EPA Analysis of Alternative SO_2 and NO_x Caps for Senator Carper

July 16, 2010

This document represents EPA's analysis of the two scenarios for SO_2 and NO_x caps requested by Senator Carper.

The analysis was conducted by EPA's Office of Air and Radiation.

Request for Analysis

THOMAS R. CARPER
DELAWARE

United States Senate
WASHINGTON, DC 20510-0803

April 15, 2009

Ms. Lisa Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Dear Administrator Jackson,

As you know, I introduced S.2995, the Clean Air Act Amendments of 2010 with Senator Lamar Alexander and nine other cosponsors to reduce the sulfur dioxide, nitrogen oxide, and mercury emissions from our nation's power plants. I thank you and your staff for the technical assistance provided for this bill, especially the modeling work completed in August 2009. After speaking with several of my colleagues on the Environment and Public Works Committee, we believe two more modeling scenarios would be beneficial to understanding the true impacts of S.2995. Therefore, I am writing to request technical assistance from the EPA to provide modeling for the two different scenarios listed below.

For each of the scenarios outlined below, please provide both cost and benefit analysis. The cost analysis should include looking at the number of control installations, changes in fuel prices and electricity prices, changes in generation mix, changes in new generation, allowance prices and incremental costs of the scenarios.

For each scenario please also provide quantitative estimates of the expected health benefits in dollars and reductions in the incidence of health effects caused by SO2 and NOx, including at least the premature deaths avoided (and other health effects as time would allow). Please use an approach similar to the one that you used in the fall 2005 Multi-Pollutant Bill Analysis that you did for Senator Carper, where EPA provided for several of the bills estimates of benefits that were based on the general relationship that EPA has found between emissions reductions of SO2 and NOx in the United States and health benefits. Also, please provide a qualitative assessment of the benefits that are not quantified for consideration, as well as assessment estimates of the air quality impacts from both scenarios.

As per discussions between our staffs, I understand that both because of the time available and the status of your efforts to develop a replacement rule for the Clean Air Interstate rule and the Utility MACT rule, it would not be possible to develop a reference case to compare these scenarios to likely requirements under the existing Clean Air Act. I also understand that the most recent reference case available is one including the Clean Air Interstate Rule and many of the provisions of the recently passed stimulus bill that was used as the reference case in the IPM modeling used to support analysis of the Waxman/Markey bill. Please use this same reference case in this analysis.

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Please analyze the following scenarios:

Scenario 1:
SO2: 2012 cap of 3.5 million tons;
2015 cap of 2.0 million tons; and
2018 and beyond cap of 1.5 million tons

NOx: Eastern NOx Cap (where eastern zone includes all States in CAIR including Minnesota and also includes all northeastern States that are not part of CAIR)
2012 cap of 1.39 million tons;
2015 and beyond cap of 1.3 million tons

Western NOx Cap (where western zone includes all States not in Eastern zone)
2012 cap of 510,000 tons; and
2015 and beyond cap of 320,000 tons

Scenario 2:
SO2: Same as scenario #1

NOx: Eastern NOx Cap (where eastern zone includes all States in CAIR including Minnesota and also includes all northeastern States that are not part of CAIR)
2012 cap of 1.30 million tons; and
2014 and beyond cap of 900,000 tons

Western NOx Cap: same as scenario #1

If possible, I would like a majority of the analysis provided to me and staff by May 5, 2010. I realize the air quality impacts may take a little longer –and if possible – I hope to have them by May 19, 2010.

Thank you for your assistance on this important issue. Should you have any additional questions, or require additional information, please do not hesitate to contact me or Laura Haynes in my office at 202-224-3168.

With best personal regards, I am,

Sincerely,

Thomas R. Carper
U.S. Senate

CC: Assistant Administrator Gina McCarthy

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Executive Summary

- This document presents the results of an analysis of two scenarios for SO_2 and NO_X caps requested by Senator Carper
  - Scenario 1 is based on the caps in S.2995
  - Scenario 2 includes the SO_2 caps in S.2995, but lowers the eastern NO_X cap to 900,000 tons in 2015
- Due to time constraints:
  - Sensitivity analysis of key variables such as natural gas prices and capital costs for pollution controls was not performed
  - Analysis of the mercury provisions of the bill was not performed
  - Health benefit and air quality analysis was performed using screening tools rather than full scale modeling but do offer substantial insights to the level of the benefits and air quality improvements for the scenarios evaluated
- The benefits of both scenarios greatly outweigh the cost. In 2025:
  - Scenario 1 annual benefits estimates are $72 billion and $170 billion while costs were approximately $4.9 billion.
  - Scenario 2 annual benefits estimates are $75 billion and $180 billion while costs were approximately $6.4 billion.
- Increases in natural gas prices were around 1-2% and 2-3% for electricity prices compared to the reference case
- SO_2 emission reductions were influenced by a combination of the emission caps and the large existing Title IV bank
  - Due to the bank actual emissions are higher than the caps
  - Reductions are generally achieved by installing emission control equipment (scrubbers) or using low sulfur coal. There is only minimal switching to natural gas and coal retirements.
- The annual benefits of the tighter NO_X cap ($2.9 billion in 2025) outweigh the annual costs ($1.5 billion in 2025) and there are significant air quality improvements.
  - The impact on retail electricity prices is less than 1%.
  - Reductions are generally achieved by installing emission control equipment (SCRs). There is only minimal switching to natural gas and coal retirements.

Analytic Approach

- This analysis estimates the emissions reductions, costs and benefits that would occur under two requested legislative scenarios, relative to currently implemented regulations including the Clean Air Interstate Rule (CAIR). This analysis does not compare the scenarios with full implementation of the Clean Air Act including National Ambient Air Quality Standards for PM (2006) and Ozone (2008).
- Under the Act, EPA is required to promulgate several rules that will achieve emissions reductions within the time frame of this analysis. We do not estimate the emissions reductions and benefits that would occur under continued implementation of the CAA, or compare those with emissions reductions and benefits of potential legislation.
- Therefore the results of this analysis can not be portrayed as the costs and benefits of the scenarios compared to what might happen under current law. It only allows comparison of the scenarios modeled with rules issued so far.

Reference case for this analysis

- The reference case for this analysis includes major federal and state rules for EGUs that are on the books and applicable to sources, as well as controls required in consent decrees. The baseline does not include any requirements beyond those on the books (climate policy, Utility MACT standard, BART limits, etc.)
- EPA must issue regulations to replace CAIR pursuant to a court decision. Those regulations have just recently been proposed and will not be finalized until 2011. For analytical purposes we assume full implementation of CAIR rather than attempting to prejudge future rulemakings (e.g. costs and benefits are incremental to CAIR and other existing federal and state rules). The Clean Air Mercury Rule (CAMR) was not included in the modeling. This is the same approach requested and used for the previous Carper scenario analysis and allows comparison of this analysis with that one from 2009.
- All emissions reductions, costs and benefits in this analysis are relative to this reference case.

3 Components of Analysis

- The IPM results inform 2 screening-level analyses for benefits and air quality improvements*

Integrated Planning Model (IPM)

•Estimates emissions reductions and allowance prices.

•Same analytic approach as July 09 Carper analysis.

•IPM approach is the same as that used for the proposed Transport Rule but the baseline is different than the proposed Transport Rule.

Health benefits per ton estimates

•Screening assessment that uses outputs from IPM.

•Same analytic approach as July 09 Carper analysis

•Uses up-to-date benefits per ton estimates derived from the Transport Rule

Air quality improvement estimates

•Screening assessment that uses outputs from IPM.

•Additional information that was not in July 09 Carper analysis

•Extrapolates air quality improvement information from existing modeling

* The results of the screening-level air quality and benefits analyses are not comparable to the results of full-scale air quality and benefits modeling, such as that done for the proposed Transport Rule, because the screening-level analysis is based on regional emissions rather than plant level emission projections. Full-scale air quality modeling for these two scenarios and accompanying benefits analysis would take 5-6 months to complete.

How Does this Analysis Compare to Other Multi-Pollutant Analyses?

To deliver the analysis in the timeframe requested, EPA used simplified estimation methodologies for the air quality and benefits analysis.

	How does it compare to Carper 09 analysis?	**How does it compare to proposed Transport Rule?**
Economic modeling	• Same approach • Same baseline	• Same approach • Different baseline
Benefits estimates	• Same approach • Uses updated benefits-per-ton metric	• Simplified approach • Benefits estimated from regional emission reductions rather than from air quality modeling
Air quality estimates	• New in this analysis	• Screening-level analysis • Not comparable to full-scale air quality modeling in proposed Transport Rule. • Assumes implementation of CAIR, which Transport Rule does not

Comparing This Analysis To What Can Be Done Under the Clean Air Act

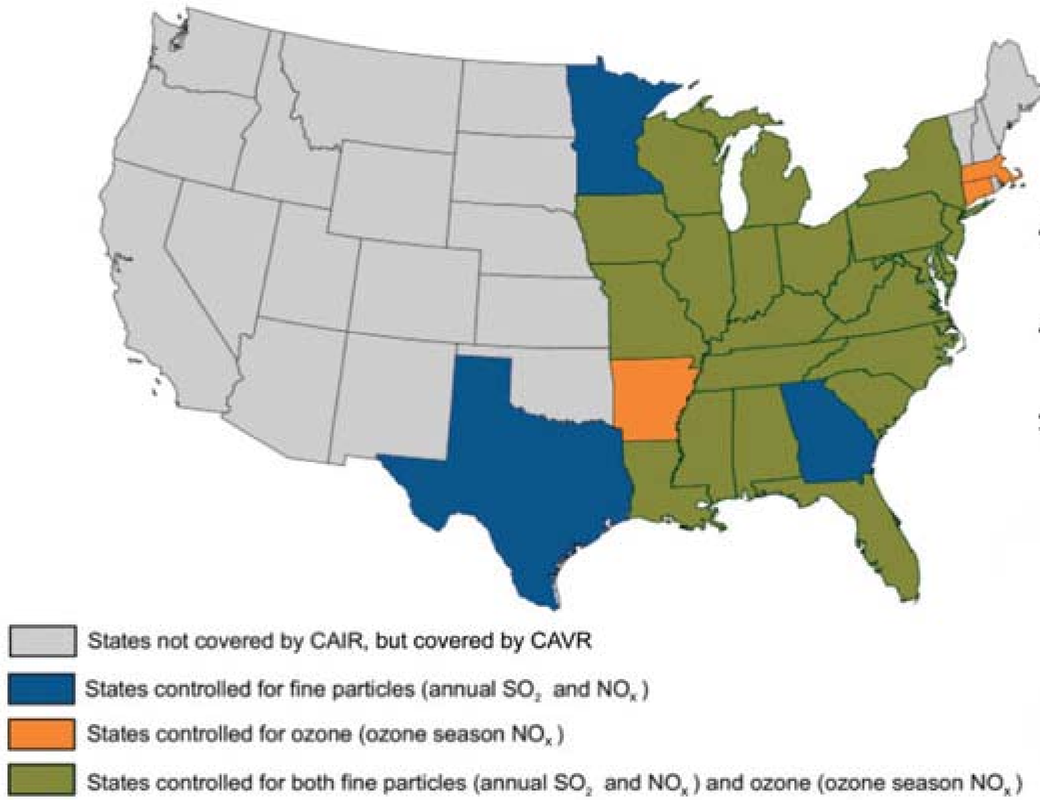
- The Transport Rule represents only one part of the reductions that the Clean Air Act requires EPA and states to achieve
- Additional SO_2 reductions are likely from a suite of other Clean Air Act Requirements
  - Potential co-benefits from a Utility MACT
  - Additional reductions from a potential transport rule addressing a new $PM_{2.5}$ NAAQS
  - RACT requirements under both the $PM_{2.5}$ and SO_2 NAAQS
  - Regional Haze
- Additional NO_x reductions are likely under both local and regional requirements for the existing and new ozone NAAQS, as well as regional haze requirements
- Air toxics reductions beyond mercury are required under the MACT requirements
- Direct PM reductions are likely from several authorities
  - Co-benefits from Utility MACT
  - $PM_{2.5}$ NAAQS requirements and regional haze requirements

Proposed Transport Rule Highlights

- In the initial years of the program, the proposed Transport Rule is more stringent than CAIR
- The proposed approach allows limited interstate trading among power plants in the 31 states covered and DC but assures that each state will meet its pollution control obligations and replaces CAIR.
- More information available at http://www.epa.gov/airtransport

Clean Air Interstate Rule
(Emission Caps Used in Reference Case)

States Covered in Clean Air Interstate Rule (CAIR) for SO_2 and NO_X



CAIR Emission Caps*
(million tons)

	2009/2010	2015
Annual SO_2 *(2010)*	3.7	2.6
Annual NO_x ***(2009)***	1.5	1.3
Seasonal NO_x *(2009)*	0.6	0.5

*for the affected regions

Source: EPA, 2007

Note: On February 8, 2008, the U.S. Court of Appeals issued a decision vacating the Clean Air Mercury Rules (CAMR) and thereby suspending the program that allowed mercury emissions trading. Also in 2008, the U.S. Court of Appeals for the DC Circuit remanded CAIR to the agency; the proposed Transport Rule will replace CAIR when final.

Analytical Scenarios

The analysis focuses on two different power sector cap & trade scenarios for SO_2 and NO_x.

Control Scenario 1: **Annual Emissions Caps**

	2012 - 2014	2015 - 2017	2018 and beyond
SO_2	3.5 million tons	2.0 million tons	1.5 million tons
Eastern NO_x	1.39 million tons	1.3 million tons	1.3 million tons
Western NO_x	510,000 tons	320,000 tons	320,000 tons
Total NO_x	1.9 million tons	1.62 million tons	1.62 million tons

Control Scenario 2: **Annual Emissions Caps**

	2012 - 2014	2015 - 2017	2018 and beyond
SO_2	3.5 million tons	2.0 million tons	1.5 million tons
Eastern NO_x	1.3 million tons	0.9 million tons in 2014	0.9 million tons
Western NO_x	510,000 tons	320,000 tons	320,000 tons
Total NO_x	1.81 million tons	1.22 million tons	1.22 million tons

Eastern region for this analysis includes ME, VT and NH in addition to the original 28 CAIR states and DC.

Currently, power sector NO_x emissions are around 2 million tons annually, of which over 1.2 million tons are in the Eastern region and 0.75 million tons are in the Western region. Power sector SO_2 emissions are less than 6 million tons nationally.

Detailed Electricity Sector Modeling Results

Detailed Electricity Sector Modeling with IPM

Motivation for Using the Integrated Planning Model (IPM):

- EPA has employed the Integrated Planning Model (IPM) to project the near-term impact of alternative SO_2 and NO_x caps on the electricity sector. IPM has also been used for modeling conventional pollutant trading programs in the past such as CAIR, multi-pollutant legislative proposals, and climate policies such as the Waxman-Markey bill.

Power Sector Modeling (IPM 2009 ARRA Ref. Case):

- The model has been updated to include assumptions from the revised Energy Information Administration's Annual Energy Outlook 2009, taking into account the impacts of the American Recovery and Reinvestment Act (ARRA) of 2009. This update changes the reference case forecast for renewable energy considerably.
- This version of IPM was used to analyze the Waxman-Markey energy and climate bill. The reference case assumes the continuation of CAIR for the entire modeling period.
- This version of the model incorporates key updates related to technology costs, state rules, current and planned emissions controls; carbon capture and storage technology for new and existing coal plants; and technology penetration constraints on emission control retrofits (page 18 provides detail on control retrofit constraints) and new generation capacity (these constraints are non-binding).
- No demand response was modeled in these scenarios.
- No allowance allocation method or auctions were modeled in these scenarios. While allocations and auctions have implications for individual sources, they do not impact the modeling results for these scenarios (allocations are not using updating approach).

Note: For more detail on the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

Key Model Updates and Major Power Sector Assumptions Modeled in IPM

Updates to IPM 2009 ARRA Ref. Case:

Electricity Demand Growth: Calibrated to AEO 2009 ARRA update (issued in April).

Cost of New Power Technologies: Consistent with AEO 2009 ARRA update.

Biomass: Supply curves and non-electricity demand for biomass are calibrated to AEO 2009 ARRA update.

Cost of Carbon: An increase to the capital charge rate for new coal plants (consistent with AEO 2009).

