Chapter 7: Conclusions and Implications of the Illustrative Benefit-Cost Analysis

7.1 Synopsis

EPA has performed an illustrative analysis to estimate the costs and human health benefits of nationally attaining alternative 0.075 ppm ozone standard. We have also considered 3 alternative standards incremental to attaining the current ozone standard: 0.079 ppm, 0.070 ppm, and 0.065 ppm. This chapter summarizes these results and discusses the implications of the analysis. This analysis serves both to satisfy the requirements of E.O. 12866 and to provide the public with an estimate of the potential costs and benefits of attaining alternative ozone standards. The benefit and cost estimates below are calculated incremental to a 2020 baseline that incorporates air quality improvements achieved through the projected implementation of existing regulations and full attainment of the current standards for ozone and PM NAAQS (including the hypothetical control strategy developed in the RIA for full attainment of the PM NAAQS 15/35 promulgated in September, 2006). This RIA presents the costs and benefits of full attainment in all locations except two areas of California, which would not be required to meet an alternate primary standard until 2024. Estimates for these two areas are presented in Appendix 7b. This chapter provides additional context for the RIA analysis and a discussion of limitations and uncertainties.

7.2 Results

7.2.1 Presentation of Results

For analytical purposes explained previously, we assume that almost all areas of the country will meet each alternate primary standard in 2020 through the development of technologies at least as effective as the hypothetical strategies used in this illustration. It is expected that benefits and costs will begin occurring earlier, as states begin implementing control measures to attain earlier or to show progress towards attainment. Some areas with very high levels of ozone do not plan to meet even the current standard until 2024; specifically, two California areas have adopted plans for post-2020 attainment as noted above. To perform an analysis beyond 2020 involves the use of highly speculative assumptions that introduce a much higher level of uncertainty to the results. Thus, in these locations, we provide estimates of the costs and benefits of fully attaining the alternate primary standards at a later date (2030) in Appendix 7b. It is important to note that, as a result, the 2020 results presented here do not represent a complete “full attainment” scenario for the entire nation. Due to the differences in attainment year and other assumptions underlying 2020 analysis presented here and the 2030 analysis in the appendix, it is not appropriate to add the results together to get a national “full attainment” scenario. Finally, Appendix 6b contains a health-based cost effectiveness analysis that complements the results found below.

The following two tables summarize the costs and benefits of attaining the alternate primary standards in 2020 for all places except South Coast and San Joaquin. For purposes of this analysis, we assume attainment by 2020 for all areas except San Joaquin Valley and South Coast air basins in California. The state has submitted plans to EPA for implementing the current ozone standard which propose that these two areas of California meet that standard by 2024. We have assumed for analytical purposes that the San Joaquin Valley and South Coast air basin would attain a new standard in 2030. There are many uncertainties associated with the year 2030 analysis. Between 2020 and 2030 several federal air quality rules are likely to further reduce emissions of NOx and VOC, such as, but not limited to National rules for Diesel Locomotives, Diesel Marine Vessels, and Small Nonroad Gasoline Engines. These emission reductions should lower ambient levels of ozone in California between 2020 and 2030. Complete emissions inventories as well as air quality modeling were not available for this year 2030 analysis. Due to these limitations, it is not possible to adequately model 2030 air quality changes that are required to develop robust controls strategies with associated costs and benefits. In order to provide a rough approximation of the costs and benefits of attaining 0.075 ppm and the alternate standards in San Joaquin and South Coast air basins, we have relied on the available data. Available data includes emission inventories, which do not include any changes in stationary source emissions beyond 2020, and 2020 supplemental air quality modeling. This data was used to develop extrapolated costs and benefits of 2030 attainment. To view the complete analysis for the San Joaquin Valley and South Coast air basins see Appendix 7b.

The costs presented here are based on reducing emissions primarily within 200 km of counties projected to fail to attain a particular standard. Changes in emissions translate into changes in ozone within and beyond the 200 km control areas. Air quality modeling is used to estimate where the changes in ozone resulting from emission changes takes place. Benefits are then estimated based on the modeled changes in ozone.

Tables 7.1a-d present benefits and costs. Table 7.2 provides the estimated reductions in premature mortality and morbidity.

Table 7.1a: Estimated Range of Annual Monetized Costs and Ozone Benefits and $PM_{2.5}$ Co-Benefits: 0.075 ppm Standard in 2020 in Billions of 2006$*

Ozone Mortality Function or Assumption	Reference	Total Benefits** 3%	Total Benefits** 7%	Total Costs*** 7%	Net Benefits 3%	Net Benefits 7%
NMMAPS	Bell et al. 2004	2.6 – 17	2.4 – 16	7.6 – 8.8	–6.3 – 9.5	–6.4 – 7.9
Meta-analysis	Bell et al. 2005	3.8 – 18	3.6 – 17	7.6 – 8.8	–5.0 – 11	–5.2 – 9.1
	Ito et al. 2005	4.4 – 19	4.3 – 17	7.6 – 8.8	–4.4 – 11	–4.5 – 9.8
	Levy et al. 2005	4.5 – 19	4.4 – 17	7.6 – 8.8	–4.3 – 11	–4.5 – 9.9
Assumption that association is not causal****		2.0 – 17	1.8 – 15	7.6 – 8.8	–6.8 – 9	–7.0 – 7.4

Table 7.1b: Estimated Range of Annual Monetized Costs and Ozone Benefits and $PM_{2.5}$ Co-Benefits: 0.079 ppm Standard in 2020 in Billions of 2006$*

