

# **APPENDIX C**

## **COSTS AND BENEFITS OF ACHIEVING THE CURRENT PM<sub>10</sub> AND OZONE STANDARDS**

## **1.0 CURRENT PM<sub>10</sub> STANDARD RESULTS IN BRIEF**

Based on projected emission levels for the year 2010, this analysis estimates that 45 counties need additional reductions beyond those currently mandated in the Clean Air Act (CAA) and partial attainment of the current ozone national ambient air quality standard (NAAQS) to meet the current particulate matter (PM<sub>10</sub>) NAAQS. The control cost associated with achieving partial attainment in 31 of these counties and full attainment in 14 counties is estimated to be \$1.1 billion (1990 dollars). The estimated national annual monetized benefits associated with partial attainment of the current standard is approximately \$5.3 billion to \$5.4 billion.

## **2.0 CURRENT OZONE STANDARD RESULTS IN BRIEF**

Based on projected emissions levels for the year 2010, this analysis estimates that 9 nonattainment areas (82 counties) are projected to need additional reductions beyond those currently mandated in the CAA to meet the current ozone NAAQS. The control cost associated with achieving partial attainment in 8 nonattainment areas (69 counties) and full attainment in 1 nonattainment area (13 counties) is estimated to be \$0.6 billion (1990 dollars). The estimated national annual monetized benefits associated with partial attainment of the current standard is approximately \$1.2 billion to \$1.6 billion.

## **3.0 INTRODUCTION**

The 2010 CAA baseline discussed in Chapter 4 contains all control measures mandated by the CAA to meet the current PM<sub>10</sub> and ozone standards. Also included in this baseline is a NO<sub>x</sub> cap-and-trade program for utilities and large industrial boilers located in the 37-States of the Ozone Transport Assessment Group (OTAG) that is being adopted to facilitate attainment of the current ozone standard. Starting from this baseline, this analysis projects that several areas do not attain the current PM<sub>10</sub> and ozone standards. Therefore, in this analysis, additional control measures are selected for specific areas with the goal of attaining the current standards in the

analysis year 2010.

This appendix presents the incremental emission reduction, air quality, and cost impacts associated with control measures selected to meet the current PM<sub>10</sub> and ozone standards, as well as the benefits associated with the estimated air quality improvements. The following sections in this chapter cover:

- Emissions, air quality, and cost impacts for the current PM<sub>10</sub> standard only;
- Emissions, air quality, and cost impacts for the current ozone standard;
- Emission reduction, air quality improvement, and control cost results for the current PM<sub>10</sub> standard;
- Benefits of attaining the current PM<sub>10</sub> standard;
- Benefits of attaining the current ozone standard; and
- Analytical uncertainties, limitations, and potential biases.

#### **4.0 ANALYSES OF THE CURRENT PM<sub>10</sub> STANDARD**

This section presents the benefits and emission, air quality, and cost impacts associated with control measures selected to meet the current PM<sub>10</sub> standard incremental to the 2010 CAA baseline and partial attainment of the current ozone standard. The partial attainment analysis of the current ozone standard is presented in Section 5.0 of this appendix.

##### **4.1 CURRENT PM<sub>10</sub> STANDARD EMISSIONS, AIR QUALITY, AND COST ANALYSIS RESULTS**

The methodology used to select control measures for the current PM<sub>10</sub> standard differs from the methodology presented in Chapter 6 for selecting PM<sub>2.5</sub>-related control measures. After PM<sub>10</sub> nonattainment counties are identified, control measures are selected to reduce PM<sub>10</sub> concentrations from the set of source category-control measure combinations in the violating county only. This model for control measure selection is believed to be consistent with current

PM<sub>10</sub> implementation practices which focus on local sources of PM<sub>10</sub> emissions. Control measures with a cost per microgram per cubic meter reduced of more than \$1 billion are not included in this analysis. A sensitivity analysis on this threshold level is conducted and presented in Appendix D. Thresholds of \$500 million and \$2 billion are examined.

The estimated number of initial and residual PM<sub>10</sub> nonattainment counties for the \$1 billion per microgram per cubic meter reduced threshold is presented in Table C.1, along with the estimated annual control cost associated with the control measures that are selected. The control measures selected are estimated to reduce the number of initial nonattainment counties by 14 at an annual cost of \$1,100 million.

