Memo: Emission Reductions, Costs, Benefits and Economic Impacts Associated with Building Blocks 1 and 2

1 Introduction

This memo provides estimates of the costs, energy impacts, and the monetized climate benefits and air pollution health co-benefits associated with emission reductions for two illustrative compliance scenarios associated with building blocks 1 and 2 only. It also includes estimates of the labor impacts on the regulated sector. The methods applied to generate these estimates are described in detail in Chapter 3, 4, and 6 of the Regulatory Impact Analysis (RIA). For brevity, this memo just reports the results of these analyses.

EPA used the Integrated Planning Model (IPM), developed by ICF International, to conduct this analysis. It provides forecasts of least cost capacity expansion, electricity dispatch, and emission control strategies while meeting energy demand and environmental, transmission, dispatch, and reliability constraints.

This analysis also evaluates the climate benefits associated with emission reductions of CO2 and the air pollution health co-benefits associated with reduced emissions of SO2, NOx, and PM2.5, which would lead to lower ambient concentrations of PM2.5 and ozone. Unlike the analysis of health co-benefits in Chapter 4 of the RIA, estimates of emissions reductions of directly emitted particles available are not available for this analysis. Similar to Chapter 4 of the RIA, unquantified co-benefits include exposure to several HAPs (including mercury and hydrogen chloride), carbon monoxide, SO2, and NO2, as well as ecosystem effects and visibility impairment.

2 State Goals for Building Blocks 1 and 2

This analysis includes state-specific rate-based goals that reflect a two-building block approach. It is also based upon the same modeling framework, assumptions and calculations as presented in the RIA. The two-blocks incorporated in the following state goals include efficiency improvements at existing coal steam electric generating units (EGUs) and use of lower emitting power sources (increased utilization of existing NGCCs) and are identical to the proposed levels, included for purposes of establishing state-specific goals, associated with Option 1 (6% efficiency improvement and no more than 70% redispatch).

**Table 1. State-specific Goals for Two-Block Approach for Existing Sources**

|  |  |
| --- | --- |
| **State** | **Rate** |
| Alabama | 1,329 |
| Alaska | 1,252 |
| Arizona | 900 |
| Arkansas | 1,115 |
| California | 838 |
| Colorado | 1,521 |
| Connecticut | 809 |
| Delaware | 1,013 |
| Florida | 910 |
| Georgia | 1,296 |
| Hawaii | 1,751 |
| Idaho | 858 |
| Illinois | 1,865 |
| Indiana | 1,834 |
| Iowa | 1,846 |
| Kansas | 2,186 |
| Kentucky | 1,986 |
| Louisiana | 1,099 |
| Maine | 848 |
| Maryland | 1,868 |
| Massachusetts | 886 |
| Michigan | 1,511 |
| Minnesota | 1,369 |
| Mississippi | 843 |
| Missouri | 1,784 |
| Montana | 2,295 |
| Nebraska | 1,941 |
| Nevada | 882 |
| New Hampshire | 878 |
| New Jersey | 905 |
| New Mexico | 1,447 |
| New York | 927 |
| North Carolina | 1,329 |
| North Dakota | 2,226 |
| Ohio | 1,714 |
| Oklahoma | 1,186 |
| Oregon | 852 |
| Pennsylvania | 1,480 |
| Rhode Island | 918 |
| South Carolina | 1,514 |
| South Dakota | 1,456 |
| Tennessee | 1,798 |
| Texas | 1,083 |
| Utah | 1,559 |
| Virginia | 1,135 |
| Washington | 811 |
| West Virginia | 1,933 |
| Wisconsin | 1,619 |
| Wyoming | 2,151 |

3 Emissions and Power Sector Impacts

Tables 2 through 16 report the emissions and power sector impacts of the two-block approach.

Table 2. Projected CO2 Emission Impacts

|  |  |  |  |
| --- | --- | --- | --- |
|   | **CO2 Emissions** **(MM Tonnes)** | **CO2 Emissions Reductions from Base Case** **(MM Tonnes)** | **CO2 Emissions Reductions: Percent Change from Base Case** |
|   | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Base Case | 2,161 | 2,231 | 2,256 |   |   |   |   |   |   |
| Two-Block Regional | 1,930 | 1,973 | 1,997 | 231 | 258 | 258 | 11% | 12% | 11% |
| Two-Block State | 1,908 | 1,947 | 1,963 | 252 | 284 | 292 | 12% | 13% | 13% |

Source: Integrated Planning Model run by EPA, 2014

Table 3. Projected Non-CO2 Emissions Reductions, 2020-2030

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case** | **Two Block** | **Two Block** |
| **Regional** | **State** | **Regional** | **State** |
| 2020 |  |  |  |  |  |
| SO2 (thousand tons) | 1,476 | 1,243 | 1,199 | -15.7% | -18.8% |
| NOX (thousand tons) | 1,559 | 1,319 | 1,286 | -15.4% | -17.5% |
| Hg (tons) | 8.3 | 7.2 | 7.1 | -12.8% | -13.9% |
| HCl (thousand tons) | 8 | 8 | 8 | 2.9% | -1.3% |
| 2025 |  |  |  |  |  |
| SO2 (thousand tons) | 1,515 | 1,228 | 1,171 | -19.0% | -22.7% |
| NOX (thousand tons) | 1,587 | 1,317 | 1,272 | -17.0% | -19.9% |
| Hg (tons) | 8.7 | 7.4 | 7.3 | -14.9% | -16.2% |
| HCl (thousand tons) | 8 | 9 | 9 | 0.8% | 3.0% |
| 2030 |  |  |  |  |  |
| SO2 (thousand tons) | 1,530 | 1,188 | 1,134 | -22.3% | -25.9% |
| NOX (thousand tons) | 1,537 | 1,274 | 1,224 | -17.1% | -20.4% |
| Hg (tons) | 8.8 | 7.4 | 7.3 | -15.2% | -16.8% |
| HCl (thousand tons) | 9 | 9 | 9 | 0.0% | -5.1% |

Source: Integrated Planning Model run by EPA, 2014

Table 4. Annualized Compliance Costs (billions of 2011$)

|  |  |  |  |
| --- | --- | --- | --- |
|   | **2020** | **2025** | **2030** |
| Two Block Regional | 3.2 | 3.0 | 6.8 |
| Two Block State | 4.4 | 4.6 | 9.8 |

