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Investigative Emissions Inventory Research Report for FY 2014-2015

Prepared by the Capital Area Council of Governments

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Executive Summary

In addition to three specific emissions inventory improvement projects that the Capital Area Council of Governments (CAPCOG) completed under Task 2.1 of its 2014-2015 biennium near-nonattainment area grant, CAPCOG also conducted miscellaneous other emissions inventory-related work during this grant period. Since this work was not completed under a formal Quality Assurance Project Plan (QAPP), this type of emissions inventory work constitutes investigative research that can be used as the basis for developing future emissions inventory projects or otherwise improving the understanding of existing emissions inventory data and steering future research.

This memo describes analyses that CAPCOG conducted on existing emissions inventory data developed by EPA, TCEQ, or CAPCOG. Specific analyses included in this memo include:

1. A review of emissions inventory data used by the U.S. Environmental Protection Agency (EPA) in its recent photochemical modeling efforts (Section 1);
2. A review of the documentation for the modeling emissions inventory data used by the Texas Commission on Environmental Quality (TCEQ) in its recent photochemical modeling efforts (Section 2);
3. A review of several emissions inventory reports developed by ERG for TCEQ covering topics including fuel properties, locomotive emissions, aircraft emissions, and oil and gas heater and boiler emissions inventories (Section 3);
4. A comparison of new emissions inventory estimates for 2012-2018 to data used in prior CAPCOG photochemical modeling efforts, including on-road sources, non-road agricultural sources, and electric generating units (Section 4);
5. A review of the documentation of the energy content of fuels in the MOVES2014 model (Section 5);
6. An estimate of 2015 ozone season day NO_X emissions (Section 6); and
7. An analysis of the future NO_X emission reduction potential from accelerated mobile source fleet turnover incentives such as Texas Emission Reduction Plan (TERP) grants and Diesel Emission Reduction Act (DERA) grants.

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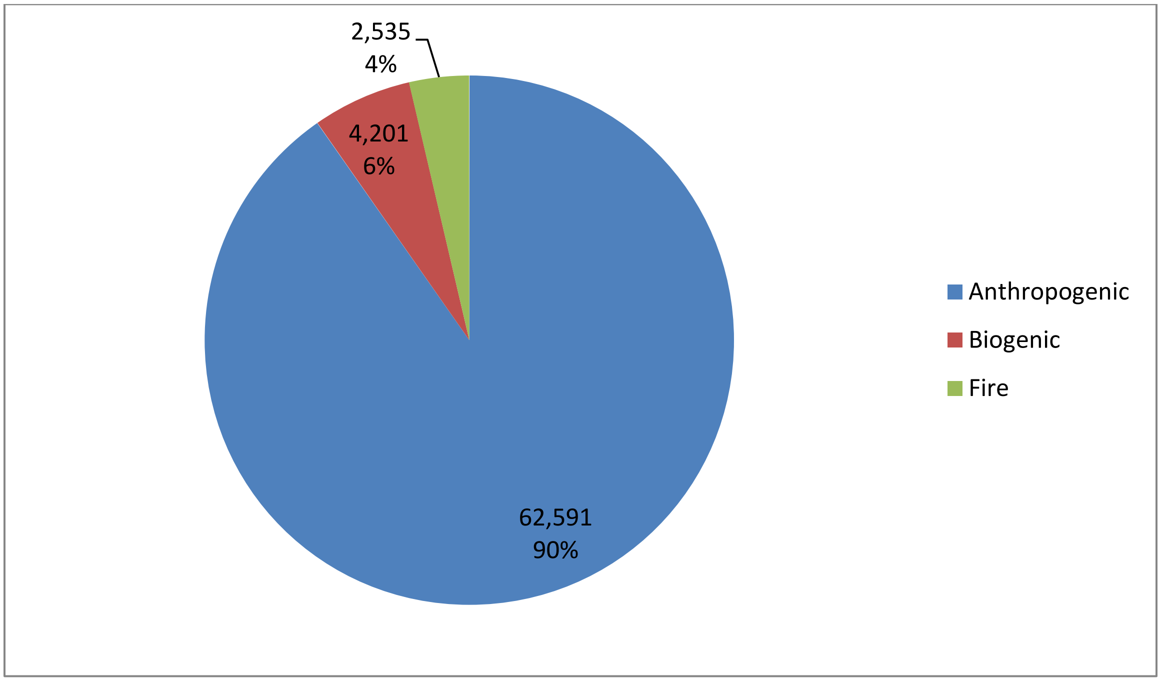
1 Review of EPA Emissions Data for 2011, 2017, and 2025

In 2015, EPA conducted nationwide, 12-kilometer (km) scale photochemical modeling using a 2011 ozone season base case and 2017 and 2025 future year projections. These modeling efforts were designed to support planning efforts related to interstate transport for the 2008 ozone National Ambient Air Quality Standard (NAAQS) (the 2017 analysis year) and support the final Regulatory Impact Analysis (RIA) for the 2015 ozone NAAQS (the 2025 analysis year). The emissions inventories used for these modeling efforts incorporated to version 6.2 of the 2011 Emissions Modeling Platform, documentation for which can be found on EPA's website.[1]

1.1 2011 Anthropogenic, Biogenic, and Fire Emissions Totals

The following charts show the relative shares of anthropogenic, biogenic, and fire emissions of NO_X and VOC across 11 Central Texas counties (Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Milam, Travis, and Williamson Counties) in 2011.[2] Milam County is included in this analysis, but is not a CAPCOG County. Since Milam County is adjacent to the MSA and is often located upwind of the Austin-Round Rock MSA on high ozone days, it has been included in this analysis to capture emissions information that could be important to understanding ozone formation in the MSA. Emissions are reported in tons per year (tpy).

Figure 1-1. 11-County Anthropogenic, Biogenic, and Wildfire NO_X Emissions, 2011 (tpy)



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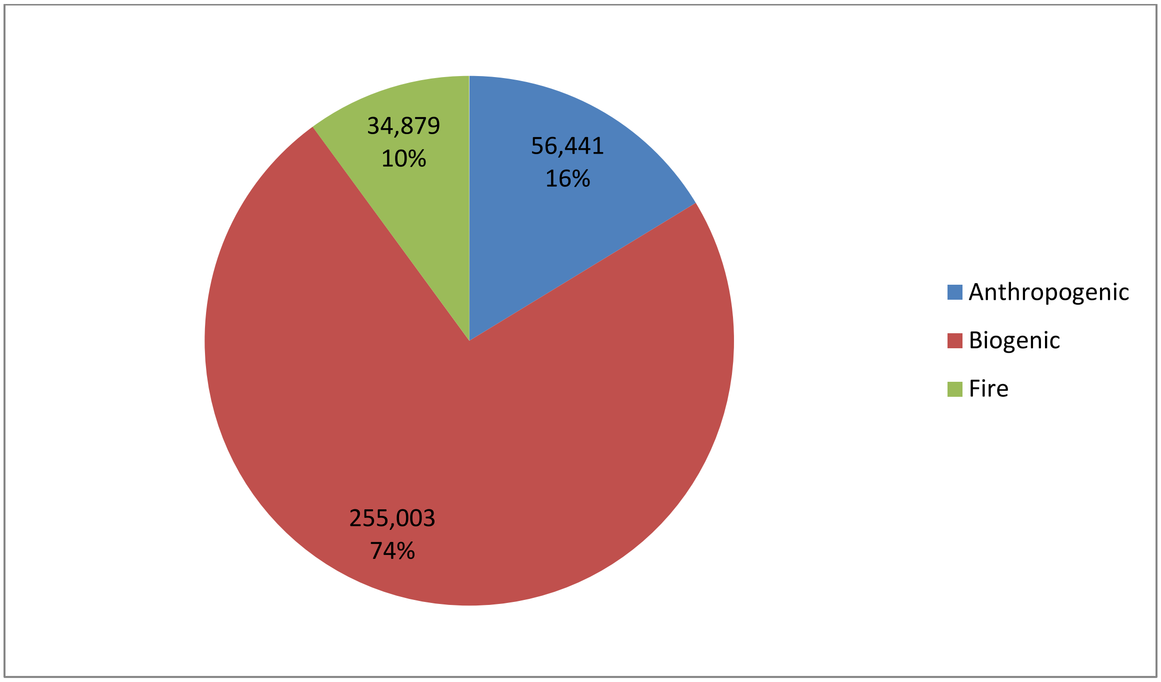
[1] http://www3.epa.gov/ttn/chief/emch/2011v6/2011v6_2_2017_2025_EmisMod_TSD_aug2015.pdf

[2] ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2011ed_2018ed_2011eh_2017eh_county_annual_totals.xlsx

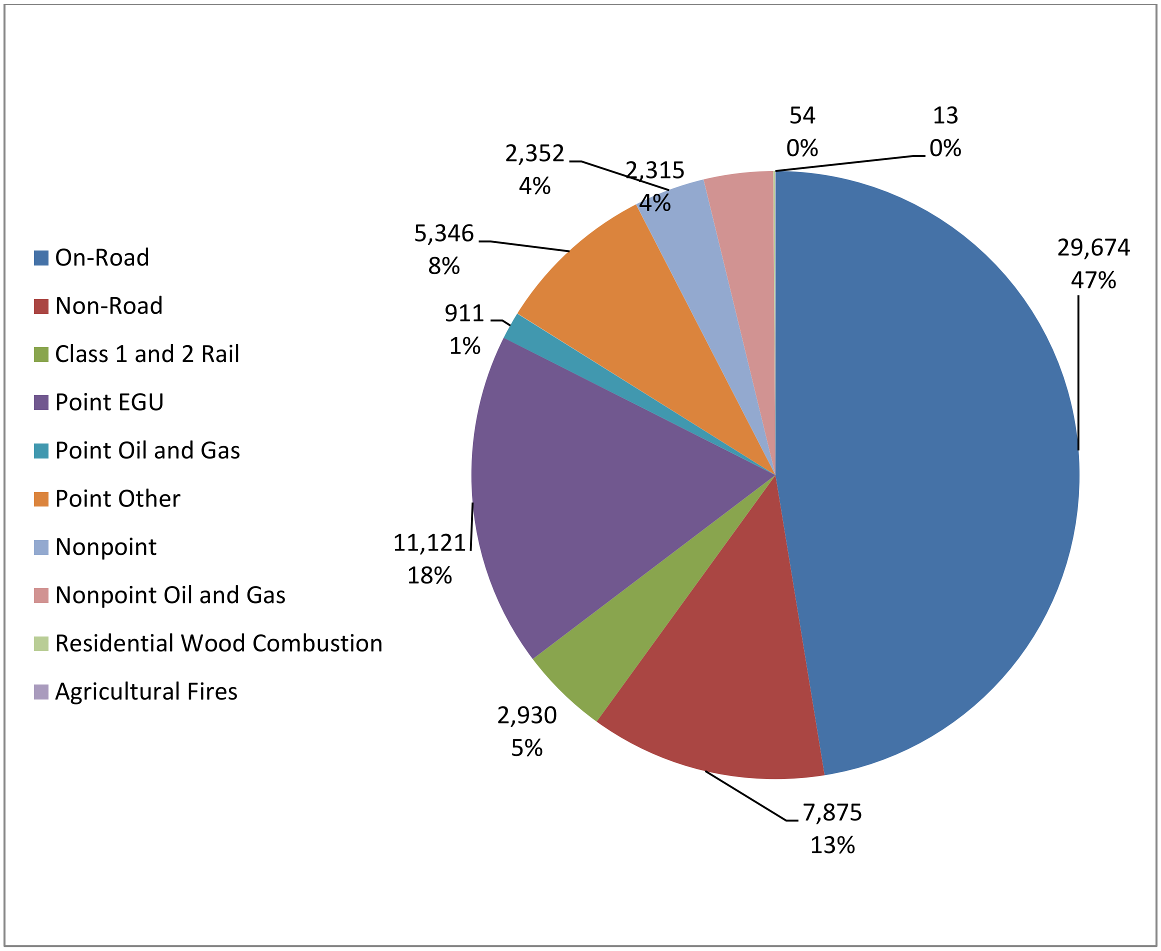
Figure 1-2. 11-County Anthropogenic, Biogenic, and Wildfire VOC Emissions, 2011 (tpy)



These data show that local NO_X emissions in 2011 were dominated by anthropogenic sources, but biogenic and fire emissions accounted for noticeable amounts of emissions. VOC emissions were dominated by biogenic sources, with anthropogenic emissions accounting for only 16%. The wildfire emissions also accounted for a sizable amount of VOC emissions when compared to anthropogenic sources – wildfire VOC emissions were equivalent to 62% of the total anthropogenic emissions in 2011. These data show that the wildfires that occurred within the region that year contributed sizable shares of the local emissions of both NO_X and VOC, and that anthropogenic VOC emissions reductions would do little to reduce overall VOC emissions within the region.

The following chart breaks downs of the anthropogenic NO_X and VOC emissions across the 11-county by 10 sectors that EPA provides county-level totals for in summary reports on its FTP site.