**Table C.1 Estimated Number of Initial and Residual Nonattainment Counties and Incremental Annual Cost for the Current PM<sub>10</sub> Standard**

| Control Region    | Number of Counties Violating the Current PM <sub>10</sub> Standard |          | Annual Cost of Partial Attainment (\$million/yr) |
|-------------------|--|----------|--|
|                   | Initial  | Residual |  |
| Midwest/Northeast | 6  | 5        | 380  |
| Southeast         | 1  | 0        | 2  |
| South Central     | 4  | 2        | 230  |
| Rocky Mountain    | 12   | 9        | 210  |
| Northwest         | 7  | 4        | 140  |
| West              | 15   | 11       | 130  |
| Nation            | 45   | 31       | 1,100  |

Table C.2 presents the average baseline and post-control PM<sub>10</sub> concentrations by control region for the 45 initial and 31 residual nonattainment counties. The regional average annual

values for the residual nonattainment areas indicate that projected residual nonattainment is driven by 24-hour rather than annual violations (i.e., all the average annual average concentration values are less than 50  $\mu\text{g}/\text{m}^3$ ).

## **4.2 CURRENT PM<sub>10</sub> STANDARD BENEFITS ANALYSIS**

The methodology (e.g., post-control air quality estimation, concentration-response functions, economic valuation) used to estimate national benefits associated with partial and full attainment of the current PM<sub>10</sub> standard is identical to the methodology presented in Chapter 12 for estimating benefits associated with the PM<sub>2.5</sub> NAAQS alternatives. Partial and full attainment benefits for the current PM<sub>10</sub> standard are estimated incremental to partial and full attainment, respectively, of the current ozone standard.

Table C.3 presents national annual health and welfare benefits attributable to partial attainment of the current PM<sub>10</sub> standard. Partial attainment PM benefits are estimated as approximately \$5.3 billion to \$5.4 billion annually. The portion of the population in the year 2010 expected to live in the nonattainment counties is approximately 24.0 million. Not presented in Table C.7 are full attainment PM<sub>10</sub> benefits. Estimation of full attainment benefits is more uncertain than partial attainment estimation because the sources from which additional emissions will be reduced are unknown. An explanation of this limitation is presented in Section 12.9 of Chapter 12. Despite the limitation, full attainment estimates are presented here for completeness purposes. National annual monetized benefits associated with full attainment of the current PM<sub>10</sub> standard are estimated at approximately \$12.4 billion to \$13.8 billion, annually. Both partial and full attainment benefits estimates are likely to be underestimated due to the inability to quantify all benefits categories. See Section 12.10 in Chapter 12 for a discussion of the benefits analysis limitations.

**Table C.2 Average Initial and Post-Control PM<sub>10</sub> Concentrations for Projected Initial and Residual Nonattainment Counties for the Current PM<sub>10</sub> Standard<sup>a</sup>**

| Control Region    | Initial Nonattainment Counties |         |              |         | Residual Nonattainment Counties |         |              |        |
|-------------------|--------------------------------|---------|--------------|---------|---------------------------------|---------|--------------|--------|
|                   | Initial                        |         | Post-Control |         | Initial                         |         | Post-Control |        |
|                   | Annual                         | 24 Hour | Annual       | 24 Hour | Annual                          | 24 Hour | Annual       | 24Hour |
| Midwest/Northeast | 39.6                           | 252.5   | 35.6         | 216.9   | 41.2                            | 272.0   | 36.6         | 229.5  |
| Southeast         | 42.8                           | 157.1   | 41.2         | 151.3   | --                              | --      | --           | --     |
| South Central     | 39.2                           | 168.8   | 35.9         | 153.7   | 41.2                            | 177.0   | 36.9         | 157.0  |
| Rocky Mountain    | 30.8                           | 196.4   | 28.9         | 183.3   | 27.4                            | 206.3   | 26.2         | 194.5  |
| Northwest         | 33.6                           | 192.4   | 31.5         | 183.5   | 34.0                            | 219.2   | 32.2         | 207.5  |
| West              | 44.1                           | 236.5   | 42.6         | 229.7   | 45.8                            | 260.6   | 45.2         | 257.3  |
| Nation            | 37.9                           | 213.7   | 35.7         | 200.0   | 37.9                            | 235.9   | 36.1         | 221.7  |

a Initial nonattainment incremental to 2010 CAA baseline and partial attainment of the current ozone standard.

