SPECIFICATION SHEET: ELECTRIC GENERATION UNITS (EGU) AS PREPARED USING THE ERTAC EGU EMISSION ESTIMATION TOOL

Description: Large EGU Units, for simulating 2016 and future year U.S. air quality

1. EXECUTIVE SUMMARY

The ERTAC Electrical Generating Unit (EGU) Committee projects activity and emissions for fossil fuel fired EGU units located in the continental United States (CONUS) that report emissions to the United States Environmental Protection Agency (USEPA) Clean Air Markets Division (CAMD) and, with some exceptions, serve a generator of at least 25 megawatts (MW).

This document details the approach and data sources used to develop the 2016 base year emissions and select future year emissions for large EGUs. Section 2, the introduction describes the source category and the general methodology and sources. Section 3, Inventory Development Methods describes the ERTAC EGU Tool input files and how they are built from data garnered from a wide variety of sources. Periodic updates of the input files drive creation of new run versions. Key data sources include:

1. Hourly NO_X, SO_2 and activity data collected by CAMD
2. State agency expert knowledge of facilities and their future plans
3. Energy Information Agency Annual Energy Outlook
4. NERC
5. CAMD NEEDS database
6. EIA Form 860

Section 4 contains summaries of emissions and generation rates for each simulation.

2. INTRODUCTION

The ERTAC Electrical Generating Unit (EGU) Committee projects activity and emissions for fossil fuel fired EGU units located in the continental United States (CONUS) that report emissions to the United States Environmental Protection Agency (USEPA) Clean Air Markets Division (CAMD) and, with some exceptions, serve a generator of at least 25 megawatts (MW). The exceptions to the 25 MW size criteria are mostly in the Northeastern United States where some units are sized less than 25 MW but are required to report emissions and activity to CAMD.

These large EGU sources are point sources in the inventory with unit identifiers and are located at facilities identified by ORIS identifiers. Stack parameters, including release height, temperature and velocity are also tracked. Load and pollutants, including SO2 and NOX from the units are recorded and reported continuously to EPA. Other pollutants are estimated by the sources and reported annually to EPA.

The ERTAC EGU Committee collects data on these sources from a wide variety of sources and uses that information to estimate hourly emissions using the ERTAC EGU tool. The committee maintains and distributes reference runs for CONUS, including the hourly input, output, summary, and documentation files for each run. These runs and complete documentation of the ERTAC EGU Tool are located on the MARAMA web site located here:
http://www.marama.org/2013-ertac-egu-forecasting-tool-documentation

This run, CONUS 16.0, is based on 2016 base year continuous emission monitoring (CEM) data as collected by CAMD and growth factors from the Energy Information Agency (EIA) Annual Energy Outlook (AEO) 2018 High Oil and Gas scenario projection. This growth projection does not include impacts of the Clean Power Plan. EGU unit level adjustments were based on input received by November 2018 from a significant outreach effort to states and stakeholders. Projections for reference case runs have been prepared for years 2020, 2023, and 2028. Other years may be prepared based on the needs of the states for SIP planning and other uses. Final v16.0 runs were done by VA DEQ in December 2018. The contact person for questions about these run files is Doris McLeod (804-698-4197). CONUS v16.0 reference runs comply with the Cross State Air Pollution Update (CSAPR Update) Rule (81 FR 74504). The runs include unit change information as provided by states. The CONUS v16.0 runs for 2020, 2023, and 2028 comply with the CSAPR Update rule.

3. INVENTORY DEVELOPMENT METHODS

The ERTAC EGU Tool input files are built from data garnered from a wide variety of sources. Periodic updates of the input files drive creation of new run versions. Key data sources include:

7. Hourly NO_X, SO_2, and activity data collected by CAMD
8. State agency expert knowledge of facilities and their future planned operation
9. Energy Information Agency Annual Energy Outlook
10. NERC

11. CAMD NEEDS database
12. EIA Form 860

Hourly NO_X, SO_2, and activity data is continuously reported electronically to CAMD by large EGU facilities as required by 40 CFR Part 75 and in certain cases state regulations. CONUSv16.0 utilizes the data set collected for 2016. Hourly SO_2 and NO_X emission rates (lbs/MMBtu) are calculated from this data by dividing hourly emissions by heat input. The tool then calculates average unit level NO_X and SO_2 emission rates for the ozone season and non-ozone season for use in projections.