Figure 1-3. 11-County Anthropogenic NO_X Emissions by Source Type (tpy)[3]



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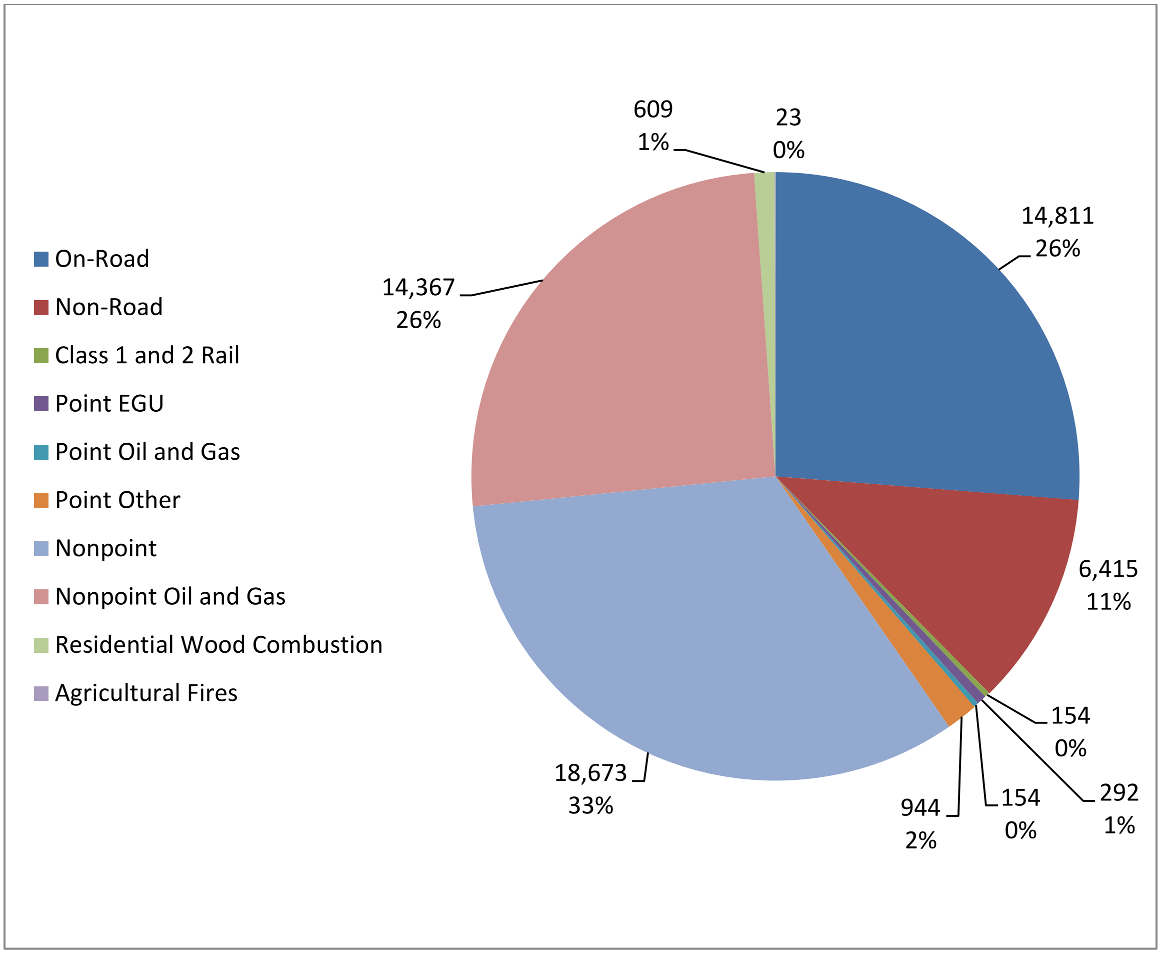
[3] ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2011eh%202025eh%20county%20sector%20comparison%20NOX.xlsx

Figure 1-4. 11-County Anthropogenic VOC Emissions by Source Type (tpy)[4]



1.2 County-Level Anthropogenic Emissions Trends 2011-2017-2025

CAPCOG tabulated the annual county-level anthropogenic NO_X and VOC emissions estimates from EPA's Emissions Modeling Clearinghouse FTP site for 2011, 2017, and 2025. The following tables show the total annual NO_X and VOC emissions for each year. CAPCOG tabulated subtotals for the five counties in the region that make up the Austin-Round Rock Metropolitan Statistical Area (MSA) – Bastrop, Caldwell, Hays, Travis, and Williamson Counties – as well as the six counties in the region outside of the MSA (referred to as "Non-MSA" counties).

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[4] ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2011eh%202025eh%20county%20sector%20comparison%20VOC.xlsx

Table 1-1. Anthropogenic NO_X Emissions 2011, 2017, and 2025 by County (tpy)[5]

County	2011 NO_X	2017 NO_X	2025 NO_X	Change 2011-2025	% Change 2011-2025	Change 2017-2025	% Change 2017-2025
Bastrop	3,325	2,153	1,513	-1,813	-55%	-640	-30%
Blanco	383	211	109	-274	-71%	-102	-48%
Burnet	1,160	697	464	-696	-60%	-232	-33%
Caldwell	2,550	2,134	1,772	-779	-31%	-362	-17%
Fayette	10,144	9,699	9,531	-613	-6%	-168	-2%
Hays	7,985	6,857	7,456	-529	-7%	599	9%
Lee	1,881	1,710	1,352	-530	-28%	-358	-21%
Llano	596	658	490	-106	-18%	-168	-26%
Milam	5,167	5,240	4,619	-548	-11%	-621	-12%
Travis	19,925	12,934	9,556	-10,368	-52%	-3,378	-26%
Williamson	9,443	6,331	4,190	-5,253	-56%	-2,141	-34%
MSA Subtotal	43,229	30,409	24,487	-18,742	-43%	-5,922	-19%
Non-MSA Subtotal	19,331	18,215	16,565	-2,766	-14%	-1,650	-9%
TOTAL	**62,560**	**48,624**	**41,052**	**-21,508**	**-34%**	**-7,572**	**-16%**

These data show a steep decrease in NO_X emissions within the MSA between 2011 and 2017 with additional reductions occurring at a somewhat slower pace between 2017 and 2025. Overall, 87% of the NO_X emission reductions that are expected between 2011 and 2025 across the 11 counties are projected to occur in the MSA. Within the MSA, there is a projected 30% reduction in NO_X emissions between 2011 and 2017 and an additional 14% reduction from 2011 levels between 2017 and 2025, meaning that the rate of annual emission reductions between 2017 and 2025 will be less than half the rate projected between 2011 and 2025. There is a 19% reduction in NO_X emissions between 2017 and 2025 within the MSA, which is relevant for understanding the ability of the region to fulfill the "reasonable further progress" requirements of Subpart 2, Part D, Title I of the Clean Air Act if the area was designated nonattainment for the 2015 ozone NAAQS and was classified as "Moderate" or higher.

While it is extremely unlikely that any of the counties in the MSA would be designated nonattainment, much less classified as "moderate" for the 2015 ozone NAAQS based on the area's own air quality measurements, it is possible that one or more counties could be designated

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[5] Data available at the following URL: ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/

nonattainment based on contributions to ozone levels in San Antonio, which is extremely likely to be designated nonattainment with a “Marginal” classification. Since it currently has an ozone design value of 78 ppb, there is a high degree of probability that it would not be able to attain the 2015 ozone NAAQS by the end of the 2019 ozone season and would therefore likely get “bumped up” to “moderate.” Since CAPCOG and our associated air quality committees have highlighted the issues with ozone implementation for years, these data help directly illustrate one of the main points that has been raised in prior comment letters to EPA on ozone implementation.

Table 1-2. Anthropogenic VOC Emissions 2011, 2017, and 2025 by County (tons)

County	2011 VOC	2017 VOC	2025 VOC	Change 2011-2025	% Change 2011-2025	Change 2017-2025	% Change 2017-2025
Bastrop	2,415	2,567	2,374	-41	-2%	-192	-7%
Blanco	496	404	346	-151	-30%	-59	-14%
Burnet	2,003	1,561	1,304	-699	-35%	-257	-16%
Caldwell	6,766	8,247	7,828	1,062	16%	-419	-5%
Fayette	4,485	6,496	6,409	1,924	43%	-87	-1%
Hays	3,831	3,157	2,911	-920	-24%	-246	-8%
Lee	3,563	5,552	5,532	1,969	55%	-20	0%
Llano	941	713	603	-339	-36%	-111	-16%
Milam	3,592	6,048	5,956	2,364	66%	-92	-2%
Travis	20,453	16,752	15,554	-4,898	-24%	-1,198	-7%
Williamson	7,896	7,057	6,729	-1,167	-15%	-329	-5%
MSA Subtotal	41,360	37,780	35,397	-5,964	-14%	-2,384	-6%
Non-MSA Subtotal	15,081	20,775	20,149	5,068	34%	-626	-3%
TOTAL	**56,441**	**58,555**	**55,545**	**-896**	**-2%**	**-3,010**	**-5%**

These data show increases in VOC emissions in some counties and decreases in others over this period. All counties show a decrease in VOC emissions between 2017 and 2025, however. For the five counties in the MSA, there would only be a 6% decrease in VOC emissions between 2017 and 2025, however. This is well short of VOC reductions that would be required of the area if it was designated nonattainment under a “Moderate” or higher classification for the “reasonable further progress” requirements of Subpart 2 of Part D, Title I of the Clean Air Act within six years of designations that are likely to occur in 2017. For a Moderate classification, the requirement would be a 15% reduction in 2017 VOC levels by 2023, while for a Serious classification, the requirement would be an additional 9% reduction in 2017 VOC levels and/or NO_X levels by 2026.

1.3 Trends in Emissions by Sector, 2011-2025

The tables below show the 11-county anthropogenic emissions totals for each major sector for 2011 and 2025. Subtotals for “mobile” include rail, non-road, and on-road sources, while subtotals for “stationary” include agricultural fires, non-point, non-point oil and gas, point oil and gas, point electric generating unit, point other, and residential wood combustion. All data presented below can be obtained from an emissions summary report from EPA’s FTP site for the 2011 emissions model.[6]

Table 1-3. 11-County NO_X Emissions by Sector 2011 and 2025 (tpy)

sector	2011 NO_X	2025 NO_X	Difference	% Difference
Agricultural Fires	13	13	0	0%
Rail	2,930	1,963	-967	-33%
Non-Point	2,352	3,555	1,203	51%
Non-Road	7,875	3,618	-4,257	-54%
Non-Point Oil and Gas	2,315	3,650	1,336	58%
On-Road	29,674	9,174	-20,501	-69%
Point Oil and Gas	911	988	77	9%
Point Electric Generating Unit	11,121	11,232	111	1%
Point Other	5,346	6,801	1,455	27%
Residential Wood Combustion	54	57	3	6%
Mobile Subtotal	40,493	14,768	-25,724	-64%
Stationary Subtotal	22,098	26,283	4,185	19%
TOTAL	**62,591**	**41,052**	**-21,539**	**-34%**

Table 1-4. 11-County VOC Emissions by Sector 2011 and 2025 (tons)

sector	2011 VOC	2025 VOC	Difference	% Difference
Agricultural Fires	23	23	0	0%
Rail	154	76	-78	-51%
Non-Point	18,673	19,319	646	3%
Non-Road	6,415	4,947	-1,468	-23%
Non-Point Oil and Gas	14,367	23,305	8,938	62%
On-Road	14,811	5,457	-9,354	-63%
Point Oil and Gas	154	253	100	65%
Point Electric Generating Unit	292	518	226	77%
Point Other	944	1,099	155	16%
Residential Wood Combustion	609	548	-61	-10%
Mobile Subtotal	21,380	10,479	-10,900	-51%
Stationary Subtotal	35,061	45,066	10,005	29%
TOTAL	**56,441**	**55,545**	**-896**	**-2%**

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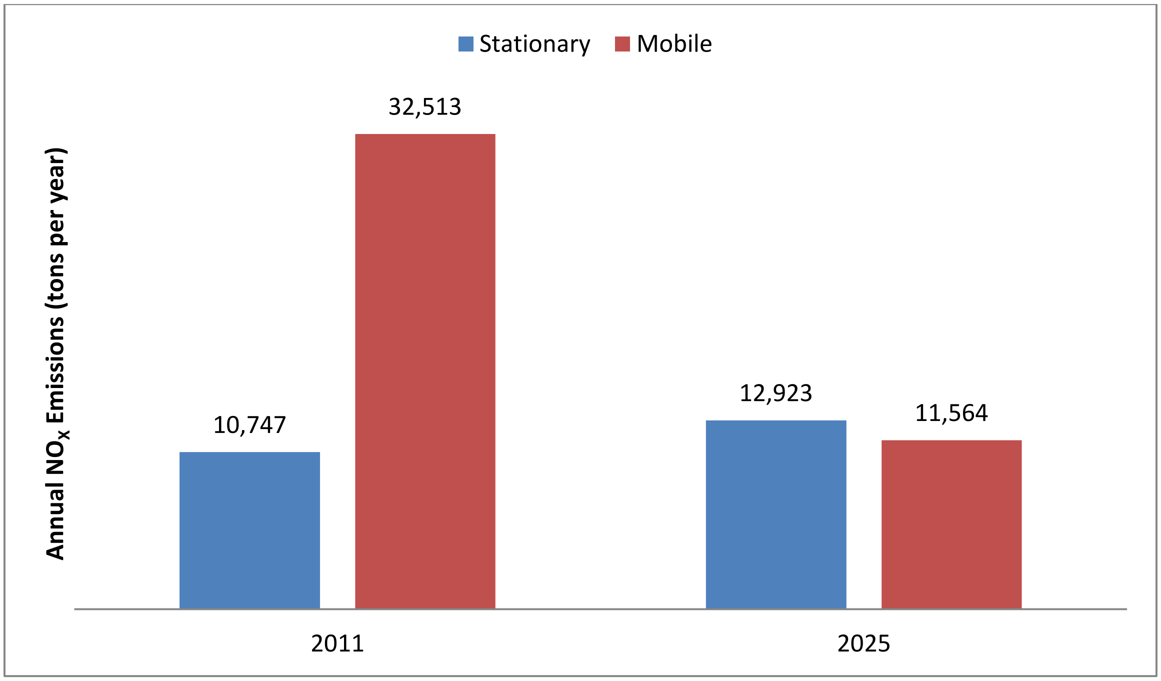
[6] ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2011eh%202025eh%20county%20sector%20comparison%20NOX.xlsx

As the tables above show, emission reductions that are projected to occur between 2011 and 2025 are concentrated among mobile sources for both NO_X and VOC. EPA's summary of county-level NO_X emissions by sector in 2011 and 2025 show that on-road NO_X reductions are expected to dominate the overall reduction in emissions, making up 80% of total NO_X reductions, followed by non-road at 17% and locomotives at 4%.[7] Stationary source NO_X emissions, including all point and non-point sources, are expected to increase over this time frame. This shift changes mobile sources' share of total NO_X emissions across the 11 counties from 65% in 2011 to 36% in 2025.

Within the MSA, these trends are projected to make stationary sources a majority of anthropogenic NO_X emissions by 2025, whereas it had only made up 25% of NO_X emissions in 2011. The figure below shows the overall trend in NO_X emissions from stationary sources (point EGU, point oil and gas, point other, nonpoint, nonpoint oil and gas, agricultural fires, residential wood combustion) and mobile sources (on-road, non-road, class 1 and 2 rail) over this period.

Figure 1-5. Trend in Regional Stationary Source and Mobile Source NO_X Emissions 2011-2025 (tpy)



In the non-MSA counties, the relative importance of mobile sources to total anthropogenic NO_X emissions declines by over half over this time frame. While local contributions to ozone formation have long been primarily driven by mobile sources, by 2025, the local contributions will be primarily from stationary sources.

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[7] ftp://ftp.epa.gov/EmisInventory/2011v6/v2platform/reports/2011eh%202025eh%20county%20sector%20comparison%20NOX.xlsx

Table 1-5. Trends in importance of mobile source emissions 2011-2025

Statistic	MSA Counties	Non-MSA Counties
Mobile Source Emissions, 2011 (tpy)	32,516	7,977
Mobile Source Emissions, 2025 (tpy)	11,567	3,201
Change, 2011-2025 (tpy)	-20,949	-4,775
% of Total Emissions, 2011	75%	41%
% of Total Emissions, 2025	47%	19%
% Change in Share of Emissions, 2011-2025	-37%	-53%

For VOC emissions, mobile sources make up a much smaller share of total anthropogenic emissions in 2011, so the decreases in emissions between 2011 and 2025 are nearly entirely negated by growth in emissions from stationary sources over this time frame. The vast majority of the growth in VOC emissions can be attributed to growth in the oil and gas sector.