Source: Integrated Planning Model run by EPA, 2014

Table 5. Generation Mix (thousand GWh)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Base Case, Generation** | **Two Block, Generation** | **Two Block, Percent Change** |
|  | **Regional** | **State** | **Regional** | **State** |
| 2020 |   |   |   |   |   |
| Pulverized Coal | 1,665 | 1,435 | 1,395 | -14% | -16% |
| NG Combined Cycle (existing) | 1,003 | 1,178 | 1,170 | 17% | 17% |
| NG Combined Cycle (new) | 85 | 153 | 199 | 81% | 134% |
| Combustion Turbine | 19 | 34 | 31 | 79% | 63% |
| Oil/Gas Steam | 52 | 25 | 26 | -51% | -50% |
| Non-Hydro Renewables | 299 | 300 | 300 | 0% | 0% |
| Hydro | 280 | 283 | 283 | 1% | 1% |
| Nuclear | 817 | 819 | 819 | 0% | 0% |
| Other | 8 | 8 | 9 | 11% | 17% |
| **Total** | 4,227 | 4,235 | 4,232 | 0% | 0% |
| 2025 |  |  |  |  |  |
| Pulverized Coal | 1,702 | 1,420 | 1,377 | -17% | -19% |
| NG Combined Cycle (existing) | 919 | 1,176 | 1,144 | 28% | 24% |
| NG Combined Cycle (new) | 280 | 310 | 385 | 11% | 37% |
| Combustion Turbine | 27 | 42 | 38 | 57% | 42% |
| Oil/Gas Steam | 37 | 20 | 20 | -47% | -46% |
| Non-Hydro Renewables | 335 | 335 | 335 | 0% | 0% |
| Hydro | 280 | 282 | 282 | 1% | 1% |
| Nuclear | 817 | 819 | 819 | 0% | 0% |
| Other | 6 | 7 | 8 | 15% | 22% |
| **Total** | 4,404 | 4,411 | 4,408 | 0% | 0% |
| 2030 |  |  |  |  |  |
| Pulverized Coal | 1,668 | 1,372 | 1,321 | -18% | -21% |
| NG Combined Cycle (existing) | 810 | 1,144 | 1,099 | 41% | 36% |
| NG Combined Cycle (new) | 599 | 551 | 644 | -8% | 7% |
| Combustion Turbine | 23 | 43 | 40 | 92% | 78% |
| Oil/Gas Steam | 23 | 15 | 17 | -34% | -29% |
| Non-Hydro Renewables | 350 | 352 | 353 | 1% | 1% |
| Hydro | 280 | 282 | 282 | 1% | 1% |
| Nuclear | 797 | 797 | 797 | 0% | 0% |
| Other | 6 | 7 | 8 | 23% | 31% |
| **Total** | 4,557 | 4,565 | 4,560 | 0% | 0% |

Note: “Other” mostly includes MSW and fuel cells. Source: Integrated Planning Model run by EPA, 2014

In 2020, incremental coal retirements relative to the base case are 24 GW in the regional scenario, and 32 GW in the state scenario.

Table 6. Total Generation Capacity by 2020-2030 (GW)

|  |  |  |  |
| --- | --- | --- | --- |
|   | Base Case | Two Block | Two Block |
|   | Reg. | State | Reg. | State |
| 2020 |   |   |   |   |   |
| Pulverized Coal | 244 | 219 | 211 | -10% | -13% |
| NG Combined Cycle (existing) | 219 | 221 | 221 | 1% | 1% |
| NG Combined Cycle (new) | 12 | 23 | 30 | 93% | 153% |
| Combustion Turbine | 146 | 148 | 149 | 1% | 2% |
| Oil/Gas Steam | 83 | 80 | 79 | -3% | -5% |
| Non-Hydro Renewables | 93 | 93 | 93 | 0% | 1% |
| Hydro | 101 | 101 | 101 | 0% | 0% |
| Nuclear | 103 | 103 | 103 | 0% | 0% |
| Other | 5 | 5 | 5 | 2% | 2% |
| Total | 1,005 | 994 | 992 | -1% | -1% |
| 2025 |   |   |   |   |   |
| Pulverized Coal | 243 | 219 | 211 | -10% | -13% |
| NG Combined Cycle (existing) | 219 | 221 | 221 | 1% | 1% |
| NG Combined Cycle (new) | 39 | 49 | 59 | 25% | 52% |
| Combustion Turbine | 149 | 160 | 160 | 8% | 7% |
| Oil/Gas Steam | 82 | 80 | 79 | -2% | -4% |
| Non-Hydro Renewables | 103 | 104 | 104 | 0% | 1% |
| Hydro | 101 | 101 | 101 | 0% | 0% |
| Nuclear | 103 | 103 | 103 | 0% | 0% |
| Other | 5 | 5 | 5 | 2% | 2% |
| Total | 1,044 | 1,042 | 1,043 | 0% | 0% |
| 2030 |   |   |   |   |   |
| Pulverized Coal | 240 | 217 | 209 | -10% | -13% |
| NG Combined Cycle (existing) | 219 | 221 | 221 | 1% | 1% |
| NG Combined Cycle (new) | 84 | 88 | 101 | 6% | 20% |
| Combustion Turbine | 156 | 174 | 172 | 12% | 10% |
| Oil/Gas Steam | 82 | 80 | 79 | -2% | -4% |
| Non-Hydro Renewables | 107 | 108 | 109 | 1% | 1% |
| Hydro | 101 | 101 | 101 | 0% | 0% |
| Nuclear | 101 | 101 | 101 | 0% | 0% |
| Other | 5 | 5 | 5 | 2% | 2% |
| Total | 1,095 | 1,095 | 1,096 | 0% | 0% |

Source: Integrated Planning Model run by EPA, 2014

**Table 7. Projected Capacity Factor of Existing Coal Steam and Natural Gas Combined Cycle Capacity**

|  |  |  |
| --- | --- | --- |
|   | **Existing Coal Steam** | **Existing Natural Gas Combined Cycle** |
|   | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Base Case | 78% | 80% | 79% | 52% | 48% | 42% |
| Option 2 Regional | 75% | 74% | 72% | 61% | 61% | 59% |
| Option 2 State | 75% | 74% | 72% | 60% | 59% | 57% |

