Chapter 9: Comparison of Benefits and Costs

Synopsis

This chapter compares estimates of the modeled and full attainment benefits with economic costs. Tables 9-1 through 9-2 compare the estimated benefits and costs across the east, west and California for the modeled and full attainment scenarios. The first of these two tables compares benefits to costs estimates by using benefits estimates derived based on a mortality function from the American Cancer Society . Finally, Table 9-3 presents net benefits of full attainment using Expert Elicitation derived mortality functions and morbidity functions from epidemiology literature.

Comparison of Costs and Benefits

Note that the estimates of net benefits in the tables that follow are derived by subtracting *social* costs from total benefits. Because these social cost estimates account for the economic impact of our illustrative control strategies, they differ from the engineering cost estimates found in the Executive Summary and Chapters 1 and 6.

Table 9-1. Comparison of Benefits and Costs of Partial and Full Attainment Scenarios for Revised Standards of 15/35 (Million 1999$)[a]

	Benefits	*Social Costs*	*Net benefits*
Partial Attainment			
3 percent discount rate			
East	$2,400	$710	$1,700
West	$680	$380	$300
California	$3,600	$55	$3,700
Total	$6,700	$1,200	$5,600
7 percent discount rate			
East	$2,100	$710	$1,400
West	$610	$380	$230
California	$3,100	$55	$3,100
Total	$5,800	$1,200	$4,700
Full Attainment			
3 percent discount rate			
East	$2,500	$710	$1,800
West	$800	$680	$120
California	$14,000	$4,000	$10,000
Total	$17,000	$5,400	$12,000
7 percent discount rate			
East	$2,200	$710	$1,500
West	$720	$680	$36
California	$12,000	$4,000	$7,600
Total	$14,500	$5,400	$9,000

[a] The benefits in this table are derived by using an effect estimate based on the concentration-response (C-R) function developed from the study of the American Cancer Society cohort reported in Pope et al (2002), which has previously been reported as the primary estimate in recent RIAs.

Table 9-2. Comparison of Benefits and Costs of Partial and Full Attainment Scenarios for Alternative More Stringent Standards of 14/35 (Million 1999$)[a]

	Benefits	*Social Costs*	*Net benefits*
Partial Attainment			
3 percent discount rate			
East	$14,000	$2,900	$11,000
West	$690	$530	$160
California	$3,500	$84	$3,400
Total	$19,000	$3,500	$15,000
7 percent discount rate			
East	$12,300	$2,900	$9,400
West	$620	$530	$86
California	$3,100	$84	$3,000
Total	$16,000	$3,500	$12,000
Full Attainment			
3 percent discount rate			
East	$15,000	$2,900	$12,000
West	$820	$840	($20)
California	$14,000	$4,100	$10,000
Total	$30,000	$7,900	$22,000
7 percent discount rate			
East	$13,000	$2,900	$9,800
West	$730	$840	($100)
California	$12,000	$4,100	$8,000
Total	$26,000	$7,900	$18,000

[a] The benefits in this table are derived by using an effect estimate based on the concentration-response (C-R) function developed from the study of the American Cancer Society cohort reported in Pope et al (2002), which has previously been reported as the primary estimate in recent RIAs.

Table 9-2. Comparison of Benefits and Social Costs: Expert Elicitation-Derived Estimates

	Net Benefits[a, b] (millions 1999$)	
	15/35 (µg/m3)	*14/35 (µg/m3)*
Using a 3% discount rate	$3,500 to $70,000	$8,700 to $130,000
Using a 7% discount rate	$2,400 to $59,000	$6,700 to $110,000

Discussion of Uncertainties and Limitations

Air Quality Modeling and Emissions

- Overall, the air quality model performs well in predicting monthly to seasonal concentrations, similar to other state-of-the-science air quality model applications for $PM_{2.5}$. However, there is less certainty in analyses involving 24-hour model predictions than those involving longer-term averages concentrations and performance is better for the Eastern U.S. than for the West. In both the East and West, secondary carbonaceous aerosols are the most challenging species for the modeling system to predict in terms of evaluation against ambient data.

- Underestimation biases in the mobile source emission inventories lead to uncertainty as to the relative contribution of mobile source emissions to overall PM levels.

- Additional uncertainty is introduced as a result of our limited understanding concerning the collective impact on future-year emission estimates from economic growth estimates, increases in technological efficiencies, and limited information on the effectiveness of future control programs.

- The regional scale used for air quality modeling can understate the effectiveness of controls on local sources in urban areas as compared to area-wide or regional controls. This serves to obscure local-scale air quality improvements that result from urban-area controls.

Controls and Cost

- The technologies applied and the emission reductions achieved in these analyses may not reflect emerging control devices that could be available in future years to meet any requirements in SIPs or upgrades to some current devices that may serve to increase control levels.

- The effects from "learning by doing" are not accounted for in the emission reduction estimates for point and area sources. It is possible that an emissions control technology may have better performance in reducing emissions due to greater understanding of how best to operate and maintain the technology. As a result, we may understate the emission reductions estimated by these analyses. The mobile source control measures do account for these learning by doing effects.

- The effectiveness of the control measures in these analyses is based on an assumption that these controls are well maintained throughout their equipment life (the amount of time they are assumed to operate). To the extent that a control measure is not well maintained, the control efficiency may be less than estimated in these analyses. Since these control measures must operate according to specified permit conditions, however, it is expected that the maintenance of controls should yield control efficiencies at or very close to those used in these analyses. As a result, we may overstate the emission reductions estimated by these analyses.