Agency expert knowledge on facilities and their future plans is collected periodically during coordinated outreach events to state staff. During outreach periods, agencies provide information on new units and controls, fuel switches, shutdowns and other unit-specific changes. Owners of facilities are encouraged to work with state staff to determine the most appropriate input characteristics for each unit. Future emission rates in projection runs are assumed to be the same as base year rates unless adjusted by the control file, which contains state knowledge of expected emission controls, fuel switches, or other unit specific revisions.

EIA Annual Energy Outlook and NERC. The primary sources of expected future change in generation is the EIA annual projection of future generation and the National Energy Reliability Corporation (NERC) projection of peak generation rates. This information is available by region and fuel type. Where states have local projections, these are preferred over EIA or NERC estimates. The ERTAC EGU growth committee prepares updates to the growth factors when new versions of the EIA AEO become available, blending the national EIA and NERC data with state specific data where available to create a unified, national growth factor table by Electricity Market Module (EMM) region. The annual change in future generation by unit is estimated by merging these national and regional growth files with state knowledge of unit level changes within a generating region. Hourly future emissions of NO_X and SO_2 are calculated by multiplying hourly projected future heat input by future emission rates.

The **CAMD NEEDS Database** contains the generation unit records used to construct the model plants that represent existing and planned/committed units in EPA modeling applications of the Integrated Planning Model (IPM). NEEDS includes basic geographic, operating, air emissions, and other data on these generating units. For the CONUSv16.0 ERTAC tool run, NEEDS v6, dated 09-14-2018, data were used to assist states in updating unit level input characteristics.

EIA Form 860 contains generator-level information about existing and planned generators and associated environmental equipment at electric power plants with 1 MW or greater of combined nameplate capacity. EIA Form 860 data from 2017 informed state updates to the unit level input characteristics.

ERTAC EGU Input Files

ERTAC EGU Tool input files for each run that are created by the ERTAC EGU committee are as follows:

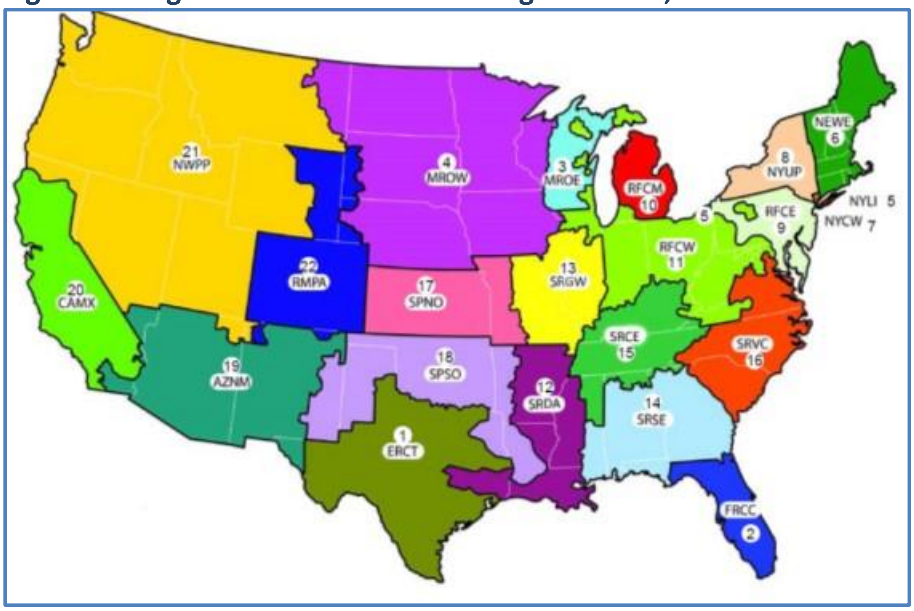
- **ERTAC Base Year Hourly CEM data** – This comma separated file contains hourly unit level generation and emissions data developed from EPA's CAMD database. This data file was generated by concatenating 2016 hourly information available on EPA's CAMD website as of February 2018.
- **ERTAC EGU nonCAMD hourly data** – This comma separated file contains updates to the hourly data. These updates include removing any negative values contained in the 2016 base year data; providing one hour of reasonable data to units that had anomalous reported data in 2016, generally due to very low usage; and providing a 2016 data set for a facility that did not report to CAMD for the entirety of 2016, since the facility only became subject to Part 75 reporting requirements in 2017.
- **Unit Availability File (UAF)** – This table contains descriptions of each generating unit derived from a variety of sources, including the CAMD NEEDS database, state input, EIA Form 860, and NERC data. Each row in the table represents a single generating unit. This file is maintained and updated by the ERTAC committee and provides information on changes to specific units from the base to the future year. For example, the UAF captures actual or planned changes to usage rates, unit efficiency, capacity, or fuels. Agencies also add information on actual and planned new units and shutdowns.
- **Control File** – This tabular file contains known future unit-specific changes to SO_2 or NO_X emission rates (in terms of lbs/mmBtu) and/or control efficiencies (for example, addition of a scrubber or selective catalytic reduction system). This information is provided by agency staff. This file also provides emission rates for units that did not operate in the base year.
- **Seasonal Controls File** – This optional tabular file may be used by agencies to enter seasonal or periodic future year emissions rates for specific units for use in future year runs. This file may be used in addition to, or as an alternative to, the Control File.
- **Input Variables File** – This tabular file specifies values for several variables used in a particular projection run.
    - **Regions and Fuel Characteristics** are not hardwired into the model. Rather, the regions and their characteristics are specified in the Input Variables File. This file allows agencies to specify variables such as the size, fuel type, and location for new units.
    - **Default New Unit Emission Rates.** Percentile of best performing existing unit emission rates for use in new units. Default is 90^{th} percentile.
    - **New Unit Hourly Profile Characteristics.** For new planned units and generation deficit units (GDUs), users may specify in this file the percentile ranking of the existing unit (operated in the base year) used to create a representative future profile of activity for new units and GDUs.
- **Growth Factor File** – This tabular file contains the annual, nonpeak, and peak electrical generation growth factors delineated by geographic region and generating unit type used in a particular run.

