Improving EPA Emissions Forecasting For Regulatory Impact Analyses

Summary of the Issue

The EPA conducts Regulatory Impact Analyses (RIAs) to assess the benefits and costs of air regulations. These RIAs require emissions forecasts for all relevant source categories. We continually improve these forecasts over time and significant advances have been made for major source categories including mobile sources and Electric Generating Units (EGUs). However, we have observed a disconnect between our emissions forecasts for certain stationary non-EGU source categories and the historical record. (For this document, stationary non-EGU or non-utility sources include large industrial combustion and process point sources (e.g., industrial boilers, petroleum refineries, chemical manufactures, etc.), as well as, small stationary commercial, institutional, and residential non-point sources.) This discrepancy appears to have led to significant over-prediction of emissions projections in longer-forecast periods required for the NAAQS and other programs. We have developed an interim approach for addressing this issue and intend to use it to develop a range of forecasts that will provide some understanding of the potential uncertainties implied by the past methodology and the historical record. This interim application will first be used for the RIA for the review of the PM NAAQS. We seek a consultation with the Council to provide advice on how to portray the interim approach and the uncertainties involved. We will continue to work to develop long-term improved approaches for addressing this issue.

Background

Overview of Emission Inventory Forecasts in RIAs

EPA has established a tradition of improving the emissions inventory and modeling platform for Regulatory Impact Analyses. As new and improved data, methods, and models become available, we incorporate this information into the emissions estimates and modeling platform at appropriate times. The drivers to the updates are the ever-evolving "state of knowledge" and comments received on previous analyses. We have placed highest priority on improving data/methods/and models for pollutants or sectors impacted by the policy (e.g., EGUs for the Clean Air Interstate Rule (CAIR); mobile sources for the Heavy Duty Diesel Engine and Fuel Rule and the Spark Ignition Nonroad Engine Rule).

For most Regulatory Impact Analyses, we use emissions from a historical year, or base year, (e.g., 2001) as the starting point for forecasting potential future-year emissions. In evaluating the potential impact of the subject regulation, we develop multiple future-year emission estimates based on a range of regulatory options. In general, EPA estimates the future-year emissions by forecasting changes in the various activities that generate emissions and using this forecasted activity to increase (or decrease) emissions. We then reduce forecasted future-year emissions for the impact of mandated Clean Air Act (CAA) emission controls.

Methods Used to Forecast Emissions Inventories

Emissions in the future will differ from current emissions inventories due the following factors:

- Changes (typically growth) in economic activity that influence emissions,
- Changes in the mix of production activities both within and between economic sectors,
- Changes in vintages of capital equipment,
- Changes in population, energy use, land use, or motor vehicle miles traveled,
- Technological innovation or changes altering:
    - Production processes for emission sources,
    - Control technologies available,
    - Substitution of inputs to production (e.g., fuel switching), and
- Emission controls implemented to satisfy CAA regulations, voluntary programs and other initiatives expected to reduce air emissions.

For many source categories, EPA uses emission factors to relate air pollution to emission-generating activities (e.g., production activities of an industry). In previous analyses, the method used to project stationary non-utility emissions involves forecasting current emissions into the future by considering the following two factors:

- Changes in economic activity (generally we have assumed a linear relationship between economic activity changes and emission changes because, as stated above, many of the other factors that may influence changes in emissions are difficult to quantify) and
- Application of emission controls mandated by various parts of the CAA.

The typical formula for estimating projected inventories follows:

Projected Future Emissions = Current Emissions * Emission Growth Adjustment * Emission Control Adjustment

The emissions growth adjustment increases or decreases (typically increases) emissions in the future from current base year levels due to forecasted changes in economic or other activities that impact emission levels (e.g., population). The emission control adjustment decreases future-year emissions for expected emissions controls resulting from mandated CAA regulations. In the past, the economic growth adjustment for stationary non-EGU sources has been based upon the results of the Policy Insight® Model for Regional Economic Model, Inc (REMI) by state and Standard Industrial Classification (SIC) codes or fuel consumption forecasts by fuel type and energy sector (e.g., industrial, commercial, residential) from the US Department of Energy.

For non-EGU stationary source categories, many factors that influence future emissions (technology innovations, changes in vintages of capital equipment, energy use, etc.) listed above are difficult to quantify and are not adequately captured in current models. Our past forecasting approaches for these source categories do appear to model economic growth and the impacts of CAA emission controls relatively well, but do not address the many other factors affecting emissions (shown above) sufficiently. Forecasting emissions for these source categories is further complicated by the multitude of non-EGU stationary source categories involved (over 800 industry categories). In 2002, emissions from non-EGU stationary sources represented approximately 62 percent of total direct $PM_{2.5}$ emissions (excluding emissions from dust and fires) and approximately 18 percent and 25 percent of important PM precursors, NO_X and SO_2, respectively. While emissions from these sources are relatively small when compared to total emissions from all sources of SO_2 and NO_X, these sources represent the major contributors to direct $PM_{2.5}$ emissions and are major source categories considered in the current PM NAAQS RIA. Emission projections for the stationary non-EGU sources will be used to estimate the benefits and costs of the PM NAAQS in the RIA and EPA recognizes the immediate need for better future year emissions estimates for these categories.