1.4 2011 Wildfire Emissions

2011 was one of the worst years for wildfires across the country, and especially in Central Texas, where Bastrop County experienced one of the worst wildfires in the history of the state over the 2011 Labor Day weekend – the "Bastrop Complex Fire." EPA's recent source apportionment modeling of 2017 ozone levels included the 2011 fire emissions estimates, and showed that emissions from wildfires and prescribed burns across the continental United States contributed an average of 2.74 ppb to 8-hour ozone averages over 60 ppb at CAMS 3 and 2.35 ppb to 8-hour ozone averages over 60 ppb at CAMS 38.[8] Since this source apportionment analysis averages the impact of all fires in the continental U.S. across all days with 8-hour ozone averages at or above 60 ppb, so it is not possible to directly assess the extent to which the local wildfires impacted local peak eight-hour ozone levels that coincided with these fires. However, it is useful to understand the extent of the emissions from these fires, especially since the region experienced another major wildfire in 2015 and such events can be flagged as exceptional events. CAPCOG obtained the day-specific emissions EPA used as part of the 2011 modeling platform that were used in the 2017 and 2025 projections as well.[9]

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[8] http://www3.epa.gov/airtransport/pdfs/2017%20Ozone%20Contributions_Transport%20NODA.xlsx

[9] ftp://ftp.epa.gov/EmisInventory/2011v6/v1platform/reports/day_specific_emissions/county/ptfire_daily_2011ed_21jan2014.zip

Figure 1-6. Daily Wildfire NO_X Emissions in 11-County Area, 2011

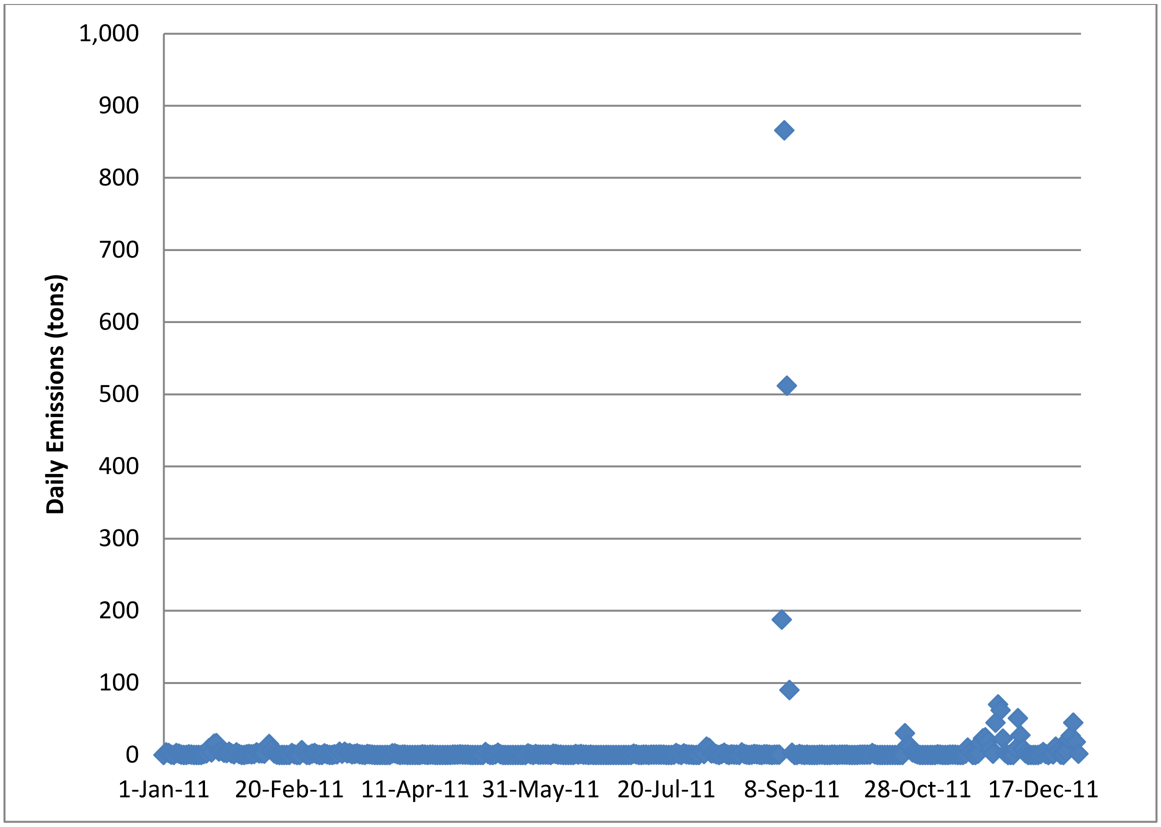
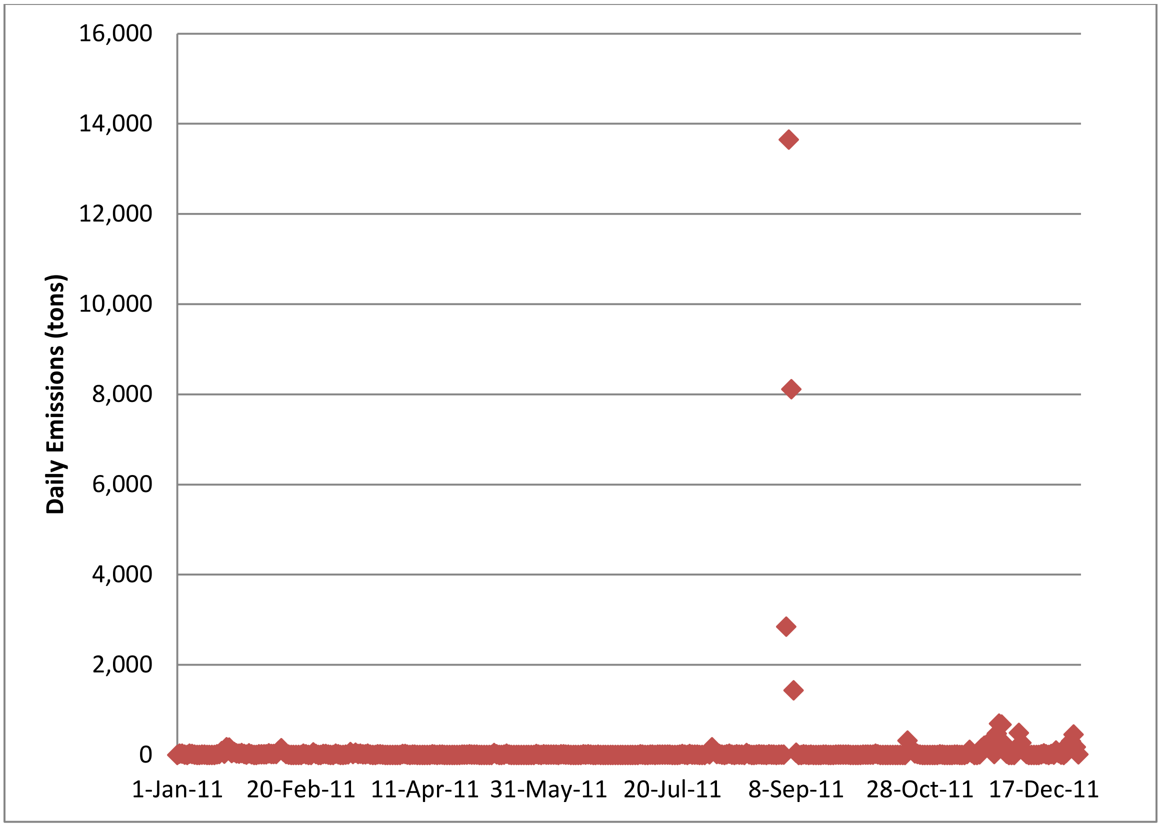


Figure 1-7. Daily Wildfire VOC Emissions in 11-County Area, 2011



As the figures above show, the wildfire emissions from the Bastrop Complex fire in September 2011 generated very significant emissions. The table below shows the sum of all wildfire NO_X and VOC emissions for each month across the 11-county area.

Table 1-6. Wildfire Emissions by Month for 11-County Area, 2011 (tons)

Month	NO_X	VOC
January	86	830
February	59	563
March	30	346
April	8	76
May	14	136
June	6	58
July	10	88
August	44	494
September	1,661	26,103
October	65	675
November	288	2,891
December	264	2,621
TOTAL	**2,535**	**34,881**

While obviously the emissions from fires in September are notable, the average daily emissions in months other than September was also significant enough to have a noticeable impact on ozone levels – 2.61 tons per day for NO_X and 26.20 tons per day for VOC.

1.5 Summary of Review of EPA Emissions Data for 2011, 2017, and 2025

Some of the key findings from CAPCOG's review of EPA's 2011, 2017, and 2025 emissions data are:

- Anthropogenic sources dominate local NO_X emissions, but biogenic and fire emissions contributed significantly to total NO_X emissions in 2011;
- Biogenic sources dominate local VOC emissions, but anthropogenic and fire emissions contributed significantly to total VOC emissions in 2011;
- Reductions in emissions from mobile sources will reduce overall anthropogenic NO_X and VOC levels between 2011 and 2025, but there are some significant increases in stationary source emissions over this period, which will cause local stationary source emissions to become a more significant factor in local ozone formation than local mobile sources by 2025; and
- Wildfire emissions can play an important role in local ozone formation.

2 Review of DFW Attainment Demonstration SIP Emissions Inventories

CAPCOG reviewed the recently proposed attainment demonstration SIP revision for the DFW 2008 ozone nonattainment area.[10] This SIP revision uses a 2006 base case, a 2006 baseline, and a 2017 future year. Understanding the basis for these emissions estimates provides an important reference point for other emissions inventory research that would seek to improve upon these estimates. The following table summarizes the basis for the various anthropogenic emissions inventories for each inventory type.[11]

Table 2-1. Summary of Basis for 2006 and 2017 Inventories Used in DFW Attainment Demonstration for 2008 Ozone NAAQS for Central Texas

Source Category	2006 base case	2006 baseline	2017 future baseline
Point, ARD units	Hourly NO_X emissions reported to AMPD[12], heat input emissions factors for other pollutants	Average NO_X emissions by hour June – September 2006, heat input emissions factors for other pollutants	Average NO_X emissions by hour June – September 2014, heat input emissions inputs for other pollutants
Point, Non-ARD units	2006 ozone season day emissions in TCEQ STARS database	2006 ozone season day emissions in TCEQ STARS database	2012 ozone season day emissions in TCEQ STARS database

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[10] https://www.tceq.texas.gov/airquality/sip/dfw/dfw-latest-ozone

[11] https://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/dfw_ad_sip_2016/DFW_SIP_Appendix_B_pro.pdf

[12] AMPD = Air Markets Program Data: http://ampd.epa.gov/ampd/

Source Category	2006 base case	2006 baseline	2017 future baseline
Area, Oil and Gas[13]	2006 Texas Railroad Commission Activity Data multiplied by ERG Emissions Factors	2006 Texas Railroad Commission Activity Data multiplied by ERG Emissions Factors	2014 Texas Railroad Commission Activity Data multiplied by ERG Emissions Factors[14] forecast to 2017[15]
Area, Other	2008 Periodic Emissions Inventory back-cast to 2006	2008 Periodic Emissions Inventory back-cast to 2006	2014 Periodic Emissions Inventory projected to 2017
On-Road	2006 Non-Link MOVES2014 school year and summer[16]	2006 Non-Link MOVES2014 school year and summer[17]	2017 Non-Link MOVES2014 school year and summer[18]
Non-Road, NONROAD model sources[19]	TexN v. 1.7.1 model run	TexN v. 1.7.1 model run	TexN v. 1.7.1 model run[20]
Non-Road, Locomotives[21]	ERG 2014 and 2008-2040 statewide inventory back-cast to 2006	ERG 2014 and 2008-2040 statewide inventory back-cast to 2006	ERG 2014 and 2008-2040 statewide inventory
Non-Road, Aircraft	2011 TexAER back-cast to 2006[22]	2011 TexAER back-cast to 2006[23]	ERG 2014 and 2008-2040 statewide inventory[24]

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[13] http://www.tceq.state.tx.us/assets/public/implementation/air/am/contracts/reports/ei/5820784003FY1026-20101124-ergi-oilGasEmissionsInventory.pdf

[14] Ibid.

[15] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821199776FY1212-20120831-erg-forecasting_oild_gas_activities.pdf

[16] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/mvs14_att_tex_06_12_18_technical_report_final_dec_2014.pdf

[17] Ibid.

[18] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/mvs14_att_tex_17_technical_report_final_aug_2015.pdf

[19] Not explicitly stated, but assumed given the file names and dates posted at: ftp://amdaftp.tceq.texas.gov/pub/Nonroad_EI/TEX/2017/

[20] Ibid.

[21] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155153802FY15-20150826-erg-locomotive_2014aerr_inventory_trends_2008to2040.pdf. Section 4.3 of Appendix B to the DFW SIP states *"The 2017 emission estimates from this study were used directly, while the 2006 emission estimates were backcast from 2008 based on changes in emission rates."*

[22] Proposed DFW Attainment Demonstration SIP Revision, Appendix B, page 86. https://www.tceq.texas.gov/assets/public/implementation/air/sip/dfw/dfw_ad_sip_2016/DFW_SIP_Appendix_B_pro.pdf.

[23] Ibid.

[24] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821551606FY1508-20150731-erg-%202014_AERR_Inventory_Aircraft.pdf.

Source Category	2006 base case	2006 baseline	2017 future baseline
Non-Road, Drill Rigs	ERG 2014 trends statewide inventory[25]	ERG 2014 and trends statewide inventory [26]	2014 activity levels estimated by ERG trends inventory, adjustments to emissions factors for 2017[27]

3 Review of TCEQ Research and Contract Projects

TCEQ's Research and Contract Projects provide information that forms the basis for many different emissions inventories developed by TCEQ and its contractors. Understanding these reports is important to understanding the basis for many of these inventories and identifying any opportunities for improvement or refinement. This section includes analyses of ERG's fuel study reports, the 2014 locomotive emissions inventory report, the 2014 aircraft emissions inventory report, and the oil and gas heaters and boilers emissions inventory report posted at https://www.tceq.texas.gov/airquality/airmod/project/pj.html.

3.1 Fuel Studies

ERG has periodically conducted fuel sampling studies for TCEQ. Typically, these have occurred during the summer in periodic emissions inventory (PEI) years. The data from these studies are used as the basis for fuel inputs for on-road and non-road emissions inventories. In the past, data collected within a Texas Department of Transportation (TxDOT) district was by TCEQ, TTI, CAPCOG, and others used as a direct fuel input property for all counties in that district. In more recent inventories, TCEQ has begun to average these data into larger geographic groupings. Inventories that use this approach include the 2014 inventories TCEQ is submitting to the EPA for the NEI and the 2006 inventories used for the most recent photochemical modeling for TCEQ's proposed attainment demonstration SIP for the DFW area, both of which were completed in recent months. Since many existing inventories rely on the older approach that involves assigning fuel properties by TxDOT region, it is useful to understand the basis for those fuel inputs and the potential implications of the data collected in those studies on regional emissions estimates.