- **Demand Transfer File** – This optional file allows users to transfer power, on an hourly basis, from one region/fuel-unit type to another. It also allows transfer to or from other, non-fossil fuel fired systems such as nuclear and renewables.

ERTAC EGU Geographic Regional System and Fuel Types

Each EGU unit included in the model is assigned to a geographic region and fuel type bin in the UAF. The geographic regional system provided in Figure 1 is used in the CONUSv16.0 run. The system is identical to the EIA Electricity Market Module (EMM) regional system with one adjustment, the EIA regions SPNO and SPSO have been combined into a single region.

Figure 1: Regional boundaries for coal generation, CONUSv16.0



AEO regions SPSO and SPNO were aggregated into a single region called SPPR. - SPP operates as a single balancing authority and single wholesale market for the SPPR region. Application of differential growth rates by fuel type between SPPS and SPPN can produce counter-intuitive fuel-specific emissions forecasts. Combining the individual net generation forecasts for a single fuel type allows for an accurate averaging of the growth rates into an integrated whole. The anticipated outcome will be more reflective of the generation efficiencies and relative fuel balance based on the application of a single wholesale market construct. The bigger regional footprint rebalances loading for each fuel-unit type.

NERC growth factors using the NERC regional system is used for peak growth. Because the EIA EMM and NERC regions are not identical, adjustment is required to align these regional systems to develop annual and peak growth rates. To match EIA and NERC, a "best fit" NERC regional growth factor is assigned to each EMM region. In the simplest case, where a clear match between EIA and NERC regional schemes exists, for example NPCC-New England, the NERC relative peak growth rate is assigned to the corresponding EMM region. In more complicated cases, where multiple EMM regions corresponded to a single NERC region, or where regions were organized along substantially different geographic boundaries, the NERC Electricity Supply & Demand (ES&D) data was aggregated and averaged to generate a relative peak growth factor for the (usually larger) corresponding NERC region and was applied to the corresponding ERTAC region (which closely resemble the EMM regions). As an example, the EIA SRVC, RFCW, and RFCE regions corresponds to two NERC regions, PJM and SERC East. In this case, the relative peak growth factors were derived from PJM and SERC East and applied to SRVC, RFCW, and RFCE ERTAC regions.

Fuel Unit Types. Within each EMM region, individual generation units are further delineated into five unit types as follows:

- Coal;
- Oil;
- Natural Gas – Combined Cycle;
- Natural Gas – Single Cycle;
- Natural Gas – Boiler gas.