Ozone Mortality Function or Assumption	Reference	Total Benefits** 3%	Total Benefits** 7%	Total Costs*** 7%	Net Benefits 3%	Net Benefits 7%
NMMAPS	Bell et al. 2004	1.4 – 11	1.3 – 9.9	2.4 – 2.9	–1.5 – 8.5	–1.6 – 7.5
Meta-analysis	Bell et al. 2005	1.9 – 11	1.8 – 10	2.4 – 2.9	–1.1 – 8.9	–1.2 – 7.9
	Ito et al. 2005	2.1 – 12	2.0 – 11	2.4 – 2.9	–0.83 – 9.2	–0.9 – 8.1
	Levy et al. 2005	2.1 – 12	2.0 – 11	2.4 – 2.9	–0.80 – 9.2	–0.9 – 8.2
Assumption that association is not causal****		1.2 – 11	1.1 – 9.7	2.4 – 2.9	–1.7 – 8.3	–1.8 – 7.3

Table 7.1c: Estimated Range of Annual Monetized Costs and Ozone Benefits and $PM_{2.5}$ Co-Benefits: 0.070 ppm Standard in 2020 in Billions of 2006$*

Ozone Mortality Function or Assumption	Reference	Total Benefits** 3%	Total Benefits** 7%	Total Costs*** 7%	Net Benefits 3%	Net Benefits 7%
NMMAPS	Bell et al. 2004	5.4 – 29	5.1 – 27	19 – 25	–20 – 10	–20 – 7.6
Meta-analysis	Bell et al. 2005	9.7 – 34	9.5 – 31	19 – 25	–15 – 15	–16 – 12
	Ito et al. 2005	12 – 36	12 – 33	19 – 25	–13 – 17	–13 – 14
	Levy et al. 2005	12 – 36	12 – 33	19 – 25	–13 – 17	–13 – 14
Assumption that association is not causal****		3.5 – 27	3.2 – 25	19 – 25	–22 – 8	–22 – 5.7

Table 7.1d: Estimated Range of Annual Monetized Costs and Ozone Benefits and $PM_{2.5}$ Co-Benefits: 0.065 ppm Standard in 2020 in Billions of 2006$*

Ozone Mortality Function or Assumption	Reference	Total Benefits** 3%	Total Benefits** 7%	Total Costs*** 7%	Net Benefits 3%	Net Benefits 7%
NMMAPS	Bell et al. 2004	9.0 – 46	8.6 – 42	32 – 44	–35 – 14	–35 – 9.7
Meta-analysis	Bell et al. 2005	17 – 54	16 – 50	32 – 44	–27 – 22	–28 – 18
	Ito et al. 2005	21 – 58	21 – 54	32 – 44	–23 – 26	–23 – 22
	Levy et al. 2005	21 – 58	21 – 54	32 – 44	–23 – 26	–23 – 22
Assumption that association is not causal****		5.5 – 42	5.1 – 38	32 – 44	–39 – 10	–39 – 6.2

*All estimates rounded to two significant figures. As such, they may not sum across columns. These estimates do not include visibility benefits. Only includes areas required to meet the current standard by 2020, does not include San Joaquin and South Coast areas in California. Appendix 7b shows the costs and benefits of attaining alternate standards in San Joaquin and South Coast California.

**Includes ozone benefits, and PM 2.5 co-benefits. Range was developed by adding the estimate from the ozone premature mortality function to both the lower and upper ends of the range of the PM2.5 premature mortality functions characterized in the expert elicitation. Tables exclude unquantified and nonmonetized benefits.

***Range reflects lower and upper bound cost estimates. Data for calculating costs at a 3% discount rate was not available for all sectors, and therefore total annualized costs at 3% are not presented here. Additionally, these estimates assume a particular trajectory of aggressive technological change. An alternative storyline might hypothesize a much less optimistic technological trajectory, with increased costs, or with decreased benefits in 2020 due to a later attainment date.

****Total includes ozone morbidity benefits and total PM co-benefits only.

The individual row estimates for benefits reflect the variability in the functions available for estimating a major source of benefits—avoided ozone premature mortality. Ranges within the total benefits column reflect variability in the estimates of PM premature mortality co-benefits across the available effect estimates. Ranges in the total costs column reflect different assumptions about the extrapolation of costs. The low end of the range of net benefits is constructed by subtracting the highest cost from the lowest benefit, while the high end of the range is constructed by subtracting the lowest cost from the highest benefit. Following these tables is a discussion of the implications of these estimates, as well as the uncertainties and limitations that should be considered in interpreting the estimates. These tables do not include visibility benefits, which are estimated at $160 million/yr.

Below are three graphs illustrating the net benefits of the selected and alternative standards. Figures 7.1 and 7.2 provide visual depictions of all available net benefit estimates. Figure 7.3 contains a subset of estimates from the graphic above, displaying four combinations of ozone and PM benefits estimates with the two primary cost estimates for each alternative. These figures depict the richness and variability in the estimates of costs and benefits that may not be captured by the truncated summary tables above.

Figure 7.1 displays all possible combinations of net benefits, utilizing the five different ozone functions, the fourteen different PM functions, and the two cost methods. Each of the 140 bars in each graph represents an independent and equally probability point estimate of net benefits under a certain combination of cost and benefit estimation methods. Thus it is not possible to infer the likelihood of any single net benefit estimate. The blue bars indicate combinations where the net benefits are negative, whereas the green bars indicate combinations where net benefits are positive.

Figure 7.2 displays a close-up view of the range of net benefits for the selected standard. For the selected standard of 0.075 ppm, the median value of all of the independent point estimates is $0.8 billion, and the majority (64%) of the combinations indicate positive net benefits for this standard.