Source: Integrated Planning Model run by EPA, 2014

Table 88. Projected Capacity Additions, Gas (GW)

|  |  |  |
| --- | --- | --- |
|  | **Cumulative Capacity Additions: Gas Combined Cycle** | **Incremental Cumulative Capacity Additions: Gas Combined Cycle** |
|  | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Base Case | 11.9 | 38.9 | 83.8 |  |  |  |
| Two Block Regional | 23.1 | 48.7 | 88.5 | 11.1 | 9.8 | 4.7 |
| Two Block State | 30.2 | 58.9 | 100.7 | 18.3 | 20.0 | 17.0 |

Source: Integrated Planning Model run by EPA, 2014

Table 9. Projected Capacity Additions, Non-hydro Renewable (GW)

|  |  |  |
| --- | --- | --- |
|  | **Cumulative Capacity Additions: Renewables** | **Incremental Cumulative Capacity Additions: Renewables** |
|  | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Base Case | 17.8 | 28.4 | 32.7 |  |  |  |
| Two Block Regional | 18.1 | 28.8 | 33.6 | 0.3 | 0.4 | 0.8 |
| Two Block State | 18.3 | 29.0 | 33.7 | 0.5 | 0.6 | 1.0 |

Source: Integrated Planning Model run by EPA, 2014

Table 10. Coal Production for the Electric Power Sector, 2020

|  |  |  |
| --- | --- | --- |
|  | **Coal Production (MM Tons)** | **Percent Change from Base Case** |
|  | **Two Block** | **Two Block** |
| **Base Case** | **Regional** | **State** | **Regional** | **State** |
| Appalachia | 140 | 110 | 111 | -22% | -21% |
| Interior | 249 | 230 | 224 | -8% | -10% |
| West | 446 | 324 | 308 | -27% | -31% |
| Waste Coal | 9 | 11 | 11 | 20% | 20% |
| Imports | 0 | 0 | 0 |  |  |
| Total | 844 | 675 | 654 | -20% | -22% |

Source: Integrated Planning Model run by EPA, 2014

Table 11. Power Sector Gas Use

|  |  |  |
| --- | --- | --- |
|  | **Power Sector Gas Use (TCF)** | **Percent Change in Power Sector Gas Use** |
| **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Base Case | 8.35 | 8.88 | 9.89 |  |  |  |
| Two Block Regional | 9.90 | 10.90 | 12.14 | 18.7% | 22.7% | 22.6% |
| Two Block State | 10.14 | 11.14 | 12.42 | 21.5% | 25.5% | 25.6% |

Table 12. Projected Average Minemouth and Delivered Coal Prices (2011$/MMBtu)

|  |  |  |
| --- | --- | --- |
|  | **Minemouth** | **Delivered - Electric Power Sector** |
| **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Base Case | 1.73 | 1.88 | 2.06 | 2.62 | 2.80 | 2.98 |
| Two Block Regional | 1.55 | 1.69 | 1.81 | 2.32 | 2.47 | 2.59 |
| Two Block State | 1.55 | 1.69 | 1.83 | 2.31 | 2.47 | 2.62 |

Table 13. Projected Average Minemouth and Delivered Coal Prices: Percent Change from Base Case Projections

|  |  |  |
| --- | --- | --- |
|  | **Minemouth** | **Delivered - Electric Power Sector** |
| **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Two Block Regional | -10.6% | -10.5% | -12.1% | -11.5% | -11.8% | -13.0% |
| Two Block State | -10.5% | -10.4% | -11.0% | -11.7% | -11.9% | -12.2% |

Table 14. Projected Natural Gas Prices (2011$/MMBtu)

|  |  |  |
| --- | --- | --- |
|   | Henry Hub | Delivered - Electric Power Sector |
|   | 2020 | 2025 | 2030 | 2020 | 2025 | 2030 |
| Base Case | 4.98 | 5.68 | 6.00 | 5.36 | 6.11 | 6.39 |
| Two Block Regional | 5.53 | 6.06 | 6.62 | 5.90 | 6.42 | 6.94 |
| Two Block State | 5.56 | 6.10 | 6.73 | 5.93 | 6.45 | 7.05 |

Table 15. Projected Natural Gas Prices: Percent Change from Base Case Projections

|  |  |  |
| --- | --- | --- |
|   | Henry Hub | Delivered - Electric Power Sector |
|   | 2020 | 2025 | 2030 | 2020 | 2025 | 2030 |
| Two Block Regional | 10.9% | 6.7% | 10.3% | 9.9% | 5.0% | 8.6% |
| Two Block State | 11.5% | 7.3% | 12.2% | 10.6% | 5.5% | 10.3% |

**Table 16. 2020 Projected Contiguous U.S. and Regional Retail Electricity Prices (cents/kWh)**

|  |  |  |
| --- | --- | --- |
|   | 2020 Projected Retail Price (cents/kWh) | Percent Change from Base Case |
|   | Base Case | Two Block Regional | Two Block State | Two Block Regional | Two Block State |
| ERCT | 9.9 | 10.3 | 10.4 | 4.8% | 5.1% |
| FRCC | 10.6 | 11.0 | 11.2 | 3.6% | 5.1% |
| MROE | 10.4 | 10.5 | 10.5 | 0.6% | 0.5% |
| MROW | 9.2 | 9.2 | 9.3 | 0.0% | 1.8% |
| NEWE | 13.8 | 14.2 | 14.5 | 2.5% | 5.0% |
| NYCW | 18.0 | 18.3 | 18.5 | 1.9% | 2.6% |
| NYLI | 14.7 | 15.1 | 15.2 | 2.5% | 3.3% |
| NYUP | 12.7 | 13.0 | 13.1 | 2.1% | 2.8% |
| RFCE | 12.2 | 12.6 | 12.7 | 3.2% | 3.6% |
| RFCM | 10.7 | 10.7 | 10.8 | 0.3% | 1.1% |
| RFCW | 10.1 | 10.3 | 10.4 | 1.7% | 2.5% |
| SRDA | 9.0 | 9.2 | 9.2 | 2.8% | 2.6% |
| SRGW | 9.3 | 9.5 | 9.6 | 1.9% | 2.9% |
| SRSE | 10.4 | 10.4 | 10.5 | 0.5% | 0.7% |
| SRCE | 8.2 | 8.2 | 8.2 | -0.9% | -0.9% |
| SRVC | 10.7 | 10.6 | 10.7 | -0.3% | -0.1% |
| SPNO | 10.6 | 10.5 | 10.5 | -1.0% | -1.3% |
| SPSO | 8.3 | 8.8 | 8.8 | 5.0% | 5.3% |
| AZNM | 10.5 | 10.7 | 10.8 | 1.7% | 2.9% |
| CAMX | 14.3 | 14.6 | 14.6 | 2.2% | 2.4% |
| NWPP | 7.3 | 7.4 | 7.4 | 1.3% | 1.4% |
| RMPA | 8.9 | 9.0 | 9.2 | 0.7% | 2.9% |
| Contiguous U.S. | 10.4 | 10.6 | 10.7 | 1.9% | 2.5% |