**TABLE C.3 PM<sub>10</sub>: National Annual Health and Welfare Benefits Estimates<sup>a</sup>**  
 Estimates are incremental to partial attainment of the current ozone NAAQS  
 (year = 2010)

| ENDPOINT <sup>b</sup>                                 | Partial Attainment Scenario |  |
|---|-----------------------------|--|
|   | Incidences Reduced          | Monetized Benefits<br>(billions of 1990\$) |
| <b>*1. Mortality<sup>c</sup>: short-term exposure</b> | 620                         | \$2.950                                    |
|   | 600                         | \$2.860                                    |
| <b>long-term exposure</b>                             |                             |  |
| <b>*2. Chronic Bronchitis</b>                         | 7,710                       | \$2.010                                    |
| <b>Hospital Admissions:</b>                           |                             |  |
| *3. all respiratory (all ages)                        | 330                         | \$0.004                                    |
| all resp. (ages 65+)                                  | 780                         | \$0.010                                    |
| pneumonia (ages 65+)                                  | 280                         | \$0.004                                    |
| COPD (ages 65+)                                       | 240                         | \$0.004                                    |
| *4. congestive heart failure                          | 210                         | \$0.003                                    |
| *5. ischemic heart disease                            | 230                         | \$0.005                                    |
| <b>*6. Acute Bronchitis</b>                           | 1,720                       | \$0  |
| <b>*7. Lower Respiratory Symptoms</b><br>(# of days)  | 17,840                      | \$0  |
| <b>*8. Upper Respiratory Symptoms</b><br>(# of cases) | 6,300                       | \$0  |
| shortness of breath                                   | 15,050                      | \$0  |
| asthma attacks  | 17,010                      | \$0.001                                    |
| <b>*9. Work Loss Days</b>                             | 179,490                     | \$0.015                                    |
| <b>*10. Minor Restricted Activity Days (MRADs)</b>    | 1,490,350                   | \$0.057                                    |
| <b>*11. Consumer Cleaning Cost Savings</b>            | N/A                         | \$0.039                                    |
| <b>*12. Visibility</b>                                | N/A                         | \$0.320                                    |
| <b>TOTAL HEALTH BENEFITS</b>                          |                             |  |
| using short-term mortality                            |                             | \$5.4                                      |
| using long-term mortality                             |                             | \$5.3                                      |

N/A = not applicable

<sup>a</sup> Totals may not completely agree due to rounding

<sup>b</sup> Only endpoints denoted with an \* are aggregated into total benefits estimates

<sup>c</sup> Mortality estimates must be aggregated using either short-term exposure or long-term exposure but not both due to double-counting issues

## **5.0 ANALYSES OF THE CURRENT OZONE STANDARD**

This section presents the benefits, and emission and cost impacts associated with control measures selected to meet the current ozone standard incremental to the 2010 CAA baseline.

### **5.1 OZONE EMISSIONS AND COST ANALYSIS**

The methodology used to select control measures for the current ozone standard is nearly identical to the methodology presented in Chapter 7 for selecting control measures for the alternative 8-hour standards. The chief difference is that a National Ozone Strategy is not applied for the current ozone standard prior to local control measure selection. After ozone nonattainment areas are identified and emission reduction targets are established, VOC and/or NO<sub>x</sub> control measures are selected from the set of control measure-source combinations from inside nonattainment boundaries. Control measures with an average annual incremental cost per ton of more than \$10,000 are not included in this analysis. A sensitivity analysis on this threshold level is conducted and presented in this chapter. Thresholds of \$7,000, \$20,000, and no cut-off are examined.

Table C.4 presents the cost results for partial attainment of the current ozone standard under alternative dollar per ton control measure selection thresholds. Total annual control costs increase as the dollar per ton threshold is gradually lifted.

Table C.5 presents the VOC and NO<sub>x</sub> reductions achieved as a percent of reductions needed under alternative dollar per ton control measure selection thresholds. The percent of VOC reductions achieved ranges from 30 to 38 percent, and the percent of NO<sub>x</sub> reductions achieved ranges from 52 to 62 percent.