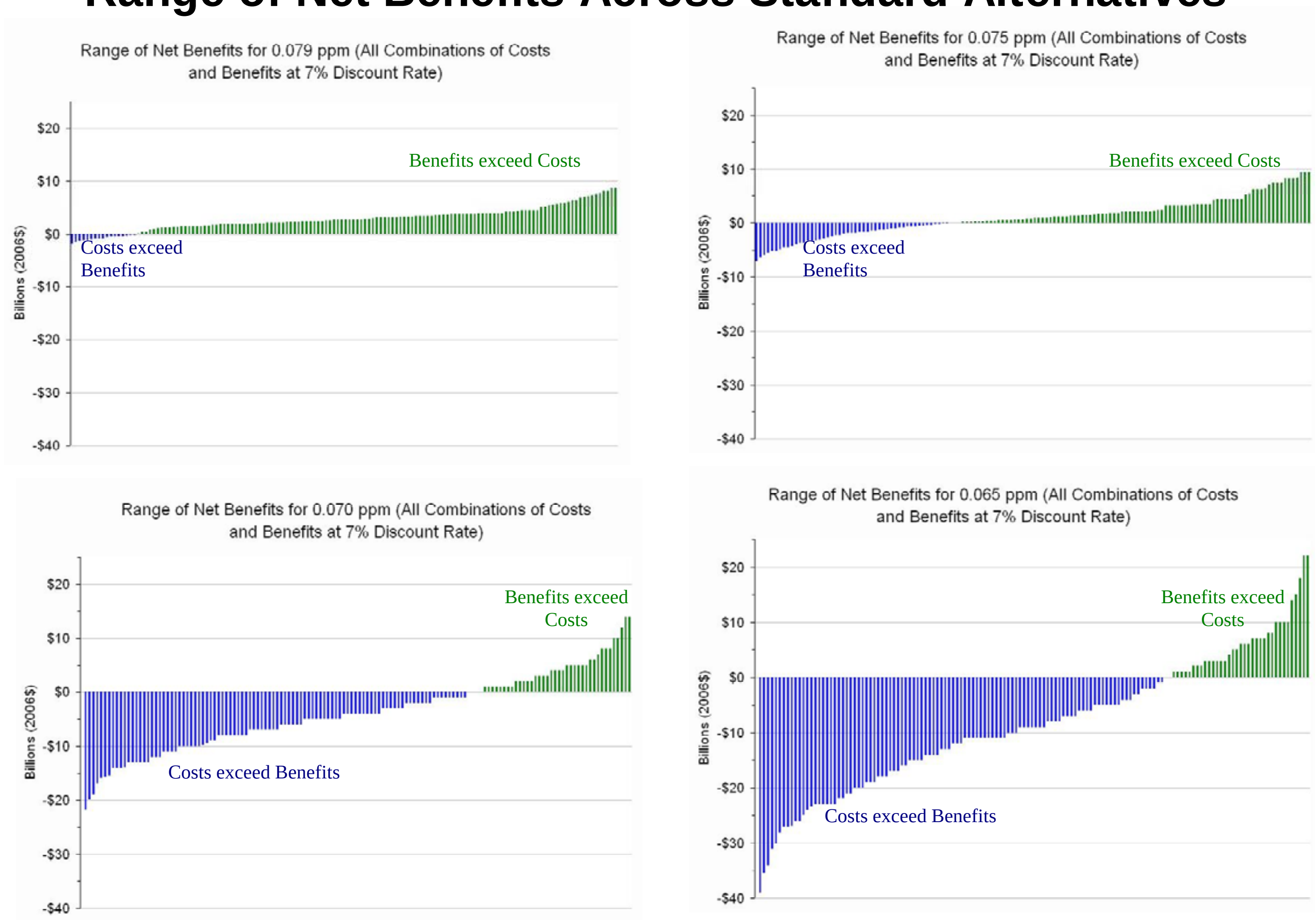
Figure 7.3 illustrates a subset of the net benefit estimates shown in Figure 7.1. While we treat each combination of costs and benefit estimates as being equally probable in our model, here we select a series of combinations of an ozone benefits estimate, a $PM_{2.5}$ co-benefit estimate, and a cost estimate. Consistent with the distribution shown in Figure 7.1 above, the net benefits estimate is very sensitive to the choice of ozone mortality function, $PM_{2.5}$ mortality function, and cost estimation approach. These intermediate combinations (which are discussed more completely in the benefits chapter) represent reference points:

- Bell 2004 is the epidemiological study that underlies the ozone NAAQS risk assessment and Pope is the PM mortality function that was in several EPA RIAs, and
- Bell 2005 is one of three ozone meta-analyses and Laden is a more recent PM epidemiological study that was used as an alternative in the PM NAAQS RIA

These figures show that for the intermediate points on the distribution the costs and benefits of the selected standard are slightly positive or slightly negative. The tails of the distribution, depending on the specific combination of assumptions, show that benefits are either significantly higher than costs (over $10 billion in net benefits) or that the benefits are significantly lower than costs (roughly negative $6 billion in net benefits).