Emissions projection methods are less of an issue for mobile sources and EGUs, and these sources are not subject to our interim approach. For these sources, EPA has developed improved models specific to mobile sources (MOBILE and NONROAD models) and EGUs (Integrated Planning Model). These models address many of the deficiencies in our current approach for stationary non-EGU sources previously discussed. The Integrated Planning Model is a market model of the electric utility industry that captures the impact of capital turnover and economically-motivated fuel switching on emissions. For EGUs, we also have better emissions source testing due to the installation of continuous emissions monitoring for these units. For mobile sources, our models directly address equipment turnover and the issue of fuel switching. More details may be obtained about these models at www.epa.gov/airmarkets/epa-ipm and http://www.epa.gov/OMSWWW/models.htm. In addition to EGUs and mobile sources, inventory projections for agricultural ammonia emissions are based on projected animal populations provided by US Department of Agriculture, and these sources are also not covered by our interim approach.

Problems with Past Projection Approaches

Using the approaches described above for stationary non-EGU sources, we logically forecast continuing emission increases relating to economic, population, and other sources of growth for any given analytical starting point. Such forecasts, however, are inconsistent with the relationships we see historically. Figure 1 compares activity variables that impact emissions (GDP, energy consumption, population, vehicle miles traveled) with historical air emissions from all sources (pollutants include SO_2, NO_x, VOC, PM_{10}, CO, and Pb). Since 1970, air emissions have been steadily declining while GDP, population, energy consumption, and vehicle miles traveled all have grown. The emissions shown in Figure 1 are dominated by mobile sources emissions. But the trend also exists when focusing on PM-related emissions from EGU or non-EGU stationary point and area sources, collectively as well as for key industry. The newly developed

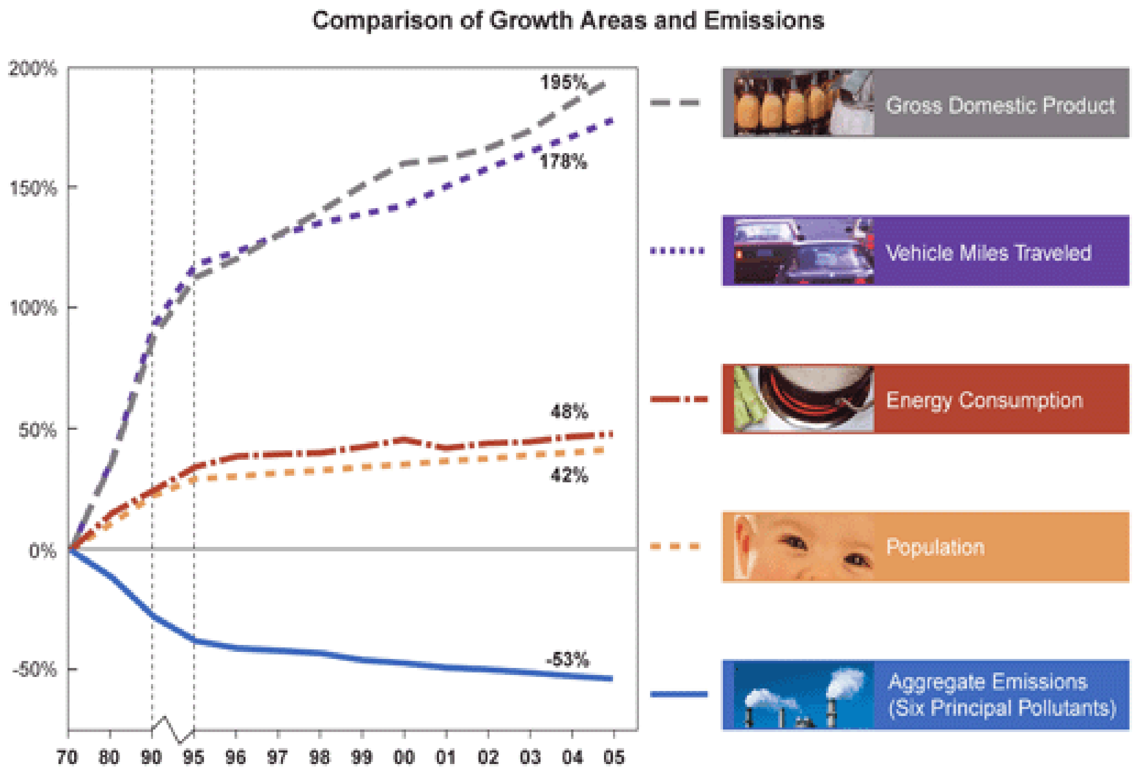
2002 National Emissions Inventory provides more historical emissions data to corroborate the historical decline in emissions we are observing. Figure 2 shows decreasing trends in $PM_{2.5}$ and the primary PM precursors SO_2 and NO_x for non-EGU stationary source emissions from 1990 through 2002. The data source for the historical year emissions inventory is the National Emissions Inventory (NEI). The NEI provides historical emission estimates for 1990, 1996, 1999, and 2002 that represent measurements and estimates of actual emissions for the particular year. The primary data source for the NEI emissions are State emission inventories. These data are supplemented by emissions estimates developed by EPA to fill gaps in the data provided by the States. Both the State and EPA developed emissions are based on actual activity or actual activity surrogate data for the given year. Thus emissions estimates in the NEI for 1990, 1996, 1999, 2002 do not rely upon the application of growth factors to actual emissions from an older emissions inventory.

