Chapter 4. Benefit-Cost Comparison

4.1 Summary of Costs and Benefits

This Regulatory Impact Analysis (RIA) provides cost, economic impact, and benefit estimates that are potentially useful for evaluating the efficiency of the Section 126 rulemaking. Benefit-cost analysis provides a systematic framework for assessing and comparing such alternatives. According to economic theory, the efficient alternative maximizes net benefits to society (i.e., social benefits minus social costs). However, there are practical limitations for the comparison of benefits to costs in this analysis. This chapter also discusses the key limitations and uncertainties associated with the benefit and cost estimates. Nonetheless, if one is mindful of these limitations, the relative magnitude of the benefit-cost comparison presented here can be useful information.

The estimated cost of implementing the Section 126 rule is **$1.1 billion (1997$)** for the selected regulatory alternative consisting of a 0.15 lb/mmBtu NOx emission limit for electricity generating units and 60 percent NOx emission control for large industrial boilers and combustion turbines. This estimate includes monitoring and administrative costs, including those associated with the trading program.

As explained in more detail in Chapters 9 and 10 of the Regulatory Impact Analysis for the Final Section 126 Petition Rule (the Section 126 RIA), selection of 2007 as the analytical year for the benefits analysis resulted in SO_2 emissions and air quality results that are not representative of the expected change in air quality for most years when the rule is in effect. Because of the SO_2 emissions banking provisions of the acid rain permit program, SO_2 emissions can increase in some years and decrease in others as long as net SO_2 emissions do not change over a specified time horizon. The 2007 analytical year is a year when there are particularly high levels of permit withdrawals (due to shifting in electricity generation and adoption of technologies that use high sulfur coal), such that SO_2 emissions in 2007 increase relative to baseline levels. In most other years, SO_2 emissions decrease, so 2007 represents a "worst case" year with respect to the change in SO_2 emissions. To account for this, we have constructed a "Representative Year" (in terms of SO_2 emissions) scenario by zeroing out all changes in sulfates, both positive and negative, in calculating the changes in $PM_{2.5}$. Changes in $PM_{2.5}$ are then driven solely by changes in nitrate concentrations. EPA believes that this "Representative Year" scenario is a closer approximation to the expected annual benefits of the Section 126 rule[1].

Total monetized benefits (ozone and PM) associated with the final Section 126 rule for the "Representative Year" are presented in Table 11-12 along with a breakdown of benefits by endpoint.

[1] Estimated benefits for two alternative scenarios, a 2007 "SO_2 increasing" scenario and a 2004 "SO_2 decreasing" scenario, are presented in Chapter 11 of the Section 126 RIA. However, EPA believes that the most representative benefits estimate is provided by the "Representative Year" scenario presented in this chapter.

Table 4-1.
Estimated Annual Quantified and Monetized Benefits of the Final Section 126 Rule in 2007 for the "Representative Year" SO_2 Emissions Banking Scenario

Endpoint	Pollutant	Avoided Incidence[a,b] (cases/year)	Monetary Benefits[c,d] (millions 1997$)
Premature mortality[e,f] (adults, 30 and over)	PM	200	$1,090
Chronic asthma (adult males, 27 and over)	Ozone	400	$10
Chronic bronchitis	PM	100	$30
Hospital Admissions from Respiratory Causes	Ozone and PM	600	$10
Hospital Admissions from Cardiovascular Causes	Ozone and PM	200	$1
Emergency Room Visits for Asthma	Ozone and PM	200	$1
Acute bronchitis (children, 8-12)	PM	400	<$1
Lower respiratory symptoms (LRS) (children, 7-14)	PM	3,800	<$1
Upper respiratory symptoms (URS) (asthmatic children, 9-11)	PM	3,900	<$1
Shortness of breath (African American asthmatics, 7-12)	PM	1,000	<$1
Work loss days (WLD) (adults, 18-65)	PM	29,900	$3
Minor restricted activity days (MRAD)/Acute respiratory symptoms	Ozone and PM	1,181,600	$60
Decreased worker productivity	Ozone	—	$100
Other health effects	Ozone and PM	U_1+U_2	B_1+B_2
Recreational (Class I Area) visibility	PM and Gases	—	$40
Residential visibility	PM and Gases	—	B_3
Household soiling damage	PM	—	B_4
Materials damage	PM	—	B_5
Nitrogen Deposition	Nitrogen	—	B_6
Agricultural crop damage	Ozone	—	$10
Commercial forest damage	Ozone	—	B_7
Other welfare effects	Ozone and PM	—	B_8+B_9
Monetized Total			**$1,360+B**

