# Documentation of 2018 Emissions from Electric Generation Units in the Eastern United States for MANE-VU's Regional Haze Modeling

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Mid-Atlantic / Northeast Visibility Union (MANE-VU)

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This report was prepared for use by the MANE-VU States and does not necessarily represent the position of the U.S. Environmental Protection Agency.

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# 1 INTRODUCTION

## 1.1 Background

Development of an emissions inventory is an important foundation for performing regional scale atmospheric modeling for regulatory air quality management. The accuracy of the atmospheric model's prediction of air quality depends, in part, on the accurate representation of emissions from a variety of source sectors including point, area, non-road, on-road and biogenic sources. Electric generating units (EGUs) are an important point source sector and are often considered for controls to meet air quality objectives. Therefore, it is especially important to accurately represent and document EGU emissions and associated characteristics in a regulatory modeling application. This report is intended to describe the development of future year EGU emission estimates for use in Mid-Atlantic/Northeast Visibility Union (MANE-VU) 2018 regional haze modeling.

This document synthesizes information from several documents that already describe parts of the process of preparing emissions estimates and provides information not yet included in other documents. It covers the following: preparation of the inter-Regional Planning Organization (RPO) Integrated Planning Model® (IPM) runs commonly referred to as the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) IPM runs, the post-processing of those runs to create Sparse Matrix Operator Kernel Emissions (SMOKE) input files, the modification of those files to reflect state estimates of emissions, and the adjustments made by MANE-VU modelers to maintain the Clean Air Interstate Rule (CAIR) cap. It also provides background information about preparing EGU forecasts and related work by the U.S. Environmental Protection Agency (EPA).

# 2 PREPARATION OF EGU FORECASTS

Emission projections for point sources are dependent upon changes in source level activity, the emission factors or installed controls. The approach taken to project point source emissions depends on the level of detail necessary in the projection year file. Changes in point source emissions are accounted for by a combination of growth, control, and retirement rates. Growth rates are applied to estimate the overall change in activity, while retirement rates are applied to estimate the decrease in emissions activity from existing sources. Retirement (and replacement of these sources with new sources) must be considered because regulations affecting new sources may differ from those affecting existing sources.

The projection year control factor accounts for both changes in emission factors due to technology improvements and new levels of control required by regulations. The control factor accounts for three variables: regulation control, rule effectiveness, and rule penetration.

Control factors are closely linked to the type of emission process (identified by Source Classification Code (SCC)) and secondarily to the type of industry identified by Standard Industrial Classification (SIC). Point source projections should account for Federal, State, and local regulations affecting these categories.

A complicating factor is the requirement for emission offsets in nonattainment areas through New Source Review requirements. This may be accounted for by 1) restricting growth under the assumption that it will be offset; 2) applying reductions to selected source categories to account for the emission growth which must be offset; or 3) selecting the individual sources, based on a cost analysis, from which offsets are likely to come.

When projecting Electricity Generating Unit (EGU) emissions in the Eastern United States, emission trading should be considered. There are three general approaches to performing projections while accounting for such trading schemes. The first option is to optimize control levels across the domain based on the cost of alternative controls. The second option is to survey individual sources to determine how they will comply (will they apply controls and sell or buy allowances) and use this as the basis for the future year control level. The third option is to apply the control level used to establish the budget to all affected sources and ignore which sources may choose to buy or sell credits/allowances.

Other factors which must be considered include programs, such as fuel switching, designed to provide source flexibility in meeting future air quality requirements. Fuel switching refers to instances where a unit historically burned one primary fuel, such as coal, and under a "fuel switching" program the unit would burn an alternate fuel, such as natural gas, during a certain period of time and may switch back to the "historic" fuel for some or all of the year. Fuel switching is often done in cases where sources average their emissions to meet federal mandates. The variation in emissions over the course of the year caused by fuels switching must be calculated properly in projections.

Repowering is another example of a planned change in emission rates which should be considered. In this case, the unit may be switching entirely from coal to gas or may be completing a major modification which would lower the emission rate.

Spatial allocation is another factor which must be considered, particularly if air quality modeling will be performed using the projection. For point sources, important questions are which facilities will retire and where new growth will occur. Changes in land use patterns may also impact the location of point source emissions. As undeveloped and rural areas become suburban and urban areas, the number of point sources in that area will increase.

As can be seen from the discussion above, any number of complicating issues can lead to emission forecasts which may differ from user to user. An inconsistent decision made between two parties can lead to significant differences in growth, control, or placement of emissions from point source forecasts. For this reason, the RPOs made a conscious decision to utilize consistent forecasting methods for EGU emissions, as they are one of the most significant contributors to regional haze in the United States. This decision, to coordinate on the projection of EGU source emissions, led to the preparation of an EGU forecast methods document from which a coordinated decision was made on methods to develop EGU emissions in future years.

## 2.1 EGU Forecast Methods Document

Early in the planning process there was a joint agreement by the RPOs to work together to develop future year EGU emissions estimates based on the use of the Integrated Planning Model® (IPM). The decision to use IPM modeling resulted in part on a study of EGU forecast methods by E.H. Pechan and Associates, Inc. (Pechan) for the Midwest Regional Planning Organization (MRPO) (Pechan, 2004), which recommended IPM as a viable methodology. Although IPM results were available from work conducted by EPA to support their rulemaking for the Clean Air Interstate Rule (CAIR), the RPOs concluded that certain model inputs needed to be revised. Thus, the RPOs decided to work together to hire contractors to conduct new IPM modeling and to post-process the IPM results. This section describes the recommendation to use IPM.

The Lake Michigan Air Directors Consortium (LADCO) sought contractor assistance in reviewing emissions inventory growth for existing and new EGUs (Pechan, 2004). Because the results of EGU emission forecasts are used in urban or regional scale air quality modeling exercises to estimate future year air pollutant concentrations, growth methods need to supply model-ready emission model inputs. The purpose of LADCO's project was to begin to examine EGU growth methods.

The primary pollutants of interest were sulfur dioxide ($SO_2$), oxides of nitrogen ($NO_x$), particulate matter (PM), ammonia ($NH_3$), and mercury (Hg). Projection years of interest included 2009 (the approximate time for ozone and $PM_{2.5}$ attainment) and 2018 (a longer term regional haze planning horizon). The geographic area of interest was the eastern half of the United States (to capture the trading issues affecting the Midwest States).

This 2004 Pechan report provided a detailed evaluation of three EGU growth modeling methods of interest to the LADCO States for consideration in developing its own approach. These evaluations addressed the following attributes of each modeling approach:

- Description of primary analytical modeling methods;
- Geographic areas of application;
- Advantages; and
- Disadvantages.

The material in this evaluation was intended to be used to determine which of the currently available modeling approaches might be best suited for use by the LADCO States (and other RPOs) for future state implementation plan (SIP) and air dispersion modeling work. The models evaluated in this report included the IPM, the National Energy Modeling System (NEMS), and the Electric Power Market Model (EPMM).

Based on the conclusions and summary of the report (Pechan, 2004), four participating RPOs (MANE-VU, MRPO, VISTAS, and the Central Regional Air Planning Association, CENRAP) decided to use IPM as the tool for forecasting EGU emissions.

## 2.2 The Integrated Planning Model (IPM)

IPM was developed by ICF Consulting, Inc. (ICF) and used to support public and private sector clients. This model is a multi-regional, dynamic, deterministic linear programming model of the U.S. electric power sector. It provides forecasts of least-cost capacity expansion, electricity dispatch, and emission control strategies for meeting energy demand and environmental, transmission, dispatch, and reliability constraints. It can be used to evaluate the cost and emissions impacts of proposed policies to limit emissions of $SO_2$, $NO_x$, carbon dioxide ($CO_2$), and Hg from the electric power sector. The IPM model was a key analytical tool used by EPA in developing CAIR and the Clean Air Mercury Rule (CAMR).

Among the factors that make IPM particularly well suited to model multi-emissions control programs are (1) its ability to capture complex interactions among the electric power, fuel, and environmental markets; (2) its detail-rich representation of emission control options encompassing a broad array of retrofit technologies along with emission reductions through fuel switching, changes in capacity mix and electricity dispatch strategies; and (3) its capability to model a variety of environmental market mechanisms, such as emissions caps, allowances, trading, and banking. IPM's ability to capture the dynamics of the allowance market and its provision of a wide range of emissions reduction options are particularly important for assessing the impact of multi-emissions environmental policies like CAIR and CAMR.

## 2.3 U.S. EPA Use of IPM

The U.S. EPA uses IPM to analyze the projected impact of environmental policies on the electric power sector in the 48 contiguous states and the District of Columbia.

### *2.3.1 EPA's Base Case 2004*

The EPA's Base Case 2004 (EPA, 2005a) served as the starting point against which EPA compared various policy scenarios. It is a projection of electricity sector activity that takes into account federal and state air emission laws and regulations whose provisions were either in effect or enacted and clearly delineated at the time the base case was finalized in August 2004. Regulations mandated under the Clean Air Act Amendments of 1990 (CAAA), but whose provisions have not yet been finalized, were not included in the base case. These include:

- Measures to Implement Ozone and Particulate Matter (PM) Standards: EPA Base Case 2004 predates and so does not include the provisions of CAIR, the primary federal regulatory measure for achieving the National Ambient Air Quality Standards (NAAQS) for ozone (8-hour standard of 0.08 ppm) and fine particles (24-hour average of 65 ug/m3 or less and annual mean of 15 ug/m3 for particles of diameter 2.5 micrometers or less, i.e., $PM_{2.5}$). EPA Base Case 2004 was used to evaluate policy alternatives which ultimately resulted in CAIR. The final CAIR was issued on March 10, 2005. EPA Base Case 2004 includes measures to implement ozone and particulate matter standards to the extent that some of the state regulations included in EPA Base Case 2004 contain measures to bring non-attainment areas into attainment. Individual permits issued by states in response to ozone and particulate matter standards are not captured in the base case.

- Mercury Regulations on Electric Steam Generating Units: EPA Base Case 2004 predates both CAMR, which was issued by EPA on March 15, 2005 and the "Maximum Achievable Control Technology" (MACT) standards, which were scheduled to be promulgated by December 15, 2004, but, pending litigation, have been superseded by CAMR. Consequently, this base case does not include any federal regulatory measures for mercury control. (CAMR was vacated in 2008.)

- Clean Air Visibility Rules: On July 1, 1999, EPA issued Regional Haze Regulations to meet the national goal for visibility established in Section 169A of the CAAA, which calls for "prevention of any future, and the remedying of any existing, impairment of visibility in Class I areas (156 national parks and wilderness areas), which impairment results from manmade air pollution." The regulations required states to submit revised SIPs that (1) establish goals that provide for reasonable progress towards achieving natural visibility conditions at Class I areas, (2) adopt a long-term control strategy that includes such measures as are necessary to achieve the reasonable progress goals, and (3) require Best Available Retrofit Technology (BART) for sources in listed source categories placed in operation between 1962 and 1977.

In effect, EPA Base Case 2004 offered a snapshot projection of the electric sector assuming that the only future environmental regulations were those with provisions known at the time that the base case assumptions were finalized. While not necessarily an accurate reflection of what would actually occur, this assumption ensured that the base case was policy neutral with respect to future environmental policies.

### *2.3.2 EPA CAIR Case*

On January 30, 2004, EPA proposed CAIR, which set emission reduction requirements for 29 States and the District of Columbia. Those emission reduction requirements were based on achieving highly cost-effective emission reductions from large electricity generating units.

While EPA believed that the modeling it initially performed for the January 2004 proposal provided a reasonable estimate of the impact of requiring highly cost-effective emission reductions from electricity generating units, it did not exactly model the proposed control region. For both $SO_2$ and $NO_x$, EPA used modeling assumptions that differed slightly from the January 2004 CAIR proposal. For $SO_2$ in particular, EPA modeled the program assuming a cap on national emissions rather than in the 29 States proposed. Although EPA believed the modeling done at that time provided a reasonable approximation of the impacts of the original CAIR, because 92 percent of the $SO_2$ emissions in the 48 contiguous States occur in the 28 States that were covered by the proposal, EPA completed additional analysis. This additional analysis examined the effect of covering the geographic region proposed in the January 30, 2004 proposal using the $NO_x$ emissions cap and a close approximation of the $SO_2$ cap proposed for CAIR (EPA, 2005a).

For the supplemental proposal, EPA performed refined modeling of the emission reduction requirements proposed on January 30, 2004. In this refined modeling, EPA modeled the exact control regions for both $SO_2$ and $NO_x$, as proposed.

### *2.3.3 EPA's CAIR Modeling Limitations*

The U.S. EPA's modeling was based on its best judgment for various input assumptions that were uncertain, particularly assumptions for future fuel prices and electricity demand growth (EPA, 2004). In addition, modeling using IPM did not take into account the potential for advancements in the capabilities of pollution control technologies for $SO_2$ and $NO_x$ removal as well as reductions in their costs over time.

Retirement Ratios: EPA issued a CAIR supplemental notice of proposed rulemaking that proposed two alternatives for how the $SO_2$ reduction target would be achieved. The proposal took comment on implementing the reduction requirements in the second phase either by using a 2.86 to 1 ratio (which would match the 65 percent reduction target) of acid rain allowances to emissions, or alternatively, by implementing the reductions using a 3 to 1 ratio (for administrative simplicity) and then letting States create and distribute additional allowances equal to the surplus created by the 3 to 1 ratio to achieve the proposed 65 percent reduction. In either case, the effective cap on $SO_2$ emissions from the power sector would be the same.

Modelers assumed a 3 to 1 Title IV allowance retirement ratio for 2015 and beyond to implement the reductions in the proposed control region. The model did not add back the 130,000 tons of over-compliance that would result from this ratio. Therefore, in this modeling, EPA analyzed slightly greater emission reductions than required by the proposal. This assumption was made for modeling simplicity and was expected to result in a slight overestimate of costs for the proposal and of the emissions reductions achieved.

BART: The EPA did not incorporate any best achievable retrofit technology (BART) modeling in this analysis. BART would achieve reductions in non-CAIR States and had the potential to mitigate leakage issues.

Demand Response: EPA's 2004 CAIR case includes a demand response to increased gas prices but not electricity prices. In the model, increased gas prices would prompt the public to curtail their use of gas and encourage them to seek substitutes. However, no provision for demand response was included for electricity prices. If demand had been allowed to change in response to increasing prices of electricity,, one can assume that consumers would have reduced their demand for electricity, lowering electricity prices and reducing generation and emissions to some extent.

State Rules: State rules were adopted that were not incorporated into EPA's modeling framework.

Because of the limitations noted above, the RPOs decided to initiate their own IPM modeling based on the EPA's latest update of the IPM input framework, called IPM 2.1.9. EPA completed the input framework for IPM 2.1.9 in March of 2003.

## 2.4 RPO Use of IPM – Phase I

In August 2004, VISTAS contracted with ICF to run IPM to provide revised utility forecasts for 2009 and 2018 under two future scenarios – Base Case and CAIR Case (ICF, 2004). The Base Case represented the current operation of the power system under laws and regulations as known at the time the run was made, including those that come into force in the study horizon. The CAIR Case was the Base Case with the proposed CAIR rule superimposed. Run results were parsed at the unit level for the 2009 and 2018 run years.

In August 2004, MRPO contracted with Pechan to post-process the VISTAS' IPM outputs to provide the (National Emission Inventory Input Format) NIF formatted emission files needed for the regional inventory. The IPM output files were delivered by ICF to VISTAS in November 2004 and the post-processed data files were delivered by Pechan to the MRPO in December 2004.

These IPM runs (VISTAS_CAIR_2) and the NIF files that were generated from the parsed data sets are commonly referred to as the Phase I Inter-RPO runs. The Phase I runs were ultimately not used in RPO modeling of regional haze, as further revisions to the inputs were necessary once CAIR was adopted.

## 2.5 RPO Adjustments to IPM – Phase II

On March 10, 2005, EPA issued the final CAIR. A consortium of RPOs, (MANE-VU, VISTAS, MRPO, and CENRAP) conducted another round of IPM modeling which reflected changes to control assumptions based on the final CAIR as well as additional changes to model inputs based on state and local agency and stakeholder comments. Several conference calls were conducted in the spring of 2005 among the participating RPOs to discuss and provide comments on IPM assumptions related to six main topics: power system operation, generating resources, emission control technologies, set-up parameters, financial assumptions, and fuel assumptions. Based on these discussions, VISTAS sponsored a new set of IPM runs to reflect the final CAIR requirements as well as certain changes to IPM assumptions that were agreed to by the RPOs. ICF performed the following four runs using IPM during the summer of 2005. This set of IPM runs is referred to as the VISTAS Phase II analysis or Inter-RPO v.2.1.9 runs.

