October 10, 2016
From: MANE-VU Technical Support Committee
To: MANE-VU Air Directors

Re: Contribution Assessment Preliminary Inventory Analysis

Overview

The Clean Air Act and the Regional Haze Rule requires that the following four factors be analyzed in order to determine what controls are feasible for inclusion in a Regional Haze SIP:

1. Costs of compliance;
2. Time necessary for compliance;
3. Energy and non-air quality environmental impacts; and
4. Remaining useful life of affected sources (40 CFR 51.308(d)(1)(i))

However, the resources needed to conduct such an analysis for every source sector would be overwhelming, and therefore the workgroup is recommending that scrutiny only be given to the larger sectors.

Emissions reductions between 2002 and 2011 in and around MANE-VU have resulted in significant improvements in visibility in MANE-VU Class I areas. In order to assist states in continuing to improve visibility, this document analyzes the emissions inventory to determine where the greatest potential for further emissions reductions exists.

A workgroup of the Technical Support Committee looked at the inventory sectors that produce the largest amounts of sulfur dioxide (SO_2) which is a precursor for sulfates, and oxides of nitrogen (NO_X) which impacts formation of nitrates and carbonaceous aerosols. These pollutants are also considered to be reasonably accurate and able to be regulated.

The inventory analyses will be based on the 2011 inventory, while also examining a 2018 inventory, since that is the first year of the second regional haze planning period. This inventory was developed for the purpose of multi-pollutant planning for OTC and MANE-VU members. Several versions of the inventory have been developed and the Alpha 2 inventory was used for this analysis because it is the inventory that was used to project or "grow" emissions to develop a 2028 inventory that will be used for modeling the 2028 Reasonable Progress Goals.[1] All sources from the inventory were included excepting fires and biogenic emissions. More information on the specific files used can be found in Appendix B of the Modeling TSD.[2]

[1] McDill, McCusker, and Sabo, "Technical Support Document: Emission Inventory Development for 2011, 2018, and 2028 for the Northeastern U.S. Alpha 2 Version."
[2] Ozone Transport Commission, *Technical Support Document for the 2011 Ozone Transport Commission/Mid-Atlantic Northeastern Visibility Union Modeling Platform*.

The analysis looked solely at annual emissions. We chose to look at annual emissions given that, with the exception of EGUs, a greater number of assumptions are needed to create daily emissions inventories, so any finer look will likely be increase inaccuracies.

Finally, this review is intended to provide a qualitative analysis of the relative importance of each sector.

Annual Emissions

Methodology

Database Setup

The pre-SMOKE processed Alpha 2 inventory is stored in the EMF system hosted by MARAMA (http://marama.org/training-center/74-general/453-emf-and-cost). The files, stored in the ff10 file format, were downloaded over the course of the week of July 25, 2016 and were imported in the Microsoft Access. All files were imported in full, except nonroad which had unanalyzed pollutants removed prior to exporting from EMF, and non-EGU point sources which were aggregated on FIPS and SCC in a separate Access database due to size limitations. Entries for states that were in WESTAR and any extra pollutants that were not being analyzed were deleted due to space constraints. Tables of SCCs were also imported from those exported from EMF.

Data Import Quality Assurance

After importing the files that had been exported from EMF to Access, SO_2 and NO_X totals were compared to SMOKE reports using the categorization found in Appendix B of the Modeling TSD. For the 2011 base year, the inventories were found to be within 2% and 1% of each other for SO_2 and NO_X, respectively, with most sectors being less than 1% apart. The 2018 future year inventory was found to be within 4% and 3% of each other for SO_2 and NO_X, respectively, with most sectors being less than 1% apart.

SCCs

Inventory sectors were aggregated based on second and third level SCCs. Aggregations were based on similarities of the source categories' processes, expected control technologies, and relative magnitudes of emissions. A translation between the SCCs of sources with SO_2 or NO_X emissions in one of the four RPOs and the categorization used in this analysis is available in Table 1.