State RPS and Climate Programs: Calibrated to AEO 2009 with finalized regulations like RGGI.

CCS in Baseline: Reflecting updated financial incentives including ARRA, 2 GW of CCS capacity are projected for 2015 in the baseline.

Other Key Assumptions

Starting Bank: Calculated using 2009 SO_2 allowance bank as a starting value and projected 2012 emissions in the reference case. Used interpolation for 2010 – 2011 emissions. Assumed current vintage year allowances would be retired before pre-2010 allowances.

Use of Banked Allowances: Allowances banked prior to 2012 (or 2015) were allowed to be used in the new trading programs. S. 2995 provides that allowances with a pre- 2010 vintage year would be used to cover 1 ton of emissions, while allowances issued for the 2010 or 2011 vintage years would be used to cover ½ ton of emissions. For this analysis, EPA assumed 2010 and 2011 vintage year allowances would be used prior to the start of the 2012 and therefore all remaining allowances would be surrendered at a 1:1 ratio.

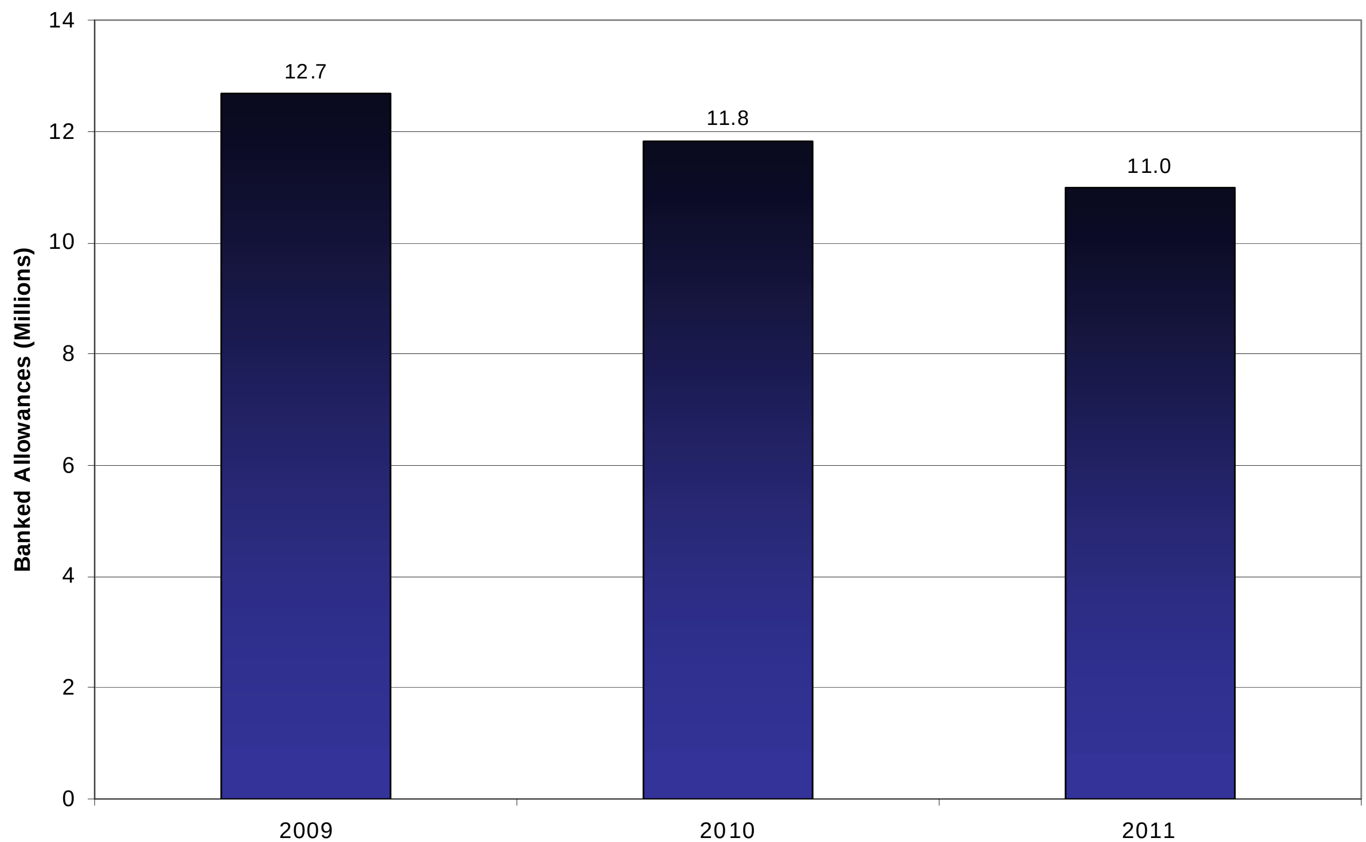
Limitation on FGD and SCR retrofits in 2012: Used reference case retrofit data to limit number of new controls that could be added in 2012 due to time/resource constraints for coal-fired units. Retrofits in the two scenarios were not allowed to exceed the reference case retrofits for the first run year.

- The limitation was not applied to SCR retrofits for oil/gas units. Additional controls were installed for oil/gas EGUs in Scenario #2. However, additional sensitivity modeling showed very little impact on emissions or costs.

State Programs: As they have done historically, States will initially rely on the cap and trade control scenarios to lower SO_2 and NO_x emissions and plan additional controls on power plants in local areas where warranted by local circumstances. For instance, in the case of the recent NAAQS for Ozone, Sulfur Dioxide, and Nitrogen Dioxide, the regulated community will not need to comply until after 2015 (when the second phase caps of the control scenarios go into effect). We do not specifically account for these actions.

Note: See Appendix for more detail on updates to IPM and key assumptions. For more detail on the all of the assumptions used in EPA's application of IPM, please see more detailed documentation for IPM at http://www.epa.gov/airmarkets/progsregs/epa-ipm/index.html.

Projected SO_2 Allowance Bank 2008 - 2011



Assumes all 2010 – 2011 vintage allowances will have been surrendered and that all remaining banked allowances may be used at a 1:1 ratio to cover emissions.

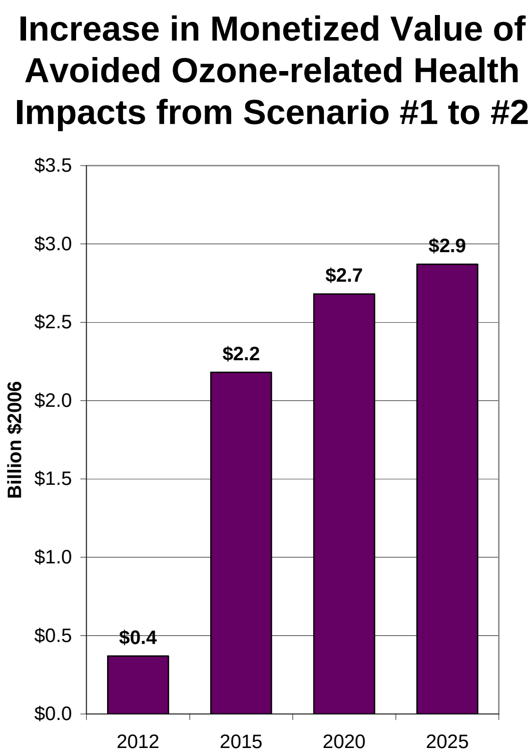
Other Considerations and Analyses

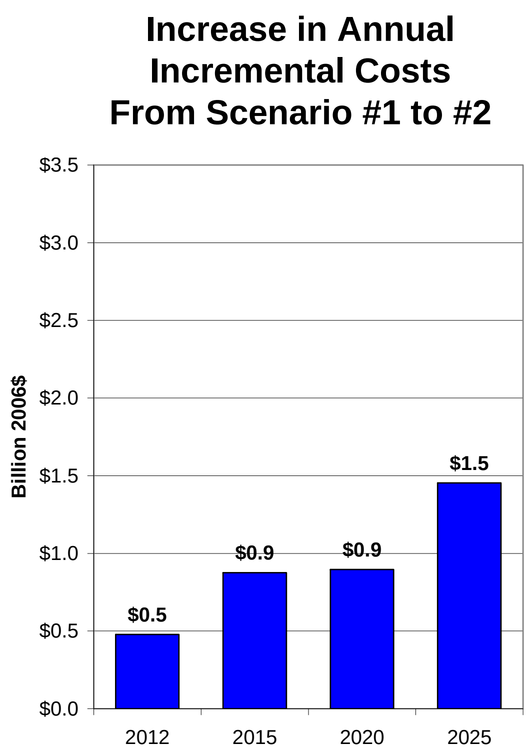
- EPA has used the existing CAIR program as part of base case in conjunction with all other EPA and state regulations and enforcement settlement agreements between power plants and EPA and the states that are in effect. Without a CAIR program, states would still have an obligation for attaining the NAAQS for fine particles and ozone.

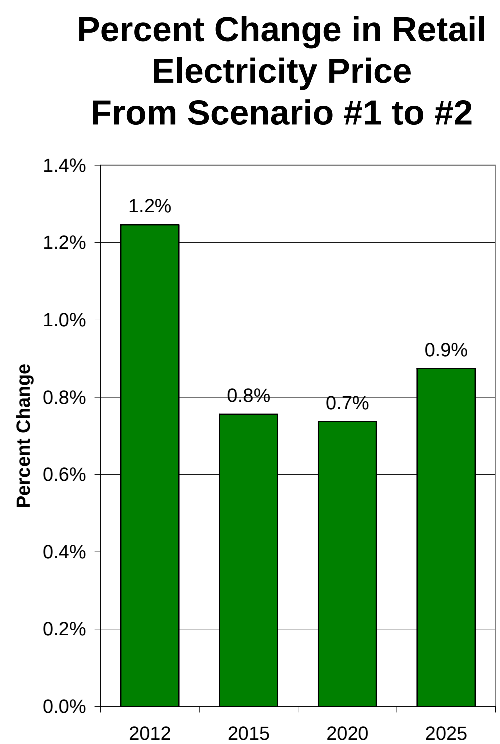
- In the last seven years, EPA and EIA have analyzed various versions of multi-pollutant control legislation, as well as regulations (consideration of CAIR, the Clean Air Mercury Rule, and the Clean Air Visibility Rule) for the power sector. These results provide a useful backdrop in considering the results of the analysis. EPA's analysis may be found at http://www.epa.gov/airmarkets/progsregs/epa-ipm/multi.html. EIA's analysis can be found at www.eia.doe.gov/oiaf/service_rpts.htm.

- With additional time, EPA would have tested the sensitivity of the results to key assumptions such as electricity demand, (physical) capital costs, fuel prices, and other factors. Some sense of the implications of these factors can be found by referencing previous EPA analysis cited above. In summary, these comparisons identified the following:
  - Higher natural gas prices tended to result in less fuel switching and more generation from coal.
  - In addition, allowance prices were higher relative to the main scenarios when higher gas prices were modeled.
  - With demand response, lower electricity demand reduced overall costs to the power sector.
  - Recent analysis done by others suggests that consideration of other environmental liabilities, higher capital costs for emission controls and lower gas prices could lead to more switching to natural gas and more coal retirements

Benefits of Incremental Change in NO_x Emissions

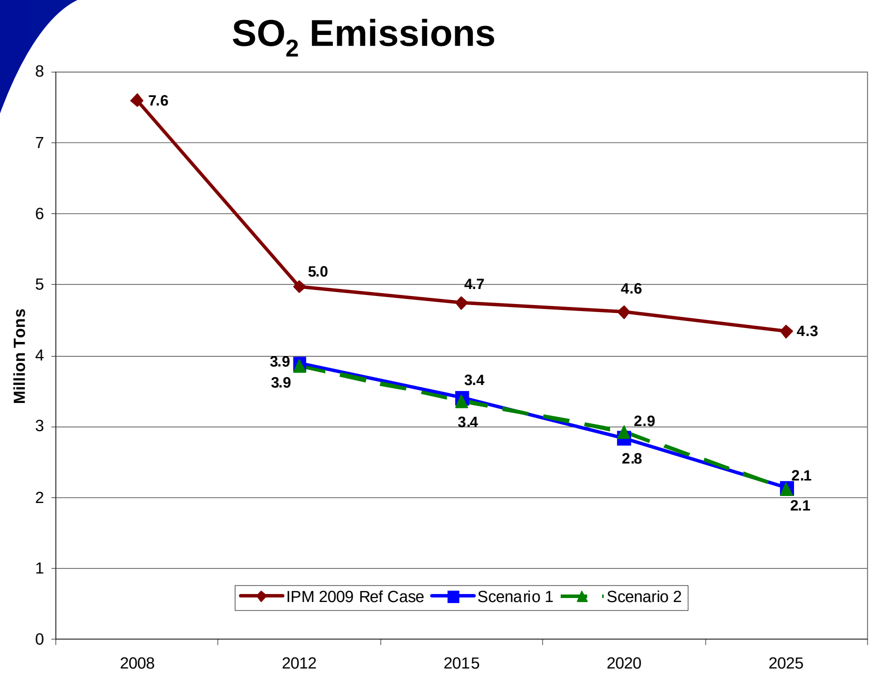


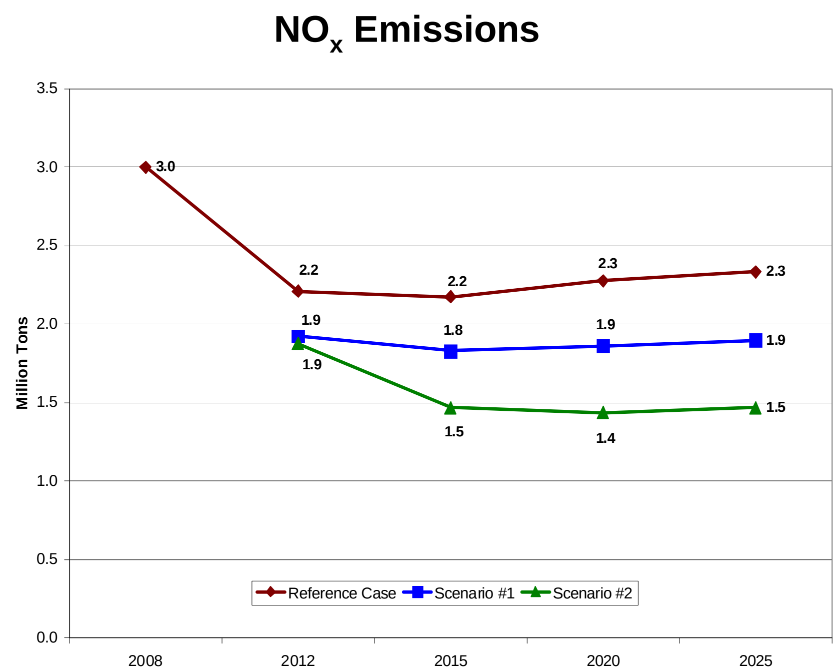




- Electricity and natural gas prices, retirements, coal production and other power sector impacts are not substantially different between the two scenarios. The small increases in Scenario #2 throughout the modeling timeframe are the result of the tighter NO_x cap and additional controls required for sources to comply.
- Allowance prices are different due to additional controls installed on smaller units with relatively low NO_X rates.
- There are also increases in $PM_{2.5}$ benefits and non-health benefits in Scenario #2 due to lower NO_X emissions.
- Unquantifiable NO_X reductions benefits are meaningful in avoiding eutrophication, acidification of surface waters, and damage to forest ecosystems and soils.

