1.0 INTRODUCTION AND OVERVIEW

The Clean Air Act (CAA) directs the Environmental Protection Agency (EPA) to identify and set national standards for pollutants which cause adverse effects to public health and the environment. The EPA is also required to review national health and welfare-based standards at least once every 5 years to determine whether, based on new research, revisions to the standards are necessary to continue to protect public health and the environment. A growing list of health effects studies on particulate matter (PM) and ozone report associations between ambient fine particles [which is PM smaller than 2.5 micrometers (μm) in diameter, termed $PM_{2.5}$] and/or ambient ozone and serious effects such as increased mortality. As a result of the most recent review process, EPA has proposed to revise the National Ambient Air Quality Standards (NAAQS) for PM and ozone. In addition, EPA is proposing a regional haze (RH) rulemaking to achieve progress toward visibility goals. Pursuant to Executive Order 12866, this Regulatory Impact Analysis (RIA) assesses the potential costs, economic impacts, and benefits associated with the *implementation* of these and alternative NAAQS for PM and ozone as well as for a proposed RH rule. Potential costs, economic impacts, and benefits are estimated incremental to attainment of existing standards.

In setting the primary air quality standards, EPA's first responsibility under the law is to select standards that protect public health. In the words of the CAA, for each criteria pollutant EPA is required to set a standard that protects public health with "an adequate margin of safety." As interpreted by the Agency and the courts, this decision is a *health-based* decision that specifically is *not* to be based on cost or other economic considerations. This reliance on science and prohibition against the consideration of cost does not mean that cost or other economic considerations are not important or should be ignored. However, under the health-based approach required by the CAA, the appropriate place for cost and efficiency considerations is during the development of implementation strategies, strategies that will allow communities to meet the health-based standards. Through the development of national emissions standards for cars, trucks, fuels, large industrial sources and power plants, for example, and through the development of appropriately tailored state and local implementation plans, the implementation process is where decisions are made -- both nationally and within each community -- affecting how much progress can be made, and what time lines, strategies and polices make the most sense. In summary, this RIA and associated analyses are intended to generally inform the public about the potential costs and benefits that may result when the new PM and ozone NAAQS are implemented by the States, but are not relevant to establishing the standards themselves. In contrast, results from this analysis may be used to support the RH rule development process.

1.1 THE NATIONAL AIR QUALITY CHALLENGE

1.1.1 Particulate Matter

PM represents a broad class of chemically and physically diverse substances. It can be principally characterized as discrete particles that exist in the condensed (liquid or solid) phase spanning several orders of magnitude in size. For regulatory purposes, fine particles can be generally defined as those particles with an aerodynamic diameter of 2.5 µm. or less, while coarse fraction particles are those particles with an aerodynamic diameter greater than 2.5 µm., but less than or equal a nominal 10 µm. The health and environmental effects of PM are strongly related to the size of the particles.

Emission sources, formation processes, chemical composition, atmospheric residence times, transport distances and other parameters of fine and coarse particles are distinct (U.S. EPA, 1996d). Fine particles are generally formed secondarily from gaseous precursors such as sulfur dioxide (SO_2) , nitrogen oxides, and/or organic compounds, and are composed of sulfate, nitrate, and/or ammonium compounds; elemental carbon; and metals. Fine particles can also be directly emitted. Combustion of coal, oil, diesel, gasoline, and wood, as well as high temperature process sources such as smelters and steel mills, produce emissions that contribute to fine particle formation. In contrast, coarse particles are typically mechanically generated by crushing or grinding and are often dominated by resuspended dusts and crustal material from paved or unpaved roads or from construction, farming, and mining activities. Fine particles can remain in the atmosphere for days to weeks and travel through the atmosphere hundreds to thousands of kilometers, while coarse particles deposit to the earth within minutes to hours and within tens of kilometers from the emission source.

Geographic differences (e.g., rural vs. urban locations, East vs. West) also exist between ambient levels of fine and coarse particles and their related characteristics (U.S. EPA, 1996d). For instance, total concentrations of coarse fraction particles are generally higher and the crustal material contribution relatively larger in arid areas of the Western and Southwestern U.S. In the Eastern U.S., fine particle sulfate is a significant component of ambient $PM_{2.5}$ concentrations. The differences in fine and coarse particle characteristics and their geographic variability are significant considerations in the design of control strategies to reduce levels of ambient PM.

