Analysis of Ozone Season NO_X Emissions Data for Coal-Fired EGUs in Four Mid-Atlantic States

EPA Clean Air Markets Division[1]

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1 Introduction

The Ozone Transport Commission (OTC) is recommending that EPA require Pennsylvania to set daily nitrogen oxides (NO_X) emissions limits during the ozone season for coal-fired electric generating units (EGUs) with already-installed selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) controls. Further, the OTC recommends that these limits be as stringent as limits set by Delaware, Maryland, and New Jersey. The purpose of this analysis is to explore recent NO_X emission rates and trends at coal-fired EGUs equipped with SCR or SNCR in Pennsylvania, Delaware, Maryland, and New Jersey. For comparison, coal-fired EGUs not equipped with SCR or SNCR are also included in this analysis.

This analysis relies on EPA Clean Air Markets Division's (CAMD's) Power Sector Emissions Data. The data used in this analysis are hourly data from the 2009-2019 ozone seasons for coal-fired EGUs in these four states, with some additional focus on the more recent ozone seasons 2015-2019. Partial hours of operation are excluded from this analysis. Hours in which substitute data were submitted for heat input, NO_X emissions rate, and/or NO_X mass emissions have also been removed from this analysis.[2] In this analysis, 5,370 substitute data observations were removed, accounting for just 0.44% of the data.

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[1] Questions about this analysis should be directed to Justine Huetteman, EPA Clean Air Markets Division, huetteman.justine@epa.gov. The data sets used in the analysis and the code used to produce the unit-specific figures in section 3.1 of this analysis are available upon request.

[2] Substitute data are required to be submitted in instances in which the monitor is not available or is not performing properly, or a quality assurance test of the monitoring equipment was missed. These substitute data values are usually similar to actual emissions; however in some rare cases, they may be significantly higher than actual emissions, sometimes representing the EGU's maximum potential emissions.

2 Overview of Recent NO_X Emission Rates and NO_X Mass Emissions

Average ozone season NO_X emission rates at coal-fired EGUs with SCR have decreased significantly in Pennsylvania since 2015, while average emission rates at SCR-equipped EGUs in Delaware, Maryland, and New Jersey have been relatively consistent (see Table 2.1). In 2017, a more stringent emissions budget for the units in Pennsylvania (as well as Maryland and New Jersey) was implemented under the Cross-State Air Pollution Rule (CSAPR) Update, and Pennsylvania units also became subject to more stringent NO_X RACT requirements. After being higher than the average emission rates for all three of the other states in 2015-2016, in 2017-2018 the average NO_X emission rates for the Pennsylvania units were below the average rate for the New Jersey units but above the average rates for the Delaware and Maryland units. The average emission rate for the Pennsylvania units increased above the average rate for the New Jersey units in 2019 but remained well below 2015-2016 levels.

Table 2.1. Weighted Average Ozone Season NO_X Emission Rates at Operating SCR-equipped Coal-fired EGUs (lb/mmBtu) †

Year	Pennsylvania units	Delaware units	Maryland units	New Jersey units
2015	0.252	0.094	0.059	0.117
2016	0.233	0.078	0.058	0.111
2017	0.099	0.084	0.057	0.112
2018	0.102	0.086	0.064	0.112
2019	0.130	0.082	0.060	0.108

† Each weighted average emission rate is computed as the sum of ozone season NO_X emissions for the group of units divided by the sum of ozone season heat input for the group of units.

With respect to NO_X mass emissions, during the 2015-2019 ozone seasons, Pennsylvania coal-fired EGUs with SCR produced significantly more NO_X emissions than coal-fired EGUs with SCR in Delaware, Maryland, and New Jersey (see Figure 2.1). The Pennsylvania coal fleet also operated for more operating hours (see Figure 2.2) and at a higher level of heat input (see Figure 2.3) than the other states during these ozone seasons. In 2017, Pennsylvania NO_X emissions declined sharply, by more than 50% over the previous year. The decrease is primarily due to generally lower NO_X emission rates, although a reduction in operating hours and heat input also contributed to the decrease. The reduction in NO_X emission rates could be due to more stringent emission rate limits set under the Pennsylvania RACT II standard and/or more stringent NO_X mass emission budgets set under the CSAPR Update, both of which took effect in 2017. Nevertheless, despite the decreases since the 2015-2016 ozone seasons, during the 2019 ozone season Pennsylvania coal-fired EGUs with SCR emitted more than six times the amount of NO_X as the SCR-equipped units in the other three states combined. While one important reason Pennsylvania's 2019 emissions were higher than the emissions of the other states' units is the generally higher heat input consumed by the Pennsylvania units, differences in emission rates also contributed, with Pennsylvania's SCR-equipped units reporting an average NO_X emission rate during the 2019 ozone season nearly twice the average NO_X emission rate for SCR-equipped units in the other three states (see Table 2.2).

Figure 2.1: Total Ozone Season NO_X Emissions by State for Coal-fired EGUs with SCR

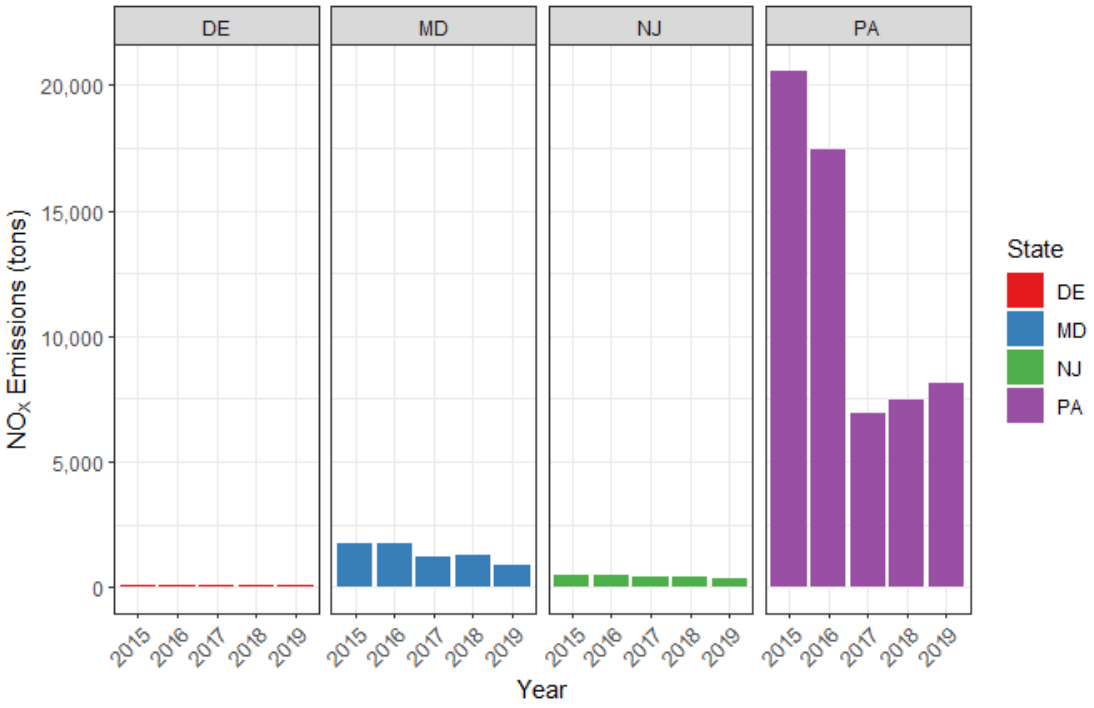


Figure 2.2: Total Ozone Season Operating Hours by State for Coal-fired EGUs with SCR

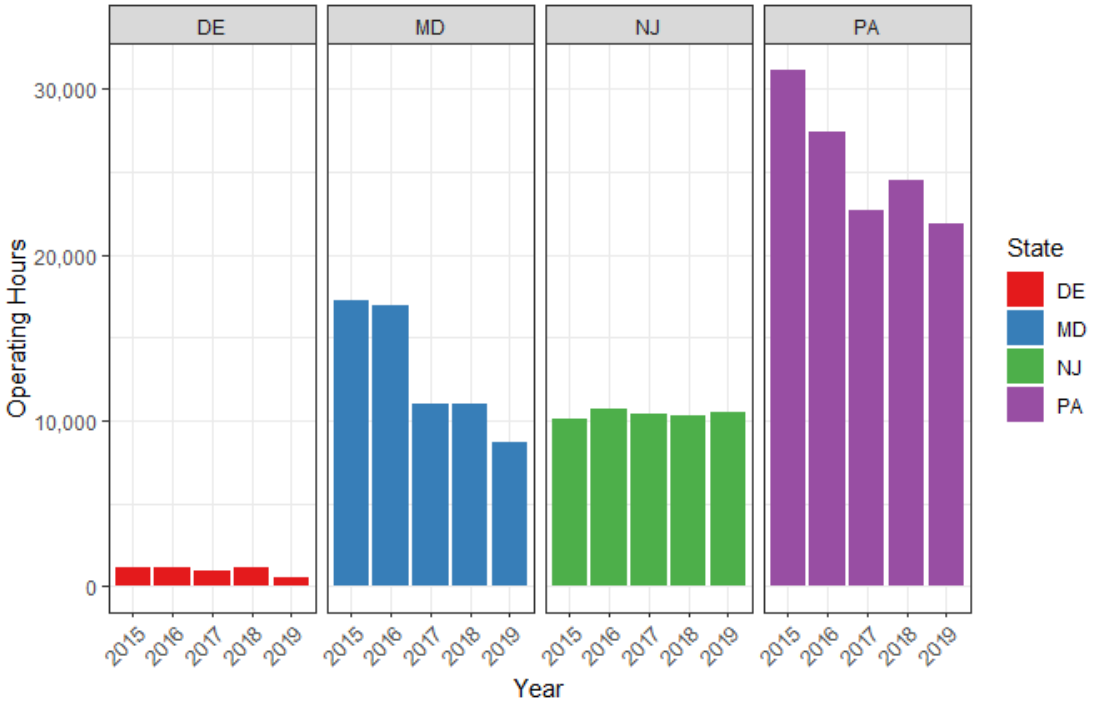


Figure 2.3: Total Ozone Season Heat Input by State for Coal-fired EGUs with SCR

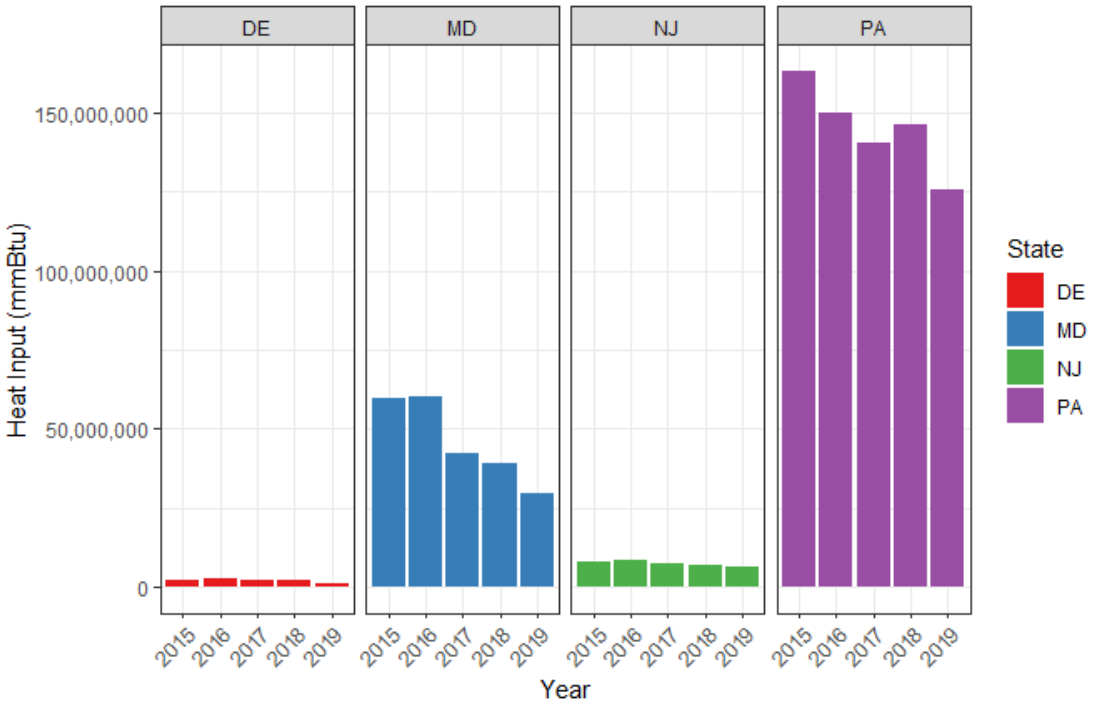


Table 2.2: 2019 Ozone Season Summary of NOx Mass Emissions and NOx Emission Rates at Coal-fired EGUs with SCR

State	NOx Emissions (tons)	Average NOx Rate (lb/mmBtu)
DE	48	0.082
MD	881	0.060
NJ	360	0.108
PA	8,156	0.130

3 NOx Emission Rates and NOx Mass Emissions by Operating Level for Individual EGUs

This section of the analysis focuses on NOx emission rates in the context of operating level, which can have an important impact on SCR performance and therefore NOx emission rates and mass emissions. The patterns of operation of some coal-fired EGUs have been changing in recent years, and considering operating level allows any effects of these changes on NOx emission rates and the operation of SCR controls to be taken into account. At lower levels of generation, the SCR may not be effective because temperatures may be too low to promote the catalytic reaction. Generally, the catalyst works more effectively as temperature in the unit increases with increasing heat input and correspondingly increasing steam and electrical output.

The plots in this section compare ozone season NO_X emission rates, NO_X mass emissions, and operating hours for individual coal-fired EGUs for either two or three years during the 2009-2019 period. Data for the year 2019 are always included for a recent snapshot. The other years shown are the years during the 2009-2019 period in which the unit achieved its lowest and third lowest average ozone season NO_X emission rates.[3] If plots are provided for only two years, then 2019 represents the year of either the unit's lowest or third-lowest average emission rate during the 2009-2019 period.

This analysis uses heat input as a proxy for operating level. Specifically, this analysis uses a heat input factor. Heat input factor was calculated for each hour by dividing the heat input in a given hour by the individual EGU's observed maximum hourly heat input during the ozone seasons in the 2009-2019 period. The hourly emission rate data are then divided into 10 bins according to the heat input factor for the hour (bin 1 contains data for all hours in which the heat input factor for the hour is between 0-10% of the unit's maximum hourly heat input, bin 2 contains data for all hours in which the heat input factor is between 10-20% of the unit's maximum hourly heat input, etc.).

The hourly emission rate data values for each heat input factor bin are displayed by means of a "box plot" or "box-and-whisker plot." Each "box" represents the middle half of all the hourly data values in that heat input factor bin – that is, the hourly data values that fall in the "interquartile range" between the 25th percentile and 75th percentile hourly data values. The horizontal line in the box represents the median hourly data value. Vertical lines, or "whiskers," extend to the highest and lowest hourly data values that fall above or below the top or bottom edges of the box within a distance of up to 1.5 times the interquartile range. Any outlying hourly data values that fall above or below the top or bottom edges of the box by a distance of more than 1.5 times the interquartile range are shown as individual dots. Thus, a lower median data value and lower overall placement of the box on the chart indicate generally lower hourly emission rates, while shorter vertical distances between the top and bottom edges of the box and between the top and bottom ends of the whiskers, as well as fewer outliers, indicate lower variability (or greater consistency) of a unit's hourly emission rates at a given heat input factor bin. In this way, each box plot provides visual representations of both the magnitude and variability of a unit's hourly NO_X emission rates at a given heat input factor bin in a single chart.

In all of the emission rate charts in this section, a horizontal dashed line showing the 0.12 lb/mmBtu emission rate limit that Pennsylvania's SCR-equipped units are required to meet

[3] Data for the ozone season with each unit's third-lowest emission rate during the 2009-2019 period are included for comparability with the data sets EPA has used to identify emission reduction opportunities in the CSAPR Update and the proposed Revised CSAPR Update. Data for the ozone season with each unit's lowest emission rate during the same period are also included for greater comparability with the data provided by the OTC to support its CAA section 184(c) recommendation. EPA notes that for some units the OTC has provided data for ozone seasons before 2009.

– under certain operating conditions, on a 30-day rolling average basis – by the state's current RACT rules is included for comparison purposes.

3.1 Unit-Level NO_X Emission Rates and NO_X Mass Emissions

3.1.1 Units with SCR Controls

The plots for SCR-equipped EGUs in this subsection show that most of the units have generally achieved lower NO_X emission rates as operating level increases. Moreover, many of the units have achieved low NO_X emission rates at low- and mid-operating levels, not just at high-operating levels when temperature is expected to be highest. Many of the EGUs have shown changes in the numbers of hours spent at the various operating levels over time. For some of the units, the relationship between NO_X emission rates and operating levels has remained generally consistent across the years evaluated, while for others, the relationship of NO_X emission rates to operating levels appears to have changed in recent years, as discussed below.

Some of the SCR-equipped EGUs analyzed show different relationships of NO_X emission rates to operating levels in the 2019 ozone season than in the other ozone seasons evaluated:

- Conemaugh units 1-2 and Keystone units 1-2 in Pennsylvania appear to have operated somewhat differently in the 2019 ozone season than in the earlier ozone seasons. These units show generally somewhat higher NO_X emission rates and greater variability in NO_X emission rates than the other SCR-equipped EGUs in this analysis, particularly in the 2019 ozone season. In their years with the lowest average ozone season NO_X emission rates in this analysis, these EGUs had relatively low NO_X emission rates at mid- and high-operating levels; moreover, there was little variability in NO_X emission rates at these operating levels. However, during the 2019 ozone season, these EGUs had higher NO_X emission rates and greater variability in NO_X emission rates across operating levels than in the past, particularly at mid-operating levels. Conemaugh units 1-2 had relatively low NO_X emission rates in bins 5-7 during the 2018 ozone season, but in 2019 had much higher NO_X emission rates and higher variability in these bins. The units also operated more frequently in these bins (particularly bin 5). Keystone units 1-2 have consistently shown higher NO_X emission rates in bins 4 and 5 compared to other operating levels, but in 2019 the units operated more frequently in these bins compared to the earlier ozone seasons. Conemaugh units 1-2 and Keystone units 1-2 are the largest individual units of the 39 units in Delaware, Maryland, New Jersey, and Pennsylvania included in this analysis, and while their total heat input has decreased somewhat across the years evaluated, the extent of the decrease has been less than for many of the other units analyzed. Partly because of their increased share of the collective heat input of the 39 units and partly because of their relatively higher emission rates, in the 2019 ozone season the collective NO_X mass emissions of these four units (6,215 tons) exceeded the collective NO_X mass emissions of the other 35 units included in the analysis (5,213 tons).

- Homer City units 1-3 in Pennsylvania showed generally lower and less variable NO_X emission rates in the 2019 ozone season at mid- and high-operating levels compared to earlier ozone seasons. Units 1 and 2 operated for fewer hours at high-operating levels in the 2019 ozone season compared to the earlier years, which contributed to their decrease in NO_X mass emissions. On the other hand, Unit 3 operated for more hours across most operating levels compared to 2017 and thus emitted more NO_X.

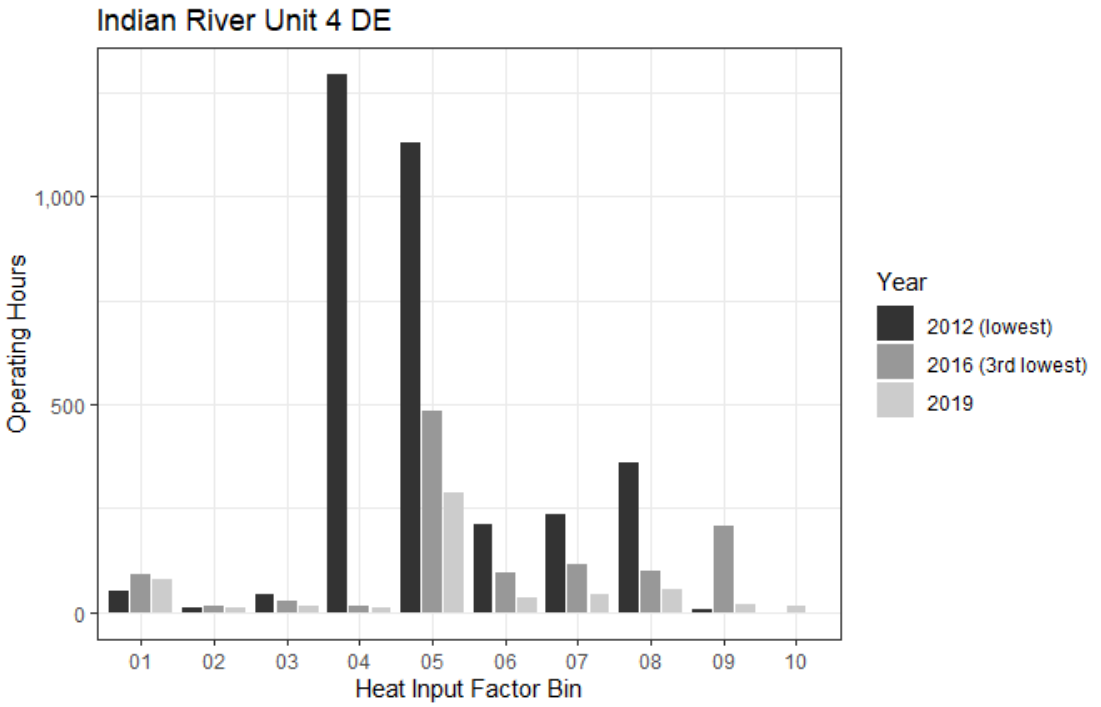
- Chalk Point unit 1 in Maryland showed relatively higher NO_X emission rates during the 2019 ozone season at a range of operating levels compared to past ozone seasons but also operated much less frequently.

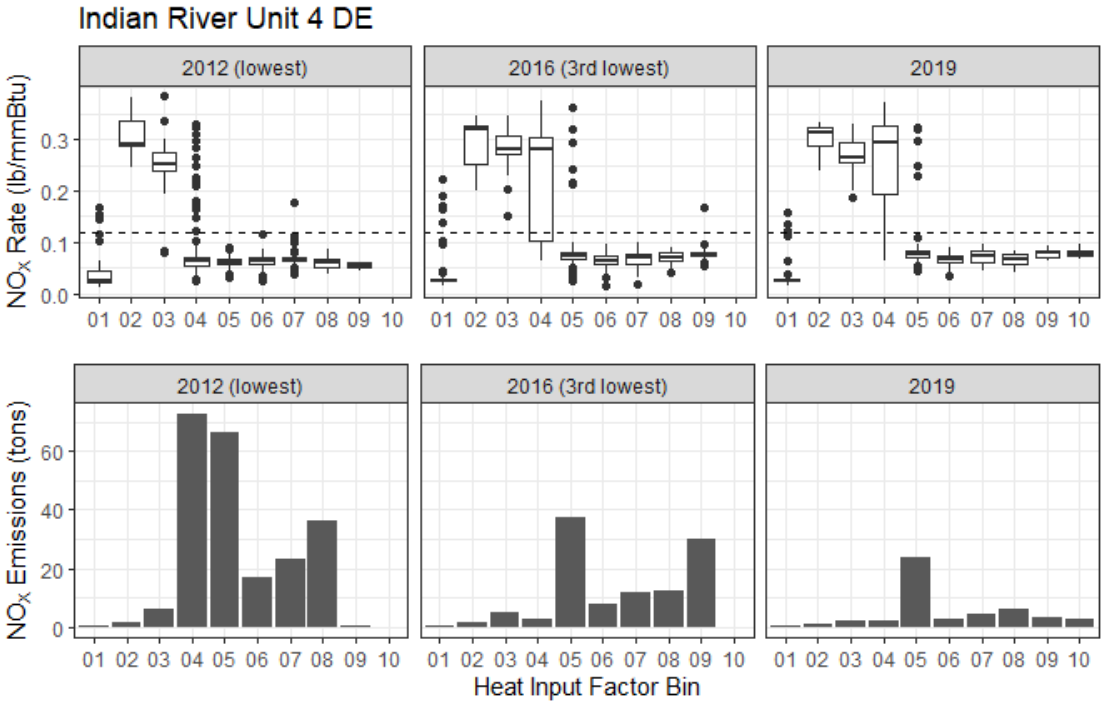
The remaining SCR-equipped EGUs analyzed show more consistent relationships of NO_X emission rates to operating levels across the different ozone seasons evaluated:

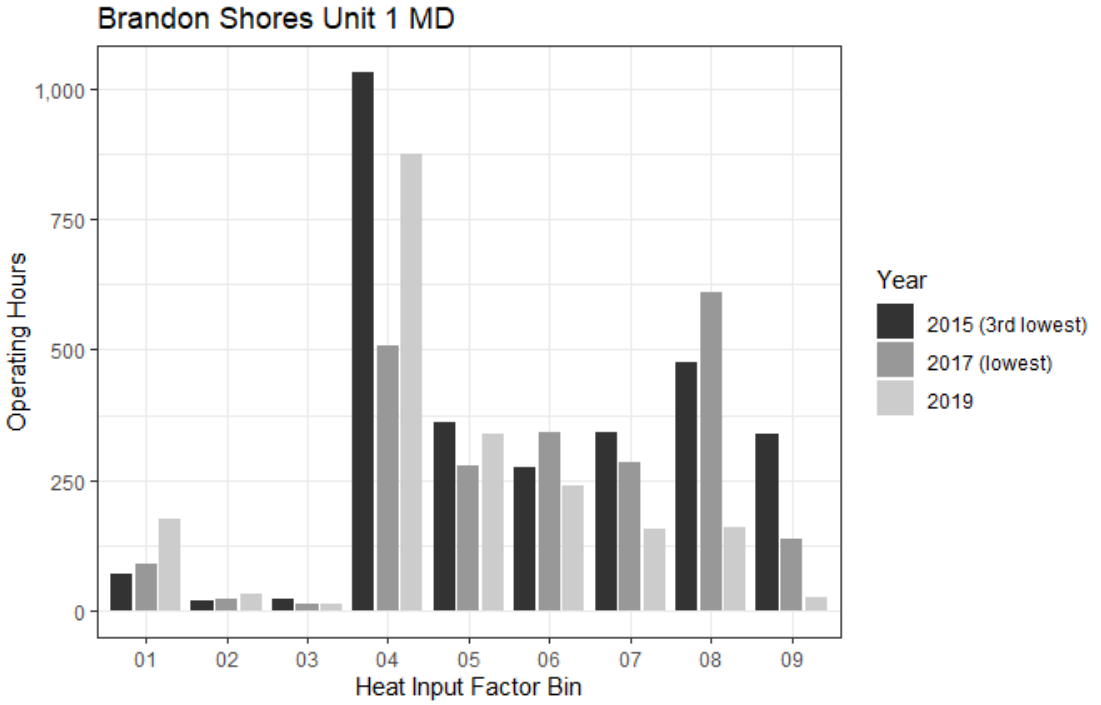
- Brandon Shores units 1-2, Morgantown units 1-2, and Wagner unit 3 in Maryland and Carneys Point units 1001-1002 and Logan unit 1001 in New Jersey consistently show low NO_X emission rates starting around bins 3 and/or 4 and continuing through the mid- and high- operating levels. The Maryland EGUs have some of the lowest NO_X emission rates and lowest variability of NO_X emission rates across operating levels in this analysis. In this group, the Brandon Shores, Morgantown, and Wagner units operated less frequently and thus had much lower total NO_X mass emissions in the 2019 ozone season, particularly at high operating levels, than they did in the past, while the other EGUs operated at similar levels (or, for the Carneys Point units, at higher levels) in the 2019 ozone season.

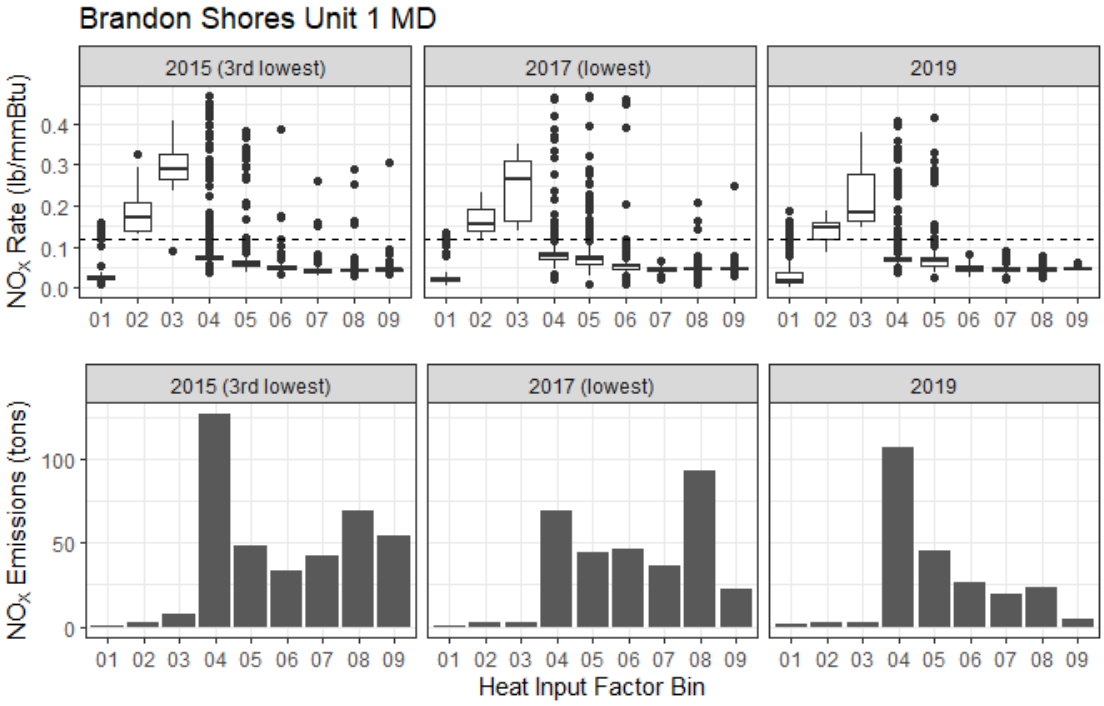
- Indian River unit 4 in Delaware and Montour units 1-2 in Pennsylvania generally show low NO_X emission rates starting at about bin 5 across all years analyzed but also operated much less frequently in the 2019 ozone season than they did in the earlier years and therefore had lower total NO_X mass emissions. NO_X emission rates at these EGUs appear to have ticked up slightly in recent ozone seasons at mid- and high-operating levels, though these differences are minor as rates remain low relative to other units.