Nationwide SO_2 and NO_x Emissions

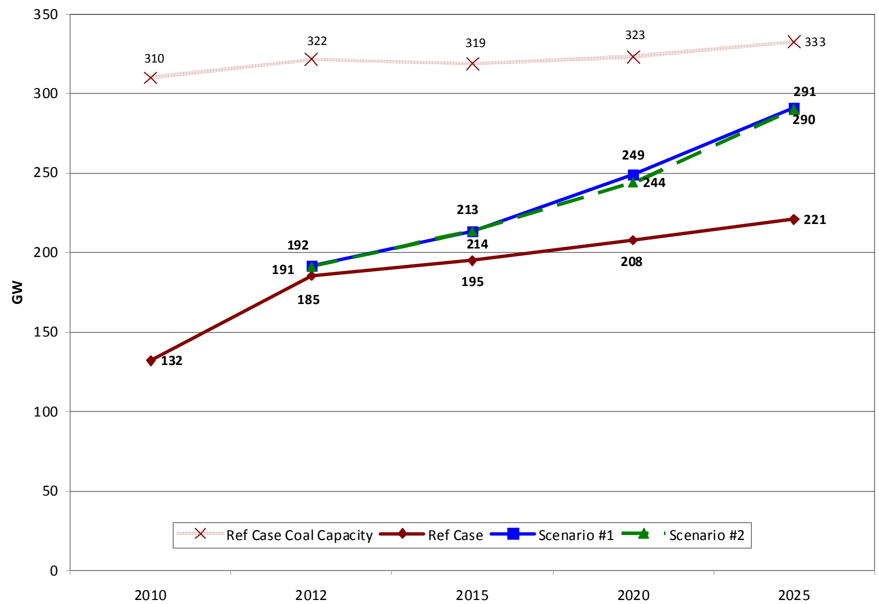




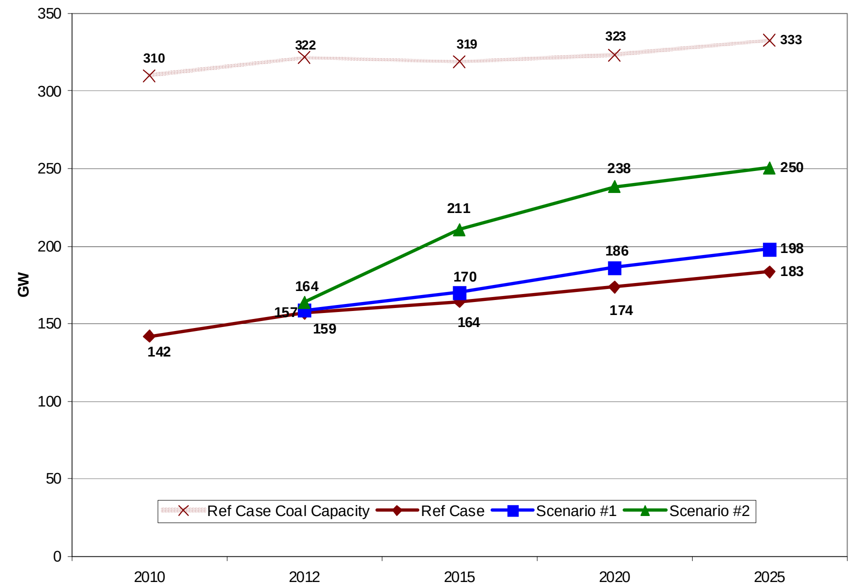
- Scenarios #1 and 2 have nearly the same results for SO_2 emissions displayed as overlapping lines in the graph.
- SO_2 emissions do not follow the same trajectory as the cap because of the pattern of allowance banking. In 2012, SO_2 allowances are banked, in later years, the SO_2 allowance bank is drawn down.
- In 2012, Scenarios #1 and #2 achieve significant additional reductions of SO_2 because higher allowance prices incentivize better operation of existing scrubbers, additional use of lower sulfur coals, and some additional use of natural gas.
- There is less banking of NO_x allowances than SO_2 allowances, and less banking of NO_x allowances in Scenario #2 than Scenario #1.
- The regional caps affect the location of emissions reductions. State level emissions data is available in Appendix A for more detailed comparisons of emissions changes.

Amount of Coal-Fired Capacity with FGD and SCR Installed

Capacity with FGD Installed (Cumulative)



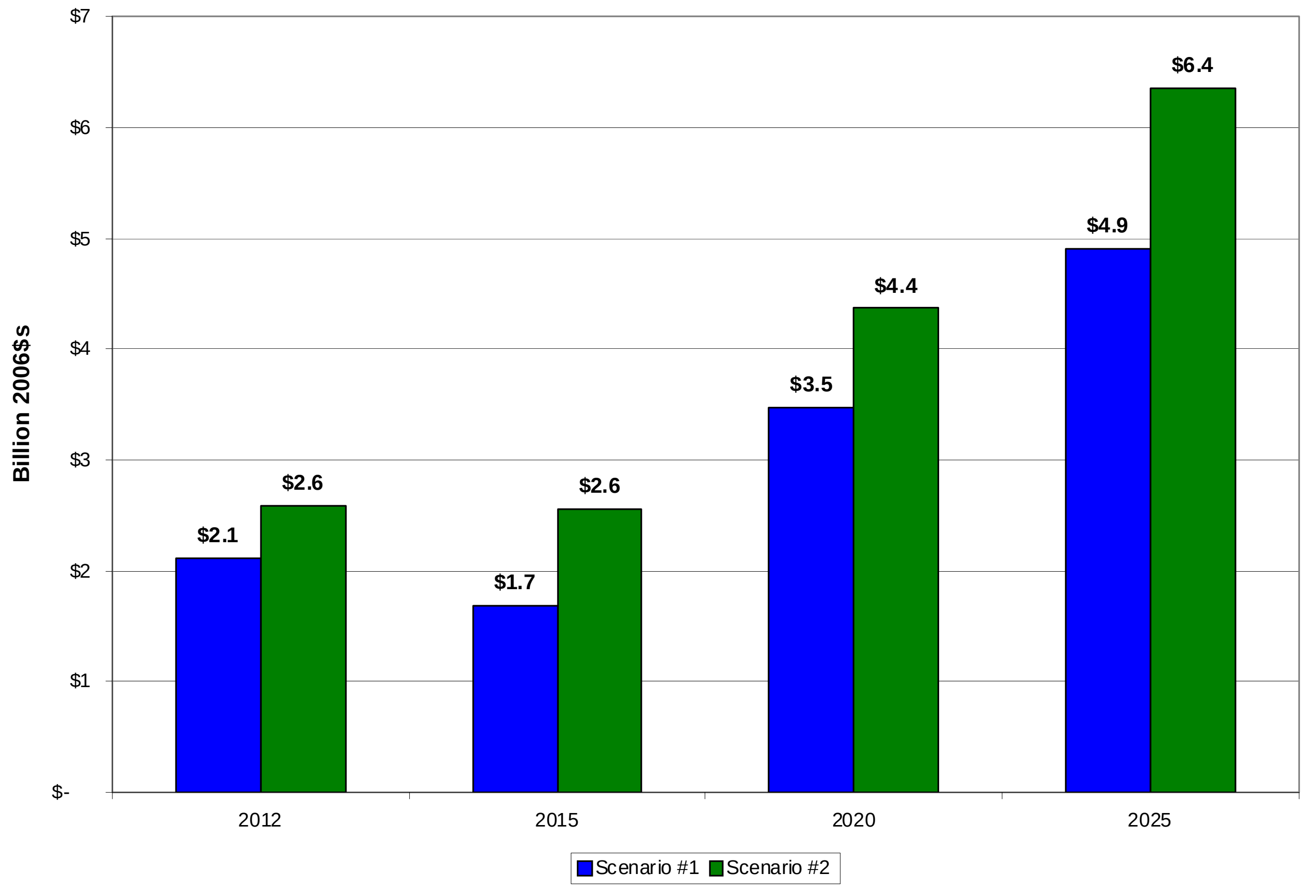
Capacity with SCR Installed (Cumulative)



- Scenarios #1 and 2 have nearly the same results for FGD additions and are displayed as overlapping lines in the graph. SCR retrofits are about 50 GW higher in Scenario #2 than Scenario #1 and 65 GW higher than the reference case in 2025.
- In 2008, there was also more than 5 GW of fluidized bed combustion (FBC) generation, which burns coal and achieves approximately 90% SO_2 capture and is generally well-controlled for NO_x.
- In addition, IPM projects around 28 GW of SNCR in 2012 to control NO_x emissions for the reference case and both scenarios.
- More detailed information about installed retrofit controls is available in Appendix A.

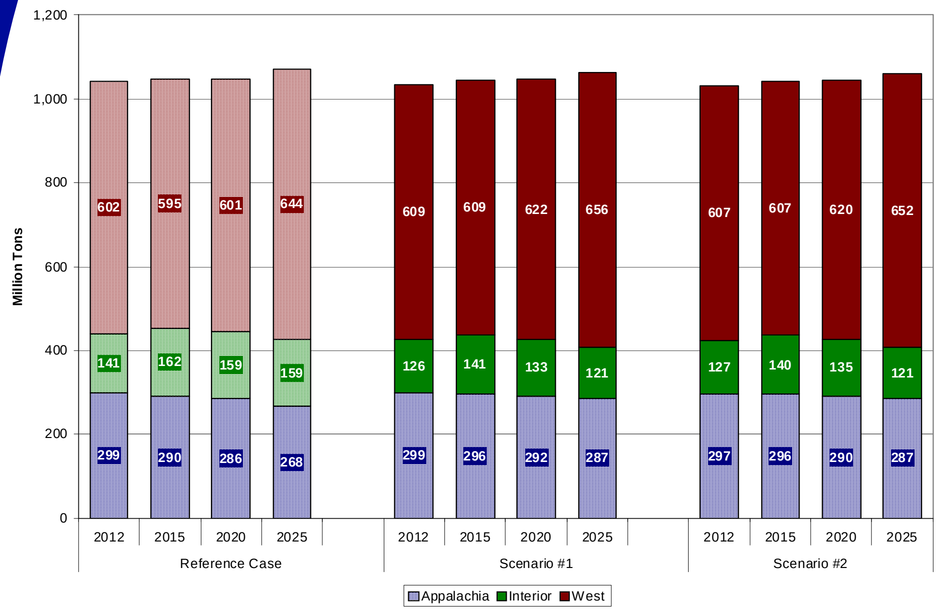
NOTE: FGD and SCR retrofits were limited in the scenarios in 2012 to the amount added in the reference case. The small differences in 2012 in these graphs is due to more units dispatching existing retrofits compared to the reference case, not adding on new ones.