**Table 17. 2025 Projected Contiguous U.S. and Regional Retail Electricity Prices (cents/kWh)**

|  |  |  |
| --- | --- | --- |
|   | 2025 Projected Retail Price (cents/kWh) | Percent Change from Base Case |
|   | Base Case | Two Block Regional | Two Block State | Two Block Regional | Two Block State |
| ERCT | 11.2 | 11.5 | 11.5 | 2.5% | 3.0% |
| FRCC | 10.9 | 11.2 | 11.3 | 2.6% | 4.0% |
| MROE | 10.5 | 10.5 | 10.4 | 0.3% | -0.8% |
| MROW | 9.2 | 9.4 | 9.6 | 1.9% | 4.2% |
| NEWE | 14.2 | 14.6 | 14.9 | 2.2% | 4.4% |
| NYCW | 18.8 | 19.2 | 19.3 | 2.0% | 2.3% |
| NYLI | 15.6 | 16.0 | 16.1 | 2.9% | 3.3% |
| NYUP | 13.2 | 13.5 | 13.6 | 2.0% | 2.3% |
| RFCE | 12.6 | 12.8 | 12.9 | 1.6% | 2.0% |
| RFCM | 10.7 | 10.8 | 10.9 | 0.7% | 1.8% |
| RFCW | 10.9 | 11.0 | 11.1 | 0.7% | 1.0% |
| SRDA | 9.3 | 9.6 | 9.6 | 2.7% | 3.0% |
| SRGW | 10.1 | 10.3 | 10.3 | 1.3% | 1.9% |
| SRSE | 10.3 | 10.5 | 10.5 | 1.1% | 1.1% |
| SRCE | 8.2 | 8.1 | 8.1 | -1.5% | -1.7% |
| SRVC | 10.6 | 10.6 | 10.6 | -0.1% | 0.1% |
| SPNO | 10.3 | 10.3 | 10.3 | -0.2% | -0.3% |
| SPSO | 8.8 | 9.3 | 9.2 | 4.9% | 4.4% |
| AZNM | 10.8 | 11.1 | 11.3 | 2.7% | 4.7% |
| CAMX | 13.9 | 14.1 | 14.1 | 1.0% | 1.0% |
| NWPP | 7.4 | 7.4 | 7.5 | 0.7% | 1.7% |
| RMPA | 9.4 | 9.5 | 9.7 | 0.9% | 3.3% |
| Contiguous U.S. | 10.8 | 10.9 | 11.0 | 1.4% | 2.0% |

**Table 18. 2030 Projected Contiguous U.S. and Regional Retail Electricity Prices (cents/kWh)**

|  |  |  |
| --- | --- | --- |
|   | 2030 Projected Retail Price (cents/kWh) | Percent Change from Base Case |
|   | Base Case | Two Block Regional | Two Block State | Two Block Regional | Two Block State |
| ERCT | 11.6 | 12.1 | 12.1 | 4.0% | 4.8% |
| FRCC | 10.9 | 11.5 | 11.6 | 5.0% | 6.3% |
| MROE | 10.5 | 10.7 | 10.7 | 2.3% | 1.6% |
| MROW | 9.4 | 9.6 | 9.8 | 2.1% | 4.9% |
| NEWE | 15.1 | 15.4 | 15.4 | 2.0% | 1.8% |
| NYCW | 19.9 | 20.3 | 20.3 | 1.7% | 1.6% |
| NYLI | 16.9 | 17.2 | 17.1 | 1.8% | 1.3% |
| NYUP | 14.2 | 14.5 | 14.5 | 1.7% | 1.6% |
| RFCE | 12.4 | 12.8 | 12.8 | 2.8% | 3.4% |
| RFCM | 10.8 | 11.0 | 11.1 | 1.8% | 2.9% |
| RFCW | 11.2 | 11.4 | 11.4 | 1.3% | 1.8% |
| SRDA | 9.5 | 9.9 | 10.0 | 4.5% | 5.0% |
| SRGW | 10.4 | 10.5 | 10.6 | 0.9% | 1.6% |
| SRSE | 10.4 | 10.6 | 10.7 | 2.4% | 2.6% |
| SRCE | 8.1 | 8.1 | 8.1 | -1.2% | -1.2% |
| SRVC | 10.4 | 10.4 | 10.5 | 0.6% | 1.1% |
| SPNO | 10.2 | 10.2 | 10.2 | -0.1% | 0.2% |
| SPSO | 9.1 | 9.7 | 9.6 | 6.3% | 6.1% |
| AZNM | 11.5 | 11.8 | 12.0 | 2.7% | 4.4% |
| CAMX | 14.1 | 14.4 | 14.5 | 1.9% | 2.3% |
| NWPP | 7.4 | 7.5 | 7.6 | 1.2% | 2.6% |
| RMPA | 9.9 | 10.1 | 10.4 | 2.1% | 5.7% |
| Contiguous U.S. | 10.9 | 11.2 | 11.3 | 2.3% | 2.9% |

4 Estimated Climate Benefits from CO2 Emission Reductions

Tables 19 through 21 report the climate benefits estimated in three analysis years (2020, 2025, and 2030) for the two illustrative compliance scenarios (i.e., state and regional) evaluated.

Table 19. Estimated Global Climate Benefits of CO2 Reductions for Building Blocks 1 and 2 in 2020 (billions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **Discount Rate and Statistic** | **State**  | **Regional** |
| Million metric tonnes of CO2 reduced |  252  |  231  |
| 5% (average) | $3.2 | $3.0 |
| 3% (average) | $12 | $11 |
| 2.5% (average) | $17 | $16 |
| 3% (95th percentile) | $34 | $31 |

\* The SCC values are dollar-year and emissions-year specific. SCC values represent only a partial accounting of climate impacts.