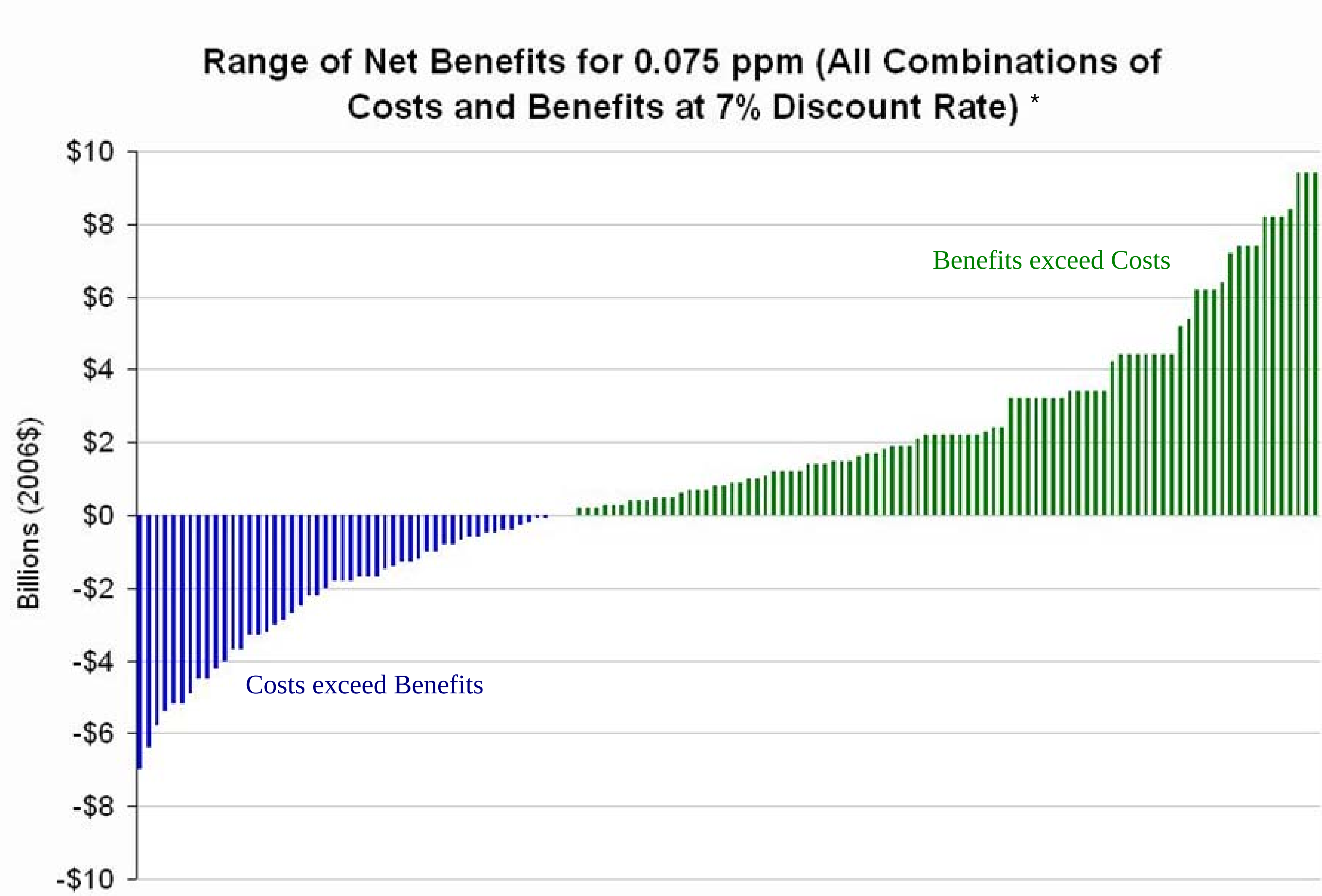
Figure 7.1: Range of Net Benefits (2006$) for All Standard Alternatives (7% discount)

Range of Net Benefits Across Standard Alternatives*



* This graph shows all 140 combinations of the 5 different ozone mortality functions and assumptions, the 14 different PM mortality functions, and the 2 cost methods. All combinations are treated as independent and equally probable. These estimates do not include visibility benefits, which are estimated at $160 million/yr. Only includes areas required to meet the current standard by 2020, does not include San Joaquin and South Coast areas in California.