- Base Case with EPA 2.1.9 coal, gas, and oil price assumptions (VISTASII_BC_1Z1).
- Base Case with EPA 2.1.9 coal and gas supply curves adjusted for the U.S. Energy Information Administration’s most recent Annual Energy Outlook (AEO 2005) reference case price and volume relationships (VISTASII_BC_2Y).
- Strategy Case with EPA 2.1.9 coal, gas and oil price assumptions (VISTASII_PC_1f).
- Strategy Case with EPA 2.1.9 coal and gas supply curves adjusted for AEO 2005 reference case price and volume relationships (VISTASII_PC_2C).

The above runs were parsed for 2009 and 2018 run years. The output taken from the Strategy Case with EPA 2.1.9 coal, gas, and oil price assumptions (VISTASII_PC_1f) is also referred to as the Inter-RPO CAIR Case IPM 2.1.9 and is the basis for discussion in the remainder of this report.

The Phase II scenarios were based on VISTAS Phase I and EPA IPM 2.1.9 assumptions (EPA, 2005b). Additional changes that were implemented in the above four runs are summarized below and in associated documentation (ICF, 2007):

- Unadjusted AEO 2005 electricity demand projections were used. (U.S. EPA runs were adjusted to reflect reduced demand due to voluntary conservation projects sponsored by U.S. EPA)
- Gas supply curves were adjusted for AEO 2005 reference case price and volume relationships. The EPA 2.1.9 gas supply curves were scaled such that IPM solved for AEO 2005 gas prices when the power sector gas demand in IPM is consistent with AEO 2005 power sector gas demand projections.
- The coal supply curves used in EPA 2.1.9 were scaled such that the average mine mouth coal prices that the IPM was solving in aggregated coal supply regions were comparable to AEO 2005. Coal grades and supply regions contained in AEO 2005 and EPA 2.1.9 were not directly comparable. An iterative approach was used to obtain comparable results. The coal transportation matrix was not updated with Energy Information Administration (EIA) assumptions due to significant differences between the EPA 2.1.9 and EIA AEO 2005 coal supply and coal demand region configurations.
- The cost and performance of new units were updated to AEO 2005 reference case levels.
- The run years 2008, 2009, 2012, 2015, 2018, 2020 and 2026 were modeled.
- The AEO 2005 life extension costs for fossil and nuclear units were incorporated.
- The extensive NEEDS comments provided by VISTAS, MRPO, CENRAP and MANE-VU were incorporated into the Phase I NEEDS input file.
- MANE-VU’s comments in regards to the northeast state regulations were incorporated.

- Northeast Renewable Portfolio Standards (RPS) were modeled based on the Regional Greenhouse Gas Initiative analysis. A single RPS cap was modeled for MA, RI, NY, NJ, MD, and CT. These states could buy credits from NY or from the PJM Interconnection and New England model regions.
- Selective Catalytic Reduction (SCR) and Scrubber Feasibility Limits: No limits were applied in 2008, 2009 and 2010 to the capacity for installing these emissions controls.
- The Clean Air Visibility Rule (CAVR) was not modeled.
- Modelers assumed a Title IV $SO_2$ Bank for 2007 of 4.98 million tons.
- The investments required under the Illinois Power, Mirant and First Energy NSR settlements (as identified during spring 2005) were incorporated in the above runs.

For the Phase II inter-RPO set of IPM runs, ICF generated two different parsed files for each of the two scenarios. One file includes all fuel burning units (fossil, biomass, landfill gas) as well as non-fuel burning units (hydro, wind, etc.). The second file contains just the fossil-fuel burning units (e.g., emissions from biomass and landfill gas are omitted). In all RPOs the fossil-only file was used for modeling. This is consistent with EPA, since EPA used the fossil only results for CAIR analyses.

## 2.6 State Results – Phase II

Table 1 presents unmodified State level fuel use and emission results from the 2018 Inter-RPO CAIR Case IPM v. 2.1.9 fossil-only parsed file (VISTASII_PC_1f). Note that IPM produces only $NO_x$ and $SO_2$ emissions estimates.

**Table 1.** State Level Fuel Use and Emission Summary; 2018 VISTASII_PC_1f.xls.

| | | **Fuel Use (TBtu)** | | **Emissions (Tons)** | | |
|---|---|---|---|---|---|---|
| **State** | **RPO** | **Summer** | **Annual** | **Summer NOx** | **Annual NOx** | **Annual SO2** |
| Connecticut | MANE-VU | 62.1572 | 142.7141 | 1,521 | 3,418 | 6,697 |
| Delaware | MANE-VU | 41.9472 | 92.7542 | 5,485 | 12,341 | 35,442 |
| District Of Columbia | MANE-VU | 2.0774 | 4.8716 | 49 | 103 | 83 |
| Maine | MANE-VU | 21.8494 | 49.8748 | 804 | 1,827 | 5,436 |
| Maryland | MANE-VU | 195.3393 | 437.8991 | 6,832 | 14,709 | 28,065 |
| Massachusetts | MANE-VU | 188.0653 | 433.3227 | 8,004 | 18,157 | 17,486 |
| New Hampshire | MANE-VU | 32.4638 | 73.8699 | 1,393 | 3,089 | 7,469 |
| New Jersey | MANE-VU | 140.8000 | 304.7240 | 6,432 | 13,636 | 32,495 |
| New York | MANE-VU | 282.4272 | 669.0821 | 10,926 | 24,376 | 51,445 |
| Pennsylvania | MANE-VU | 687.1446 | 1,540.1322 | 36,329 | 82,881 | 135,946 |
| Rhode Island | MANE-VU | 15.1701 | 40.0407 | 244 | 576 | 55 |
| Vermont | MANE-VU | 1.3677 | 3.0597 | 74 | 105 | 35 |
| | **MANE-VU Total** | **1,670.8093** | **3,792.3450** | **78,093** | **175,219** | **320,651** |
| Alabama | VISTAS | 605.2513 | 1,329.1117 | 19,416 | 41,715 | 190,029 |
| Florida | VISTAS | 831.5942 | 1,813.5433 | 26,620 | 56,506 | 139,526 |
| Georgia | VISTAS | 687.9659 | 1,530.2279 | 26,228 | 56,180 | 178,196 |
| Kentucky | VISTAS | 494.6026 | 1,121.9188 | 27,904 | 64,099 | 229,596 |
| Mississippi | VISTAS | 211.7079 | 443.3923 | 4,269 | 8,895 | 27,226 |
| North Carolina | VISTAS | 431.1262 | 984.5996 | 25,412 | 57,774 | 102,217 |
| South Carolina | VISTAS | 326.3757 | 749.2039 | 20,240 | 46,318 | 118,584 |
| Tennessee | VISTAS | 300.8087 | 672.6405 | 13,348 | 29,873 | 112,343 |
| Virginia | VISTAS | 305.6546 | 710.9991 | 18,443 | 43,144 | 80,602 |
| West Virginia | VISTAS | 477.7910 | 1,080.9570 | 22,556 | 51,208 | 124,464 |
| | **VISTAS Total** | **4,672.8781** | **10,436.5940** | **204,435** | **455,711** | **1,302,784** |
| Illinois | MRPO | 564.3359 | 1,281.6624 | 31,214 | 71,234 | 241,136 |
| Indiana | MRPO | 665.8976 | 1,534.4126 | 40,820 | 95,376 | 376,864 |
| Michigan | MRPO | 537.6731 | 1,257.6784 | 42,629 | 98,685 | 398,562 |
| Ohio | MRPO | 773.6334 | 1,785.3989 | 35,888 | 83,129 | 215,501 |
| Wisconsin | MRPO | 303.7451 | 691.5260 | 19,794 | 45,701 | 155,369 |
| | **MRPO Total** | **2,845.2851** | **6,550.6783** | **170,345** | **394,124** | **1,387,433** |
| Arkansas | CENRAP | 211.9455 | 479.1864 | 14,836 | 33,097 | 82,605 |
| Iowa | CENRAP | 238.7101 | 548.7369 | 22,252 | 51,119 | 147,305 |
| Kansas | CENRAP | 213.4288 | 465.8685 | 37,207 | 83,333 | 81,486 |
| Louisiana | CENRAP | 225.6282 | 481.9880 | 14,240 | 30,432 | 74,263 |
| Minnesota | CENRAP | 175.6582 | 388.8279 | 17,940 | 41,029 | 85,847 |
| Missouri | CENRAP | 416.5504 | 918.5720 | 34,350 | 77,660 | 280,887 |
| Nebraska | CENRAP | 113.8064 | 255.2901 | 22,524 | 50,781 | 73,629 |
| Oklahoma | CENRAP | 357.5522 | 745.1097 | 36,695 | 76,048 | 113,680 |
| Texas | CENRAP | 1,710.8244 | 3,236.6605 | 79,449 | 153,837 | 339,433 |
| | **CENRAP Total** | **3,664.1040** | **7,520.2400** | **279,493** | **597,336** | **1,279,135** |
| Arizona | WRAP | 442.6160 | 1,022.0551 | 36,168 | 81,858 | 60,640 |
| California | WRAP | 602.8505 | 1,403.6297 | 10,464 | 23,767 | 5,447 |
| Colorado | WRAP | 215.1782 | 486.7281 | 31,074 | 70,171 | 87,163 |
| Idaho | WRAP | 14.5575 | 34.1372 | 309 | 718 | 0 |
| Montana | WRAP | 88.4363 | 200.1442 | 17,034 | 38,504 | 22,066 |
| Nevada | WRAP | 179.3334 | 408.0758 | 20,978 | 47,404 | 31,172 |
| New Mexico | WRAP | 155.2294 | 344.7868 | 32,965 | 74,010 | 52,917 |
| North Dakota | WRAP | 131.5025 | 297.0199 | 31,745 | 71,711 | 108,645 |
| Oregon | WRAP | 109.6842 | 255.3128 | 4,968 | 11,330 | 10,034 |
| South Dakota | WRAP | 16.3929 | 36.8730 | 6,457 | 14,574 | 12,085 |
| Utah | WRAP | 146.1278 | 330.1164 | 26,905 | 60,782 | 37,819 |
| Washington | WRAP | 155.7190 | 362.9219 | 11,625 | 26,379 | 12,236 |
| Wyoming | WRAP | 202.3566 | 457.1643 | 35,935 | 81,182 | 40,265 |
| | **WRAP Total** | **2,459.9843** | **5,638.9652** | **266,628** | **602,390** | **480,488** |
| **National Total** | | **15,313.0609** | **33,938.8226** | **998,994** | **2,224,779** | **4,770,490** |

## 2.7 MANE-VU Sponsored CAIR Plus IPM Modeling

Using the IPM Phase II RPO modeling platform MANE-VU contracted with ICF to evaluate the impact of both tightening the $SO_2$ and $NO_x$ CAIR caps and to expand the CAIR region to include the electricity generating sector in additional states the Eastern United States. As part of this analysis, ICF developed a new Base Case that implemented EPA’s CAIR, CAMR and CAVR policies and a Policy Case with lower $SO_2$ and $NO_x$ CAIR caps in an extended region. The new Base Case was developed for comparison to the Policy Case. The model assumptions and data used in this analysis are somewhat different than those in the RPO Phase II analysis and are described in Section B of the project report (ICF, 2007). Neither the base or policy cases from the CAIR Plus project were used in subsequent SIP modeling.

# 3 POST PROCESSING OF IPM OUTPUT

## 3.1 Use of SMOKE Emissions Processing Model

On behalf of MANE-VU, NESCAUM modelers used an emissions processing model to prepare data produced by the IPM model for use in air quality and visibility modeling. The Sparse Matrix Operator Kernel Emissions (SMOKE) Modeling System is an emissions processing system designed to create gridded, speciated, hourly emissions for input into a variety of air quality models, such as EPA's Community Multi-Scale Air Quality (CMAQ) model and Regional Modeling System for Aerosols and Deposition (REMSAD) (Houyoux, et. al., 2000). SMOKE supports area, biogenic, mobile (both onroad and nonroad), and point source emissions processing for criteria, particulate, and toxic pollutants. For biogenic emissions modeling, SMOKE uses the Biogenic Emission Inventory System, version 2.3 (BEIS2) and version 3.09 and 3.12 (BEIS3). SMOKE is also integrated with the onroad emissions model MOBILE6.

The sparse matrix approach used throughout SMOKE permits rapid and flexible processing of emissions data. Flexible processing comes from splitting the processing steps of inventory growth, controls, chemical speciation, temporal allocation, and spatial allocation into independent steps whenever possible. The results from these steps are merged together in the final stage of processing using vector-matrix multiplication. It allows individual steps (such as adding a new control strategy, or processing for a different grid) to be performed and merged without having to redo all of the other processing steps. Individual emission scenarios were simulated for MANE-VU using the SMOKE Modeling System.

The Northeast States for Coordinated Air Use Management (NESCAUM), on behalf of MANE-VU and its participating States, conducted regional air quality simulations for calendar year 2002 and several future periods (NESCAUM, 2008). This work was directed at satisfying a number of goals under the Haze State Implementation Plan (SIP), including a contribution assessment, a pollution apportionment for 2018, and the evaluation of visibility benefits of control measures being considered for achieving reasonable progress goals and establishing a long-term emissions management strategy for MANE-VU Class I areas. The modeling tools utilized for these analyses include the Fifth-Generation NCAR / Penn State Mesoscale **Model** (MM5), SMOKE, CMAQ and REMSAD, and incorporate tagging features that allow for the tracking of individual source regions or measures. These tools have been evaluated and found to perform adequately relative to U.S. EPA modeling guidance.

As described below, in order for NESCAUM to process the Electric Generating Unit (EGU) emissions generated by the Integrated Planning Model® (IPM) procedures noted above, a series of intermediate steps were required to get the activity and emission data into the appropriate format for SMOKE processing.

## 3.2 Preparing IPM Output for Use in SMOKE Model

IPM can produce projections at the regional, state, plant, or unit level. Data must be parsed to provide the unit level information required for chemical transport modeling. Parsing involves developing detailed unit level information from the model's projections at the model plant level. ICF parsed the VISTASII_PC_1f data for use by the RPOs.

Further post-processing of IPM parsed output is needed to prepare the files for use by the SMOKE emissions processing model. The following sections describe the intermediate steps necessary to make these conversions. The first step is the augmentation of the IPM parsed output files to include additional unit level characteristics and pollutant estimates necessary for one atmosphere modeling. This step converts the IPM parsed data files into EPA's National Emission Inventory Input Format (NIF). The second step is the additional conversion of these NIF files into the Inventory Data Analyzer (IDA) format required by the SMOKE emissions processor.

### *3.2.1 IPM to NIF*

After running IPM, ICF provided an initial spreadsheet file containing unit-level records for both:

(1) "existing" units (those currently in operation during the modeled base year) and
(2) committed/planned or new generic aggregates (new generic units expected to come online or identified as needed to meet electric generation demand in a geographic area).

IPM parsed file records include unit and fuel type data; existing, retrofit (for $SO_2$ and $NO_x$), and separate $NO_x$ control information; annual $SO_2$ and $NO_x$ emissions and heat input; summer season (May-September) $NO_x$ and heat input; July day $NO_x$ and heat input; coal heat input by coal type; nameplate capacity megawatt (MW), and State FIPS codes (Federal Information Processing codes used to identify geographic areas). Existing units also had county FIPS code, a unique plant identifier (ORISPL) and unit ID (also called boiler ID) (BLRID); generic units did not have these data.

The processing of IPM parsed data to NIF format included estimating emissions not generated by IPM and adding control efficiencies, stack parameters, latitude-longitude coordinates, and State identifiers (plant ID, point ID, stack ID, process ID) from a series of lookup tables or by matching to individual units as configured in base year 2002 emission files (Pechan, 2005). Additionally, new generic units created by IPM were sited in a county and given appropriate IDs. This processing is described in more detail below.

<u>Generic Units:</u> The new generic units and associated data were prepared by transforming the generic aggregates into units similar in size and fuel to existing units in terms of the available data. Generic aggregates were split into smaller generic units based on their unit types and capacity. Each generic unit was provided a dummy ORIS unique plant and boiler ID, and were given a county FIPS code based on an algorithm that sited each generic unit by assigning a sister plant that is in a county based on its attainment/nonattainment status. Within a State, existing plants (in county then ORIS plant code order) in attainment counties were used first as sister sites to new generic units (to obtain county location), followed by existing plants in PM nonattainment counties, followed by existing plants in 8-hour ozone nonattainment counties. No States identified counties that should not be considered when siting new generic units, so this process was identical to the one used for EPA IPM post-processing under CAIR.