Table 20. Estimated Global Climate Benefits of CO2 Reductions in 2025 (billions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **Discount Rate and Statistic** | **State**  | **Regional** |
| Million metric tonnes of CO2 reduced |  284  |  258  |
| 5% (average) | $4.2 | $3.9 |
| 3% (average) | $14 | $13 |
| 2.5% (average) | $21 | $19 |
| 3% (95th percentile) | $43 | $39 |

\* The SCC values are dollar-year and emissions-year specific. SCC values represent only a partial accounting of climate impacts.

Table 21. Estimated Global Climate Benefits of CO2 Reductions in 2030 (billions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **Discount Rate and Statistic** | **State**  | **Regional** |
| Million metric tonnes of CO2 reduced |  292  |  258  |
| 5% (average) | $5.0 | $4.4 |
| 3% (average) | $16 | $14 |
| 2.5% (average) | $23 | $21 |
| 3% (95th percentile) | $50 | $44 |

\* The SCC values are dollar-year and emissions-year specific. SCC values represent only a partial accounting of climate impacts.

5 Estimated Human Health Co-Benefits

Tables 22 through 24 provide the emission reductions estimated to occur in three analysis years (2020, 2025, and 2030) for two illustrative compliance scenarios (i.e., state and regional) by region (i.e., East, West, and California). Tables 25 through 27 report the health co-benefits estimated in three analysis years (2020, 2025, and 2030) for the two illustrative compliance scenarios (i.e., state and regional) evaluated.

Table 22. Emission Reductions of Criteria Pollutants in 2020 (thousands of short tons)

|  |  |  |  |
| --- | --- | --- | --- |
| **Region** | **SO2** | **All-year NOx** | **Ozone-Season NOx** |
| State |  |  |  |
| East | 253 | 233 | 96 |
| West | 23 | 40 | 17 |
| California | 0 | 0 | 0 |
| Total | 277 | 273 | 113 |
| Regional | 216 | 209 | 86 |
| East | 15 | 29 | 12 |
| West | 1 | 2 | 1 |
| California | 232 | 240 | 98 |
| Total | 216 | 209 | 86 |

Table 23. Emission Reductions of Criteria Pollutants in 2025 (thousands of short tons)

|  |  |  |  |
| --- | --- | --- | --- |
| **Region** | **SO2** | **All-year NOx** | **Ozone-Season NOx** |
| State |  |  |  |
| East | 318 | 265 | 111 |
| West | 26 | 41 | 17 |
| California | 0 | 9 | 1 |
| Total | 344 | 315 | 128 |
| Regional |  |  |  |
| East | 265 | 237 | 97 |
| West | 22 | 26 | 11 |
| California | 1 | 8 | 1 |
| Total | 287 | 270 | 109 |

Table 24. Emission Reductions of Criteria Pollutants in 2030 (thousands of short tons)

|  |  |  |  |
| --- | --- | --- | --- |
| **Region** | **SO2** | **All-year NOx** | **Ozone-Season NOx** |
| State |  |  |  |
| East | 365 | 265 | 108 |
| West | 31 | 48 | 21 |
| California | 0 | 0 | 0 |
| Total | 396 | 313 | 128 |
| Regional |  |  |  |
| East | 316 | 233 | 92 |
| West | 26 | 29 | 12 |
| California | 1 | 1 | 0 |
| Total | 342 | 263 | 105 |

Table 25. Summary of Estimated Monetized Health Co-benefits in 2020 (millions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **Pollutant** | **3% Discount Rate** | **7% Discount Rate** |
| State |  |
| SO2 | $10,000 | to | $23,000 | $9,300 | to | $21,000 |
| NOx (as PM2.5) | $1,600 | to | $3,600 | $1,400 | to | $3,200 |
| NOx (as Ozone) | $450 | to | $1,900 | $450 | to | $1,900 |
| **Total** | **$12,000** | **to** | **$29,000** | **$11,000** | **to** | **$26,000** |
| Regional |  |
| SO2 | $8,900 | to | $20,000 | $8,000 | to | $18,000 |
| NOx (as PM2.5) | $1,500 | to | $3,300 | $1,300 | to | $3,000 |
| NOx (as Ozone) | $410 | to | $1,700 | $410 | to | $1,700 |
| **Total** | **$11,000** | **to** | **$25,000** | **$9,800** | **to** | **$23,000** |

\* All estimates are rounded to two significant figures so numbers may not sum down columns. The estimated monetized co-benefits do not include climate benefits or reduced health effects from direct exposure to NO2, SO2, ecosystem effects, or visibility impairment. All fine particles are assumed to have equivalent health effects, but the benefit-per-ton estimates vary depending on the location and magnitude of their impact on PM2.5 levels, which drive population exposure. The monetized co-benefits incorporate the conversion from precursor emissions to ambient fine particles and ozone. Co-benefits for PM2.5 precursors are based on regional benefit-per-ton estimates. Co-benefits for ozone are based on ozone season NOx emissions. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology. In general, the 95th percentile confidence interval for monetized PM2.5 benefits ranges from approximately -90 percent to +180 percent of the central estimates based on Krewski et al. (2009) and Lepeule et al. (2012).

Table 26. Summary of Estimated Monetized Health Co-benefits in 2025 (millions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **Pollutant** | **3% Discount Rate** | **7% Discount Rate** |
| State |  |
| SO2 | $14,000 | to | $32,000 | $13,000 | to | $29,000 |
| NOx (as PM2.5) | $2,100 | to | $4,800 | $1,900 | to | $4,300 |
| NOx (as Ozone) | $680 | to | $2,900 | $680 | to | $2,900 |
| **Total** | **$17,000** | **to** | **$40,000** | **$15,000** | **to** | **$36,000** |
| Regional |  |
| SO2 | $12,000 | to | $27,000 | $11,000 | to | $24,000 |
| NOx (as PM2.5) | $1,900 | to | $4,200 | $1,700 | to | $3,800 |
| NOx (as Ozone) | $600 | to | $2,600 | $600 | to | $2,600 |
| **Total** | **$14,000** | **to** | **$34,000** | **$13,000** | **to** | **$30,000** |

\* All estimates are rounded to two significant figures so numbers may not sum down columns. The estimated monetized co-benefits do not include climate benefits or reduced health effects from direct exposure to NO2, SO2, ecosystem effects, or visibility impairment. All fine particles are assumed to have equivalent health effects, but the benefit-per-ton estimates vary depending on the location and magnitude of their impact on PM2.5 levels, which drive population exposure. The monetized co-benefits incorporate the conversion from precursor emissions to ambient fine particles and ozone. Co-benefits for PM2.5 precursors are based on regional benefit-per-ton estimates. Co-benefits for ozone are based on ozone season NOx emissions. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology. In general, the 95th percentile confidence interval for monetized PM2.5 benefits ranges from approximately -90 percent to +180 percent of the central estimates based on Krewski et al. (2009) and Lepeule et al. (2012).