Table 1: SCC Categorization Methodology for Analysis Inventory Analysis

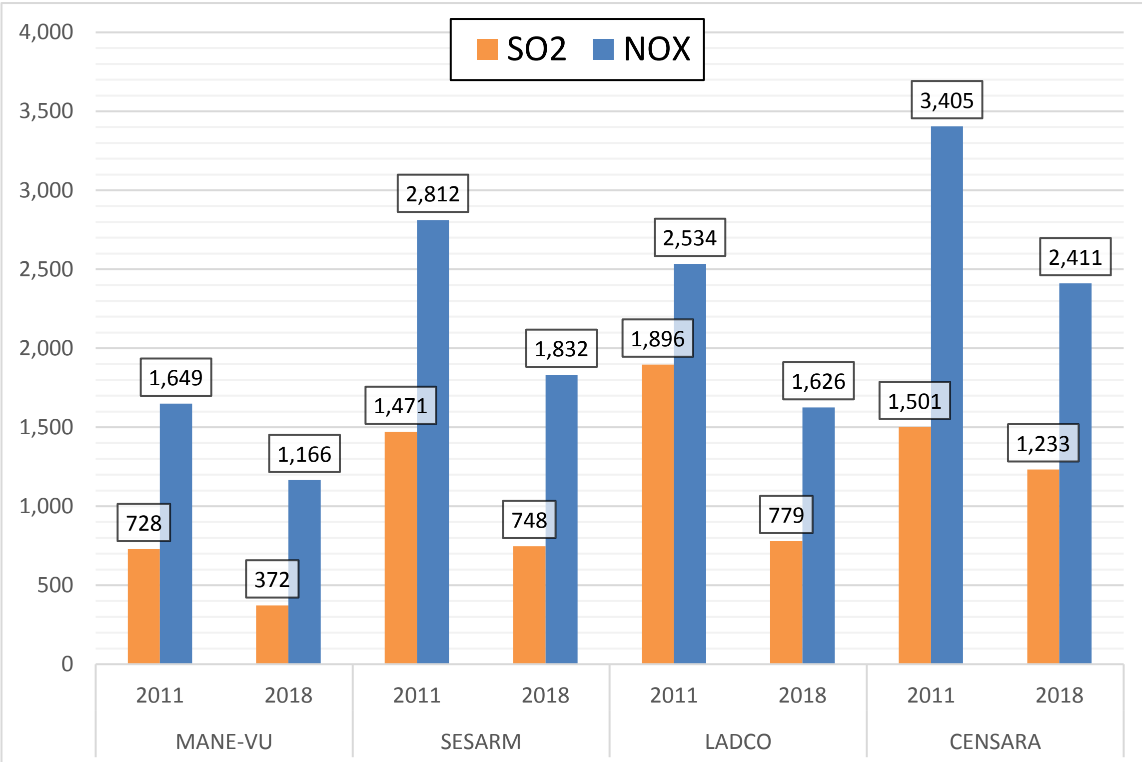
Sector	Subsector	SCC beginning with
Ag.	Other	2801500
		302
Area Comm./Inst.	Coal	2103001
		2103002
	Dist. Oil	2103005
	Kerosene	2103011
	LPG	2103007
	Natural Gas	2103006
	Resid. Oil	2103004
	Wood	2103008
Area Industrial	Coal	2102002
	Dist. Oil	2102004
	Kerosene	2102011
	LPG	2102007
	Natural Gas	2102006
	Oil	2102012
	Resid. Oil	2102005
	Wood	2102008
Area Residential	Coal	2104001
		2104002
	Kerosene	2104011
	LPG	2104007
	Natural Gas	2104006
	Resid. Oil	2104004
	RWC	2104008
		2104009
EGUS	Coal	101001
		101002
	Natural Gas	101006
		101007
	Oil	101004
		101005
		101021
	Other	101008
		101009
		10101
ICE	Aircraft Engine Tests	204001
	Diesel	201001
		202001
		203001