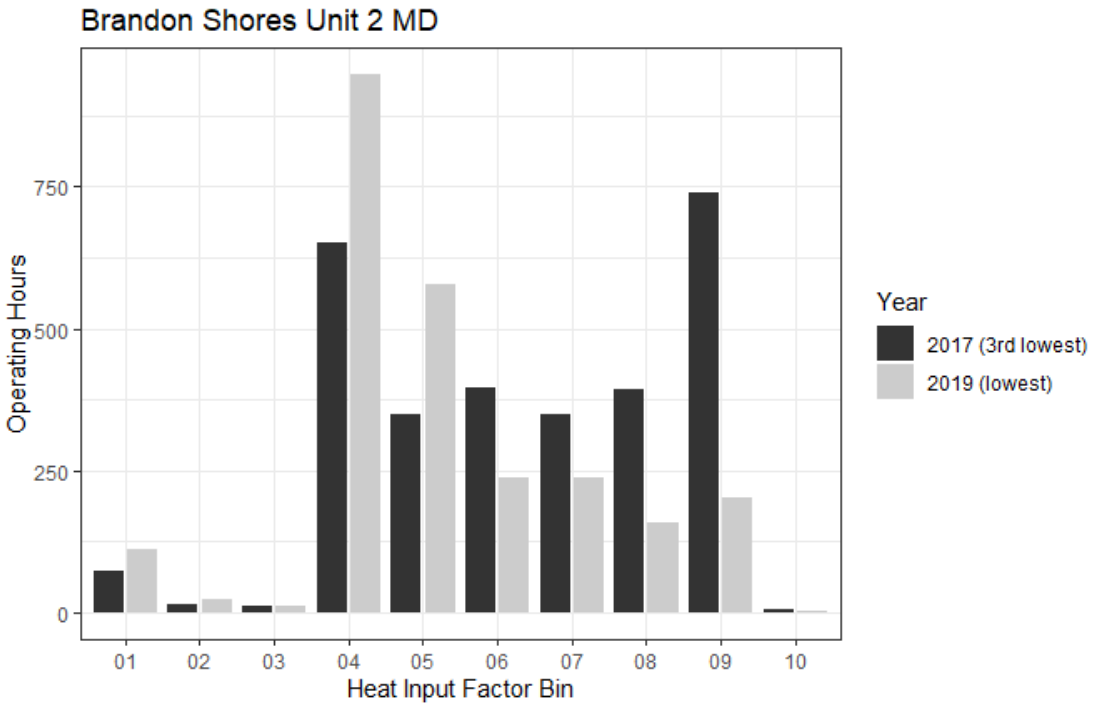
- Cheswick unit 1 in Pennsylvania shows NO_X emission rates at various operating levels that have been consistent or decreased slightly over the years evaluated, although the emission rates achieved generally have not been as low as many of the other SCR-equipped EGUs in this analysis. The most notable change in the data for this unit across the years evaluated has been a shift in operating hours from the high operating levels (bins 8 and 9) where the unit achieves its lowest NO_X emission rates to mid-operating levels (particularly bin 4) where the unit's NO_X emission rates have been significantly higher. As a result of this shift in operating patterns, in the 2019 ozone season, the unit emitted most of its NO_X mass emissions in bin 4.

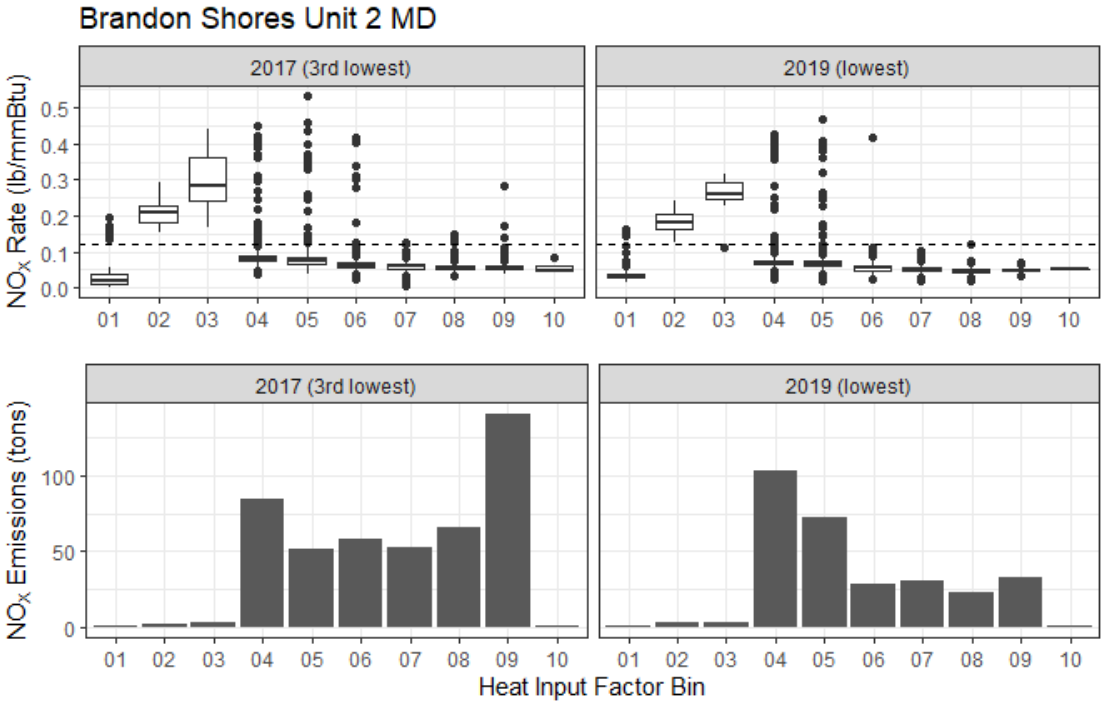

Indian River Unit 4 DE
Operating Hours
1,000
500
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2012 (lowest)
2016 (3rd lowest)
2019

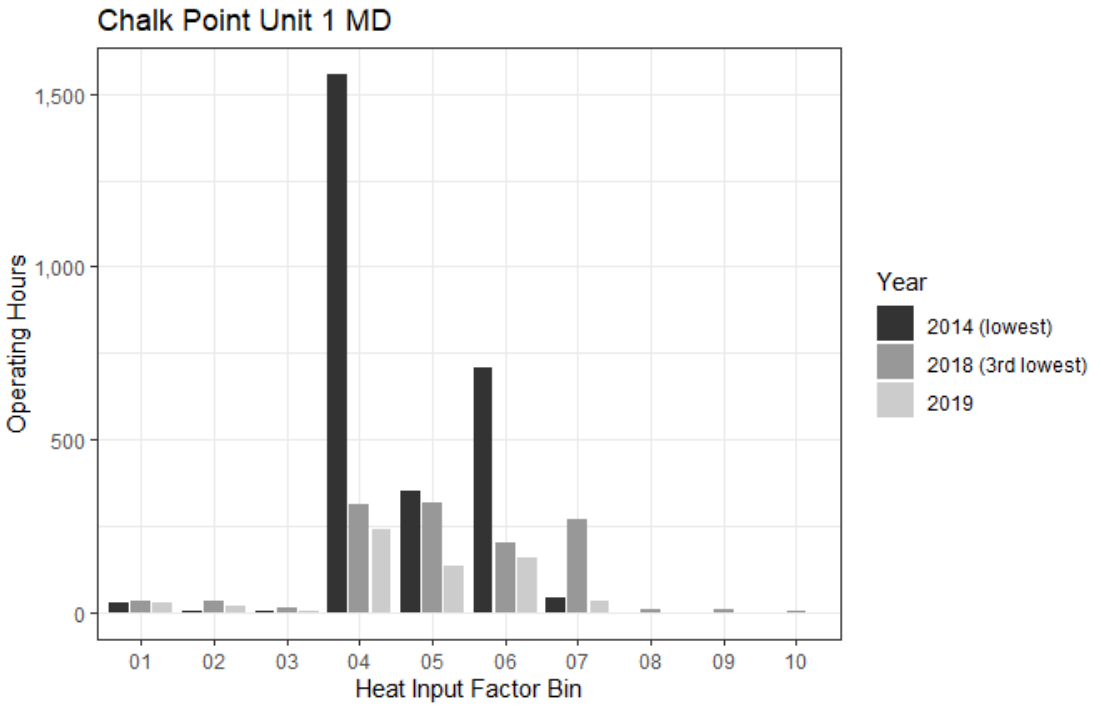

Indian River Unit 4 DE
2012 (lowest)
2016 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
60
40
20
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

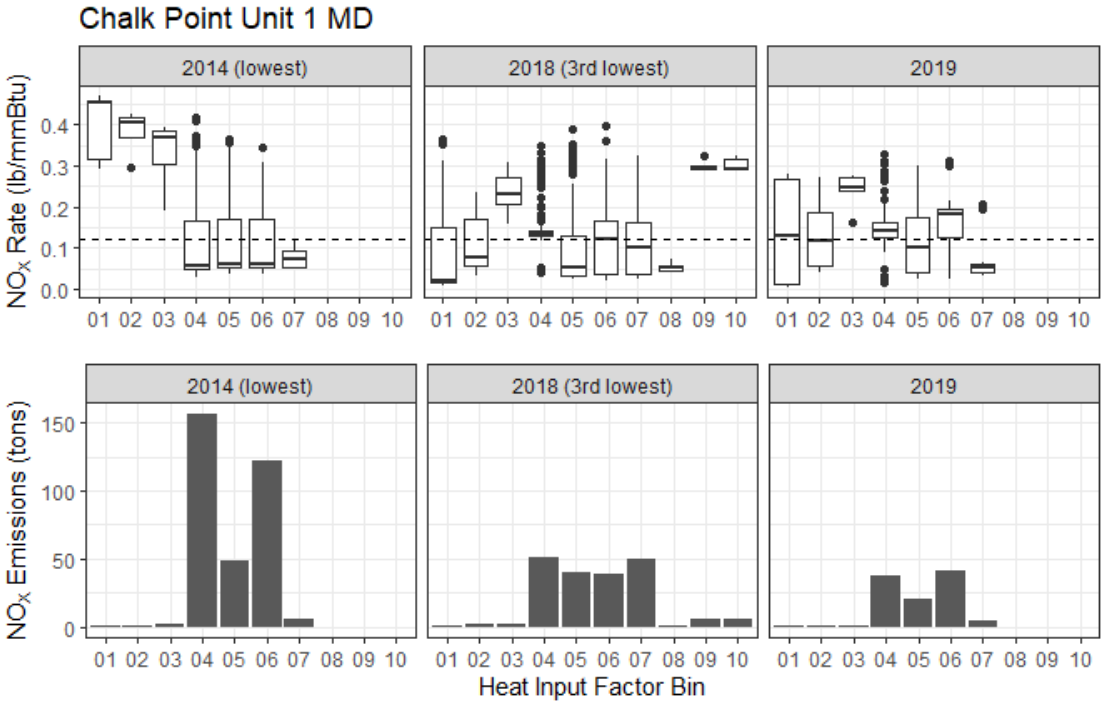

Brandon Shores Unit 1 MD
Operating Hours
1,000
750
500
250
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2015 (3rd lowest)
2017 (lowest)
2019

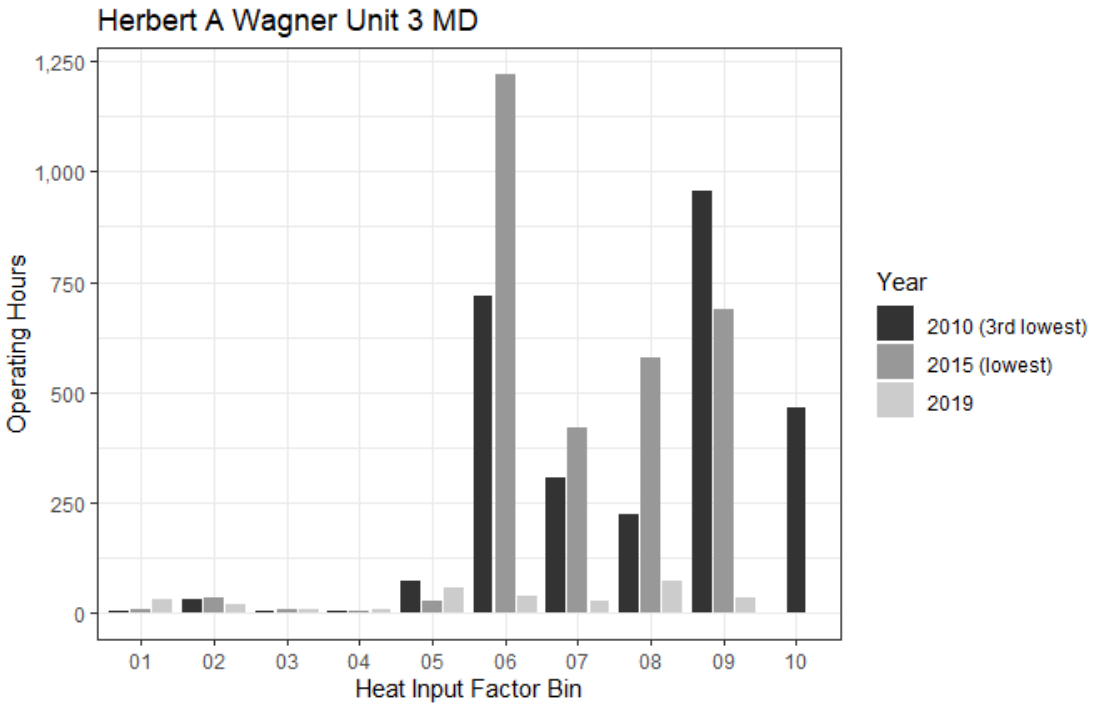

Brandon Shores Unit 1 MD
2015 (3rd lowest)
2017 (lowest)
2019
NOX Rate (lb/mmBtu)
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
100
50
0
01 02 03 04 05 06 07 08 09
Heat Input Factor Bin

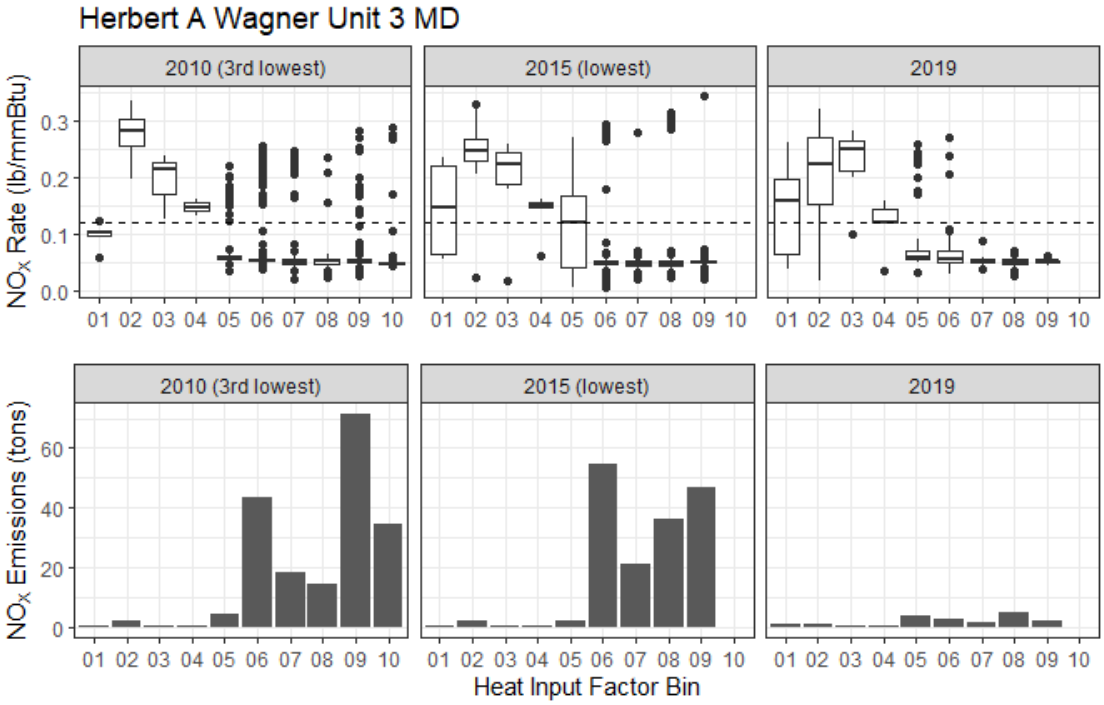

Brandon Shores Unit 2 MD
Operating Hours
750
500
250
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2017 (3rd lowest)
2019 (lowest)

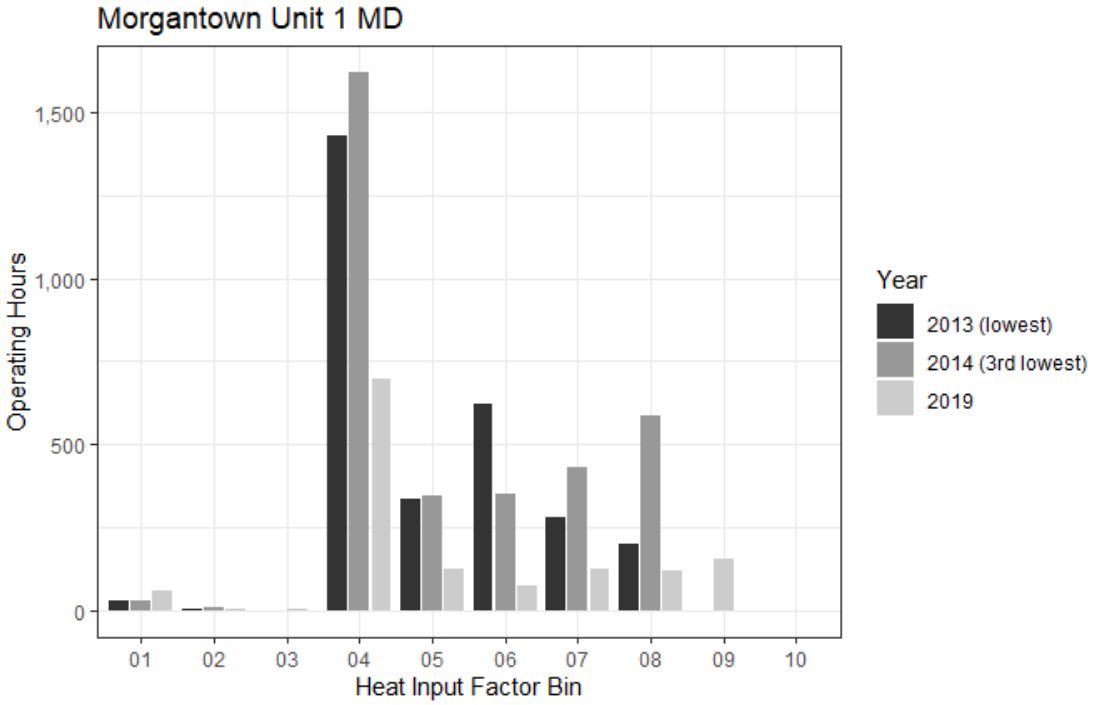

Brandon Shores Unit 2 MD
2017 (3rd lowest)
2019 (lowest)
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
100
50
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin

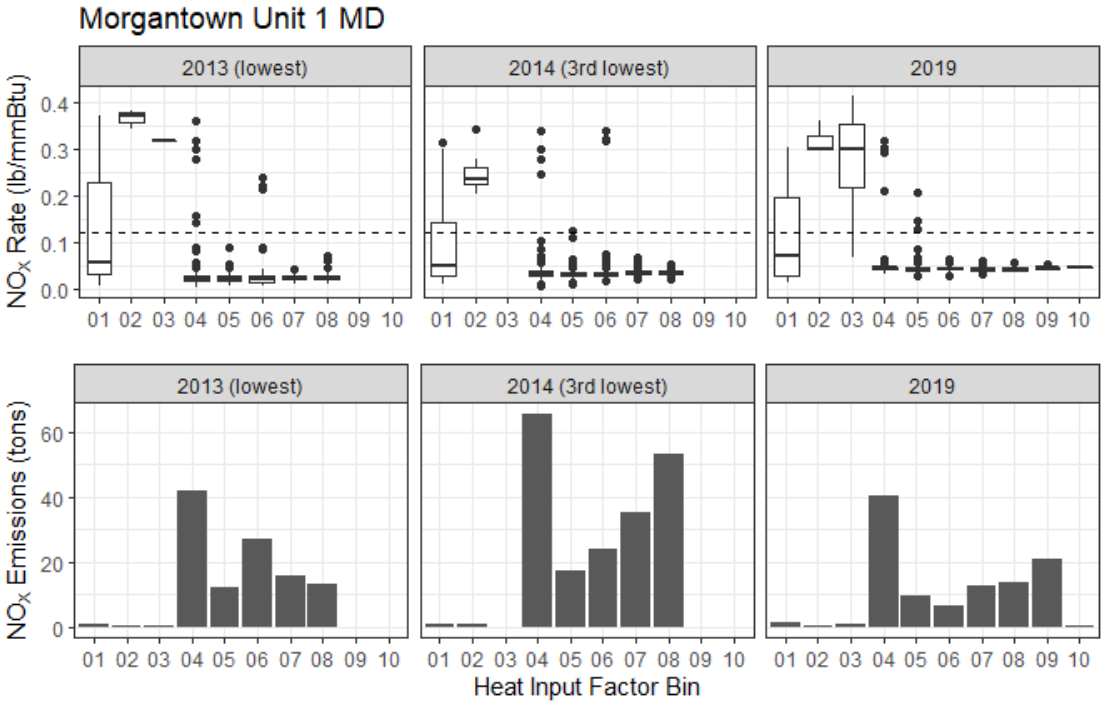

Chalk Point Unit 1 MD
Operating Hours
1,500
1,000
500
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2014 (lowest)
2018 (3rd lowest)
2019

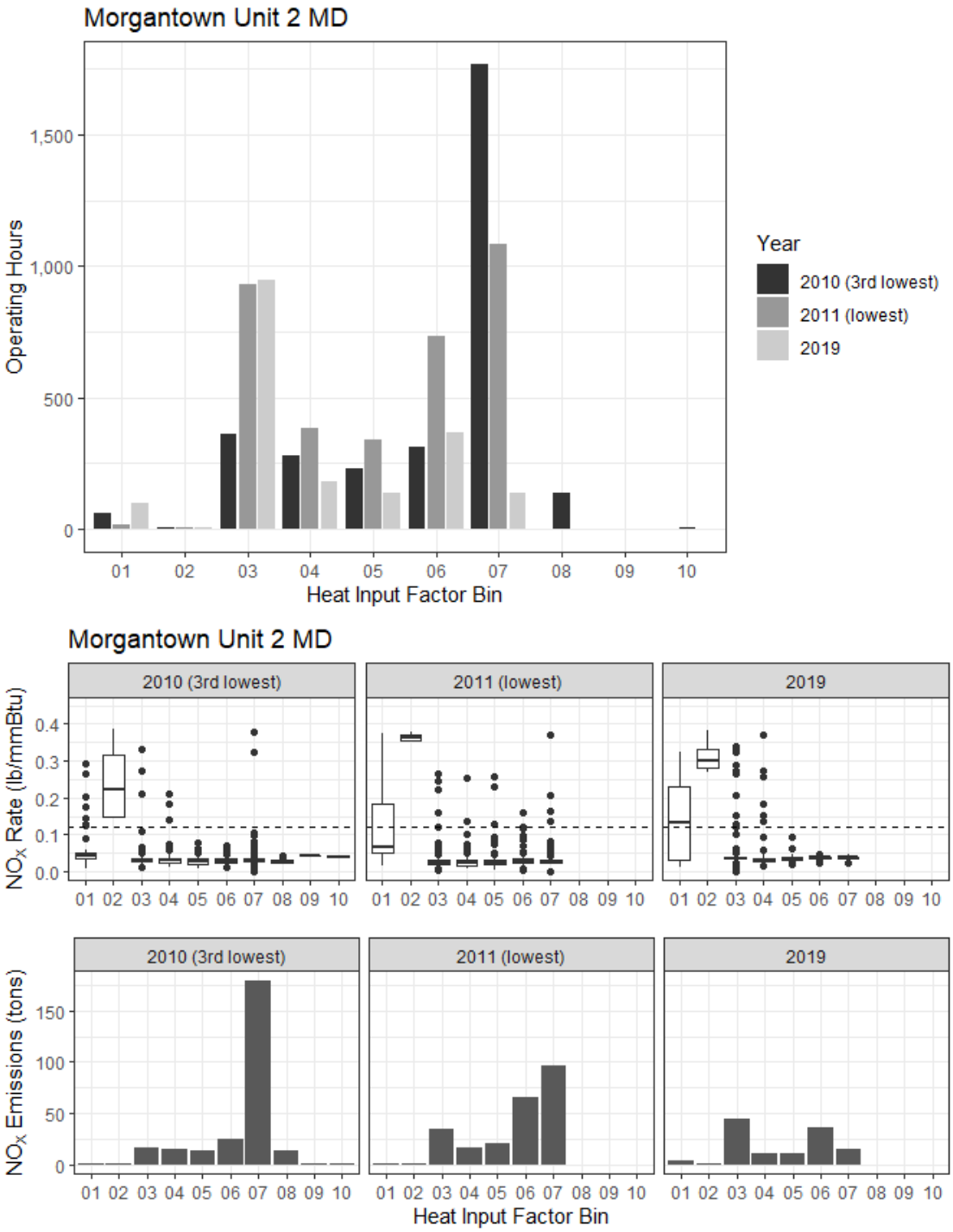

Chalk Point Unit 1 MD
2014 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
150
100
50
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin


Herbert A Wagner Unit 3 MD
Operating Hours
1,250
1,000
750
500
250
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2010 (3rd lowest)
2015 (lowest)
2019

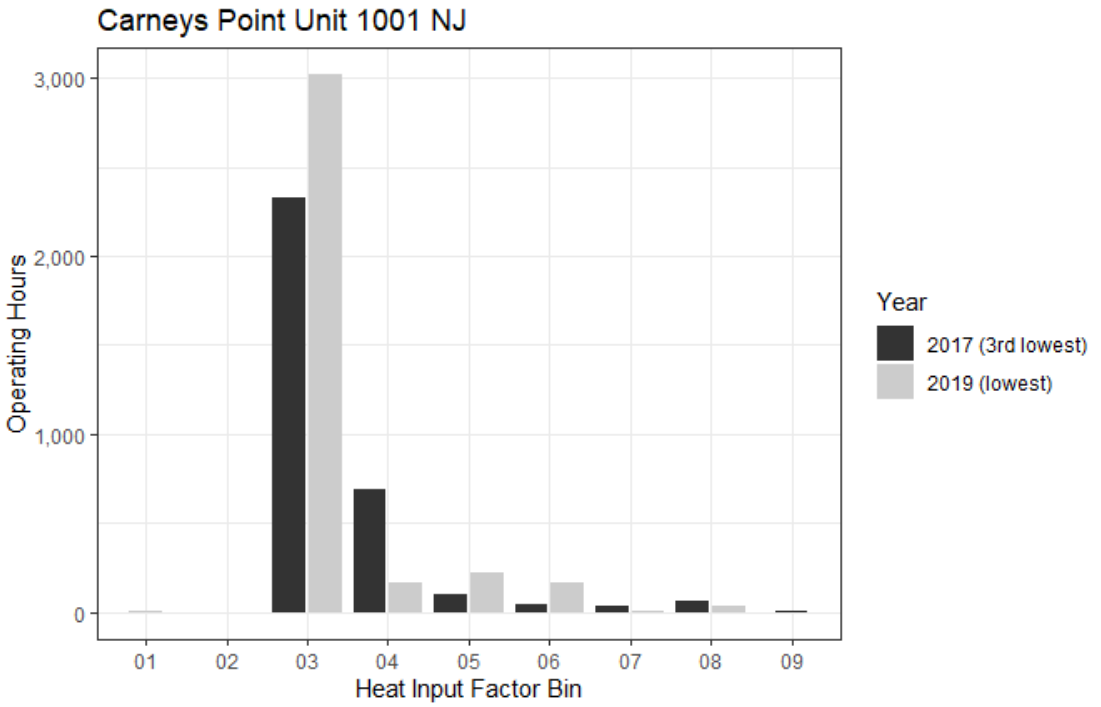

Herbert A Wagner Unit 3 MD
2010 (3rd lowest)
2015 (lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
60
40
20
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