Since the last review of the PM air standards, there has been significant new evidence from community epidemiological studies that serious health effects are associated with exposures to ambient concentrations of fine particle PM found in the urban U.S. even at levels below current PM standards. The U.S. EPA PM Criteria Document (U.S. EPA, 1996b) and U.S. EPA PM Staff Paper (U.S. EPA, 1996d) discuss and evaluate scientific information identifying the key health effects associated with fine particle PM, including: premature mortality (particularly among the elderly and people with respiratory or cardiovascular disease), increased hospital admissions and emergency room visits (primarily for the elderly and individuals with cardiopulmonary disease); increased respiratory symptoms and disease (e.g., for children and individuals with cardiopulmonary disease); decreased lung function (particularly in children and individuals with asthma); and alterations in lung tissue and structure and in respiratory tract defense mechanisms. Elevated concentrations of fine particles also contribute to visibility impairment, and materials damage and soiling effects.

1.1.2 Ozone

Ozone is created when its two primary components, volatile organic compounds (VOC) and oxides of nitrogen (NOx), combine in the presence of sunlight under specific meteorological conditions. VOC and NOx, are often referred to as ozone *precursors*, which are, for the most part, emitted directly into the atmosphere from a combination of natural and anthropogenic sources. Attempts to decrease ozone pollution in the United States have been confounded by a number of factors, including the inherent non-linearity of the photochemical mechanism, the contribution of natural precursor emissions, long range transport of ozone and its precursors (primarily NOx), meteorological variability, the general lack of essential data (primarily inventory related), and the limitations of current modeling tools.

Recent scientific evidence indicates that ground-level ozone not only affects people with impaired respiratory systems (such as asthmatics), but healthy adults and children as well. The new studies taken into account during this latest review show health effects at levels below that of the current standard (0.12 ppm, 1-hour form) (U.S. EPA, 1996a,c). In particular, active children and outdoor workers exposed for 6-8 hours of ozone levels as low as 0.08 ppm may experience several acute effects such as decreased lung function, acute lung inflammation, and premature aging of the lung. Recent epidemiological studies also provide evidence of an association between elevated ozone levels and increases in hospital admissions and mortality; and animal studies indicate repeated exposure to high levels of ozone for several months can produce permanent structural damage in the lungs.

1.1.3 Regional Haze

Under Section 16A and 169B of the CAA, 156 Class I Federal areas are identified for visability protection. The CAA require that “reasonable progress” be made toward achieving a visibility goal of essentially no manmade visibility impairment in areas of concern. The EPA is proposing that reasonable progress be defined as equivalent to a 1 deciview improvement (a perceptible change) in the most impaired days over a 10-year period, with no degradation occurring in the cleanest days. Impairment is primarily due to transport since there are few emission sources within the areas of concern. Thus to achieve reasonable progress, emission controls must be employed in surrounding areas.

1.1.4 The Integrated Air Quality Management Challenge

The EPA is promulgating the PM and ozone NAAQS and proposing the RH rule concurrently. While not all attributes of ozone and PM are linked, important commonalities exist among the PM, ozone, and RH problems, which provide the technical and scientific rationale for integrated analysis. Similarities in pollutant sources, formation, and control exist between PM, ozone, and RH, in particular with respect to the fine fraction of particles addressed by the current PM NAAQS. These similarities include:

(1) atmospheric residence times of several days, leading to regional-scale transport of the pollutants,

(2) similar gaseous precursors, including NOx and VOC, which may contribute to the formation of PM, ozone, and RH in the atmosphere,

(3) similar combustion-related source categories, such as utilities, industrial boilers, and mobile sources, which emit particles directly as well as gaseous precursors of particles (e.g., SO_2, NOx, VOC) and ozone (e.g., NOx, VOC), and

(4) similar atmospheric chemistry driven by the same chemical reactions and intermediate chemical species which often favor high fine particle levels, ozone, and RH.