Sector	Subsector	SCC beginning with
Industrial Processes	Cement Production	305006
		305007
	Chemicals	301
	Glass Production	305014
	Metal Production	303
		304
	Oil & Gas Production	2310
		310
	Other Mineral Products	305001
		305002
		305003
		305004
		305005
		305008
		305009
		305010
		305011
		305012
		305013
		305015
		305016
		305017
		305018
		30502
		30503
		30504
		30505
		30509
		30510
		30515
		30588
		30590
		30599
	Pulp & Paper	307
	Refining	306
	Other	2301
		2306
		2399
		308
		309

Sector	Subsector	SCC beginning with
Onroad	Diesel/Buses	22024
	Diesel/HDV	220252
		220253
		22026
	Diesel/LDT1	220231
	Diesel/LDT2	220232
	Diesel/LDV	22022
	Diesel/MDT	220251
		220254
	E-85 Fueled	2205
	Gas/HDV	22014
		22015
		22016
	Gas/LDT1	220131
	Gas/LDT2	220132
	Gas/LDV	22012
	Gas/Motorcycle	22011
	Other	22034
Stationary Comm./Inst.	Coal	103001
		103002
	Dist. Oil	103005
	Natural Gas	103006
		103007
	Resid Oil	103004
	Wood	103009
	Other	103008
		10301
Stationary Industrial	Coal	102001
		102002
		102003
	Dist. Oil	102005
	Natural Gas	102006
		102007
	Pet. Coke	102008
	Resid. Oil	102004
	Wood	102009
	Other	10201
Waste Disposal	Incineration	2601
		501001
		501005

Sector	Subsector	SCC beginning with	Sector	Subsector	SCC beginning with	Sector	Subsector	SCC beginning with
	Landfill Gas	201008			312			502001
		203008			313			502005
	Large Bore Engines	202004			314			503001
	Natural Gas	201002			315			503005
		202002			316		**Open Burning**	2610
		203002			330		**Other**	2620
	Other	201003			360			501002
		201007			385			501004
		201009			390			501006
		20101			399			501007
		201900	**Nonroad**	**Aircraft**	22750			501900
		202003		**Marine Vessels**	22800			502002
		202005		**Nonroad Equip - Diesel**	22700			502006
		202007		**Nonroad Equip - Gas**	22600			502900
		202009			22650			503002
		20201		**Nonroad Equip - Other**	22670			503006
		202800			22680			503007
		203003		**Pleasure Craft**	22820			503008
		203007		**Railroad Equipment**	22850			503825
		203009			285002			503900
		20301		**Other**	270003			504
		204002			273003	**Other**		2461023
		204003	**Space Heaters**	**Other**	105			288888
		204004						4 or 6

Figure 1: Annual 2011/2018 SO2 and NOX emissions (thousands tons) by RPO



SO_2 Analysis

SO_2 reductions are projected to occur in all four of the RPOs examined (Figure 1). Annually, SO_2 is projected to decrease by 51% in MANE-VU, 51% in SESARM, 61% in LADCO, and 18% in CENSARA. These are substantial reductions, but they are not enough to return the Class I areas to natural visibility conditions yet.