Historical emissions trends for key industrial sectors (chemical and allied products, petroleum refining and allied products, paper and allied products, and primary metals manufacturing) important to the PM NAAQS analysis are shown in Figure 3. We also see similar general downward trends in historical emissions across different regions of the country. Figure 4 compares historical trends for the stationary non-EGU source categories with the CAA baseline (includes control programs that would be implemented by 2010) emissions forecast made in the 1997 NAAQS RIA. This figure indicates the inconsistency between the forecasts and the trends thus far.

Our projection methods used to estimate growth for stationary non-EGU sources until now have focused on estimates of economic growth and emission reductions resulting from CAA mandates. We've assumed logically that the "growth" part of emission trends correlates linearly with economic or other emission generating activities. Our methods have attempted to forecast growth in the general economy and to match this growth to those industry sectors that generate air emissions. This approach assumes that the emission rate per unit of activity is the same in the base year and future years for the stationary non-EGU sources unless emission controls are applied (i.e., emission controls are the only factor that reduces emission rates.) Based upon historical data, we recognize this assumption is likely incomplete. It is now apparent that the focus exclusively on economic growth forecasts and consideration of CAA emission controls overlooks important factors that influence emission trends.

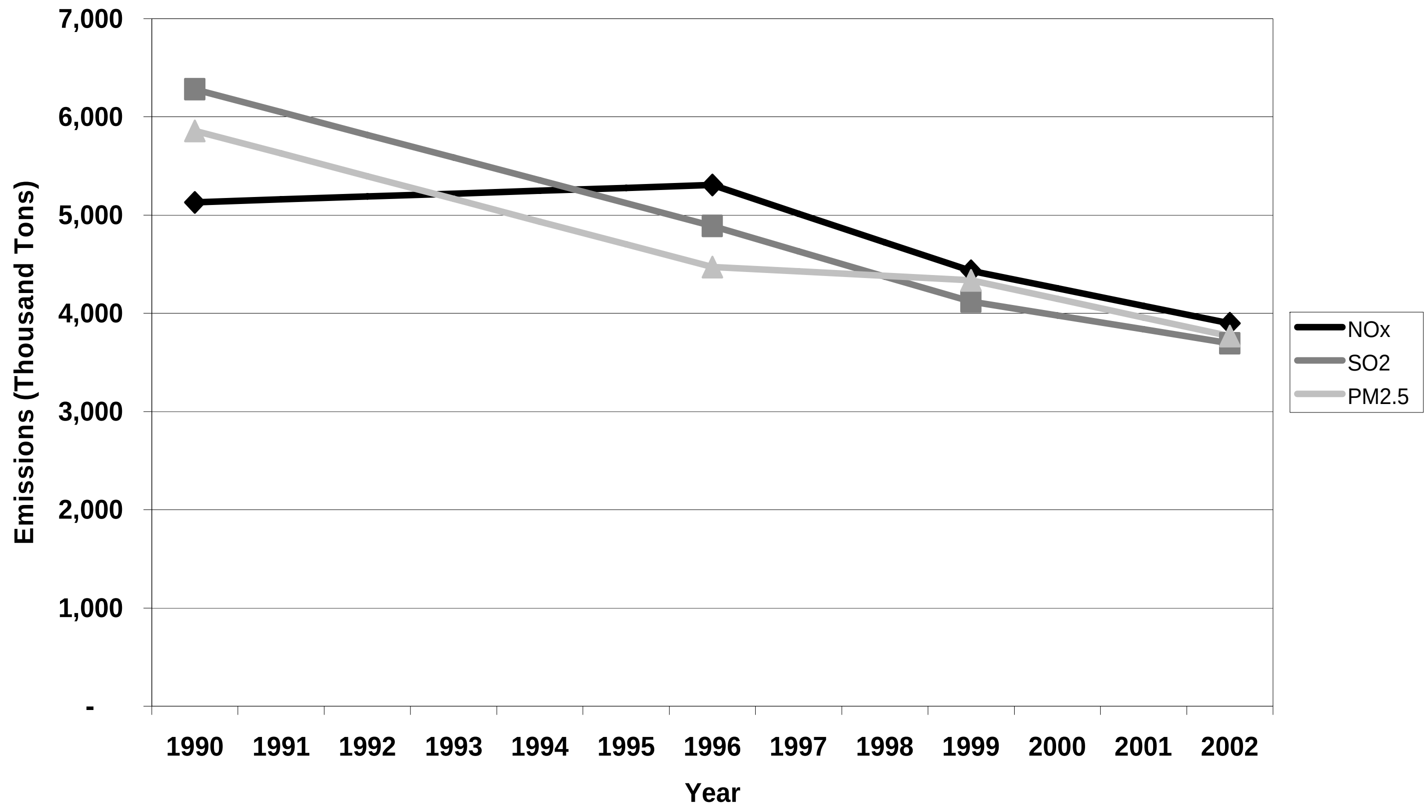
While information needed for a full understanding is lacking, we have several plausible explanations for the differences we observe in economic growth projections and emission trends and reasons to believe these trends may continue in the future. These explanations involve the replacement of older vintages of capital equipment and emission