Figure 7.2: Range of Net Benefits (2006$) for Selected Standard

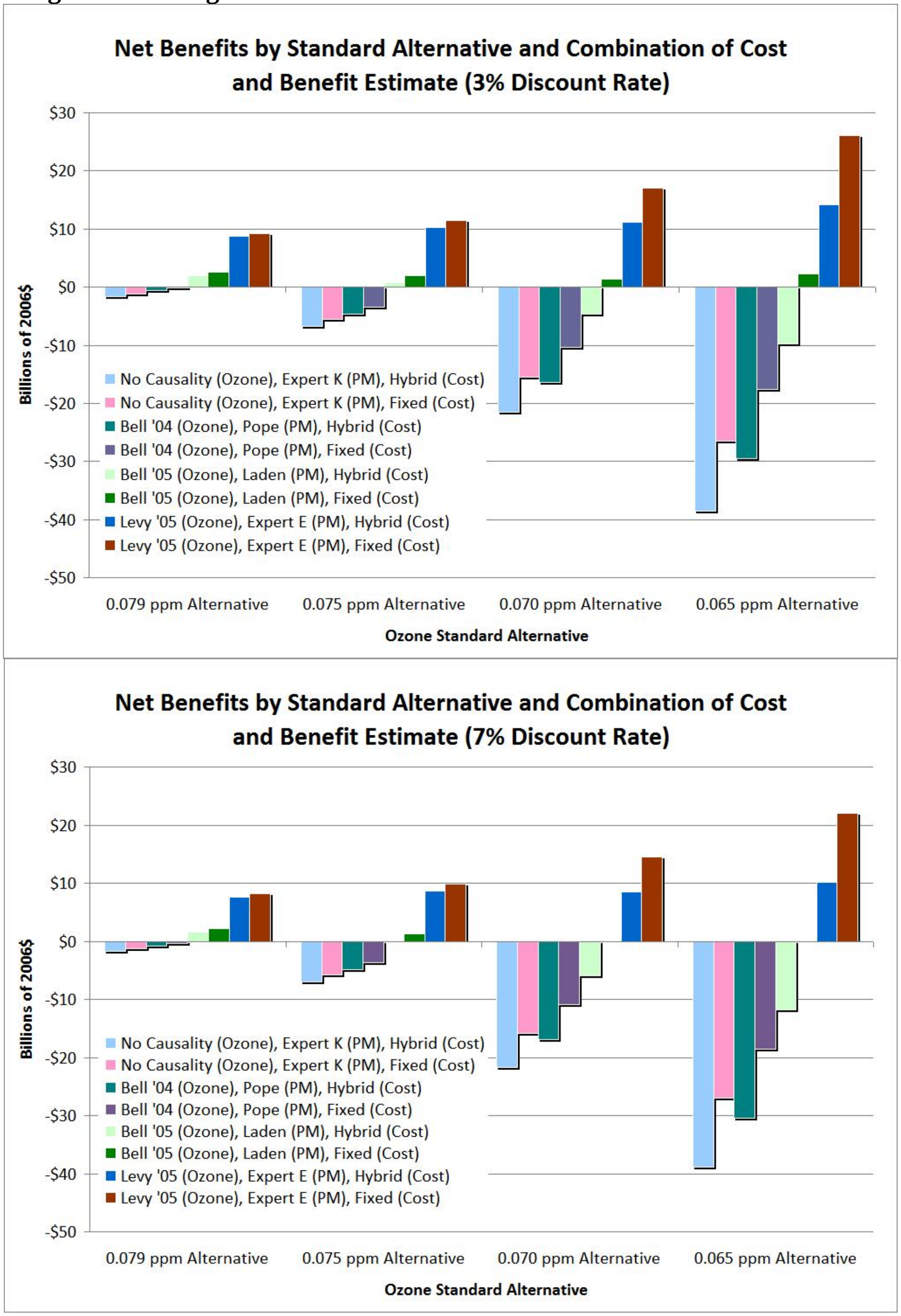


* This graph shows all 140 combinations of the 5 different ozone mortality functions and assumptions, the 14 different PM mortality functions, and the 2 cost methods. All combinations are treated as independent and equally probable.

For the selected standard of 0.075 ppm, the median value of all of the independent point estimates is $0.8 billion, and the majority (64%) of the combinations indicate positive net benefits for this standard.

These estimates do not include visibility benefits, which are estimated at $160 million/yr. Only includes areas required to meet the current standard by 2020, does not include San Joaquin and South Coast areas in California.

Figure 7.3: Range of Net Benefits for Select Combinations at 3% and 7%*



*See Section 7.3 for discussion of the ozone and PM premature mortality estimates. See Section 5.2 for discussion of the hybrid and fixed cost estimates.

Table 7.2: Summary of Total Number of Annual Ozone and $PM_{2.5}$-Related Premature Mortalities and Premature Morbidity Avoided: 2020 National Benefits*

Combined Estimate of Mortality Standard Alternative and Model or Assumption		Combined Range of Ozone Benefits and $PM_{2.5}$ Co-Benefits**			
		0.079 ppm	0.075 ppm	0.070 ppm	0.065 ppm
NMMAPS	Bell (2004)	140 – 1,300	260 – 2,000	560 – 3,500	940 – 5,500
Meta-Analysis	Bell (2005)	200 – 1,300	420 – 2,200	560 – 4,100	2,000 – 6,500
	Ito (2005)	230 – 1,300	500 – 2,300	1,100 – 4,300	2,500 – 7,000
	Levy (2005)	230 – 1,400	510 – 2,300	1,400 – 4,400	2,500 – 7,100
Assumption that association is not causal		120 – 1,200	190 – 2,000	310 – 3,200	490 – 5,000
Combined Estimate of Morbidity					
Acute Myocardial Infarction		570	890	1,500	2,300
Upper Respiratory Symptoms		3,100	4,900	8,100	13,000
Lower Respiratory Symptoms		4,200	6,700	11,000	17,000
Chronic Bronchitis		240	380	630	970
Acute Bronchitis		640	1,000	1,700	2,600
Asthma Exacerbation		3,900	6,100	10,000	16,000
Work Loss Days		28,000	43,000	72,000	110,000
School Loss Days		72,000	200,000	640,000	1,100,000
Hospital and ER Visits		890	1,900	5,100	9,400
Minor Restricted Activity Days		340,000	750,000	2,100,000	3,500,000

*Only includes areas required to meet the current standard by 2020, does not include San Joaquin Valley and South Coast air basins in California. Appendix 7b shows the costs and benefits of attaining alternate standards in San Joaquin and South Coast California.

**Includes ozone benefits, and PM 2.5 co-benefits. Range was developed by adding the estimate from the ozone premature mortality function to both the lower and upper ends of the range of the PM2.5 premature mortality functions characterized in the expert elicitation described in Chapter 6.

7.3 Discussion of Results

7.3.1 Sensitivity of Changes to Costs and Benefits Under an Alternate Baseline Scenario

Circular A-4 of the Office of Management and Budget's (OMB) guidance under Executive Order 12866 defines a no-action baseline as "what the world will be like if the proposed rule is not adopted". The illustrative analysis in this RIA assesses the costs and benefits of moving from this "no-action" baseline to a suite of possible new standards. Circular A-4 states that the choice of an appropriate baseline may require consideration of a wide range of potential factors, including:

- evolution of the market,
- changes in external factors affecting expected benefits and costs,
- changes in regulations promulgated by the agency or other government entities, and
- the degree of compliance by regulated entities with other regulations. (OMB 2003)

Circular A-4 also recommends that…

> When more than one baseline is reasonable and the choice of baseline will significantly affect estimated benefits and costs, you should consider measuring benefits and costs against alternative baselines. In doing so you can analyze the effects on benefits and costs of making different assumptions about other agencies' regulations, or the degree of compliance with your own existing rules. (OMB 2003)

This sensitivity analysis is intended to provide information about how the no-action baseline would differ under different assumptions about mobile technologies. It also assesses nationally what the change would be to costs and benefits of all standards. Cost for all standards would increase by $1.8[1] billion and benefits for all standards would increase by $360 million to $3.1 billion using 2006$ and a 3% discount rate, and $330 million to $2.8 billion when using a 7% discount rate.

The primary analysis baseline included some mobile controls characterized as additional technology changes in the onroad transportation sector. The application of these controls to the baseline assumes an optimistic future where reductions in emissions are achieved through the implementation nationally of cutting-edge mobile technologies. This sensitivity analysis estimates nationally how the costs and benefits of attaining 0.075 and the alternate primary standards would change if these technology changes were not implemented to meet the current standard, but were instead implemented as part of the strategy for attaining a new tighter standard.