Table 27. Summary of Estimated Monetized Health Co-benefits in 2030 (millions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **Pollutant** | **3% Discount Rate** | **7% Discount Rate** |
| State |  |
| SO2 | $17,000 | to | $39,000 | $16,000 | to | $35,000 |
| NOx (as PM2.5) | $2,100 | to | $4,700 | $1,900 | to | $4,200 |
| NOx (as Ozone) | $700 | to | $3,000 | $700 | to | $3,000 |
| Total | $20,000 | to | $47,000 | $18,000 | to | $43,000 |
| Regional |   |
| SO2 | $15,000 | to | $34,000 | $14,000 | to | $31,000 |
| NOx (as PM2.5) | $1,800 | to | $4,100 | $1,700 | to | $3,700 |
| NOx (as Ozone) | $600 | to | $2,600 | $600 | to | $2,600 |
| Total | $18,000 | to | $41,000 | $16,000 | to | $37,000 |

\* All estimates are rounded to two significant figures so numbers may not sum down columns. The estimated monetized co-benefits do not include climate benefits or reduced health effects from direct exposure to NO2, SO2, ecosystem effects, or visibility impairment. All fine particles are assumed to have equivalent health effects, but the benefit-per-ton estimates vary depending on the location and magnitude of their impact on PM2.5 levels, which drive population exposure. The monetized co-benefits incorporate the conversion from precursor emissions to ambient fine particles and ozone. Co-benefits for PM2.5 precursors are based on regional benefit-per-ton estimates. Co-benefits for ozone are based on ozone season NOx emissions. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. Confidence intervals are unavailable for this analysis because of the benefit-per-ton methodology. In general, the 95th percentile confidence interval for monetized PM2.5 benefits ranges from approximately -90 percent to +180 percent of the central estimates based on Krewski et al. (2009) and Lepeule et al. (2012).

6 Combined Climate Benefits and Health Co-benefits

Tables 28 through 30 provide the combined climate and health benefits for each compliance scenarios evaluated for 2020, 2025, and 2030.

Table 28. Combined Climate Benefits and Health Co-Benefits in 2020 (billions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **SCC Discount Rate** | **Climate Benefits Only** | **Climate Benefits and Health Co-Benefits** **(Discount Rate Applied to Health Co-Benefits)** |
| **3%** | **7%** |
| State | 252 | million metric tonnes CO2 |  |
| 5% | $3.2 | $16 | to | $32 | $14 | to | $29 |
| 3% | $12 | $24 | to | $40 | $23 | to | $38 |
| 2.5% | $17 | $30 | to | $46 | $28 | to | $43 |
| 3% (95th percentile) | $34 | $47 | to | $63 | $46 | to | $61 |
| Regional | 231 | million metric tonnes CO2 |  |
| 5% | $3.0 | $14 | to | $28 | $13 | to | $26 |
| 3% | $11 | $21 | to | $36 | $20 | to | $33 |
| 2.5% | $16 | $27 | to | $41 | $26 | to | $39 |
| 3% (95th percentile) | $31 | $42 | to | $57 | $41 | to | $54 |

\*All estimates are rounded to two significant figures. Climate benefits are based on reductions in CO2 emissions. Co-benefits are based on regional benefit-per-ton estimates. Co-benefits for ozone are based on ozone season NOx emissions. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. The health co-benefits reflect the sum of the PM2.5 and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). The monetized health co-benefits do not include reduced health effects from direct exposure to NO2, SO2, and HAP; ecosystem effects; or visibility impairment.

Table 29. Combined Climate Benefits and Health Co-Benefits in 2025 (billions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **SCC Discount Rate** | **Climate Benefits Only** | **Climate Benefits and Health Co-Benefits** **(Discount Rate Applied to Health Co-Benefits)** |
| **3%** | **7%** |
| State | 284 | million metric tonnes CO2 |  |
| 5% | $4.2 | $21 | to | $44 | $20 | to | $40 |
| 3% | $14 | $31 | to | $54 | $30 | to | $50 |
| 2.5% | $21 | $38 | to | $61 | $36 | to | $57 |
| 3% (95th percentile) | $43 | $60 | to | $83 | $59 | to | $79 |
| Regional | 258 | million metric tonnes CO2 |  |
| 5% | $3.9 | $18 | to | $37 | $17 | to | $34 |
| 3% | $13 | $27 | to | $46 | $26 | to | $43 |
| 2.5% | $19 | $33 | to | $52 | $32 | to | $49 |
| 3% (95th percentile) | $39 | $54 | to | $73 | $52 | to | $70 |

\*All estimates are rounded to two significant figures. Climate benefits are based on reductions in CO2 emissions. Co-benefits are based on regional benefit-per-ton estimates. Co-benefits for ozone are based on ozone season NOx emissions. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. The health co-benefits reflect the sum of the PM2.5 and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). It is important to note that the monetized health co-benefits do not include reduced health effects from direct exposure to NO2, SO2, and HAP; ecosystem effects; or visibility impairment.