Annual Incremental Costs

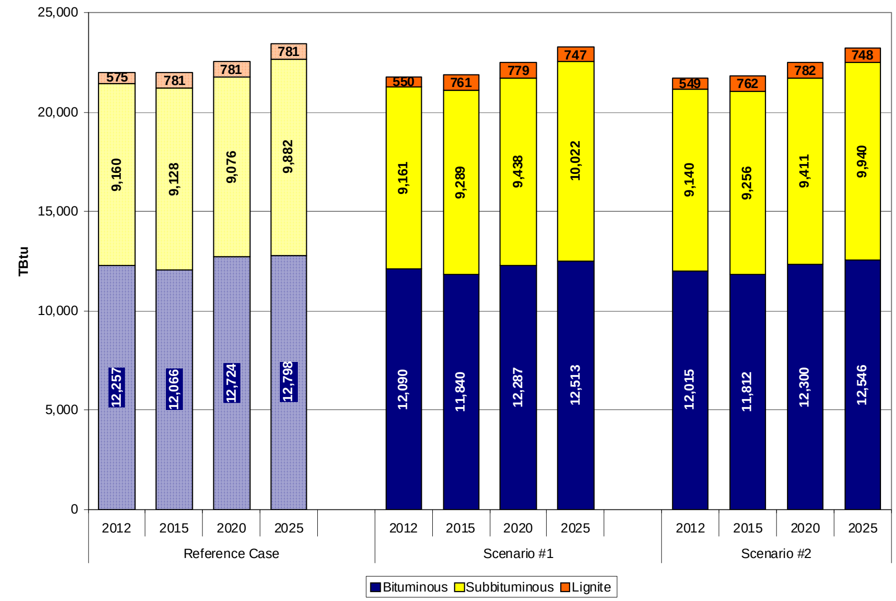


Coal Production and Use in the Power Sector

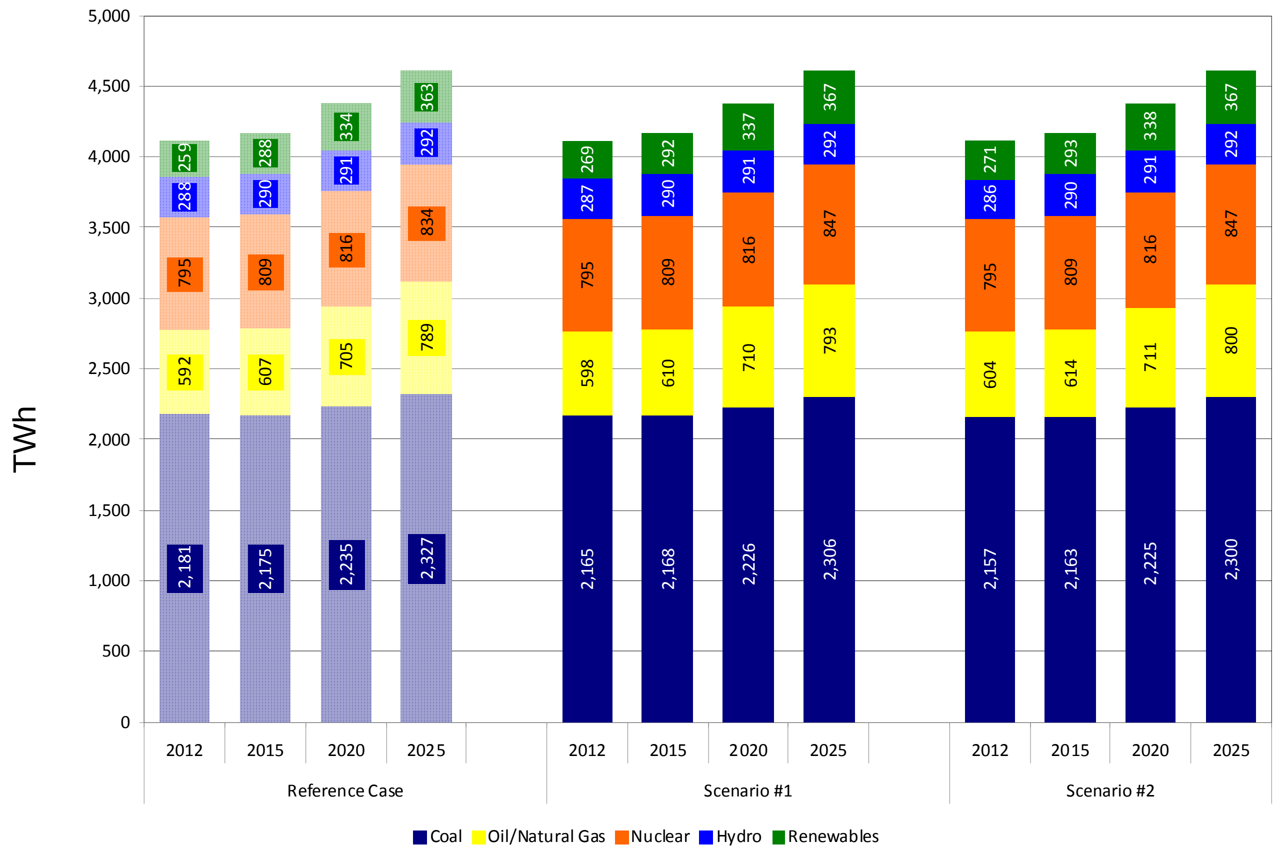
Coal Production by Region



Coal Use by Type

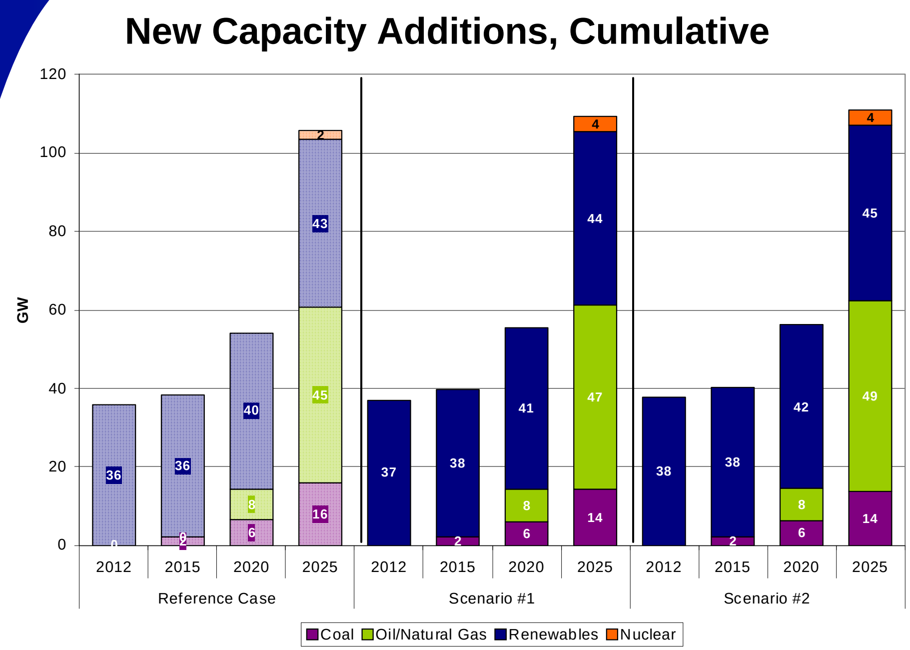


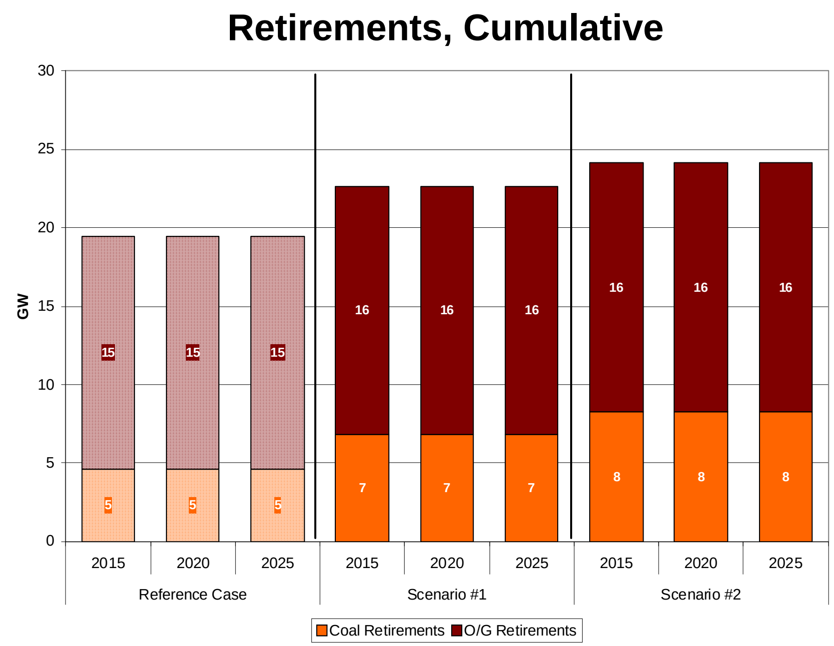
Generation Mix



In this analysis, there is a minimal amount of fuel switching between coal and natural gas by 2025. It is less expensive to reduce emissions from coal plants rather than switching to natural gas. However, switching between coal types does take place (See Coal Production and Use slide)

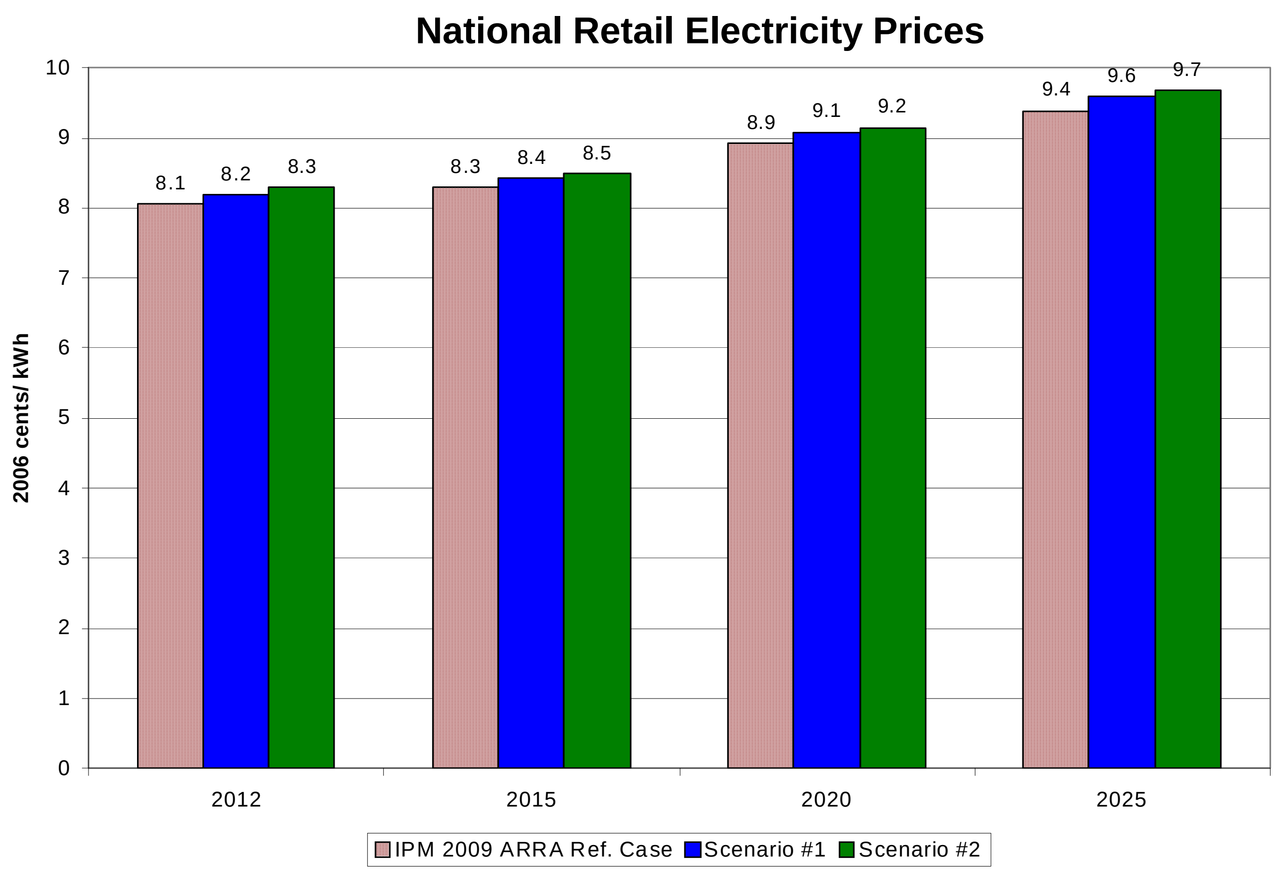
New Capacity Additions and Retirements





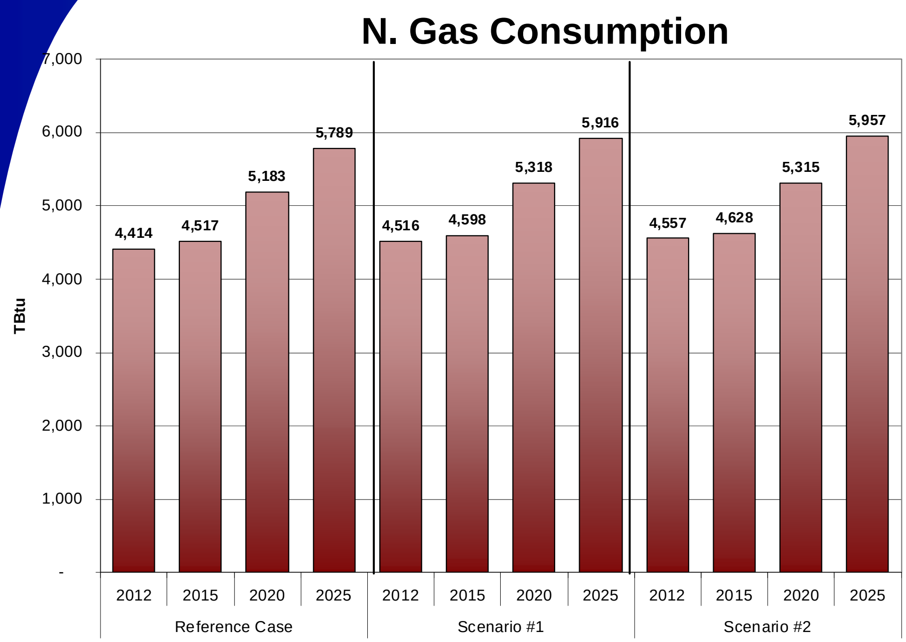
- Natural gas new capacity additions in 2025 in all scenarios are a function of electricity demand, low gas prices, and its cost competitiveness relative to other technologies.
- The mix of new renewables capacity is roughly 75% wind, over 15% biomass, and less than 10% other types
- In reality, uneconomic units may be “mothballed,” retired, or kept running to ensure generation reliability. The model is unable to distinguish among these potential outcomes.
- Most uneconomic units are part of larger plants that are expected to continue generating. Currently, there are roughly 115 GW of oil/gas steam capacity and 310 GW of coal capacity.
- Oil/gas units that are retired are generally older steam units, while new builds are either natural gas combined cycle units or natural gas combustion turbines

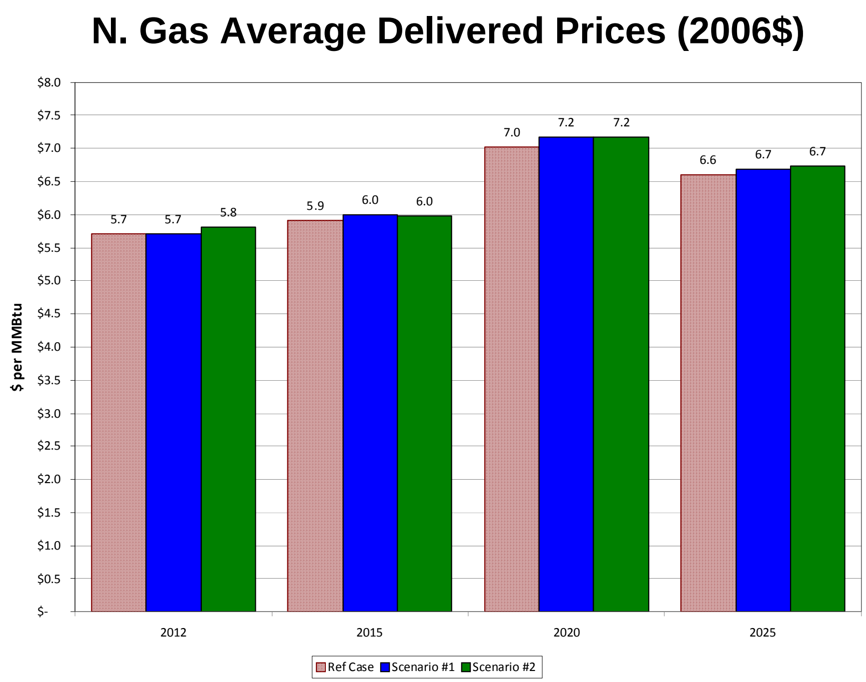
Retail Electricity Prices



Electricity prices rise only slightly relative to the reference case– between 2-3%-- and are within a normal range of variation for retail prices. Prices are highest in Scenario #2 with the tightest NO_x cap.

Natural Gas Use and Prices in the Power Sector

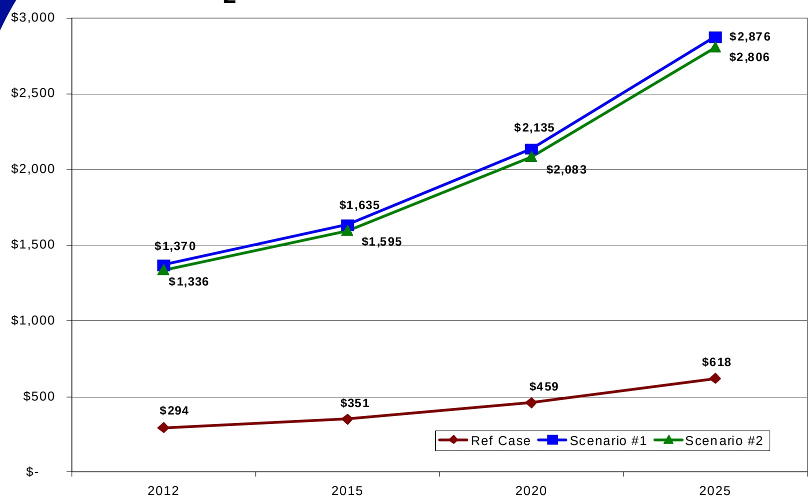




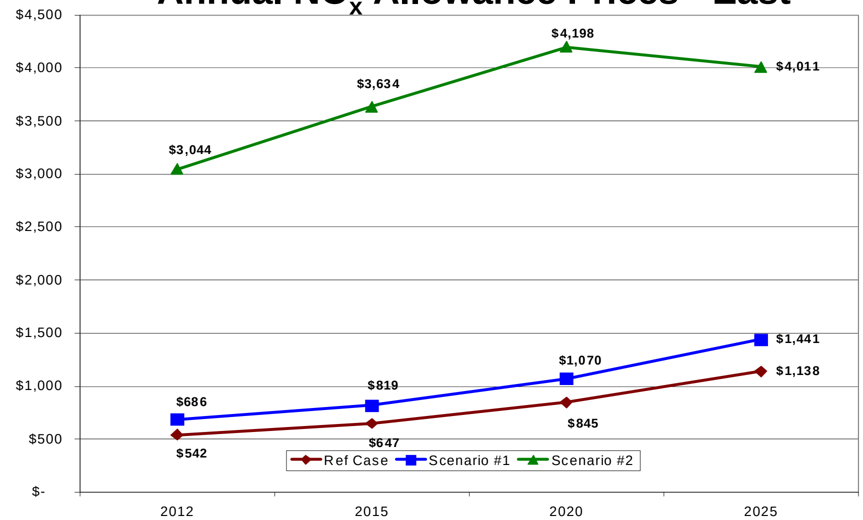
Natural gas prices increase by a small amount relative to the reference case and are within the normal range or variation for gas prices. The increase for both scenarios is about 2% in 2020 and between 1-2% in 2025. This is the delivered fuel price for the power sector only. Natural gas prices for other sectors were not modeled, but they would experience a similar small increase in prices.

Nationwide SO_2 and NO_x Allowance Prices

SO_2 Allowance Prices (2006$)

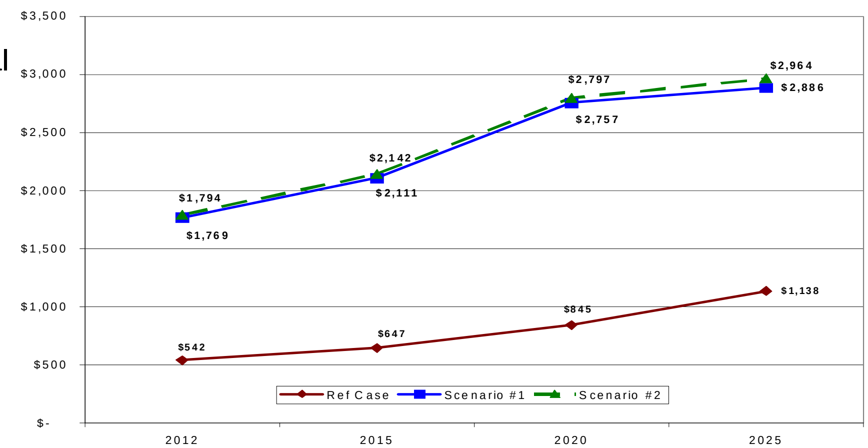


Annual NO_x Allowance Prices - East



- While NO_x allowance prices are significantly higher in the East in Scenario #2, the impact on electricity and natural gas prices and unit retirements is very modest.
- Allowance prices increase, especially in the East, due to additional controls installed on smaller units with relatively low NO_x rates.
- For the reference case (with CAIR), the price actually represents the total cost a company would pay for the allowances needed to cover one ton of SO_2 or NO_x (or the allowance price per ton of emissions).
- Current allowance prices are lower than modeled prices. The DC Circuit Court decision limited EPA's ability to use Title IV allowances in future programs, which has caused uncertainty and lower prices in the allowance markets.