ERG's approach involves calculating average fuel parameters for a TxDOT region based on weighted averages of properties from samples of regular-grade, medium-grade, and premium-grade gasoline collected within that region. Each fuel grade is weighted by the Energy Information Administration's (EIA's) estimated market share for each fuel grade.

3.1.1 Review of 2008, 2011, and 2014 Gasoline Sulfur Content Averages

ERG's fuel sampling data for the Austin district showed an average sulfur content higher than 40 ppm in 2008, 2011, and 2014. In 2011 and 2014, the Austin district had the highest average sulfur content, as

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[25] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821552832FY1505-20150731-erg-drilling_rig_2014_inventory.pdf

[26] Ibid.

[27] Ibid.

the table below shows. By way of comparison, TCEQ's recent 2014 emissions inventory for the NEI used a sulfur content input of 30.84 ppm. The table below shows a summary of the sulfur content data from these three sampling studies.

Table 3-1. Gasoline Sulfur Content Statistics from Summer Fuel Studies (ppm)

Year	Minimum	Average	Maximum	Austin
2008[28]	8.4	41.8	160.7	42.6
2011[29]	12.6	26.4	42.6	42.6
2014[30]	12.1	28.1	41.9	41.9

Under Federal Tier 2 gasoline sulfur standards, beginning in 2006, the average sulfur content at the refinery gate in each of these years was not allowed to exceed 30 ppm, and maximum sulfur content was not allowed to exceed 80 ppm.[31] There is a downstream cap of 95 ppm. Under the Federal Tier 3 gasoline sulfur standards, which will take effect on January 1, 2017, the refinery gate standard will be 10 ppm, with the same 80 ppm cap for the refinery gate and 95 ppm downstream cap as the Tier 2 standards.[32] The data above show that the average sulfur content for the Austin area was in compliance with the downstream cap, but was higher than the average for all areas of the state, and also higher than the refinery gate standard of 30 ppm.

3.1.2 Estimated Impact of Elevated Gasoline Sulfur Content on Vehicle Emissions

Standard emissions inventory procedures use regulated values when assessing future year fuel formulations. Previous inventories developed for the area that included future year projections prior to EPA's finalization of the Tier 3 standards used the 30 ppm refinery gate average as an emissions modeling input. Since the Tier 3 standards were adopted, projections by EPA for 2017 and beyond have used the refinery gate average of 10 ppm. However, in light of the consistency of the sulfur content in the Austin samples across these three studies and the 2011 and 2014 averages being over 10 ppm higher than the current refinery gate average standard of 30 ppm, it is not clear what impact the new Tier 3 fuel standards will have on local fuel properties once they take effect. And since the new Tier 3 vehicle standards rely on these lower-sulfur content levels, a downstream sulfur content that was higher in the Austin area compared to the refinery gate standard would be expected to reduce the expected impact from these new federal fuel and vehicle standards relative to current projections.

EPA's emissions modeling technical support document for the final Tier 3 vehicle and fuel standards would reduce on-road NO_X nationwide by 9% in 2018 and 25% in 2030.[33] Since light-duty gasoline-

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[28] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/summer_2008_fuels_final.pdf

[29] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/5821199776FY1103-20110831-ergi-summer_2011_fuels.pdf

[30] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/mob/5821199776FY1420-20140815-ergi-summer_2014_fuels.pdf

[31] http://www3.epa.gov/tier2/documents/f99051.pdf

[32] http://www3.epa.gov/otaq/documents/tier3/420f14009.pdf

[33] http://www3.epa.gov/otaq/documents/tier3/454r14003.pdf, see tables 5-2, 5-3, 5-4, and 5-5

powered vehicles only account for about half of these emissions, the relative impact of these standards on the affected vehicles should actually be significantly higher. Some portion of these emission reductions can be attributed to the lower sulfur content in the gasoline, while another portion of these reductions can be attributed to more stringent emissions standards available on new 2017 and 2018 model year vehicles that are able to achieve lower emission rates and meet more stringent emissions standards due to the lower sulfur content. The relative importance of these two factors is not immediately evident in EPA's emissions modeling documentation for the Tier 3 standards.

Even though the study is several years old now, and uses an older version of MOVES, TTI's MOVES sensitivity analysis can be used to obtain estimates of the potential emissions impact on Tier 2 and earlier vehicles of downstream sulfur content that is higher than the refinery gate average.[34] The study included data showing the impact of gasoline sulfur content on gasoline vehicle NO_X emissions in 2008 and 2030. While a more rigorous study or evaluation of the sensitivity of emissions estimates to changes in sulfur content would now need to rely on MOVES2014, TTI's analysis using MOVES2010 at least provides some indication of the scale of impact that sulfur properties had previously been estimated to have on NO_X emissions from gasoline-powered vehicles. Since the impacts of the Tier 3 standards won't occur until 2017, this analysis also should provide some idea of the total impact that the difference in sulfur content is currently having on emissions from gasoline vehicles. Since a MOVES2014 sensitivity analysis is not currently available, this TTI sensitivity analysis is the only secondary source of data that CAPCOG was able to identify that enabled these analyses.

Using the MOVES2010 sensitivity analysis, CAPCOG estimated the impact of the 2014 Austin average sulfur content of 41.9 ppm on Tier 2 and earlier gasoline vehicle NO_X emissions would be an increase of about 2% relative to the 30 ppm sulfur content standard, and an increase of over 3% on Tier 2 and earlier gasoline vehicle NO_X emissions in 2017 when the new 10 ppm sulfur content average will be in effect. This is based on the differences between the combined running and start NO_X emissions at the 10, 30, and 60 ppm sulfur content levels in 2008 and 2030. CAPCOG interpolated the emissions at a 41.9 ppm sulfur content using the 30 and 60 ppm estimates, and then interpolated the values at the 10, 30, and 41.9 ppm content levels in intermediate years. This analysis does not account for the fact that the shape of the emission reduction curve between these years is non-linear, and most of the emission reductions from on-road sources would be occurring during the earlier years within this timeframe. It is important to note that this also does not account for any new information on sulfur impacts on emissions of Tier 2 and earlier vehicles that has been incorporated into MOVES2014, and does not account for any added impacts from sulfur on Tier 3 pollution control systems in model year 2017 and beyond. However, this analysis does provide some indication of the current impact of elevated downstream sulfur content in the Austin area compared to the refinery gate on Tier 2 and earlier gasoline vehicle emissions.

The following table shows the comparison of the 10 ppm, 30 ppm, and 41.9 ppm levels for each year from 2008 – 2030.

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[34] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/MOVES/Sensitivity/

Table 3-2. Estimated Impact of 41.9 ppm Sulfur Content on Tier 2 and Earlier Gasoline Vehicle NO_X Emissions

Year	NO_X Emissions at 10 ppm (g)	NO_X Emissions at 30 ppm (g)	NO_X Emissions at 41.9 ppm (g)	% Difference 41.9 ppm – 30 ppm	% Difference 41.9 ppm – 10 ppm
2008	262,768	264,760	269,567	1.82%	2.59%
2009	253,842	255,812	260,579	1.86%	2.65%
2010	244,916	246,864	251,592	1.92%	2.73%
2011	235,991	237,916	242,605	1.97%	2.80%
2012	227,065	228,968	233,618	2.03%	2.89%
2013	218,140	220,020	224,631	2.10%	2.98%
2014	209,214	211,072	215,643	2.17%	3.07%
2015	200,288	202,124	206,656	2.24%	3.18%
2016	191,363	193,177	197,669	2.33%	3.30%
2017	182,437	184,229	188,682	2.42%	3.42%
2018	173,512	175,281	179,695	2.52%	3.56%
2019	164,586	166,333	170,707	2.63%	3.72%
2020	155,660	157,385	161,720	2.75%	3.89%
2021	146,735	148,437	152,733	2.89%	4.09%
2022	137,809	139,489	143,746	3.05%	4.31%
2023	128,884	130,541	134,759	3.23%	4.56%
2024	119,958	121,593	125,771	3.44%	4.85%
2025	111,032	112,645	116,784	3.67%	5.18%
2026	102,107	103,697	107,797	3.95%	5.57%
2027	93,181	94,749	98,810	4.29%	6.04%
2028	84,256	85,801	89,823	4.69%	6.61%
2029	75,330	76,853	80,835	5.18%	7.31%
2030	66,404	67,905	71,848	5.81%	8.20%

While the comparison between the 41.9 ppm level and the 30 ppm level is useful for understanding the impacts under the Tier 2 fuel standards, a more relevant comparison for 2017 and beyond would account for the scale of the difference between the 2014 average of 41.9 ppm to the refinery gate limit of 30 ppm. This can be calculated either using the absolute difference of 11.9 ppm (which would mean the downstream concentration would be 21.9 ppm) or a relative difference of 40% (which would mean the downstream concentration would be 14.0 ppm). The table below shows the calculated emissions impacts of those content levels relative to the 10 ppm refinery gate level for 2017-2030.

Table 3-3. Estimated Impact of 14.0 ppm and 21.9 ppm Sulfur Content Relative to 10 ppm on NO_X Emissions from Tier 2 and Earlier Gasoline Vehicle, 2017-2030

Year	%Increase at 14.0 ppm Level	% Increase at 21.9 ppm Level
2017	0.20%	0.58%
2018	0.20%	0.61%
2019	0.21%	0.63%
2020	0.22%	0.66%
2021	0.23%	0.69%
2022	0.24%	0.73%
2023	0.26%	0.76%
2024	0.27%	0.81%
2025	0.29%	0.86%
2026	0.31%	0.93%
2027	0.34%	1.00%
2028	0.37%	1.09%
2029	0.40%	1.20%
2030	0.45%	1.34%

These data show a noticeable impact from higher downstream sulfur content, with the impact of the higher downstream sulfur content on Tier 2 and earlier vehicles dropping significantly once the new 10 ppm standard becomes effective. However, this impact grows further out towards 2030. Since Tier 3 vehicles are expected to have pollution control systems that are more sensitive to increased sulfur content above 10 ppm, this impact would be expected to be more pronounced for overall gasoline vehicle emissions between 2017 and 2030.

3.1.3 Detailed Analysis of 2011 and 2014 Fuel Data

CAPCOG reviewed the detailed sampling data for the Austin area in 2011 and 2014 in order to better understand the basis for the higher-than average sulfur content for the Austin area indicated in ERG's reports. In each case, ERG used the EIA's 2009 market share data to weight the three grades as follows:

- Regular: 87.8%
- Medium: 6.5%
- Premium: 5.7%

For 2011, the details for the 15 samples collected at 5 locations in the Austin district (1 for each grade – regular, medium, and premium) are shown in the table below.

Table 3-4. 2011 Gasoline Samples Collected in the Austin Area

Sample IDs	980619-980621	980575-980577	980747-980749	980783-980785	980819-980821	Avg.
Project Sequence	56542, 56520, 56519	56538, 56537, 56536	56531, 53532, 56586	56586, 56587, 56593	56567, 56568, 56569	n/a
Location Name	Kwik Star	Kwik Chek 56	Courtesy Shell 2	Exxon RS 60500	Wag-a-bag 16	n/a
Address	3839 Airport Blvd.	105 State Highway 71 W	3906 S. Congress Ave	1625 E. Parmer Ln.	10990 W. Highway 29	n/a
City	Austin	Bastrop	Austin	Austin	Liberty Hill	n/a
Premium Sulfur Content (ppm)	36.6	36.0	34.9	33.4	37.8	35.74
Medium Sulfur Content (ppm)	37.7	39.1	37.7	35.4	39.4	37.86
Regular Sulfur Content (ppm)	40.9	42.2	38.3	54.2	41.4	43.4
Weighted Avg.	**40.4**	**41.6**	**38.1**	**51.8**	**41.1**	**42.6**

As the 2011 data show, the sulfur content was lower at the medium and premium grades compared to the regular grades. All samples had sulfur content above the 30 ppm refinery gate average required by federal standards, but were also well below the 95 ppm downstream cap.

The standard deviations for the three different grades for the 2011 sampling were as follows:

- Regular: 6.2 ppm (15.0% of average);
- Medium: 1.9 ppm (4.0% of average); and
- Premium: 1.7 ppm (4.4% of average).

The details for the 15 samples collected at 5 locations in the Austin district (1 for each grade – regular, medium, and premium) in 2014 are shown in the table below. The average in the far right column represents the average for all samples, but since the samples collected in Fredericksburg and Burnet may not be representative of fuel properties in the counties in the Austin-Round Rock MSA due to differences in fuel regulations, CAPCOG also calculated an average just for the samples collected in Austin. This did not have a large impact on the overall picture of the sulfur content, since the average of the three Austin samples was 42.5 ppm, while the average for all five samples was 41.9 ppm.

Table 3-5. 2014 Gasoline Samples Collected in the Austin Area

Sample IDs	1086072-1286074	1286084-1286086	1286077-1286079	1286068-1286070	1286081-1286082	Avg.
Project Sequence	57782, 57783, 57784	57840, 58741, 57842	57950, 57951, 57953	58114, 58115, 58116	58117, 58118, 58119	n/a
Location Name	7-Eleven	Jeks West	M&S Food Mart	Stripes 2432	Discover Food Mart 1	n/a
Address	1625 E. Parmer Lane	528 W. Main St.	5511 Cameron Rd.	2501 S. Water St.	7200 N. IH 35	n/a
City[35]	Austin	Fredericksburg	Austin	Burnet	Austin	n/a
Premium Sulfur Content (ppm)	30.0	31.2	29.2	30.1	30.2	30.1
Medium Sulfur Content (ppm)	40.3	35.3	39.3	37.0	37.8	37.9
Regular Sulfur Content (ppm)	44.7	42.1	44.8	41.9	41.1	42.9
Weighted Avg.	**43.6**	**41.0**	**43.6**	**40.9**	**40.3**	**41.9**

As the 2014 data show, the sulfur content was again lower at the medium and premium grades compared to the regular grades. Even though fuel in Fredericksburg and Burnet are subject to different fuel regulations than the samples collected in Austin, the sulfur content appears to be very consistent across all five samples collected in 2014, as well as the samples collected in 2011. The average for premium grade was below 30 ppm, but the averages for both medium and regular grades were well above 30 ppm refinery gate standard but below the 95 ppm downstream limit.

The standard deviations for the three different grades were as follows:

- Regular: 1.7 ppm (4.0% of average);
- Medium: 2.0 ppm (5.2% of average); and
- Premium: 0.7 ppm (2.4% of average).