In this sensitivity analysis scenario, 169,000 tons of NOx would not be reduced prior to the benefit/cost analysis. The alternate baseline or starting point for assessing the costs and benefits of the standard of 0.075 and the alternate primary standards would be higher across the board. Benefits from improved ozone and co-controlled PM2.5 air quality would increase. The costs of control would increase, as well The air quality improvements would be accomplished by including additional onroad transportation control measures in the control scenario, equivalent to the reductions 'removed' from the alternate baseline. The value in benefits of those improvements is estimated on a $/ton emissions reduced basis derived from the Locomotive Marine Diesel Rule.

It should be noted that these benefits are only a partial accounting of the total benefits associated with the mobile controls included in this sensitivity analysis. The sensitivity analysis does not estimate the benefits of other co-controlled emission reductions achieved by the mobile controls, such as VOCs (a precursor to ozone formation) and direct PM. The benefits presented here are therefore an underestimate of total benefits. Furthermore, these estimates are highly uncertain and are purely illustrative estimates of the potential costs and benefits of these mobile source

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[1] This cost could be offset in states that choose to replace existing periodic physical inspection of vehicles with remote onboard diagnostic device inspection in I/M programs. As explained in Appendix 9a, Remote OBD eliminates the need for periodic inspections of OBD-equipped vehicles by car owners. EPA estimates that the nationwide installation of Remote OBD would save the nation's motorists about $16 to $22 billion in inspection and convenience costs over a 10 year period.

control strategies. We present them only as screening-level estimates to provide a bounding estimate of the costs and benefits of including these emissions controls in the ozone NAAQS baseline. As such, it would be inappropriate to apply these benefit per-ton estimates to other policy contexts, including other regulatory impact analyses. For more details on the baseline sensitivity analysis, please reference Appendix 7a.

7.3.2 Relative Contribution of PM Benefits to Total Benefits

Because of the relatively strong relationship between $PM_{2.5}$ concentrations and premature mortality, PM co-benefits resulting from reductions in NO_x emissions can make up a large fraction of total montetized benefits, depending on the specific PM mortality impact function used, and on the relative magnitude of ozone benefits, which is dependent on the specific ozone mortality function assumed. PM co-benefits based on daily average concentrations are calculated over the entire year, while ozone related benefits are calculated only during the summer ozone season. Because the control strategies evaluated in this RIA are assumed to operate year round rather than only during the ozone season, this means that PM benefits will accumulate during both the ozone season and the rest of the year.

For the 0.075ppm alternative, PM2.5 co-benefits account for between 42 and 99 percent of total benefits. The lower end of the range assumes a combination of Levy et al. (2005) & Expert K. The upper end of the range assumes a combination of the assumption of no causality & Expert E.

7.3.3 Challenges to Modeling Full Attainment in All Areas

Because of relatively higher ozone levels in several large urban areas (Southern California, Chicago, Houston, and the Northeastern urban corridor) and because of limitations on the available database of currently known emissions control technologies, EPA recognized from the outset that known and reasonably anticipated emissions controls would likely be insufficient to bring some areas into attainment with either the current or alternative, more stringent ozone standards. Therefore, we designed this analysis in two stages: the first stage focused on analyzing the air quality improvements that could be achieved through application of documented, well-characterized emissions controls, and the costs and benefits associated with those controls. The second stage utilized extrapolation methods to estimate the costs and benefits of additional emissions reductions needed to bring all areas into full attainment with the standards. Clearly, the second stage analysis is a highly speculative exercise, because it is based on estimating emission reductions and air quality improvements without any information about the specific controls that would be available to do so.

The structure of the RIA reflects this 2-stage analytical approach. Separate chapters are provided for the cost, emissions and air quality impacts of modeled controls and for extrapolated costs and air quality impacts. We have used the information currently available to develop reasonable approximations of the costs and benefits of the extrapolated portion of the emissions reductions necessary to reach attainment. However, due to the high level of uncertainty in all aspects of the extrapolation, we judged it appropriate to provide separate estimates of the costs and benefits for the modeled stage and the extrapolated stage, as well as an overall estimate for reaching full attainment. There is a single chapter on benefits, because the methodology for estimating benefits does not change between stages. However, in that chapter, we again provide separate estimates of the benefits associated with the modeled control scenario which provides the foundation upon which benefits for full attainment are extrapolated for all four alternate primary standards (0.079, 0.075, 0.070, and 0.065 ppm).

In both stages of the analysis, it should be recognized that all estimates of future costs and benefits are not intended to be forecasts of the actual costs and benefits of implementing revised standards. Ultimately, states and urban areas will be responsible for developing and implementing emissions control programs to reach attainment of the ozone NAAQS, with the timing of attainment being determined by future decisions by states and EPA. Our estimates are intended to provide information on the general magnitude of the costs and benefits of alternative standards, rather than precise predictions of control measures, costs, or benefits. With these caveats, we expect that this analysis can provide a reasonable picture of the types of emissions controls that are currently available, the direct costs of those controls, the levels of emissions reductions that may be achieved with these controls, the air quality impact that can be expected to result from reducing emissions, and the public health benefits of reductions in ambient ozone levels. This analysis identifies those areas of the U.S. where our existing knowledge of control strategies is not sufficient to allow us to model attainment, and where additional data or research may be needed to develop strategies for attainment.

The ozone NAAQS RIA provided great challenges when compared to previous RIAs. Why was this so? Primarily because as we tighten standards across multiple pollutants with overlapping precursors (e.g., the recent tightening of the $PM_{2.5}$ standards), we move further down the list of cost-effective known and available controls. As we deplete our database of available choices of known controls, we are left with background emissions and remaining anthropogenic emissions for which we do not have enough knowledge to determine how and at what cost reductions can be achieved in the future when attainment would be required. With the more stringent NAAQS, more areas will need to find ways of reducing emissions, and as existing technologies are either inadequate to achieve desired reductions, or as the stock of low-cost existing technologies is depleted (causing the cost per ton of pollution reduced to increase), there will be pressure to develop new technologies to fill these needs. While we can speculate on what some of these technologies might look like based on current research and development and model programs being evaluated by states and localities, the actual technological path is highly uncertain.