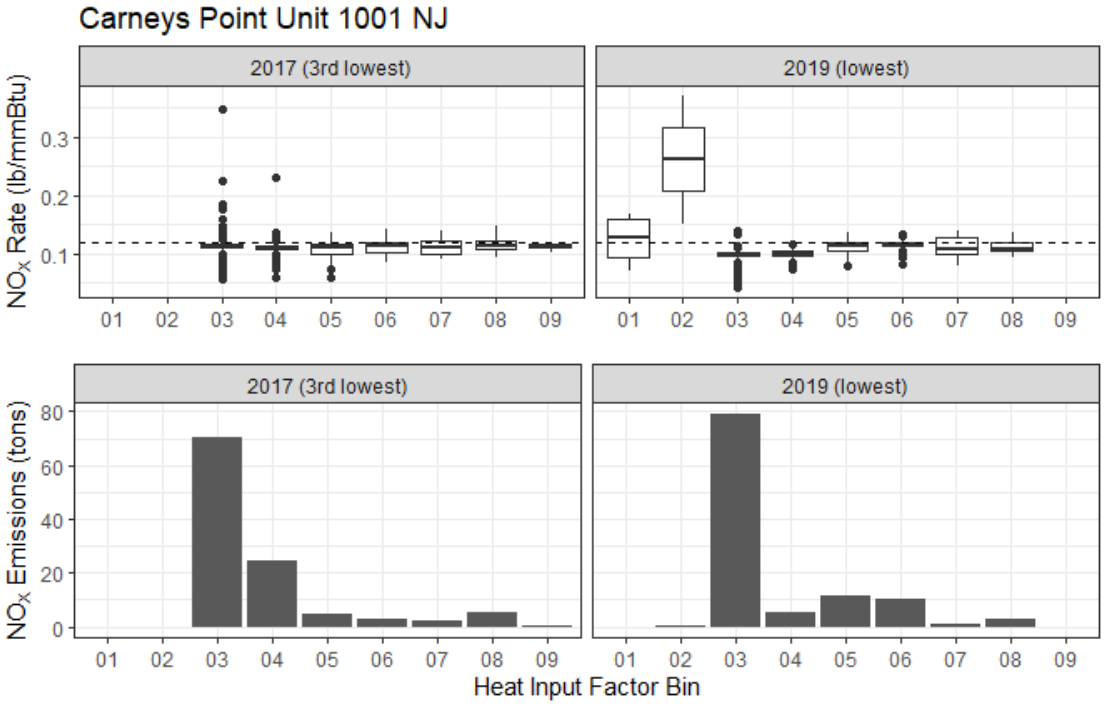

Morgantown Unit 1 MD
Operating Hours
1,500
1,000
500
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2013 (lowest)
2014 (3rd lowest)
2019

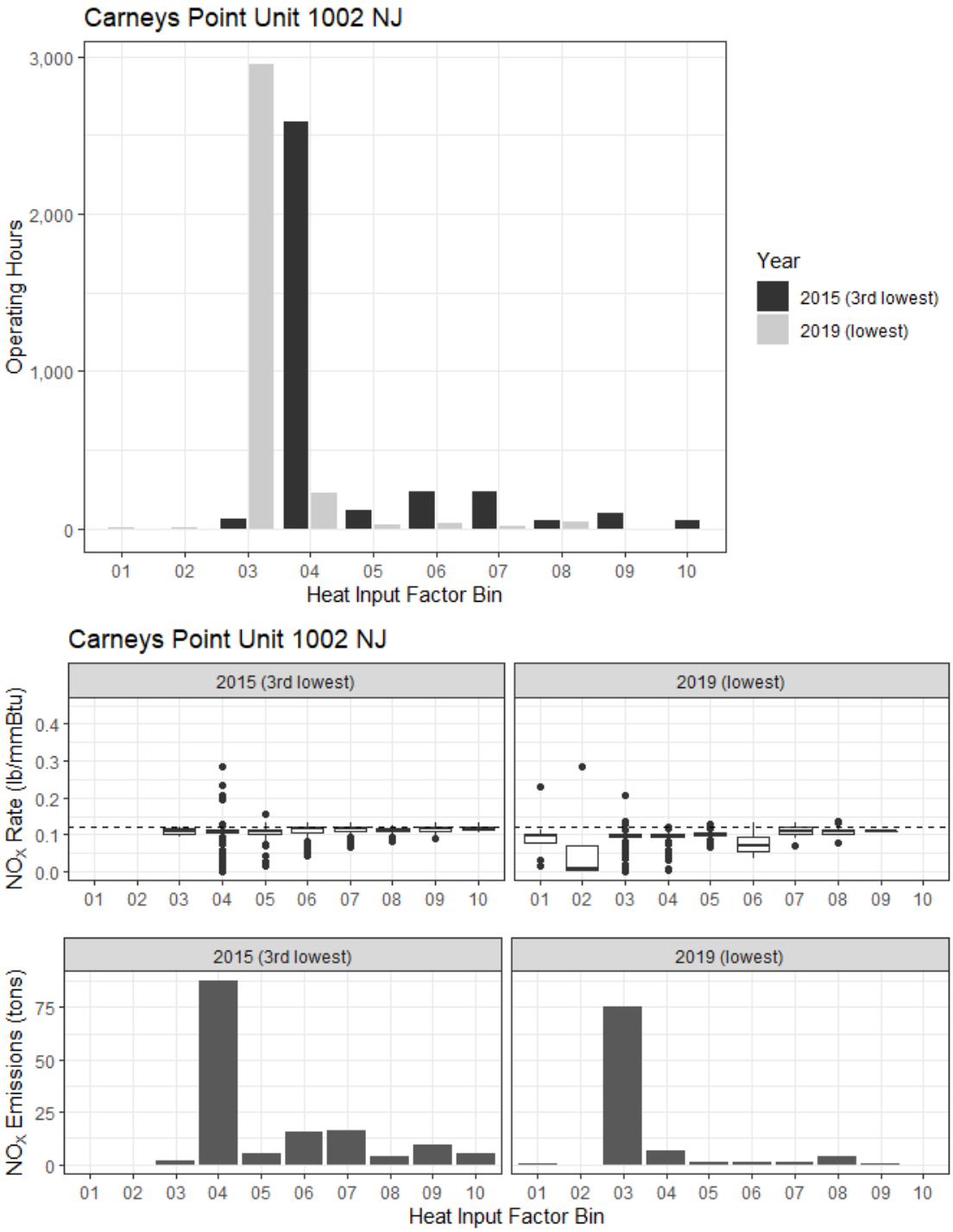

Morgantown Unit 1 MD
2013 (lowest)
2014 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
60
40
20
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin



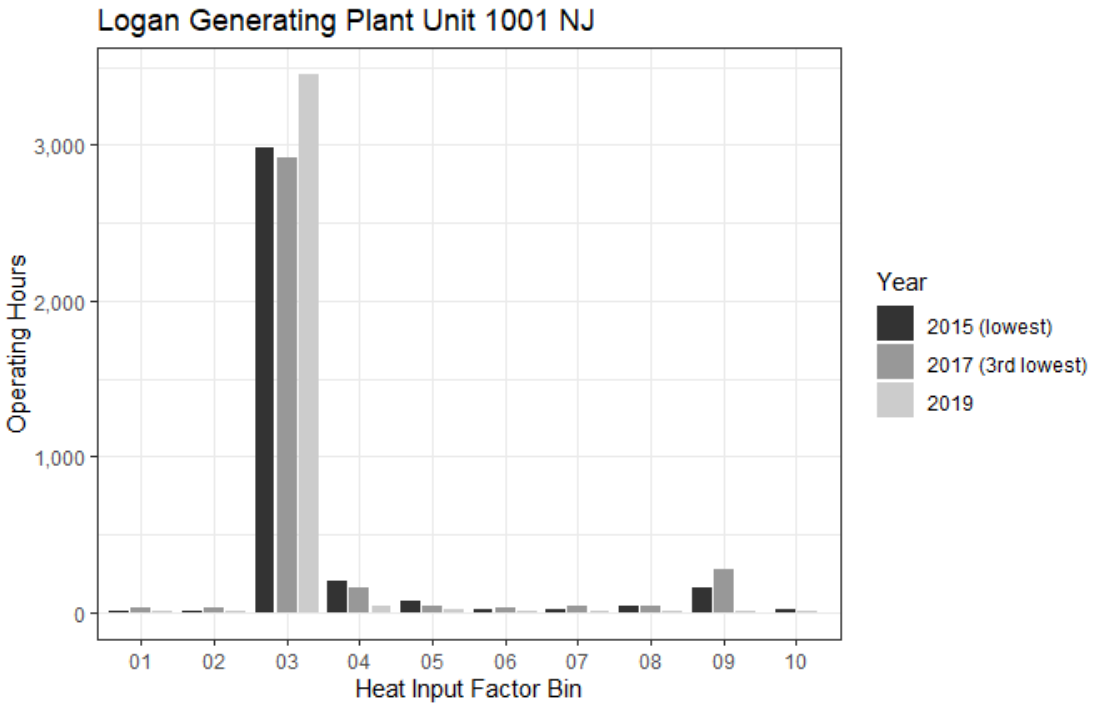
Note: Morgantown unit 2 has one hourly NO_X emission rate above 2.0 lb/mmBtu in bin 6 in 2011 that is not shown here for visualization purposes.

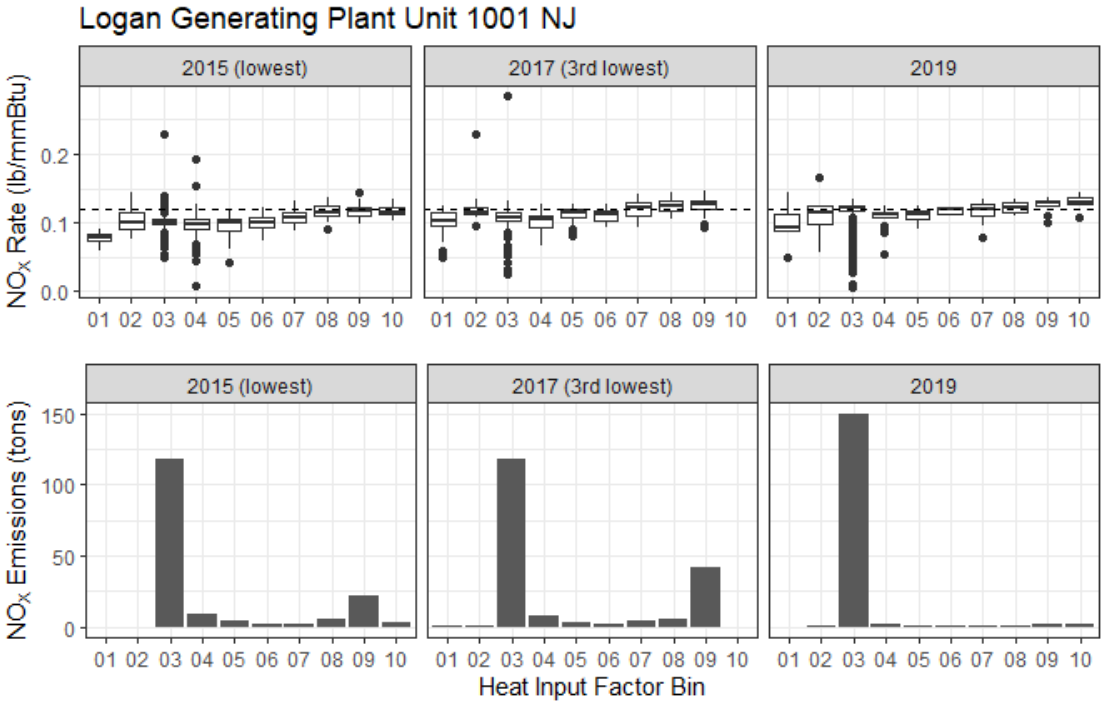

Carneys Point Unit 1001 NJ
Operating Hours
3,000
2,000
1,000
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2017 (3rd lowest)
2019 (lowest)

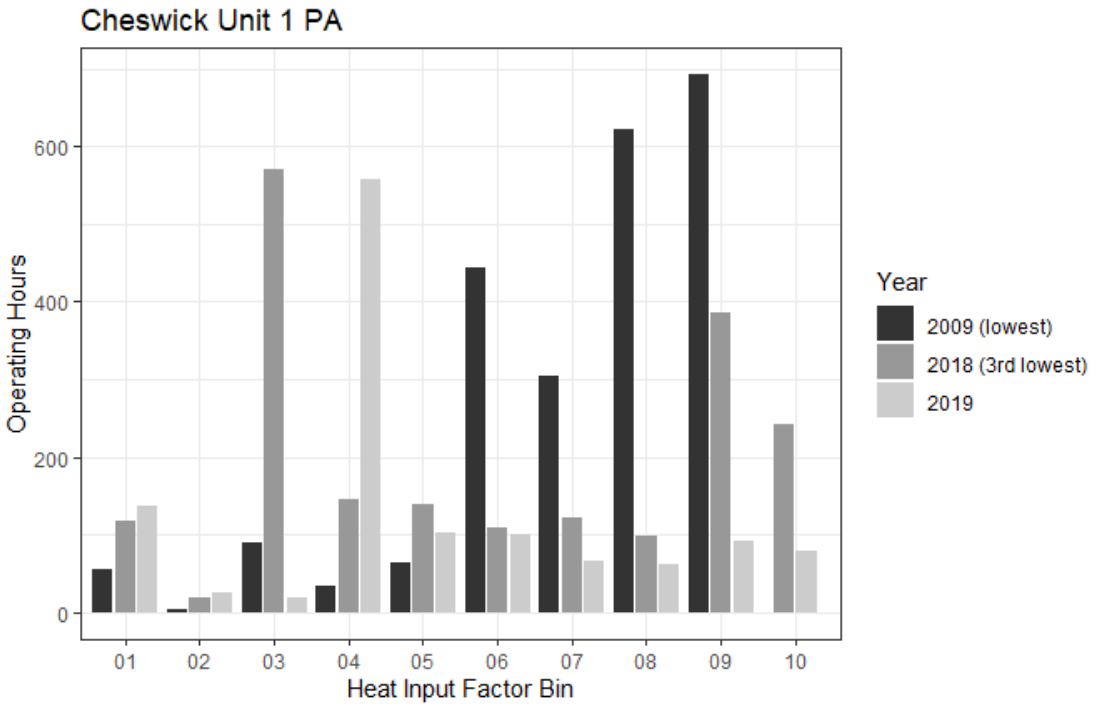

Carneys Point Unit 1001 NJ
2017 (3rd lowest)
2019 (lowest)
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
NOX Emissions (tons)
80
60
40
20
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin

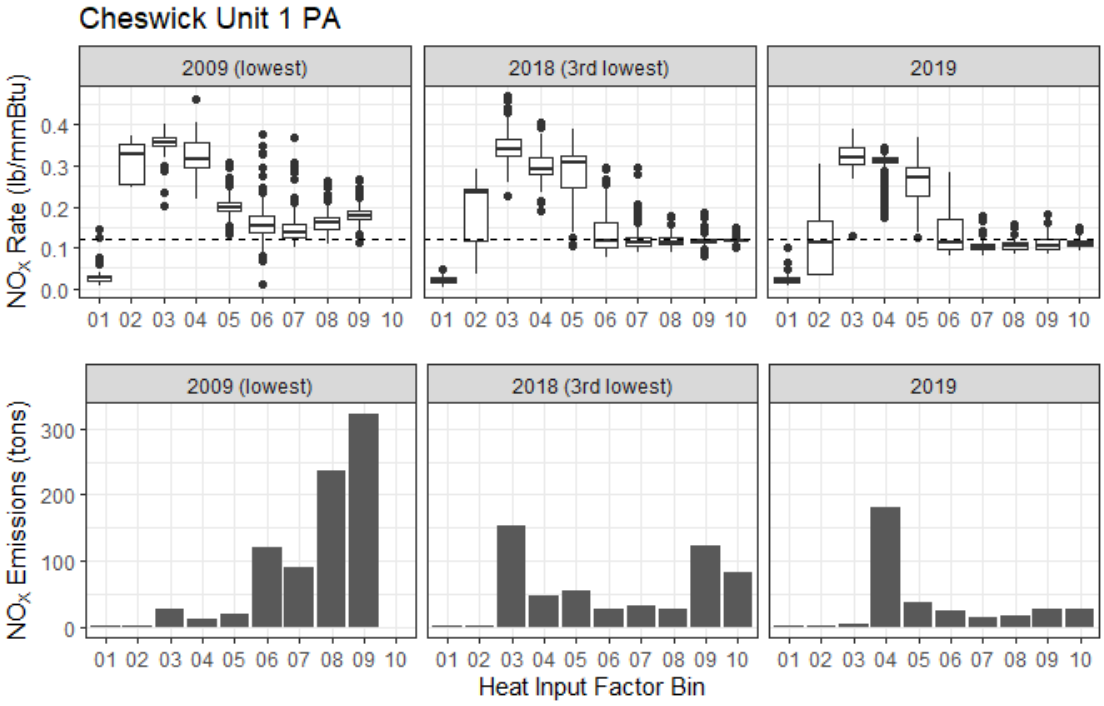


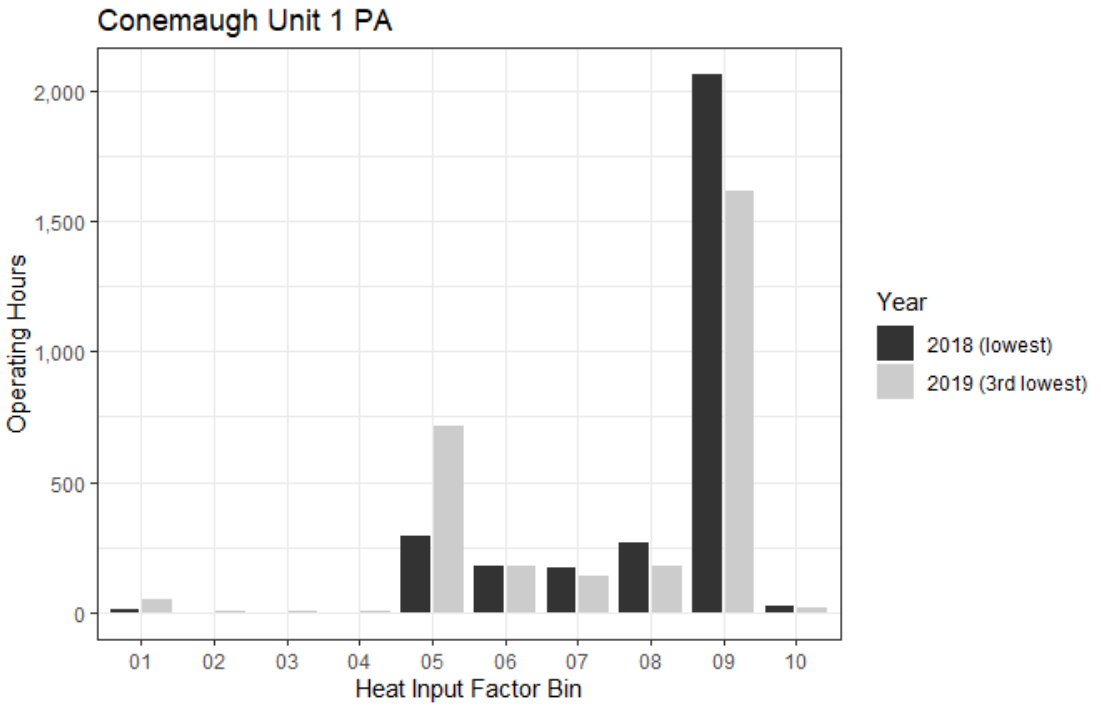
Note: Carneys Point unit 1002 has one hourly NO_X emission rate above 2.0 lb/mmBtu in bin 6 in 2015 that is not shown here for visualization purposes.

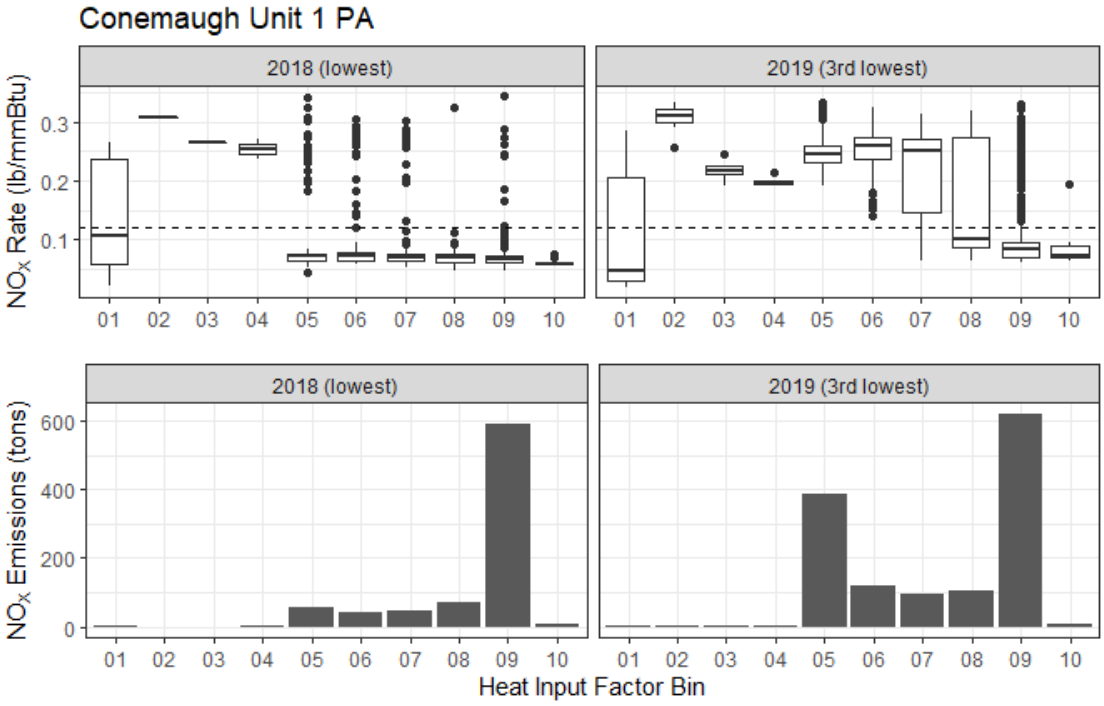

Logan Generating Plant Unit 1001 NJ
Operating Hours
3,000
2,000
1,000
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2015 (lowest)
2017 (3rd lowest)
2019

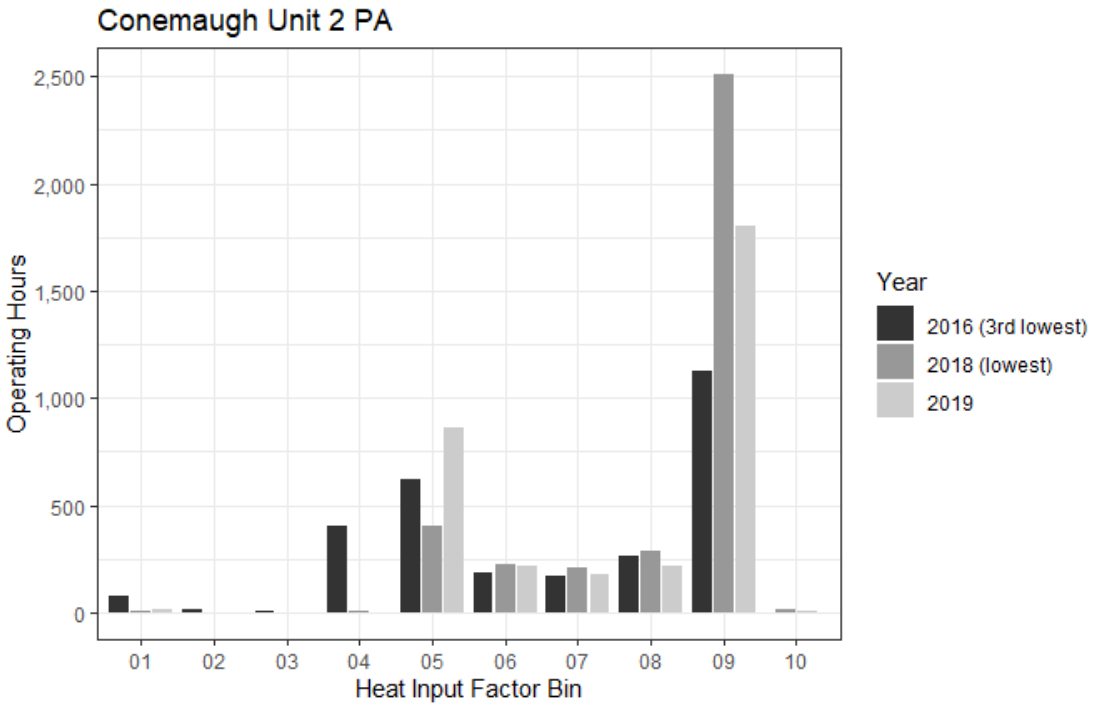

Logan Generating Plant Unit 1001 NJ
2015 (lowest)
2017 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.2
0.1
0.0
NOX Emissions (tons)
150
100
50
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

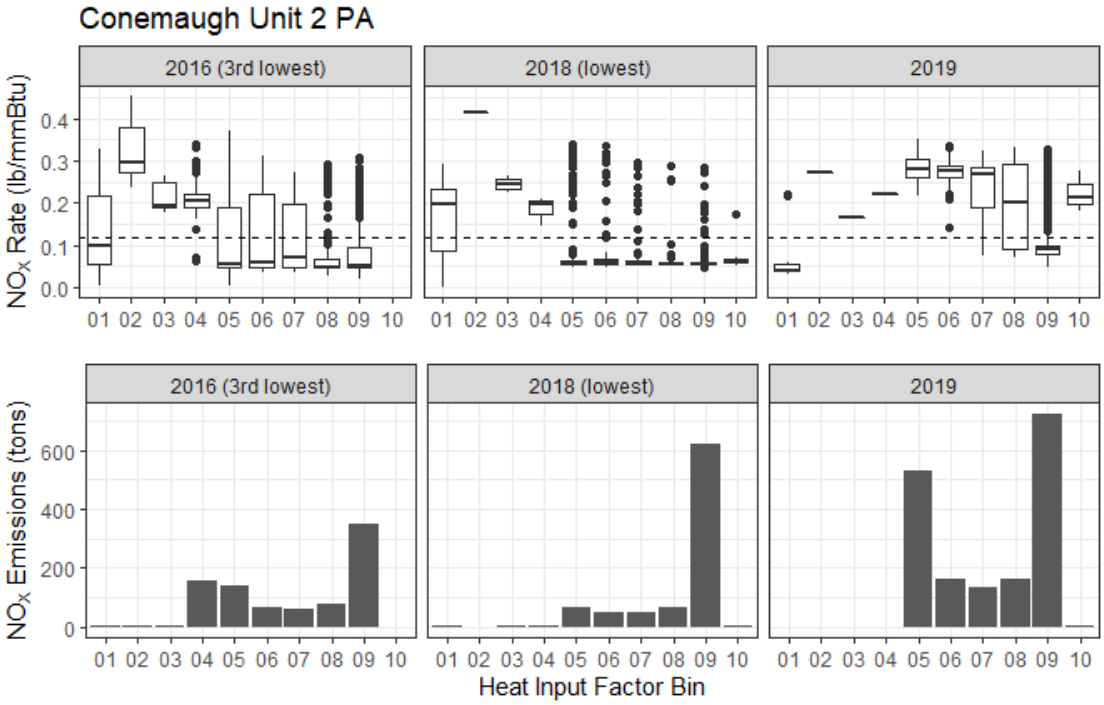

Cheswick Unit 1 PA
Operating Hours
600
400
200
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2009 (lowest)
2018 (3rd lowest)
2019

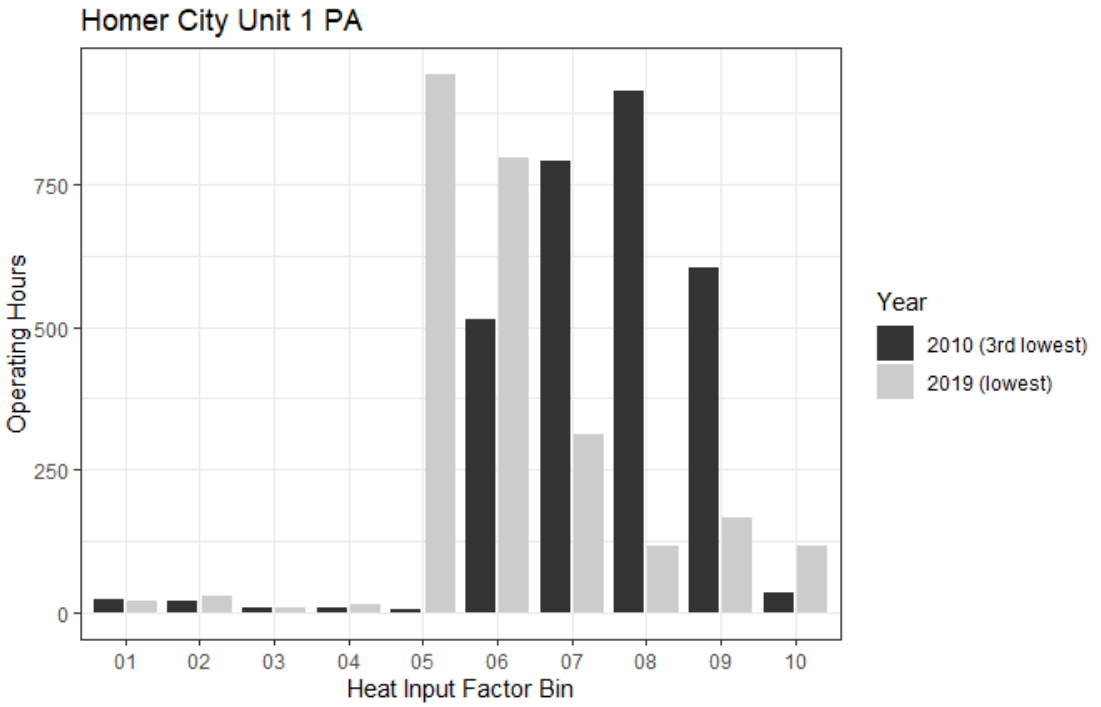

Cheswick Unit 1 PA
2009 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
300
200
100
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