3.1.4 Review of EIA Data on Refiner Gasoline Market Share

The EIA provides annual data on refiner motor gasoline sales volumes by grade beyond 2009 that could be used for weighing the fuel samples.[36] The table below shows the market share by year. Data is

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[35] Fredericksburg and Burnet are located in counties that have different regulations on fuel content than the counties in the Austin-Round Rock MSA.

available nationwide through 2014 and for Texas up through 2011[37]. Data after 2011 for Texas have been withheld to protect confidentiality. Given the differences between the U.S. market share data and the Texas market share data, it would not be appropriate to use the more recent U.S. data for Texas. However, in light of the availability of more recent data that is Texas-specific, CAPCOG recommends that the 2011 and 2014 sampling data be re-weighted using 2011 market share data prior to the next round of emissions inventory development.

Figure 3-1. Gasoline grade market share for the U.S. and Texas, 2008-2013

Geography	Grade	2009	2010	2011	2012	2013	2014
U.S.	Regular	84.7%	85.2%	85.9%	84.6%	84.4%	84.3%
U.S.	Midgrade	7.1%	6.8%	6.4%	6.5%	6.5%	6.3%
U.S.	Premium	8.2%	7.9%	7.8%	8.8%	9.2%	9.4%
Texas	Regular	87.8%	87.8%	88.1%	W	W	W
Texas	Midgrade	6.5%	6.4%	6.1%	W	W	W
Texas	Premium	5.8%	5.8%	5.8%	W	W	W

3.1.5 Review of Fuel Content Assumptions in Recent On-Road Emissions Inventories

The following table provides a summary of the sulfur input assumptions used in a number of on-road emissions inventories developed in recent years for the 2012, 2015, 2017, and 2018 analysis years. These projects included:

- MOVES 2010a Non-Link-Based Inventories for 2012 and 2018 developed by TTI for TCEQ;[38]
- MOVES 2010b Link-Based Inventories for 2015 developed by TTI for CAMPO;
- MOVES 2010b Link-Based Inventories for 2012 and 2018 by TTI for CAMPO;
- MOVES 2014 Non-Link-Based Inventories for 2012 and 2018 developed by TTI for TCEQ (December 2014);[39]
- MOVES 2014 Non-Link-Based Inventories for 2017 developed by TTI for TCEQ;[40]
- MOVES2014 Link-Based Inventories for 2012 and 2018 developed by ERG for CAPCOG;

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[36] http://www.eia.gov/dnav/pet/pet_cons_refmg_d_STX_VTR_mgalpd_a.htm

[37] "W" indicates that the data were withheld for confidentiality reasons

[38] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/mvs10a_july_2011/mvs10a_att_tex_06_08_12_18_technical_report_final.pdf

[39] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/mvs14_att_tex_06_12_18_technical_report_final_dec_2014.pdf

[40] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/reports/mvs14_att_tex_17_technical_report_final_aug_2015.pdf.

Table 3-6. Summary of Sulfur Content Inputs Used in Recent Austin-Area On-Road Emissions

Inventory Date	MOVES Version	Analysis Year	Activity Data	Sulfur Content Input (ppm)	Basis
Jul. 2011	MOVES 2010a	2012	Non-Link	22.91	Default
Jul. 2011	MOVES 2010a	2018	Non-Link	22.91	Default
Jan. 2013	MOVES 2010b	2015	Link	22.91	Default
Jun. 2013	MOVES 2010b	2012	Link	22.91	Default
Jun. 2013	MOVES 2010b	2018	Link	22.91	Default
Dec. 2014	MOVES 2014	2012	Non-Link	42.6	2011 Study
Dec. 2014	MOVES 2014	2018	Non-Link	10	Tier 3 Std.
Aug. 2015	MOVES 2014	2017	Non-Link	10	Tier 3 Std.
Nov. 2015	MOVES 2014	2012	Link	42.6	2011 Study
Nov. 2015	MOVES 2014	2018	Link	10	Tier 3 Std.

3.1.6 Summary of Fuel Study Analysis Findings

CAPCOG's analysis of the ERG fuel studies indicates the following:

- For reasons that are not clear at this point, Austin-area gasoline sulfur content in 2011 and 2014 was higher than the current refinery-gate annual average of 30 ppm and noticeably higher than the averages for other areas of the state, although still below the downstream cap of 95 ppm in effect during this periods;
- This difference in the Austin area's sulfur content relative to other areas of the state and the refinery gate average, if it persists, could cause future NO_X emissions from gasoline vehicles to be higher than current emissions projections for on-road sources, which currently assume downstream sulfur content at the refinery gate average of 10 ppm in 2017 and beyond;
- Newer data on market shares for different fuel grades is currently available than what was used for the 2011 and 2014 fuel studies, although U.S. data likely over-represents premium grade and under-represents regular grade market share in Texas.

3.2 2014 Locomotive Emissions Inventory

ERG recently completed an emissions inventory project for TCEQ that involved producing a 2014 locomotive emissions inventory for the 2014 National Emissions Inventory (NEI), and "trends" inventories for 2008-2040 to illustrate the relative change in emissions over this period using the same underlying assumptions that were used for the 2014 inventory.[41]

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[41] Perez, Heather. "2014 Texas Statewide Locomotive Emissions Inventory and 2008 through 2040 Trend Inventories." Prepared by ERG for Cody McLain, Texas Commission on Environmental Quality. Morrisville, North Carolina, August 26, 2015, TCEQ Contract No. 582-15-50416, Work Order No. 582-15-51538-02-FY2015-11. Available online at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/582155153802FY15-20150826-erg-locomotive_2014aerr_inventory_trends_2008to2040.pdf.

3.2.1 Summary of 2014 Locomotive Activity and Emissions

The following table shows the 2014 locomotive fuel consumption and NO_X and VOC emissions estimates for each county in the region.

Table 3-7. 2014 Locomotive Activity and Emissions Estimates by County

County	Fuel Consumption (gallons)	NOX Emissions (tpy)	VOC Emissions (tpy)
Bastrop	1,259,262	191.27	9.83
Blanco	0	0.00	0.00
Burnet	205,601	51.45	2.79
Caldwell	1,506,236	210.25	10.67
Fayette	2,573,487	359.32	18.23
Hays	1,389,846	194.20	9.86
Lee	1,443,601	206.38	10.51
Llano	103,587	25.92	1.41
Milam[42]	5,241,037	733.56	37.24
Travis	1,143,812	184.67	9.65
Williamson	1,547,992	227.74	11.77
MSA Subtotal	6,847,148	1,008.14	51.779
TOTAL	**16,414,461**	**2,384.76**	**121.95**

3.2.2 2008-2040 Statewide Emissions and Growth Factors

ERG's report also included estimates for 2008-2040. The following table shows the statewide emissions projections and growth factors.

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[42] As explained earlier, Milam County is not part of CAPCOG, but for several years has been included in CAPCOG's emissions analyses due to its proximity to the Austin-Round Rock MSA.

Table 3-8. Statewide NO_X and VOC Locomotive Emissions Estimates and Growth Factors 2008-2040

Year	NO_X (tpy)	NO_X factor (relative to 2014)	VOC (tpy)	VOC factor (relative to 2014)
2008	70,469.07	1.297	4,245.97	1.494
2009	56,676.31	1.043	3,386.32	1.192
2010	58,207.13	1.071	3,485.32	1.226
2011	58,224.50	1.071	3,419.87	1.203
2012	55,463.51	1.021	3,121.83	1.098
2013	54,748.85	1.007	2,951.30	1.038
2014	54,343.87	1.000	2,841.95	1.000
2015	52,348.24	0.963	2,690.75	0.947
2016	47,590.93	0.876	2,350.49	0.827
2017	46,755.16	0.860	2,231.42	0.785
2018	45,635.85	0.840	2,116.37	0.745
2019	44,263.02	0.814	2,015.26	0.709
2020	42,783.10	0.787	1,881.49	0.662
2021	41,358.91	0.761	1,817.59	0.640
2022	39,853.93	0.733	1,742.38	0.613
2023	38,239.93	0.704	1,667.19	0.587
2024	36,355.05	0.669	1,577.32	0.555
2025	34,539.68	0.636	1,483.59	0.522
2026	32,385.96	0.596	1,426.34	0.502
2027	30,866.62	0.568	1,339.70	0.471
2028	28,986.62	0.533	1,234.47	0.434
2029	27,373.94	0.504	1,184.29	0.417
2030	25,703.35	0.473	1,136.00	0.400
2031	23,868.24	0.439	1,033.63	0.364
2032	22,599.39	0.416	985.81	0.347
2033	21,125.72	0.389	926.41	0.326
2034	19,668.42	0.362	867.32	0.305
2035	18,349.05	0.338	817.35	0.288
2036	17,461.10	0.321	766.09	0.270
2037	16,306.43	0.300	749.12	0.264
2038	15,429.54	0.284	704.00	0.248
2039	14,497.73	0.267	697.09	0.245
2040	14,033.40	0.258	648.76	0.228

3.2.3 Comparison of Statewide Fuel Consumption Estimates to EIA Data

CAPCOG compared the statewide fuel consumption estimate in the ERG report to the quantity of fuel consumption reported for Texas in the Energy Information Administration's (EIA's) "Distillate Fuel Oil and Kerosene Sales by End Use."[43] The following table compares the EIA's estimates for distillate fuel oil

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[43] http://www.eia.gov/dnav/pet/pet_cons_821use_dcu_STX_a.htm

consumption by the railroad sector from 2008-2013 compared to ERG's estimates for statewide fuel consumption.

Table 3-9. Comparison of EIA to ERG Fuel Consumption Estimates 2008-2013

Year	ERG	EIA	EIA Compared to ERG
2008	389,415,283	495,604,000	127.27%
2009	320,563,151	429,026,000	133.84%
2010	344,250,122	467,128,000	135.69%
2011	360,298,630	498,006,000	138.22%
2012	354,986,546	483,096,000	136.09%
2013	361,342,800	504,823,000	139.71%

If the EIA data translated directly into fuel consumption, then this analysis would suggest that ERG's emissions estimates may be 25-40% lower than the EIA fuel sales data would indicate. However, an important difference between the two estimates is that the EIA data is based on sales of fuel, whereas the ERG estimate is based on use of fuel. Since Texas includes major rail hubs, it is possible that fuel sold in Texas that would be consumed in other states. Additional research for this source category in the future may be useful to accounting for this difference in fuel consumption estimates.

3.3 2014 Aircraft Emissions Inventory

ERG recently completed an emissions inventory project for TCEQ that involved producing a 2014 aircraft emissions inventory for the 2014 National Emissions Inventory (NEI), and "trends" inventories for 2008-2040 to illustrate the relative change in emissions over this period using the same underlying assumptions that were used for the 2014 inventory.[44]

3.3.1 2014 Emissions by County

The following table shows the total NO_X and VOC emissions from aircraft in 2014 for each county.

Table 3-10. Summary of 2014 Aircraft Emissions

TOTAL	NO_X (tpy)	VOC (tpy)
Bastrop	0.33	0.73
Blanco	0.03	0.06
Burnet	1.58	3.64
Caldwell	2.56	5.69
Fayette	0.39	0.86
Hays	0.03	0.07
Lee	0.17	0.37
Llano	0.78	1.63

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[44] Chang, Roger. "Aircraft Emissions Inventory for Texas Statewide 2014 AERR Inventory and 2008-2040 Trend Analysis Years." Prepared by ERG for Anusuya Iyer, Texas Commission on Environmental Quality. Morrisville, North Carolina, July 31, 2015, TCEQ Contract No. 582-15-50416, Work Order No. 582-15-51606-03-FY2015-08. Available online at: https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821551606FY1508-20150731-erg-%202014_AERR_Inventory_Aircraft.pdf.

TOTAL	NO_X (tpy)	VOC (tpy)
Milam	0.14	0.32
Travis	798.43	116.61
Williamson	6.83	14.69
MSA Subtotal	808.19	137.80
TOTAL	**811.27**	**144.66**

3.3.2 2008-2040 Statewide Emissions and Growth Factors

The following table shows the statewide aircraft NO_X and VOC emissions and growth factors calculated relative to 2014.

Table 3-11. Statewide NO_X and VOC Locomotive Emissions Estimates and Growth Factors 2008-2040

Year	NO_X (tpy)	NO_X factor (relative to 2014)	VOC (tpy)	VOC factor (relative to 2014)
2008	9,424.52	1.297	3,040.87	1.494
2009	8,565.95	1.043	2,841.18	1.192
2010	8,499.76	1.071	2,800.86	1.226
2011	8,583.58	1.071	2,826.72	1.203
2012	8,399.32	1.021	2,711.21	1.098
2013	8,562.10	1.007	2,742.27	1.038
2014	8,631.33	1.000	2,767.93	1.000
2015	8,829.20	0.963	2,822.08	0.947
2016	9,021.47	0.876	2,874.93	0.827
2017	9,220.07	0.860	2,928.89	0.785
2018	9,418.27	0.840	2,980.06	0.745
2019	9,612.44	0.814	3,030.51	0.709
2020	9,795.58	0.787	3,078.16	0.662
2021	9,957.74	0.761	3,120.52	0.640
2022	10,113.53	0.733	3,161.55	0.613
2023	10,267.90	0.704	3,202.55	0.587
2024	10,426.53	0.669	3,244.58	0.555
2025	10,582.78	0.636	3,286.32	0.522
2026	10,738.54	0.596	3,328.01	0.502
2027	10,890.00	0.568	3,368.98	0.471
2028	11,048.19	0.533	3,411.62	0.434
2029	11,217.88	0.504	3,456.91	0.417
2030	11,398.21	0.473	3,504.81	0.400
2031	11,588.45	0.439	3,554.50	0.364
2032	11,781.34	0.416	3,604.64	0.347
2033	11,973.44	0.389	3,654.72	0.326
2034	12,162.42	0.362	3,704.08	0.305
2035	12,352.37	0.338	3,753.82	0.288
2036	12,541.97	0.321	3,803.62	0.270
2037	12,727.47	0.300	3,852.55	0.264
2038	12,910.65	0.284	3,900.96	0.248

Year	NO_X (tpy)	NO_X factor (relative to 2014)	VOC (tpy)	VOC factor (relative to 2014)
2039	13,090.72	0.267	3,948.60	0.245
2040	13,270.09	0.258	3,996.19	0.228

3.4 Oil and Gas Heaters and Boilers

3.4.1 Review of 2013 ERG Report on Oil and Gas Heaters and Boilers

CAPCOG reviewed ERG's report on upstream oil and gas heaters and boilers in August 2013. August 2013.[45] This report was released too late for CAPCOG to change its emissions estimates developed for the modeling AACOG conducted in 2013.