Because of the lack of knowledge regarding the development of future emissions control technologies, a significant portion of our analysis is based on extrapolated tons generated from air quality sensitivity modeling necessary to reach full attainment of an alternative ozone NAAQS and the resulting costs and benefits. Studies indicate that it is not uncommon for pre-regulatory cost estimates to be higher than later estimates, in part because of inability to predict technological advances. Over longer time horizons, such as the time allowed for areas with high levels of ozone pollution to meet the ozone NAAQS, the opportunity for technical advances is greater (see Chapter 5 for details).

Our estimates of costs of attainment in 2020 assume a particular trajectory of aggressive technological change. This trajectory leads to a particular level of emissions reductions and costs which we have estimated based on two different approaches, the fixed cost and hybrid approaches. An alternative storyline might hypothesize a much less optimistic technological change path, such that emissions reductions technologies for industrial sources would be more expensive or would be unavailable, so that emissions reductions from many smaller sources might be required for 2020 attainment, at a potentially greater cost per ton. Under this alternative storyline, two outcomes are hypothetically possible: Under one scenario, total costs associated with full attainment might be substantially higher. Under the second scenario, states may choose to take advantage of flexibility in the Clean Air Act to adopt plan with later attainment dates to allow for additional technologies to be developed and for existing programs like EPA's Onroad Diesel, CAIR, Nonroad Diesel, and Locomotive and Marine rules to be fully implemented. If states were to submit plans with attainment dates beyond our 2020 analysis year, benefits would clearly be lower than we have estimated under our analytical storyline. However, in this case, state decision makers, seeking to maximize economic efficiency, would not impose costs, including potential opportunity costs of not meeting their attainment date, when they exceed the expected health benefits that states would realize from meeting their modeled 2020 attainment date. In this case, upper bound costs are difficult to estimate because we do not have an estimate of the point where marginal costs are equal to marginal benefits plus the costs of nonattainment.

Due to the nature of the extrapolation method for benefits (which focuses on reductions in ozone only at monitors that exceed the NAAQS), we generally understate the total benefits that would result from implementing additional emissions controls to fully attain the ozone NAAQS (i.e., assuming that the application of control strategies would result in ozone reductions both at nonattaining and attaining monitors). On the other hand, the possibility also exists that benefits are overestimated, both because it is possible that new technologies might not meet the specifications, development time lines, or cost estimates provided in this analysis and because the analysis assumes there are quantifiable benefits to reducing ambient ozone below each of the alternative standards.

Estimated benefits and costs may reflect both bias and uncertainty. While we strive to avoid bias and characterize uncertainty to the extent possible, we note that in some cases, biased estimates were used due to data and/or methodological limitations. In these cases we have tried to identify the direction and potential magnitude of the bias. These extrapolated benefits are uncertain, but the relative uncertainty compared to the modeled benefits is similar, once the underestimation bias has been taken into account. The emissions and cost extrapolations do not have a clear directional bias, however, they are much more uncertain relative to the modeled emissions and cost estimates, because of the lack of refined information about the relationship between emissions reductions and ozone changes in specific locations, and because of the difficulties in extrapolating costs well beyond the observed data. Of course, these benefits and costs will only be realized if the emission reductions projected in this extrapolated approach actually occur in the future.

7.4 What Did We Learn through this Analysis?

1. As in our analysis for the PM NAAQS RIA, in selecting controls, we focused more on the ozone cost-effectiveness (measured as $/ppb) than on the NO_x or VOC cost-effectiveness (measured as $/ton). When compared on a $/ton basis, many VOC controls appear cost-effective relative to NO_x reductions (see Figures 5.1 and 5.2). However, the air quality sensitivity analysis showed that NOx reductions were more effective than

VOC reductions in reducing Ozone concentrations except in urban areas which are VOC limited. In those locations, NO_x reductions can actually result in increases in ozone, and as such, VOC reductions can be cost-effective relative to NO_x on a $/ppb basis.

2. *Our knowledge of technologies that might achieve NO_x and VOC reductions to attain alternative ozone NAAQS is insufficient.* In some areas of the U.S., our existing controls database was insufficient to meet even the current ozone standard. After applying existing rules and the hypothetical controls applied in the PM NAAQS RIA across the nation we were able to identify controls that reduced overall NO_x emissions nationwide by 6 percent and VOC by 2 percent. After these reductions, remaining emissions were still substantial, with over 9 million tons of NO_x and 12 million tons of VOCs remaining nationwide. The large remaining inventories of NO_x and VOC emissions suggests that additional control measures need to be developed, with appropriate consideration of the relative effectiveness of NO_x and VOC in achieving ozone reductions.

3. *Most of the overall reductions in NO_x achieved in our illustrative control strategy were from nonEGU point sources.* This was due to the fact that: 1) EGUs have been heavily controlled under the recent NO_x SIP call and Clean Air Interstate Rules. The EGU program we included in our strategy for meeting the alternative ozone standards was not intended to achieve overall reductions in NO_x beyond the CAIR caps, but instead to obtain NO_x emission reductions in areas where they would more effectively reduce ozone concentrations in downwind nonattainment areas; and 2) mobile sources are already subject to ongoing emission reduction programs through the Tier 2 highway, onroad diesel and nonroad diesel rules. Thus, the opportunities for controlling NO_x emissions were much greater in the nonEGU point sector than in the mobile or EGU sectors. However, the remaining uncontrolled NO_x emissions from EGU and mobile sectors are still greater than nonEGU point sources[2], and additional reductions from these sectors may need to be considered in developing strategies to achieve full attainment. Exploratory analyses indicate that there are opportunities to achieve emission reductions from EGU peaking units on High Energy Demand Days (HEDD) with targeted strategies. Another area under analysis is the energy efficiency/clean distributed generation based emission reductions.