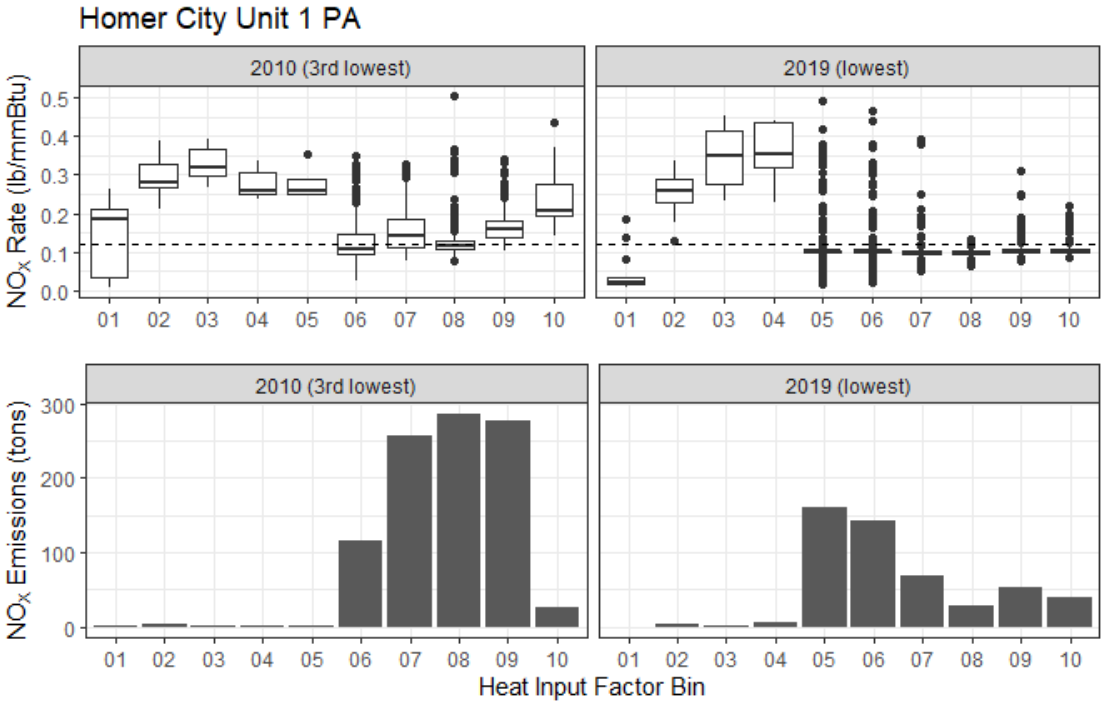

Conemaugh Unit 1 PA
Operating Hours
2,000
1,500
1,000
500
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2018 (lowest)
2019 (3rd lowest)

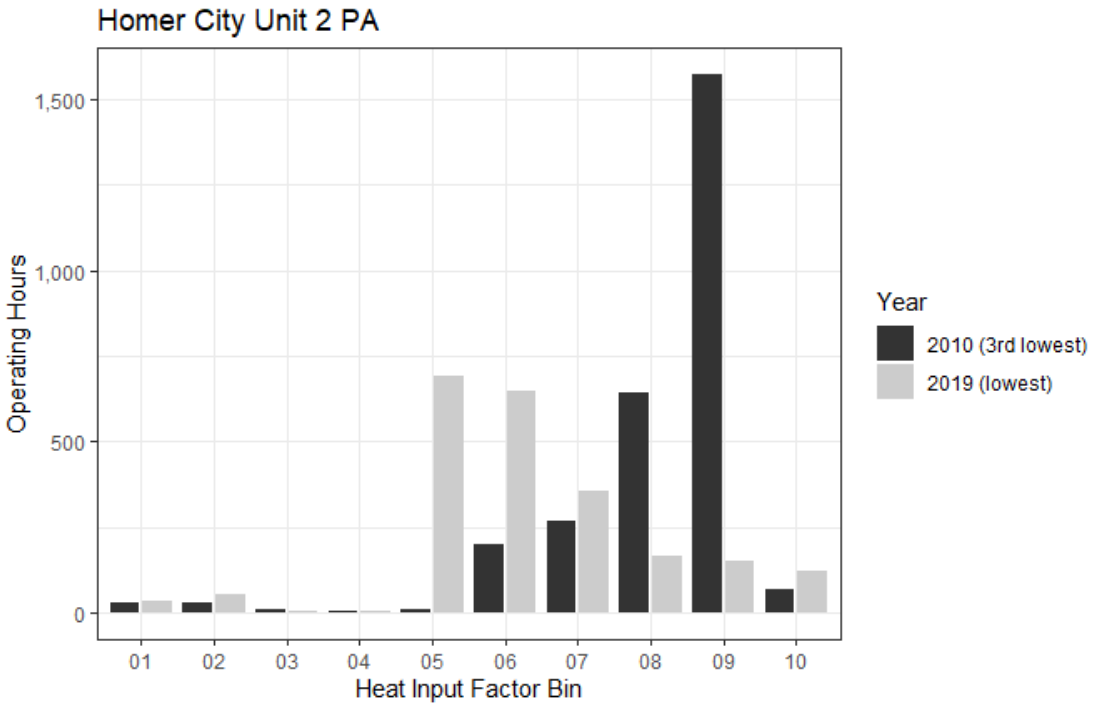

Conemaugh Unit 1 PA
2018 (lowest)
2019 (3rd lowest)
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
NOX Emissions (tons)
600
400
200
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin

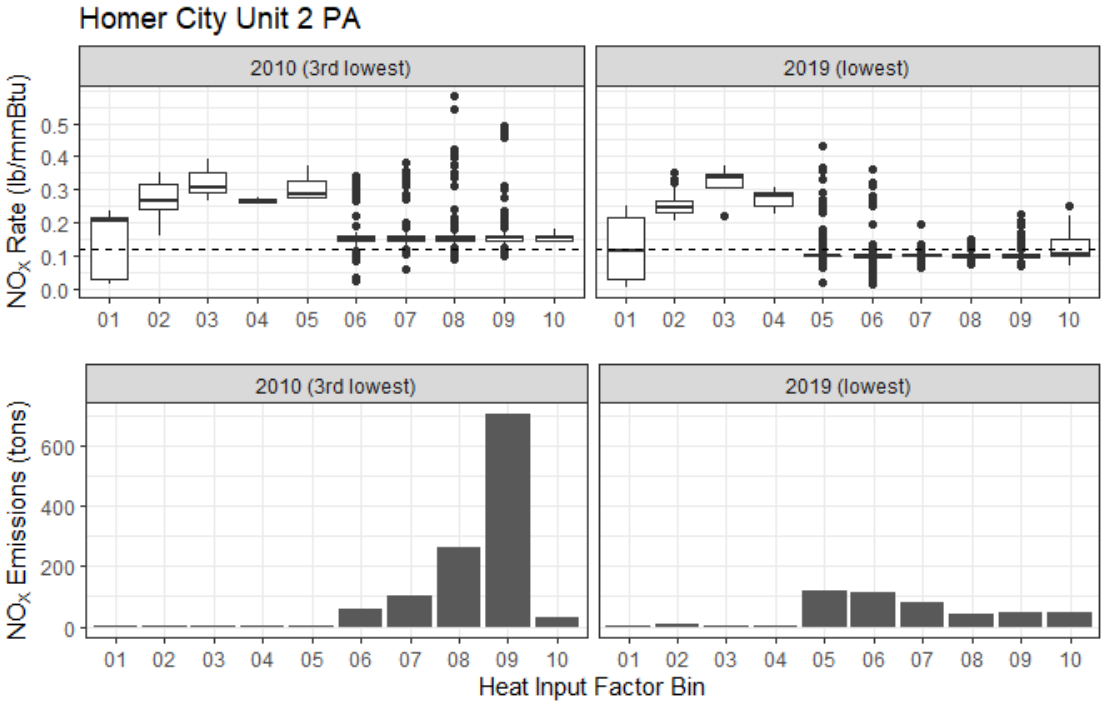

Conemaugh Unit 2 PA
Operating Hours
2,500
2,000
1,500
1,000
500
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2016 (3rd lowest)
2018 (lowest)
2019

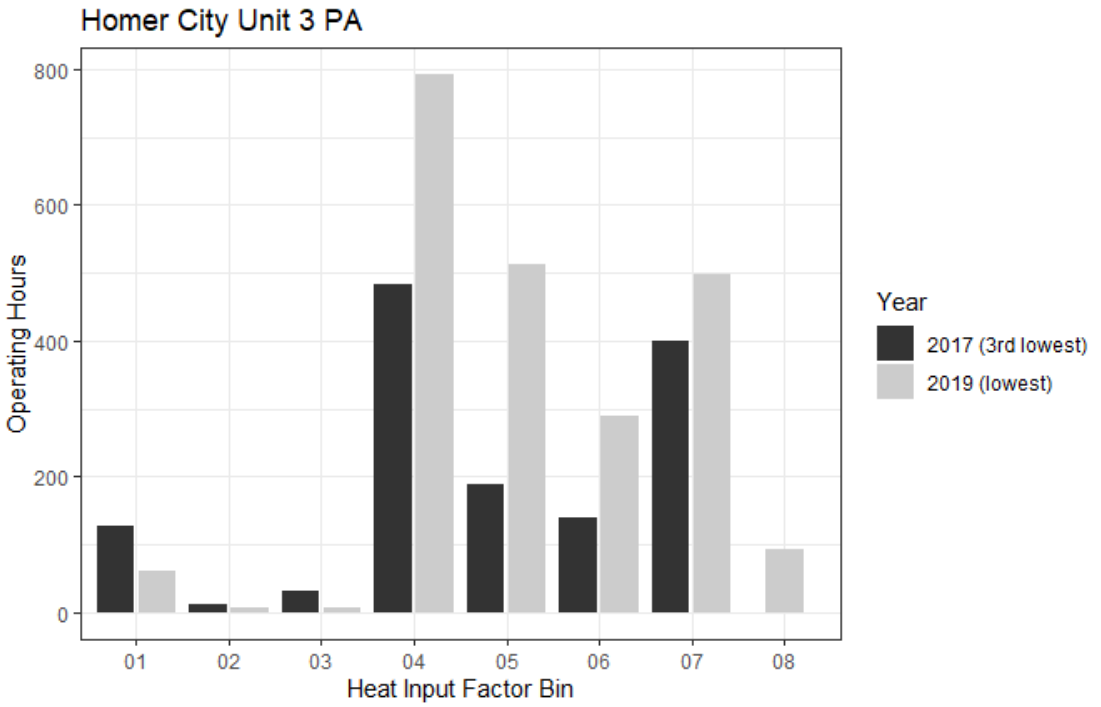

Conemaugh Unit 2 PA
2016 (3rd lowest)
2018 (lowest)
2019
NOX Rate (lb/mmBtu)
0.4
0.3
0.2
0.1
0.0
01 02 03 04 05 06 07 08 09 10
NOX Emissions (tons)
600
400
200
0
Heat Input Factor Bin

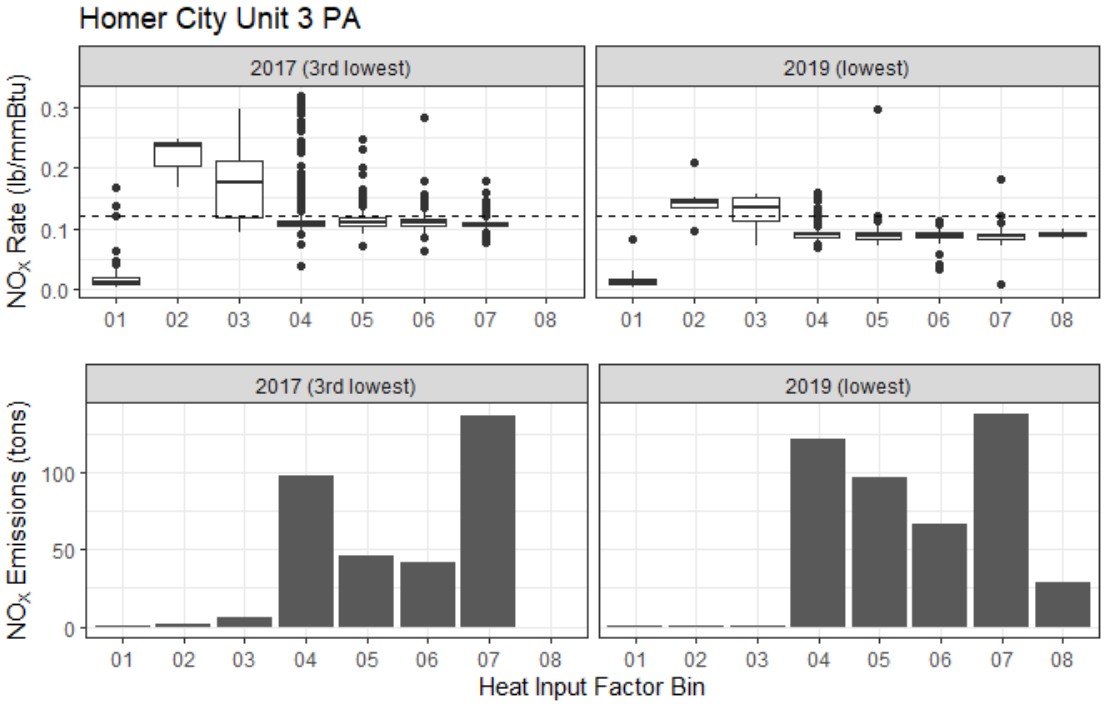

Homer City Unit 1 PA
Operating Hours
750
500
250
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2010 (3rd lowest)
2019 (lowest)

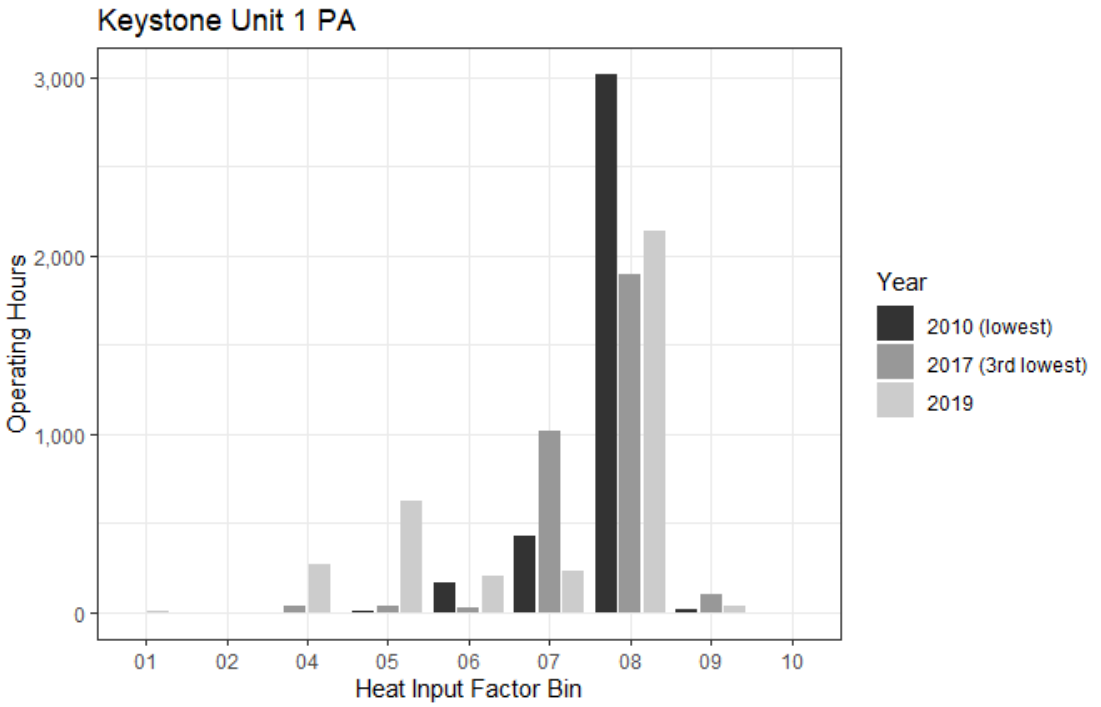

Homer City Unit 1 PA
2010 (3rd lowest)
2019 (lowest)
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
300
200
100
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin

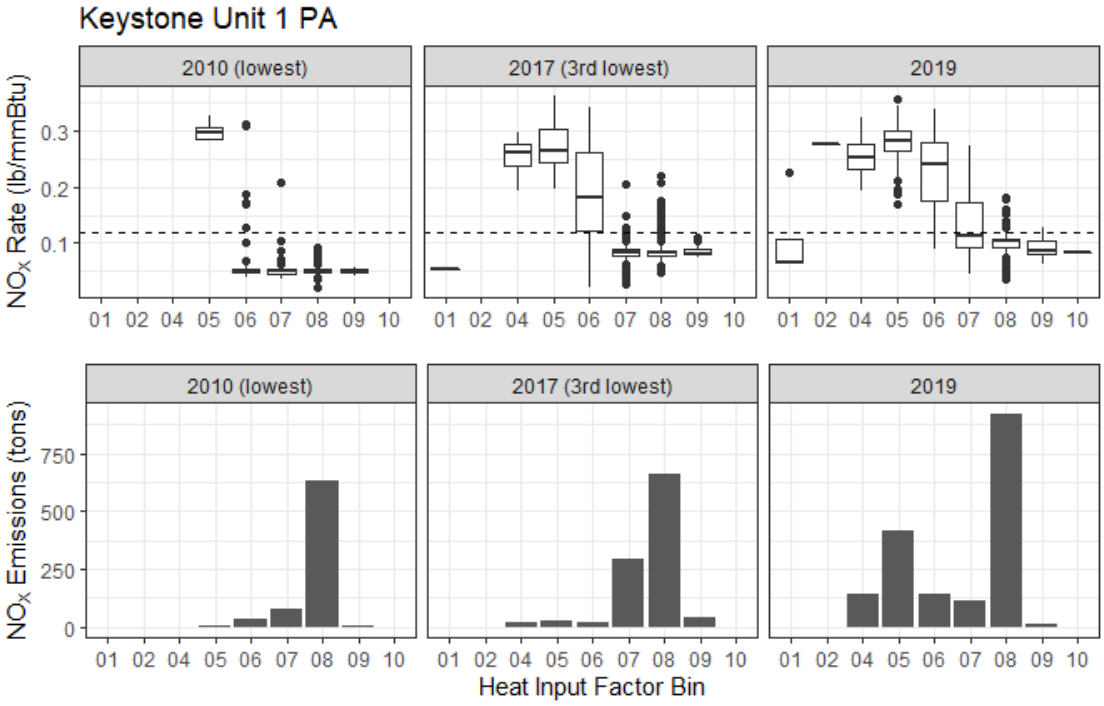

Homer City Unit 2 PA
Operating Hours
1,500
1,000
500
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2010 (3rd lowest)
2019 (lowest)

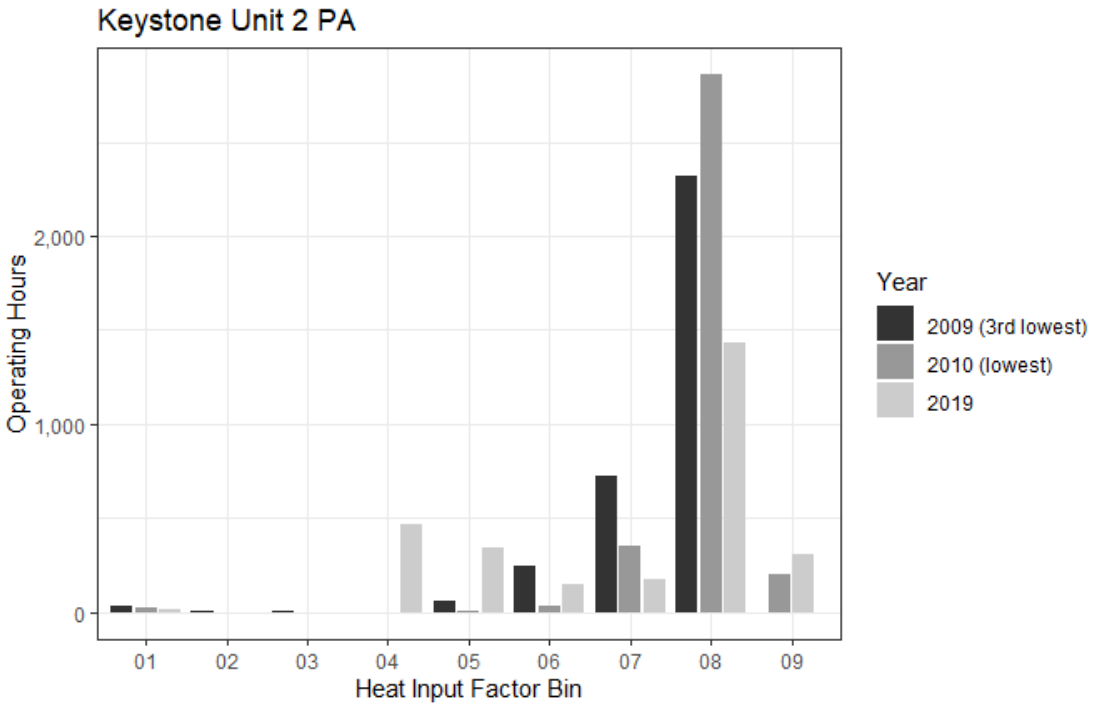

Homer City Unit 2 PA
2010 (3rd lowest)
2019 (lowest)
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
600
400
200
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin

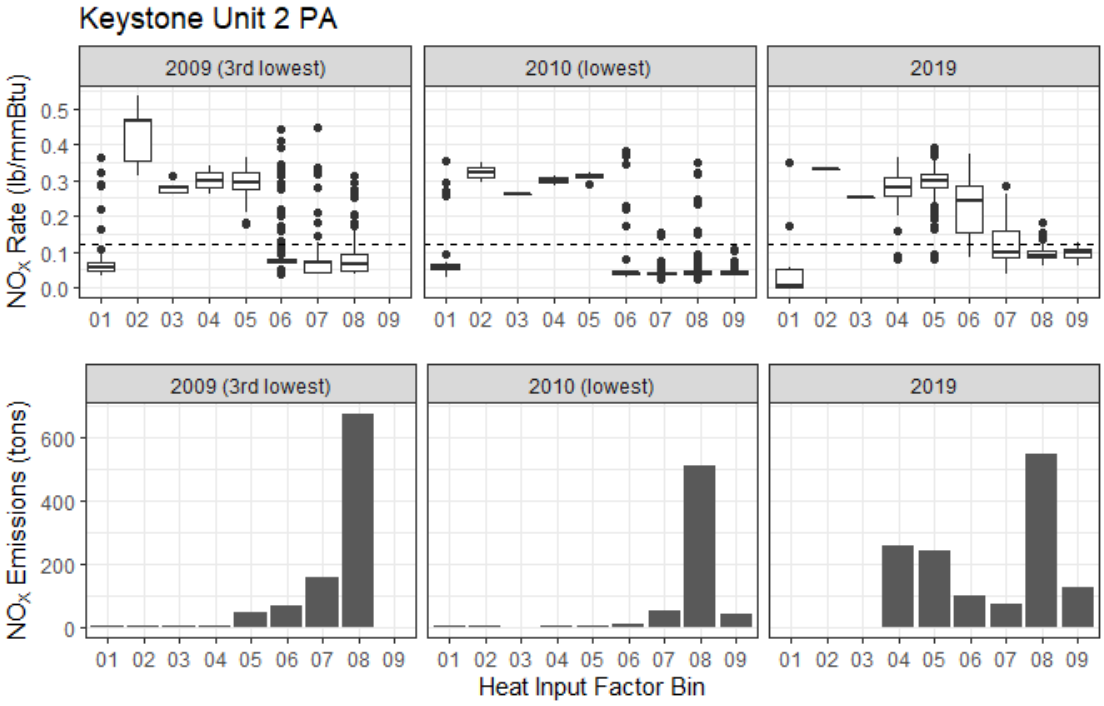

Homer City Unit 3 PA
Operating Hours
800
600
400
200
0
01
02
03
04
05
06
07
08
Heat Input Factor Bin
Year
2017 (3rd lowest)
2019 (lowest)

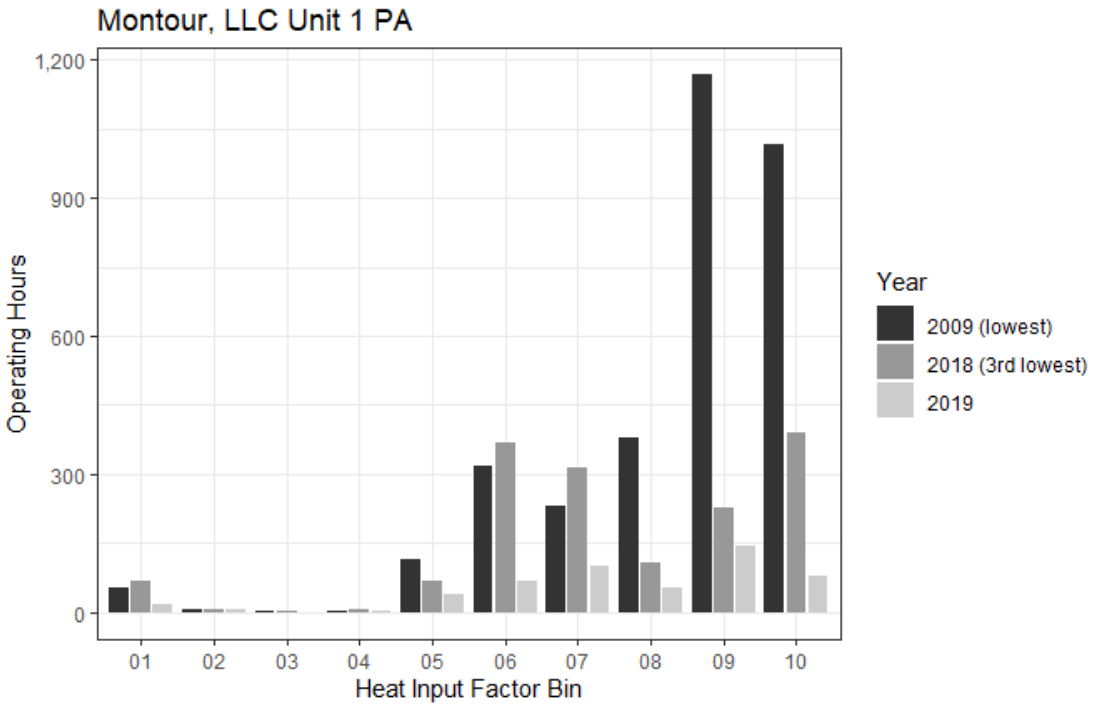

Homer City Unit 3 PA
2017 (3rd lowest)
2019 (lowest)
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
100
50
0
01
02
03
04
05
06
07
08
Heat Input Factor Bin

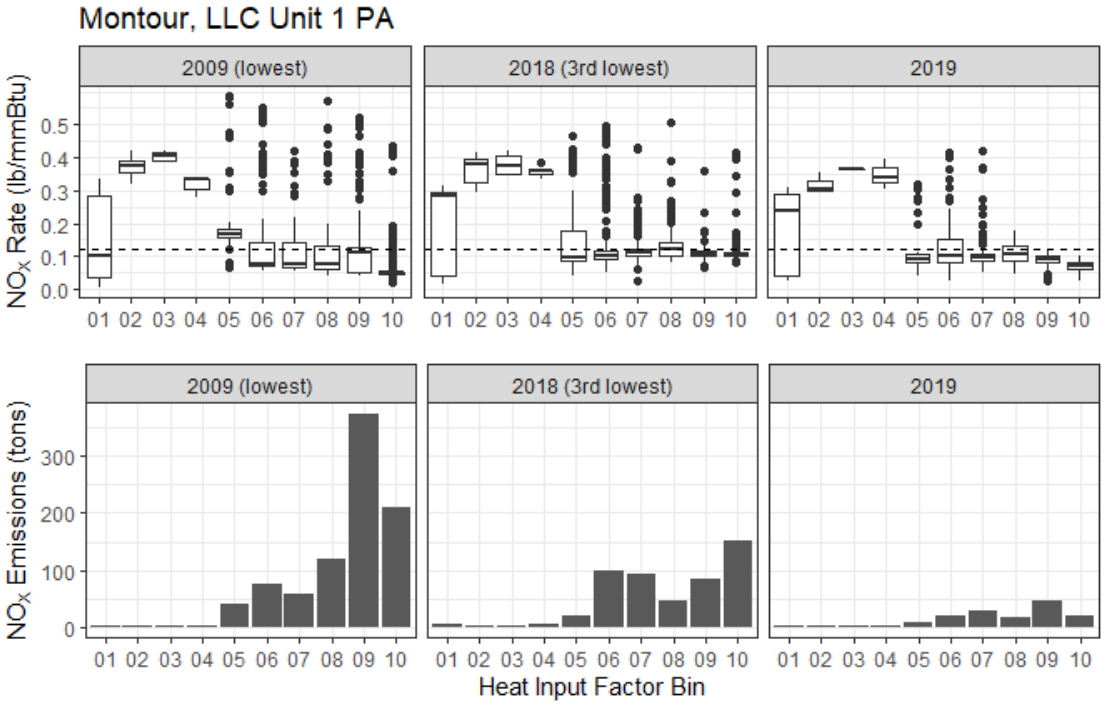

Keystone Unit 1 PA
Operating Hours
3,000
2,000
1,000
0
01
02
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2010 (lowest)
2017 (3rd lowest)
2019