Table 3-12. Oil and Gas Heater-Boiler Profiles by County

County	Region	Heaters Per Well	Heater Size (MMBtu/hr)	Operation (hrs/yr)	Heat Content (Btu/scf)
Bastrop	Western Gulf	0.20	1.897	6,935	1,102
Blanco	Arch Bend-Fort Worth Basin/Barnett Shale	0.15	0.500	1,414	1,040
Burnet	Arch Bend-Fort Worth Basin/Barnett Shale	0.15	0.500	1,414	1,040
Caldwell	Western Gulf	0.20	1.897	6,935	1,102
Fayette	Eagle Ford Shale	0.54	0.906	7,574	1,289
Hays	Western Gulf	0.20	1.897	6,935	1,102
Lee	Eagle Ford Shale	0.54	0.906	7,574	1,289
Llano	Arch Bend-Fort Worth Basin/Barnett Shale	0.15	0.500	1,414	1,040
Milam	Eagle Ford Shale	0.54	0.906	7,574	1,289
Travis	Western Gulf	0.20	1.897	6,935	1,102
Williamson	Western Gulf	0.20	1.897	6,935	1,102

3.4.2 2015 Well Counts

CAPCOG reviewed the Texas Railroad Commission's oil well counts[46] and gas well counts[47] for September 2015. The following table shows the number of regular producing wells in each county.

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[45] https://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821199776FY1317-20130831-erg-upstream_oil_gas_heaters_boilers.pdf

[46] http://www.rrc.state.tx.us/media/30161/oilwellct_092015.pdf

[47] http://www.rrc.state.tx.us/media/30160/gaswellct_092015.pdf

Table 3-13. Oil and Gas Well Counts by County, September 2015

County	Oil Wells	Gas Wells
Bastrop	228	70
Blanco	0	0
Burnet	0	0
Caldwell	2,843	6
Fayette	621	218
Hays	0	0
Lee	781	68
Llano	0	0
Milam	1,851	10
Travis	22	0
Williamson	47	0
TOTAL	**6,393**	**372**

3.4.3 Estimate of 2015 Emissions from Oil and Gas Heaters and Boilers

CAPCOG applied the heater and boiler profiles developed by ERG to the September 2015 well counts in order to estimate the NO_X emissions from this source category for 2015.

Table 3-14. Estimated Number of Heaters, Fuel Consumption, and NOX Emissions from Oil and Gas Heaters

County	Heaters	MMCF per year	NOX per year (tons)	NOX per day (tpd)
Bastrop	60	712	21	0.06
Blanco	0	0	0	0.00
Burnet	0	0	0	0.00
Caldwell	570	6,802	198	0.54
Fayette	453	2,412	70	0.19
Hays	0	0	0	0.00
Lee	458	2,441	71	0.19
Llano	0	0	0	0.00
Milam	1,005	5,350	156	0.43
Travis	4	53	2	0.00
Williamson	9	112	3	0.01
TOTAL	**2,560**	**17,881**	**520**	**1.43**

4 Comparison of Recent 2012-2018 Emissions Inventories

4.1 On-Road

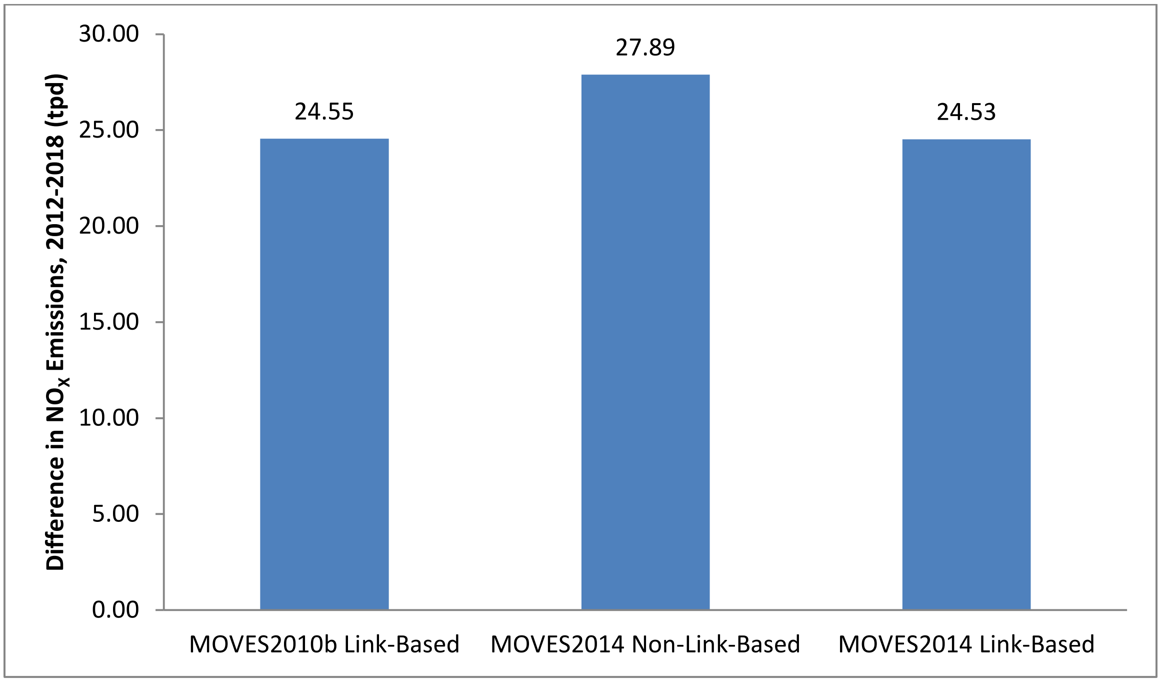
There have been a number of on-road emissions inventories created for the counties in the Austin-Round Rock MSA in recent years, and CAPCOG determined that it was useful to provide side-by-side comparisons of these estimates, which were generated using different versions of MOVES and different types of activity inputs, including vehicle miles traveled (VMT), vehicle speeds, starts, age distributions, fuel inputs, meteorological inputs, and idling hours. CAPCOG reviewed the summer weekday NOX emissions estimates from these inventories in order to review how these estimates have changed over time and enable assessments of the range of estimates that should be expected from using different models and activity inputs for such inventories. These inventories include data generated using MOVES2010a, MOVES2010b, and MOVES2014 using both link and non-link-based activity data. The table below shows summer weekday emissions for the MSA from each emissions inventory.

Table 4-1. Comparison of On-Road Summer Weekday NO_X Emissions Estimates 2012-2018

Inventory Date	MOVES Version	Analysis Year	Activity Data	Mon. – Thu. (tpd)	Fri. (tpd)	Avg. Weekday (tpd)
Jul. 2011	MOVES 2010a	2012	Non-Link	46.85	48.91	47.26
Jun. 2013	MOVES 2010b	2012	Link	55.27	58.17	55.85
Dec. 2014	MOVES 2014	2012	Non-Link	53.50	56.60	54.12
Nov. 2015	MOVES 2014	2012	Link	51.64	54.19	52.15
Jan. 2013	MOVES 2010b	2015	Link	n/a	n/a	37.81
Aug. 2015	MOVES 2014	2017	Non-Link	29.17	30.67	29.47
Jul. 2011	MOVES 2010a	2018	Non-Link	25.90	27.06	26.13
Jun. 2013	MOVES 2010b	2018	Link	30.97	32.62	31.30
Dec. 2014	MOVES 2014	2018	Non-Link	25.96	27.33	26.23
Nov. 2015	MOVES 2014	2018	Link	27.43	28.40	27.62

The most important comparison for CAPCOG was the comparison of CAPCOG's latest link-based emissions inventories using MOVES2014 to the June 2013 MOVES2010b link-based inventories and the December 2014 MOVES2014 non-link-based inventories since existing photochemical modeling work completed for CAPCOG by AACOG has used these other two inventories. The following figure shows a comparison of the change in emissions between 2012 and 2018 estimated for each set of inventories. Interestingly, although the MOVES2010b Link-Based inventories and the MOVES2014 Link-Based inventories rely on different models and input data, the change in emissions is only 0.02 tons per day. The difference from the MOVES2014 Non-Link-Based inventories, which would now be considered the "default" inventories used for modeling, are more significant at 3.36 tons per day. The differences can attributed to multiple potential factors including differences in emissions models, VMT, speeds, age distribution, etc. However, since CAPCOG's purpose for this comparison is primarily to just to see how the emissions estimates differ, a more thorough analysis of the relative contribution of these factors to the differences in emissions estimates was beyond the scope of this report.

Figure 4-1. Estimated reduction in weekday Austin-Round Rock MSA NO_X emissions from on-road sources, 2012-2018



4.2 Agricultural Equipment Data

In 2013, CAPCOG developed projections for non-road agricultural equipment emissions that were incorporated into photochemical modeling that AACOG performed for CAPCOG later in the year. In 2015, CAPCOG completed updates to the 2012 and 2018 agricultural equipment emissions inventories. The report did not include a direct comparison of the data used in the 2013 modeling data, so CAPCOG prepared a comparison of the NO_X emissions estimates for this report.

Table 4-2. Comparison of 11-County Agricultural Equipment NO_X Emissions

Inventory	2012 (tpd)	2018 (tpd)	Difference (tpd)	% Difference
NONROAD2008	3.85	2.74	-1.11	-29%
TexN v. 1.7.1	9.94	5.38	-4.55	-46%
CAPCOG June 2013	11.38	7.63	-3.75	-33%
CAPCOG August 2015	8.60	6.30	-2.29	-27%

CAPCOG's 2015 estimates show significantly lower estimates for 2012 and 2018 than the previous estimate. However, the 2015 estimates also anticipate slower emission reductions over this time frame than the previous CAPCOG estimate. The default TexN estimates and both CAPCOG estimates are well above the estimates derived from default NONROAD2008 runs.

4.3 Electric Generating Units

Emissions data for EGUs are reported quarterly to the EPA's Clean Air Markets Database (CAMD). Although the annual emissions inventory reports for 2014 that owners of EGUs submitted to the TCEQ in March 2015 have not been released by TCEQ yet, the data that forms the basis for the vast majority of the NO_X emissions from EGU – data collected by continuous emissions monitoring system (CEMS) – is available for all of 2014 and for 2015 up through September. CAPCOG analyzed the 2015 ozone season

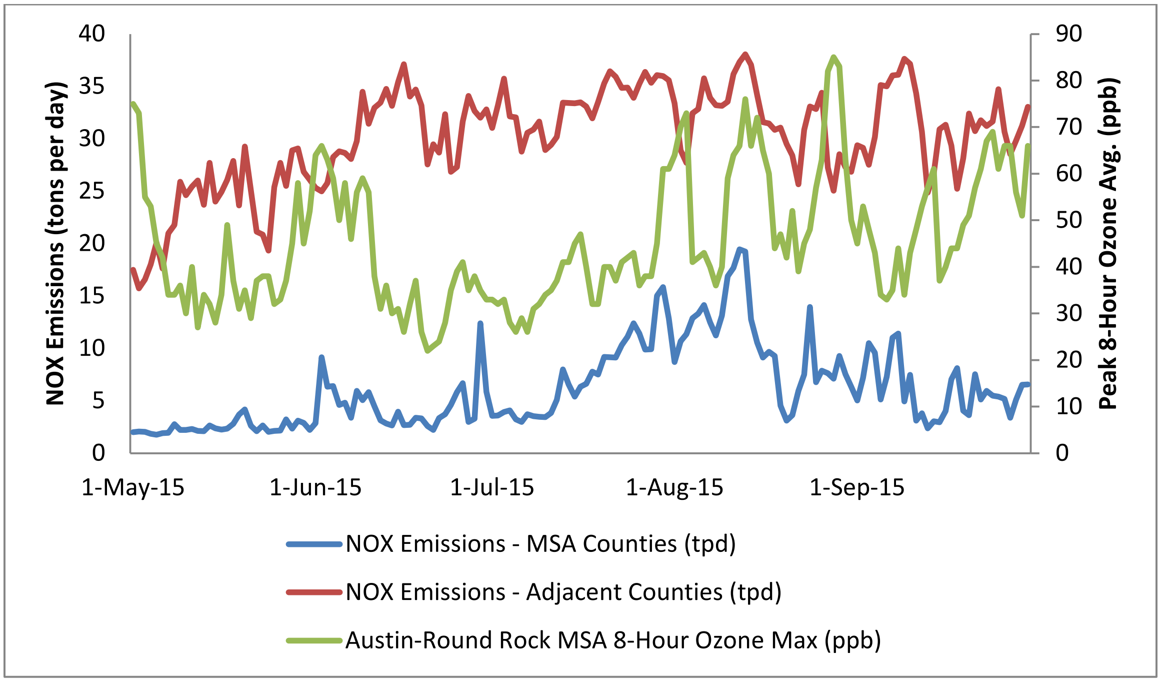
(May – September) data since it is the most recent and relevant to this report. Since the EGU emissions used in the 2013 photochemical modeling for the region were from 2012, a comparison of 2012 emissions to the emissions in 2013, 2014, and 2015 is useful.

CAPCOG reviewed both the emissions from plants within the MSA and plants in adjacent counties, including Bell, Guadalupe, Fayette, Llano, and Milam Counties. While Llano County is technically not adjacent to the MSA, it is located right at the Llano-Burnet County line, and Burnet County is adjacent to the MSA. CAPCOG adjusted the NO_X emissions estimates for the Decker Creek Power Plant's eight gas turbines to reflect the relative difference between the 2013 annual emissions inventory provided by Austin Energy and the 2013 CAMD data, which is 4-5 times higher due to the use of default emission rates as a result of reporting rules. The 2013 emissions data provided by Austin Energy reflects the results of stack tests that were conducted in the late 1980s, which are the last stack test data available. The following figure and tables reflect these adjustments.

4.3.1 Detailed Analysis of 2015 Data

The following figure shows the daily NO_X emissions estimates for counties within the MSA and in the adjacent counties, as well as the peak 8-hour ozone averages measured within the Austin-Round Rock MSA.

Figure 4-2. EGU NO_X Emissions and Peak 8-Hour Ozone Levels in the Austin-Round Rock MSA and Adjacent Counties



The following table shows the average ozone season NO_X emissions, heat input, electricity output, and emissions rates for each facility.