Figure 1



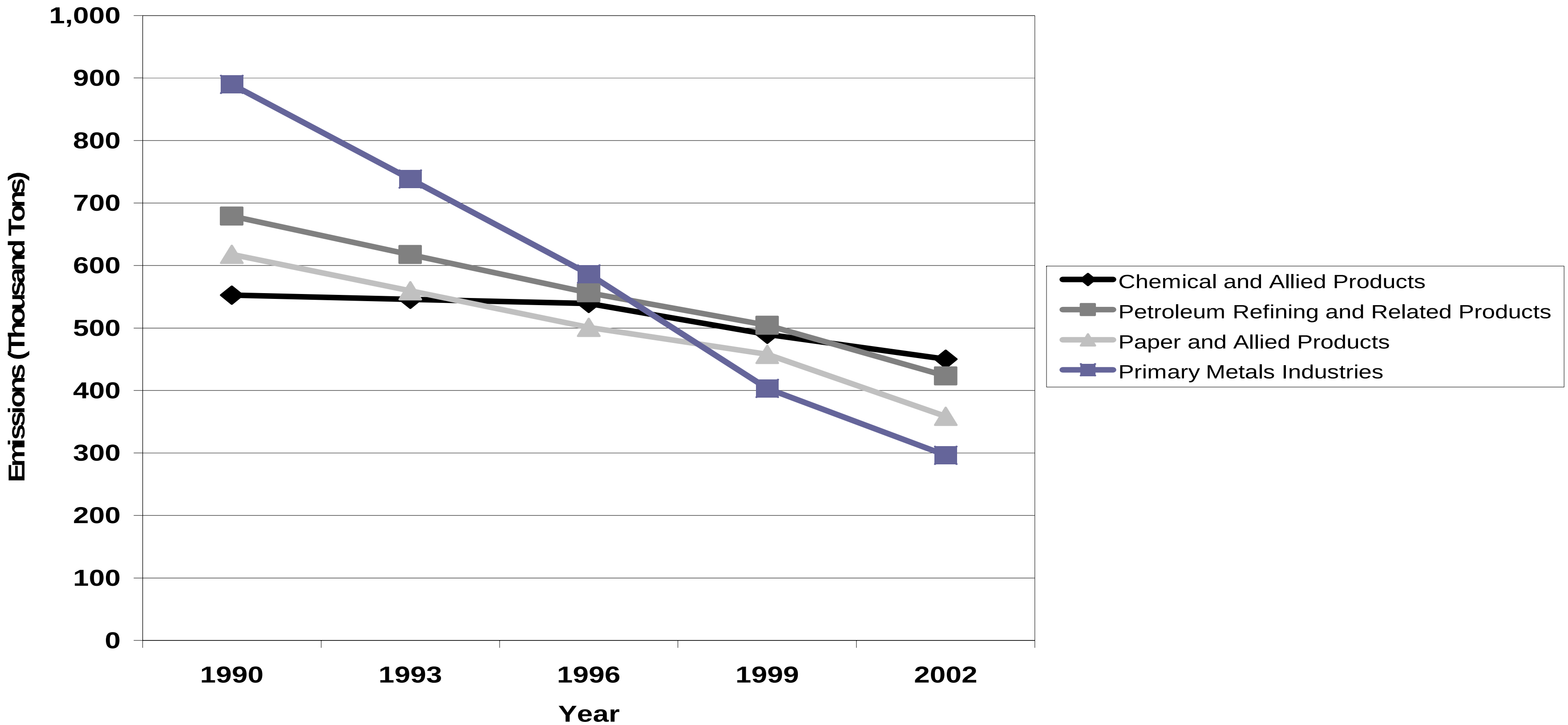
Data Sources: US Department of Commerce, Bureau of Economic Analysis, US Dept. of Transportation, Federal Highway Administration, US Census Bureau, and US Department of Energy.