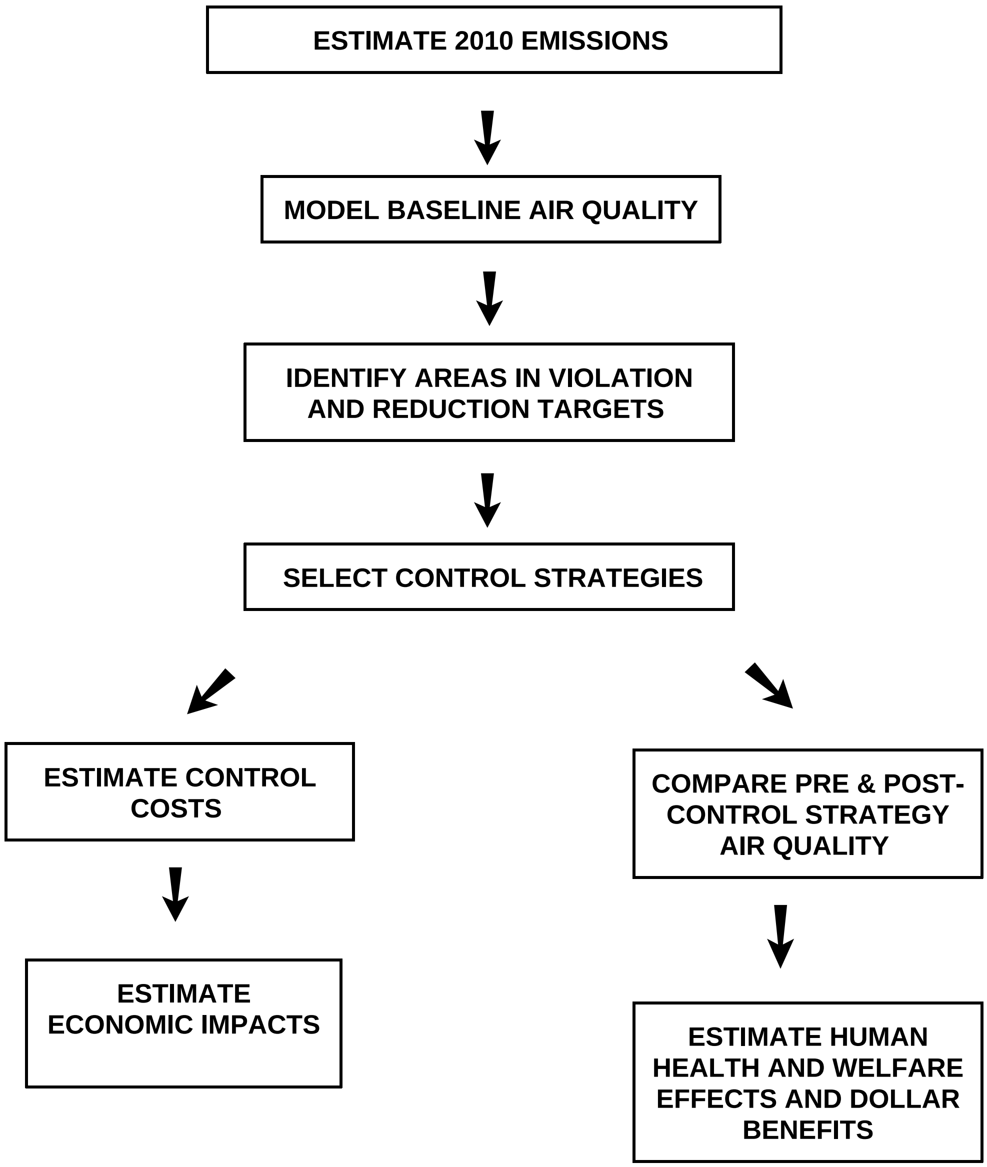
These similarities provide opportunities for optimizing technical analysis tools (i.e., monitoring networks, emission inventories, air quality models) and integrated emission reduction strategies to yield important co-benefits across various air quality management programs. Integration of implementation is likely to result in a net reduction of the regulatory burden on some source category sectors that would otherwise be impacted separately by PM, ozone, and visibility protection control strategies.

1.2 OVERVIEW OF THE RIA METHODOLOGY

1.2.1 Basic Analytical Approach

Figure 1.1 displays the basic analytical structure of this RIA. An emissions inventory is developed and projected to the year 2010 (see Chapter 4). The year 2010 was selected as the base year for the analysis primarily because by this year the vast majority of CAA Amendment requirements will have fully taken effect. Baseline air quality is then estimated using air quality models, areas in violation with alternative NAAQS and with regional haze targets are identified, and air quality or emission reduction targets are computed (see Chapter 4). Control strategies to achieve air quality goals are then selected and potential costs are computed based on the control measures chosen (see Chapters 5-8). Based on these potential costs as well as potential administrative costs to governments (see Chapter 10), potential economic impacts to large and small businesses and governments are assessed (see Chapter 11). Since the controls employed and costed in chapters 5-7 do not achieve full attainment of the NAAQS, a rough full attainment cost assessment also is provided (see Chapter 9). Based on estimated air quality changes resulting from the control measures employed, the resulting change in human health and welfare effects is predicted and the monetized value of these effects is estimated (see Chapter 12). Finally, benefit and cost estimates are compared (see Chapter 13).