Table 4-3: Summary CAMD Data for May 1, 2015 - September 30, 2015

Facility Name	County	Avg. Daily NO_X Emissions (tpd)	Avg. Daily Heat Input (MMBTU)	Avg. Daily Output (MWh)	Heat Input NO_X Rate (lbs/MMBtu)	Output NO_X Rate (lbs/MWh)
Bastrop Clean Energy Center	Bastrop	1.13	74,973	10,612	0.030	0.212
Decker Creek	Travis	2.03	35,683	3,254	0.114	1.248
Guadalupe Generating Station	Guadalupe	1.97	125,925	16,023	0.031	0.246
Hays Energy Facility	Hays	0.70	113,655	15,801	0.012	0.089
Lost Pines 1	Bastrop	0.59	63,125	5,569	0.019	0.211
Panda Temple Power Station	Bell	0.58	173,614	23,438	0.007	0.050
Rio Nogales Power Project, LP	Guadalupe	1.41	101,464	14,796	0.028	0.191
Sam Seymour	Fayette	18.19	349,277	33,205	0.104	1.096
Sand Hill Energy Center	Travis	0.37	55,287	7,070	0.014	0.106
Sandow	Milam	4.22	127,248	12,685	0.066	0.665
Sandow Station	Milam	3.60	107,348	11,936	0.067	0.603
Sim Gideon	Bastrop	1.34	16,294	1,526	0.165	1.761
T C Ferguson Power Plant	Llano	0.21	76,484	7,156	0.005	0.059
Winchester Power Park	Fayette	0.01	1,149	113	0.009	0.095
MSA Subtotal	n/a	6.16	359,017	43,833	0.034	0.281
Non-MSA		30.19	1,062,509	119,352	0.057	0.506
TOTAL	**n/a**	**36.35**	**1,421,526**	**163,185**	**0.051**	**0.445**

The Decker Creek power plant was again the largest source of NO_X emissions among EGUs located in the Austin-Round Rock MSA, followed by Sim Gideon. These older plants have significantly higher emissions rates than the other EGUs in the MSA, accounting for 55% of the NO_X emissions from EGU from within the MSA, but only 11% of the electricity generated from fossil fuel plants in the MSA between May 1 and September 30. These plants had combined average emissions rates of 0.130 lbs of NO_X per MMBtu of heat input and 1.412 lbs per MWh of electricity generated. These are about 25% higher than the emissions rate on a heat input basis and 29% higher on an output basis than the Fayette Power Project, which has the next-highest emissions rates after these two gas-fired plants.

On days when at least one monitor in the MSA measured an 8-hour ozone average over 70 ppb, average emissions from local EGU emissions within the MSA were 2.64 tpd higher than on days when peak 8-hour ozone averages were at or below 70 ppb, while average emissions from EGUs in adjacent counties were actually lower on days above 70 ppb than days at or below 70 ppb.

Table 4-4. Total EGU Emissions on High, Moderate, and Low Ozone Days (tons per day)

8-Hour Ozone	MSA EGUs	Adjacent County EGUs
>70 ppb	8.66	26.75
55-70 ppb	7.55	30.33
<55 ppb	5.54	30.39
<=70 ppb	6.02	30.38
Overall Avg.	**6.16**	**30.19**

CAPCOG also calculated the emissions from EGUs within the MSA on the days with the top four daily 8-hour ozone concentrations for 2015, as well as the top four daily emissions overall. These are shown in the tables below.

Table 4-5. MSA EGU Emissions on 4 Highest Ozone Days at CAMS 3 and CAMS 38 (tpd)

Ozone Rank	CAMS 3	CAMS 38
1st Highest	7.12	7.12
2nd Highest	9.26	7.64
3rd Highest	7.64	9.26
4th Highest	19.24	2.07
Avg.	**10.81**	**6.52**

Table 4-6. Top 4 Days for Combined EGU Emissions from MSA and Adjacent Counties (tpd)

Emissions Rank	MSA	Adjacent Counties	Combined
1st Highest	19.45	38.07	57.31
2nd Highest	19.24	37.63	56.76
3rd Highest	17.68	37.31	53.84
4th Highest	16.87	37.14	51.81

As these tables show, the same meteorological conditions that lead to high ozone levels can also make it more likely that these peaker plants will be used, causing an even higher level of NO_X emissions in the region and potentially higher ozone levels. In other words:

High temperatures => *High ozone levels,*

But also:

High temperatures => *Higher peaker plant emissions* => *Even higher ozone levels.*

As described in CAPCOG's point source emissions inventory refinement report in 2015, TCEQ's typical approach to modeling peaker plants in "baseline" and "future baseline" scenarios has not accounted for the relationship between a peaker plant's emissions and underlying daily and hourly variations in meteorology.[48] Existing photochemical modeling data that relied on average ozone season day emissions estimates showed that peak ozone levels had a sensitivity of about 0.17 ppb per tpd of NO_X at the Decker Creek Power Plant, and about 0.03-0.04 ppb per tpd of NO_X at the Sim Gideon Power Plant. The 2015 data again show that the potential exists for these plants to have a more significant contribution to peak ozone levels than what the modeled impact of their average ozone season day emissions estimates would indicate. A proper estimation of the NO_X sensitivity of local ozone formation should account for this relationship.

In general, what these data tend to indicate is that emissions from local EGUs within the MSA tended to be higher on days when ozone levels were higher. This observation is not intended to suggest that emissions from these plants are the only reasons that these ozone levels are higher. On some days, emissions from EGUs within the MSA could be more than double the average for high ozone days (>70 ppb). In fact, there were 26 days between May 1 and September 30 when total EGU emissions were over 10 tpd from within the MSA. On average, emissions from Decker and Sim Gideon make up 76% of the total emissions from EGUs within the region. On days when 8-hour ozone averages were above 70 ppb, these two plants accounted for 68% of total EGU emissions from within the MSA, accounting for basically all of the difference between average EGU emissions on low-ozone days and average EGU emissions on high-ozone days within the region.

Table 4-7. Total EGU Emissions on High, Moderate, and Low Ozone Days (tons per day)

8-Hour Ozone	Decker + Sim Gideon	Other EGUs in MSA
>70 ppb	5.86	2.80
55-70 ppb	4.62	2.93
<55 ppb	2.80	2.74
<=70 ppb	3.24	2.79
Overall Avg.	**3.37**	**2.79**

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[48] http://www.capcog.org/documents/airquality/reports/2015/Point_Source_Emissions_Inventory_Refinement.08-31-15.pdf

These data highlight the importance of these two “peaker” plants in terms of local EGU emissions. These data also further highlight the need to better account for the relationship between peaker plant emissions and meteorology in future modeling projects that CAPCOG undertakes.

4.3.2 Comparison of 2012-2015 EGU Emissions Data

CAPCOG compared the 2015 emissions data to the 2012, 2013, and 2014 data in order to understand any trends that might be discernable over this timeframe. Since 2012 emissions were used in the photochemical modeling that AACOG performed for CAPCOG in 2013, this was used as the initial year for this analysis. The following two figures show the average and maximum daily NO_X emissions from EGUs inside the MSA and from adjacent counties. Both the average and maximum emissions in 2015 were higher for both sets of areas in 2015 compared to all three of the previous years.

Figure 4-3. Average Daily NO_X Emissions from EGUs, May-September 2012-2015 (tons per day)

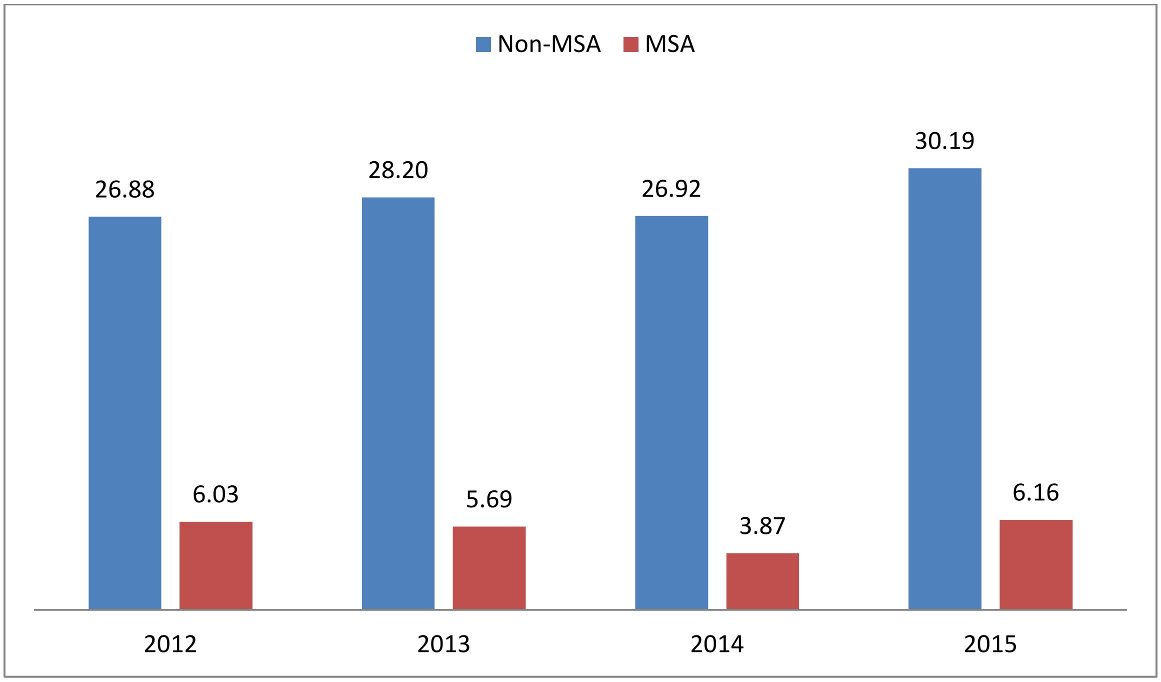
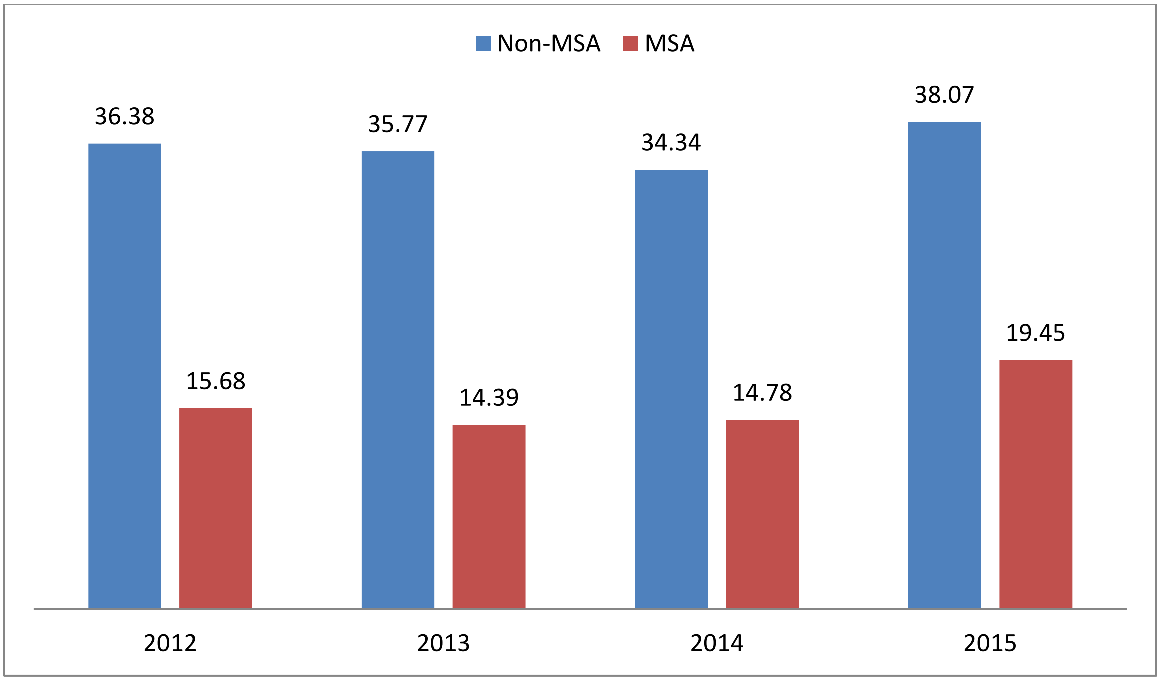


Figure 4-4. Maximum Daily NO_X Emissions from EGUs, May-September 2012-2015 (tons per day)



Whereas the maximum NO_X emissions from EGUs in adjacent counties was 26% higher than the average for May 1- September 30, 2015, the maximum NO_X emissions from EGUs within the MSA was more than 3 times the average. This highlights the risk that exists of very high-output days coinciding with conditions conducive to ozone formation, which may significantly increase the contribution of local power plants to high ozone levels when that occurs. Future photochemical modeling could evaluate the exact extent of this by using 2015 emissions data and using the “high ozone day” profile and “low ozone day” profile in order to assess the differences in these facilities’ impacts.

5 MOVES2014 Energy Consumption Documentation

CAPCOG reviewed EPA’s documentation of the energy consumption rates in MOVES2014 in EPA’s technical report *Greenhouse Gas and Energy Consumption Rates for On-Road Vehicles: Updates for MOVES2014*.[49] Since MOVES provides energy consumption as an output, it is possible to use this information to calculate aggregated county-level emissions rates for on-road sources in terms of mass of emissions per gallon of fuel consumed. CAPCOG often must contend with incomplete data that is not fully convertible into MOVES inputs. For example, several jurisdictions report total fuel consumption as part of their annual reporting, but may not keep track of certain information that would be needed for direct MOVES inputs. In the absence of the more detailed data that enable emissions modeling directly in MOVES, calculating general ratios of NO_X and VOC emissions per unit of fuel consumed enables general assessments of the emissions impact of our partner organizations’ fleet operations.

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[49] http://www3.epa.gov/otaq/models/moves/documents/420r15003.pdf

CAPCOG plans to use this information in conjunction with the energy consumption outputs from the recent link-based on-road inventories in order to calculate average emission rates in terms of units of emissions per gallon of fuel in order to simplify assessments of emissions impacts from various fleets and on-road emissions activities. This will provide approximate emissions rates that can be applied to fuel consumption data collected in CAPCOG's annual air quality report developed in 2015 in order to develop preliminary assessments of organizations' emissions impacts. These data can also be used in conjunction with information collected by the CLEAN AIR Force under the Clean Air Partners Program. Any such future analysis will explain the limitations of using this method for estimating emissions.

The tables below show the density and energy content of the various fuels that are accounted for in the model, as well as the calculated energy content converted into kilowatt-hours per gallon and million British Thermal Units (MMBtu) per gallon.