Figure 2: EMM to NERC Crosswalk – ERTAC EGU V16.0

EMM Fuel Region #	Fuel	EMM Region Name	ERTAC Regional Code	Single "Best-Fit" NERC Subregion Peak Growth Code
1	Coal, NG, Oil	Texas Regional Entity (ERCT)	ERCT	ERCOT
2	Coal, NG, Oil	Florida Reliability Coordinating Council (FRCC)	FRCC	FRCC
3	Coal, NG, Oil	Midwest Reliability Council / East (MROE)	mroe	MISO / SPP / SERC-N
4	Coal, NG, Oil	Midwest Reliability Council / West (MROW)	MROW	MISO / SPP / SERC
5	Coal, NG, Oil	Northeast Power Coordinating Council / Northeast (NEWE)	NEWE	NPCC - NE
6	Coal, NG, Oil	Northeast Power Coordinating Council / NYC Westchester (NYCW)	NYCW	NPCC - NY
7	Coal, NG, Oil	Upstate New York (NYUP)	NYUP	NPCC – NY
8	Coal, NG, Oil	Long Island (NYLI)	NYLI	NPCC - NY
9	Coal, NG, Oil	Reliability First Corporation / East (RFCE)	RFCE	PJM / SERC - E
10	Coal, NG, Oil	Reliability First Corporation / Michigan	RFCM	MISO / SPP / SERC

EMM Fuel Region #	Fuel	EMM Region Name	ERTAC Regional Code	Single "Best-Fit" NERC Subregion Peak Growth Code
11	Coal, NG, Oil	Reliability First Corporation / West	RFCW	PJM / SERC - E
12	Coal, NG, Oil	SERC Reliability Corporation / Delta (SRDA)	SRDA	MISO / SPP / SERC
13	Coal, NG, Oil	SERC Reliability Corporation / Gateway (SRGW)	SRGW	MISO / SPP / SERC
14	Coal, NG, Oil	SERC Reliability Corporation / Southeastern (SRSE)	SRSE	SERC - SE
15	Coal, NG, Oil	SERC Reliability Corporation / Central (SRCE)	SRCE	MISO / SPP / SERC
16	Coal, NG, Oil	SERC Reliability Corporation / Virginia Carolina (SRVC)	SRVC	PJM / SERC - E
17+18	Coal, NG, Oil	South West Power Pool / North (SPNO) + South (SPSO)	SPPR	MISO / SPP / SERC
19	Coal, NG, Oil	Western Electricity Coordinating Council / Southwest (AZNM)	AZNM	WECC-WECC-SWSG
20	Coal, NG, Oil	Western Electricity Coordinating Council / California (CAMX)	CAMX	WECC-CAMX US
21	Coal, NG, Oil	Western Electricity Coordinating Council / Northwest Power Pool Area (NWPP)	NWPP	WECC-NWPP US
22	Coal, NG, Oil	Western Electricity Coordinating Council / Rockies (RMPA)	RMPA	WECC-WECC-RMRG