Annual NO_x Allowance Prices - West



Health Benefits Per Ton Screening Model Results

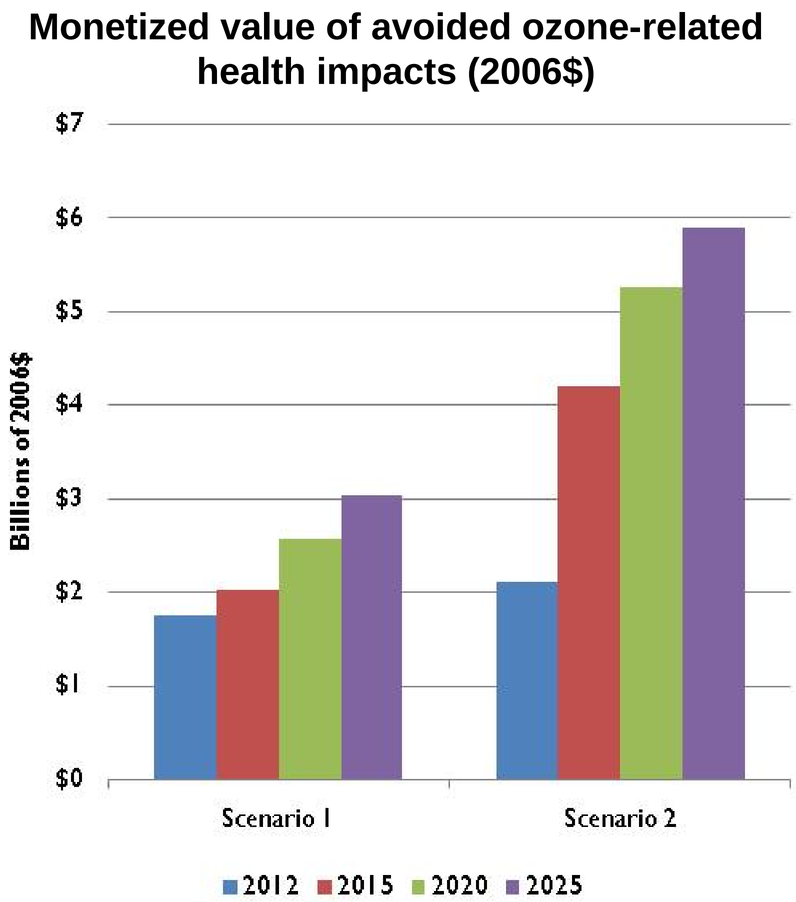
Human Health-Related Benefits: Methodology

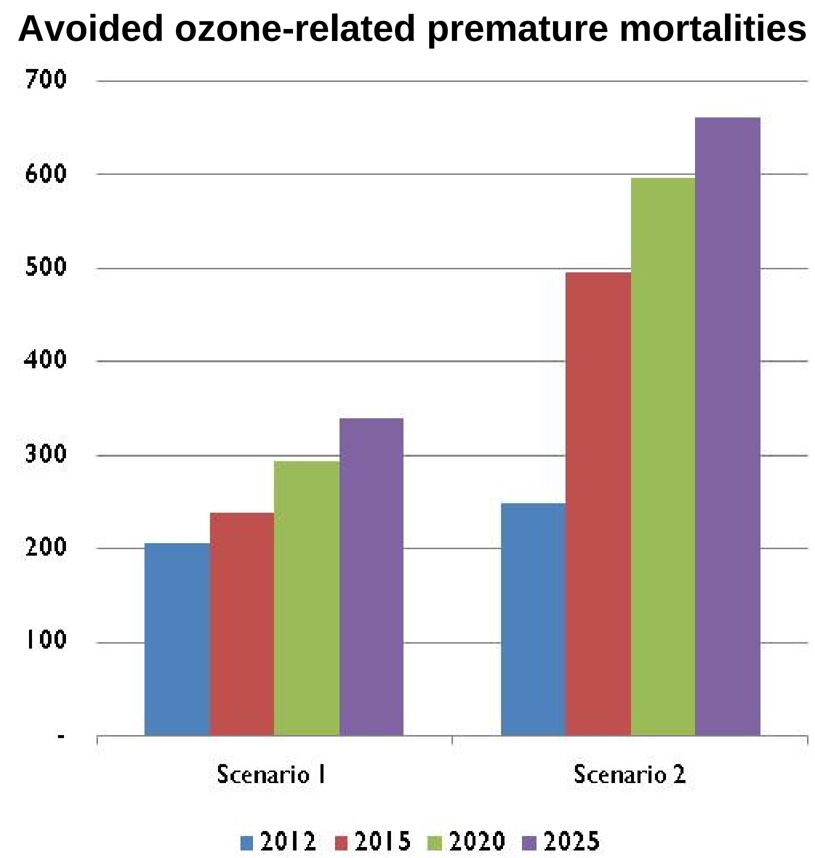
- Using a simplified methodology to estimate avoided human health impacts and associated economic benefits of reducing EGU SO_2 emissions by applying benefit per ton estimates to IPM modeled emission reductions.
- $PM_{2.5}$ benefit per ton
  - $PM_{2.5}$ benefit per ton factors are consistent with those used for the 2010 proposed Transport Rule. The factors reflect the most current assumptions EPA applies when estimating human health benefits of air quality improvements.
  - We present two concentration response functions estimating incidences of adult premature mortality
    - Pope et al. 2002 (American Cancer Society cohort) – historically used by EPA as the central estimate of premature mortality
    - Laden et al. 2006 (Harvard Six Cities study) – a more recent study used by EPA in recent health assessments and regulatory impact analyses
  - Consistent with 2010 proposed Transport Rule, we are using benefit per ton values to quantify PM-related benefits from reductions in SO_2. Complex non-linear chemistry governing PM formation from NO_x reductions limits our ability to estimate NO_x-related impacts using benefit per ton estimates. We believe that this SO_2-only approach still accounts for the great majority of PM-related benefits in the Eastern U.S. PM benefits in the Western U.S. are likely underestimated due to the greater levels of nitrate in Western locations.
- Ground-level ozone benefits
  - Ozone benefit per ton factors for the total value of all health endpoints are derived from the 2010 proposed Transport Rule

Human Health-Related Benefits: Methodology

- The per ton estimates used here were derived from the 2010 proposed Transport Rule, which modeled a specific pattern of regional SO_2 emission reductions.
- There are important differences in the size and distribution of SO_2 emission reductions between this analysis and the proposed Transport Rule. In particular, as compared to the proposed Transport Rule, this analysis projects a larger proportion of SO_2 reductions in the southern and western U.S. and a smaller proportion of SO_2 reductions in the Ohio valley states.
- The significant differences in the size and pattern of emission reductions between the proposed Transport Rule and this analysis introduce important uncertainties that are likely to affect the size of the estimated benefits. Specifically, a key uncertainty introduced through the use of benefit per ton estimates arises from the fact that the per ton benefits are partly a function of the total population level that benefits from the reduction in emissions, and the total population receiving the reduction in PM2.5 and ozone exposure is different in these scenarios relative to the Transport Rule because the geographic pattern of emissions reductions is different.
- Uncertainties in estimating $PM_{2.5}$-related premature mortality
  - Inhalation of fine particles is causally associated with premature death at concentrations near those experienced by most Americans on a daily basis. Although biological mechanisms for this effect have not been established definitively yet, the weight of the available epidemiological evidence supports an assumption of causality.
  - All fine particles, regardless of their chemical composition, are modeled to be equally potent in causing premature mortality. This is an important assumption, because PM produced via transported precursors emitted from EGUs may differ significantly from direct PM released from diesel engines and other industrial sources, but no clear scientific grounds exist for supporting differential effects estimates by particle type. Recent epidemiological studies do however suggest the possibility that PM mixtures with higher concentrations of black carbon and specific metals might be more potent than the average PM2.5 mixture.
- As in recent regulatory analyses, consistent with current scientific consensus, EPA estimated PM-related mortality without applying an assumed concentration threshold. We note that as we model mortality impacts among populations exposed to levels of PM2.5 that are successively lower than the lowest measured level of each study our confidence in the results diminishes. However, because most of the air quality impacts are in the Eastern U.S., the great majority of the impacts are likely to occur at or above each study's LML.

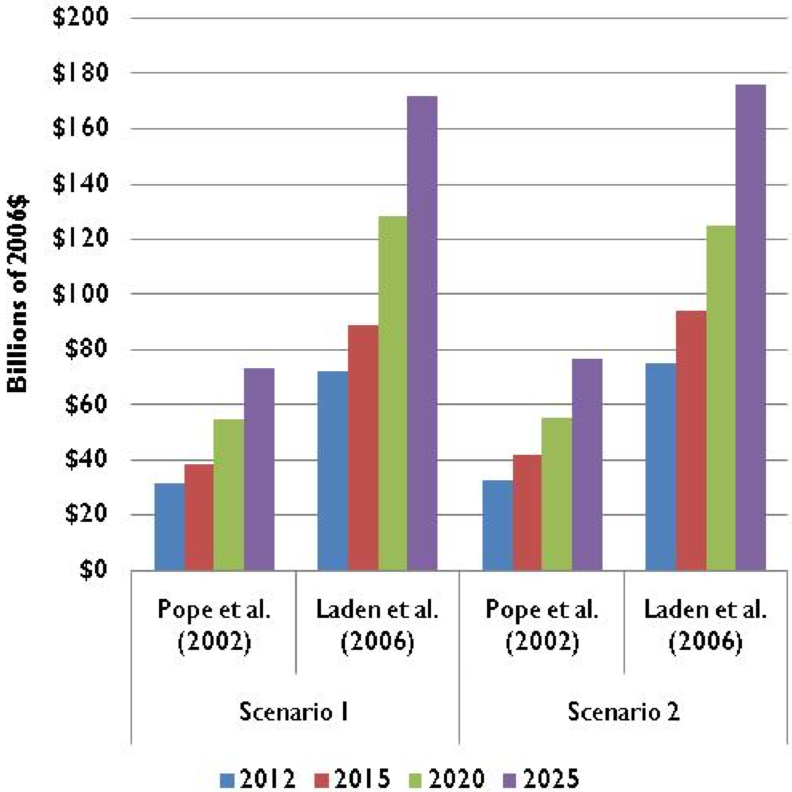
Human Health-Related Benefits: Avoided Ozone Impacts



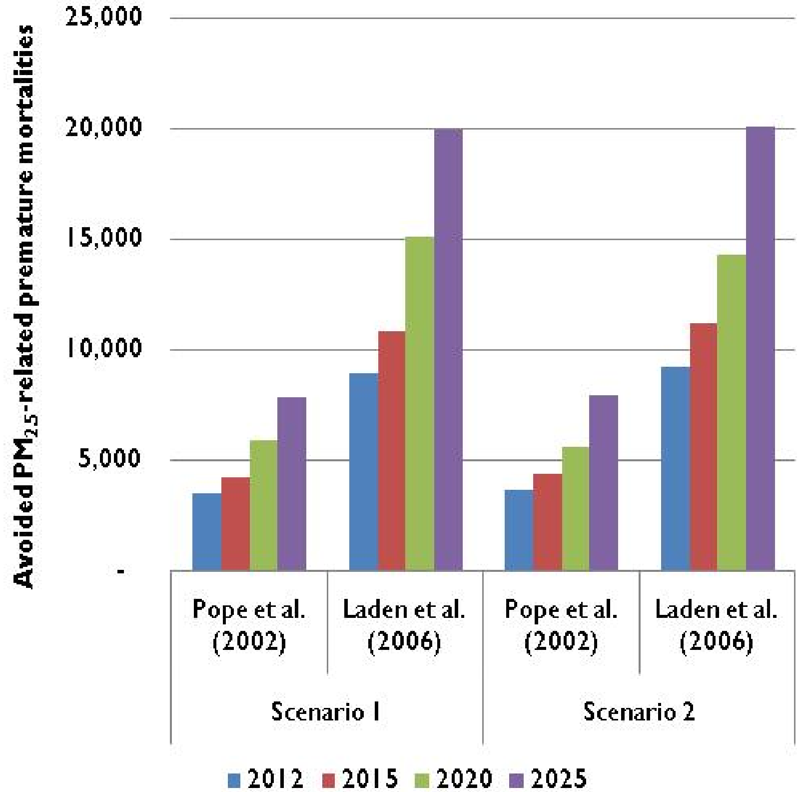


Human Health-Related Benefits: Avoided $PM_{2.5}$ Impacts

Monetized value of avoided $PM_{2.5}$-related health impacts (2006$, 3% discount rate)



Avoided $PM_{2.5}$-related premature mortalities



*PM-related benefits of reductions in SO2 only

** Using a 7% discount rate, benefits would be approximately 10 percent lower, based on a similar analysis conducted for the proposed Transport Rule

Human Health-Related Benefits: Avoided $PM_{2.5}$ Impacts

- We also calculated morbidity benefits using impact per ton estimates derived from the proposed Transport Rule, based on well established concentration-response functions from the epidemiological literature, which are described in detail in the RIA for the proposed Transport Rule.
- Each scenario would also yield significant non-mortality benefits
  - By 2025, Scenario #1 would avoid:
    - 12,000 non-fatal heart attacks per year
    - 130,000 exacerbations of asthma among existing asthmatics per year
    - 14,000 hospitalizations and emergency department visits for cardiovascular and respiratory illness
    - 1 million lost work days
  - Scenario #2 provides comparable benefits

Unquantified Impacts

- Improvements in visibility in national parks and recreational areas
- Improvements in visibility in residential areas
- Decreases in sulfur deposition (resulting in reduced acidification of surface waters and damage to forest ecosystems and soils)
- Decreases in nitrogen deposition (resulting in reduced acidification of surface waters, damage to forest ecosystems and soils, and coastal eutrophication)
- Decreases in mercury deposition, leading to reduced exposure to mercury through fish consumption
- Decreases in ozone-related damage to agricultural and forest production
- Reduction in PM2.5-related health impacts from decreases in NO_x
- NO_2 and SO_2-related health impacts
- Climate Change Impacts: while both NO_x and SO_2 are considered to be net cooling, they have a range of effects on temperatures, some of which are cooling, some of which are warming. EPA did not attempt to analyze the full range of impacts in order to speak meaningfully about the degree and extent of climate impact from the bill. Additionally, the analysis shows reductions in CO_2 for both scenarios.

* Many of these benefits could be quantified given full scale air quality modeling of scenarios and additional modeling. However, not all of these effects can currently be monetized, including improvements in visibility in residential areas, improvements in visibility in some parks and recreational areas, and decreases in nitrogen and sulfur deposition. While there are significant impacts associated with these unquantified categories of benefits, our monetized health benefits capture most of the monetized benefits of these scenarios.

Air Quality Improvement Screening Results

Estimates of Air Quality Improvements

- We used existing tools to provide screening-level estimates of air quality improvements that may occur under the specifications for the two scenarios.
- The results provide screening-level estimates of projected improvements in regional average PM2.5 and ozone design values.
- **For PM2.5** the estimates are derived from existing Response Surface Modeling (RSM), based on the Community Multiscale Air Quality (CMAQ) model.
  - This tool provides estimates of design value improvements in 2012, 2015, 2020 and 2025.
- **For ozone** the estimates are derived from CMAQ sensitivity modeling done as part of the 2008 ozone NAAQS Regulatory Impact Analysis (RIA).
  - The sensitivity modeling provides estimate of design value improvements in 2020 only.