- The application of area source control technologies in these analyses assume that a constant estimate for emission reduction is reasonable despite variation in the extent or scale of application (e.g. dust control plans at construction sites). To the extent that there are economies of scale in area source control applications, we may overstate the emission reductions estimated by these analyses.

- The cost extrapolation method used to develop full attainment costs is highly uncertain and may significantly under or overstate future costs of full attainment.

Benefits

- This analysis assumes that inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis. Although biological mechanisms for this effect have not yet been specifically identified, the weight of the available epidemiological, toxicological, and experimental evidence supports an assumption of causality. The impacts of including a probabilistic representation of causality are explored using the results of the expert elicitation.

- This analysis assumes that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality. This is an important assumption, because the composition of PM produced via transported precursors emitted from EGUs may differ significantly from direct PM released from automotive engines and other industrial sources. In accordance with advice from the CASAC, EPA has determined that no clear scientific grounds exist for supporting differential effects estimates by particle type, based on information in the most recent Criteria Document. In chapter 5, we provide a decomposition of benefits by PM component species to provide additional insights into the makeup of the benefits associated with reductions in overall $PM_{2.5}$ mass (See Tables 5-32 and 5-33).

- This analysis assumes that the concentration-response (CR) function for fine particles is approximately linear within the range of ambient concentrations under consideration (above the assumed threshold of 10 $\mu g/m^3$). Thus, we assume that the CR functions are applicable to estimates of health benefits associated with reducing fine particles in areas with varied concentrations of PM, including both regions that are in attainment with $PM_{2.5}$ standards and those that do not meet the standards. However, we examine the impact of this assumption by looking at alternative thresholds in a sensitivity analysis.

- A key assumption underlying the entire analysis is that the forecasts for future emissions and associated air quality modeling are valid. Because we are projecting emissions and air quality out to 2020, there are inherent uncertainties in all of the factors that underlie the future state of emissions and air quality levels.

Conclusions and Insights

EPA's analysis has estimated the health and welfare benefits of reductions in ambient concentrations of particulate matter resulting from a set of illustrative control strategies to reduce emissions of $PM_{2.5}$ precursors. The results suggest there will be significant additional health and welfare benefits arising from reducing emissions from a variety of sources in and around projected nonattaining counties in 2020. While 2020 is the latest date by which states would generally need to demonstrate attainment with the revised standards, it is expected that benefits (and costs) will begin occurring earlier, as states begin implementing control measures to show progress towards attainment.

There are several important factors to consider when evaluating the relative benefits and costs of the attainment strategies for the revised 15/35 and alternative 14/35 standards:

- California accounts for a large share of the total benefits and costs for both of the evaluated standards (80 percent of the benefits and 78 percent of the costs of attaining the revised standards, and 50 percent of the benefits and 58 percent of the costs of attaining the alternative standards). Because we were only able to model a small fraction of the emissions controls that might be needed to reach attainment in California, the proportion of California benefits in the "residual attainment" category are large relative to other areas of the U.S. Both the benefits and the costs associated with the assumed reductions in California are particularly uncertain.

- The comparative magnitudes and distributions of benefits estimates for the revised and alternative standards are significantly affected by differences in assumed attainment strategies. As noted above, attainment with the revised standards was simulated using mainly local reductions, while a supplemental eastern regional SO2 reduction program was used for the alternative. Under the assumptions in the analyses, the regional strategy used in meeting the alternative standard resulted in significant additional benefits in attainment areas than the local area strategy used for the revised standard. This makes the difference in benefits between the revised and alternative standards larger than can be accounted for by only the 1 µg/m3 lower annual level for the alternative standards.

- Given current scientific uncertainties regarding the contribution of different components to the effects associated with $PM_{2.5}$ mass, this analysis continues to assume the contribution is directly proportional to their mass. In the face of uncertainties regarding this assumption, we believe that strategies which reduce a wide array of types of PM and precursor emissions will have more certain health benefits than strategies that are more narrowly focused. For this reason, the analysis provides a rough basis for comparing the assumed benefits associated with different components for different strategies. The illustrative attainment strategy for the revised standards results in a more balanced mix of reductions in different $PM_{2.5}$ components than does the regional strategy for the alterative standards. Until a more robust scientific basis exists for making reliable judgments about the relative toxicity of PM, it will not be possible to determine whether the strategy of reducing a wide array of PM types is the optimal approach.

- Because of the limitations and uncertainties in the emissions and air quality components of our assessment, the specific control strategies that might be the most effective in helping areas to reach attainment are still very uncertain. For example, the high likelihood of mobile sources emissions being significantly understated biases the analyses by requiring additional controls from other sources in both the base case and the analyses of the 1997, revised, and alternative standards.

- Previous analyses have focused on measuring cost-effectiveness by comparing control measures in terms of cost per ton of emissions reduced. In those analyses, direct PM controls usually appear to be less cost-effective because the cost per ton is in the tens of thousands of dollars per ton, while SO2 and NOx controls are on the order of thousands of dollars per ton. The current analysis demonstrates that when considered on a cost per microgram reduced basis, controls on directly emitted PM are often the most cost-effective, because of the significant local contribution of direct PM emissions to nonattaining monitors in urban areas. This finding suggests that states should consider ranking controls on a cost per microgram basis rather than a cost per ton basis to increase the overall cost-effectiveness of attainment strategies.