SCCs were assigned to existing units using unit/fuel/firing/bottom type data. SCCs were assigned to generic units using unit and fuel type information. Latitude-longitude coordinates were assigned, first using the EPA-provided data files, secondly using an in-house contractor developed latitude-longitude file, and lastly using county centroids. These additional location files were only used when the data were not provided in the original 2002 base year files. Stack parameters were then assigned to each unit, first using the EPA-provided data files, secondly using an in-house stack parameter file based on previous EIA-767 data, and lastly using an EPA June 2003 SCC-based default stack parameter file. These data were only used when the data were not provided in the 2002 base year files.

IPM does not calculate emissions for all pollutants necessary for regional haze modeling. Therefore additional data were required to estimate VOC, CO, filterable primary $PM_{10}$ and $PM_{2.5}$, PM condensable, and $NH_3$ emissions. Thus, ash and sulfur contents were assigned by first using 2002 EIA-767 values for existing units or SCC-based defaults; filterable $PM_{10}$ and $PM_{2.5}$ efficiencies were obtained from the 2002 EGU NEI that were based on 2002 EIA-767 control data and the PM Calculator program (a default of 99.2 percent is used for coal units if necessary); fuel use was back calculated from the given heat input and a default SCC-based heat content; and emission factors were obtained from an EPA-approved emission factor file based on AP-42 emission factors. Table 2 presents the SCC-based default heat content and stack parameters used when actual data were not available. Table 3 (worksheet sccemfac100704 from MRPOpostprocdatafiles.xls, Pechan 2005) reflects emission factors used to develop emission estimates of CO, VOC, filterable PM, and $NH_3$.

**Table 2.** SCC Default Heat Content and Stack Parameters from IPM to NIF Conversion.

| | | | Stack Parameters | | | |
|---|---|---|---|---|---|---|
| **SCC** | **Fuel** | **Heat Content (Btu/SCC Unit)** | **Height (ft)** | **Diameter (ft)** | **Temp (degrees F)** | **Velocity (ft/s)** |
| 10100201 | Bituminous Coal | 23.4286 | 603.2 | 19.8 | 281.2 | 76.5 |
| 10100202 | Bituminous Coal | 23.4286 | 509.7 | 14.6 | 226.0 | 62.0 |
| 10100203 | Bituminous Coal | 23.4286 | 491.6 | 16.6 | 278.4 | 80.5 |
| 10100204 | Bituminous Coal | 23.4286 | 225.0 | 0.6 | 67.2 | 2.4 |
| 10100211 | Bituminous Coal | 23.4286 | 0.0 | 0.0 | 0.0 | 0.0 |
| 10100212 | Bituminous Coal | 23.4286 | 445.6 | 17.4 | 275.2 | 77.6 |
| 10100217 | Bituminous Coal | 23.4286 | 399.3 | 10.8 | 245.6 | 40.1 |
| 10100221 | Subbituminous Coal | 17.8870 | 983.0 | 22.8 | 350.0 | 110.0 |
| 10100222 | Subbituminous Coal | 17.8870 | 468.5 | 16.0 | 254.7 | 65.6 |
| 10100223 | Subbituminous Coal | 17.8870 | 446.8 | 15.9 | 308.0 | 93.6 |
| 10100224 | Subbituminous Coal | 17.8870 | 255.5 | 10.0 | 251.3 | 15.3 |
| 10100226 | Subbituminous Coal | 17.8870 | 495.8 | 18.9 | 259.2 | 91.2 |
| 10100238 | Subbituminous Coal | 17.8870 | 600.0 | 22.5 | 315.0 | 78.0 |
| 10100301 | Lignite Coal | 12.9149 | 427.5 | 22.3 | 232.8 | 74.2 |
| 10100302 | Lignite Coal | 12.9149 | 483.5 | 21.0 | 229.4 | 92.4 |
| 10100303 | Lignite Coal | 12.9149 | 462.0 | 21.7 | 271.3 | 72.5 |
| 10100317 | Lignite Coal | 12.9149 | 326.7 | 12.3 | 326.7 | 74.7 |
| 10100601 | Natural Gas | 1023.8846 | 263.9 | 10.3 | 236.0 | 46.9 |
| 10100801 | Coke | 27.4376 | 371.3 | 5.5 | 122.4 | 20.4 |
| 10102018 | Waste Coal | 12.0929 | 0.0 | 0.0 | 0.0 | 0.0 |
| 20100201 | Natural Gas | 1023.8846 | 62.0 | 10.0 | 585.3 | 61.3 |
| 20100301 | Gasified Coal | 1023.8846 | 62.0 | 10.0 | 585.3 | 61.3 |

**Table 3.** EPA-Approved Emission Factor File for CO, VOC, filterable PM, and $NH_3$.

| SCC | FUEL | COEF | VOCEF | PM10EF | PM25EF | NH3EF | PMFLAG |
|---|---|---|---|---|---|---|---|
| 10100201 | BIT | 0.5000 | 0.0400 | 2.6000 | 1.4800 | 0.030 | A |
| 10100202 | BIT | 0.5000 | 0.0600 | 2.3000 | 0.6000 | 0.030 | A |
| 10100203 | BIT | 0.5000 | 0.1100 | 0.2600 | 0.1100 | 0.030 | A |
| 10100204 | BIT | 5.0000 | 0.0500 | 13.2000 | 4.6000 | 0.030 | |
| 10100211 | BIT | 0.5000 | 0.0400 | 2.6000 | 1.4800 | 0.030 | A |
| 10100212 | BIT | 0.5000 | 0.0600 | 2.3000 | 0.6000 | 0.030 | A |
| 10100217 | BIT | 18.0000 | 0.0500 | 12.4000 | 1.3640 | 0.030 | |
| 10100221 | SUB | 0.5000 | 0.0400 | 2.6000 | 1.4800 | 0.030 | A |
| 10100222 | SUB | 0.5000 | 0.0600 | 2.3000 | 0.6000 | 0.030 | A |
| 10100223 | SUB | 0.5000 | 0.1100 | 0.2600 | 0.1100 | 0.030 | A |
| 10100224 | SUB | 5.0000 | 0.0500 | 13.2000 | 4.6000 | 0.030 | |
| 10100226 | SUB | 0.5000 | 0.0600 | 2.3000 | 0.6000 | 0.030 | A |
| 10100238 | SUB | 18.0000 | 0.0500 | 16.1000 | 4.2000 | 0.030 | |
| 10100301 | LIG | 0.2500 | 0.0700 | 1.8170 | 0.5214 | 0.030 | A |
| 10100302 | LIG | 0.6000 | 0.0700 | 2.3000 | 0.6600 | 0.030 | A |
| 10100303 | LIG | 0.6000 | 0.0700 | 0.8710 | 0.3690 | 0.030 | A |
| 10100317 | LIG | 0.1500 | 0.0300 | 12.0000 | 1.4000 | 0.030 | |
| 10100601 | NG | 84.0000 | 5.5000 | 1.9000 | 1.9000 | 3.200 | |
| 10100801 | PC | 0.6000 | 0.0700 | 7.9000 | 4.5000 | 0.397 | A |
| 10102018 | WC | 0.1500 | 0.0300 | 12.0000 | 1.4000 | 0.030 | |
| 20100201 | NG | 83.8628 | 2.1477 | 1.9380 | 1.9380 | 6.560 | |
| 20100301 | IGCC | 34.6500 | 2.2050 | 11.5500 | 11.5500 | 6.560 | |

Notes:

1. SCCs beginning with 101002 (coal), 101003 (coal), 101008 (coke), or 101020 (waste coal), emission factors in LB/TON; SCCs beginning with 101006 (natural gas), 201002 (natural gas), or 201003 (IGCC), emission factors are in LB/E6FT3.
2. If PMFLAG = 'A', then multiply ash content with PM emission factor.

Source: Table derived from worksheet sccemfac100704 from MRPOpostprocdatafiles.xls, Pechan 2005.

<u>Condensable PM:</u> To estimate total primary PM emissions, additional calculations were conducted to derive condensable PM emissions from these sources. In MANE VU and VISTAS PM condensable emissions were calculated based on factors derived from AP-42 defaults. In MRPO no condensable emissions were estimated or included in the inventory. (Janssen, 2008) Table 4 (worksheet pmcdef from MRPOpostprocdatafiles.xls, Pechan 2005) shows these PM condensable emission factors and SCC assignments.

**Table 4.** EPA-Approved Condensable PM Emission Factor Assignment.

| SCC | PMCDEF (LB/E6BTU) |
|---|---|
| 10100201, 10100202, 10100203, 10100211, 10100212, 10100221, 10100222, 10100223, 10100226, 10100301, 10100302, 10100303 | 0.0200[2] |
| 10100201, 10100202, 10100203, 10100211, 10100212, 10100221, 10100222, 10100223, 10100226, 10100301, 10100302, 10100303 [1] | (0.1 * sulfur content - 0.03)[3] |
| 10100204, 10100224 | 0.0400 |
| 10100217, 10100238, 10100317, 10102018 | 0.0100 |
| 10100601 | 0.0057 |
| 10100801 | 0.0100 |
| 20100201, 20100301 | 0.0047 |
| Notes: | |
| 1. If the emission factor is less than 0.01, then it is set equal to 0.01. | |
| 2. AND there is either an $SO_2$ FGD or a PM scrubber (for MRPO post-processing); or AND there is an $SO_2$ wet FGD (for EPA post-processing). | |
| 3. AND there is any PM control other than a scrubber and there is no $SO_2$ control (for MRPO post-processing); or AND there is any control other than an $SO_2$ wet FGD (for EPA post-processing). | |

Source: Table derived from worksheet pmcdef from MRPOpostprocdatafiles.xls, Pechan 2005.

Additional Pollutants: As noted above, in processing IPM parsed data to convert it to NIF format, emissions of additional pollutants were estimated. Emissions for 28 temporal-pollutant combinations were estimated since there are seven pollutants (VOC, CO, primary $PM_{10}$ and $PM_{2.5}$, $NH_3$, $SO_2$ and $NO_x$) and four temporal periods (annual, summer season, winter season, July day).

Crosswalk Match to 2002 Inventory: The final step in the IPM to NIF conversion process was to match the IPM unit IDs with the identifiers in the base year 2002 inventory for existing EGUs. A crosswalk file was used to obtain FIPS State and county, plant ID (within State and county), and point ID. If the FIPS State and county, plant ID and point ID were in the 2002 base year NIF tables, then the process ID and stack ID were obtained from the NIF; otherwise, defaults, described above, were used.

The post-processed files were then provided in NIF 3.0 format. Two sets of tables were developed : "NIF files" for IPM units that had a crosswalk match and were in the 2002 base year inventory, and "NoNIF files" for IPM units that were not in the 2002 base year inventory (which included existing units with or without a crosswalk match as well as generic units). Two special cases relating to the crosswalk match were handled as follows:

1. One-to-many match: At a given plant, if one IPM boiler ID was matched to more than one point ID, the boiler data were put on the first point ID records; records from the other point IDs were deleted from the relevant tables.

2. Many-to-one match: At a given plant, if more than one IPM boiler ID was matched to one point ID, all the boilers' emissions (tons), throughput (really heat input in MMBtu), and capacity (MW) were summed ("summed boiler") and put on that point

ID's records in the relevant tables. The values for stack parameters and latitude-longitude values were those from the first record summed.

### 3.3 State Results – Phase II Augmented

Summarizing the results of the estimation of additional pollutants, Table 5 presents additional pollutant augmented State level emission results from the 2018 Inter-RPO CAIR Case IPM v. 2.1.9 fossil-only parsed file (VISTASII_PC_1f with pollutant augmentation; found in modeling file *ida_egu_18_basef_2453605.txt* from VISTAS BaseF). A comparison of RPO totals for $SO_2$ and $NO_x$ shows that these are the same as presented in Table 1.

### 3.4 NIF to IDA

The main purpose of the SMOKE conversion task was to convert EGU emission inventories provided in NIF format into the IDA format required by the SMOKE model for the criteria pollutants VOC, $NO_x$, CO, $SO_2$, $PM_{10}$, $PM_{2.5}$, and $NH_3$. Annual and seasonal emissions were taken directly from the NIF structured inventories with no alternate temporal calculations performed (e.g., estimate seasonal emissions from annual or annual from seasonal). The temporal allocation module of the SMOKE emissions processor was intended to be used to further define temporal distribution of these emissions.

No quality assurance (QA) related to the reported values in the NIF files was conducted (e.g., it was assumed that reported emission levels were correct) and therefore the QA focus was to maintain the integrity of the mass files in the conversion to IDA.

Each set of NIF structured data had a unique set of relational tables necessary to maintain the information required in each source sector based on its reporting requirements. Conversion scripts to read the information from each of these relational data sets and convert them to the IDA structures required by this task were implemented by Alpine (Alpine, 2006). Prior to and after the conversion from NIF to IDA, a list of emission summary reports was developed to check that the emissions input into the conversion process were the same as output into the IDA formatted files.

**Table 5.** State Level Emission Summary; 2018 VISTASII_PC_1f with Pollutant Augmentation. Modeling file *ida_egu_18_basef_2453605.txt* from VISTAS BaseF. (fossil-only)

| | | **Annual Emissions (Tons)** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **IPM Generated** | | **Augmented Pollutants** | | | | |
| **State** | **RPO** | **NOx** | **SO2** | **VOC** | **CO** | **PM-10** | **PM-2.5** | **NH3** |
| Connecticut | MANE-VU | 3,418 | 6,697 | 145 | 9,837 | 959 | 927 | 341 |
| Delaware | MANE-VU | 12,341 | 35,442 | 117 | 1,183 | 2,950 | 2,438 | 76 |
| District Of Columbia | MANE-VU | 103 | 83 | 5 | 154 | 104 | 99 | 12 |
| Maine | MANE-VU | 1,827 | 5,436 | 53 | 4,057 | 296 | 279 | 139 |
| Maryland | MANE-VU | 14,709 | 28,065 | 575 | 11,831 | 8,253 | 6,433 | 435 |
| Massachusetts | MANE-VU | 18,157 | 17,486 | 484 | 13,860 | 3,918 | 3,233 | 1,059 |
| New Hampshire | MANE-VU | 3,089 | 7,469 | 73 | 1,697 | 2,268 | 2,156 | 124 |
| New Jersey | MANE-VU | 13,636 | 32,495 | 352 | 7,611 | 4,017 | 3,515 | 564 |
| New York | MANE-VU | 24,376 | 51,445 | 758 | 22,242 | 11,031 | 9,343 | 1,472 |
| Pennsylvania | MANE-VU | 82,881 | 135,946 | 1,920 | 41,445 | 31,580 | 23,756 | 1,790 |
| Rhode Island | MANE-VU | 576 | 55 | 42 | 1,627 | 157 | 156 | 127 |
| Vermont | MANE-VU | 105 | 35 | 3 | 117 | 26 | 25 | 9 |
| | **MANE-VU Total** | **175,218** | **320,651** | **4,528** | **115,659** | **65,558** | **52,360** | **6,148** |
| Alabama | VISTAS | 41,714 | 190,029 | 1,599 | 27,888 | 20,401 | 15,936 | 2,009 |
| Florida | VISTAS | 56,506 | 139,526 | 2,027 | 58,982 | 24,804 | 18,403 | 3,948 |
| Georgia | VISTAS | 56,180 | 178,196 | 1,940 | 33,040 | 25,929 | 19,087 | 2,374 |
| Kentucky | VISTAS | 64,099 | 229,596 | 1,623 | 17,103 | 24,659 | 18,813 | 782 |
| Mississippi | VISTAS | 8,895 | 27,226 | 511 | 12,228 | 7,270 | 4,358 | 918 |
| North Carolina | VISTAS | 57,774 | 102,217 | 1,232 | 14,386 | 31,797 | 26,551 | 847 |
| South Carolina | VISTAS | 46,318 | 118,584 | 932 | 11,263 | 26,740 | 22,629 | 793 |
| Tennessee | VISTAS | 29,873 | 112,343 | 922 | 7,391 | 15,008 | 12,988 | 449 |
| Virginia | VISTAS | 43,144 | 80,602 | 863 | 16,482 | 19,652 | 17,300 | 881 |
| West Virginia | VISTAS | 51,208 | 124,464 | 1,447 | 12,946 | 23,538 | 16,968 | 721 |
| | **VISTAS Total** | **455,711** | **1,302,784** | **13,096** | **211,709** | **219,798** | **173,034** | **13,722** |
| Illinois | MRPO | 71,233 | 241,136 | 2,229 | 17,868 | 32,650 | 30,132 | 1,152 |
| Indiana | MRPO | 95,376 | 376,864 | 2,105 | 19,416 | 35,082 | 27,835 | 1,274 |
| Michigan | MRPO | 98,685 | 398,562 | 1,623 | 17,522 | 38,902 | 34,276 | 1,091 |
| Ohio | MRPO | 83,129 | 215,501 | 2,254 | 23,832 | 42,754 | 33,323 | 1,773 |
| Wisconsin | MRPO | 45,701 | 155,369 | 1,101 | 11,901 | 15,629 | 14,246 | 626 |
| | **MRPO Total** | **394,124** | **1,387,432** | **9,312** | **90,539** | **165,016** | **139,813** | **5,915** |
| Arkansas | CENRAP | 33,097 | 82,605 | 696 | 11,429 | 3,897 | 3,326 | 814 |
| Iowa | CENRAP | 51,119 | 147,305 | 770 | 8,759 | 10,033 | 8,615 | 569 |
| Kansas | CENRAP | 83,333 | 81,486 | 798 | 7,203 | 8,520 | 6,807 | 461 |
| Louisiana | CENRAP | 30,432 | 74,263 | 660 | 11,043 | 3,966 | 3,590 | 919 |
| Minnesota | CENRAP | 41,029 | 85,847 | 674 | 5,563 | 8,162 | 7,034 | 343 |
| Missouri | CENRAP | 77,660 | 280,887 | 1,579 | 13,165 | 18,456 | 16,769 | 800 |
| Nebraska | CENRAP | 50,781 | 73,629 | 450 | 3,590 | 2,296 | 1,915 | 217 |
| Oklahoma | CENRAP | 76,048 | 113,680 | 1,008 | 28,182 | 5,561 | 4,840 | 1,355 |
| Texas | CENRAP | 153,837 | 339,433 | 4,988 | 102,583 | 38,952 | 31,631 | 6,424 |
| | **CENRAP Total** | **597,336** | **1,279,135** | **11,622** | **191,518** | **99,842** | **84,528** | **11,902** |
| Arizona | WRAP | 81,858 | 60,640 | 1,170 | 29,037 | 11,515 | 9,644 | 2,189 |
| California | WRAP | 23,767 | 5,447 | 1,496 | 56,188 | 5,442 | 5,337 | 4,402 |
| Colorado | WRAP | 70,171 | 87,163 | 667 | 12,139 | 4,751 | 4,166 | 609 |
| Idaho | WRAP | 718 | 0 | 36 | 1,398 | 113 | 113 | 109 |
| Montana | WRAP | 38,504 | 22,066 | 326 | 3,035 | 7,217 | 4,636 | 193 |
| Nevada | WRAP | 47,404 | 31,172 | 479 | 9,862 | 5,244 | 4,315 | 750 |
| New Mexico | WRAP | 74,010 | 52,916 | 554 | 5,991 | 13,435 | 7,637 | 388 |
| North Dakota | WRAP | 71,711 | 108,645 | 784 | 9,937 | 5,670 | 4,757 | 324 |
| Oregon | WRAP | 11,330 | 10,034 | 276 | 9,322 | 1,311 | 1,305 | 722 |
| South Dakota | WRAP | 14,574 | 12,085 | 110 | 536 | 362 | 297 | 33 |
| Utah | WRAP | 60,782 | 37,819 | 423 | 3,523 | 6,459 | 4,881 | 211 |
| Washington | WRAP | 26,379 | 12,236 | 451 | 11,848 | 3,780 | 3,192 | 898 |
| Wyoming | WRAP | 81,182 | 40,265 | 678 | 5,672 | 8,537 | 7,116 | 341 |
| | **WRAP Total** | **602,389** | **480,488** | **7,449** | **158,487** | **73,834** | **57,395** | **11,170** |
| **National Total** | | **2,224,778** | **4,770,490** | **46,007** | **767,912** | **624,049** | **507,129** | **48,857** |