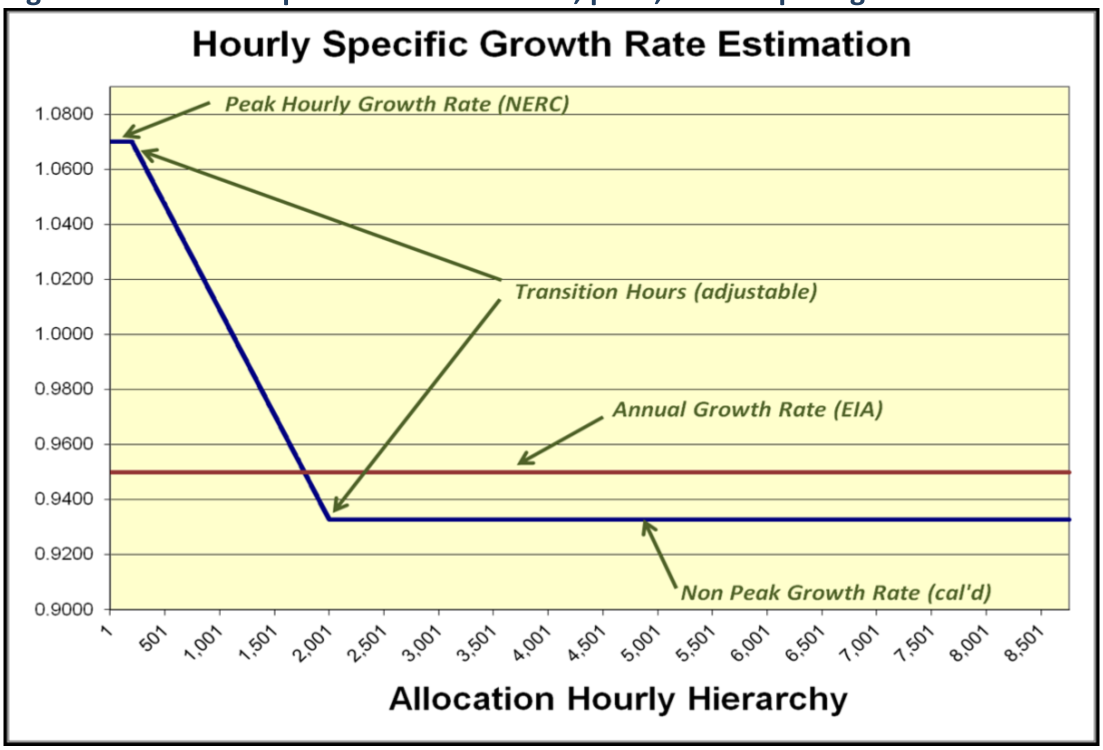
Growth Factors
Generation for future years by fuel type are based on growth rates differentiated by annual, nonpeak, and peak rates.

Average annual regional growth rates are developed by the ERTAC EGU Growth subcommittee from the EIA AEO. EIA annual average regional growth factors are calculated by dividing AEO future projected generation by base year generation. In certain cases, agencies have developed more refined region-specific growth factors, which are then used to replace the EIA/NERC factors developed from other information sources along with supporting documentation for those growth rates.

Peak growth rates are derived by determining relative peak growth from NERC ES&D data and applying it to the annual growth rates. The derived relative peak growth rates are not delineated by fuel so the ratio of peak to nonpeak growth rates for each fuel within a single region is constant.

Nonpeak growth rates are calculated within the ERTAC EGU Tool using annual and peak growth rates. Annual average regional growth rates are adjusted to account for the peak hours. Peak and nonpeak growth is assigned to every hour by ordering all hours in the year by base year utilization. The peak growth factor is assigned by fuel to a limited number of hours with the highest utilization in the base year. Growth is then transitioned gradually to the non-peak growth rate. The number of peak and transition hours are differentiated by fuel and region and are assigned in the Input Variables File. Figure 3 shows graphically the relationship between annual, peak, and nonpeak growth rates.

Figure 3: Relationship between the annual, peak, and nonpeak growth rates



Finally, fuel specific hourly regional growth factors are adjusted to account for activity from new units and shutdowns. The tool then applies the adjusted hourly growth factors to the base year hourly generation data to estimate hourly future generation. This generation is assigned to the units burning the specified fuel within the region. After generation is assigned, the tool confirms that unit capacity is not exceeded. If the available capacity is fully utilized, new, generic units ("Generation Deficit Units" or "GDUs") are created to carry demand that exceeds known unit capacity.

NO_X and SO_2 Emission Rates

For base year runs, actual CAMD data is averaged to calculate base year ozone season and non-ozone season NO_X emission rates. SO_2 rates are calculated on an annual average in CONUSv16.0. For future year runs, calculated base year average emission rates for existing units are adjusted to account for new control equipment or other changes provided in the input files. For new units, two approaches are employed. First, if a state provides new unit emission rates those are used. Where emission rates are not provided, these are estimated based on the 90th percentile best performing existing unit for that fuel type and region. The user may adjust this percentile within the input variables file.

The emission rates are applied to each unit's future year heat input activity to calculate NO_X and SO_2 emissions.

Output

The ERTAC tool estimates hourly generation and emissions for each unit included in the system. In addition, post processors create summary files to facilitate review of the results as follows:

- Annual base and future year generation (MW-hrs), heat input (mmbtu), SO_2, NO_X emission (tons) and average emission rate (lbs/mmbtu)
- Ozone season base and future year generation and heat input, NO_X emission (tons) and average emission rate (lbs/mmbtu)

Post processors are also available to generate CO_2 estimates.