**Table C.4 Estimated Annual Control Cost for the Current Ozone Standard Under Alternative Dollar Per Ton Control Measure Selection Thresholds**

| <b>\$/Ton Control Measure Selection Threshold<sup>a</sup></b> | <b>Annual Cost (\$million/year)</b> |
|---|-------------------------------------|
| \$7,000   | 300                                 |
| \$10,000  | 610                                 |
| \$20,000  | 820                                 |
| No Cut-Off  | 1,100                               |

a The \$10,000 per ton control measure selection threshold is considered in the main analysis; all other thresholds are sensitivity analyses.

**Table C.5 National Summary of Local VOC and NO<sub>x</sub> Emission Reductions Achieved as Percent of Reductions Needed for the Current Ozone Standard Under Alternative Dollar Per Ton Control Measure Selection Thresholds<sup>a</sup>**

| <b>\$/Ton Control Measure Selection Threshold<sup>b</sup></b> | <b>2010 CAA Baseline Emissions (tons per day)</b> |                       | <b>Target Reductions (tons per day)</b> |                       | <b>Reductions Achieved Relative to Targets (tons per day)</b> |                       | <b>Percent Achieved Relative to Targets</b> |                       |
|---|---|-----------------------|---|-----------------------|---|-----------------------|---|-----------------------|
|   | <b>VOC</b>  | <b>NO<sub>x</sub></b> | <b>VOC</b>                              | <b>NO<sub>x</sub></b> | <b>VOC</b>  | <b>NO<sub>x</sub></b> | <b>VOC</b>                                  | <b>NO<sub>x</sub></b> |
| \$7,000   | 5,368   | 2,199                 | 1,723                                   | 515                   | 509   | 266                   | 30%   | 52%                   |
| \$10,000  | 5,368   | 2,199                 | 1,723                                   | 515                   | 610   | 285                   | 35%   | 55%                   |
| \$20,000  | 5,368   | 2,199                 | 1,723                                   | 515                   | 643   | 302                   | 37%   | 59%                   |
| No Cut-Off  | 5,368   | 2,199                 | 1,723                                   | 515                   | 657   | 320                   | 38%   | 62%                   |

a Emission reduction targets and achieved reductions are incremental to the 2010 CAA Baseline. Reductions in pollutants not targeted in each area are not included in this table.

b The \$10,000 per ton control measure selection threshold is considered in the main analysis; all other thresholds are sensitivity analyses.

## 5.2 OZONE BENEFITS ANALYSIS

The methodology (e.g., post-control air quality estimation, concentration-response functions, economic valuation) used to estimate national benefits associated with partial and full attainment of the current ozone standard is identical to the methodology presented in Chapter 12 for estimating benefits associated with the ozone NAAQS alternatives. Partial and full attainment benefits for the current ozone standard are estimated incremental from the 2010 baseline.

Table C.6 through and C.8 present national annual health and welfare benefits attributable to partial attainment of the current ozone standard. Partial attainment ozone benefits are estimated as approximately \$1.2 to \$1.6 billion, annually. The portion of the population in the year 2010 expected to live in the identified nonattainment areas is approximately 51.4 million. Not presented in Tables C.6 through C.8 are full attainment benefits associated with the current ozone NAAQS. Full attainment ozone benefits estimation is limited for the same reason as the PM full attainment analysis. Given this limitation, ancillary PM benefits are proportionally scaled to ozone benefits. See Section 12.9 for a discussion of this limitation and the proportional scaling procedure. Despite the limitation, full attainment estimates are presented here for completeness purposes. National annual monetized benefits associated with full attainment of the current ozone NAAQS are estimated as approximately \$3.5 billion to \$4.8 billion, annually. Both partial and full attainment benefits estimates are likely to be underestimated due to the inability to quantify all benefits categories. See Section 12.10 in Chapter 12 for a discussion of the benefits analysis limitations.