[a] Incidences are rounded to the nearest 100.
[b] The U_i are the incidences for the unquantified category i.
[c] Dollar values are rounded to the nearest 10.
[d] **B** is equal to the sum of all unmonetized categories, i.e. $B_1+B_2+...+B_{17}$.

[e] Premature mortality associated with ozone is not separately included in this analysis. It is assumed that the Pope et al. C-R function for premature mortality captures both PM mortality benefits and any mortality benefits associated with other air pollutants.
[f] These estimates are based on the EPA preferred approach for valuing reductions in premature mortality, the VSL approach. This approach and an alternative, age-adjusted approach – the VSLY approach – are discussed more fully in section 11.9 of the Section 126 RIA.

Using EPA's preferred approach for monetizing reductions in PM-related premature mortality – the VSL approach – total monetized benefits (ozone plus PM) of the final Section 126 rule are projected to be around **$1.4 billion (1997$)** for the selected regulatory alternatives for EGUs and non-EGUs. However, the adoption of a value for the projected reduction in the risk of premature mortality is the subject of continuing discussion within the economic and public policy analysis community within and outside the Administration. In response to the sensitivity on this issue, we provide estimates reflecting two alternative approaches. The first approach -- supported by some in the above community and preferred by EPA -- uses a Value of a Statistical Life (VSL) approach developed for the Clean Air Act Section 812 benefit-cost studies. This VSL estimate of $5.9 million (1997$) was derived from a set of 26 studies identified by EPA using criteria established in Viscusi (1992), as those most appropriate for environmental policy analysis applications.

An alternative, age-adjusted approach is preferred by some others in the above community both within and outside the Administration. This approach was also developed for the Section 812 studies and addresses concerns with applying the VSL estimate –reflecting a valuation derived mostly from labor market studies involving healthy working-age manual laborers– to PM-related mortality risks that are primarily associated with older populations and those with impaired health status. This alternative approach leads to an estimate of the value of a statistical life year (VSLY), which is derived directly from the VSL estimate. It differs only in incorporating an explicit assumption about the number of life years saved and an implicit assumption that the valuation of each life year is not affected by age.[2] The mean VSLY is $360,000 (1997$); combining this number with a mean life expectancy of 14 years yields an age-adjusted VSL of $3.6 million (1997$).

Both approaches are imperfect, and raise difficult methodological issues which are discussed in depth in the recently published Section 812 Prospective Study, the draft EPA Economic Guidelines, and the peer-review commentaries prepared in support of each of these documents. For example, both methodologies embed assumptions (explicit or implicit) about which there is little or no definitive scientific guidance. In particular, both methods adopt the assumption that the risk versus dollars trade-offs revealed by available labor market studies are applicable to the risk versus dollar trade-offs the general population would make in an air pollution context.

[2] Specifically, the VSLY estimate is calculated by amortizing the $5.9 million mean VSL estimate over the 35 years of life expectancy associated with subjects in the labor market studies. The resulting estimate, using a 5 percent discount rate, is $360,000 per life-year saved in 1997 dollars. This annual average value of a life-year is then multiplied times the number of years of remaining life expectancy for the affected population (in the case of PM-related premature mortality, the average number of life-years saved is 14.