Figure 2
1990 -2002 Emission Inventories
Non-EGU Stationary Sources Only[1]



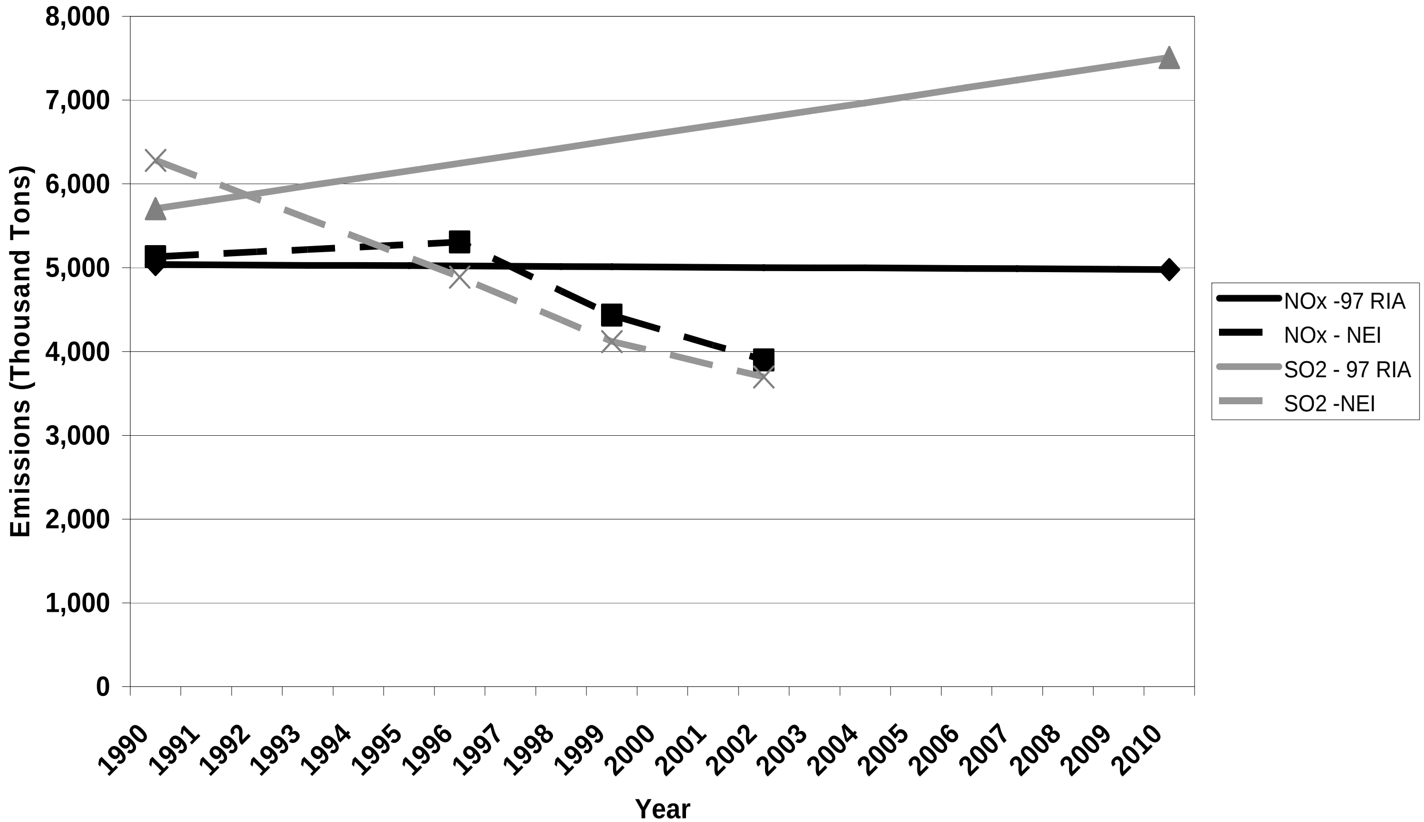
[1] Emissions shown reflect non-utility stationary point and non-point sources only, excluding fires. Source: National Emissions Inventory

Figure 3
Historical SO2 Emission Trends for Large Industrial Categories



[1] Emissions shown reflect 2 digit-SIC source categories. Source: National Emissions Inventory

Figure 4
Comparison of 1997 PM NAAQS RIA Forecasts and NEI Actual Emissions
Non-EGU Stationary Sources Only[1]



[1] Sources: National Emissions Inventory and Regulatory Impact Analysis for the Ozone and PM NAAQS, 1997.