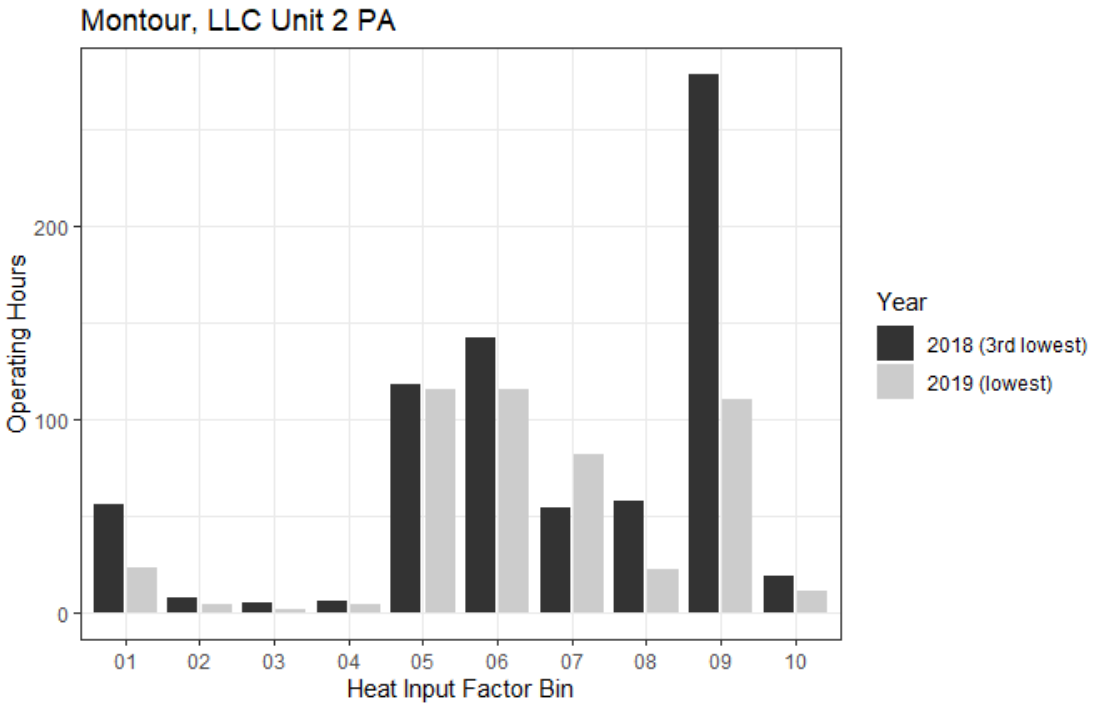

Keystone Unit 1 PA
2010 (lowest)
2017 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
NOX Emissions (tons)
750
500
250
0
01 02 04 05 06 07 08 09 10
Heat Input Factor Bin

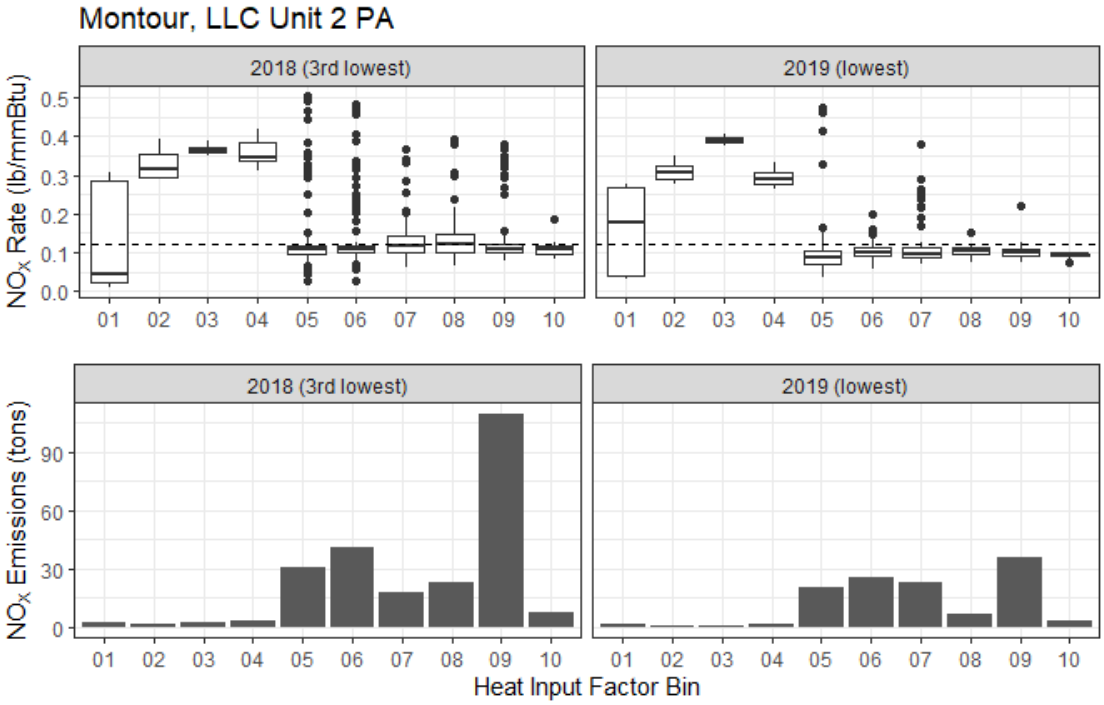

Keystone Unit 2 PA
Operating Hours
2,000
1,000
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2009 (3rd lowest)
2010 (lowest)
2019


Keystone Unit 2 PA
2009 (3rd lowest)
2010 (lowest)
2019
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
600
400
200
0
01 02 03 04 05 06 07 08 09
Heat Input Factor Bin


Montour, LLC Unit 1 PA
Operating Hours
1,200
900
600
300
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2009 (lowest)
2018 (3rd lowest)
2019


Montour, LLC Unit 1 PA
2009 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
01 02 03 04 05 06 07 08 09 10
NOX Emissions (tons)
300
200
100
0
Heat Input Factor Bin


Montour, LLC Unit 2 PA
Operating Hours
200
100
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2018 (3rd lowest)
2019 (lowest)


Montour, LLC Unit 2 PA
2018 (3rd lowest)
2019 (lowest)
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
90
60
30
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin

3.1.2 Units with SNCR Controls

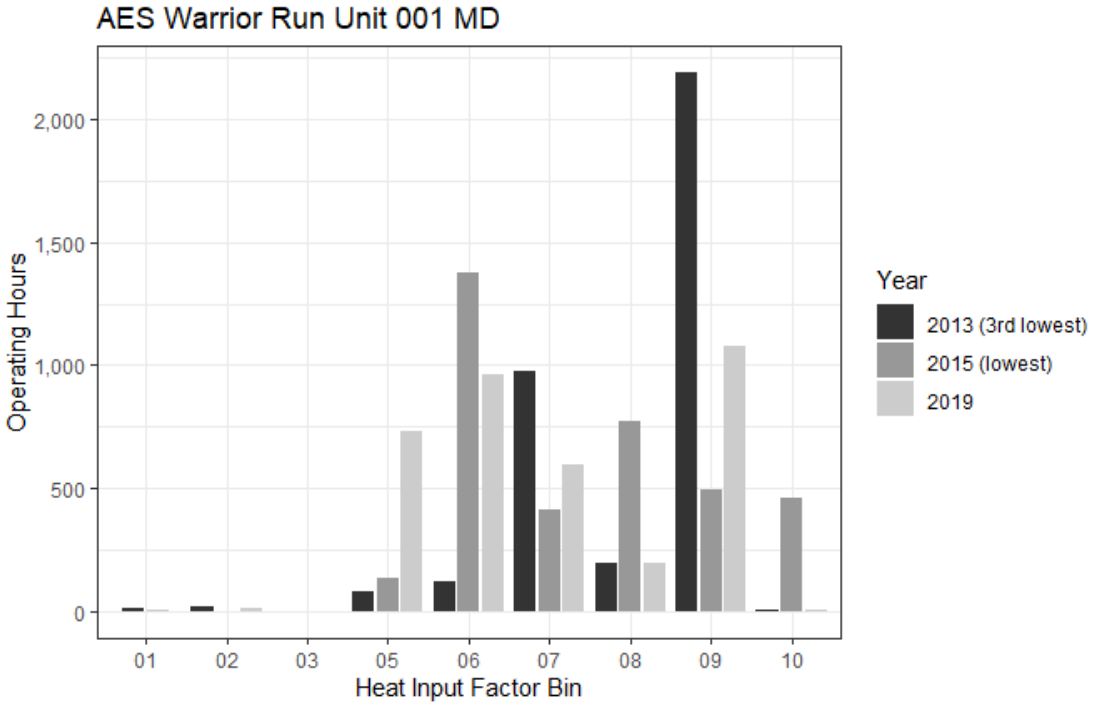
The plots for SNCR-equipped[4] EGUs in this subsection show that some of the units have achieved NO_X emission rates comparable to the rates achieved by SCR-equipped units. Some of the units show NO_X emission rates that vary or increase with operating level while others have relatively flat NO_X emission rates across operating levels.

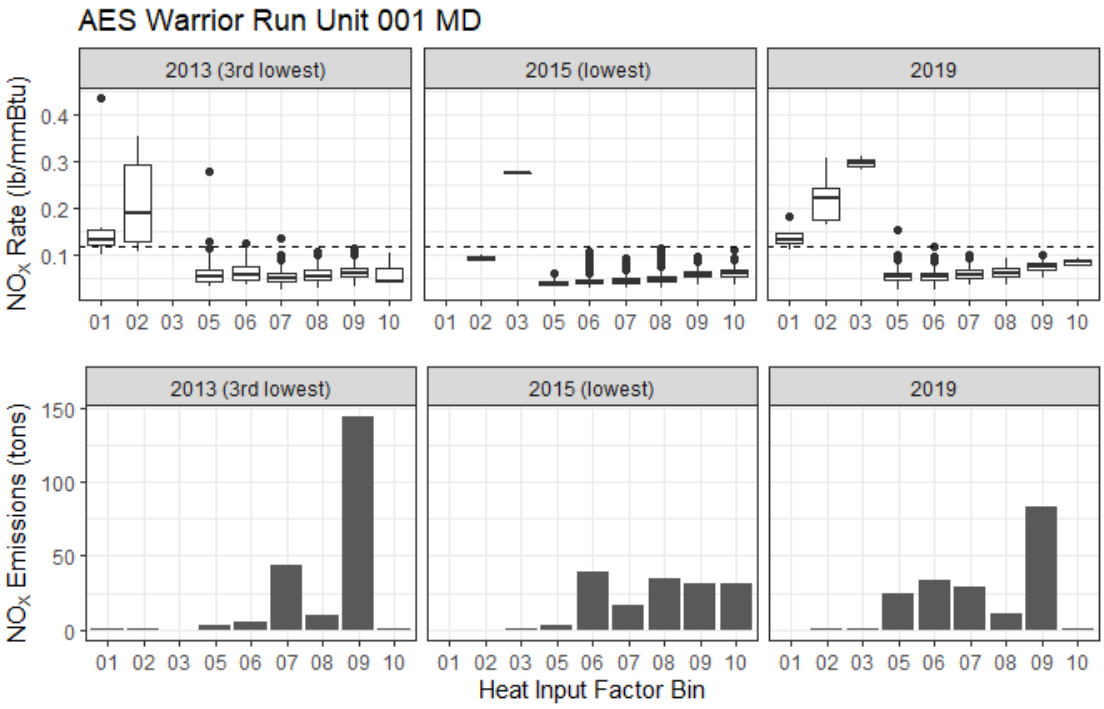
The SNCR-equipped EGUs analyzed generally show fairly consistent relationships of NO_X emission rates to operating levels across the different ozone seasons evaluated:

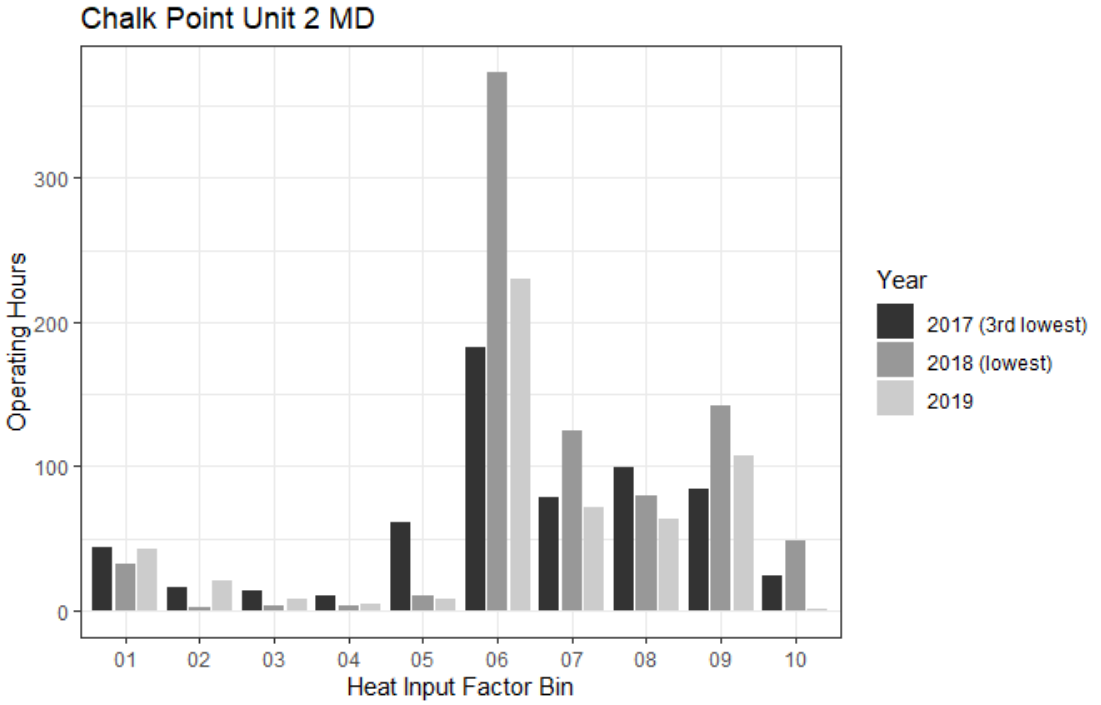
- Colver unit AAB01 in Pennsylvania shows NO_X emission rates that do not appear to increase significantly with operating level and do not have any clear trend of changes over time. The unit operated for a similar number of hours in the 2019 ozone season as it has previously. This unit accounted for the largest amount of NO_X emissions in the 2019 ozone season (309 tons) of any of the SNCR-equipped units analyzed.
- Scrubgrass units 1-2 in Pennsylvania show NO_X emission rates that do not appear to increase significantly with operating level and do not have any clear trend of changes over time. These EGUs operated for fewer hours in the 2019 ozone season than in the earlier ozone seasons evaluated, contributing to lower NO_X emissions.
- Chalk Point unit 2 in Maryland shows NO_X emission rates that generally increase with operating level and are generally consistent over time. The unit's emission rates are generally the highest of the SNCR-equipped units analyzed, but in the years evaluated the unit operated in fewer hours than most of those other units. Because of the smaller amount of operating hours, the unit's 2019 NO_X mass emissions were lower than the emissions from Colver.
- AES Warrior Run unit 001 in Maryland shows NO_X rates that increase slightly with operating level but generally remain low at all levels, and the rates are consistent over time. In the 2019 ozone season, the unit operated at about the same operating level as it has in previous ozone seasons.
- Northampton unit NGC01, Panther Creek units 1 and 2, and Seward units 1 and 2 in Pennsylvania show NO_X emission rates that generally increase with operating level and are generally consistent over time. In the 2019 ozone season, these EGUs all operated

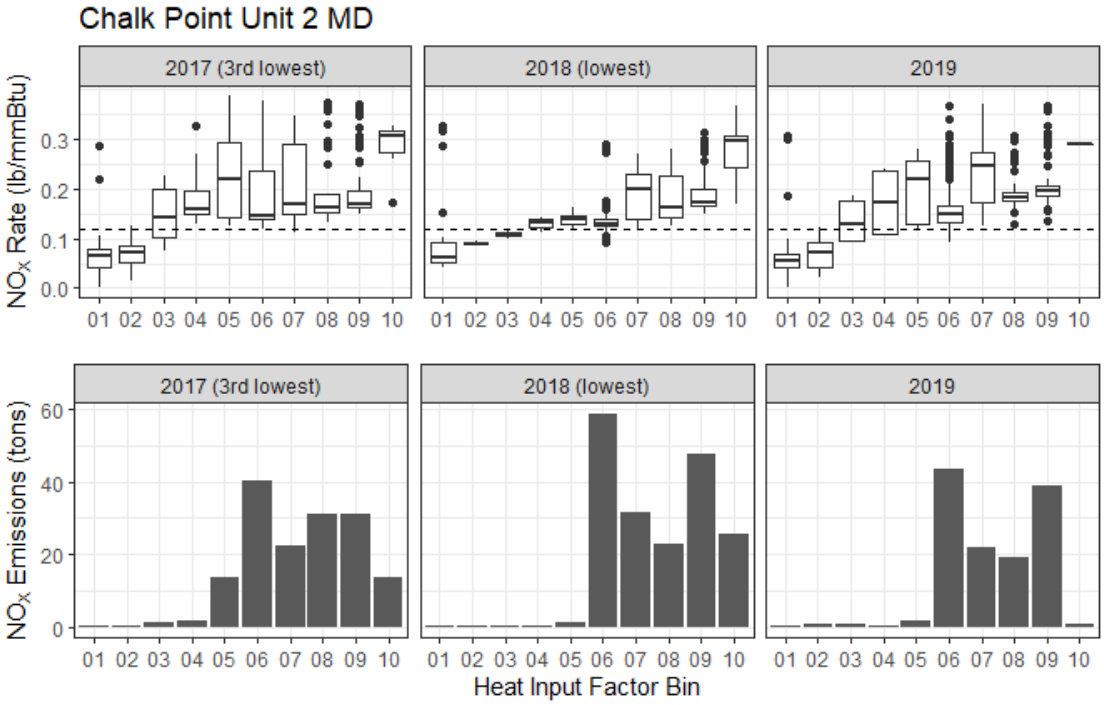
[4] The Colver, Northampton, and Panther Creek units report "ammonia injection" controls; EPA has grouped these units with the units reporting SNCR controls. Chalk Point unit 2 reports selective autocatalytic reduction (SACR) controls, which rely on simultaneous injection of ammonia and hydrocarbons (such as natural gas) to reduce NO_X through a catalytic reaction without a separate catalyst; EPA has also grouped this unit with the SNCR-equipped units for purposes of this analysis. Indian Point unit 4 reports both SCR and SNCR controls; EPA has grouped this unit with the SCR-equipped units.

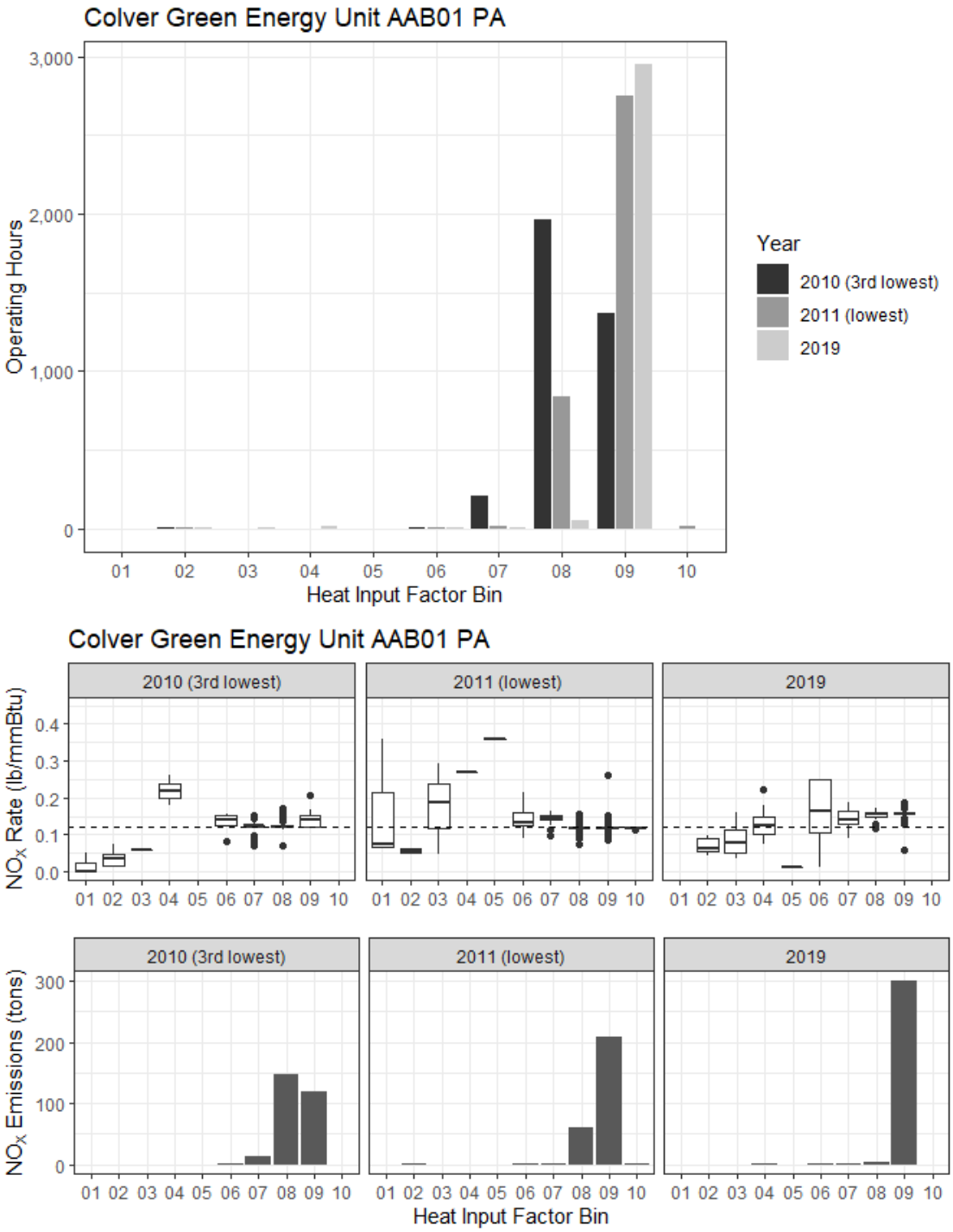
for fewer hours across mid- and high-operating levels than they have in the past, contributing to lower NO_X emissions.



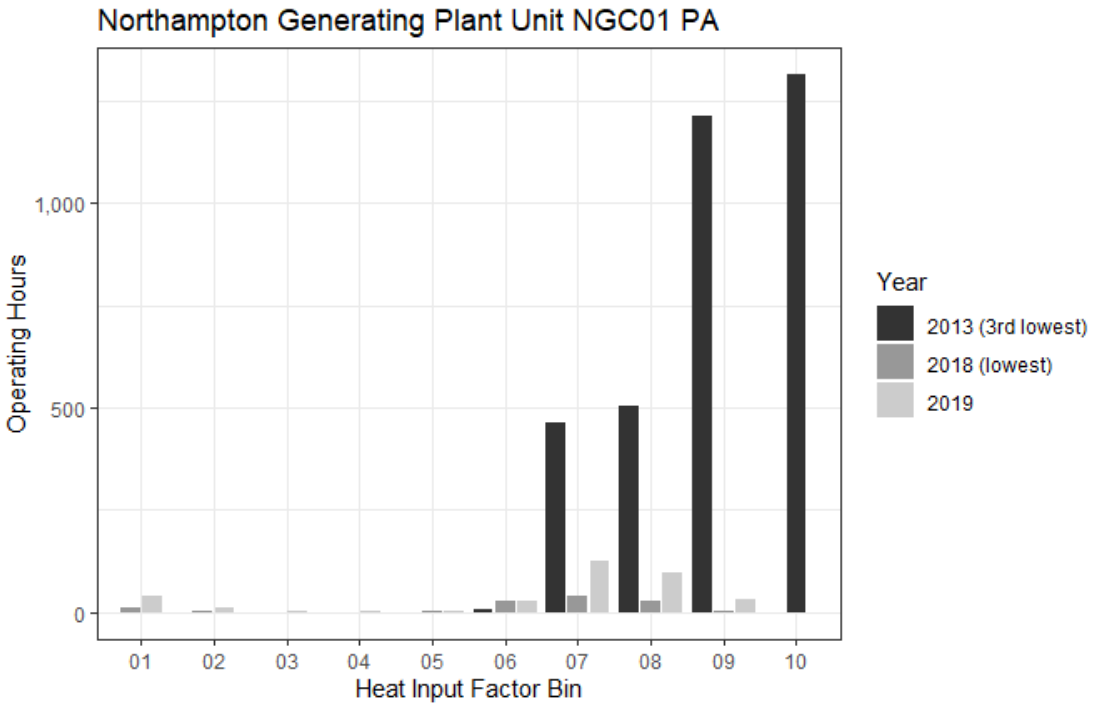


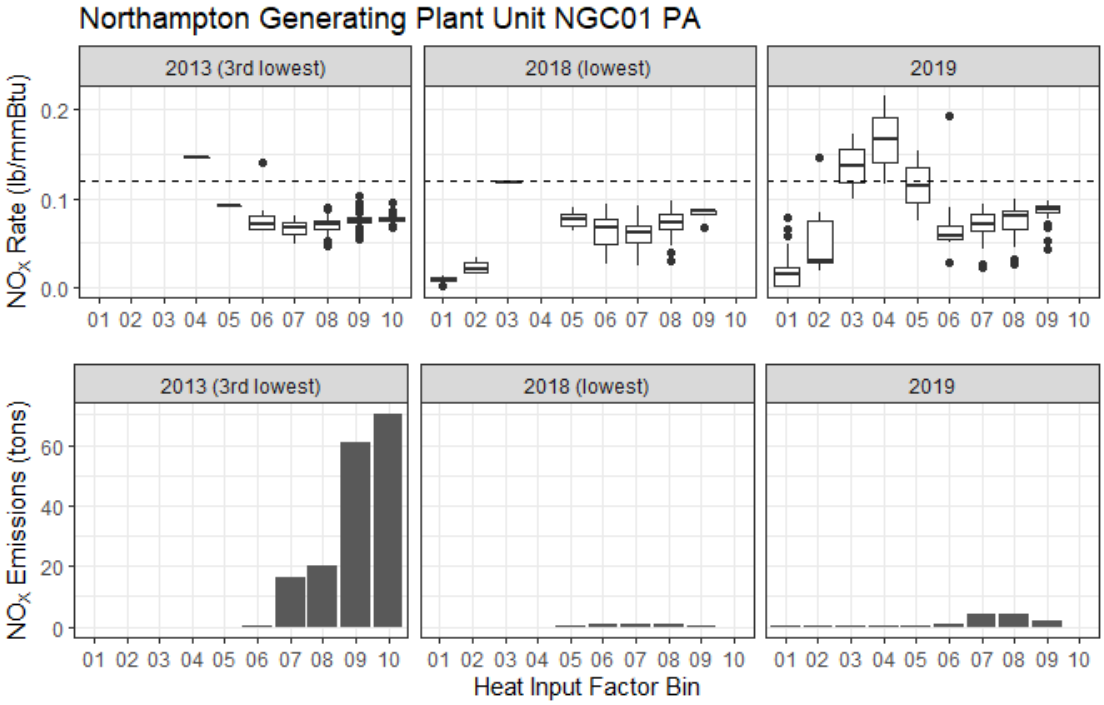

Chalk Point Unit 2 MD
Operating Hours
300
200
100
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2017 (3rd lowest)
2018 (lowest)
2019

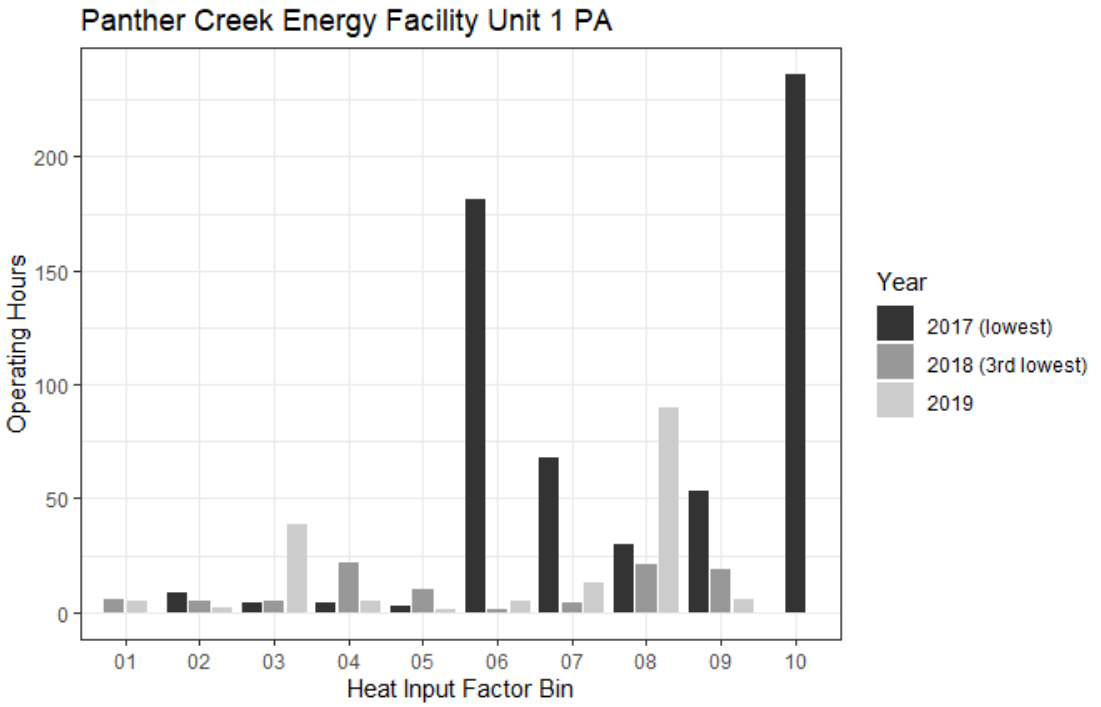

Chalk Point Unit 2 MD
2017 (3rd lowest)
2018 (lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
60
40
20
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