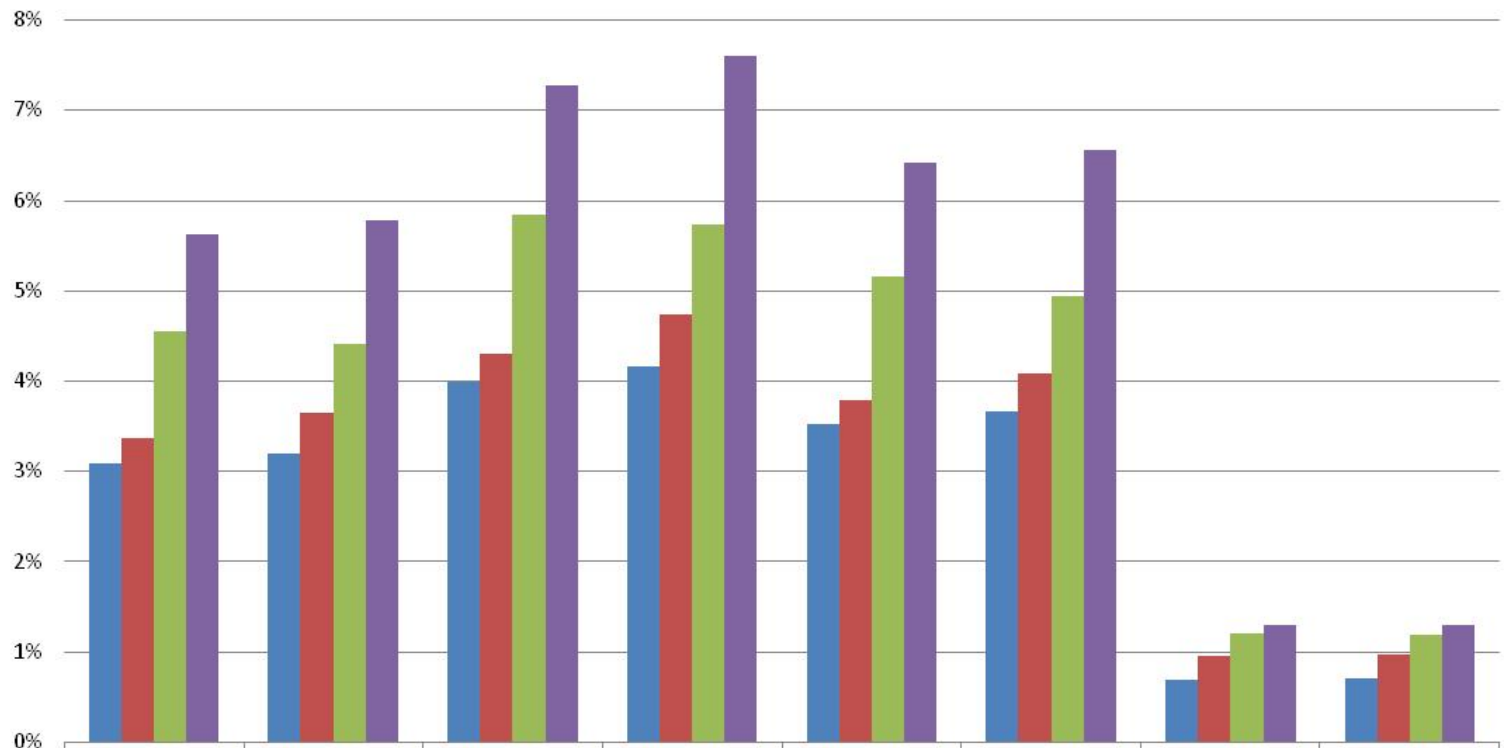
Limitations of PM2.5 Estimates

- Response Surface Modeling (RSM) does not reflect the location of source specific reductions (as projected by IPM), so this approach includes uncertainty in predicting location-specific air quality results (e.g, projected nonattainment for specific area).
- The RSM starts from a baseline that includes the 2005 CAIR, and reflects the impacts of an equal proportional reduction across all EGU sources, determined by the difference in the future baseline and the cap levels included in the two scenarios.
- Therefore, RSM assumes that all EGU sources get the same percent reduction, rather than distributing the percent reductions based on IPM simulated emissions changes at each source that result from the SO_2 and NO_X trading programs.

Air Quality: 98th Percentile Daily Average PM2.5 (μg/m³)

(Relative to an Emissions Baseline Including the 2005 CAIR Provisions)

Projected Improvement in PM2.5 Daily Design Values



	Total U.S.		Southeast		Northeast		West	
	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2	Scenario 1	Scenario 2
2012	3.1%	3.2%	4.0%	4.2%	3.5%	3.7%	0.7%	0.7%
2015	3.4%	3.6%	4.3%	4.7%	3.8%	4.1%	0.9%	1.0%
2020	4.5%	4.4%	5.8%	5.7%	5.2%	4.9%	1.2%	1.2%
2025	5.6%	5.8%	7.3%	7.6%	6.4%	6.6%	1.3%	1.3%

Southeast includes AL, AR, FL, GA, LA, MS, NC, OK, SC, TN, TX

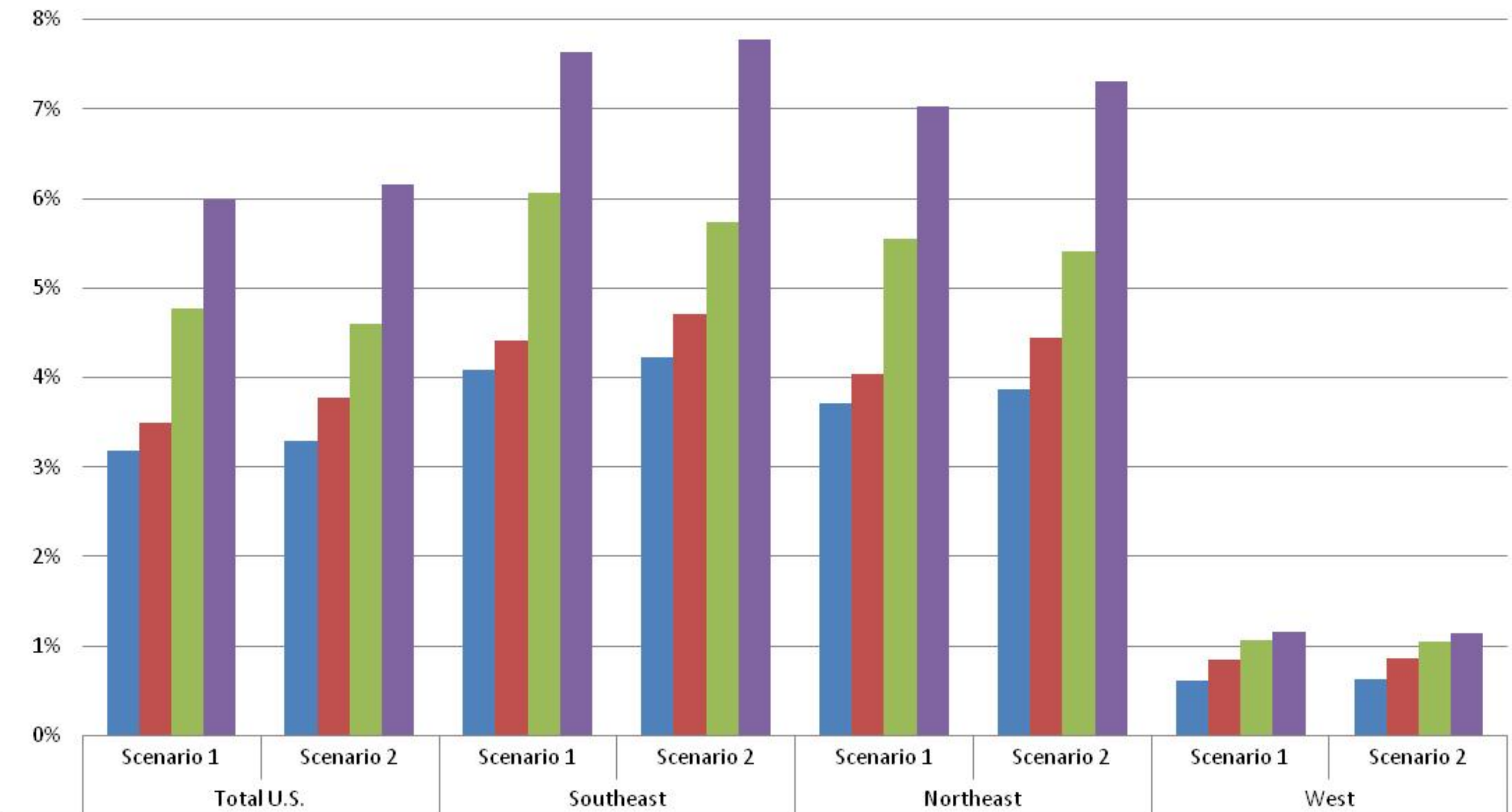
Northeast includes CT, DE, DC, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MO, NE, NH, NJ, NY, ND, OH, PA, RI, SD, VT, VA, WV, WI

West includes AZ, CA, CO, ID, MT, NV, NM, OR, UT, WA, WY

Air Quality: Annual Mean PM2.5 (µg/m[3])

(Relative to an Emissions Baseline Including the 2005 CAIR Provisions)

Projected Improvement in PM2.5 Annual Design Values



	Total U.S. Scenario 1	Total U.S. Scenario 2	Southeast Scenario 1	Southeast Scenario 2	Northeast Scenario 1	Northeast Scenario 2	West Scenario 1	West Scenario 2
2012	3.2%	3.3%	4.1%	4.2%	3.7%	3.9%	0.6%	0.6%
2015	3.5%	3.8%	4.4%	4.7%	4.0%	4.4%	0.9%	0.9%
2020	4.8%	4.6%	6.1%	5.7%	5.5%	5.4%	1.1%	1.1%
2025	6.0%	6.2%	7.6%	7.8%	7.0%	7.3%	1.2%	1.2%

Southeast includes AL, AR, FL, GA, LA, MS, NC, OK, SC, TN, TX

Northeast includes CT, DE, DC, IL, IN, IA, KS, KY, ME, MD, MA, MI, MN, MO, NE, NH, NJ, NY, ND, OH, PA, RI, SD, VT, VA, WV, WI

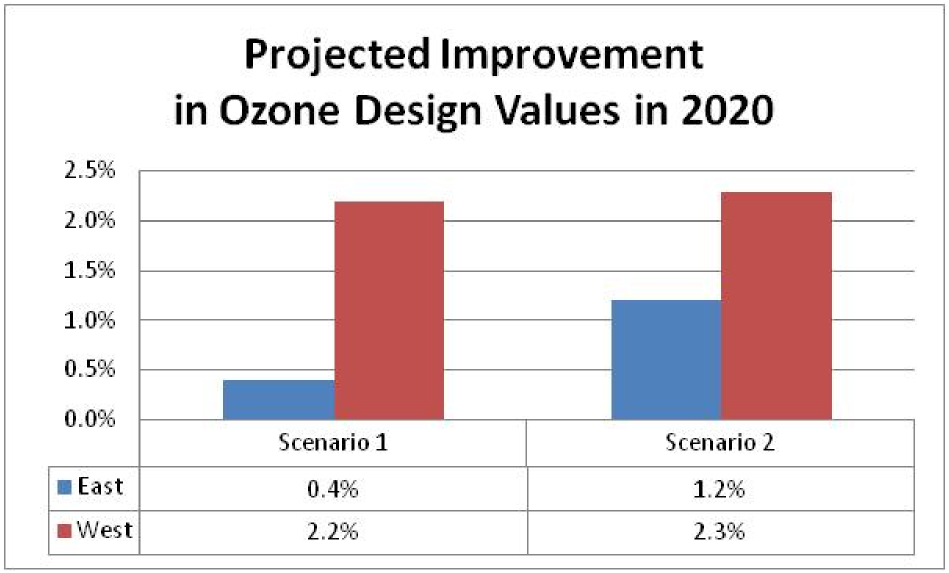
West includes AZ, CA, CO, ID, MT, NV, NM, OR, UT, WA, WY

Limitations of Ozone Estimates

- The ozone sensitivity modeling used for this analysis simulated the impacts in 2020 of a 30% reduction in anthropogenic NO_x within four geographic areas expected to have difficulty in attaining the NAAQS in the future.
- The impacts of the EGU NO_x emissions on ozone were estimated using the total percent NO_x reduction that would be realized by this legislation and scaling the results of the 30% reduction runs accordingly. Changes in ozone levels were only calculated for 2020 for those areas analyzed in the sensitivity runs.
- The approach assumes that all EGU sources get the same percent reduction, rather than distributing the reductions based on IPM-simulated emissions changes at each source in the Carper trading program.
- Thus, the scenario ozone estimates do not reflect the location of source-specific reductions (as projected by IPM), so this approach includes uncertainty in predicting location-specific air quality results.
- Additional uncertainty is introduced by applying sensitivity modeling results based on four areas to estimate the impacts across the eastern and western US.

Air Quality: 4th Highest Daily 8-hour Maximum Ozone (ppb)

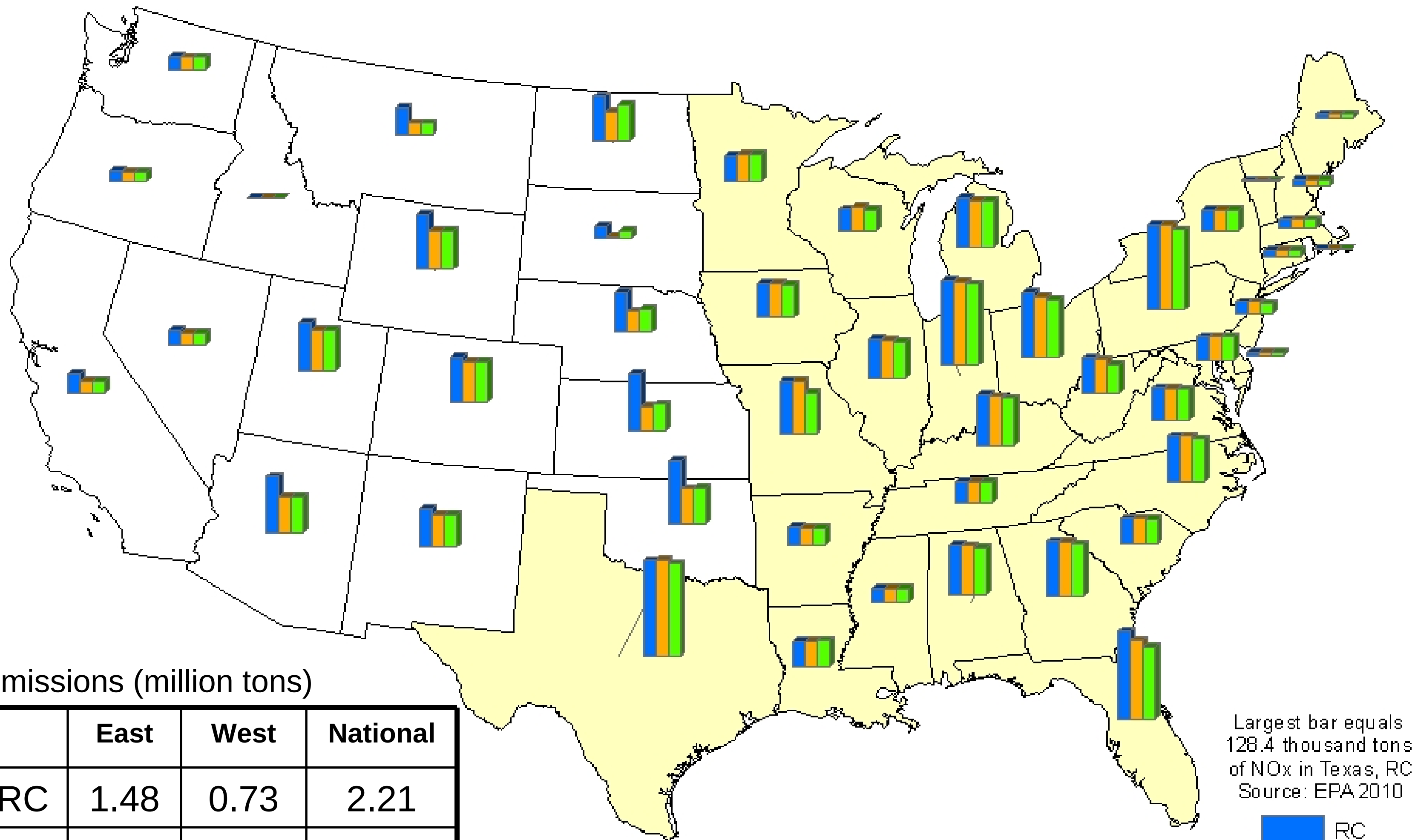
(Relative to an Emissions Baseline Including the 2005 CAIR Provisions)



- East includes AL, AR, CT, DC, DE, FL, GA, IA, IL, IN, KS, KY, LA, MA, MD, ME, MI, MN, MO, MS, NC, ND, NE, NH, NJ, NY, OH, OK, PA, RI, SC, SD, TN, TX, VA, VT, WI, WV
- West includes AZ, CA, CO, ID, MT, NM, NV, OR, UT, WA, WY
- **Note:** El Paso, Texas is modeled with the West

APPENDIX A: Additional Information on Emissions Projections and Cost Projection Methodology