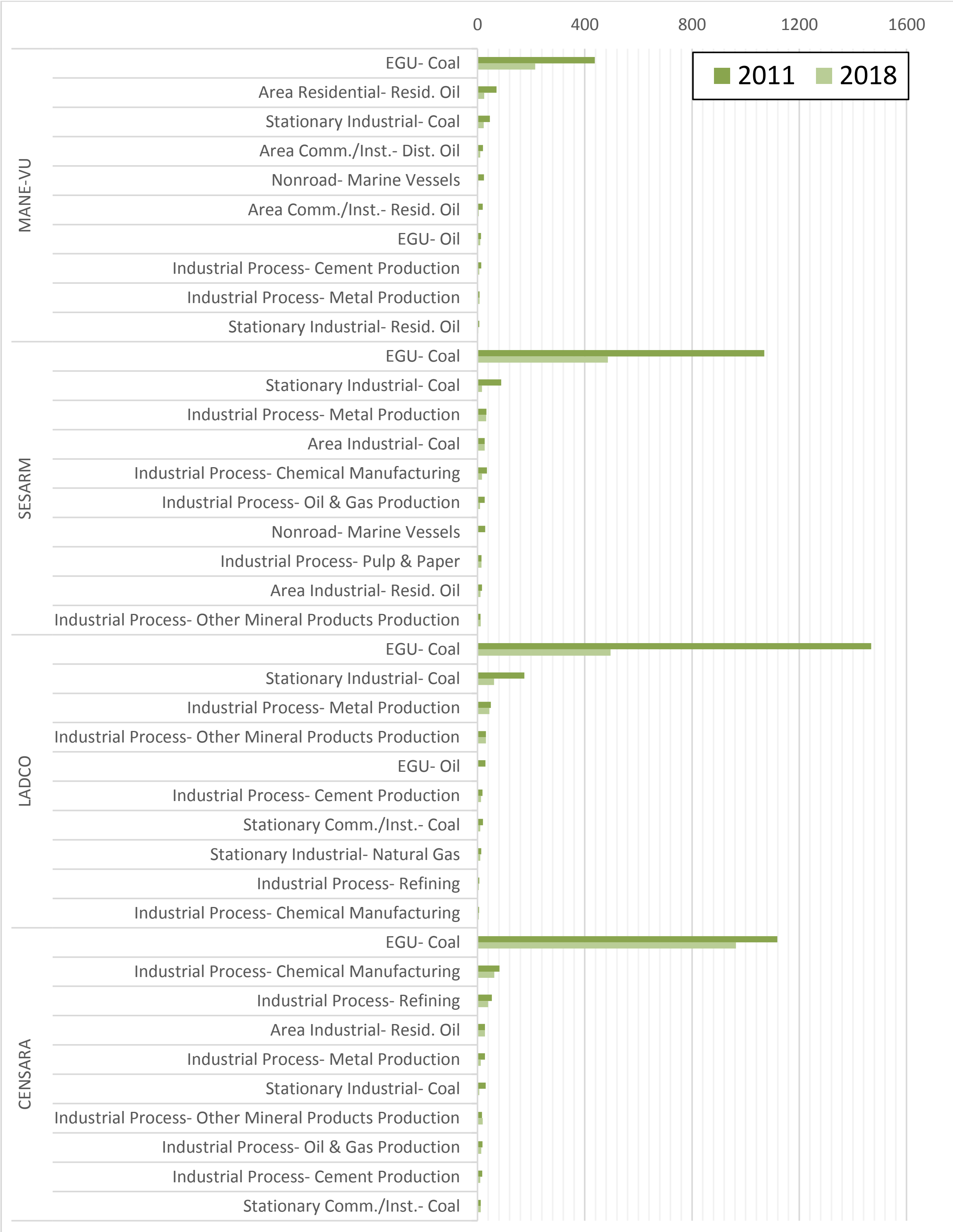
Table 2: Annual SO2 emissions by upper level category and RPO in 2011 and 2018