ERTAC EGU Code Version

Version 16.0 used the ERTAC EGU v2.1.1 code, dated November 26, 2018. Code Version 2.1 was used for the last 2011 base year run (2.7) and had added new functionality, including the ability to transfer load between fuel types and regions. The ERTAC EGU v2.1.1 code also has the load transfer capability and additionally, has corrected a variety of minor bugs in the various processors.

Base Year 2016 Development

ERTAC EGU v16.0 is the first set of runs to use the base year 2016 data. Base year input files were created from EPA files available on the CAMD website. ERTAC EGU v16.0 input files combined information from prior runs with the 2016 CAMD hourly data. State updates to the UAF and control file received by November 2018 were included.

2016 is a leap year, with 8784 hours. In projection years that are leap years, including 2020, 2024, and 2028, the projection year contains the additional hours comprising February 29th for a total of 8,784 hours. In other years, the preprocessor strips out the Feb 29th data from 2016 so that both the base year and the future year will have 8,760 hours. This adjustment may affect averages between leap year and non-leap year unit level data.

Unit Availability File (UAF)

The UAF includes a record for each generation unit and captures actual or planned changes to utilization fractions, unit efficiency, capacity, or fuels. Agencies also add information on actual and planned new units and shutdowns.

Numerous detailed corrections and adjustments to these files were made based on agency comments regarding the configuration, characteristics, and utilization estimates of their units. The file name for the final unit availability file is:

2016BASEUnit_Availability_v16.0_18HOGnocPPNovember142018_code2.1.1.xlsx.

After the various sources are collated, adjustments were required to create a functional and consistent v16.0 UAF as follows:

- **Two UAFs are used**. One for years 2020-2025 where the South Carolina Cross 2 (ORIS 130) is retired. The second is for years 2026-2030 where Cross 2 (ORIS 130) is on line. This is to account for South Carolina's IRP, which states that the unit will go into cold storage 3/1/2017 and is expected back on line 12/1/2025. All other data in these two UAFs are identical.
- **Substitutions.** In most cases actual 2016 operational data, as recorded in the 2016 CAMD hourly files, were used by the code to estimate unit characteristics. To ensure that this would occur, prior estimates that was obtained from various resources used to build the UAF was deleted to allow the code to use the 2016 data. Deleted characteristics are as follows:

    - Nominal_heat_rates for existing units
    - Max_annual_ERTAC_UAF_state_input for all units
    - Unit_optimal_load_threshold from all units

  After using the code to estimate the 2016 values, in some cases inadequate 2016 operational data was available to the code to estimate unit characteristics. In these cases, the UAF was filled with the following values:

  Heat rate could not be calculated, or heat rate was out of range, therefore the following defaults applied to:

    - Boiler gas units – 10,000
    - Coal units – 11,000
    - Combined Cycle Gas Units – 8,000
    - Simple Cycle Gas Units – 10,000
    - Oil Units – 12,000

  Optimal load threshold (Column AV) could not be calculated, therefore a default of 50% of the maximum_unit_heat_input, converted to MW by 10000 btu/kw-hr and 1000 kw/mw was applied to such units**.**

  Max_annual_UF_state_input (Column AM) could not be calculated, therefore a default of 0.9 was applied to such units.

  In many cases such units needed more than one default value to run successfully.

> One boiler gas EGU unit operated in 2016 in the SRGW region, unit 8 at ORIS 2123 (Columbia). Two additional units come on line in 2017 and retire in 2022. These units are ORIS 2104 Unit IDs 1 and 2 (Meramec). These two units are not included in the outputs 2020, 2021, 2022 as there is no existing unit in the second spot of the hierarchy on which to base the presumptive profile. They do not appear in 2023 and later outputs since those two units commenced operations after 2016 and retired prior to the projection year.

Non-CAMD Hourly File – Adjustments to Abnormal or Missing Data in CAMD
ORIS 7991, Units U1 and U2, had no base year activity in 2016 as reported to CAMD because the units did not fall under Part 75 reporting requirements until 2017. WI requested the use of 2017 hourly data in lieu of 2016 hourly data to ensure that the units had reasonable profiles and activity represented in the base year. Since the 2017 data did not include information for February 29, the hourly data for this day in the 2016 data were left blank.

