production	$COST_0$	$COST_t$	Progress Ratio
Electronic Ballasts	1986-1993	52.7 million	$37.65	$18.23	90%
Magnetic Ballasts	1977-1993	629.3 million	$7.86	$6.47	97%
Fluidized Bed Coal	1987-1992	n/a	n/a	n/a	95%
Gas Turbines	1987-1992	n/a	n/a	n/a	95%
Wind Turbines	1987-1992	n/a	n/a	n/a	90%
Integrated Circuits	1962-1968	$828 million	$50.00	$2.33	67%
Low-E Windows	1993-2010	11.3 bsf	$2.90	$1.20	86%
CFC Substitutes	1988-1993	8.9 billion tons	$3.55	$2.45	93%
Photovoltaics	1975-1994	516 MW	$75/watt	$4/watt	70%
Solar Thermal	1996-2020	800 MW	$3335/kW	$2070/kW	90%
Gasified Turbines	1997-2000	156 MW	$2000/kW	$1400/kW	84%
Scrubbers	1985-1995	85,700 MW	$129/kW	$122/kW	88%

The Influence of Progress Ratios on Potential Technology Costs for the NAAQS

In the current analysis only economies of scale are reflected in estimates of technology control costs in the year 2010. However, both the capital and operating costs of incremental control measures are likely to be affected by the impact of learning or experience curves. To the extent that experience curves are not reflected in such cost estimates, the cost of control technologies will be overstated. For example, let us assume that costs in the year 2010 are projected to be only 80 percent of the current projections -- because of cumulative experience in the production and installation of a given set of control technologies. If the year 2010 baseline cost projection is $1.5 million (in 1990 dollars) for a given technology, assuming a 20 percent drop as a result cumulative production experience would lower that cost estimate to $1.5 million * 0.80, or $1.2 million. The basis of this adjustment is the Progress Ratio.

US EPA ARCHIVE DOCUMENT

9.6 REFERENCES

Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists (1997), Energy Innovations: A Prosperous Path to a Clean Environment. Washington, DC, June.

Laitner, S. (1977), Working Notes on Technology Cost Deflators. U.S. Environmental Protection Agency, Washington, DC, May.

South Coast Air Quality Management District (1993), RECLAIM: Socioeconomic and Environmental Assessments. 3:6.1, October.

South Coast Air Quality Management District (1997), Second Annual RECLAIM Program Audit Report, February.

Federal Register (1996), National Volatile Organic Compounds Emissions Standard for Consumer Products. National Archives and Records Administration; Vol. 61, No. 64: 14531-14535, April.

US EPA ARCHIVE DOCUMENT