Table 30. Combined Climate Benefits and Health Co-Benefits in 2030 (billions of 2011$)\*

|  |  |  |
| --- | --- | --- |
| **SCC Discount Rate** | **Climate Benefits Only** | **Climate Benefits and Health Co-Benefits** **(Discount Rate Applied to Health Co-Benefits)** |
| **3%** | **7%** |
| State | 292 | million metric tonnes CO2 |  |
| 5% | $5.0 | $25 | to | $52 | $23 | to | $48 |
| 3% | $16 | $36 | to | $63 | $35 | to | $59 |
| 2.5% | $23 | $44 | to | $70 | $42 | to | $66 |
| 3% (95th percentile) | $50 | $70 | to | $97 | $68 | to | $92 |
| Regional | 258 | million metric tonnes CO2 |  |
| 5% | $4.4 | $22 | to | $45 | $20 | to | $41 |
| 3% | $14 | $32 | to | $55 | $30 | to | $51 |
| 2.5% | $21 | $38 | to | $62 | $37 | to | $58 |
| 3% (95th percentile) | $44 | $61 | to | $85 | $60 | to | $81 |

\*All estimates are rounded to two significant figures. Climate benefits are based on reductions in CO2 emissions. Co-benefits are based on regional benefit-per-ton estimates. Co-benefits for ozone are based on ozone season NOx emissions. Ozone co-benefits occur in analysis year, so they are the same for all discount rates. The health co-benefits reflect the sum of the PM2.5 and ozone co-benefits and reflect the range based on adult mortality functions (e.g., from Krewski et al. (2009) with Bell et al. (2004) to Lepeule et al. (2012) with Levy et al. (2005)). It is important to note that the monetized health co-benefits do not include reduced health effects from direct exposure to NO2, SO2, and HAP; ecosystem effects; or visibility impairment.

7 Net Benefits

Tables 31 through 33 summarize the benefits, costs, and net benefits for 2020, 2025, and 2030 for the two illustrative compliance scenarios evaluated for building blocks 1 and 2 only.

Table 31. Summary of Monetized Benefits, Compliance Costs, and Net Benefits in 2020 (billions of 2011$) a

|  |  |
| --- | --- |
|  | **State** |
| **3% Discount Rate** | **7% Discount Rate** |
| Climate Benefits b 5% discount rate3% discount rate2.5% discount rate95th percentile at 3% discount rate | $3.2$12$17$34 |
| Air pollution health co-benefits c | $12 to $29 | $11 to $26 |
| Total Compliance Costs d | $4.4 |
| Net Benefits e | $20 to $36 | $18 to $33 |
| Non-Monetized Benefits | Direct exposure to SO2 and NO21.1 tons of Hg Ecosystem EffectsVisibility impairment |
|  | **Regional** |
| **3% Discount Rate** | **7% Discount Rate** |
| Climate Benefits b5% discount rate3% discount rate2.5% discount rate95th percentile at 3% discount rate | $3.0$11$16$31 |
| Air pollution health co-benefits c | $11 to $25 | $9.8 to $23 |
| Total Compliance Costs d | $3.2 |
| Net Benefits e | $18 to $32 | $17 to $30 |
| Non-Monetized Benefits | Direct exposure to SO2 and NO21.1 tons of Hg Ecosystem EffectsVisibility impairment |

a All estimates are for 2020 and are rounded to two significant figures, so figures may not sum.

b The climate benefit estimates in this summary table reflect global impacts from CO2 emission changes and do not account for changes in non-CO2 GHG emissions. Also, different discount rates are applied to SCC than to the other estimates because CO2 emissions are long-lived and subsequent damages occur over many years. The SCC estimates are year-specific and increase over time.

c The air pollution health co-benefits reflect reduced exposure to PM2.5 and ozone associated with emission reductions of directly emitted PM2.5, SO2 and NOX. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 90 percent of total monetized co-benefits from PM2.5 and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type.

d Total costs are approximated by the illustrative compliance costs estimated using the Integrated Planning Model and a discount rate of approximately 5%. This estimate includes monitoring, recordkeeping, and reporting costs and demand side energy efficiency program and participant costs.

e The estimates of net benefits in this summary table are calculated using the global SCC at a 3 percent discount rate (model average). Tables 10-12 in this memo present combined climate and health estimates based on additional discount rates.

Table 32. Summary of Monetized Benefits, Compliance Costs, and Net Benefits in 2025 (billions of 2011$) a

|  |  |
| --- | --- |
|  | **State** |
| **3% Discount Rate** | **7% Discount Rate** |
| Climate Benefits b 5% discount rate3% discount rate2.5% discount rate95th percentile at 3% discount rate | $4.2$14$21$43 |
| Air pollution health co-benefits c | $17 to $40 | $15 to $36 |
| Total Compliance Costs d | $4.6 |
| Net Benefits e | $27 to $49 | $25 to $46 |
| Non-Monetized Benefits | Direct exposure to SO2 and NO21.4 tons of Hg Ecosystem EffectsVisibility impairment |
|  | **Regional** |
| **3% Discount Rate** | **7% Discount Rate** |
| Climate Benefits b5% discount rate3% discount rate2.5% discount rate95th percentile at 3% discount rate | $3.9$13$19$39 |
| Air pollution health co-benefits c | $14 to $34 | $13 to $30 |
| Total Compliance Costs d | $3.0 |
| Net Benefits e | $24 to $43 | $23 to $40 |
| Non-Monetized Benefits | Direct exposure to SO2 and NO21.3 tons of Hg Ecosystem EffectsVisibility impairment |

a All estimates are for 2025 and are rounded to two significant figures, so figures may not sum.

b The climate benefit estimates in this summary table reflect global impacts from CO2 emission changes and do not account for changes in non-CO2 GHG emissions. Also, different discount rates are applied to SCC than to the other estimates because CO2 emissions are long-lived and subsequent damages occur over many years. The SCC estimates are year-specific and increase over time.

c The air pollution health co-benefits reflect reduced exposure to PM2.5 and ozone associated with emission reductions of directly emitted PM2.5, SO2 and NOX. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 90 percent of total monetized co-benefits from PM2.5 and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type.

d Total costs are approximated by the illustrative compliance costs estimated using the Integrated Planning Model and a discount rate of approximately 5%. This estimate includes monitoring, recordkeeping, and reporting costs and demand side energy efficiency program and participant costs.

e The estimates of net benefits in this summary table are calculated using the global SCC at a 3 percent discount rate (model average). Tables 10-12 in this memo present combined climate and health estimates based on additional discount rates.