	MANE-VU		SESARM		LADCO		CENSARA	
	2011	2018	2011	2018	2011	2018	2011	2018
Agriculture	232.33	171.09	4,024.16	3,217.08	2,794.34	2,278.85	7,343.12	7,343.12
Area Comm./Inst.	41,883.65	16,120.21	7,997.42	6,394.31	3,769.14	3,672.57	367.89	367.88
Area Industrial	14,779.10	8,715.45	51,012.03	43,529.67	5,418.87	5,333.68	34,283.65	33,956.16
Area Residential	77,939.54	30,579.93	7,365.06	6,689.54	13,764.88	14,259.29	3,032.51	3,071.90
EGU	451,574.98	225,871.85	1,083,115.43	506,739.65	1,510,168.48	501,901.33	1,119,575.96	965,319.37
ICE	2,873.30	2,708.71	1,306.93	2,896.20	2,364.32	1,939.88	2,900.14	2,185.38
Industrial Process	37,386.68	31,785.80	110,879.32	90,803.45	115,918.66	101,723.86	150,157.26	111,363.89
Nonroad	27,525.51	6,110.23	33,239.93	4,707.97	8,435.52	3,142.67	25,288.54	4,811.39
Onroad	5,069.48	1,948.30	6,040.19	2,546.71	5,474.86	2,271.97	5,594.50	2,450.87
Space Heaters	91.23	83.25	78.50	77.97	7.62	6.19	6.39	6.09
Stationary Comm./Inst.	5,785.57	1,827.03	11,689.73	4,465.13	20,381.36	10,713.74	12,058.22	11,986.26
Stationary Industrial	57,749.62	27,527.16	115,421.65	26,318.99	196,868.92	75,131.49	56,458.54	24,194.37
Waste Disposal	5,020.48	4,896.39	2,797.33	2,718.22	5,223.60	5,006.14	865.56	874.77
Other	29.29	30.44	108.44	67.41	246.68	239.23	1,544.01	1,716.91
SO2 Total	**727,940.76**	**358,375.85**	**1,435,076.13**	**701,172.32**	**1,890,837.24**	**727,620.88**	**1,419,476.29**	**1,169,648.37**

Annually, across all four RPOs, EGU's made up the vast majority of the anthropogenic SO_2 inventory in the 2011 base year Table 2. Even in the 2018 future projected inventories, despite substantial reductions through a variety of Federal programs, EGU's are still the largest emitters of SO_2 in the nation. Area sources, nonroad, and other stationary sources produce SO_2 emissions at levels that warrant further scrutiny as well.

We then summarized emissions further and looked at the top 10 categories at the sector resolution (Figure 2). Coal-fired EGU's are the biggest emitter of SO_2 by far. Several other point source categories emit at a smaller magnitude, but are of noteworthy levels. Industrial boilers that run on coal or oil can produce high levels of emissions as can oil fired EGU's. Oil fired area sources, whether residential, commercial, or industrial as a category make up a significant emitter in some regions. Depending on the region, one or two industrial processes (e.g., cement manufacturing, glass manufacturing, chemicals manufacturing, oil and gas production) are high emitting sectors. The only mobile category to emit high levels of SO_2 is marine vessels.

Figure 2: Annual 2011/2018 SO2 emissions (thousands tons) by RPO and category, top 10 categories for 2011



NO_X Analysis

NO_X reductions are projected to occur in all four of the RPOs examined (**Error! Reference source not found.**). Annually, NO_X is projected to decrease by 30% in MANE-VU, 36% in SESARM, 37% in LADCO, and 29% in CENSARA. Though less percentage wise than SO_2 reductions over the same period, these are still substantial reductions.