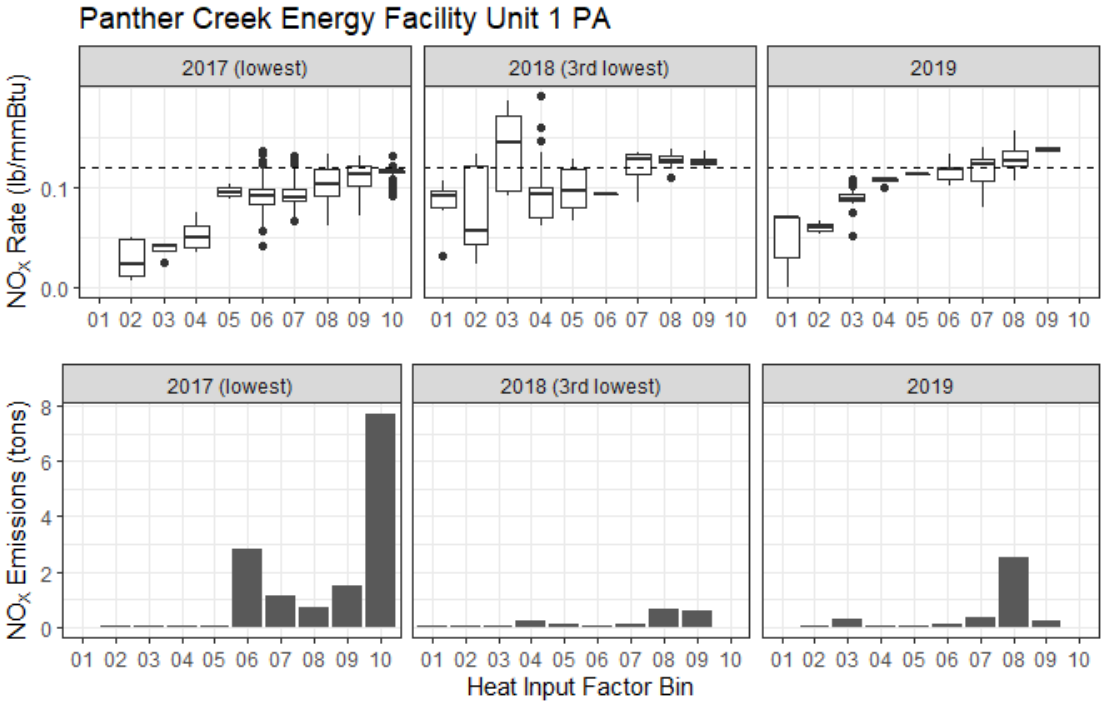


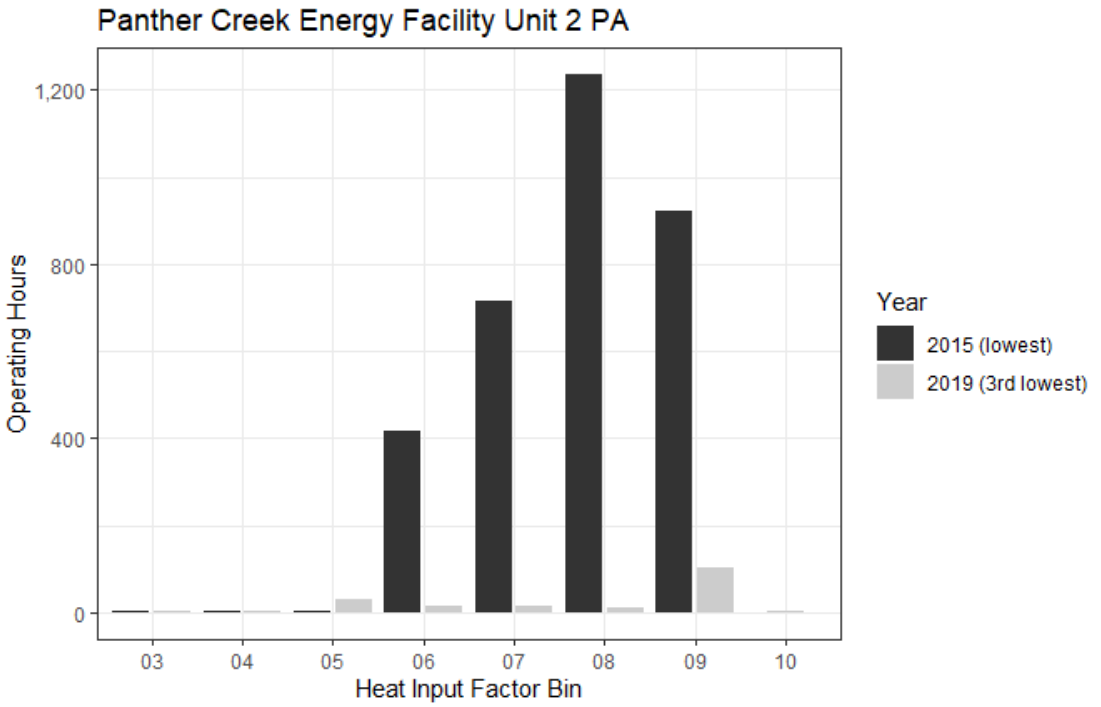
Note: Colver unit AAB01 has one hourly NO_X emission rate above 1.9 lb/mmBtu in bin 2 in 2011 that is not shown here for visualization purposes.

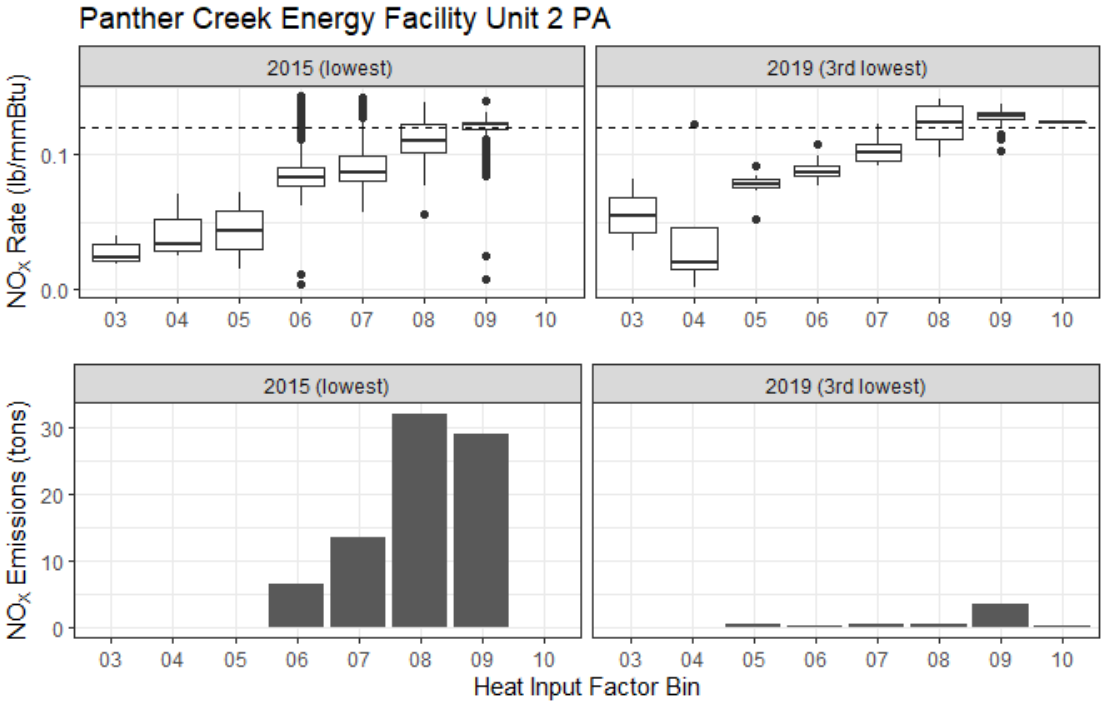

Northampton Generating Plant Unit NGC01 PA
Operating Hours
1,000
500
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2013 (3rd lowest)
2018 (lowest)
2019

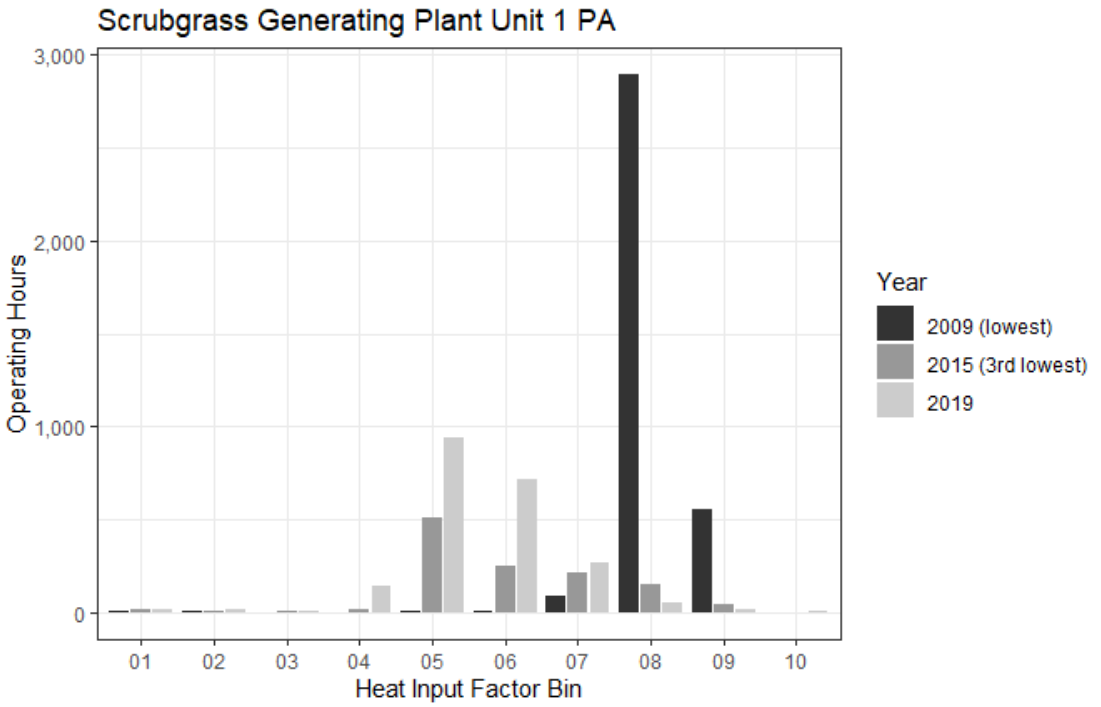

Northampton Generating Plant Unit NGC01 PA
2013 (3rd lowest)
2018 (lowest)
2019
NOX Rate (lb/mmBtu)
0.2
0.1
0.0
NOX Emissions (tons)
60
40
20
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

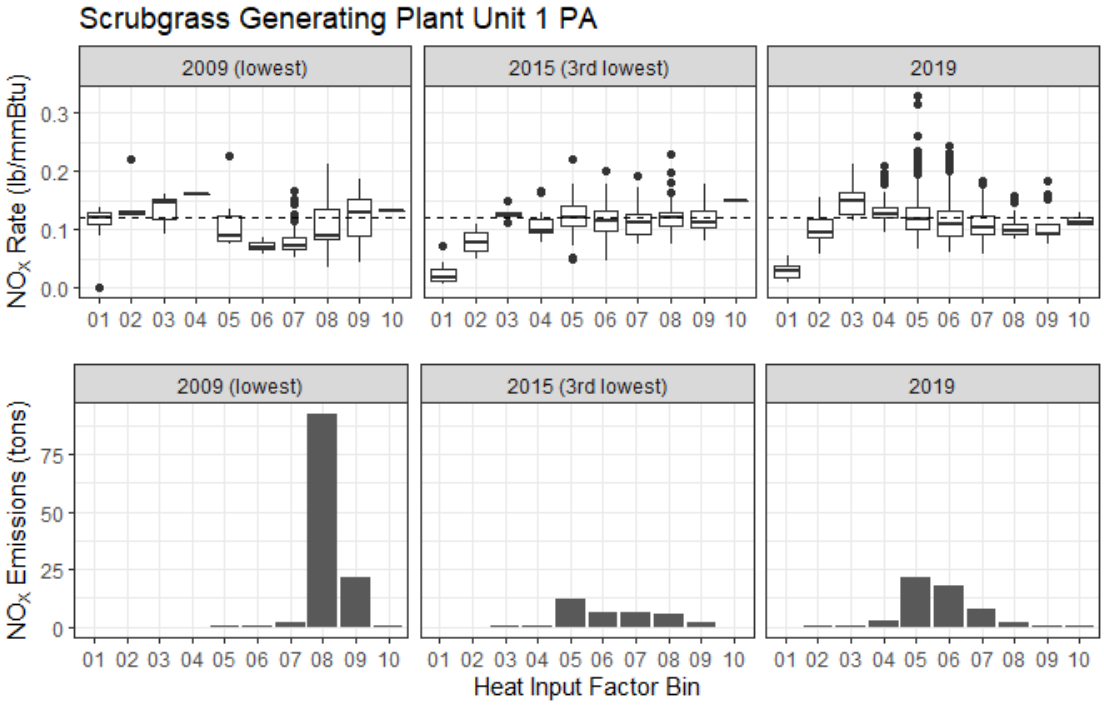

Panther Creek Energy Facility Unit 1 PA
Operating Hours
200
150
100
50
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2017 (lowest)
2018 (3rd lowest)
2019

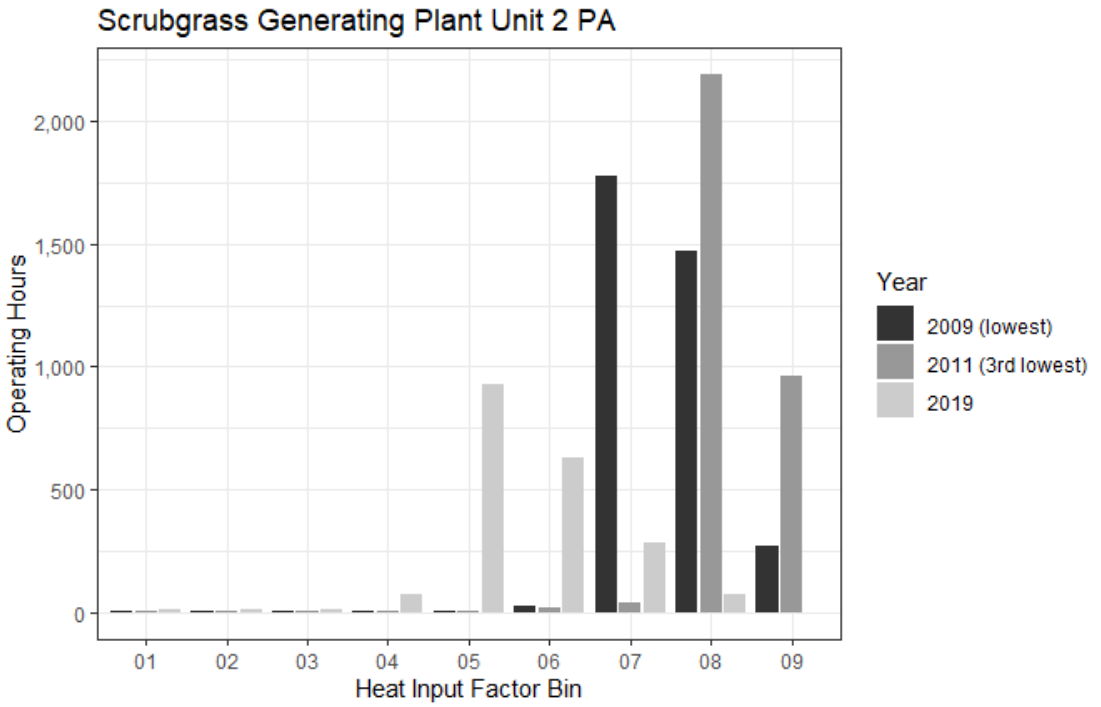

Panther Creek Energy Facility Unit 1 PA
2017 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.1
0.0
NOX Emissions (tons)
8
6
4
2
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

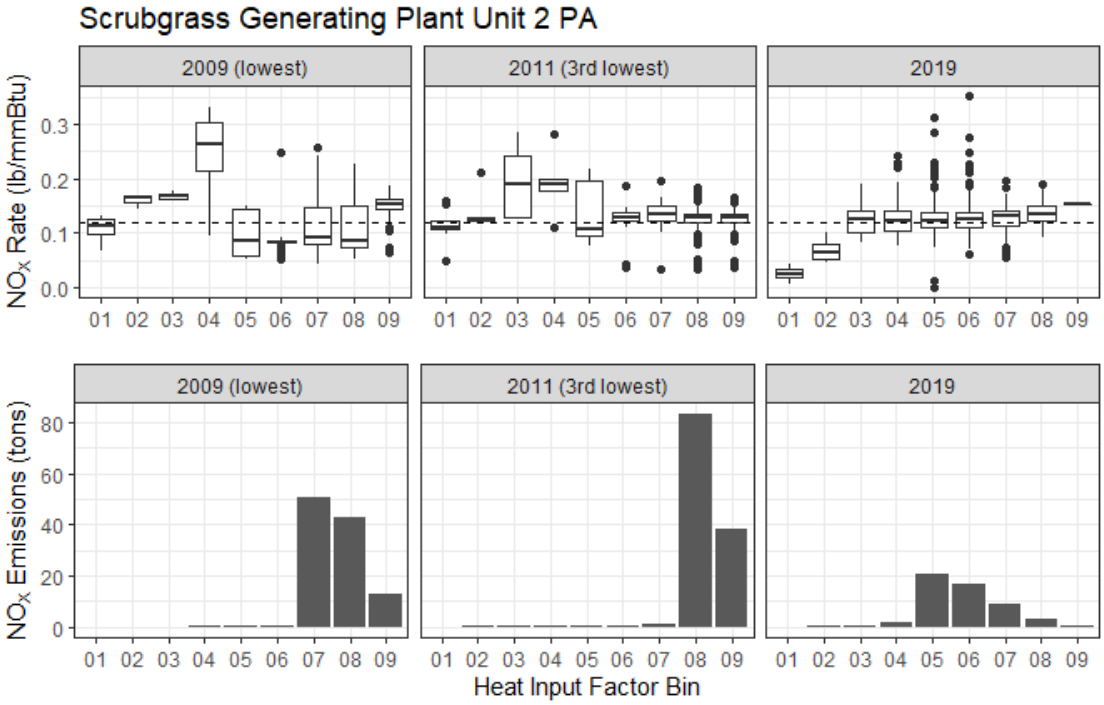

Panther Creek Energy Facility Unit 2 PA
Operating Hours
1,200
800
400
0
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2015 (lowest)
2019 (3rd lowest)

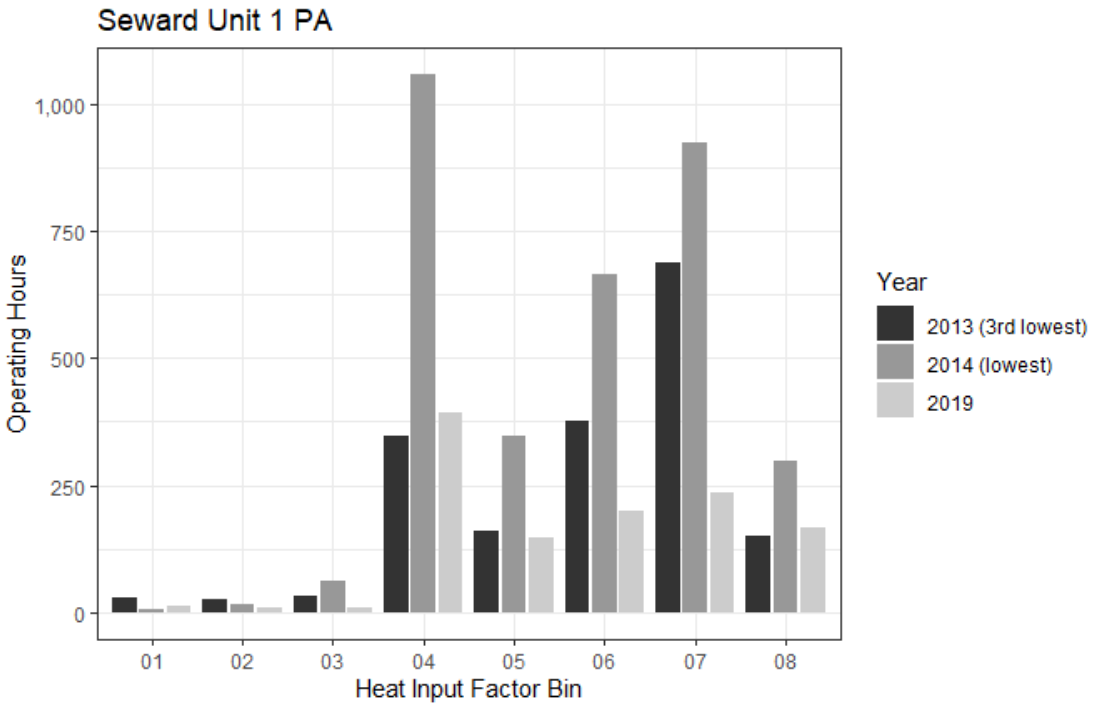

Panther Creek Energy Facility Unit 2 PA
2015 (lowest)
2019 (3rd lowest)
NOX Rate (lb/mmBtu)
0.1
0.0
NOX Emissions (tons)
30
20
10
0
03
04
05
06
07
08
09
10
Heat Input Factor Bin

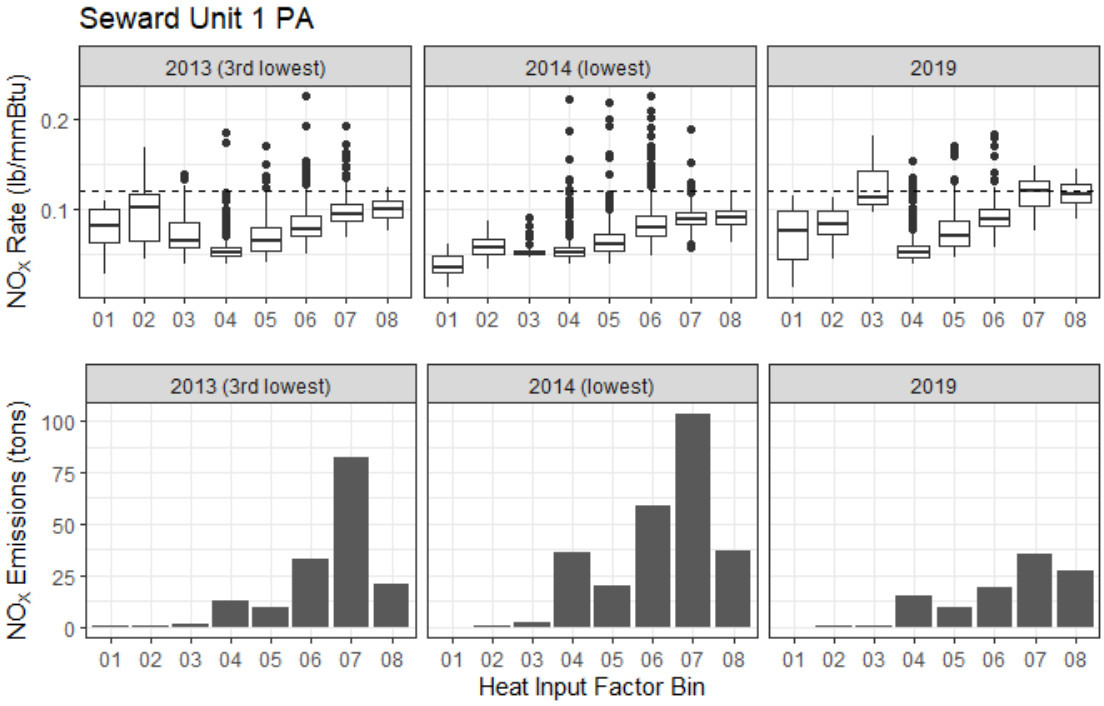

Scrubgrass Generating Plant Unit 1 PA
Operating Hours
3,000
2,000
1,000
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2009 (lowest)
2015 (3rd lowest)
2019

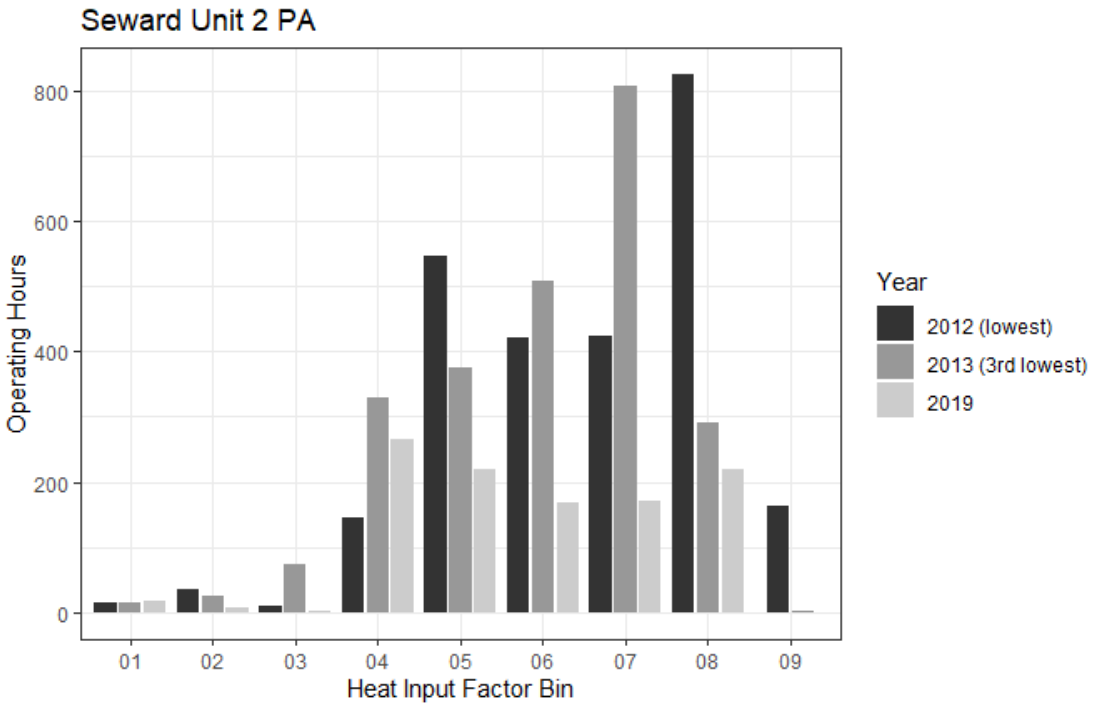

Scrubgrass Generating Plant Unit 1 PA
2009 (lowest)
2015 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
01 02 03 04 05 06 07 08 09 10
NOX Emissions (tons)
75
50
25
0
Heat Input Factor Bin

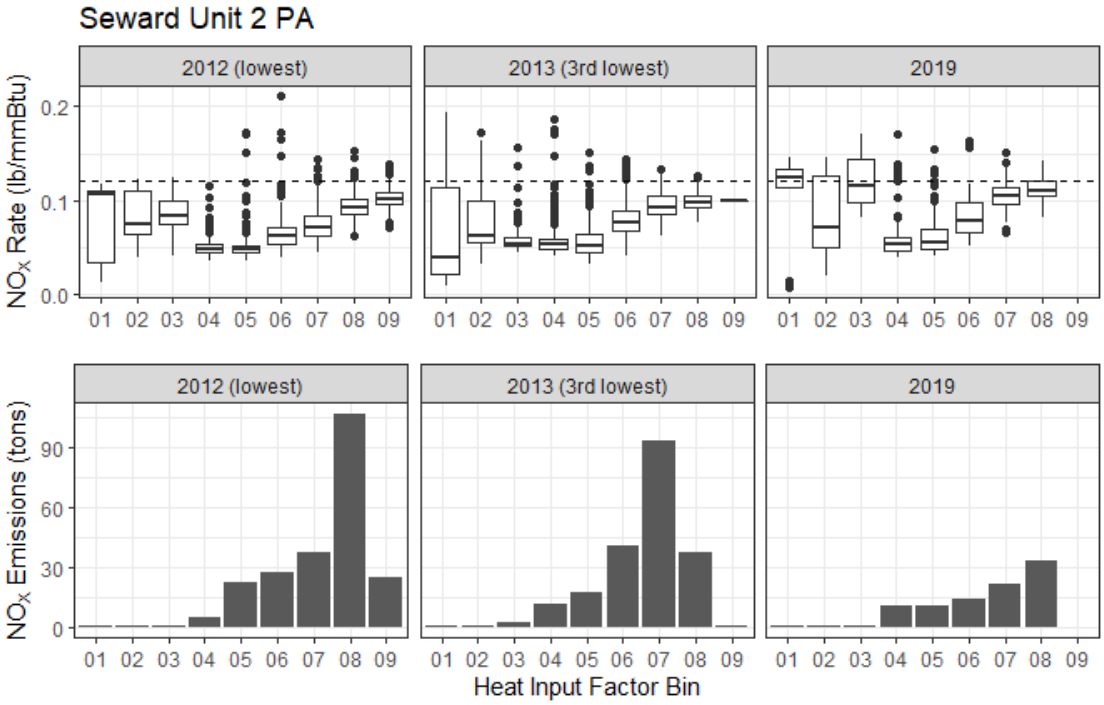

Scrubgrass Generating Plant Unit 2 PA
Operating Hours
2,000
1,500
1,000
500
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2009 (lowest)
2011 (3rd lowest)
2019