Table 5-1. Fuel Energy Content Parameters for MOVES2014

Fuel Type ID	FuelSubtypeID	FuelSubtypeDesc	Fuel Density (g/gallon)	Energy Content (KJ/g)
1	10	Conventional Gasoline	2839	43.488
1	11	Reformulated Gasoline (RFG)	2839	42.358
1	12	Gasohol (E10)	2839	41.762
1	13	Gasohol (E8)	2839	42.100
1	14	Gasohol (E5)	2839	42.605
1	15	Gasohol (E15)	2839	40.920
1	18	Ethanol (E20)	2839	40.077
2	20	Conventional Diesel Fuel	3167	43.717
2	21	Biodiesel	3167	43.247
2	22	Fischer-Tropsch Diesel	3167	43.247
3	30	Compressed Natural Gas	NULL	48.632
4	40	Liquefied Petroleum Gas (LPG)	1923	46.607
5	50	Ethanol	2944	26.592
5	51	Ethanol (E85)	2944	29.12
5	52	Ethanol (E75)	2944	31.649
9	90	Electricity	NULL	NULL

Table 5-2. Calculated Energy Content Parameters for Fuels from MOVES2014

Fuel Type ID	FuelSubtypeID	FuelSubtypeDesc	KWh/gallon	MMBtu/gallon
1	10	Conventional Gasoline	34.30	0.1170
1	11	Reformulated Gasoline (RFG)	33.40	0.1140
1	12	Gasohol (E10)	32.93	0.1124
1	13	Gasohol (E8)	33.20	0.1133
1	14	Gasohol (E5)	33.60	0.1146
1	15	Gasohol (E15)	32.27	0.1101
1	18	Ethanol (E20)	31.61	0.1078
2	20	Conventional Diesel Fuel	38.46	0.1312

Fuel Type ID	FuelSubtypeID	FuelSubtypeDesc	KWh/gallon	MMBtu/gallon
2	21	Biodiesel	38.05	0.1298
2	22	Fischer-Tropsch Diesel	38.05	0.1298
4	40	Liquefied Petroleum Gas (LPG)	24.90	0.0849
5	50	Ethanol	21.75	0.0742
5	51	Ethanol (E85)	23.81	0.0813
5	52	Ethanol (E75)	25.88	0.0883

6 Estimate of 2015 Ozone Season NO_X Emissions

The following table summarizes the estimated 2015 anthropogenic ozone season weekday NO_X emissions estimate for the Austin-Round Rock MSA.

Table 6-1. Average Austin-Round Rock MSA 2015 Ozone Season NO_X Emissions Estimate by Source Category (tons per day)

County	On-Road	Non-Road	Point	Area	TOTAL
Bastrop	2.60	1.69	3.11	0.66	8.06
Caldwell	2.01	1.28	0.75	3.55	7.60
Hays	5.13	1.56	7.42	0.57	14.69
Travis	20.06	9.33	6.37	5.14	40.91
Williamson	8.01	5.20	0.12	1.57	14.89
TOTAL	**37.81**	**19.06**	**17.77**	**11.50**	**86.14**

The basis for these estimates are outlined below:

- On-Road: CAMPO 2015 Link-Based Weekday Emissions
- Non-Road:
  - Default TexN v. 1.7.1 Ozone Season Day Run for 2015
  - 2014 Locomotive Emissions Inventory projected to 2015
  - 2014 Aircraft Emissions Inventory projected to 2015
  - 2014 Drill Rig Emissions Inventory
- Point Sources:
  - EGUs: 2015 Average Emissions May 1 – September 30, 2015 from CAMD;
    - Decker turbines adjusted using 2013 annual adjustment factors to reflect emissions rates reported in the facility's 2013 emissions inventory;
  - Non-EGUs: 2013 OSD Emissions;
- Area Sources: Average of 2012 and 2018 emissions inventories used in photochemical modeling for DFW and HGB areas by TCEQ.

7 Analysis of Future NO_X Reduction Potential from Fleet Turnover

CAPCOG analyzed the emission reduction potential of fleet turnover programs like the Texas Emission Reduction Plan (TERP) Emission Reduction Incentive Grant (ERIG) program or the Diesel Emission Reduction Act (DERA) grant administered by the EPA in 2018 and 2025 in order to better understand the extent to which strategies targeted at replacing, repowering, or retrofitting old diesel-powered engines could reduce emissions in the future.

7.1 On-Road

For on-road emissions, CAPCOG analyzed data prepared by TCEQ to develop adjustment factors for diesel-powered vehicles to reflect the impact of Texas Low-Emission Diesel (TxLED).[50] Since the impact of TxLED on NO_X emissions varies by model year, TCEQ's analysis provides data on the relative contribution of each model year to a vehicle source use type's total NO_X emissions and vehicle miles traveled. Used in conjunction with the total emissions by source use type, it is possible to calculate the total emissions by model year and analyze the extent to which accelerated fleet turnover programs like TERP and DERA could further reduce emissions through accelerated engine turnover. The following table summarizes the approximate emission reduction potential from accelerated retirement of on-road diesel vehicles in 2018 and 2025.

Table 7-1. On-Road Diesel Fleet Turnover Emission Reduction Potential

Year	Baseline Emissions	Reduction Potential	% Reduction Potential
2018	12.07	8.10	67%
2025	6.01	2.03	34%

CAPCOG followed the following steps for estimating the emission reduction potential in 2018:

1. Obtained the data used by TCEQ to develop the TxLED adjustment factors for 2018, including the NO_X emissions and VMT by source use type and model year.
2. Calculated the percentage of NO_X emissions and VMT that each model year contributed to each source use type's total emissions and VMT in step 1.
3. Obtained the MOVES2014 non-link-based NO_X emissions and VMT for Bastrop, Caldwell, Hays, Travis, and Williamson Counties for 2018 summer weekdays.
4. Multiplied the MOVES2014 non-link-based NO_X emissions and VMT totals for each diesel source use type by each source use type/model year percentages calculated in step 2 in order to obtain an estimate of the emissions and VMT in each model year for each source use type.
5. Calculated the NO_X emissions rates for each source use type and model year in terms of NO_X emissions per vehicle mile traveled obtained in step 4.
6. Multiplied the total VMT for each source use type by the 2018 emissions rate for that source use type in order to obtain a "fully controlled" emissions estimate that would reflect complete fleet turnover.
7. Sum the total "baseline" emissions and "fully controlled" emissions estimates across all source use types.
8. Compared the "baseline" estimate to the "fully controlled" emissions estimate for 2018 in order to obtain the estimated 2018 emission reduction potential of 67%.

For the 2025 analysis, CAPCOG followed the following steps:

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[50] ftp://amdaftp.tceq.texas.gov/pub/Mobile_EI/Statewide/mvs/txled/mvs14-statewide-txled-analysis-06-12-17-18.zip

1. Multiplied the VMT for each source use type/model year combination (calculated in step 4 for the 2018 estimate) by the emissions rates for each source use type/model combination shifted by 7 years to account for the extra 7 years of fleet turnover:
   a. The rates for 2018 were multiplied by the VMT for 2011-2018 (which translates into 2018-2025) model years in order to obtain the estimated emissions for each SUT/model year combination for 2018-2025 model years;
   b. The rate for each previous year were multiplied by the VMT for the n-7 model year in the 2018 spreadsheet (for example, the 2017 emissions rate was applied to 2010 VMT, and the 2016 emissions rate was applied to 2009 VMT);
2. CAPCOG calculated the emission reduction potential using steps 6-8 in the 2018 calculations.

7.2 Non-Road

Since the “aggregate.out” file produced by the TexN model does not include model year-specific data, CAPCOG used default NONROAD and TexN model NR.bmx output for Travis County for average ozone season days in 2018 and 2025 in order to estimate the NO_X emission reduction potential for non-road equipment in those two years. For each run, CAPCOG aggregated the fuel consumption and NO_X emissions by technology type. The “Tier 3” grouping included anything coded as “T3” or “T3B,” and the “Tier 4” group included anything coded as “T4,” “T4A,” “T4B,” and “T4N.” The following table shows the average NO_X emissions rate for each technology type in terms of grams of NO_X emissions per pound of diesel fuel consumed. These emissions rates do not account for the impact of TxLED, since that is a post-processing adjustment.

Table 7-2. Non-road diesel NO_X emissions rates by technology type for 2018 and 2025 (grams of NO_X per pound of fuel)

Technology Type	2018 (NONROAD)	2025 (TexN)	2025 (NONROAD)	2025 (TexN)
Base	169	173	167	171
T0	135	134	133	142
T1	102	100	101	99
T2	78	78	78	78
T3	50	50	50	50
T3B	54	54	54	54
T4	49	50	50	50
T4A	63	56	59	55
T4B	76	76	76	76
T4N	9	5	10	6
TOTAL	**41**	**38**	**24**	**22**

CAPCOG aggregated the fuel consumption and NO_X emissions for each run into the five primary bins of emissions certification level – Base, Tier 0, Tier 1, Tier 2, Tier 3, and Tier 4. The following four tables show these results for 2018 and 2025 for both the NONROAD model and the TexN model.

Table 7-3. Estimated distribution of non-road diesel NO_X emissions and fuel consumption by certification level, 2018 (NONROAD)

Certification Level	Fuel Consumed (lbs)	% of Fuel	NO_X Emissions (grams)	% of NOX	Rate (g NOX/lb fuel)
Base	704	0.5%	119,197	1.9%	169
Tier 0	3,864	2.5%	521,402	8.3%	135
Tier 1	10,999	7.2%	1,126,261	18.0%	102
Tier 2	11,963	7.8%	929,370	14.8%	78
Tier 3	22,829	14.9%	1,157,053	18.5%	51
Tier 4	102,468	67.0%	2,417,067	38.5%	24
TOTAL	**152,826**	**100.0%**	**6,270,350**	**100.0%**	**41**

Table 7-4. Estimated distribution of non-road diesel NO_X emissions and fuel consumption by certification level, 2018 Ozone Season Day (TexN, no post-processing adjustments)

Certification Level	Fuel Consumed (lbs)	% of Fuel	NO_X Emissions (grams)	% of NOX	Rate (g NO_X/lb fuel)
Base	437	0.4%	75,788	1.8%	173
Tier 0	2,978	2.6%	399,064	9.3%	134
Tier 1	7,639	6.7%	762,387	17.7%	100
Tier 2	6,873	6.0%	537,230	12.5%	78
Tier 3	15,326	13.4%	780,313	18.1%	51
Tier 4	80,703	70.8%	1,745,872	40.6%	22
TOTAL	**113,956**	**100.0%**	**4,300,655**	**100.0%**	**38**

Table 7-5. Estimated distribution of non-road diesel NO_X emissions and fuel consumption by certification level, 2025 (NONROAD)

Certification Level	Fuel Consumed (lbs)	% of Fuel	NO_X Emissions (grams)	% of NO_X	Rate (g NO_X/lb fuel)
Base	226	0.1%	37,756	0.9%	167
Tier 0	1,217	0.7%	162,130	3.8%	133
Tier 1	3,873	2.2%	392,721	9.3%	101
Tier 2	4,391	2.5%	344,289	8.2%	78
Tier 3	7,655	4.4%	389,665	9.2%	51
Tier 4	156,522	90.0%	2,892,747	68.6%	18
TOTAL	**173,885**	**100.0%**	**4,219,309**	**100.0%**	**24**

Table 7-6. Estimated distribution of non-road diesel NO_X emissions and fuel consumption by certification level, 2025 Ozone Season Day (TexN, no post-processing adjustments)

Certification Level	Fuel Consumed (lbs)	% of Fuel	NO_X Emissions (grams)	% of NOX	Rate (g NO_X/lb fuel)
Base	149	0.1%	25,571	0.9%	171
Tier 0	734	0.6%	104,004	3.7%	142
Tier 1	2,810	2.2%	279,371	9.9%	99
Tier 2	3,037	2.4%	236,629	8.4%	78
Tier 3	4,601	3.7%	234,531	8.3%	51
Tier 4	113,720	90.9%	1,930,683	68.7%	17
TOTAL	**125,051**	**100.0%**	**2,810,788**	**100.0%**	**22**

These tables show that while Tier 4 equipment is expected to account for large majorities of the diesel fuel consumed in 2018 and 2025, older equipment accounts for a majority of NO_X emissions in 2018 and about a third of NO_X emissions in 2025 from non-road sources.

CAPCOG then calculated the emission reduction potential in each year by multiplying the total fuel consumption by the Tier 4 emissions rate in order to obtain a “fully controlled” emissions estimate and then subtracting that from the baseline estimates. This difference was then divided by the baseline estimate for Travis County in order to obtain the emission reduction potential percentages. The equations below illustrate these calculations, whereby “Y” is the year that the emission reduction potential was calculated for.

$$Fully\ Controlled_Y = Tier\ 4\ Rate_Y \times Total\ Fuel\ Consumption_Y$$

$$Reduction\ Potential\ \%_Y = \frac{Baseline_Y - Fully\ Controlled_Y}{Baseline_Y} \times 100\%$$

Table 7-7. Summary of Non-Road Diesel NO_X Emission Reduction Potential Calculations

Analysis Year	Model	Pre-Tier 4 Models % of Fuel	Pre-Tier 4 Models % of NOX Emissions	Travis County NO_X Emission Reduction Potential (tpd)	NOX Emission Reduction Potential%
2018	NONROAD	33.0%	61.5%	2.87	43%
2018	TexN	29.2%	59.4%	1.98	43%
2025	NONROAD	10.0%	31.4%	1.20	24%
2025	TexN	9.1%	31.3%	0.75	24%

CAPCOG then applied these reduction potentials to the aggregated 5-county MSA non-road diesel emissions estimates from the TexN model in order to develop approximate 5-county emission reduction potentials for each year.

Table 7-8. Analysis of Non-Road Diesel NO_X Emission Reduction Potential for MSA, 2018 and 2025 (tons per day)

Analysis Year	Baseline	Reduction Potential
2018	9.26	3.98
2025	5.80	1.39

7.3 Locomotive

The 2014 locomotive emissions inventory that ERG developed for TCEQ provides information on fuel consumption and emissions by year that can be used to analyze the emission reduction potential from locomotives operating in the Austin area (or statewide) through grant programs like TERP. The following table summarizes the data for 2018 and 2025.

Table 7-9. Emission Reduction Potential from Locomotives in the MSA, 2018 and 2025

Year	NO_X Rate (g/gallon of diesel)	NO_X Emissions (tpd)	% Reduction Potential	Reduction Potential (tpd)
2018	109.32	2.32	72%	1.66
2025	76.64	1.76	60%	1.10

7.4 Summary of NO_X Emission Reduction Potential

While more direct and comprehensive methods would be necessary to obtain robust estimates, the analyses described above do broadly indicate the continued value of accelerated mobile source engine replacement efforts such as TERP and DERA grants in 2018 and 2025. Based on NO_X sensitivities calculated by CAPCOG using modeling conducted on the June 2006 photochemical model,[51] CAPCOG estimates that local "legacy" diesel engines that do not meet the most up-to-date emissions standards are likely contributing approximately 0.8 – 1.3 ppb to peak ozone levels in the region in 2018 and 0.3 – 0.4 ppb in 2025.

Table 7-10. Summary of Mobile Source Diesel NOX Emission Reduction Potential for the MSA, 2018 and 2025

Year	2018 % Reduction Potential	2018 tpd Reduction Potential	2025 % Reduction Potential	2025 tpd Reduction Potential
On-Road	67%	8.10	34%	2.03
Non-Road	43%	3.98	24%	1.39
Locomotive	72%	1.66	60%	1.10
Combined	58%	13.74	33%	4.52

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[51] http://www.capcog.org/documents/airquality/reports/2015/Photochemical_Modeling_Analysis_Report_2015-09-04_Final_Combined.pdf