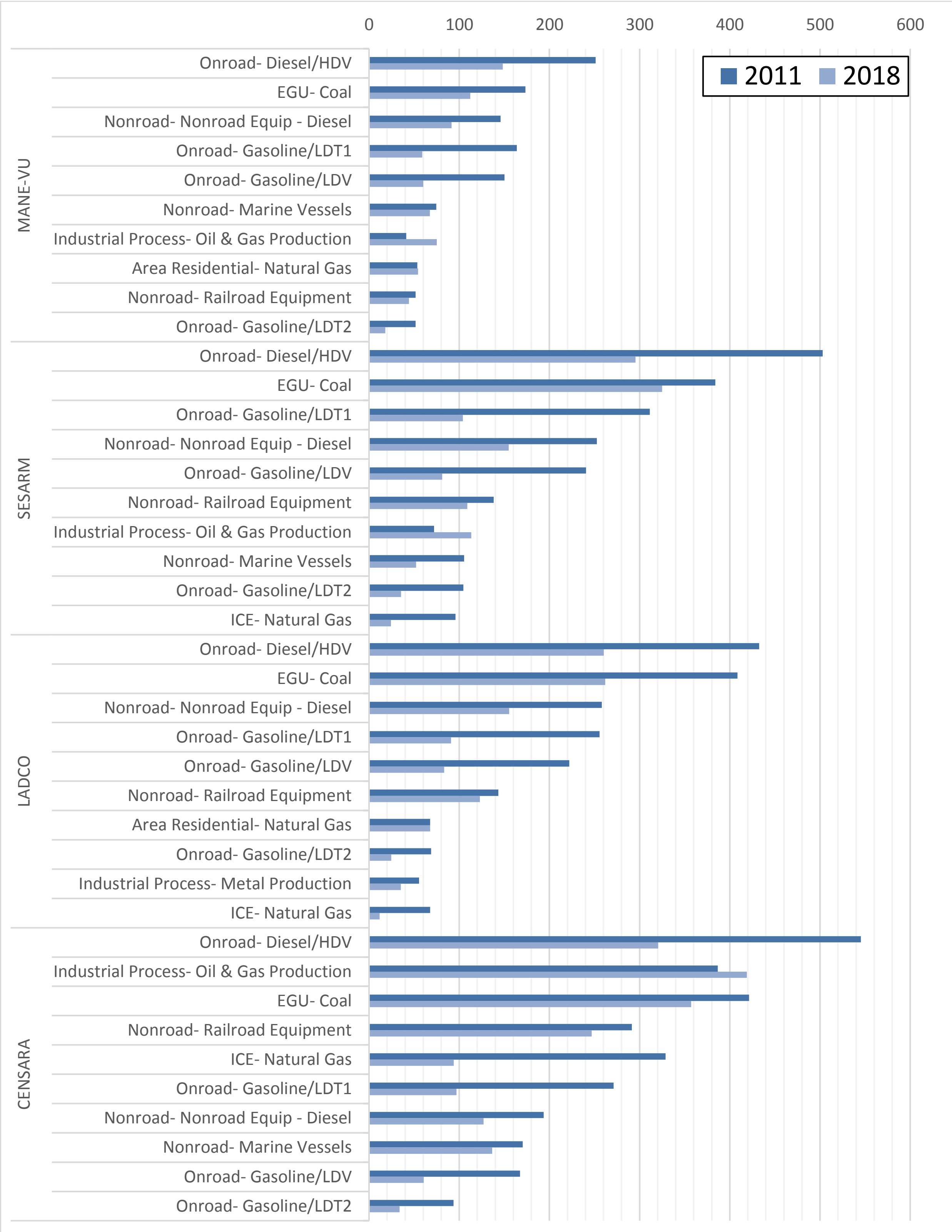
Annually in the four RPOs, onroad vehicles, nonroad vehicles, and EGUs play the largest role in the NO_X emissions inventory for both 2011 and 2018 Table 3. Onroad emissions are decreasing at a much higher rate than the other sectors, which puts nonroad and industrial processes on equal footing with onroad emissions in CENSARA in 2018.