Scrubgrass Generating Plant Unit 2 PA
2009 (lowest)
2011 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
80
60
40
20
0
01 02 03 04 05 06 07 08 09
Heat Input Factor Bin


Seward Unit 1 PA
Operating Hours
1,000
750
500
250
0
01
02
03
04
05
06
07
08
Heat Input Factor Bin
Year
2013 (3rd lowest)
2014 (lowest)
2019


Seward Unit 1 PA
2013 (3rd lowest)
2014 (lowest)
2019
NOX Rate (lb/mmBtu)
0.2
0.1
NOX Emissions (tons)
100
75
50
25
0
01
02
03
04
05
06
07
08
Heat Input Factor Bin

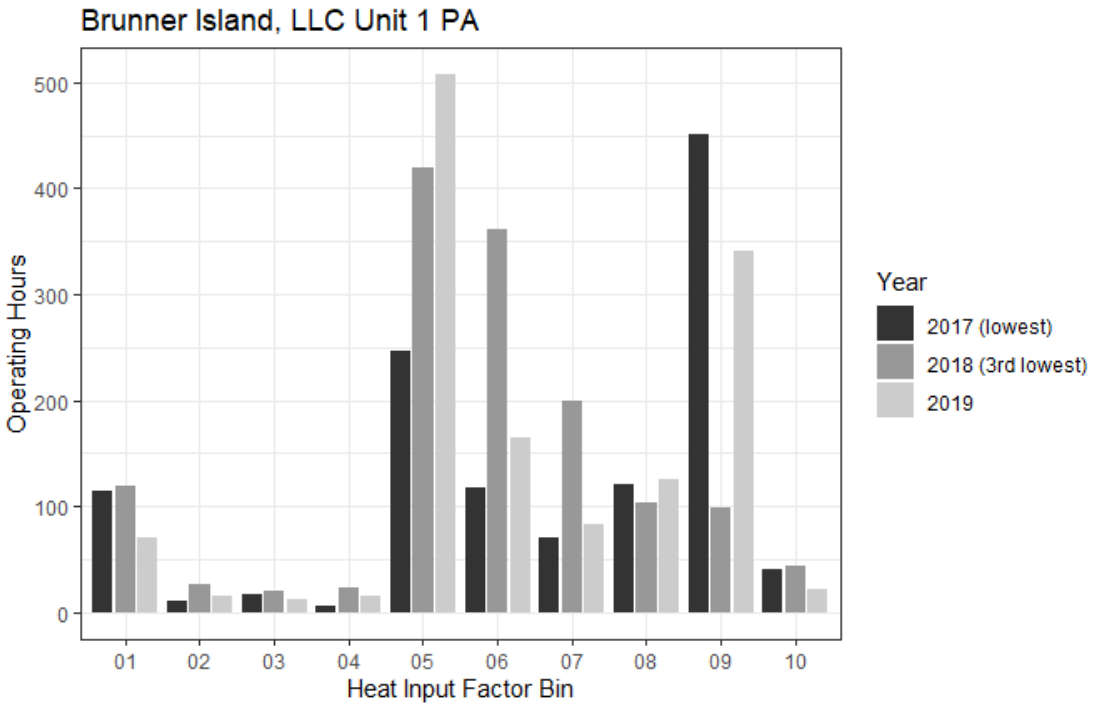

Seward Unit 2 PA
Operating Hours
800
600
400
200
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2012 (lowest)
2013 (3rd lowest)
2019

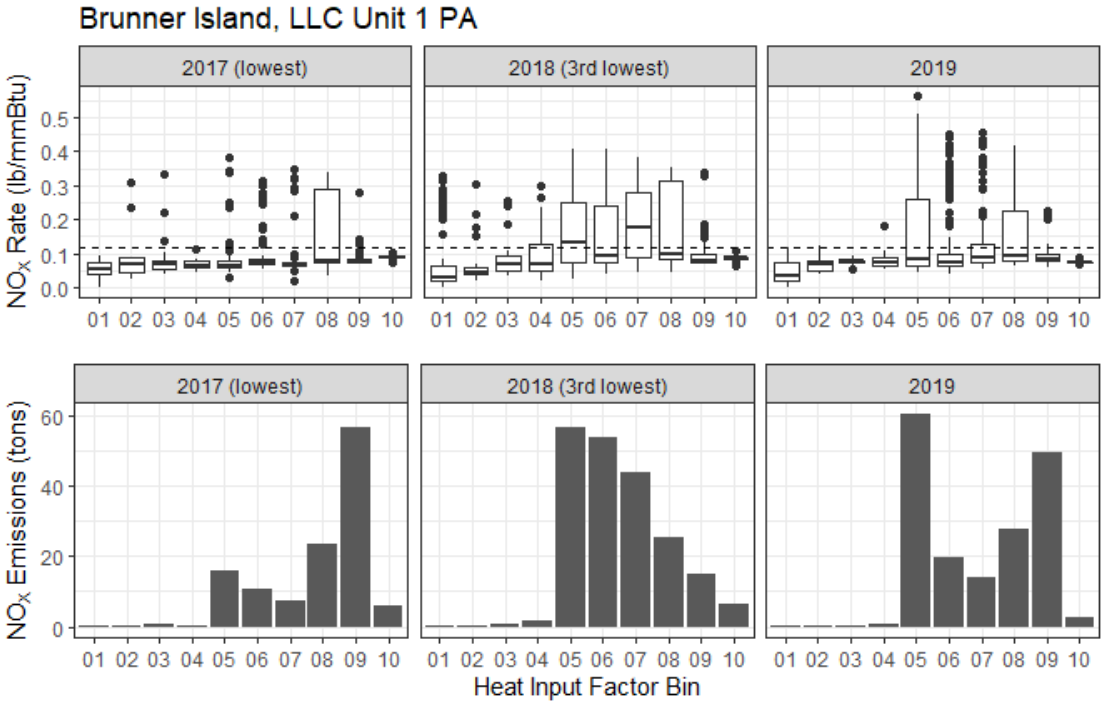

Seward Unit 2 PA
2012 (lowest)
2013 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.2
0.1
0.0
NOX Emissions (tons)
90
60
30
0
01 02 03 04 05 06 07 08 09
Heat Input Factor Bin

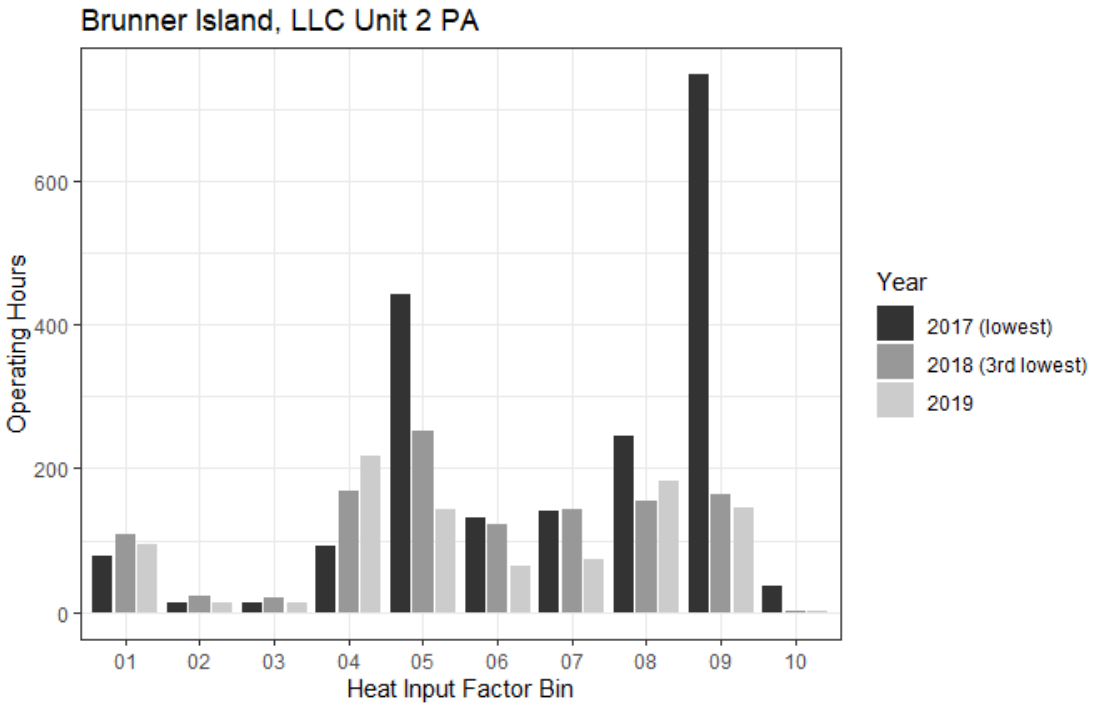
3.1.3 Units Without SCR or SNCR Controls

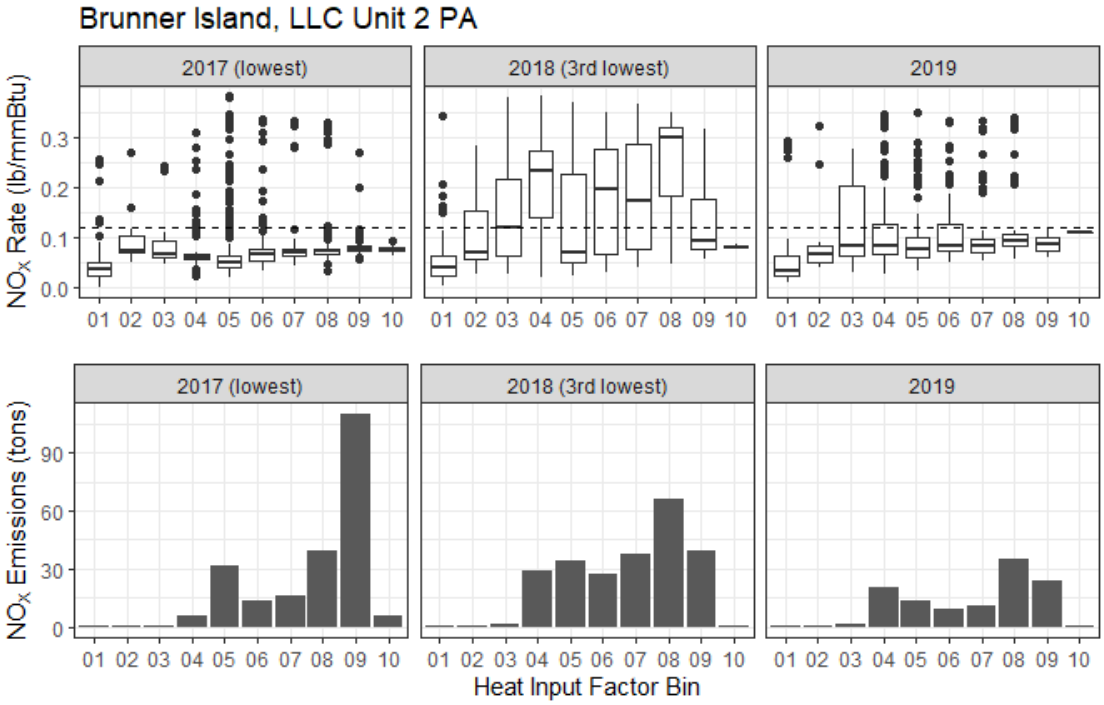
The plots in this subsection are for coal-fired units without SCR or SNCR controls. Because there are no longer any coal-fired units operating without SCR or SNCR controls in Delaware, Maryland, or New Jersey, all the units covered in this section are located in Pennsylvania. EPA notes that Brunner Island units 1-3, which are capable of combusting coal and are included in the analysis for that reason, combusted primarily natural gas in each of the ozone seasons evaluated.

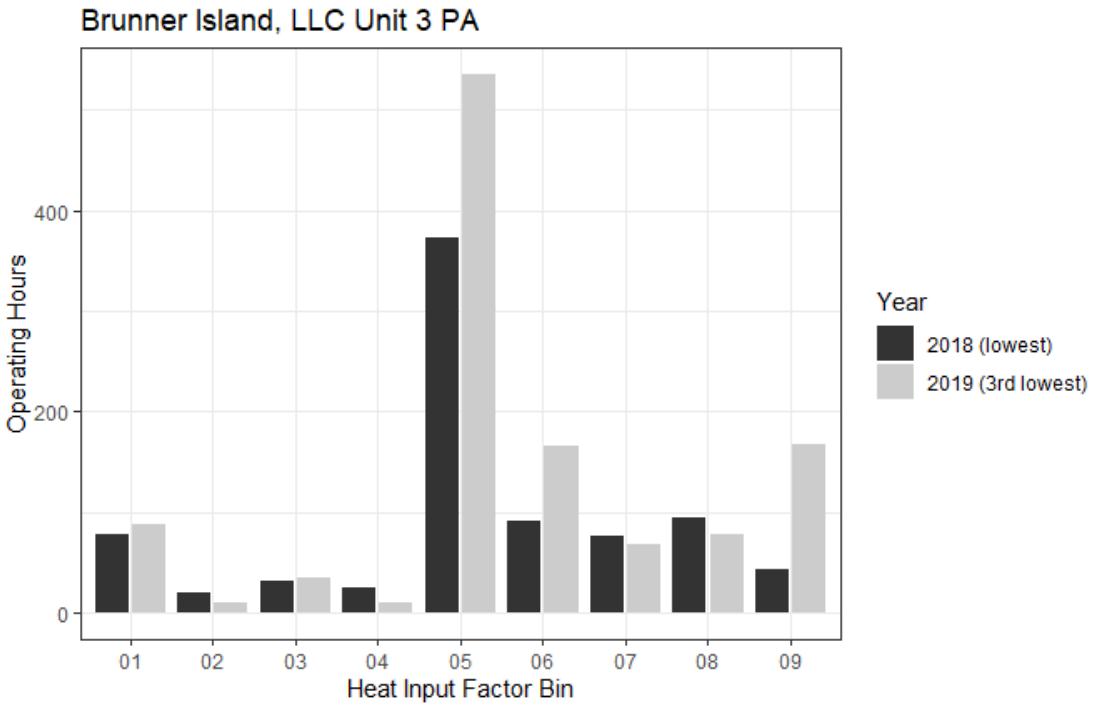
Some of the units without SCR or SNCR controls show NO_X emission rates that increase across operating levels while others show rates that are relatively flat across operating levels. Most of the units show little change in the NO_X emission rates achieved at various operating levels across the years evaluated. Gilberton units 031-032 are exceptions, showing different patterns of emission rates and operating levels across the years evaluated. However, notwithstanding the relative inconsistency across years, the Gilberton units generally show low emission rates at all operating levels in all the years evaluated.

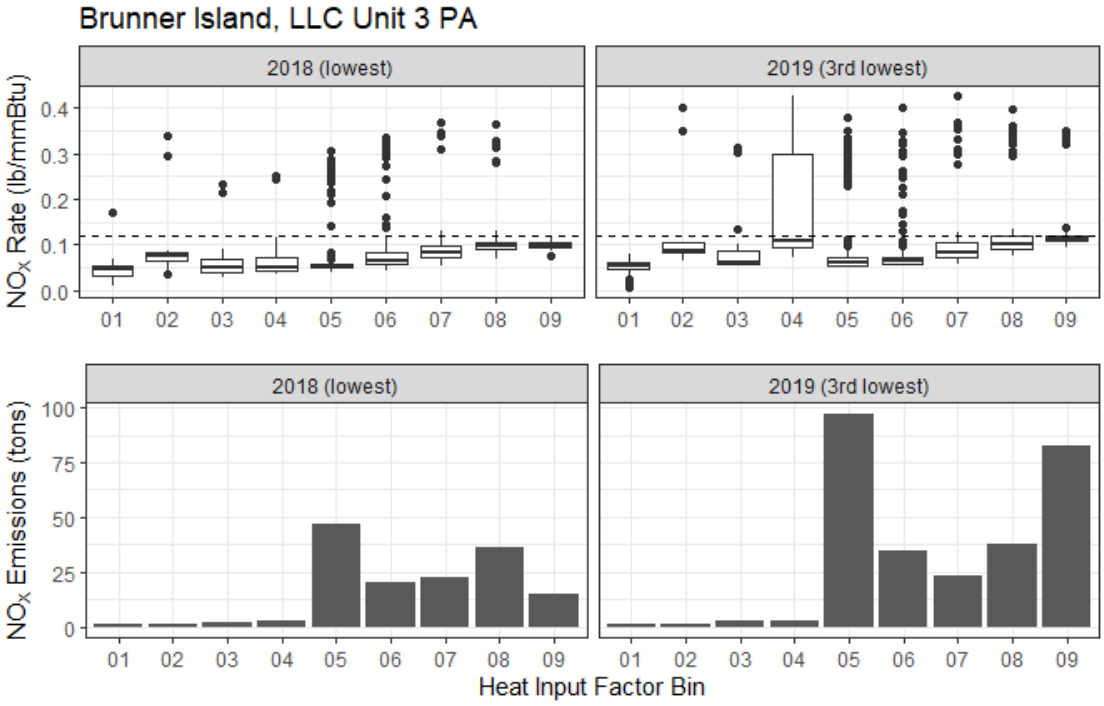

Brunner Island, LLC Unit 1 PA
Operating Hours
0
100
200
300
400
500
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2017 (lowest)
2018 (3rd lowest)
2019

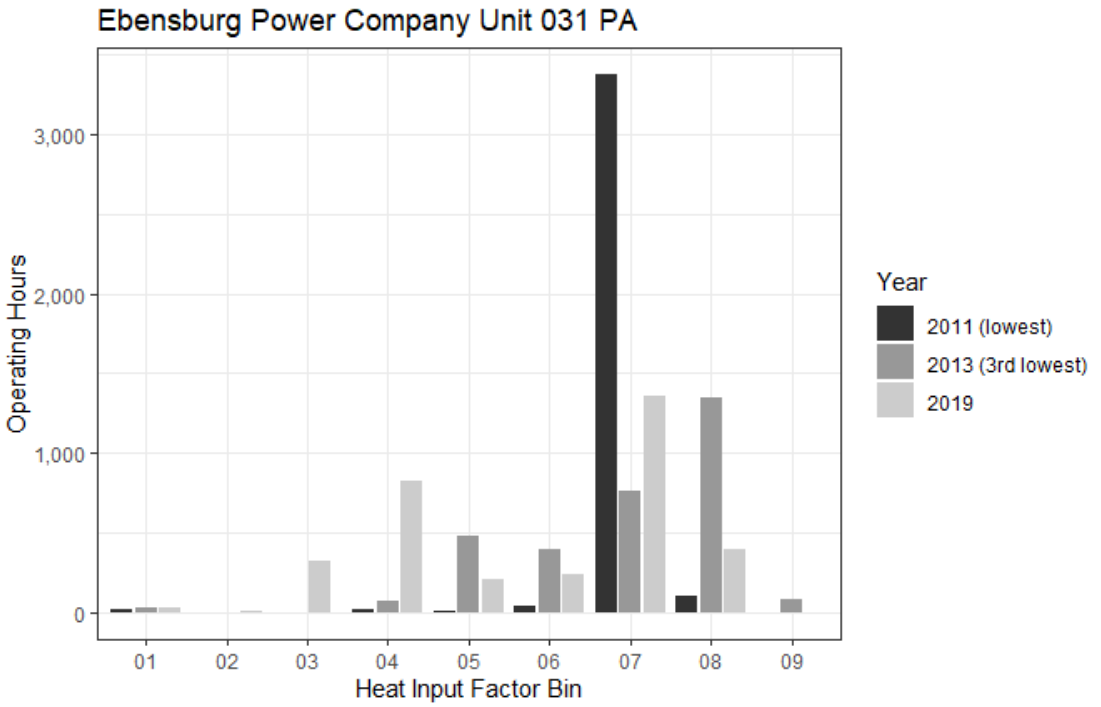

Brunner Island, LLC Unit 1 PA
2017 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.0
0.1
0.2
0.3
0.4
0.5
01 02 03 04 05 06 07 08 09 10
NOX Emissions (tons)
0
20
40
60
Heat Input Factor Bin

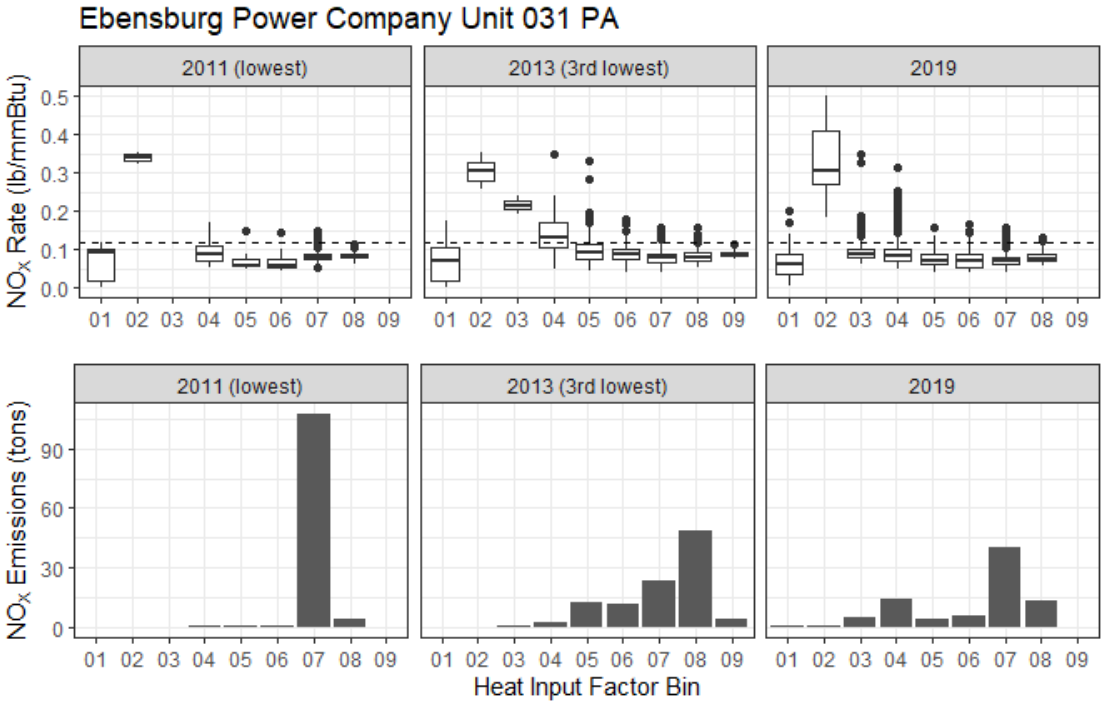

Brunner Island, LLC Unit 2 PA
Operating Hours
600
400
200
0
01
02
03
04
05
06
07
08
09
10
Heat Input Factor Bin
Year
2017 (lowest)
2018 (3rd lowest)
2019

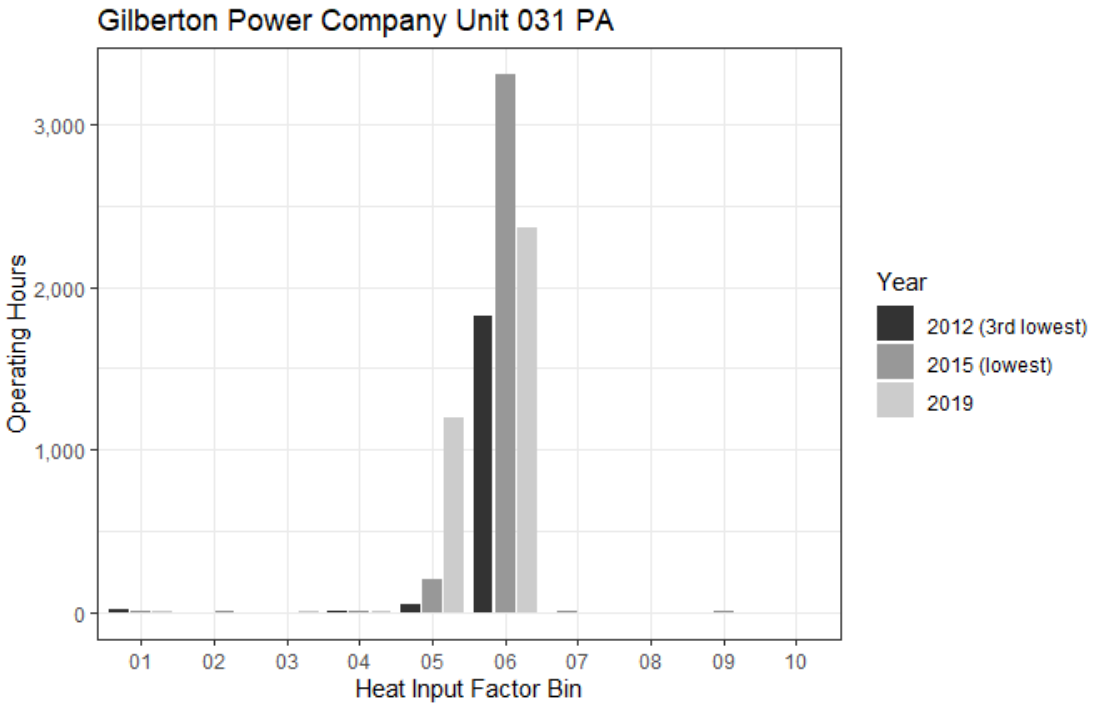

Brunner Island, LLC Unit 2 PA
2017 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
90
60
30
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

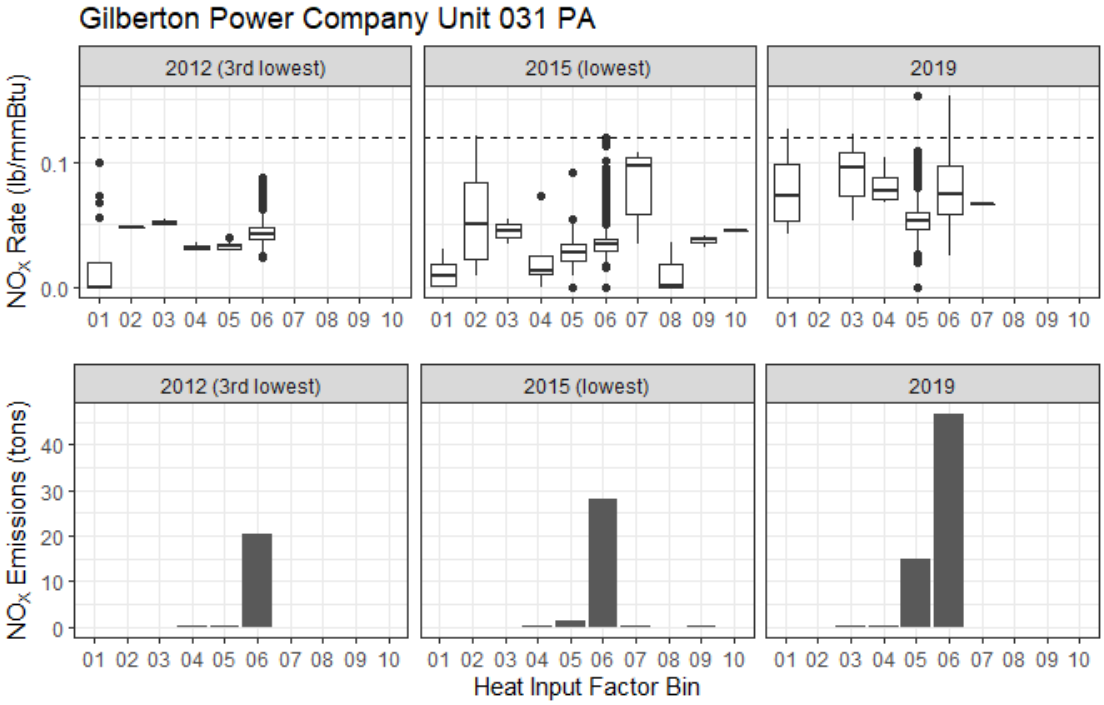

Brunner Island, LLC Unit 3 PA
Operating Hours
400
200
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2018 (lowest)
2019 (3rd lowest)