EPA currently prefers the VSL approach because, essentially, the method reflects the direct, application of what EPA considers to be the most reliable estimates for valuation of premature mortality available in the current economic literature. While there are several differences between the labor market studies EPA uses to derive a VSL estimate and the particulate matter air pollution context addressed here, those differences in the affected populations and the nature of the risks imply both upward and downward adjustments. For example, adjusting for age differences may imply the need to adjust the $5.9 million VSL downward as would adjusting for health differences, but the involuntary nature of air pollution-related risks and the lower level of risk-aversion of the manual laborers in the labor market studies may imply the need for upward adjustments. In the absence of a comprehensive and balanced set of adjustment factors, EPA believes it is reasonable to continue to use the $5.9 million value while acknowledging the significant limitations and uncertainties in the available literature. Furthermore, EPA prefers not to draw distinctions in the monetary value assigned to the lives saved even if they differ in age, health status, socioeconomic status, gender or other characteristic of the adult population.

Those who favor the alternative, age-adjusted approach (i.e. the VSLY approach) emphasize that the value of a statistical life is not a single number relevant for all situations. Indeed, the VSL estimate of $5.9 million (1997 dollars) is itself the central tendency of a number of estimates of the VSL for some rather narrowly defined populations. When there are significant differences between the population affected by a particular health risk and the populations used in the labor market studies - as is the case here - they prefer to adjust the VSL estimate to reflect those differences. While acknowledging that the VSLY approach provides an admittedly crude adjustment (for age though not for other possible differences between the populations) they point out it has the advantage of yielding an estimate that is not presumptively biased. Proponents of adjusting for age differences using the VSLY approach fully concur that enormous uncertainty remains on both sides of this estimate - upwards as well as downwards - and that the populations differ in ways other than age (and therefore life expectancy). But rather than waiting for all relevant questions to be answered, they prefer a process of refining estimates by incorporating new information and evidence as it becomes available.

The estimates of total benefits do not include the monetary value of several known PM-related welfare effects, including residential visibility, household soiling and materials damage, and deposition of nitrogen to sensitive estuaries. Detailed estimates of the benefits for individual ozone and PM-related health and welfare endpoints are provided in Chapter 11 of the Section 126 RIA.

Any comparison of benefits and costs for this rule will provide limited information, given the incomplete estimate of benefits. However, even with the limited set of benefit categories we were able to monetize, monetized net benefits using EPA's preferred method for valuing avoided incidences of premature mortality are approximately **$0.3 billion (1997$).** Using the alternative, age-adjusted approach – the VSLY approach – total monetized benefits are projected to be around **$0.9 billion (1997$)**. Monetized net benefits using this approach are approximately **$-0.3 billion (1997$)**. Costs, benefits, and net benefits for the two alternative valuation methods are summarized in Tables 4-2 and 4-

3.

As with any estimate based on a complex, multi-stage model, there are numerous sources of uncertainty that can affect the confidence in the estimates of benefits. These uncertainties are discussed in the Section 126 RIA in the individual chapters on emissions (Chapter 9), air quality (Chapter 10), and benefits (Chapter 11).

In addition to the monetized benefits listed in Table 4-1, the final Section 126 rule will result in significant improvements in visibility in urban and suburban residential areas, increases in yields of commercial forests currently exposed to elevated ozone levels, and reductions in loadings of nitrogen to sensitivity estuaries, helping state and local governments reach target reduction goals for important estuaries including the Chesapeake Bay, the Albemarle-Pamlico Sound, and Long Island Sound. The final Section 126 rule will help reduce loadings in these estuaries by up to 22 percent of stated reduction goals.

Table 4-2.
2007 "Representative Year" Estimated Annual Monetized Costs, Benefits, and Net Benefits for the Section 126 Rule[a]: EPA Preferred Estimates Using the Value of Statistical Lives Saved Approach to Value Reductions in Premature Mortality

	Million 1997$
Compliance costs	$1,200
Monetized PM-related benefits[b,c]	$1,200
Monetized Ozone-related benefits[b]	$200
Projected Monetized net benefits[c]	$200

[a] For this chapter, all costs and benefits are rounded to the nearest 100 million. Thus, figures presented in this chapter may not exactly equal benefit and cost numbers presented in earlier chapters.
[b] Not all possible benefits or disbenefits are quantified and monetized in this analysis. Potential benefit categories that have not been quantified and monetized are listed in Table 11-1 in Chapter 11 of the Section 126 RIA.
[c] These estimates are based on the EPA preferred approach for valuing reductions in premature mortality, the VSL approach. This approach and an alternative, age-adjusted approach – the VSLY approach – are discussed more fully in section 11.9 of Chapter 11 in the Section 126 RIA.