**TABLE C.6 Ozone : National Annual Health Benefits Estimates<sup>a</sup>**  
 Estimates are incremental to the 2010 CAA Baseline  
 (year = 2010)

| ENDPOINT <sup>b</sup>  | Partial Attainment Scenario |   |
|--|-----------------------------|---|
|  | Incidences Reduced          | Monetized Benefits<br>(billions of 1990 \$) |
| <b>Ozone Health:</b><br><b>*1. Mortality</b>                                     | 120                         | \$0.570                                     |
| <b>Hospital Admissions</b><br>*2. all respiratory (all ages)                     | 520                         | \$0.007                                     |
| all resp. (ages 65+)   | 1,620                       | \$0   |
| pneumonia (ages 65+)   | 620                         | \$0.010                                     |
| COPD (ages 65+)  | 200                         | \$0.003                                     |
| emer. dept. visits for asthma  | 230                         | \$0.002                                     |
| <b>*3. Acute Respiratory Symptoms</b><br>(any of 19)                             | 52,360                      | \$0.001                                     |
| asthma attacks   | 110                         | \$0   |
| MRADs  | 1,140                       | \$0   |
| <b>*4. Mortality from air toxics</b>   | 1                           | \$0.003                                     |
| <b>Ancillary PM Health:</b><br><b>*1. Mortality<sup>c</sup>: short-term exp.</b> | 50                          | \$0.240                                     |
| <b>long-term exposure</b>  | 150                         | \$0.700                                     |
| <b>*2. Chronic Bronchitis</b>  | 340                         | \$0.090                                     |
| <b>Hospital Admissions:</b><br>*3. all respiratory (all ages)                    | 60                          | \$0.001                                     |
| all resp. (ages 65+)   | 40                          | \$0   |
| pneumonia (ages 65+)   | 10                          | \$0   |
| COPD (ages 65+)  | 10                          | \$0   |
| *4. congestive heart failure   | 10                          | \$0   |
| *5. ischemic heart disease   | 10                          | \$0   |
| <b>*6. Acute Bronchitis</b>  | 300                         | \$0   |
| <b>*7. Lower Respiratory Symptoms</b>  | 3,110                       | \$0   |
| <b>*8. Upper Respiratory Symptoms</b>  | 280                         | \$0   |
| shortness of breath  | 560                         | \$0   |
| asthma attacks   | 3,320                       | \$0   |
| <b>*9. Work Loss Days</b>  | 33,140                      | \$0.003                                     |
| <b>*10. Minor Restricted Activity Days<br/>(MRADs)</b>                           | 276,160                     | \$0.011                                     |
| <b>TOTAL MONETIZED HEALTH BENEFITS</b>   | N/A                         | \$0.920                                     |
| using short-term PM mortality  | N/A                         | \$1.380                                     |
| using long-term PM mortality   |                             |   |

N/E = not estimated

N/A = not applicable

<sup>a</sup> Totals may not completely agree due to rounding

<sup>b</sup> Only endpoints denoted with an \* are aggregated into total benefits estimates

<sup>c</sup> Mortality estimates must be aggregated using either short-term exposure or long-term exposure but not both due to double-counting issues



**TABLE C.7 Ozone : National Annual Welfare Benefits Estimates<sup>a</sup>**  
 Estimates are incremental to the 2010 CAA Baseline  
 (millions of 1990\$; year = 2010)

| Category                                | Partial Attainment Scenario: Monetized Benefits |
|---|---|
| Commodity Crops                         | \$38  |
| Fruits and Vegetables                   | \$147   |
| Commercial Forests                      | \$4   |
| Worker Productivity                     | \$14  |
| Consumer Cleaning Cost Savings          | \$2   |
| Visibility                              | \$29  |
| <b>TOTAL MONETIZED WELFARE BENEFITS</b> | <b>\$234</b>                                    |

**TABLE C.8 Ozone : Total National Benefits Estimates<sup>a</sup>**  
 Estimates are incremental to the 2010 CAA Baseline  
 (billions of 1990\$; year = 2010)

| Category                        | Partial Attainment Scenario: Monetized Benefits |
|---------------------------------|---|
| Health Benefits                 | \$0.92 - \$1.4                                  |
| Welfare Benefits                | \$0.23  |
| <b>TOTAL MONETIZED BENEFITS</b> | <b>\$1.2 - \$1.6</b>                            |

## 6.0 ANALYTICAL UNCERTAINTIES, LIMITATIONS, AND POTENTIAL BIASES

Generally, the same uncertainties, limitations, and potential biases cited in Sections 6.7, 7.6, and 12.10 apply to the analyses and results presented in this chapter.

---

<sup>a</sup> Totals may not completely agree due to rounding