rates. Firms replace emission generating equipment for multiple reasons including regulatory requirements, enhanced productivity, retirement of obsolete equipment, energy efficiency (e.g., fuel switching) and other reasons. Profit seeking firms will attempt to maximize profits for the firm with each capital investment. Thus, installation of new more efficient equipment may result in an increase in production of goods and services without the corollary per unit increase in emissions or in maintenance of current levels of production with lower levels of emissions. These outcomes are reasonably likely regardless of the rationale for the equipment replacement (i.e., enhanced productivity, regulatory requirements, obsolescence of existing equipment, or energy efficiency measures such as fuel switching) for firms seeking to maximize profits. Our current growth projection methods do not explicitly capture such a phenomenon, and there is a lag in our ability to recognize newly installed emission control equipment in our current emission inventory process. We have particular difficulty in accounting for potential emission reductions from regulatory actions such as CAA New Source Review and New Source Performance Standards. In addition, emission rates may not reflect current conditions. The emission rates are determined through source testing. Although we suspect that average emission rates are declining, we have not been able to verify this fact through updated sources testing due to budget constraints.

While it is not clear that all of the factors that have served to produce this historical decline will continue to operate in the future, it appears unreasonable to assume that we currently have arrived at an ‘inflection point’ past which the trend will stop or reverse itself. Indeed, because the available data show that a number of large sources in the sectors of interest have no or limited pollution controls, it is reasonable to expect emissions rates will be steady or decline. Continuing to ignore this factor in future-year emission projections may increasingly skew the predicted emissions increase, and the farther into the future the forecast the more dramatic the impact. The preceding and other explanations suggested that we need to reevaluate our emission forecasting approaches for stationary non-EGU sources to incorporate factors not adequately considered in past methodologies.

Interim Approach to Address this Issue

We are currently reviewing the PM NAAQS and completing an RIA that estimates the benefits and costs of the standard. The stationary non-EGU sectors are important sectors for this analysis and emission projections are more important for this analysis than they have been in some previous analyses. Over-predicting future emissions for these sectors will lead to an over-prediction of the benefits and costs of the PM NAAQS. We also believe that potential prediction errors will be greater in distant future years (e.g., 2020) due to compounding of growth. As recent and upcoming analyses are examining policies that will be implemented in 2020 or later, these over-prediction errors have become magnified. As a result, we explored alternative methods of addressing this problem. Due to a court-ordered schedule for this analysis, the time needed to complete a comprehensive revamp of our forecasting model for these source categories was not possible.

As we develop a more comprehensive approach, we are making an interim change in our analysis to better align our forecasts of future growth in the stationary non-EGU sectors with the historical record. As an interim approach, we will not apply economic growth to emissions for many stationary non-EGU sources. Table 1 shows the emission forecasting techniques planned for the PM NAAQS RIA. As shown, the interim approach affects stationary non-EGU point and non-point sources only. We recognize that this solution is a short term one at best, and needs to be improved for the future. Our RIA for the PM NAAQS will show a sensitivity analysis of the implications of the interim approach relative to our traditional approach. Figure 5 shows the forecasted emission trends for the non-utility stationary sources using the old methodology and the new interim approach. As depicted in Figure 5, the new interim approach will result in lower future-year emission projections for these sources that more closely match the observed historical trends. It is worthwhile to recognize that the emissions from these stationary non-EGU sectors are a subset of total emissions and the interim approach adjustment is minimal when looking at emissions from all source categories (see Figure 6).

In the long term, we recognize the need to improve our forecasting methods and models for these important source categories. The technical work needed for a more sophisticated and improved approach will take time to develop. In the interim, our approach has been implemented in the short time frame needed for our ongoing regulatory work. The interim approach minimizes the over-prediction error in future year emission estimates for stationary non-utility sources. This approach does not have an *a priori* bias in either direction, as it simply holds non-utility stationary source emissions to be consistent with the observed levels in 2001, accounting for known control programs to be implemented in future years. The interim approach does not apply the observed downward trend in emissions, and as such may still overstate future emissions levels if historical trends continue.

To develop an improved approach to emission projections, we are focusing first on sectors that are the largest contributors to precursors of ozone, PM, regional haze, and high risk toxics. Developing the appropriate emissions projection technique is a complex process that requires more analysis to first identify and understand the sources of change in historical emissions. As previously discussed, our past methods do appropriately reflect the impact of economic growth and emission control impacts on future-year emissions, but do not adequately reflect the impact of other factors such as technological innovation, capital turnover, fuel switching, and other activities that may have significant impacts on emissions. After gaining the necessary understanding of these trends, we will develop models that better reflect historical and anticipated future trends for key stationary non-EGU sectors. This focus on important sectors will provide the most benefit for the effort expended to improve emissions projections.