A small number of units with abnormal or missing base year hourly data were corrected. Where data is missing, units are assigned one hour of reasonable, minimal activity in the non-CAMD hourly file to ensure processing. This improvement has negligible impact on base year data. Any negative values were replaced with blank values. The details of these anomalies were corrected.

Projection Input Files Development – Growth Rate File
Growth factors used in v16.0 reference were developed based on AEO2018 High Oil and Gas and No Clean Power Plan Scenario. Relative peak factors were derived from 2017 NERC ES&D. The file containing annual and peak growth factors was provided by Tom Shanley of the ERTAC EGU Growth committee and is named:

AEO2018HOGv16_0 SPPR_BY2016_ertac_growth_rates.xlsx

Preliminary runs using the AEO2018 reference case yielded future year generation for which there was inadequate coal fleet to meet the projected demand. Therefore, the ERTAC EGU committee decided to use the High Oil and Gas scenario.
These growth factors and default growth curve parameters impacted regions located within New York. NYDEC replaced certain **NYCW, NYLI, and NYUP** AEO annual growth rates with values based on regional information. The updated local values were developed for years 2017 through 2030.

Projection Input Files Development – Demand Transfer
Demand transfer is the movement of generation from one fuel bin to another in order to alleviate the generation of a GDU. Another use for a demand transfer is the case where a significant system change occurs which was not anticipated by the EIA in the AEO. For example, this approach was taken in v2.7 to address the retirement of Indian Point, a large nuclear power

plant near New York City that was not anticipated in AEO2017 projections. AEO2018 includes the retirement of Indian Point, and therefore this adjustment was no longer needed in v16.0.

For v16.0 demand transfer was used to prevent coal-fired GDUs from being created. In most cases the coal demand is transferred to combined cycle. Occasionally simple cycle, boiler gas, or oil is the recipient of the transfer. The amount of generation transferred, and the number of hours required varied by region and projection year as follows:

Region		$MROE			RFCW			SRGW			RFCE			NYUP		
Year		2020	2023	2028	2020	2023	2028	2020	2023	2028	2020	2023	2028	2020	2023	2028
Hourly threshold for transfer		2,900	2,000	2,000	54,000	47,795	46,000	NA	12,000	12,000	13,000	NA	NA	877	NA	NA
Capacity transferred	From coal (MW-Hr)	820	820	820	3,500	3,500	3,400	NA	1,400	1,400	3,900	NA	NA	230	NA	NA
	To combined cycle NG (MW-Hr)	820	410	410	3,500	3,500	NA	NA	1,400	1,400	2,500	NA	NA	NA	NA	NA
	To Simple cycle NG (MW-Hr)	NA	410	410	NA	NA	3,400	NA	NA	NA	1,400	NA	NA	NA	NA	NA
	To Boiler Gas (MW-Hr)	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Hours affected		1,525	1,525	2,456	172	172	234	NA	790	790	793	NA	NA	83	NA	NA
Total Transferred (M MW)		1.25	1.25	2.01	0.6	0.6	0.8	NA	1.11	1.11	3.09	NA	NA	0.02	NA	NA

Projection Input Files Development – Controls File/Seasonal Controls File
The V16.0 Controls File is based on 2016BASEControl File_v16.0_18HOGnoCPPNovember 262018_code2_1_1.xls.

Seasonal Controls File: The seasonal controls file is based on the information contained in 2016BASEControl File_v16.0_18HOGnoCPPNovember262018_code2_1_1.xls.
In 16.0, Maryland, Pennsylvania, Indiana, West Virginia, and Georgia included seasonal controls.

4. Emissions Summaries

Figure 4: National Generation By Unit Type (MW-Hrs) for Base Year and Future Projections