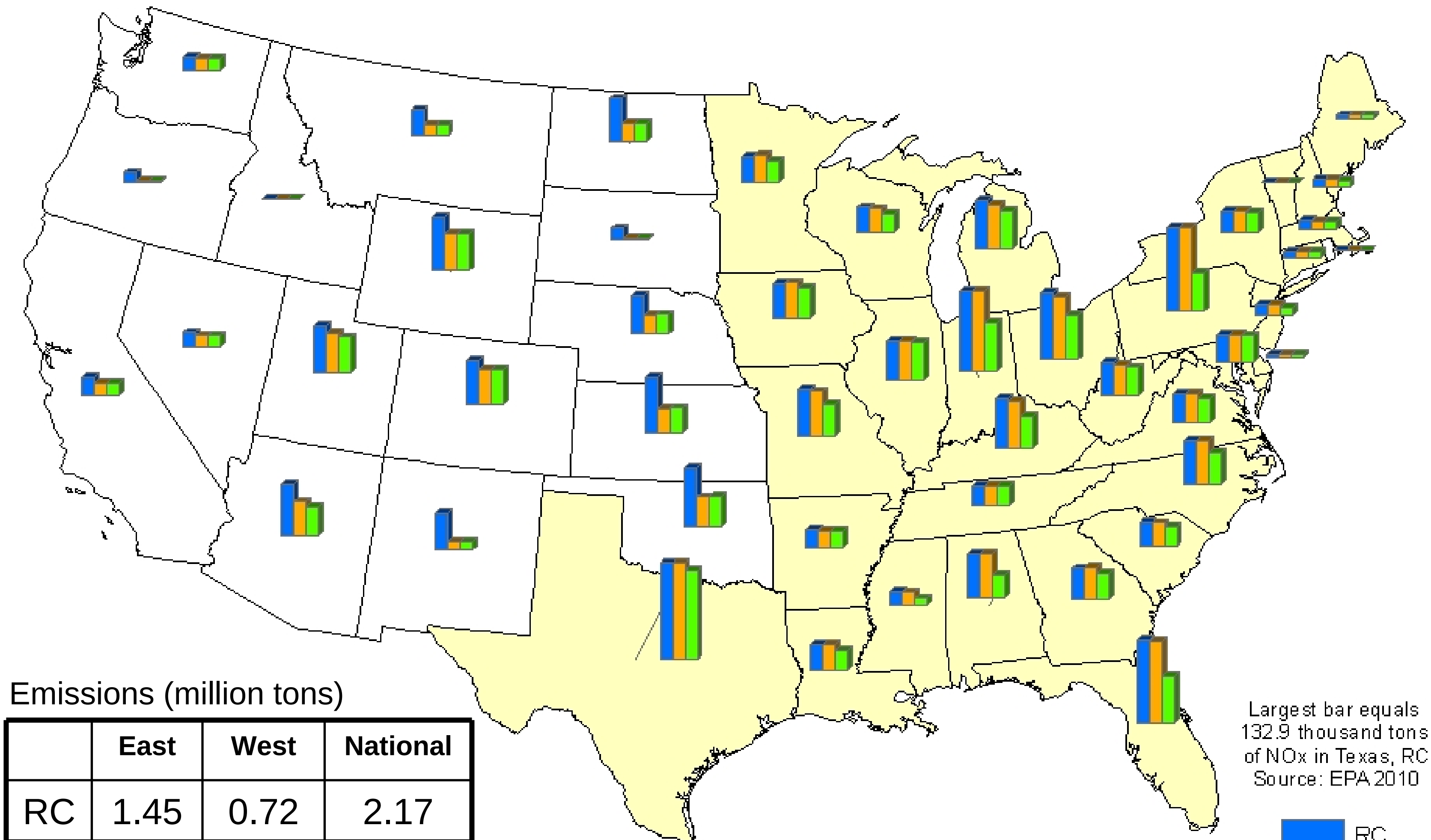
State-by-State Annual NOx Emission Levels, 2012



Emissions (million tons)

	East	West	National
RC	1.48	0.73	2.21
S1	1.45	0.48	1.92
S2	1.37	0.50	1.87

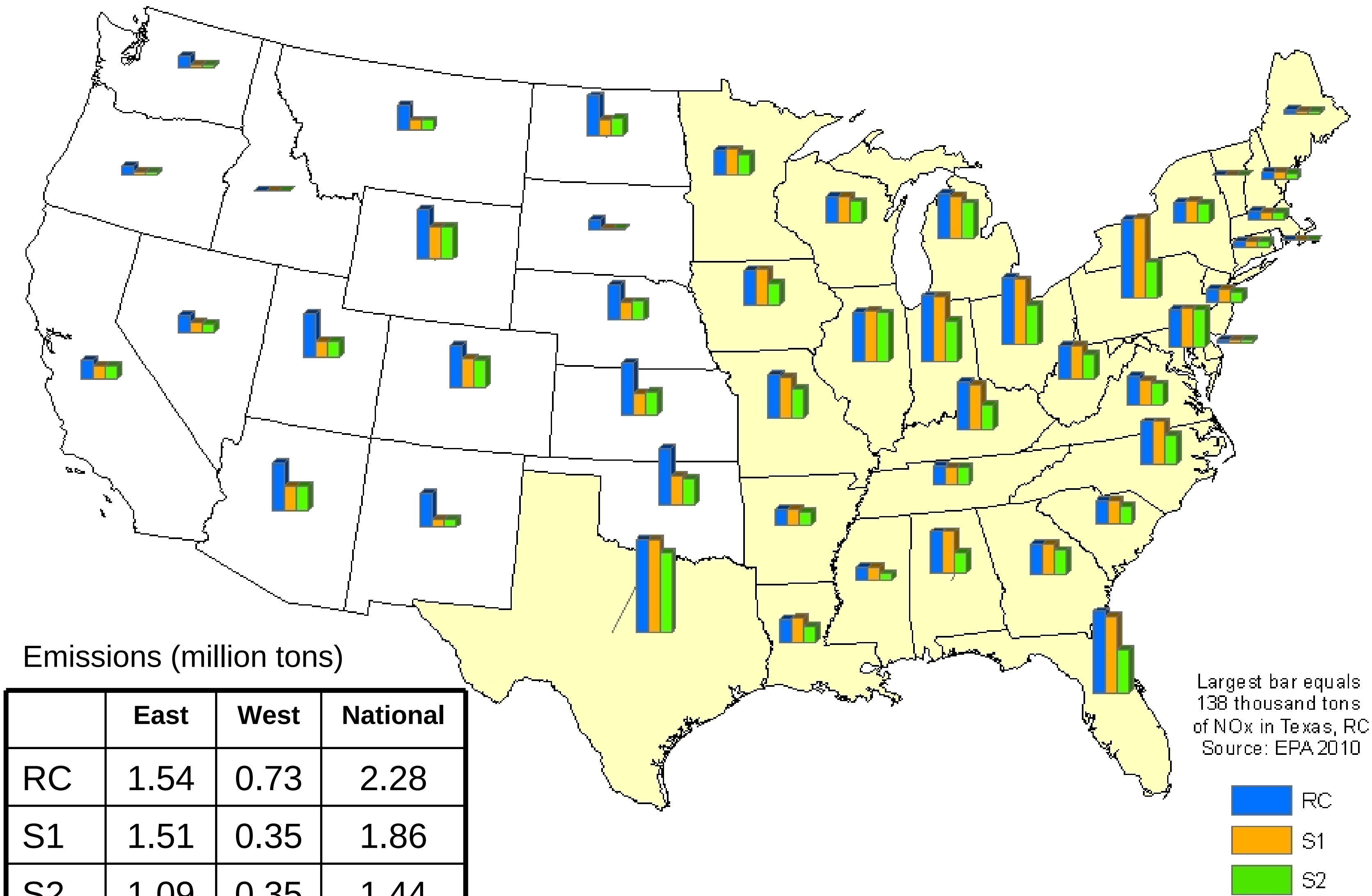
State-by-State Annual NOx Emission Levels, 2015



Emissions (million tons)

	East	West	National
RC	1.45	0.72	2.17
S1	1.42	0.41	1.83
S2	1.07	0.40	1.47

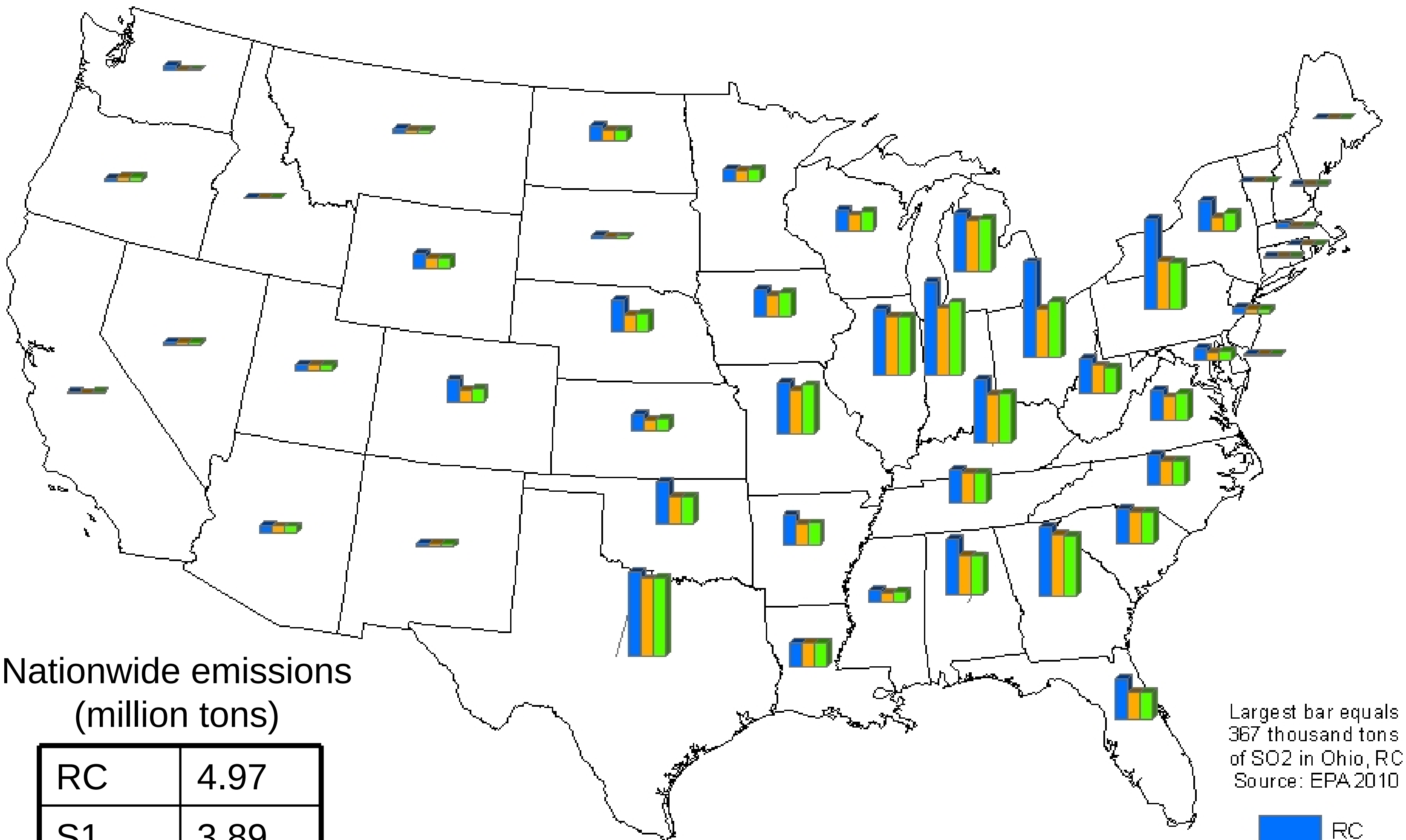
State-by-State Annual NOx Emission Levels, 2020



Emissions (million tons)

	East	West	National
RC	1.54	0.73	2.28
S1	1.51	0.35	1.86
S2	1.09	0.35	1.44

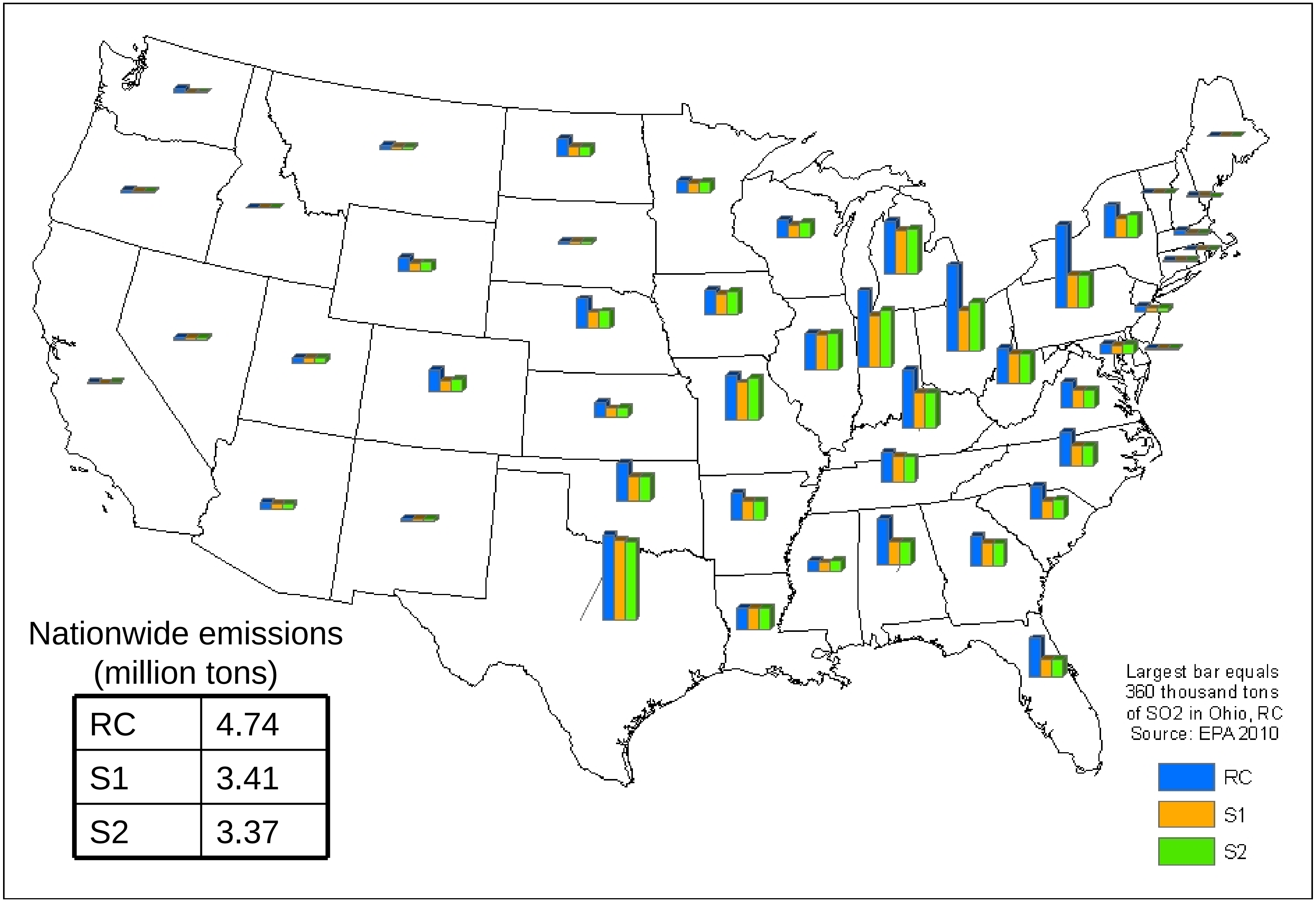
State-by-State Annual SO2 Emission Levels, 2012



Nationwide emissions
(million tons)