# 4 MODIFICATIONS BY OTHER REGIONS

## 4.1 Emission Control Modifications within VISTAS, MRPO, and CENRAP

State and local agencies and invited stakeholders from VISTAS, MRPO, and CENRAP reviewed the results of the Inter-RPO Phase II set of IPM runs. These stakeholders primarily reviewed and commented on the IPM results with respect to IPM decisions on $NO_x$ post-combustion controls and $SO_2$ scrubbers and provided additional information on when and where new $SO_2$ and $NO_x$ controls were planned to come online based on the best available data from state rules, enforcement agreements, compliance plans, permits, and discussions/commitments from individual companies. They also reviewed the IPM results to verify that known and existing controls and emission rates were properly reflected in the IPM runs. After considering comments, adjustments to the IPM results were made to specific units using any new information they had as part of the permitting process or other contact with the industry that indicated which units would install controls as a result of CAIR and when these new controls would come on-line (MACTEC, 2007; MRPO 2006; ENVIRON 2007).

As described in the following section, some entities specified changes to the controls assigned by IPM to reflect their best estimates of emission control levels. These changes typically involved either 1) adding selective catalytic reduction (SCR) or scrubber controls to units where IPM did not predict SCR or scrubber controls, or 2) removing IPM-assigned SCR or scrubber controls at units where the commenting entity indicated there were no firm plans for controls at those units.

At this point in the process MANE-VU decided not to make any changes to the northeastern state IPM output regardless of state knowledge of discrepancies with actual conditions. MANE-VU determined that IPM provided a reasonable estimate of the impact of the CAIR cap and trade program consistent with methods used by EPA, and planners were concerned that adjustments would not reflect the allocation of ALL allowed emissions under CAIR.

In MANE-VU’s final modeling, many of the changes made by the other RPOs were included, but due to the timing of the release of revised data, the location with respect to the modeling domain, and need to progress with modeling, MANE-VU did not incorporate changes reflected in the final CENRAP EGU files.

## 4.2 Emission Factor and Control Modifications for VISTAS Emission Sources

VISTAS reviewed the PM and $NH_3$ emissions from its States’ EGUs provided after the original IPM to NIF conversation conducted for the RPOs and identified significantly higher emissions in 2009/2018 than in 2002. VISTAS determined this conversion used a set of PM and $NH_3$ emission factors that were “the most recent EPA approved uncontrolled emission factors” for estimating 2009/2018 EGU emissions but were most likely not the same emission factors used by States for estimating these emissions in 2002. Thus, the emission increase from 2002 to 2009/2018 was simply an artifact of the change in emission factors, not anything to do with changes in activity or control technology application. During this review, VISTAS additionally identified an inconsistent use of SCCs for determining emission factors between the base and future years.

Documentation (Alpine, 2005a, b) indicates that VISTAS adjusted the 2002 base year emissions inventory to account for these discrepancies in base year and future year PM and $NH_3$ emission factor use. Using the latest "EPA-approved" uncontrolled emission factors by SCC, Alpine utilized data collected under EPA's Consolidated Emissions Reporting Rule (CERR) or data reported by VISTAS. Alpine used reported annual heat input, fuel throughput, heat, ash, and sulfur content to estimate annual uncontrolled emissions for units identified as output by IPM. This step was conducted for non-CEM pollutants (CO, VOC, PM, and $NH_3$) only. For PM emissions, the condensable component of emissions was calculated and added to the resulting PM primary estimations. The resulting emissions were then adjusted by any control efficiency factors reported in the CERR or VISTAS data collection effort. The second adjustment was to the future year inventories. Alpine updated the SCCs in the future year inventory to assign the same base year SCC. Using the same methods as described for the 2002 revisions, those non-IPM generated pollutants were estimated using IPM predicted fuel characteristics and base year 2002 SCC assignments.

In addition to the changes to the emission factor assignments, SCC, and IPM-assigned controls, VISTAS also specified other changes to the IPM results or converted IPM to NIF files. Comments on changes in stack parameters from the 2002 inventory were implemented in the converted files for the 2018 inventory. Changes to stack parameters were also made in cases where new controls were scheduled to be installed. In cases where an emission unit was projected to have an $SO_2$ scrubber by 2018, some States were able to provide revised stack parameters for some units based on design features for the new control system. Other units projected to install scrubbers by 2018 were not far enough along in the design process to have specific design details. For those units, VISTAS made the following assumptions: 1) the scrubber is a wet scrubber; 2) keep the current stack height the same; 3) keep the current flow rate the same, and 4) change the stack exit temperature to 169 degrees F (this is the virtual temperature derived from a wet temperature of 130 degrees F) (MACTEC, 2007). VISTAS determined that exit temperature (wet) of 130 degrees F +/- 5 degrees F is representative of different size units and wet scrubber technology.

## 4.3 Emission Inventory Replacement within WRAP Domain

During the development of their EGU emission forecast, the western states RPO (WRAP) conducted an exercise where IPM was not used to prepare emission estimates from EGU sources. Using capacity factor adjustments and emission control assumptions, WRAP developed a forecast of EGU emissions based on its initial 2002 base year inventory (ERG, 2006). This revised forecast was used by many of the RPOs and replaced the emissions generated for the domain by IPM. This change by WRAP is reflected in the difference in State emission totals between Tables 5 and 6. As WRAP is outside the MANE VU modeling domain, this change was not reflected in MANE-VU modeling. MANE-VU did not change its boundary conditions to reflect this change.

## 4.4 Eliminating Double Counting of EGU Units

An additional set of procedures was used by MANE-VU and VISTAS to avoid double counting of EGU emissions in the 2018 point source inventory (MACTEC, 2006, 2007). Since each

RPO’s 2002 emissions inventory file contained both EGUs and non-EGU point sources, and EGU emissions were projected using IPM, it was necessary to split the 2002 point source file into two components. The first component contained those emission units accounted for in the IPM forecasts. The second component contained all other point sources not accounted for in IPM.

As described in the previous section, 2018 NIF files for EGUs were prepared from the IPM parsed files. All IPM matched units were initially removed from the 2018 point source inventory to create the non-EGU inventory (which was projected to 2018 using non-EGU growth and control factors). This was done on a unit-by-unit basis based on a cross-reference table that matched IPM emission unit identifiers (ORISPL plant code and BLRID emission unit code) to NIF emission unit identifiers (FIPSST state code, FIPSCNTY county code, State Plant ID, State Point ID). When there was a match between the IPM ORISPL/BLRID and the emission unit ID, the unit was assigned to the EGU inventory; all other emission units were assigned to the non-EGU inventory.

If an emission unit was contained in the NIF files created from the IPM output, the corresponding unit was removed from the initial 2018 point source inventory. For VISTAS, the NIF 2018 EGU files from the IPM parsed files were then merged with the non-EGU 2018 files to create a complete 2018 point source scenario.

Next, several ad-hoc QA/QC queries were done to verify that there was no double-counting of emissions in the EGU and non-EGU inventories:

- The IPM parsed files were reviewed to identify EGUs accounted for in IPM. This list of emission units was compared to the non-EGU inventory derived from the IPM-NIF cross-reference table to verify that units accounted for in IPM were not double-counted in the non-EGU inventory. As a result of this comparison, a few adjustments were made in the cross-reference table to add emission units for plants to ensure these units accounted for in IPM were moved to the EGU inventory.

- The non-EGU inventory was further reviewed to identify remaining emission units with an Standard Industrial Classification (SIC) code of “4911 Electrical Services” or Source Classification Code of “1-01-xxx-xx External Combustion Boiler, Electric Generation”. The list of sources meeting these selection criteria were compared to the IPM parsed file to ensure that these units were not double-counted.

- VISTAS invited various stakeholder groups to review the 2018 point source inventory to verify whether there was any double counting of EGU emissions. In some instances, corrections were provided where an emission unit was double counted.

### 4.5 Preliminary Results from Phase II Additional Modifications

Table 6 summarizes the Base G emissions inventory for EGUs, presenting State level emission results from the 2018 Inter-RPO CAIR Case IPM v. 2.1.9 parsed file modified by VISTAS, MRPO, and WRAP per the methods noted in the above sections. Note that no changes occurred to the MANE-VU state emissions as a result of these changes.

**Table 6.** State Level Emission Summary; 2018 VISTAS Base G Modeling file ptinv_egu_2018_11sep2006.txt. Based on 2018 VISTASII_PC_1f (fossil-only) with adjustments from VISTAS, MRPO, and WRAP.

| | | **Annual Emissions (Tons)** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **State** | **RPO** | **NOx** | **SO2** | **VOC** | **CO** | **PM-10** | **PM-2.5** | **NH3** |
| Connecticut | MANE-VU | 3,418 | 6,697 | 145 | 9,836 | 959 | 927 | 341 |
| Delaware | MANE-VU | 12,341 | 35,442 | 117 | 1,183 | 2,950 | 2,438 | 76 |
| District Of Columbia | MANE-VU | 103 | 83 | 5 | 154 | 104 | 99 | 12 |
| Maine | MANE-VU | 1,827 | 5,436 | 53 | 4,057 | 296 | 279 | 139 |
| Maryland | MANE-VU | 14,709 | 28,065 | 575 | 11,831 | 8,253 | 6,433 | 435 |
| Massachusetts | MANE-VU | 18,157 | 17,486 | 484 | 13,860 | 3,917 | 3,233 | 1,059 |
| New Hampshire | MANE-VU | 3,089 | 7,469 | 73 | 1,697 | 2,268 | 2,156 | 124 |
| New Jersey | MANE-VU | 13,636 | 32,495 | 352 | 7,611 | 4,017 | 3,515 | 564 |
| New York | MANE-VU | 24,376 | 51,445 | 758 | 22,242 | 11,031 | 9,343 | 1,471 |
| Pennsylvania | MANE-VU | 82,881 | 135,946 | 1,919 | 41,446 | 31,580 | 23,756 | 1,790 |
| Rhode Island | MANE-VU | 576 | 55 | 42 | 1,627 | 157 | 156 | 127 |
| Vermont | MANE-VU | 105 | 35 | 3 | 117 | 26 | 25 | 9 |
| | **MANE-VU Total** | **175,219** | **320,651** | **4,528** | **115,660** | **65,558** | **52,360** | **6,148** |
| Alabama | VISTAS | 62,860 | 135,782 | 1,620 | 21,611 | 7,385 | 4,380 | 1,033 |
| Florida | VISTAS | 56,827 | 133,037 | 1,857 | 42,573 | 9,287 | 6,288 | 2,665 |
| Georgia | VISTAS | 69,308 | 226,477 | 1,805 | 35,584 | 18,217 | 11,319 | 1,676 |
| Kentucky | VISTAS | 59,740 | 211,225 | 1,344 | 12,125 | 6,194 | 4,067 | 436 |
| Mississippi | VISTAS | 10,455 | 15,143 | 1,055 | 11,822 | 7,007 | 6,853 | 545 |
| North Carolina | VISTAS | 56,526 | 96,402 | 1,147 | 16,376 | 32,676 | 26,014 | 608 |
| South Carolina | VISTAS | 50,068 | 87,202 | 860 | 13,078 | 28,110 | 24,454 | 578 |
| Tennessee | VISTAS | 30,008 | 112,353 | 886 | 7,126 | 15,861 | 13,321 | 241 |
| Virginia | VISTAS | 60,615 | 109,391 | 921 | 14,017 | 13,505 | 11,757 | 553 |
| West Virginia | VISTAS | 51,177 | 115,322 | 1,382 | 11,896 | 6,344 | 3,643 | 177 |
| | **VISTAS Total** | **507,583** | **1,242,334** | **12,877** | **186,205** | **144,586** | **112,094** | **8,513** |
| Illinois | MRPO | 71,233 | 241,136 | 2,229 | 17,868 | 32,649 | 30,132 | 1,152 |
| Indiana | MRPO | 95,376 | 351,858 | 2,105 | 19,416 | 35,081 | 27,835 | 1,274 |
| Michigan | MRPO | 78,605 | 288,006 | 1,623 | 17,521 | 38,902 | 34,276 | 1,091 |
| Ohio | MRPO | 83,129 | 215,501 | 2,254 | 23,832 | 42,753 | 33,322 | 1,772 |
| Wisconsin | MRPO | 45,701 | 155,369 | 1,101 | 11,901 | 15,629 | 14,246 | 626 |
| | **MRPO Total** | **374,044** | **1,251,871** | **9,311** | **90,539** | **165,015** | **139,812** | **5,915** |
| Arkansas | CENRAP | 33,097 | 82,605 | 696 | 11,429 | 3,897 | 3,326 | 814 |
| Iowa | CENRAP | 51,119 | 147,305 | 770 | 8,758 | 10,033 | 8,615 | 569 |
| Kansas | CENRAP | 83,333 | 81,486 | 798 | 7,203 | 8,520 | 6,807 | 461 |
| Louisiana | CENRAP | 30,432 | 74,263 | 660 | 11,043 | 3,966 | 3,590 | 919 |
| Minnesota | CENRAP | 41,029 | 85,847 | 674 | 5,563 | 8,162 | 7,035 | 343 |
| Missouri | CENRAP | 77,660 | 280,887 | 1,579 | 13,165 | 18,456 | 16,769 | 799 |
| Nebraska | CENRAP | 50,781 | 73,629 | 450 | 3,590 | 2,296 | 1,914 | 217 |
| Oklahoma | CENRAP | 76,048 | 113,680 | 1,008 | 28,182 | 5,561 | 4,840 | 1,355 |
| Texas | CENRAP | 153,837 | 339,433 | 4,988 | 102,581 | 38,952 | 31,630 | 6,424 |
| | **CENRAP Total** | **597,336** | **1,279,135** | **11,622** | **191,515** | **99,842** | **84,527** | **11,901** |
| Arizona | WRAP | 59,774 | 55,941 | 724 | 17,806 | 2,811 | 634 | 630 |
| California | WRAP | 17,537 | 1,528 | 2,558 | 31,173 | 1,219 | 1,059 | 0 |
| Colorado | WRAP | 77,113 | 60,914 | 1,465 | 18,939 | 3,138 | 307 | 537 |
| Idaho | WRAP | 2,236 | 1,683 | 50 | 3,283 | 335 | 87 | 0 |
| Montana | WRAP | 44,733 | 31,303 | 565 | 11,818 | 1,796 | 247 | 13 |
| Nevada | WRAP | 54,300 | 22,118 | 1,570 | 10,598 | 4,230 | 768 | 903 |
| New Mexico | WRAP | 32,925 | 17,796 | 695 | 10,976 | 794 | 627 | 43 |
| North Dakota | WRAP | 82,741 | 152,828 | 909 | 13,647 | 3,958 | 2,645 | 383 |
| Oregon | WRAP | 15,742 | 15,096 | 474 | 5,753 | 1,288 | 323 | 219 |
| South Dakota | WRAP | 17,681 | 13,522 | 118 | 689 | 247 | 217 | 52 |
| Utah | WRAP | 76,136 | 41,394 | 597 | 17,150 | 4,637 | 2,000 | 1,350 |
| Washington | WRAP | 16,884 | 7,011 | 249 | 4,008 | 1,474 | 1,027 | 12 |
| Wyoming | WRAP | 104,142 | 96,745 | 1,147 | 18,871 | 10,445 | 7,411 | 404 |
| | **WRAP Total** | **601,942** | **517,879** | **11,122** | **164,711** | **36,371** | **17,353** | **4,547** |
| **National Total** | | **2,256,124** | **4,611,869** | **49,460** | **748,629** | **511,371** | **406,146** | **37,024** |

### 4.6 Revised Results – VISTAS Base G2 Adjustment

VISTAS further refined their future predictions based on further state input. The resulting modeling file was called the Base G2 inventory. Table 7 presents State level emission results from the Base G2 2018 Inter-RPO CAIR Case IPM v. 2.1.9 parsed file modified by VISTAS.