After gaining an understanding of historical trends, EPA will evaluate currently available forecasting models capable of estimating local, regional, and national economic trends. Key considerations will be the efficacy of these models to forecast growth for key stationary non-EGU industry sectors. In addition, EPA will consider techniques to model technological innovation and adoption for both productive processes and control equipment and models that consider new facility location decision-making. EPA’s goal is to implement these improvements as a part of the new 2002 emissions based modeling platform. These changes may not be available for the initial version 2002 platform, but could be incorporated into the modeling platform along with other updates. When an improved approach is formulated, the EPA will consult with the Council to obtain feedback on the new methodology prior to its implementation.

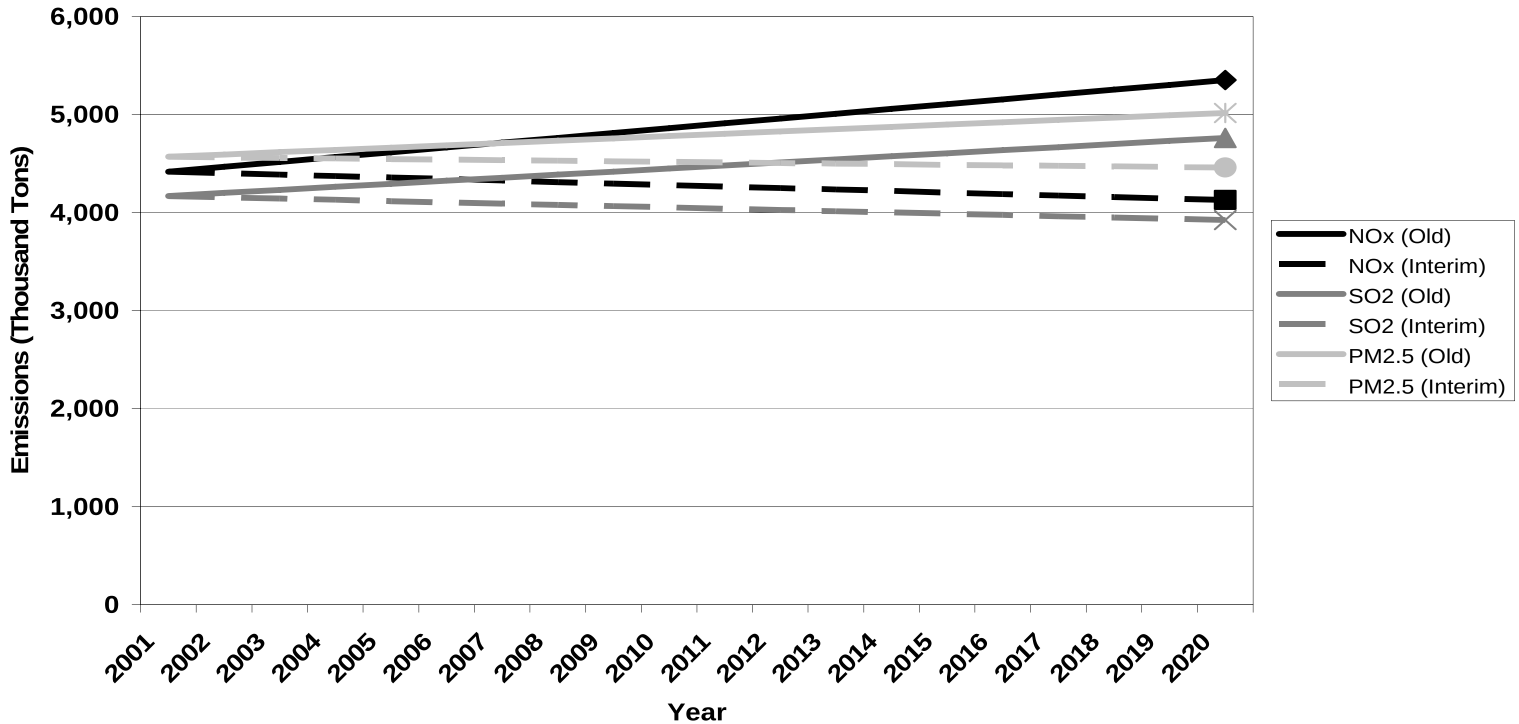
Question for the Council

Please provide your advice and comments on EPA’s discussion and underlying development of the interim forecasting approach for stationary non-EGU sources described above. Are there caveats and sensitivities that should be provided in the discussion of this interim approach in our analyses? Are there additional suggestions or data you could provide to help with the development of a longer term approach?