FIGURE 1.1: Flowchart of Analytical Steps



1.2.2 Limited PM/Ozone/RH Integration

Ideally, analyses of the concurrent implementation of the PM and ozone NAAQS and a proposed RH rule should be fully integrated. However, since each NAAQS review is a separate regulatory decision, the health effects and scientific information for each pollutant need to be judged separately and on their own merits. For purposes of consistency, this RIA presents cost, benefit, and other economic impact results of a separate PM and a separate ozone NAAQS.

It is not possible at this time to perform a fully integrated benefit-cost analysis of these rules. Air quality models are not currently available to sufficiently assess the atmospheric interactions of PM, ozone, and precursor pollutants at the national level. Moreover, efforts to develop integrated implementation strategies have not been completed. The joint impacts of a PM and ozone NAAQS are assessed as a sensitivity study in this RIA by a layering strategy. For example, attainment of one NAAQS is attempted, baseline emissions and air quality are changed, then attainment of the other NAAQS is attempted. This approach eliminates double-counting of controls and allows for the computation of the ancillary benefits associated with attaining one NAAQS toward attaining the other NAAQS. Full integration is not achieved, however, since air chemistry interactions associated with joint implementation are not modeled and because the control selection approach to attain one standard does not consider the potential beneficial impact toward achievement of the other standard. For this latter reason, a least cost estimate associated with joint implementation of a PM and ozone NAAQS is not presented in this analysis.

Concurrent with the review of the PM and ozone NAAQS and development of the RH proposed rule, EPA has requested the assistance of stakeholder groups to help design a new implementation approach to controlling PM, ozone, and RH and is setting forth critical implementation principles accompanying the new standards. This stakeholder group has been charged to evaluate new approaches to controlling these pollutants, focusing on the interaction of these pollutants in the atmosphere. As part of this process, EPA will strive to perform more fully integrated analyses to support subsequent stages of the implementation process.

1.2.3 Control Strategies Modeled

To perform an RIA for NAAQS and for a proposed RH rule, it is necessary for EPA to make certain broad assumptions concerning control strategies on a national level. The fact the EPA has selected control strategies as part of this assessment should not be taken to mean that EPA recommends these control strategies or anticipates that these control strategies and measures will be imposed in all nonattainment areas. The CAA requires EPA to set NAAQS and develop a RH rule, and it requires the states, with assistance from EPA, to develop implementation plans and submit them to EPA for review. This places primary responsibility for implementing the air quality management process on the states and allows for Federal oversight of states' efforts to achieve and maintain the required level of air quality. Because states have considerable flexibility in developing control strategies for attaining the PM and ozone NAAQS as well as the RH rule, it is unlikely that the control strategy assumptions in this RIA will exactly correspond to the attainment strategy ultimately developed for any particular area. Moreover, this analysis forecasts control strategies for year 2010. Substantial uncertainty is inherent in any projections so far into the future. Finally, there may be some cases where the strategies that are assumed to be applied nationwide are not appropriate for application in a particular area.

The CAA allows for substantial flexibility in the development of implementation strategies, both for control strategies and schedules, for attaining the new NAAQS and RH reduction goals. Specific to the new standards, EPA has established a formal advisory committee under the Federal Advisory Committee Act (FACA). The specific purpose of the broad-based stakeholder group is to advise EPA on ways to develop innovative, flexible, practical and cost-effective implementation strategies, and to advise us directly on transitional strategies as well.

Control strategies employed in this RIA are limited in part because of our inability to predict the breadth and depth of the creative approaches to implementation that may be forthcoming via the FACA process, and in part by technical limitations in modeling capabilities. For example, lower-cost "market-based" strategies are modeled in this analysis only to a limited extent. This limitation, in effect, may force cost estimates to be developed based on compliance strategies that reflect suboptimal implementation approaches. Thus, cost estimates presented in this analysis may overstate actual implementation costs.