Some states specified changes to the controls assigned by IPM to reflect their best estimates of emission control levels. These changes typically involved either 1) adding selective catalytic reduction (SCR) or scrubber controls to units where IPM did not predict SCR or scrubber controls, or 2) removing IPM-assigned SCR or scrubber controls at units where the commenting entity indicated their were no firm plans for controls at those units. These changes were based on those states' best available information about where and when emissions controls were expected to be installed, as well as information concerning IPM-predicted plant closures that were deemed unlikely to occur. In comparing Table 7 with Table 6, it can be seen that the changes included in the Base G2 inventory were requested by the states of Florida, Georgia, and North Carolina.

Note that no changes were made at this time by the MANE-VU states. The net effect of these changes was to reduce emissions of SO2 relative to either Table 5 or Table 6.

**Table 7.** State Level Emission Summary; 2018 VISTAS Base G2 Modeling file egu_18_vistas_g2_20feb2007.txt. Based on 2018 VISTASII_PC_1f (fossil-only) with adjustments from VISTAS, MRPO, and WRAP.

| | | **Annual Emissions (Tons)** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **State** | **RPO** | **NOx** | **SO2** | **VOC** | **CO** | **PM-10** | **PM-2.5** | **NH3** |
| Connecticut | MANE-VU | 3,418 | 6,697 | 145 | 9,836 | 959 | 927 | 341 |
| Delaware | MANE-VU | 12,341 | 35,442 | 117 | 1,183 | 2,950 | 2,438 | 76 |
| District Of Columbia | MANE-VU | 103 | 83 | 5 | 154 | 104 | 99 | 12 |
| Maine | MANE-VU | 1,827 | 5,436 | 53 | 4,057 | 296 | 279 | 139 |
| Maryland | MANE-VU | 14,709 | 28,065 | 575 | 11,831 | 8,253 | 6,433 | 435 |
| Massachusetts | MANE-VU | 18,157 | 17,486 | 484 | 13,860 | 3,917 | 3,233 | 1,059 |
| New Hampshire | MANE-VU | 3,089 | 7,469 | 73 | 1,697 | 2,268 | 2,156 | 124 |
| New Jersey | MANE-VU | 13,636 | 32,495 | 352 | 7,611 | 4,017 | 3,515 | 564 |
| New York | MANE-VU | 24,376 | 51,445 | 758 | 22,242 | 11,031 | 9,343 | 1,471 |
| Pennsylvania | MANE-VU | 82,881 | 135,946 | 1,919 | 41,446 | 31,580 | 23,756 | 1,790 |
| Rhode Island | MANE-VU | 576 | 55 | 42 | 1,627 | 157 | 156 | 127 |
| Vermont | MANE-VU | 105 | 35 | 3 | 117 | 26 | 25 | 9 |
| | **MANE-VU Total** | **175,219** | **320,651** | **4,528** | **115,660** | **65,558** | **52,360** | **6,148** |
| Alabama | VISTAS | 62,860 | 135,782 | 1,620 | 21,611 | 7,385 | 4,380 | 1,033 |
| Florida | VISTAS | 58,341 | 139,200 | 1,904 | 42,947 | 9,355 | 6,331 | 2,665 |
| Georgia | VISTAS | 69,308 | 75,051 | 1,805 | 35,584 | 18,217 | 11,319 | 1,676 |
| Kentucky | VISTAS | 59,740 | 211,225 | 1,344 | 12,125 | 6,194 | 4,067 | 436 |
| Mississippi | VISTAS | 10,455 | 15,143 | 1,055 | 11,822 | 7,007 | 6,853 | 545 |
| North Carolina | VISTAS | 56,526 | 102,680 | 1,147 | 16,376 | 32,676 | 26,014 | 608 |
| South Carolina | VISTAS | 50,068 | 87,202 | 860 | 13,078 | 28,110 | 24,454 | 578 |
| Tennessee | VISTAS | 30,008 | 112,353 | 886 | 7,126 | 15,861 | 13,321 | 241 |
| Virginia | VISTAS | 60,615 | 109,391 | 921 | 14,017 | 13,505 | 11,757 | 553 |
| West Virginia | VISTAS | 51,177 | 105,932 | 1,382 | 11,896 | 6,344 | 3,643 | 177 |
| | **VISTAS Total** | **509,098** | **1,093,959** | **12,923** | **186,579** | **144,654** | **112,137** | **8,513** |
| Illinois | MRPO | 71,233 | 241,136 | 2,229 | 17,868 | 32,649 | 30,132 | 1,152 |
| Indiana | MRPO | 95,376 | 351,858 | 2,105 | 19,416 | 35,081 | 27,835 | 1,274 |
| Michigan | MRPO | 78,605 | 288,006 | 1,623 | 17,521 | 38,902 | 34,276 | 1,091 |
| Ohio | MRPO | 83,129 | 215,501 | 2,254 | 23,832 | 42,753 | 33,322 | 1,772 |
| Wisconsin | MRPO | 45,701 | 155,369 | 1,101 | 11,901 | 15,629 | 14,246 | 626 |
| | **MRPO Total** | **374,044** | **1,251,871** | **9,311** | **90,539** | **165,015** | **139,812** | **5,915** |
| Arkansas | CENRAP | 33,097 | 82,605 | 696 | 11,429 | 3,897 | 3,326 | 814 |
| Iowa | CENRAP | 51,119 | 147,305 | 770 | 8,758 | 10,033 | 8,615 | 569 |
| Kansas | CENRAP | 83,333 | 81,486 | 798 | 7,203 | 8,520 | 6,807 | 461 |
| Louisiana | CENRAP | 30,432 | 74,263 | 660 | 11,043 | 3,966 | 3,590 | 919 |
| Minnesota | CENRAP | 41,029 | 85,847 | 674 | 5,563 | 8,162 | 7,035 | 343 |
| Missouri | CENRAP | 77,660 | 280,887 | 1,579 | 13,165 | 18,456 | 16,769 | 799 |
| Nebraska | CENRAP | 50,781 | 73,629 | 450 | 3,590 | 2,296 | 1,914 | 217 |
| Oklahoma | CENRAP | 76,048 | 113,680 | 1,008 | 28,182 | 5,561 | 4,840 | 1,355 |
| Texas | CENRAP | 153,837 | 339,433 | 4,988 | 102,581 | 38,952 | 31,630 | 6,424 |
| | **CENRAP Total** | **597,336** | **1,279,135** | **11,622** | **191,515** | **99,842** | **84,527** | **11,901** |
| Arizona | WRAP | 59,774 | 55,941 | 724 | 17,806 | 2,811 | 634 | 630 |
| California | WRAP | 17,537 | 1,528 | 2,558 | 31,173 | 1,219 | 1,059 | 0 |
| Colorado | WRAP | 77,113 | 60,914 | 1,465 | 18,939 | 3,138 | 307 | 537 |
| Idaho | WRAP | 2,236 | 1,683 | 50 | 3,283 | 335 | 87 | 0 |
| Montana | WRAP | 44,733 | 31,303 | 565 | 11,818 | 1,796 | 247 | 13 |
| Nevada | WRAP | 54,300 | 22,118 | 1,570 | 10,598 | 4,230 | 768 | 903 |
| New Mexico | WRAP | 32,925 | 17,796 | 695 | 10,976 | 794 | 627 | 43 |
| North Dakota | WRAP | 82,741 | 152,828 | 909 | 13,647 | 3,958 | 2,645 | 383 |
| Oregon | WRAP | 15,742 | 15,096 | 474 | 5,753 | 1,288 | 323 | 219 |
| South Dakota | WRAP | 17,681 | 13,522 | 118 | 689 | 247 | 217 | 52 |
| Utah | WRAP | 76,136 | 41,394 | 597 | 17,150 | 4,637 | 2,000 | 1,350 |
| Washington | WRAP | 16,884 | 7,011 | 249 | 4,008 | 1,474 | 1,027 | 12 |
| Wyoming | WRAP | 104,142 | 96,745 | 1,147 | 18,871 | 10,445 | 7,411 | 404 |
| | **WRAP Total** | **601,942** | **517,879** | **11,122** | **164,711** | **36,371** | **17,353** | **4,547** |
| **National Total** | | **2,257,639** | **4,463,494** | **49,506** | **749,003** | **511,439** | **406,189** | **37,024** |

# 5 ADDITIONAL ADJUSTMENTS BY NORTHEASTERN STATES AND MODELERS FOR REGIONAL HAZE SIP MODELING

## 5.1 Introduction

MANE VU used the G2 inventory as the basis for further adjustments that incorporated further state changes and also to represent the MANE VU control strategy for key EGUs. These modifications resulted in a) $SO_2$ emissions reductions at one MANE-VU EGU source subject to Best Available Retrofit Technology (BART) requirements, 2) emissions increases in MANE-VU to reflect states' best estimates that some sources predicted by IPM to be closed would continue to operate and information about where and when emission controls would be installed, 3) $SO_2$ emissions reductions at key EGUs (or alternative facilities) to reflect the MANE-VU EGU strategy, and 4) increases in SO2 emissions to estimate the effect of emissions trading under the CAIR program. Each of these is explained below.

## 5.2 Best Available Retrofit Technology (BART)

To assess the impacts of the implementation of the BART provisions of the Regional Haze Rule, NESCAUM included estimated reductions anticipated for BART-eligible facilities not covered by CAIR in the MANE-VU region in the 2018 CMAQ modeling analysis. A survey of state staff indicated that eight units would likely be controlled under BART alone. State-provided potential control technologies and levels of control for these sources were incorporated into the 2018 emission inventory projections used in MANE-VU's March 2008 modeling run (NESCAUM, 2008b). The eight BART-eligible units included one EGU point source in Maine (Wyman Station).

## 5.3 MANE-VU State Modifications of IPM Results

Previously, during development of the Base G and Base G2 inventories, MANE-VU states had relied on the RPO IPM model results (Base F) without revisions. In 2007, the MANE-VU states decided that they should revise the estimates, as other RPOs had done, to reflect their best estimates of future source operations and controls. State and regional staff reviewed and revised the IPM results with respect to when and where new $SO_2$ controls were planned to come online. Modifications were based on state rules, enforcement agreements, compliance plans, permits, and commitments from individual companies. States reviewed the IPM results to verify that known and existing controls and emission rates were properly reflected in the IPM results. In addition, states noted that some units predicted by IPM to close were very unlikely to cease operation.

The net effect of these adjustments was an increase in $SO_2$ emissions in the MANE-VU region as a whole. In Delaware $SO_2$ emissions decreased due to controls on a major source. Emissions in Connecticut, the District of Columbia, Rhode Island, and Vermont remained the same as predicted by RPO IPM 2.1.9 (Base F). Emissions of $SO_2$ in other MANE-VU states increased. No changes were made in emissions of other pollutants.

## 5.4 MANE-VU EGU Strategy

MANE-VU states have recognized that $SO_2$ emissions from power plants are the single largest contributing sector to visibility impairment in the Northeast's Class I areas. Sulfate formed through atmospheric processes from $SO_2$ emissions are responsible for over half the mass and approximately 70-80 percent of the extinction on the worst visibility days (NESCAUM, 2006a, and b). The emissions from power plants dominate the $SO_2$ inventory.

A modeling analysis was conducted to identify those EGUs with the greatest impact on visibility in MANE-VU. As part of the MANE VU Contribution Assessment, two MANE-VU modeling centers undertook CALPUFF modeling to identify the top 100 stacks that impacted three of the MANE VU Class I areas in the base year, 2002. These three areas are Acadia, Brigantine and Lye Brook. Details of the modeling are provided in Appendix D of the Contribution Assessment. (NESCAUM, 2006a) The 100 top stacks for each Class I area are listed in Tables 10 and 20 from Appendix D "Dispersion Model Techniques" of the Contribution Assessment.

The two modeling centers used 2002 U.S. EPA Continuous Emission Monitoring System (CEMS) data reported by the power companies, which is stack based rather than emission unit based. A power plant may have several stacks. Each stack may vent emissions from one or more units at the plant.

The two modeling centers used a different meteorological data—one used data from the MM5 model and the other used National Weather Service observation-based meteorology. There are differences between results from the two centers because of the differences in meteorological input data and also because of rounding when summing annual emissions. As a result the MM5-based modeling identified some stacks as being in the top 100 impacting a MANE-VU Class I area that were not identified by the observation-based modeling, and vice versa. For purposes of identifying key stacks, all stacks on either list were included.

MARAMA combined the lists of the top 100 EGU stacks in Tables 10 and 20 from Appendix D of the Contribution Assessment and eliminated both duplications and stacks that were outside the MANE-VU consultation area. (The consultation area includes states contributing at least 2% of the sulfate monitored at MANE-VU Class I areas in 2002.) This process resulted in 167 unique stacks impacting one or more of the three MANE-VU Class I areas. The use of stacks rather than units or facilities was chosen as more consistent with the results of the modeling presented in the Contribution Assessment. The Contribution Assessment Appendix D tables did not identify the units or facilities that were modeled, only providing a CEMS Identification number. MARAMA used information contained in IPM input files to match up the plant name and type where the stack was located. The resulting list of 167 stacks is found in Appendix A, below.

MANE-VU asked states in the consultation area to pursue 90 percent control on all units emitting from those stacks by 2018. MANE-VU recognized that this level of control may not be feasible in all cases. NESCAUM modelers incorporated State comments gathered during the inter-RPO consultation process in estimating the impact of this strategy on visibility at Class I areas. This process is described below.

## 5.5 Implementation of MANE-VU Control Strategy for Key EGUs

As part of the MANE-VU strategy to improve visibility, MANE-VU asked states to pursue a 90 percent reduction in SO2 emissions from the 167 EGU stacks identified as described in Section 5.4 and listed in Appendix A. MARAMA gathered information from MANE-VU, MRPO, and VISTAS states and regional staff to obtain information about anticipated emissions changes.

State and local agencies and individual stakeholders from MANE-VU, MRPO and VISTAS reviewed and revised the IPM results with respect to controls planned to come online. They also reviewed the IPM results to verify that known and existing controls and emission rates were properly reflected in the IPM runs. In addition, commenters noted that some units predicted by IPM to be shutdown would not shutdown.

Adjustments to the IPM results were made to specific units using information states had obtained as part of the permitting process or other contact with the industry that indicated which units would install controls as a result of CAIR and when these new controls would come on-line (Koerber, 2007; VISTAS 2007).