Table 3: Annual NOX emissions by upper level category and RPO in 2011 and 2018

	MANE-VU		SESARM		LADCO		CENSARA	
	2011	2018	2011	2018	2011	2018	2011	2018
Agriculture	591.93	568.80	8,697.65	7,220.71	3,348.21	3,322.08	19,367.63	19,362.48
Area Comm./Inst.	68,116.28	67,369.67	19,598.15	17,271.55	48,720.57	48,386.55	18,696.73	18,519.33
Area Industrial	16,082.96	17,732.96	43,981.63	30,063.88	31,692.06	31,457.95	61,005.47	60,763.91
Area Residential	104,301.04	103,002.78	37,371.64	35,392.05	91,699.84	92,486.19	40,264.60	40,452.39
EGU	187,633.05	120,756.45	409,221.01	351,634.74	423,802.46	268,811.61	432,393.59	368,074.94
ICE	34,870.25	22,913.36	102,505.62	29,597.66	80,208.59	23,615.12	335,286.01	99,992.81
Industrial Process	99,925.45	130,154.05	181,807.80	223,460.16	156,713.49	131,340.72	512,196.12	541,454.54
Nonroad	368,092.20	282,103.43	614,266.09	412,904.89	521,911.17	373,721.73	707,065.55	554,820.28
Onroad	699,944.19	345,810.72	1,245,114.31	577,072.41	1,064,831.89	527,639.35	1,150,395.05	574,792.29
Space Heaters	418.88	441.94	511.70	504.18	920.89	917.63	290.42	275.30
Stationary Comm./Inst.	7,388.05	6,421.80	6,600.86	6,545.29	11,141.03	9,053.09	6,366.74	6,392.39
Stationary Industrial	31,282.47	25,172.63	95,701.85	82,414.42	76,172.49	63,844.03	66,616.20	67,096.80
Waste Disposal	28,698.95	27,753.08	22,538.13	21,601.65	16,576.93	14,827.24	8,710.97	8,265.79
Other	362.04	373.48	1,066.97	1,006.57	912.09	911.95	891.71	973.28
NOX Total	**1,647,707.75**	**1,150,575.17**	**2,788,983.43**	**1,796,690.16**	**2,528,651.70**	**1,590,335.22**	**3,359,546.81**	**2,361,236.54**

We then summarized emissions further and looked at the top 10 categories at the sector resolution (Figure 3). Heavy-duty diesel trucks are the highest emitting NOX sector in all of the RPOs. When different types of mobile sources are separated out, coal-fired EGUs become a more dominate category, in all RPOs, but the CENSARA region is the highest emitter of NOx. Onroad light duty gasoline-powered cars and trucks, nonroad diesel equipment, rail and marine vessels are sectors that appear in the top 10 for most if not all of the RPOs. Oil & gas production is also found throughout the RPOs as a high NOX emitter, as is residential natural gas heating. Oil & gas production is the only sector expected to increase in emissions from 2011 to 2018.

Figure 3: Annual 2011/2018 NOX emissions (thousands tons) by RPO and category, top 10 categories for 2011



Conclusions

Based on the quantity of emissions, this analysis indicates that the highest priority for analysis is SO_2 controls from coal fired power plants. This should be taken up in the four-factor analysis as well as in a review of the controls installed on the 167 stacks that were analyzed during the last planning period.

The second priority should be given to controls for

1. Residential combustion area sources (SO_2),
2. Industrial point combustion sources (SO_2),
3. Oil fired power plants (SO_2),
4. Marine engines (SO_2),
5. Coal fired power plants (NO_X),
6. Heavy duty diesel vehicles(NO_X), and
7. Nonroad diesel equipment (NO_X).

A third priority should be given to controls for

1. Oil & gas sector (SO_2 & NO_X),
2. Commercial ICI boilers (SO_2 & NO_X),
3. Residential wood combustion (SO_2),
4. Aircraft (NO_X), and
5. Locomotives (NO_X).

The workgroup recommends that these categories, in order by tier, should be the foci for obtaining updated cost information and conducting the four-factor analysis, as resources permit. Additionally, the workgroup recommends, as resources permit, compiling a list of available cost data sources in order to provide a contractor with some of the upfront research needed to update the EMF Cost tool, which would be beneficial to both save resources and allow greater consistency with other OTC and MANE-VU efforts.