1.3 KEY IMPROVEMENTS FROM THE PROPOSAL RIAs

In December, 1996, EPA published separate RIAs that assessed the benefits, costs, and other economic impacts associated with the proposed PM and ozone NAAQS. Since December, EPA has made various revisions, updates, and other improvements to the these proposal RIAs. This document incorporates these improvements, merges and to some extent integrates the PM and ozone analyses, and includes an assessment of the proposed RH rule.

Many of the improvements made to the proposal RIAs and incorporated in this document are made as the direct result of helpful comments received by the EPA from RIA Interagency Committee members and the public. Among the most important of these improvements are:

- A more integrated analysis that avoids double-counting of costs is performed based on a common emission inventory;

- Air quality modeling is improved (e.g., an updated source receptor matrix is used for PM, ozone attainment targets are revised in accordance with new modeling information, etc.);

- The baseline year for the analyses is changed from 2007 to 2010, primarily to better reflect the actual implementation of the new standards;

- Administrative costs are estimated;

- Costs in marginal ozone nonattainment areas are estimated;

- Additional control measures are included and control cost and emission reduction estimates are updated;

- The residual nonattainment problem is assessed and characterized more fully and explicitly;

- The potential impact of technological progress in pollution control is more fully assessed;

- Rough estimates of full-attainment costs are calculated;

- Additional benefit categories are monetized and qualitatively discussed;

- The analysis of valuation of mortality risk reduction from reduced ozone is updated and strengthened substantially;

- Long-term mortality risk from PM is reassessed to correct for a previous statisticalerror;

- The valuation estimate for cases of chronic bronchitis has been adjusted downward to reflect new information;

- The economic impact assessment is revised (e.g., the cost to sales ratio approach is improved, impacts on the utility and pollution control industries are assessed, etc.);

- A plausible range of monetized benefits is presented that reflects some of the key uncertainties in the analysis.

- Various additional sensitivity analyses are performed.

While these changes have significantly improved the quality of this analysis, this RIA is still limited in various ways and substantial uncertainties regarding the results from this analysis remain. Data, modeling, time, and resource constraints inevitably limit the rigor of any RIA. Qualitative, and when possible, quantitative discussions of uncertainties, limitations, and potential biases are included in this RIA. Additional refinements to this analysis are planned to support later stages of the implementation process.

1.4 KEY LIMITATIONS

1.4.1 General Limitations of Benefit-Cost Analysis

The consideration of cost and the use of benefit-cost analyses, provides a structured means of evaluating and comparing various implementation policies, as well as a means of comparing the variety of tools and technologies available for air pollution control efforts. The EPA has found the use of such analyses to be of significant value in developing regulatory options over the years.

General limitations, however, continue to affect the accuracy and usefulness of benefit-cost analyses. Wide ranges of uncertainties and omissions often exist within an analysis, especially within complex studies of national scope involving forecasts over extended periods of time. Benefit-cost analyses and results, continue to be limited by inabilities to monetize certain benefit categories. Comparisons of such incomplete benefits to the more quantifiable and usually more complete cost estimates can be misleading. Benefit-cost analyses also can not provide a basis for resolving distributional issues, i.e., to assess the equity of policies that provide benefits to some and costs to others. At best, the distribution of benefits and costs can be described.

These limitations notwithstanding, the process of developing such analyses can provide useful insights for environmental managers and policy makers. These insights can be especially useful to those working to develop implementation strategies because the analytical framework provides a mechanism for measuring, however roughly, alternative strategies or tools against a common framework.

1.4.2 Specific Limitations with this RIA

In addition to the general limitations associated with benefit-cost analysis described above, the reader should be fully aware of the numerous limitations associated with this particular analysis. Significant uncertainties and limitations exist associated with each analytical block within Figure 1.1. Existing emissions inventories are limited, projections to the year 2010 may involve significant error, available air quality models are limited, control cost estimates are inexact, health and welfare effect predictions are not precise, valuation approaches are controversial and potentially significant benefit categories are not monetized, and so on. The accumulation of these uncertainties is substantial.

To the degree feasible, the analysis that follows attempts to identify and characterize in some detail the various uncertainties and limitations related to the specific components of this analysis. In many cases, however, the lack of data prevent a rigorous quantitative treatment of uncertainties. Whether quantified or not, the reader should keep in mind all of the above uncertainties and limitations when reviewing and interpreting the results presented in the chapters that follow.

1.5 REFERENCES

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