Table 1. Emissions Sources and Basis for Current and Future-Year Inventories

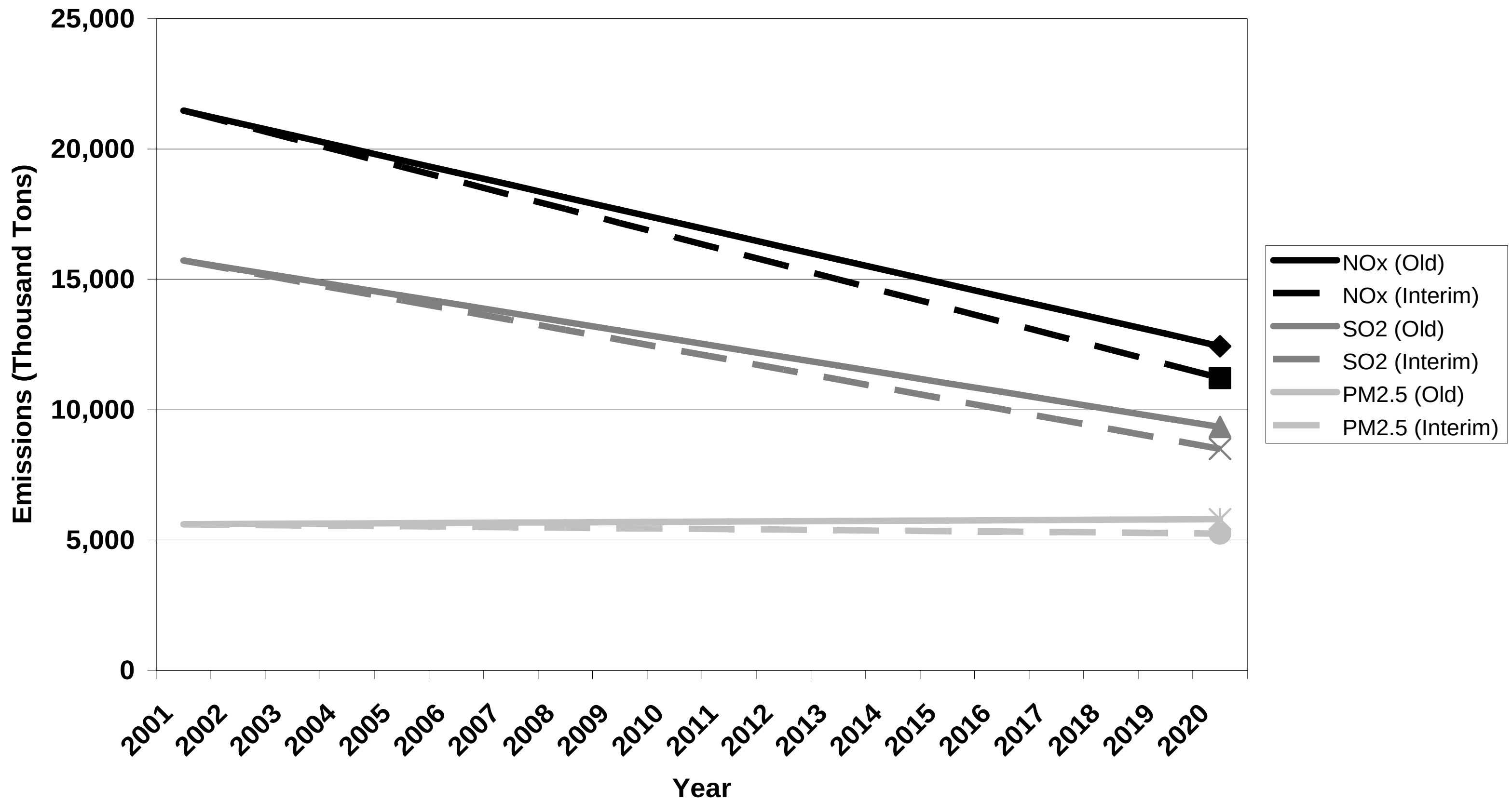
Sector	Interim Projection Method Applied	Future-Year Base Case Projections
EGU	No	Integrated Planning Model (IPM)
Non-EGU Point Sources	Yes	Apply CAA mandated controls to base year emissions to project future emissions. Projected changes in economic activity not applied to emission projection.
Other Stationary Non-point	Yes	Apply CAA mandated controls to base year emissions to project future emissions. Projected changes in economic activity not applied to emission projection.
Fires	No	Average fires from 1996 through 2002 (based on state-total acres burned), with the same emissions rates and county distributions of emissions as in the 2001 NEI
Ag -NH3	No	Livestock – USDA projections of future animal population Fertilizer – Held constant at 2001 level
On-road	No	Projected vehicle miles traveled (VMT) DOE Energy Outlook VMT projections, future-year emissions rates from MOBILE6.2 model via National Mobile Inventory Model (NMIM)
Nonroad	No	NONROAD 2004 model via NMIM

Figure 5
2020 Emission Forecasts - Old and Interim Methods
Non-EGU Stationary Sources Only[1]



Source: Analysis completed for the PM NAAQS RIA (forthcoming).

Figure 6
2020 Emission Forecasts - Old and Interim Methods
All Sources



Source: Analysis completed for the PM NAAQS RIA (forthcoming).

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