4. *Tightening the ozone standards can provide significant, but not uniform, health benefits.* The magnitude of the benefits is highly uncertain, <u>and is not expected to be uniform throughout the nation</u>. While our illustrative analyses showed that the benefits of implementing a tighter standard will likely result in reduced health impacts for the nation as a whole, the particular scenarios that we modeled show that some areas of the U.S. will see ozone (and $PM_{2.5}$) levels increase. This is due to two reasons. The first reason is that the complexities involved in the atmospheric processes which govern the transformation of emissions into ozone result in some locations and times when reducing NO_x emissions can actually increase ozone levels on some days (see Chapter 2 for more discussion). For most locations, these days are few relative to the days when ozone levels are decreased. However, in some urban areas the net effect of implementing NO_x controls

[2] NonEGU point source emission projections currently do not include estimated activity or economic growth.

is to increase overall ozone levels and increase the health effects associated with ozone. This same phenomenon results in some areas also seeing increases in $PM_{2.5}$ formation. The second reason is that the particular control strategy that we modeled for EGU sources is a modification to controls on sources within the overall cap and trade program in the Eastern U.S., established under the CAIR. As with any cap and trade program, changes in requirements at particular sources will result in shifts in power generation and emissions at other sources. Because under our chosen EGU control scenario the overall emissions cap for the CAIR region remains the same, some areas of the country will see a decrease in emissions, while others will see an increase. This is not unexpected, and is an essential element of the cap and trade program. Our goal in selecting the EGU control strategy was to focus the emissions reductions in areas likely to benefit the most from EGU NO_x emissions reductions, with emissions increases largely occurring in areas in attainment with the ozone NAAQS. However, this necessarily means that in those areas where emissions increases occurred, ozone levels would also be expected to increase, with commensurate increases in health impacts. On a national level, however, we expected overall health benefits of the modeled EGU strategy to be positive. In addition, our air quality modeling analysis showed that while ozone levels did increase in some areas, none of these increases resulted in an attaining area moving into nonattainment. Adjustments to our control scenario might achieve a pattern of reductions that achieves further air quality improvement.

5. *The 0.079 ppm and 0.075 ppm benefits estimates reflect special uncertainties.* EPA interpolated the benefits of the 0.070 ppm alternative to estimate the full attainment benefits of the less stringent 0.075 ppm and 0.079 ppm alternatives. These two interpolated benefits estimates are subject to two sources of uncertainty: (1) the uncertainties inherent in the original 0.070 ppm benefits analysis that was the basis for the interpolation; (2) the incremental uncertainty added through the interpolation approach. A chief source of uncertainty in the 0.070 ppm analysis was the use of the monitor rollback technique to estimate full attainment benefits. This approach likely understates the benefits that would result from state implementation of emissions controls because controls implemented to reduce ozone concentrations at the highest monitor would likely result in some reductions in ozone concentrations at nearby attaining monitors. Therefore, air quality improvements and resulting health benefits from full attainment would be more widespread than we estimated in our rollback analysis for the 0.070 ppm alternative. The interpolation approach adds its own uncertainties. We made a reasonable judgment regarding the geographic area within which to interpolate benefits. However, this area may not match the ultimate geographic distribution of air quality improvements under a state-implemented control strategy to attain either the 0.075 ppm or 0.079 ppm alternative; this could result in an under- or over-estimate of benefits. The complexity of the various uncertainties makes it challenging to draw conclusions about their combined directional influence on the benefits estimates.

6. *Tightening the ozone standards can incur significant, but uncertain, costs*. An engineering cost comparison demonstrates that the cost of the 0.070 ppm Ozone NAAQS

known control costs ($3.3 billion per year[3] (2006$)) is only slightly lower than the Clean Air Interstate Rule (approximately $4 billion per year (2006$)) and roughly one and half to just over four times higher than the PM NAAQS 15/35 control strategy with annual engineering costs of $1.0 billion (2006$). It should be noted that for the Ozone NAAQS $3.3 billion represent the engineering cost of partial attainment. Full attainment using extrapolation methods are expected to increase total costs significantly. For example, total costs for the 0.070 ppm standard are significant at $19 to $25 billion (2006$). Yet, the magnitude and distribution of costs across sectors and areas is highly uncertain. Our estimates of costs for a set of modeled NO_x and VOC controls comprise only a small part of the estimated costs of full attainment. These estimated costs for the modeled set of controls are still uncertain, but they are based on the best available information on control technologies, and have their basis in real, tested technologies. Estimating costs of full attainment required several techniques for extrapolation of the costs based upon the degree of difficulty to reach attainment Based on air quality supplemental modeling, there is clearly significant spatial variability in the relationship between local and regional NO_x emission reductions and ozone levels across urban areas. For some locations, the extrapolation requires only a modest reduction beyond known controls. In these cases, the extrapolation is likely reasonable and not as prone to uncertainties. However, for areas where the bulk of air quality improvements were derived from extrapolated emissions reductions that go well beyond the area of the known controls, the uncertainty associated with costs increases.

7. *NonEGU point source controls dominate the estimated costs.* These costs account for about 54 percent of modeled control costs. The average cost per ton for these reductions is approximately $3,800 (2006$) and the highest marginal cost for the last known control applied is $22,000 (2006$). Mobile source controls were also significant contributors to overall costs, accounting for over 23 percent of total modeled control costs.

8. *Costs and benefits will depend on implementation timeframes.* States will ultimately select the specific timelines for implementation as part of their State Implementation Plans. To the extent that states seek classification as extreme nonattainment areas, the timeline for implementation may be extended beyond 2020, meaning that the amount of emissions reductions that will be required in 2020 will be less, and costs and benefits in 2020 will also be lowered.

7.5 References

U.S. Office of Management and Budget. September 2003. Circular A-4, Regulatory Analysis Guidance sent to the Heads of Executive Agencies and Establishments. Washington, DC. http://www.whitehouse.gov/omb/circulars/a004/a-4.pdf.

[3] Known controls include the modeled control strategy ($2.8 billion dollars per year (2006$)) as well as any supplemental and giveback controls applied (Appendix 5a.4).