In general, the changes at specific EGUs provided by VISTAS reflected their Base G2 inventory, and, as discussed with MRPO, the changes made to emissions from sources in the MRPO were consistent with sources where controls were predicted in EPA's IPM 3.0 run for 2018, since MRPO modeling relied on IPM 3.0. In addition to the 167 stacks MANE-VU incorporated further corrections to source emissions as requested by VISTAS states at the following locations: North Carolina (Cliffside), South Carolina (Jefferies), Kentucky (Spurlock), Virginia (Chesapeake and Clinch River).

NESCAUM determined the desired emissions levels for the 167 key stacks based on a 90 percent reduction in continuous emissions monitoring data from 2002. This established a target emissions level for the region from those stacks. NESCAUM compared these levels with the information provided by the states for those sources. In each region, predicted 2018 emissions exceeded the target level. Therefore, emissions reductions from other sources were considered in order to meet the target emissions reductions for the region.(both within MANE-VU and in other RPOs). This resulted in a net decrease in emissions in all three affected RPOs. Emissions of $SO_2$ would have decreased by over 14,000 tons per year in MANE-VU, over 304,000 tons per year in the Midwest, and over 197,000 tons per year in the VISTAS region.

However, MANE-VU planners recognized that CAIR allows emissions trading, and that reductions at one unit could be offset increases at another unit within the CAIR region. Because most states do not restrict trading, MANE-VU decided that emissions should be increased.

Therefore, NESCAUM increased the emissions from states subject to the CAIR cap and trade program. For MANE-VU, 75,809 tons were added back, leaving total regional emissions from the MANE-VU region greater than the original Inter-RPO IPM-based estimate but consistent with state projections. The remaining 440,541 tons added back were allocated to VISTAS and MRPO based on the fraction of their contribution to the total $SO_2$ emissions. The additional emissions correspond to an increase of 20.5 percent, with a total of 223,856 tons added to MRPO and 216,685 added to VISTAS.

Table 8 shows the emissions difference between the inter-RPO IPM run and MANE-VU's modeling inventory, and between EPA's IPM 3.0 and MANE-VU's modeling inventory.

**Table 8.** Regional $SO_2$ Emissions Comparison: Difference between RPO CAIR base case, adjusted emissions used in MANE-VU modeling, and EPA 3.0 predictions (expressed in 1000s of tons per year)

| | MANE-VU | MRPO | VISTAS | TOTAL |
|---|---|---|---|---|
| **RPO 2.1.9 (VISTASII_PC_1f) (fossil only)** | **321** | **1,387** | **1,303** | **3,011** |
| **Reductions made by VISTAS and MRPO (Base G2)** | 0 | -136 | -209 | -344 |
| **Net additional changes made by MANE-VU** | 66 | 24 | 222 | 311 |
| **MANE-VU March 2008 Modeling Inventory (fossil only)** | **387** | **1,276** | **1,316** | **2,978** |
| **MANE-VU minus RPO 2.1.9 (negative numbers mean MANE-VU's modeling inventory was less than RPO 2.1.9)** | 66 | -112 | 13 | -33 |
| **EPA 3.0 (fossil only)** | **421** | **1,328** | **1,458** | **3,207** |
| **RPO 2.1.9 minus EPA 3.0 (negative number means RPO 2.1.9 was less than EPA 3.0)** | -100 | 59 | -155 | -196 |
| **MANE-VU 3/08 minus EPA 3.0 (negative numbers mean MANE-VU's modeling inventory was less than EPA 3.0)** | -34 | -53 | -142 | -229 |

The intent of the MANE-VU modelers' final EGU emissions adjustments was to retain the same level of emissions as predicted by the RPO CAIR IPM run for the three regions together. The locations of the emissions, however, were modified to better reflect the states' estimates of where emissions would be reduced and to achieve reductions at the 167 stacks identified as important contributors to regional haze at MANE-VU Class I areas. As shown in Table 8, above, due to unintended variations in emissions processing, the MANE-VU adjustments resulted in total emissions from the three regions being about 1% less than the $SO_2$ emissions predicted by the RPO 2.1.9 IPM run. Overall, regional emissions increased in both MANE-VU and VISTAS in comparison to the VISTAS/Inter-RPO IPM run and declined in the Midwest. Results from IPM 3.0 are provided for comparison, since these results were used by MRPO modelers. MANE-VU believes its process of adding back emissions resulted in a reasonable, conservative estimate of the implementation of the MANE-VU request for a 90% reduction at key EGU facilities.

## 5.6 State Results – Northeastern State Adjustments

Table 9 presents State level emission results as modified by the Northeastern States per the methods noted in the above sections. This table summarizes the input data used in the MANE-VU 2018 Best and Final Modeling run as documented in NESCAUM's *2018 Visibility Projections* report dated March 2008.

**Table 9.** State Level 2018 Emission Summary; March 2008 MANE-VU EGU Modeling Inventory.

| | | **Annual Emissions (Tons)** | | | | | | |
|---|---|---:|---:|---:|---:|---:|---:|---:|
| **State** | **RPO** | **NOx** | **SO2** | **VOC** | **CO** | **PM-10** | **PM-2.5** | **NH3** |
| Connecticut | MANE-VU | 3,418 | 6,697 | 145 | 9,836 | 959 | 927 | 341 |
| Delaware | MANE-VU | 12,341 | 10,941 | 117 | 1,183 | 2,950 | 2,438 | 76 |
| District Of Columbia | MANE-VU | 103 | 83 | 5 | 154 | 104 | 99 | 12 |
| Maine | MANE-VU | 1,827 | 6,806 | 53 | 4,057 | 296 | 279 | 139 |
| Maryland | MANE-VU | 14,709 | 43,764 | 575 | 11,831 | 8,253 | 6,433 | 435 |
| Massachusetts | MANE-VU | 18,157 | 45,941 | 484 | 13,860 | 3,917 | 3,233 | 1,059 |
| New Hampshire | MANE-VU | 3,089 | 10,766 | 73 | 1,697 | 2,268 | 2,156 | 124 |
| New Jersey | MANE-VU | 13,636 | 15,918 | 352 | 7,611 | 4,017 | 3,515 | 564 |
| New York | MANE-VU | 24,376 | 74,587 | 758 | 22,242 | 11,031 | 9,343 | 1,471 |
| Pennsylvania | MANE-VU | 82,881 | 170,992 | 1,919 | 41,446 | 31,580 | 23,756 | 1,790 |
| Rhode Island | MANE-VU | 576 | 55 | 42 | 1,627 | 157 | 156 | 127 |
| Vermont | MANE-VU | 105 | 35 | 3 | 117 | 26 | 25 | 9 |
| | **MANE-VU Total** | **175,219** | **386,584** | **4,528** | **115,660** | **65,558** | **52,360** | **6,148** |
| Alabama | VISTAS | 62,860 | 163,567 | 1,620 | 21,611 | 7,385 | 4,380 | 1,033 |
| Florida | VISTAS | 58,341 | 167,685 | 1,903 | 42,946 | 9,355 | 6,330 | 2,665 |
| Georgia | VISTAS | 69,308 | 90,408 | 1,805 | 35,584 | 18,217 | 11,319 | 1,676 |
| Kentucky | VISTAS | 59,740 | 255,559 | 1,344 | 12,125 | 6,194 | 4,067 | 436 |
| Mississippi | VISTAS | 10,455 | 18,241 | 1,055 | 11,822 | 7,007 | 6,853 | 545 |
| North Carolina | VISTAS | 56,526 | 126,042 | 1,147 | 16,376 | 32,676 | 26,014 | 608 |
| South Carolina | VISTAS | 50,068 | 105,436 | 860 | 13,078 | 28,110 | 24,454 | 578 |
| Tennessee | VISTAS | 30,008 | 135,344 | 886 | 7,126 | 15,861 | 13,320 | 241 |
| Virginia | VISTAS | 60,615 | 125,849 | 921 | 14,017 | 13,505 | 11,757 | 553 |
| West Virginia | VISTAS | 51,177 | 127,609 | 1,382 | 11,896 | 6,344 | 3,643 | 177 |
| | **VISTAS Total** | **509,098** | **1,315,740** | **12,922** | **186,579** | **144,653** | **112,137** | **8,512** |
| Illinois | MRPO | 71,233 | 208,832 | 2,229 | 17,868 | 32,649 | 30,132 | 1,152 |
| Indiana | MRPO | 95,376 | 403,473 | 2,105 | 19,416 | 35,081 | 27,835 | 1,274 |
| Michigan | MRPO | 78,605 | 213,066 | 1,623 | 17,521 | 38,902 | 34,276 | 1,091 |
| Ohio | MRPO | 83,129 | 353,293 | 2,254 | 23,832 | 42,753 | 33,322 | 1,772 |
| Wisconsin | MRPO | 45,701 | 96,934 | 1,101 | 11,901 | 15,629 | 14,246 | 626 |
| | **MRPO Total** | **374,044** | **1,275,598** | **9,311** | **90,539** | **165,015** | **139,812** | **5,915** |
| Arkansas | CENRAP | 33,097 | 82,605 | 696 | 11,429 | 3,897 | 3,326 | 814 |
| Iowa | CENRAP | 51,119 | 147,305 | 770 | 8,758 | 10,033 | 8,615 | 569 |
| Kansas | CENRAP | 83,333 | 81,486 | 798 | 7,203 | 8,520 | 6,807 | 461 |
| Louisiana | CENRAP | 30,432 | 74,263 | 660 | 11,043 | 3,966 | 3,590 | 919 |
| Minnesota | CENRAP | 41,029 | 85,847 | 674 | 5,563 | 8,162 | 7,035 | 343 |
| Missouri | CENRAP | 77,660 | 280,887 | 1,579 | 13,165 | 18,456 | 16,769 | 799 |
| Nebraska | CENRAP | 50,781 | 73,629 | 450 | 3,590 | 2,296 | 1,914 | 217 |
| Oklahoma | CENRAP | 76,048 | 113,680 | 1,008 | 28,182 | 5,561 | 4,840 | 1,355 |
| Texas | CENRAP | 153,837 | 339,433 | 4,988 | 102,581 | 38,952 | 31,630 | 6,424 |
| | **CENRAP Total** | **597,336** | **1,279,135** | **11,622** | **191,515** | **99,842** | **84,527** | **11,901** |
| Arizona | WRAP | 59,774 | 55,941 | 724 | 17,806 | 2,811 | 634 | 630 |
| California | WRAP | 17,537 | 1,528 | 2,558 | 31,173 | 1,219 | 1,059 | 0 |
| Colorado | WRAP | 77,113 | 60,914 | 1,465 | 18,939 | 3,138 | 307 | 537 |
| Idaho | WRAP | 2,236 | 1,683 | 50 | 3,283 | 335 | 87 | 0 |
| Montana | WRAP | 44,733 | 31,303 | 565 | 11,818 | 1,796 | 247 | 13 |
| Nevada | WRAP | 54,300 | 22,118 | 1,570 | 10,598 | 4,230 | 768 | 903 |
| New Mexico | WRAP | 32,925 | 17,796 | 695 | 10,976 | 794 | 627 | 43 |
| North Dakota | WRAP | 82,741 | 152,828 | 909 | 13,647 | 3,958 | 2,645 | 383 |
| Oregon | WRAP | 15,742 | 15,096 | 474 | 5,753 | 1,288 | 323 | 219 |
| South Dakota | WRAP | 17,681 | 13,522 | 118 | 689 | 247 | 217 | 52 |
| Utah | WRAP | 76,136 | 41,394 | 597 | 17,150 | 4,637 | 2,000 | 1,350 |
| Washington | WRAP | 16,884 | 7,011 | 249 | 4,008 | 1,474 | 1,027 | 12 |
| Wyoming | WRAP | 104,142 | 96,745 | 1,147 | 18,871 | 10,445 | 7,411 | 404 |
| | **WRAP Total** | **601,942** | **517,879** | **11,122** | **164,711** | **36,371** | **17,353** | **4,547** |
| **National Total** | | **2,257,639** | **4,774,936** | **49,505** | **749,003** | **511,439** | **406,188** | **37,023** |

## 6 EGU PREPARATION TIMELINE

The following section provides a chronological review of the events and milestones that occurred during the preparation of EGU emission forecasts in support of regional haze SIP preparation. Within each year noted, events occurred in the order listed.

**2004**

- VISTAS/MRPO sponsor first IPM 2.1.6 runs for 2018 (Phase I)
- Phase I (VISTAS_CAIR_2) results released

**2005**

- RPOs move to IPM 2.1.9 (Phase II)
- Revisions to NEEDS input file and global parameters submitted by RPOs for revised runs
- Phase II (VISTAS_II_PC_1f) results released
- IPM parsed to NIF and NIF to SMOKE IDA format conversion occurs
- Initial RPO adjustments and modifications of IPM results
- RPOs share IPM 2.1.9 inputs and configuration from Phase II with EPA
- EPA releases IPM 2.1.9 results of CAIR/CAMR modeling

**2006**

- Additional RPO control and modeling file adjustments to Phase II runs
- RPOs simulate 2018 forecast year to support regional haze SIP submittals
- RPOs work with EPA to configure NEEDS 3.0 for next round of EPA modeling
- EPA releases IPM 2006 revised projections
- RPOs identify potential control measures and estimate benefits for meeting reasonable progress goals
- Additional RPO control and modeling file adjustments to Phase II runs

**2007**

- RPOs analyze cost and other factors associated with potential control measures
- RPOs coordinate with EPA on inputs and runs of IPM 3.0
- EPA releases IPM 3.0 results of revised CAIR/CAMR/CAVR modeling
- Interstate and inter-regional consultation regarding potential control measures
- MANE-VU states agree to pursue several control measures
- RPOs begin regional modeling to assess visibility impacts of controls

**2008**

- RPOs model to determine progress goals for regional haze SIP
- States finalize regional haze SIPs

# 7 REFERENCES

**Alpine Geophysics, LLC, 2005a**. *EGU Emission Factors and Emission Factor Assignment*, technical memorandum prepared for VISTAS EGU Special Interest Workgroup, 2005.

**Alpine Geophysics, LLC, 2005b**. *Emission Factor/Rate Development for IPM Post-Processing,* technical memorandum prepared for VISTAS EGU Special Interest Workgroup.

**Alpine Geophysics, LLC, 2006**. *Future Year Emissions Inventories, Draft Work Assignment #1, Technical Memorandum - Task 1,* prepared for MARAMA, 2006.

**E.H. Pechan & Associates, Inc., 2004.** *Electricity Generating Unit (EGU) Growth Modeling Method Task 2 Evaluation – Final Report*, prepared for Lake Michigan Air Directors Consortium, 2004.

**E.H. Pechan & Associates, Inc., 2005**. *LADCO IPM Model Parsed File Post-Processing Methodology and File Preparation (January 2005) – Technical Memorandum*, prepared for Lake Michigan Air Directors Consortium, 2005.

**ENVIRON, 2007.** *Technical Support Document for CENRAP Emissions and Air Quality Modeling to Support Regional Haze State Implementation Plans*, prepared for Central Regional Air Planning Association.

**EPA, 2004**. *Analysis in Support of the Clean Air Interstate Rule Using the Integrated Planning Model*, Technical Support Document for the Final Clean Air Interstate Rule, 2004.

**EPA, 2005a**. *Modeling of Control Costs, Emissions, and Control Retrofits for Cost Effectiveness and Feasibility Analyses*, Technical Support Document for the Final Clean Air Interstate Rule, 2005.

**EPA, 2005b**. *Standalone Documentation for EPA Base Case 2004 (V.2.1.9) Using the Integrated Planning Model*, EPA 430-R-05-011. Available at http://www.epa.gov/airmarkets/progsregs/epa-ipm/past-modeling.html#version2004.

**ERG, 2006**. *WRAP Point and Area Source Emissions Projections for the 2018 Base Case Inventory, Version 1,* prepared for Emission Inventory Workgroup, 2006.

**Houyoux**, M.; Vukovich, J.; Brandmeyer, J., 2000. Sparse Matrix Operator Kernal Emissions Modeling System (SMOKE) User Manual, Version 1.1.2 Draft, MCNC-North Carolina Supercomuting Center Environmental Programs.

**ICF Resources, LLC., 2005.** *Future Year Electricity Generating Sector Emission Inventory Development Using the Integrated Planning Model (IPM®) in Support of Fine Particulate Mass and Visibility Modeling in the VISTAS and Midwest RPO Regions,* prepared for VISTAS, 2005.

**ICF Resources, LLC., 2007**. *Comparison of CAIR and CAIR Plus Proposal using the Integrated Planning Model (IPM®),* prepared for MARAMA.

**Koerber,. 2007.** Personal and electronic communication from Mark Janssen to Julie McDill, MARAMA and Andy Bodnarik, New Hampshire DEP.