RC	4.97
S1	3.89
S2	3.86

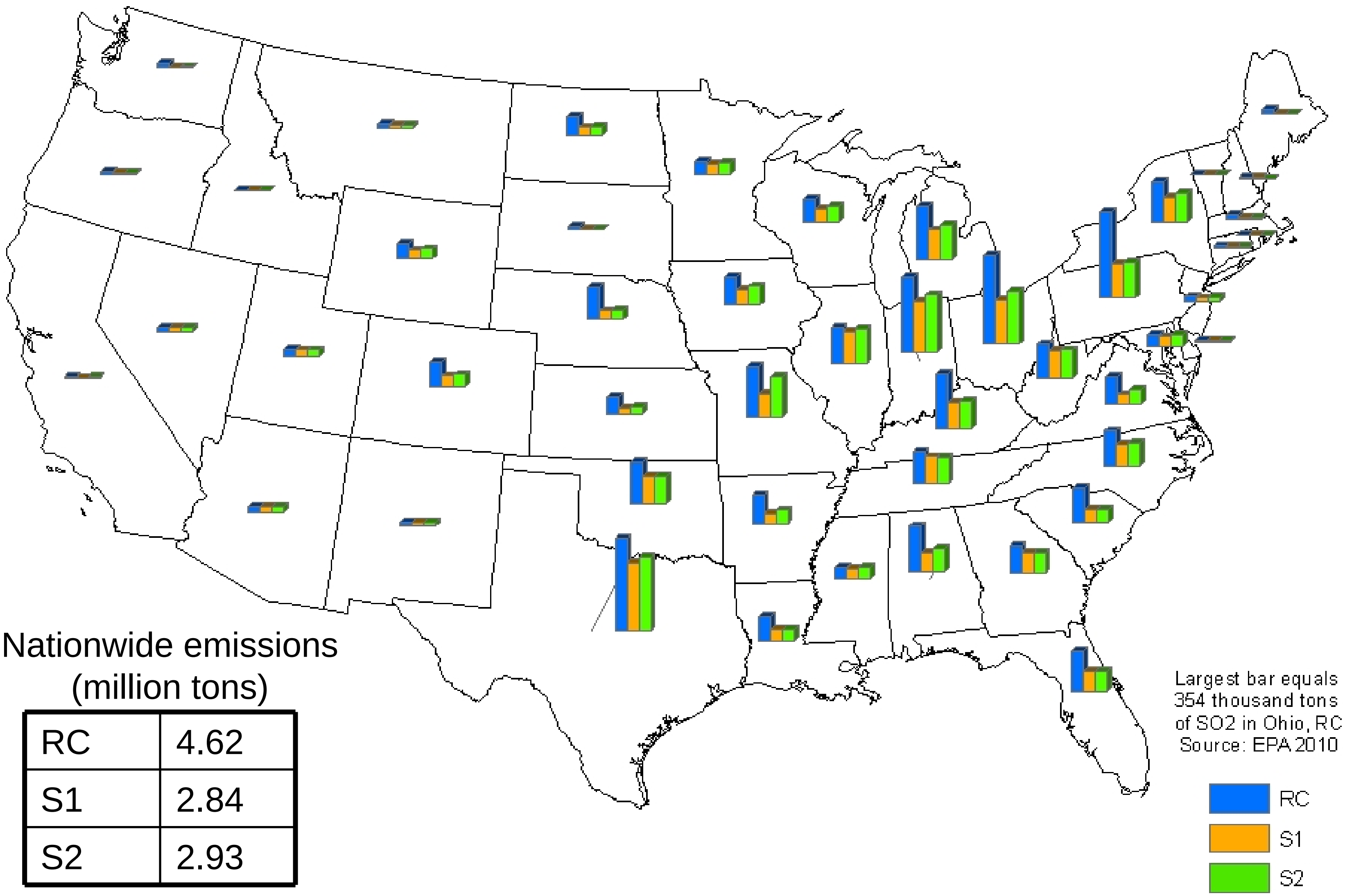
State-by-State Annual SO2 Emission Levels, 2015



Nationwide emissions (million tons)

RC	4.74
S1	3.41
S2	3.37

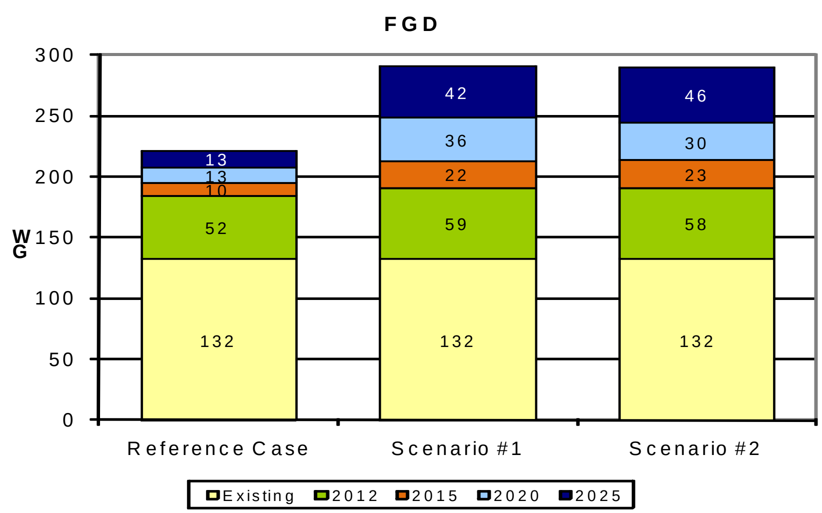
State-by-State Annual SO2 Emission Levels, 2020

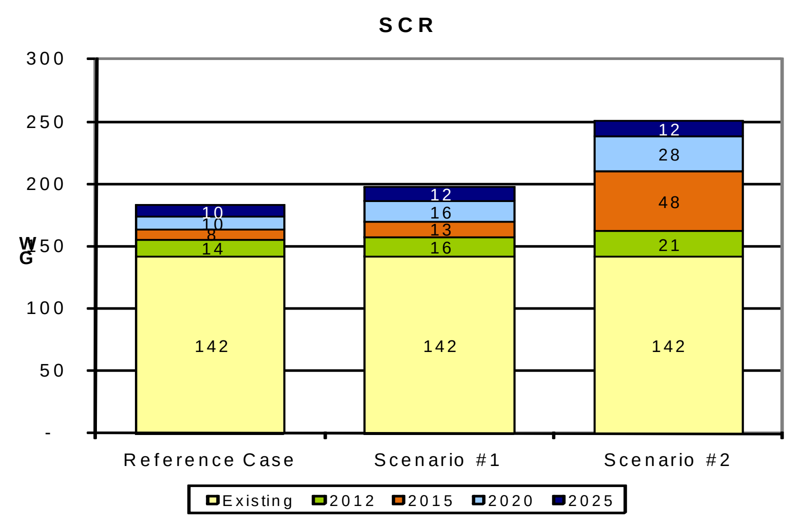


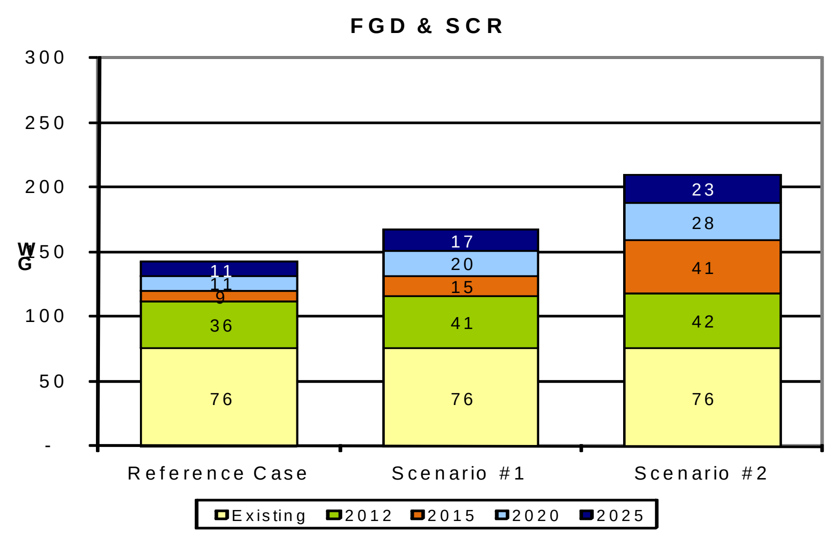
Nationwide emissions
(million tons)

RC	4.62
S1	2.84
S2	2.93

Installed Retrofit Control Details by Year







NOTE: FGD graph includes generation with either FGD only or FGD and SCR combined. Similarly, the SCR graph includes generation with either SCR only or FGD and SCR combined.

Comparison of Carper Scenarios and Proposed Transport Rule Baselines

Model Assumptions/ Inputs	Carper Scenarios	Proposed Transport Rule
Electricity Demand	Based on EIA 2009 projections with ARRA	Based on EIA 2009 projections prior to ARRA
Generation Resources	Projected EGUs as of mid-2009, including significant renewables due to ARRA and state RPS requirements	Projected EGUs as of 2008
Size of Title IV Bank in 2012	11 million	1.6 million
Regulatory Programs	Full implementation of CAIR in Reference Case	No CAIR in Reference Case
State power sector rules and settlements	Similar to proposed Transport Rule plus emissions control updates	Based on information as of 2008

2009 Request for Analysis

THOMAS R. CARPER
DELAWARE

United States Senate
WASHINGTON, DC 20510-0803

July 10, 2009

Ms. Lisa Jackson
Administrator
U.S. Environmental Protection Agency
1200 Pennsylvania Avenue, N.W.
Washington, DC 20460

Dear Administrator Jackson,

As you know, I am currently drafting legislation with Senator Lamar Alexander that will address sulfur dioxide, nitrogen oxide, and mercury emissions from our nation's power plants. This is one of my top legislative priorities for this Congress, and I am writing to request technical assistance from the EPA to provide modeling for six different scenarios. If possible, I would like these scenarios to be finished and delivered to me by July 31, 2009.

For each of the scenarios outlined below, please provide both cost and benefit analysis. The cost analysis should include looking at the number of control installations, changes in fuel prices and electricity prices, changes in generation mix, changes in new generation, allowance prices and incremental costs of the scenarios.

For each scenario please also provide quantitative estimates of the expected health benefits in dollars and reductions in the incidence of health effects caused by SO2 and NOx, including at least the premature deaths avoided (and other health effects as time would allow). Please use an approach similar to the one that you used in the fall 2005 Multi-Pollutant Bill Analysis that you did for Senator Carper, where EPA provided for several of the bills estimates of benefits that were based on the general relationship that EPA has found between emissions reductions of SO2 and NOx in the United States and health benefits. Also, provide a qualitative assessment of the benefits that are not quantified for consideration as well.

As per discussions between our staffs, I understand that both because of the time available and the status of your efforts to develop a replacement rule for the Clean Air Interstate rule and the Utility MACT rule, it would not be possible to develop a reference case to compare these scenarios to likely requirements under the existing Clean Air Act. I also understand that the most recent reference case available is one including the Clean Air Interstate Rule and many of the provisions of the recently passed stimulus bill that was used as the reference case in the IPM modeling used to support analysis of the Waxman/Markey bill. Please use this same reference case in this analysis.

Please analyze the following scenarios:

Scenario #1:
- SO2: 2012 to 2014, cap of 3.5 million tons; 2015 and beyond, cap of 2.0 million tons

1

- Eastern NOx Cap (where eastern zone includes all States in CAIR including Minnesota and also includes all northeastern States that are not part of CAIR) 2012 to 2014, cap of 1.39 million tons; 2015 and beyond cap of 1.3 million tons
- Western NOx Cap (where western zone includes all States not in Eastern zone), 2012 to 2014, cap of 400,000 tons; 2015 and beyond cap of 320,000 tons

Scenario #2:
- SO2: 2012 to 2014, cap of 3.5 million tons; 2015 and beyond, cap of 1.5 million tons
- Same NOx caps as scenario #1

Scenario #3:
- SO2: 2012 to 2014, cap of 3.5 million tons; 2015 and beyond, cap of 1.5 million tons
- Eastern NOx Cap (where eastern zone includes all States in CAIR including Minnesota and also includes all northeastern States that are not part of CAIR) 2012 to 2014, cap of 1.39 million tons; 2015 and beyond cap of 1.0 million tons
- Western NOx Cap (where western zone includes all States not in Eastern zone), 2012 to 2014, cap of 400,000 tons; 2015 and beyond cap of 250,000 tons

Scenario #4:
- SO2: 2012 to 2014, cap of 3.5 million tons; 2015 and beyond, cap of 1.0 million tons
- Same NOx Caps as scenario #1

Scenario #5:
- SO2: 2012 to 2014, cap of 3.5 million tons; 2015 and beyond, cap of 1.5 million tons
- National NOx cap of 1.79 million tons in 2012 and 1.62 million tons in 2015

Scenario #6:
- SO2: Same as scenario #2
- NOx: Same as scenario #1 without the 2012 caps – only the 2015 caps.

Thank you for your assistance on this important issue. Should you have any additional questions, or require additional information, please do not hesitate to contact me or Laura Haynes in my office at 202-224-3168.

With best personal regards, I am,

Sincerely,

Thomas R. Carper

Tom Carper
U.S. Senate

CC: Assistant Administrator Gina McCarthy

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APPENDIX B: Additional Benefits Information

Scenario 1 Monetized Benefits

Pollutant, precursor and risk estimate	Analysis year and estimate of monetized benefits (billions of 2006$)[A]			
$PM_{2.5}$	2012	2015	2020	2025
Pope et al. 2002	$28	$35	$51	$69
Laden et al. 2006	$70	$86	$130	$170
Ozone	$1.7	$2	$2.6	$3
CO_2[B]	$0.4	$0.21	$0.25	$0.6
Total Benefits				
Pope et al. 2002	$31	$38	$54	$72
Laden et al. 2006	$72	$88	$130	$170

[A] Estimates rounded to two significant figures
[B] CO_2-related benefits calculated using Social Cost of Carbon described in the proposed Transport Rule benefits chapter

Scenario 2 Monetized Benefits

Pollutant, precursor and risk estimate	**Analysis year and estimate of monetized benefits (billions of 2006$)[A]**			
$PM_{2.5}$	2012	2015	2020	2025
Pope et al. 2002	$29	$37	$49	$69
Laden et al. 2006	$72	$89	$120	$170
Ozone	$2.1	$4.2	$5.3	$5.9
CO_2[B]	$0.51	$0.3	$0.27	$0.66
Total Benefits				
Pope et al. 2002	$32	$41	$54	$75
Laden et al. 2006	$75	$94	$120	$180

[A] Estimates rounded to two significant figures
[B] CO_2-related benefits calculated using Social Cost of Carbon described in the proposed Transport Rule benefits chapter

Scenario 1 $PM_{2.5}$ Mortalities and Morbidities Avoided

Health endpoint	Analysis year[A]			
$PM_{2.5}$	2012	2015	2020	2025
Mortality				
Pope et al. 2002	3,500	4,200	5,900	7,800
Laden et al. 2006	8,900	11,000	15,000	20,000
Non-fatal heart attacks	5,300	6,700	9,400	12,000
Respiratory hospitalizations	820	1,000	1,500	1,900
Cardiovascular hospitalizations	1,700	2,200	3,100	4,100
Emergency department visits	3,300	4,100	5,700	7,600
Acute bronchitis	5,000	6,300	8,800	12,000
Asthma exacerbation	56,000	70,000	98,000	130,000
Acute respiratory symptoms	2,500,000	3,100,000	4,400,000	5,800,000
Lower respiratory symptoms	59,000	75,000	100,000	140,000
Upper respiratory symptoms	45,000	57,000	80,000	110,000

[A] Estimates rounded to two significant figures

Scenario 2 $PM_{2.5}$ Mortalities and Morbidities Avoided

Health endpoint	Analysis year[A]			
	2012	2015	2020	2025
Mortality				
Pope et al. 2002	3,600	4,400	5,600	7,900
Laden et al. 2006	9,200	11,000	14,000	20,000
Non-fatal heart attacks	5,400	7,000	8,900	12,000
Respiratory hospitalizations	850	1,100	1,400	1,900
Cardiovascular hospitalizations	1,800	2,300	3,000	4,200
Emergency department visits	3,400	4,300	5,500	7,700
Acute bronchitis	5,100	6,500	8,300	12,000
Asthma exacerbation	58,000	72,000	93,000	130,000
Acute respiratory symptoms	2,600,000	3,300,000	4,200,000	5,800,000
Lower respiratory symptoms	61,000	78,000	99,000	140,000
Upper respiratory symptoms	47,000	59,000	76,000	110,000

[A] Estimates rounded to two significant figures