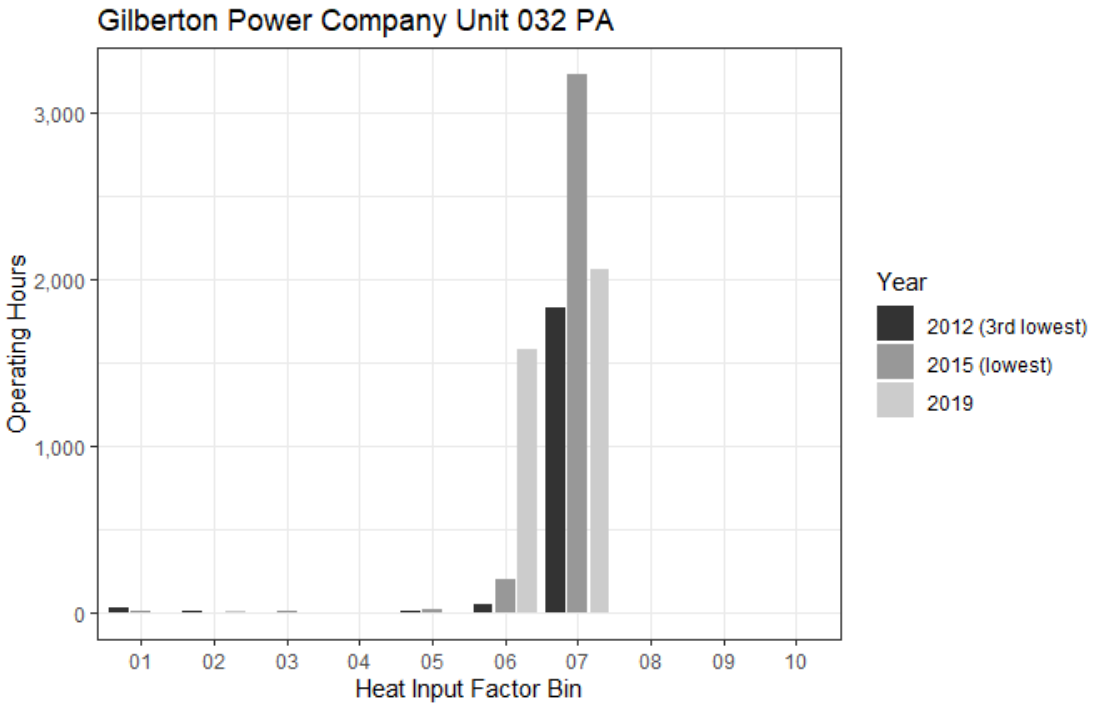

Brunner Island, LLC Unit 3 PA
2018 (lowest)
2019 (3rd lowest)
NOX Rate (lb/mmBtu)
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
100
75
50
25
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin

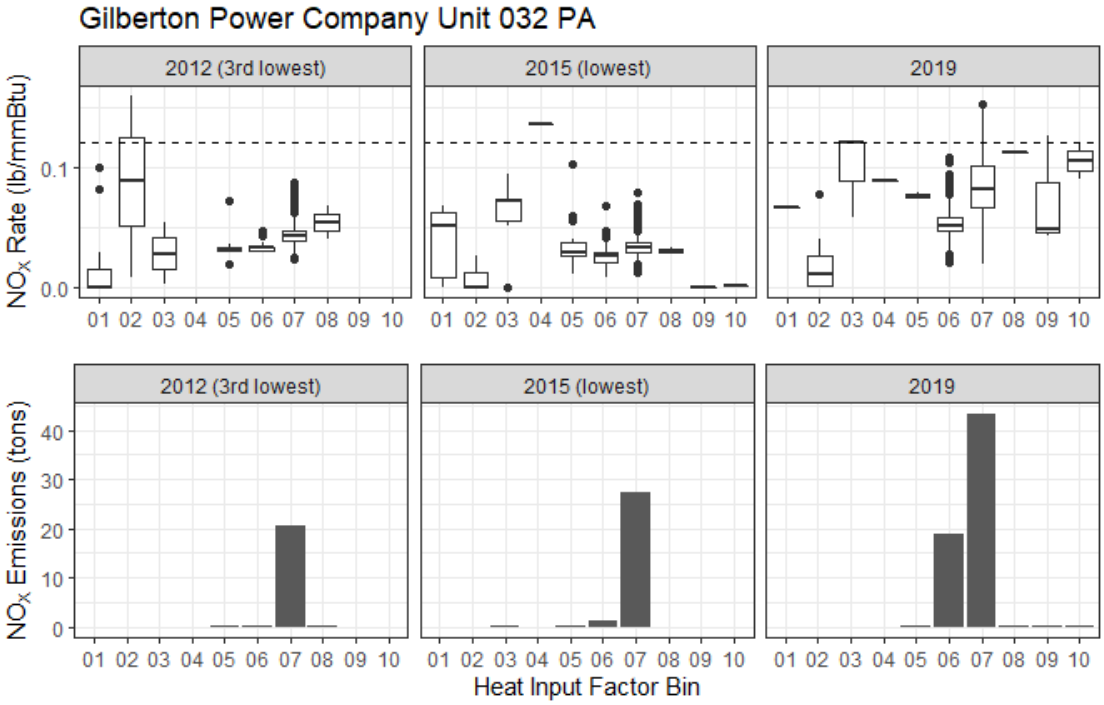

Ebensburg Power Company Unit 031 PA
Operating Hours
3,000
2,000
1,000
0
01
02
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2011 (lowest)
2013 (3rd lowest)
2019

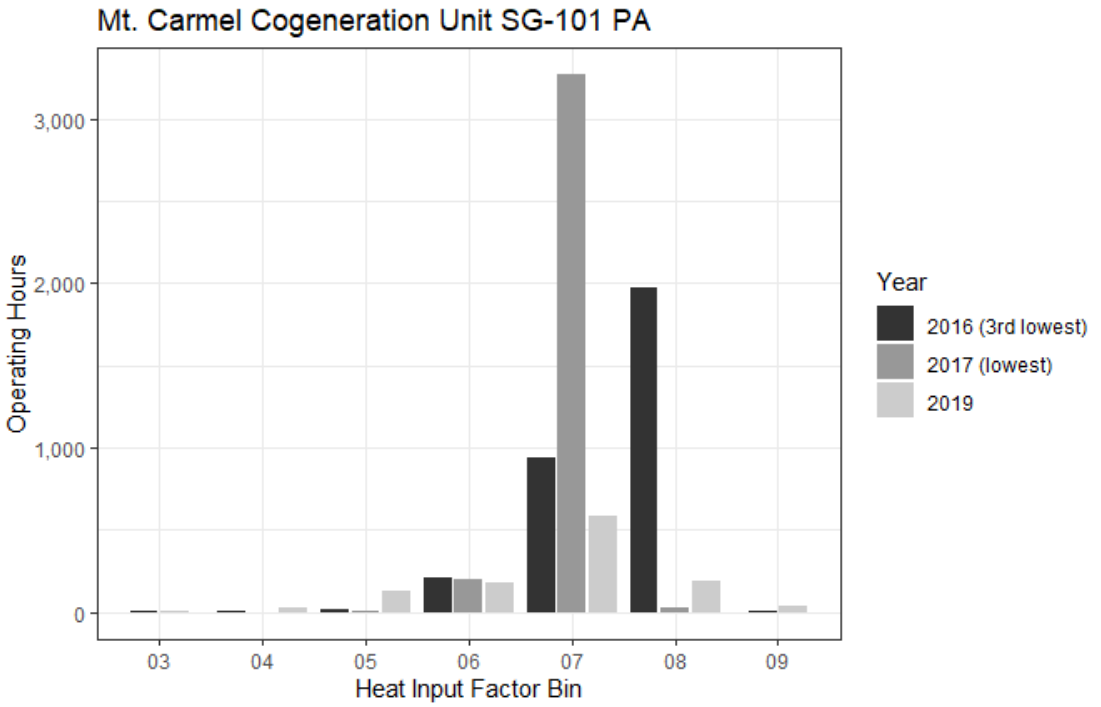

Ebensburg Power Company Unit 031 PA
2011 (lowest)
2013 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
0.0
NOX Emissions (tons)
90
60
30
0
01 02 03 04 05 06 07 08 09
Heat Input Factor Bin

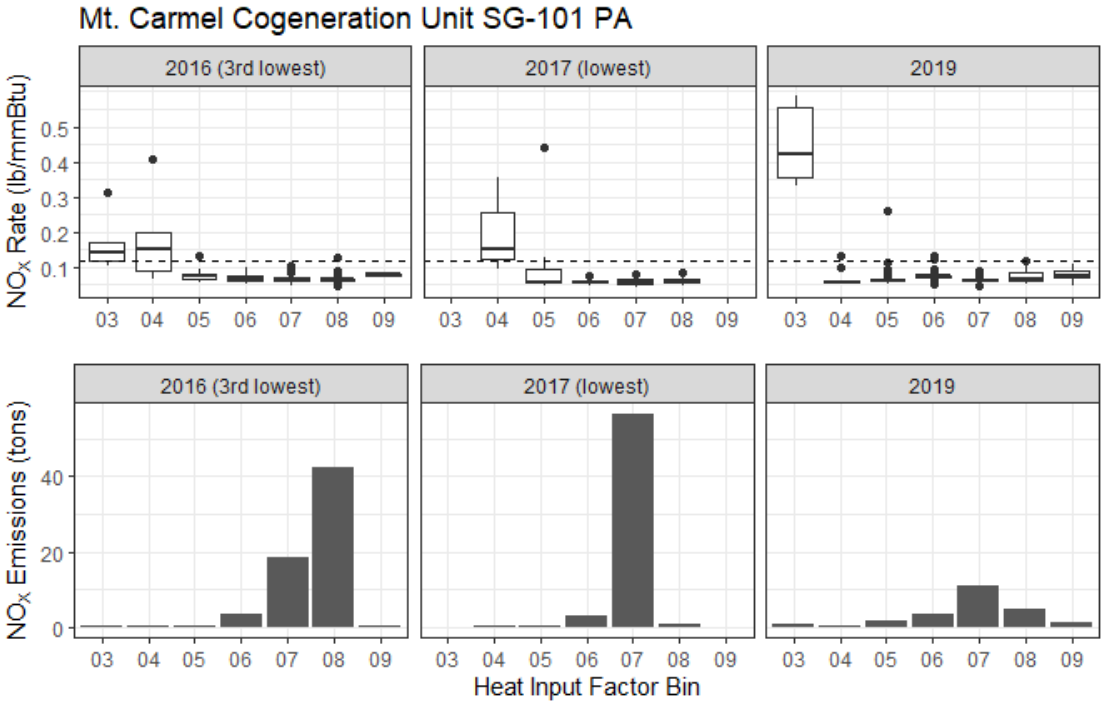

Gilberton Power Company Unit 031 PA
Operating Hours
3,000
2,000
1,000
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2012 (3rd lowest)
2015 (lowest)
2019

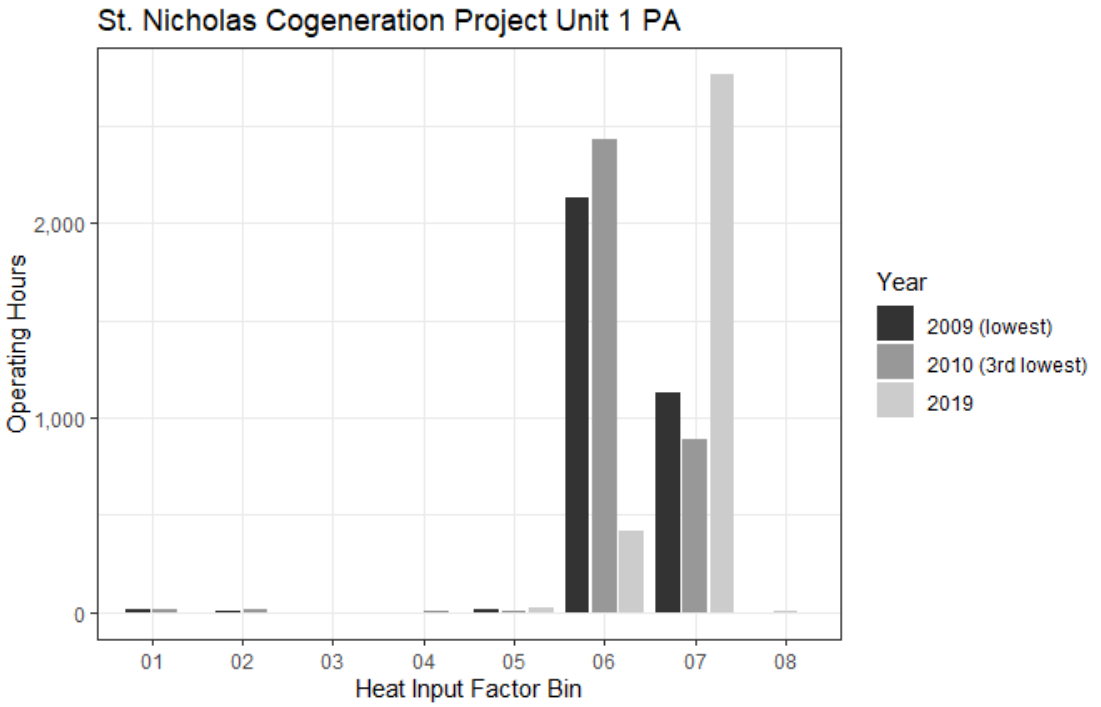

Gilberton Power Company Unit 031 PA
2012 (3rd lowest)
2015 (lowest)
2019
NOX Rate (lb/mmBtu)
0.1
0.0
NOX Emissions (tons)
40
30
20
10
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

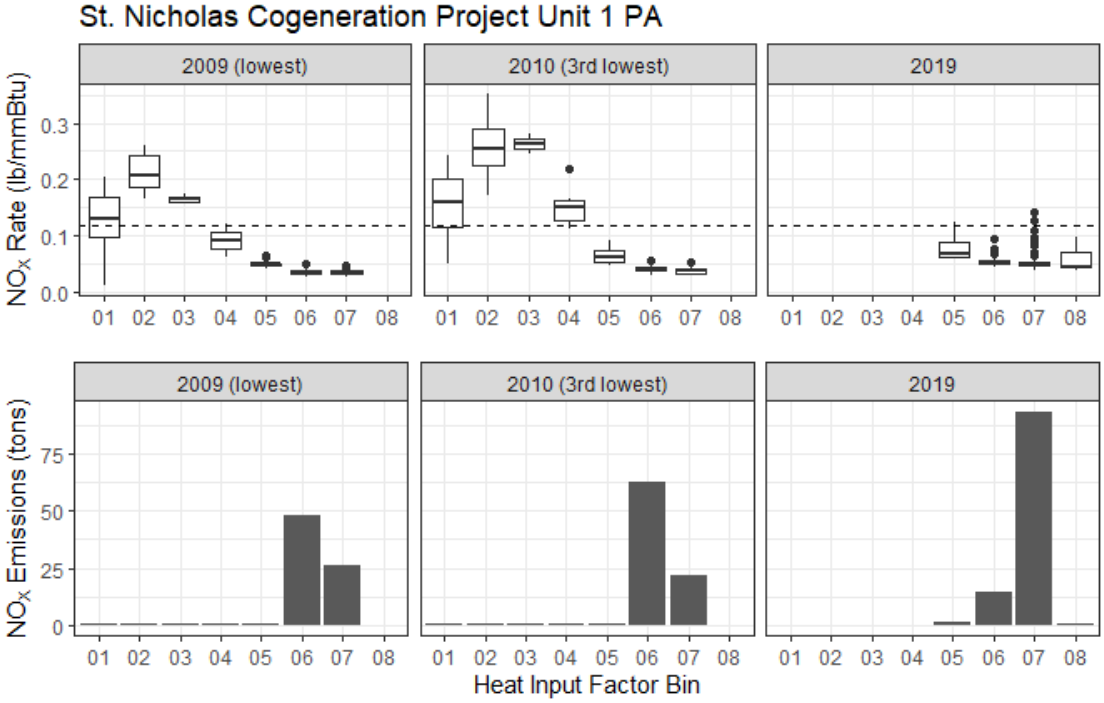

Gilberton Power Company Unit 032 PA
Operating Hours
3,000
2,000
1,000
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2012 (3rd lowest)
2015 (lowest)
2019

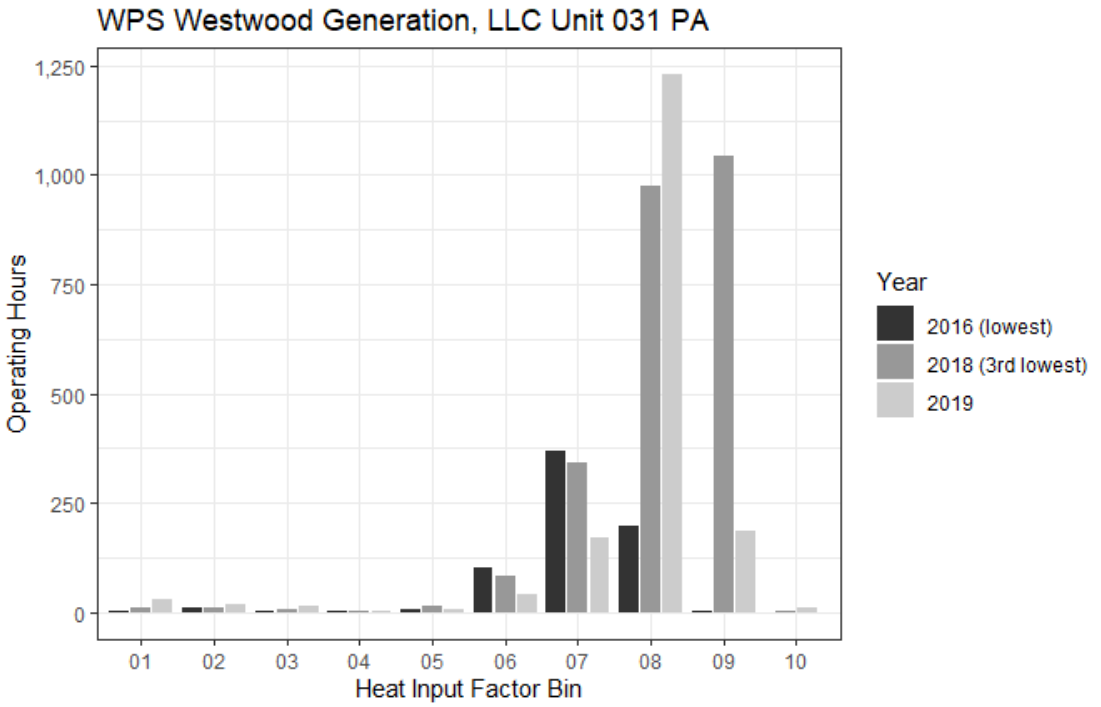

Gilberton Power Company Unit 032 PA
2012 (3rd lowest)
2015 (lowest)
2019
NOX Rate (lb/mmBtu)
0.1
0.0
NOX Emissions (tons)
40
30
20
10
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin

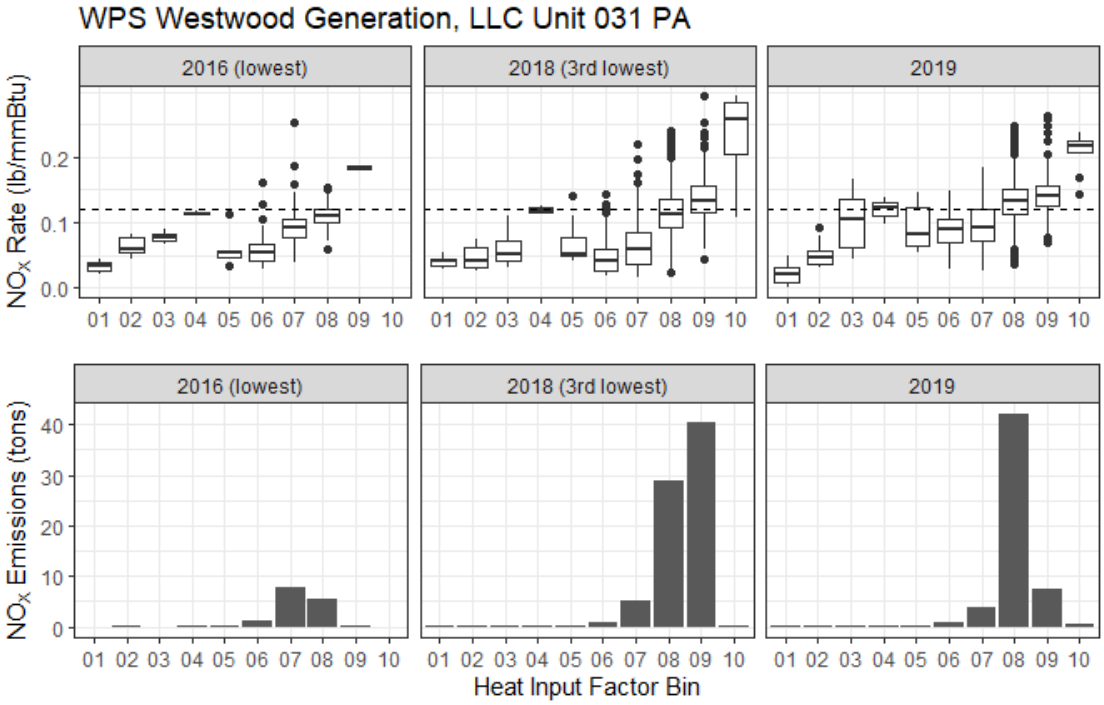

Mt. Carmel Cogeneration Unit SG-101 PA
Operating Hours
3,000
2,000
1,000
0
03
04
05
06
07
08
09
Heat Input Factor Bin
Year
2016 (3rd lowest)
2017 (lowest)
2019


Mt. Carmel Cogeneration Unit SG-101 PA
2016 (3rd lowest)
2017 (lowest)
2019
NOX Rate (lb/mmBtu)
0.5
0.4
0.3
0.2
0.1
NOX Emissions (tons)
40
20
0
03
04
05
06
07
08
09
Heat Input Factor Bin


St. Nicholas Cogeneration Project Unit 1 PA
Operating Hours
2,000
1,000
0
01
02
03
04
05
06
07
08
Heat Input Factor Bin
Year
2009 (lowest)
2010 (3rd lowest)
2019


St. Nicholas Cogeneration Project Unit 1 PA
2009 (lowest)
2010 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.3
0.2
0.1
0.0
NOX Emissions (tons)
75
50
25
0
01
02
03
04
05
06
07
08
Heat Input Factor Bin


WPS Westwood Generation, LLC Unit 031 PA
Operating Hours
1,250
1,000
750
500
250
0
01 02 03 04 05 06 07 08 09 10
Heat Input Factor Bin
Year
2016 (lowest)
2018 (3rd lowest)
2019


WPS Westwood Generation, LLC Unit 031 PA
2016 (lowest)
2018 (3rd lowest)
2019
NOX Rate (lb/mmBtu)
0.2
0.1
0.0
01 02 03 04 05 06 07 08 09 10
NOX Emissions (tons)
40
30
20
10
0
Heat Input Factor Bin

3.2 Evaluation of Hourly NO_X Emission Rate Outlier Data

The plots in this section provide more information on the high outlier data values from the earlier analysis. For purposes of the analysis, high outliers for a given unit in a given year are defined as hourly emission rate data values that exceed the 75th percentile data value for the respective heat input factor bin for that year by more than 1.5 times the interquartile range (75th - 25th percentile). The purpose of the outlier analysis was to evaluate whether there was any clustering of outliers that could indicate a pattern of operation or whether, instead, the outliers simply indicate unplanned variability.

Figure 3.1 shows the total number of high NO_X emission rate outliers that occur on each day of the 2019 ozone season for all SCR-equipped coal-fired EGUs in each of the four states analyzed. Outliers do not appear to be clustered around particular days. They occur with some regularity across the 2019 ozone season for both Maryland and Pennsylvania.

Figure 3.2 performs the same analysis for Conemaugh units 1-2 and Keystone units 1-2 in Pennsylvania and Brandon Shores units 1-2 in Maryland. The four Conemaugh and Keystone units had the largest amounts of 2019 ozone season NO_X emissions of all the units in this analysis, as noted in section 3.1.1, while the two Brandon Shores units had the largest amounts of 2019 ozone season NO_X emissions of all the units in Delaware, Maryland, and New Jersey. The outliers for each unit at each of the three plants are spread across the ozone season. There are different distributions for the two units at each plant and no particular indication of clustering on individual days for any of the six units.

EPA notes that the levels of individual hourly NO_X emission rate values that are considered outliers can vary across facilities. The Brandon Shores units have outliers fairly frequently throughout the ozone season; however, these EGUs generally have much lower NO_X emission rates and less variability in NO_X emission rates than the Conemaugh and Keystone units. In fact, many points that are considered outliers for the Brandon Shores units in the 2019 ozone season occurred at emission rate levels that would not be considered outliers at the Conemaugh and Keystone units, because the Conemaugh and Keystone units have higher NO_X emission rates and higher variability in NO_X rates.

Figure 3.2 also highlights in blue the days on which select monitors in the OTC exceeded the 2015 ozone NAAQS (>70 ppb) during the 2019 ozone season.[5] There does not appear to be a correlation between the occurrence of outliers and high ozone days in the 2019 ozone season.

[5] EPA used the list of monitors on page 6 of Attachment 2 in the OTC's recommendation in the table titled "Part 2A – Measured ozone data through 2019 ozone season" for Figure 3.2.

Figure 3.1: Ozone Season 2019 NO_X Rate Outliers at Coal-fired EGUs with SCR

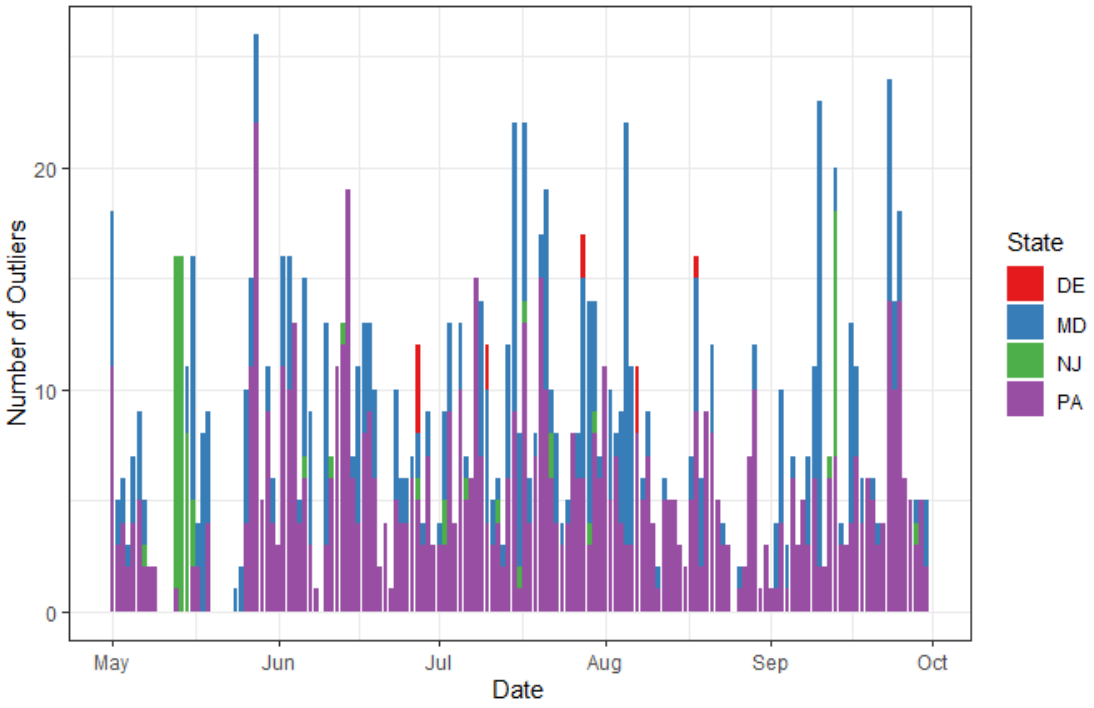
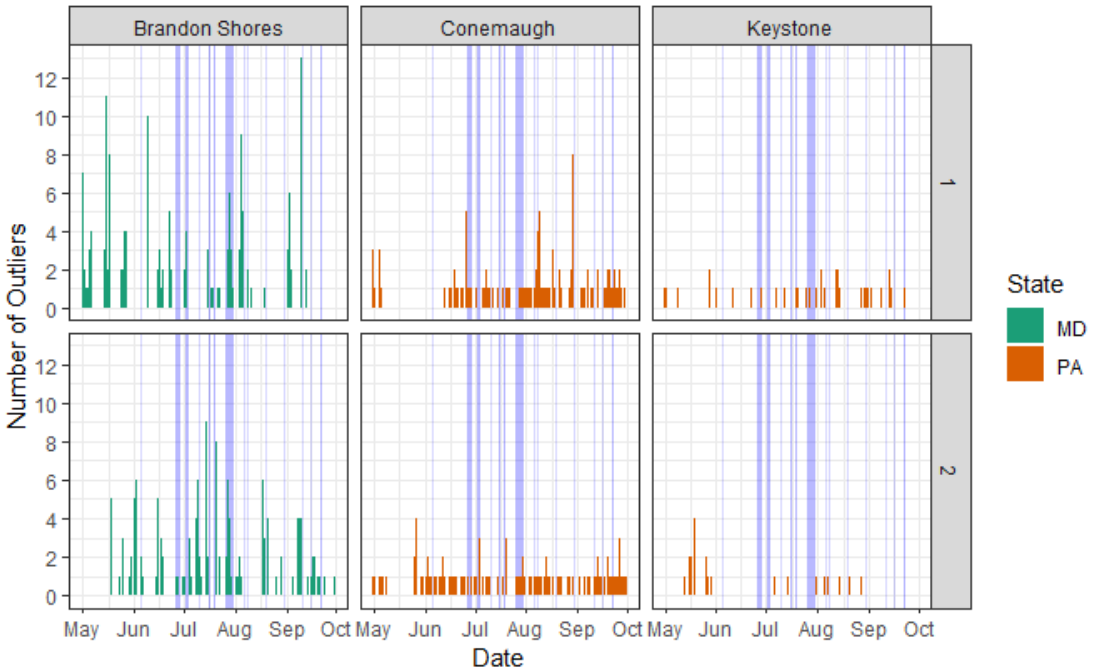


Figure 3.2: Ozone Season 2019 NO_X Rate Outliers by Unit: Brandon Shores units 1-2, Conemaugh units 1-2, and Keystone units 1-2



Note: Blue sections represent high ozone days at select monitors in OTC states.