**MACTEC, 2006**. *Development of Emission Projections for 2009, 2012, and 2018 for NonEGU Point, Area, and Nonroad Sources in the MANE-VU Region*, prepared for MARAMA.

**MACTEC, 2007**. *Documentation of the Base G 2002 Base Year, 2009 and 2018, Emission Inventories for VISTAS*, prepared for VISTAS, 2007.

**MRPO, 2006**. Personal and electronic communication from Mark Janssen to Gregory Stella, Alpine Geophysics, LLC., 2006.

**NESCAUM, 2006a**. *Contributions to Regional Haze in the Northeast and Mid-Atlantic U.S.*, Northeast States for Coordinated Air Use Management, Boston, MA, 2006a.

**NESCAUM, 2006b**. *The Nature of the Fine Particle and Regional Haze Air Quality Problems in the MANE-VU Region: A Conceptual Description*, Available at: http://www.nescaum.org/documents/2006-1102-pm-conceptual-model.pdf/, Northeast States for Coordinated Air Use Management, Boston, MA, 2006b.

**NESCAUM, 2008a**. *MANE-VU Modeling for Reasonable Progress Goals Model performance evaluation, pollution apportionment, and control measure benefits*, prepared for MANE-VU, 2008a.

**NESCAUM, 2008b**. *2018 Visibility Projections*, prepared for MANE-VU.

**VISTAS, 2007.** Electronic communication from Doris McLeod 11/7/2007.

**Janssen, 2008.** Personal communication from Mark Janssen 3/28/2008.

## Appendix A

# TOP ELECTRIC GENERATING EMISSION POINTS CONTRIBUTING TO VISIBILITY IMPAIRMENT IN MANE-VU - MODELED BY BOTH VTDEC AND MM5

June, 2007

For each of three MANE-VU Class I Areas the 100 Electric Generating Unit (EGU) stacks with the most significant impact on visibility impairment were identified by Calpuff modeling conducted by two modeling centers. Many of these stacks have a regional impact and therefore significantly impact more than one Class I Area. When the "Top Impacting" stacks are aggregated into a single group there are 167 individual "Top Impacting" stacks identified.

Information in columns of the following table:

1. Row Number (1 through 167)
2. CEMS Unit ID: an arbitrary number identifying the CEMS unit
3. ORIS ID: a standard identification number associated with each unit
4. Acadia MM5: The impact in micrograms per cubic meter predicted to have occurred at Acadia National Park based on 2002 emissions and meteorological data from the MM5 model
5. Acadia VTDEC: The impact in micrograms per cubic meter predicted to have occurred at Acadia National Park based on 2002 emissions and meteorological data from the national weather service
6. Brig MM5: The impact in micrograms per cubic meter predicted to have occurred at Brigantine Wilderness Area based on 2002 emissions and meteorological data from the MM5 model
7. Brig VTDEC: The impact in micrograms per cubic meter predicted to have occurred at Brigantine Wilderness Area based on 2002 emissions and meteorological data from the national weather service
8. Lye MM5: The impact in micrograms per cubic meter predicted to have occurred at Lye Brook based on 2002 emissions and meteorological data from the MM5 model
9. Lye VTDEC: The impact in micrograms per cubic meter predicted to have occurred at Lye Brook based on 2002 emissions and meteorological data from the national weather service
10. MM5 2002 SO2 Tons per Year: Emissions calculated from CEMS data and used by modelers who used the MM5 generated meteorological data
11. VTDEC 2002 SO2 Tons per Year: Emissions calculated from CEMS data and used by modelers who used the national weather service generated meteorological data
12. Plant Number (1 through 105): The 167 stacks are located at 105 plants.
13. Plant Name
14. Plant Type: coal fired or oil/gas fired electric generating units
15. State Name
16. State Code

| Row number | CEMS Unit | ORIS ID | Acadia MM5 | Acadia VTDEC | Brig MM5 | Brig VTDEC | Lye MM5 | Lye VTDEC | MM5 2002 S02 TPY | VTDEC 2002 SO2 TPY | | Plant Name | Plant Type | State Name | State Code |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | D005935 | 593 | | | 90 | 54 | | | 2,138 | 2,136 | 1 | EDGE MOOR | O/G Steam | Delaware | 10 |
| 2 | D005941 | 594 | | | | 95 | | | | 3,742 | 2 | INDIAN RIVER | Coal Steam | Delaware | 10 |
| 3 | D005942 | 594 | | | | 74 | | | | 3,760 | 2 | INDIAN RIVER | Coal Steam | Delaware | 10 |
| 4 | D005943 | 594 | | | 84 | 44 | | | 4,686 | 4,682 | 2 | INDIAN RIVER | Coal Steam | Delaware | 10 |
| 5 | D005944 | 594 | | | 69 | 21 | | | 7,390 | 7,384 | 2 | INDIAN RIVER | Coal Steam | Delaware | 10 |
| 6 | D007031LR | 703 | 79 | | | 86 | | 75 | 38,520 | 38,486 | 3 | BOWEN | Coal Steam | Georgia | 13 |
| 7 | D007032LR | 703 | 72 | | 89 | | 61 | 68 | 37,289 | 37,256 | 3 | BOWEN | Coal Steam | Georgia | 13 |
| 8 | D007033LR | 703 | 71 | 99 | 74 | 64 | 63 | 94 | 43,067 | 43,029 | 3 | BOWEN | Coal Steam | Georgia | 13 |
| 9 | D007034LR | 703 | 69 | 95 | 86 | 58 | 60 | 89 | 41,010 | 40,974 | 3 | BOWEN | Coal Steam | Georgia | 13 |
| 10 | D00709C02 | 709 | | 84 | | 75 | 89 | 71 | 47,591 | 47,549 | 4 | HARLLEE BRANCH | Coal Steam | Georgia | 13 |
| 11 | D00861C01 | 861 | 28 | 96 | | 65 | 46 | 62 | 42,355 | 42,318 | 5 | COFFEEN | Coal Steam | Illinois | 17 |
| 12 | D010011 | 1001 | | | 53 | | | | 28,876 | 28,851 | 6 | CAYUGA | Coal Steam | Indiana | 18 |
| 13 | D010012 | 1001 | 95 | | 46 | 68 | | | 26,016 | 25,992 | 6 | CAYUGA | Coal Steam | Indiana | 18 |
| 14 | D00983C01 | 983 | | | | | 52 | | 19,922 | | 7 | CLIFTY CREEK | Coal Steam | Indiana | 18 |
| 15 | D00983C02 | 983 | | | | | 54 | | 18,131 | | 7 | CLIFTY CREEK | Coal Steam | Indiana | 18 |
| 16 | D0099070 | 990 | | 55 | 100 | 70 | | 37 | 29,801 | 29,774 | 8 | ELMER W STOUT | O/G Steam | Indiana | 18 |
| 17 | D06113C03 | 6113 | 30 | 48 | 14 | 43 | 22 | 41 | 71,182 | 71,119 | 9 | GIBSON | Coal Steam | Indiana | 18 |
| 18 | D06113C04 | 6113 | 44 | 70 | 97 | 83 | 73 | 83 | 27,848 | 27,823 | 9 | GIBSON | Coal Steam | Indiana | 18 |
| 19 | D01008C01 | 1008 | | | 73 | | 100 | 47 | 24,109 | 24,087 | 10 | R GALLAGHER | Coal Steam | Indiana | 18 |
| 20 | D01008C02 | 1008 | | | 98 | | | 55 | 23,849 | 23,828 | 10 | R GALLAGHER | Coal Steam | Indiana | 18 |
| 21 | D06166C02 | 6166 | 62 | 44 | 30 | 81 | 33 | 57 | 51,708 | 51,663 | 11 | ROCKPORT | Coal Steam | Indiana | 18 |
| 22 | D00988C03 | 988 | | | | | | 77 | | 15,946 | 12 | TANNERS CREEK | Coal Steam | Indiana | 18 |
| 23 | D00988U4 | 988 | 14 | 29 | 52 | 34 | 7 | 19 | 45,062 | 45,022 | 12 | TANNERS CREEK | Coal Steam | Indiana | 18 |
| 24 | D01010C05 | 1010 | 43 | 32 | 12 | 28 | 31 | 17 | 60,747 | 60,693 | 13 | WABASH RIVER | Coal Steam | Indiana | 18 |
| 25 | D067054 | 6705 | 34 | 60 | 34 | | 44 | 73 | 40,118 | 40,082 | 14 | WARRICK | Coal Steam | Indiana | 18 |
| 26 | D06705C02 | 6705 | 92 | | 75 | | 96 | | 27,895 | | 14 | WARRICK | Coal Steam | Indiana | 18 |
| 27 | D01353C02 | 1353 | 38 | 30 | 15 | 26 | 85 | 29 | 41,545 | 41,508 | 15 | BIG SANDY | Coal Steam | Kentucky | 21 |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 28 | D01384CS1 | 1384 | 22 | | | | 58 | | 21,837 | 21,817 | 16 | COOPER | Coal Steam | Kentucky | 21 |
| 29 | D01355C03 | 1355 | 21 | | 51 | 99 | 68 | 52 | 38,104 | 38,070 | 17 | E W BROWN | Coal Steam | Kentucky | 21 |
| 30 | D060182 | 6018 | 83 | | | | 39 | | 12,083 | | 18 | EAST BEND | Coal Steam | Kentucky | 21 |
| 31 | D01356C02 | 1356 | 93 | 71 | | 88 | 50 | 59 | 25,646 | 25,623 | 19 | GHENT | Coal Steam | Kentucky | 21 |
| 32 | D060411 | 6041 | 61 | | | | | | 18,375 | | 20 | H L SPURLOCK | Coal Steam | Kentucky | 21 |
| 33 | D060412 | 6041 | 53 | | 91 | | | 98 | 20,491 | 20,473 | 20 | H L SPURLOCK | Coal Steam | Kentucky | 21 |
| 34 | D013644 | 1364 | | | 81 | | | | 7,185 | | 21 | MILL CREEK | Coal Steam | Kentucky | 21 |
| 35 | D013782 | 1378 | | | | | 87 | | 20,245 | | 22 | PARADISE | Coal Steam | Kentucky | 21 |
| 36 | D013783 | 1378 | 76 | 100 | 11 | 84 | 55 | 42 | 46,701 | 46,660 | 22 | PARADISE | Coal Steam | Kentucky | 21 |
| 37 | D015074 | 1507 | 78 | | | | | | 1,170 | | 23 | WILLIAM F WYMAN | O/G Steam | Maine | 23 |
| 38 | D006021 | 602 | 90 | | 38 | | | 100 | 20,014 | 19,996 | 24 | BRANDON SHORES | Coal Steam | Maryland | 24 |
| 39 | D006022 | 602 | 99 | | 29 | | | 99 | 19,280 | 19,263 | 24 | BRANDON SHORES | Coal Steam | Maryland | 24 |
| 40 | D015521 | 1552 | | | 63 | | | | 17,782 | 17,767 | 25 | C P CRANE | Coal Steam | Maryland | 24 |
| 41 | D015522 | 1552 | | | 68 | | | | 14,274 | 14,262 | 25 | C P CRANE | Coal Steam | Maryland | 24 |
| 42 | D01571CE2 | 1571 | 42 | 47 | 1 | 4 | 20 | 28 | 48,566 | 48,522 | 26 | CHALK POINT | Coal Steam | Maryland | 24 |
| 43 | D01572C23 | 1572 | 73 | 79 | 47 | 45 | 69 | 32 | 32,188 | 32,159 | 27 | DICKERSON | Coal Steam | Maryland | 24 |
| 44 | D015543 | 1554 | | | 77 | | | | 10,084 | 10,075 | 28 | HERBERT A WAGNER | O/G Steam | Maryland | 24 |
| 45 | D015731 | 1573 | 67 | 50 | 16 | 12 | 56 | 38 | 36,823 | 36,790 | 29 | MORGANTOWN | Coal Steam | Maryland | 24 |
| 46 | D015732 | 1573 | 59 | 53 | 10 | 13 | 51 | 39 | 30,788 | 30,761 | 29 | MORGANTOWN | Coal Steam | Maryland | 24 |
| 47 | D016191 | 1619 | 37 | 80 | | | | | 9,252 | 9,244 | 30 | BRAYTON POINT | Coal Steam | Massachusetts | 25 |
| 48 | D016192 | 1619 | 35 | 66 | | | | | 8,889 | 8,881 | 30 | BRAYTON POINT | Coal Steam | Massachusetts | 25 |
| 49 | D016193 | 1619 | 4 | 14 | 65 | 56 | 79 | | 19,325 | 19,308 | 30 | BRAYTON POINT | Coal Steam | Massachusetts | 25 |
| 50 | D015991 | 1599 | 5 | 36 | | | 65 | | 13,014 | 13,002 | 31 | CANAL | O/G Steam | Massachusetts | 25 |
| 51 | D015992 | 1599 | 7 | 27 | | | 74 | | 8,980 | 8,971 | 31 | CANAL | O/G Steam | Massachusetts | 25 |
| 52 | D016061 | 1606 | | | | | | 48 | | 5,249 | 32 | MOUNT TOM | Coal Steam | Massachusetts | 25 |
| 53 | D016261 | 1626 | 85 | | | | | | 3,430 | | 33 | SALEM HARBOR | Coal Steam | Massachusetts | 25 |
| 54 | D016263 | 1626 | 91 | 78 | | | | | 4,971 | 4,966 | 33 | SALEM HARBOR | Coal Steam | Massachusetts | 25 |
| 55 | D016264 | 1626 | 32 | 25 | | | | | 2,880 | 2,878 | 33 | SALEM HARBOR | O/G Steam | Massachusetts | 25 |
| 56 | D016138 | 1613 | 94 | | | | | | 4,376 | | 34 | SOMERSET | Coal Steam | Massachusetts | 25 |
| 57 | D01702C09 | 1702 | | | | | | 96 | | 4,565 | 35 | DAN E KARN | Coal Steam | Michigan | 26 |
| 58 | D01733C12 | 1733 | 49 | 24 | 80 | 80 | 45 | 22 | 46,081 | 46,040 | 36 | MONROE | Coal Steam | Michigan | 26 |
| 59 | D01733C34 | 1733 | 27 | 26 | | 76 | 26 | 27 | 39,362 | 39,327 | 36 | MONROE | Coal Steam | Michigan | 26 |
| 60 | D017437 | 1743 | | 91 | | | | | | 15,805 | 37 | ST CLAIR | Coal Steam | Michigan | 26 |
| 61 | D017459A | 1745 | | | | | 76 | 61 | 18,341 | 18,324 | 38 | TRENTON CHANNEL | Coal Steam | Michigan | 26 |
| 62 | D023641 | 2364 | 2 | 57 | | | | | 9,356 | 9,348 | 39 | MERRIMACK | Coal Steam | New Hampshire | 33 |
| 63 | D023642 | 2364 | 1 | 17 | 99 | | 28 | 87 | 19,453 | 19,435 | 39 | MERRIMACK | Coal Steam | New Hampshire | 33 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 64 | D080021 | 8002 | 45 | 74 | | | | | 5,033 | 5,028 | 40 | NEWINGTON | O/G Steam | New Hampshire | 33 |
| 65 | D023781 | 2378 | | 81 | 2 | 15 | | | 9,747 | 9,738 | 41 | B L ENGLAND | Coal Steam | New Jersey | 34 |
| 66 | D024032 | 2403 | 63 | 97 | 25 | 50 | 40 | 44 | 18,785 | 18,768 | 42 | HUDSON | O/G Steam | New Jersey | 34 |
| 67 | D024081 | 2408 | | | 95 | | | | 8,076 | | 43 | MERCER | Coal Steam | New Jersey | 34 |
| 68 | D024082 | 2408 | | | 60 | | | | 5,675 | | 43 | MERCER | Coal Steam | New Jersey | 34 |
| 69 | D02549C01 | 2549 | | 64 | 41 | | 42 | 72 | 25,343 | 25,320 | 44 | C R HUNTLEY | Coal Steam | New York | 36 |
| 70 | D02549C02 | 2549 | | | | | 99 | | 12,317 | | 44 | C R HUNTLEY | Coal Steam | New York | 36 |
| 71 | D024804 | 2480 | | | | | 71 | | 7,720 | | 45 | DANSKAMMER | O/G Steam | New York | 36 |
| 72 | D02554C03 | 2554 | 33 | 51 | 62 | | 27 | 51 | 30,151 | 30,125 | 46 | DUNKIRK | Coal Steam | New York | 36 |
| 73 | D02526C03 | 2526 | | | | | 78 | | 14,929 | | 47 | WESTOVER | Coal Steam | New York | 36 |
| 74 | D025276 | 2527 | | | | | 80 | | 12,650 | | 48 | GREENIDGE | Coal Steam | New York | 36 |
| 75 | D025163 | 2516 | | | 96 | | | | 7,359 | | 49 | NORTHPORT | O/G Steam | New York | 36 |
| 76 | D025945 | 2594 | | 76 | | | | | | 1,747 | 50 | OSWEGO | O/G Steam | New York | 36 |
| 77 | D02642CS2 | 2642 | | | | | 91 | | 14,086 | | 51 | ROCHESTER 7 | Coal Steam | New York | 36 |
| 78 | D080061 | 8006 | | | | | | 93 | | 3,817 | 52 | ROSETON | O/G Steam | New York | 36 |
| 79 | D080062 | 8006 | | | | | | 88 | | 2,840 | 52 | ROSETON | O/G Steam | New York | 36 |
| 80 | D080421 | 8042 | 13 | 12 | 18 | 5 | 10 | 34 | 57,820 | 57,769 | 53 | BELEWS CREEK | Coal Steam | North Carolina | 37 |
| 81 | D080422 | 8042 | 23 | 15 | 32 | 10 | 15 | 49 | 45,296 | 45,256 | 53 | BELEWS CREEK | Coal Steam | North Carolina | 37 |
| 82 | D027215 | 2721 | 98 | 45 | 87 | 39 | 97 | 85 | 19,145 | 19,128 | 54 | CLIFFSIDE | Coal Steam | North Carolina | 37 |
| 83 | D027133 | 2713 | | 61 | | | | | | 14,460 | 55 | L V SUTTON | Coal Steam | North Carolina | 37 |
| 84 | D027093 | 2709 | | | | 97 | | | | 9,390 | 56 | LEE | Coal Steam | North Carolina | 37 |
| 85 | D027273 | 2727 | 100 | 40 | | 48 | 75 | 84 | 26,329 | 26,305 | 57 | MARSHALL | Coal Steam | North Carolina | 37 |
| 86 | D027274 | 2727 | 89 | 39 | 83 | 51 | 66 | 82 | 27,308 | 27,284 | 57 | MARSHALL | Coal Steam | North Carolina | 37 |
| 87 | D06250C05 | 6250 | 60 | 59 | | 35 | 37 | | 27,395 | 27,371 | 58 | MAYO | Coal Steam | North Carolina | 37 |
| 88 | D027121 | 2712 | | | | 59 | | | 12,031 | 12,020 | 59 | ROXBORO | Coal Steam | North Carolina | 37 |
| 89 | D027122 | 2712 | 82 | 41 | 54 | 23 | 94 | | 29,337 | 29,310 | 59 | ROXBORO | Coal Steam | North Carolina | 37 |
| 90 | D02712C03 | 2712 | 56 | 37 | 57 | 24 | 21 | 78 | 30,776 | 30,749 | 59 | ROXBORO | Coal Steam | North Carolina | 37 |
| 91 | D02712C04 | 2712 | 88 | 72 | | 47 | 47 | | 22,962 | 22,941 | 59 | ROXBORO | Coal Steam | North Carolina | 37 |
| 92 | D0283612 | 2836 | 55 | 20 | 48 | 89 | 29 | 35 | 41,432 | 41,395 | 60 | AVON LAKE | Coal Steam | Ohio | 39 |
| 93 | D028281 | 2828 | 29 | 9 | 31 | 30 | 24 | 8 | 37,307 | 37,274 | 61 | CARDINAL | Coal Steam | Ohio | 39 |
| 94 | D028282 | 2828 | | | | | | 56 | 20,598 | 20,580 | 61 | CARDINAL | Coal Steam | Ohio | 39 |
| 95 | D028283 | 2828 | | | | | | 80 | | 15,372 | 61 | CARDINAL | Coal Steam | Ohio | 39 |
| 96 | D028404 | 2840 | 3 | 1 | 6 | 2 | 2 | 3 | 87,801 | 87,724 | 62 | CONESVILLE | Coal Steam | Ohio | 39 |
| 97 | D02840C02 | 2840 | 84 | 73 | | | 81 | 63 | 22,791 | 22,771 | 62 | CONESVILLE | Coal Steam | Ohio | 39 |
| 98 | D028375 | 2837 | | 86 | 56 | | 35 | 70 | 35,970 | 35,938 | 63 | EASTLAKE | Coal Steam | Ohio | 39 |
| 99 | D081021 | 8102 | | | 23 | 71 | 59 | 95 | 18,207 | 18,191 | 64 | GEN J M GAVIN | Coal Steam | Ohio | 39 |
| 100 | D081022 | 8102 | | | | 78 | | | 12,333 | 12,322 | 64 | GEN J M GAVIN | Coal Steam | Ohio | 39 |