Table 4-3.
2007 "Representative Year" Estimated Annual Monetized Costs, Benefits, and Net Benefits for the Section 126 Rule[a]: Alternative Estimates Using the Value of Statistical Life Years Saved Approach to Value Reductions in Premature Mortality

	Million 1997$
Compliance costs	$1,200
Monetized PM-related benefits[b,c]	$700
Monetized Ozone-related benefits[b]	$200
Projected Monetized net benefits[c]	$-300

[a] For this chapter, all costs and benefits are rounded to the nearest 100 million. Thus, figures presented in this chapter may not exactly equal benefit and cost numbers presented in earlier chapters.
[b] Not all possible benefits or disbenefits are quantified and monetized in this analysis. Potential benefit categories that have not been quantified and monetized are listed in Table 11-1 in Chapter 11 of the Section 126 RIA.
[c] The VSLY estimate is calculated by amortizing the $5.9 million mean VSL estimate over the 35 years of life expectancy associated with subjects in the labor market studies used to obtain the VSL estimate. The resulting estimate, using a 5 percent discount rate, is $360,000 per life-year saved in 1997 dollars. This approach is discussed more fully in section 11.9 of Chapter 11 in the Section 126 RIA.

4.2 Findings and Qualifications

Cost-benefit analysis provides a valuable framework for organizing and evaluating information on the effects of environmental programs. When used properly, cost-benefit analysis helps illuminate important potential effects of alternative policies and helps set priorities for closing information gaps and reducing uncertainty. However, not all relevant costs and benefits can be captured in any analysis. Executive Order 12866 clearly indicates that unquantifiable or nonmonetizable categories of both costs and benefits should not be ignored. There are many important unquantified and unmonetized costs and benefits associated with reductions in NOx emissions, including many health and welfare effects. Potential benefit categories that have not been quantified and monetized are listed in Chapter 11, Table 11-1 of the final Section 126 RIA.

Several specific limitations deserve to be mentioned:

- The state of atmospheric modeling is not sufficiently advanced to provide a workable "one atmosphere" model capable of characterizing ground-level pollutant exposure for all pollutants of interest (e.g., ozone, particulate matter, carbon monoxide, nitrogen deposition, etc). Therefore, the Environmental Protection Agency (EPA) must employ several different pollutant models to characterize the effects of alternative policies on relevant pollutants. Also, not all atmospheric models have been widely validated against actual ambient data. In particular, since a broad-scale monitoring network does not yet exist for fine particulate matter ($PM_{2.5}$), atmospheric models designed to capture the effects of alternative policies on $PM_{2.5}$ are not fully validated. Additionally, significant shortcomings exist in the data that are available to perform these analyses. While containing identifiable shortcomings and uncertainties, EPA believes the models and assumptions used in the analysis are reasonable based on the available evidence.

- Another dimension adding to the uncertainty of this analysis is time. In the case of air pollution control, 10 years is a very long time over which to carry assumptions. Pollution control technology has advanced considerably in the last 10 years and can be expected to continue to advance in the future. Yet there is no clear way to model this advance for use in this analysis. In addition, there is no clear way to predict future meteorological conditions, or the growth in source-level emissions over time. Again, EPA believes that the assumptions to capture these elements are reasonable based on the available evidence.

- Qualitative and more detailed discussions of the above and other uncertainties and limitations are included in the final Section 126 RIA. Where information and data exist, quantitative characterizations of these uncertainties are included. However, data limitations prevent an overall quantitative estimate of the uncertainty associated with final estimates. Nevertheless, the reader should keep all of these uncertainties and limitations in mind when reviewing and

interpreting the results.