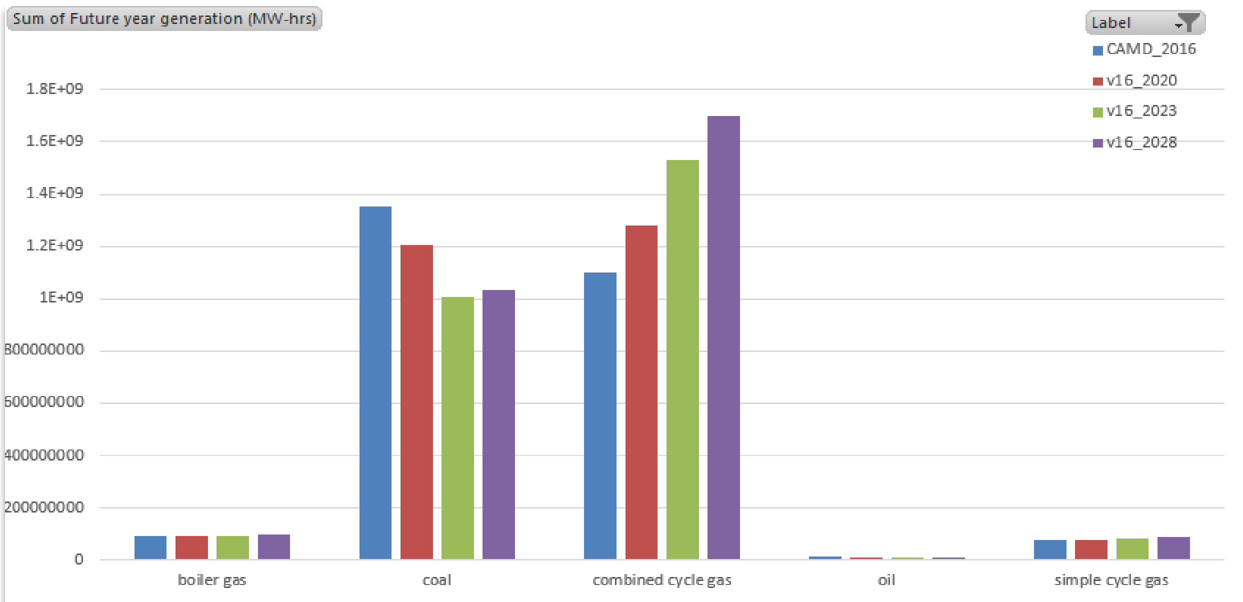


Figure 5: NOX Emissions by State for Base Year 2016 and future projections (TPY)

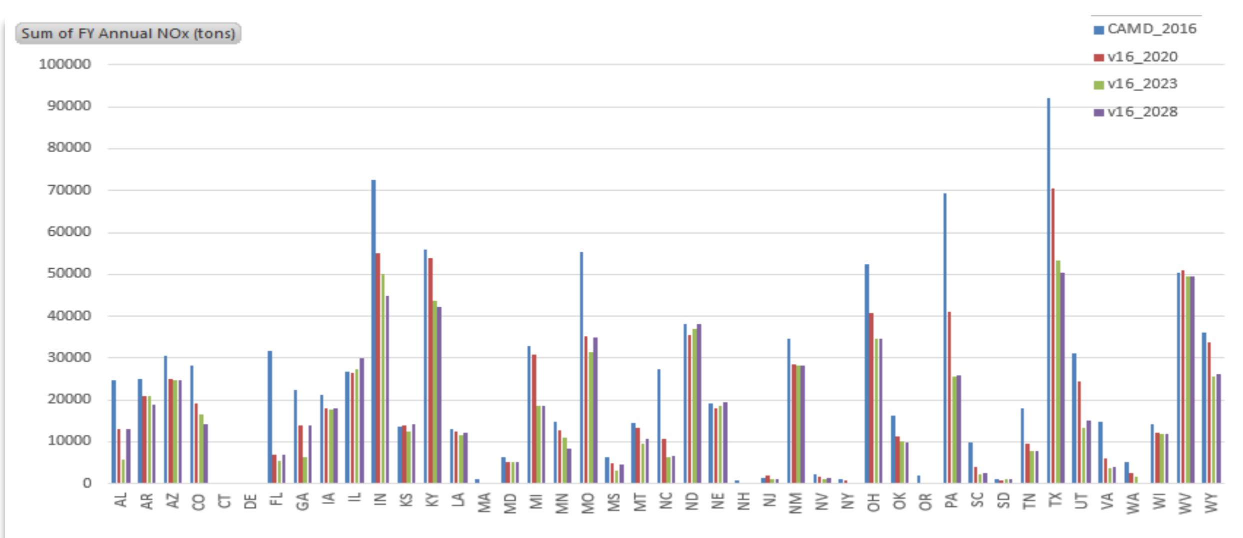


Figure 6: SO2 Emissions by State for Base Year 2016 and future projections (TPY)