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| 101 | D028501 | 2850 | 36 | 67 | 39 | 53 | | 45 | 30,798 | 30,771 | 65 | J M STUART | Coal Steam | Ohio | 39 |
| 102 | D028502 | 2850 | 24 | 65 | 40 | 49 | 98 | 46 | 28,698 | 28,673 | 65 | J M STUART | Coal Steam | Ohio | 39 |
| 103 | D028503 | 2850 | 26 | | 72 | 62 | | | 27,968 | 27,944 | 65 | J M STUART | Coal Steam | Ohio | 39 |
| 104 | D028504 | 2850 | 20 | 77 | 45 | 52 | 88 | 54 | 27,343 | 27,319 | 65 | J M STUART | Coal Steam | Ohio | 39 |
| 105 | D060312 | 6031 | | | 67 | 77 | | 90 | 19,517 | 19,500 | 66 | KILLEN STATION | Coal Steam | Ohio | 39 |
| 106 | D02876C01 | 2876 | 40 | 7 | 3 | 9 | 30 | 10 | 72,593 | 72,529 | 67 | KYGER CREEK | Coal Steam | Ohio | 39 |
| 107 | D028327 | 2832 | 65 | 28 | 59 | 22 | 48 | 20 | 46,991 | 46,950 | 68 | MIAMI FORT | Coal Steam | Ohio | 39 |
| 108 | D02832C06 | 2832 | | | | 60 | 43 | 64 | 23,694 | 23,673 | 68 | MIAMI FORT | Coal Steam | Ohio | 39 |
| 109 | D028725 | 2872 | 74 | 92 | 78 | | 90 | 36 | 30,079 | 30,052 | 69 | MUSKINGUM RIVER | Coal Steam | Ohio | 39 |
| 110 | D02872C04 | 2872 | 6 | 19 | 13 | 6 | 19 | 15 | 83,134 | 83,060 | 69 | MUSKINGUM RIVER | Coal Steam | Ohio | 39 |
| 111 | D02864C01 | 2864 | 70 | 56 | 61 | 63 | 49 | 24 | 35,193 | 35,162 | 70 | R E BURGER | Coal Steam | Ohio | 39 |
| 112 | D07253C01 | 7253 | | 89 | 58 | 57 | | 33 | 30,977 | 30,949 | 71 | RICHARD GORSUCH | | Ohio | 39 |
| 113 | D028665 | 2866 | | 82 | | | | 53 | 19,796 | 19,779 | 72 | W H SAMMIS | Coal Steam | Ohio | 39 |
| 114 | D028667 | 2866 | 57 | 16 | 42 | 41 | 41 | 16 | 33,601 | 33,572 | 72 | W H SAMMIS | Coal Steam | Ohio | 39 |
| 115 | D02866C01 | 2866 | 97 | 54 | 93 | 96 | 92 | 30 | 24,649 | 24,627 | 72 | W H SAMMIS | Coal Steam | Ohio | 39 |
| 116 | D02866C02 | 2866 | | 69 | 92 | | | 50 | 26,022 | 25,999 | 72 | W H SAMMIS | Coal Steam | Ohio | 39 |
| 117 | D02866M6A | 2866 | | 85 | | | | 58 | 19,564 | 19,546 | 72 | W H SAMMIS | Coal Steam | Ohio | 39 |
| 118 | D060191 | 6019 | | 93 | | 72 | | 60 | | 21,496 | 73 | W H ZIMMER | Coal Steam | Ohio | 39 |
| 119 | D028306 | 2830 | 46 | 38 | 70 | 40 | 12 | 69 | 30,466 | 30,439 | 74 | WALTER C BECKJORD | Coal Steam | Ohio | 39 |
| 120 | D031782 | 3178 | 77 | 63 | | | | 81 | 16,484 | 16,469 | 75 | ARMSTRONG | Coal Steam | Pennsylvania | 42 |
| 121 | D031403 | 3140 | 31 | 34 | 9 | 46 | 18 | 18 | 38,801 | 38,767 | 76 | BRUNNER ISLAND | Coal Steam | Pennsylvania | 42 |
| 122 | D03140C12 | 3140 | 52 | 46 | 49 | 69 | 25 | 23 | 29,736 | 29,709 | 76 | BRUNNER ISLAND | Coal Steam | Pennsylvania | 42 |
| 123 | D082261 | 8226 | 25 | 21 | 33 | 42 | 36 | 9 | 40,268 | 40,232 | 77 | CHESWICK | Coal Steam | Pennsylvania | 42 |
| 124 | D03179C01 | 3179 | 16 | 10 | 5 | 8 | 5 | 4 | 79,635 | 79,565 | 78 | HATFIELD'S FERRY | Coal Steam | Pennsylvania | 42 |
| 125 | D031221 | 3122 | 11 | 6 | 26 | 38 | 17 | 14 | 45,754 | 45,714 | 79 | HOMER CITY | Coal Steam | Pennsylvania | 42 |
| 126 | D031222 | 3122 | 9 | 4 | 37 | 92 | 13 | 11 | 55,216 | 55,167 | 79 | HOMER CITY | Coal Steam | Pennsylvania | 42 |
| 127 | D031361 | 3136 | 8 | 2 | 4 | 14 | 6 | 1 | 87,434 | 87,357 | 80 | KEYSTONE | Coal Steam | Pennsylvania | 42 |
| 128 | D031362 | 3136 | 18 | 3 | 8 | 19 | 8 | 2 | 62,847 | 62,791 | 80 | KEYSTONE | Coal Steam | Pennsylvania | 42 |
| 129 | D03148C12 | 3148 | | | 71 | | 84 | | 17,214 | | 81 | MARTINS CREEK | Coal Steam | Pennsylvania | 42 |
| 130 | D031491 | 3149 | 19 | 8 | 35 | 7 | 1 | 6 | 60,242 | 60,188 | 82 | MONTOUR | Coal Steam | Pennsylvania | 42 |
| 131 | D031492 | 3149 | 15 | 5 | 21 | 20 | 3 | 5 | 50,276 | 50,232 | 82 | MONTOUR | Coal Steam | Pennsylvania | 42 |
| 132 | D031131 | 3113 | | | 82 | | | | 9,674 | | 83 | PORTLAND | Coal Steam | Pennsylvania | 42 |
| 133 | D031132 | 3113 | | | 36 | | 93 | | 14,294 | | 83 | PORTLAND | Coal Steam | Pennsylvania | 42 |
| 134 | D03131CS1 | 3131 | 54 | 31 | 79 | | 32 | 65 | 22,344 | 22,324 | 84 | SHAWVILLE | Coal Steam | Pennsylvania | 42 |
| 135 | D033193 | 3319 | | | | 100 | | | | 11,045 | 85 | JEFFERIES | O/G Steam | South Carolina | 45 |
| 136 | D033194 | 3319 | | 90 | | 87 | | | | 11,838 | 85 | JEFFERIES | O/G Steam | South Carolina | 45 |
| 137 | D03297WT1 | 3297 | | 68 | | 61 | | | | 17,671 | 86 | WATEREE | Coal Steam | South Carolina | 45 |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 138 | D03297WT2 | 3297 | | 83 | | 73 | | | | 17,199 | 86 | WATEREE | Coal Steam | South Carolina | 45 |
| 139 | D03298WL1 | 3298 | | 35 | 94 | 37 | | | 25,170 | 25,148 | 87 | WILLIAMS | Coal Steam | South Carolina | 45 |
| 140 | D062491 | 6249 | | 58 | | 82 | | | | 17,920 | 88 | WINYAH | Coal Steam | South Carolina | 45 |
| 141 | D03403C34 | 3403 | | | 85 | | | | 20,314 | | 89 | GALLATIN | Coal Steam | Tennessee | 47 |
| 142 | D03405C34 | 3405 | 39 | | | | | | 19,368 | | 90 | JOHN SEVIER | Coal Steam | Tennessee | 47 |
| 143 | D03406C10 | 3406 | 10 | 11 | 27 | 33 | 4 | 43 | 104,523 | 104,431 | 91 | JOHNSONVILLE | Coal Steam | Tennessee | 47 |
| 144 | D03407C15 | 3407 | 64 | 87 | | 66 | 67 | 76 | 37,308 | 37,274 | 92 | KINGSTON | Coal Steam | Tennessee | 47 |
| 145 | D03407C69 | 3407 | 48 | 98 | | 91 | 82 | 91 | 38,645 | 38,611 | 92 | KINGSTON | Coal Steam | Tennessee | 47 |
| 146 | D038033 | 3803 | | | | 55 | | | | 9,493 | 93 | CHESAPEAKE | Coal Steam | Virginia | 51 |
| 147 | D038034 | 3803 | | 94 | | 16 | | | | 10,806 | 93 | CHESAPEAKE | Coal Steam | Virginia | 51 |
| 148 | D037974 | 3797 | | | | 90 | | | | 9,293 | 94 | CHESTERFIELD | Coal Steam | Virginia | 51 |
| 149 | D037975 | 3797 | | 88 | 44 | 27 | 86 | | 19,620 | 19,602 | 94 | CHESTERFIELD | Coal Steam | Virginia | 51 |
| 150 | D037976 | 3797 | 66 | 18 | 7 | 3 | 34 | 66 | 40,570 | 40,534 | 94 | CHESTERFIELD | Coal Steam | Virginia | 51 |
| 151 | D03775C02 | 3775 | 47 | | | | | | 16,674 | | 95 | CLINCH RIVER | Coal Steam | Virginia | 51 |
| 152 | D038093 | 3809 | | 52 | 64 | 29 | | | 10,477 | 10,468 | 96 | YORKTOWN | Coal Steam | Virginia | 51 |
| 153 | D03809CS0 | 3809 | 96 | 43 | 19 | 17 | 62 | | 21,219 | 21,201 | 96 | YORKTOWN | Coal Steam | Virginia | 51 |
| 154 | D039423 | 3942 | | | | | | 79 | | 10,126 | 97 | ALBRIGHT | Coal Steam | West Virginia | 54 |
| 155 | D039431 | 3943 | 51 | 23 | 20 | 32 | 16 | 13 | 42,385 | 42,348 | 97 | FORT MARTIN | Coal Steam | West Virginia | 54 |
| 156 | D039432 | 3943 | 50 | 22 | 22 | 31 | 14 | 12 | 45,850 | 45,809 | 97 | FORT MARTIN | Coal Steam | West Virginia | 54 |
| 157 | D039353 | 3935 | 41 | 33 | 28 | 11 | 64 | 26 | 42,212 | 42,174 | 98 | JOHN E AMOS | Coal Steam | West Virginia | 54 |
| 158 | D03935C02 | 3935 | 17 | 42 | 43 | 1 | 11 | 21 | 63,066 | 63,010 | 98 | JOHN E AMOS | Coal Steam | West Virginia | 54 |
| 159 | D03947C03 | 3947 | 86 | 62 | 55 | | 57 | 25 | 38,575 | 38,541 | 99 | KAMMER | Coal Steam | West Virginia | 54 |
| 160 | D03936C02 | 3936 | | | | 98 | | | 15,480 | 15,467 | 100 | KANAWHA RIVER | Coal Steam | West Virginia | 54 |
| 161 | D03948C02 | 3948 | 58 | 13 | 17 | 36 | 9 | 7 | 55,405 | 55,356 | 101 | MITCHELL | Coal Steam | West Virginia | 54 |
| 162 | D062641 | 6264 | 75 | 49 | 50 | 18 | 77 | 40 | 42,757 | 42,719 | 102 | MOUNTAINEER | Coal Steam | West Virginia | 54 |
| 163 | D03954CS0 | 3954 | 68 | | 24 | 25 | 23 | 67 | 20,130 | 20,112 | 103 | MT STORM | Coal Steam | West Virginia | 54 |
| 164 | D0393851 | 3938 | | | | 79 | | 97 | 12,948 | 12,936 | 104 | PHILIP SPORN | Coal Steam | West Virginia | 54 |
| 165 | D03938C04 | 3938 | | | | 94 | | | 26,451 | 26,427 | 104 | PHILIP SPORN | Coal Steam | West Virginia | 54 |
| 166 | D060041 | 6004 | | | 66 | | 83 | 31 | 21,581 | 21,562 | 105 | PLEASANTS | Coal Steam | West Virginia | 54 |
| 167 | D060042 | 6004 | | | 88 | | | 92 | 20,550 | 20,532 | 105 | PLEASANTS | Coal Steam | West Virginia | 54 |