Table 33. Summary of Monetized Benefits, Compliance Costs, and Net Benefits in 2030 (billions of 2011$) a

|  |  |
| --- | --- |
|  | **State** |
| **3% Discount Rate** | **7% Discount Rate** |
| Climate Benefits b 5% discount rate3% discount rate2.5% discount rate95th percentile at 3% discount rate | $5.0$16$23$50 |
| Air pollution health co-benefits c | $20 to $47 | $18 to $43 |
| Total Compliance Costs d | $9.8 |
| Net Benefits e | $27 to $53 | $25 to $49 |
| Non-Monetized Benefits | Direct exposure to SO2 and NO21.5 tons of HgEcosystem EffectsVisibility impairment |
|  | **Regional** |
| **3% Discount Rate** | **7% Discount Rate** |
| Climate Benefits b5% discount rate3% discount rate2.5% discount rate95th percentile at 3% discount rate | $4.4$14$21$44 |
| Air pollution health co-benefits c | $18 to $41 | $16 to $37 |
| Total Compliance Costs d | $6.8 |
| Net Benefits e | $25 to $48 | $23 to $45 |
| Non-Monetized Benefits | Direct exposure to SO2 and NO21.3 tons of Hg Ecosystem EffectsVisibility impairment |

a All estimates are for 2030, and are rounded to two significant figures, so figures may not sum.

b The climate benefit estimates in this summary table reflect global impacts from CO2 emission changes and do not account for changes in non-CO2 GHG emissions. Also, different discount rates are applied to SCC than to the other estimates because CO2 emissions are long-lived and subsequent damages occur over many years. The SCC estimates are year-specific and increase over time.

c The air pollution health co-benefits reflect reduced exposure to PM2.5 and ozone associated with emission reductions of directly emitted PM2.5, SO2 and NOX. The range reflects the use of concentration-response functions from different epidemiology studies. The reduction in premature fatalities each year accounts for over 90 percent of total monetized co-benefits from PM2.5 and ozone. These models assume that all fine particles, regardless of their chemical composition, are equally potent in causing premature mortality because the scientific evidence is not yet sufficient to allow differentiation of effect estimates by particle type.

d Total costs are approximated by the illustrative compliance costs estimated using the Integrated Planning and a discount rate of approximately 5%. This estimate includes monitoring, recordkeeping, and reporting costs and demand side energy efficiency program and participant costs.

e The estimates of net benefits in this summary table are calculated using the global SCC at a 3 percent discount rate (model average). Tables 10-12 in this memo present combined climate and health estimates based on additional discount rates.

8 Labor

Table 34 presents the labor changes estimated in job-years associated with the illustrative building blocks 1 and 2 analysis.

**Table 34. Engineering-Baseda Changes in Labor Utilization, Building Blocks 1 & 2 (Number of Job-Years of Employment in Year)**

|  |  |  |
| --- | --- | --- |
| **Category** | **Regional Compliance** | **State Compliance** |
|  | **2017-2020** | **2021-2025** | **2026-2030** | **2017-2020** | **2021-2025** | **2026-2030** |
| Construction-related (One-time) Changes\* |
| Heat Rate Improvement: Total | **37,400** | **0** | **0** | **35,300** | **0** | **0** |
| Boilermakers and General Construction | 26,000 | 0 | 0 | 24,500 | 0 | 0 |
| Engineering and Management | 6,900 | 0 | 0 | 6,500 | 0 | 0 |
| Equipment-related | 3,300 | 0 | 0 | 3,200 | 0 | 0 |
| Material-related | 1,200 | 0 | 0 | 1,100 | 0 | 0 |
| New Capacity Construction: Total | **7,700** | **7,300** | **1,600** | **11,000** | **9,400** | **1,000** |
| Renewables | 0 | 500 | 1,600 | -700 | 500 | 1,600 |
| Natural Gas  | 7,700 | 6,800 | 0 | 11,700 | 8,900 | -600 |
| Recurring Changes\*\* |
|  | **2020** | **2025** | **2030** | **2020** | **2025** | **2030** |
| Operation and Maintenance: Total | **-10,970** | **-9,500** | **-8,300** | **-14,100** | **-12,200** | **-10,600** |
| Changes in Gas | 1,330 | 1,500 | 1,100 | 2,200 | 2,400 | 2,100 |
| Retired Coal | -11,800 | -10,700 | -9,200 | -15,600 | -14,100 | -12,300 |
| Retired Oil and Gas | -500 | -300 | -200 | -700 | -500 | -400 |
| Fuel Extraction: Total | **-1,900** | **-1,000** | **-700** | **-1,500** | **-1,000** | **-800** |
| Coal | -9,700 | -11,100 | -12,000 | -10,500 | -12,400 | -13,500 |
| Natural Gas | 7,800 | 10,100 | 11,300 | 9,000 | 11,400 | 12,700 |
| Supply Side Employment Impacts – Quantified | **32,230** | **-3,200** | **-7,400** | **30,700** | **-3,800** | **-10,400** |
| a Job-year estimates are derived from IPM investment and O&M cost estimates, as well as IPM fuel use estimates (tons coals or MMBtu gas) |
| bAll job-year estimates on this are Full Time Equivalent (FTE) jobs. Job estimates in the Demand-Side energy efficiency section (below) include both full time and part time jobs |
| \*Construction-related job-year changes are one-time impacts, occurring during each year of the 2 to 4 year period during which construction and HRI installation activities occur. Figures in table are average job-years during each of the years in each range. Negative job-year estimates when additional generating capacity must be built in the base case, but is avoided in the Guideline implementation scenarios due to HRI or Demand-side energy efficiency programs.  |
| \*\*Recurring Changes are job-years associated with annual recurring jobs including operating and maintenance activities and fuel extraction jobs. Newly built generating capacity creates a recurring stream of positive job-years, while retiring generating capacity, as well as avoided new built capacity, create a stream of negative job-years. In addition, there are recurring jobs prior to 2020 to fuel and operate new generating capacity brought online before 2020; the recurring jobs prior to 2020 are not estimated. |

9 References

Bell, M.L., et al. 2004. “Ozone and Short-Term Mortality in 95 U.S. Urban Communities, 1987-2000.” Journal of the American Medical Association, 292(19): pp. 2372-8.

Krewski D; M. Jerrett; R.T. Burnett; R. Ma; E. Hughes and Y. Shi, et al. 2009. Extended Follow-Up and Spatial Analysis of the American Cancer Society Study Linking Particulate Air Pollution and Mortality. HEI Research Report, 140, Health Effects Institute, Boston, MA.

Lepeule, J.; F. Laden; D. Dockery and J. Schwartz. 2012. “Chronic Exposure to Fine Particles and Mortality: An Extended Follow-Up of the Harvard Six Cities Study from 1974 to 2009.” Environmental Health Perspectives, July, 120(7): pp. 965-70.

Levy, J.I.; S.M. Chemerynski and J.A. Sarnat. 2005. “Ozone Exposure and Mortality: An Empiric Bayes Meta-regression Analysis.” Epidemiology, 16(4): pp. 458-68.