Local and Voluntary Emission Reduction Quantification Report

Prepared by the Capital Area Council of Governments
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Executive Summary

The Capital Area Council of Governments (CAPCOG) is 10-county regional planning commission in Central Texas that includes Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson Counties. Five of these counties – Bastrop, Caldwell, Hays, Travis, and Williamson Counties – make up the Austin-Round Rock Metropolitan Statistical Area (MSA) and participate in CAPCOG's Central Texas Clean Air Coalition (CAC). The purpose of this project was to quantify the magnitude and spatial and temporal characteristics of the emissions reduction measures that have been implemented within the Austin-Round Rock MSA as a part of the region's Ozone Advance Program (OAP) Action Plan and earlier under the 8-Hour Ozone Flex Plan. These data will be helpful in CAPCOG's research and analysis of the costs and benefits of the region's air quality planning efforts under Task 1.5 and other planning activities. The report focuses on emissions of nitrogen oxides (NO_X), but also includes emission reductions of other pollutants when such information was readily available.

CAPCOG completed analyses of the following programs:

- The Texas Emission Reduction Plan (TERP) grant programs
- Vehicle emissions inspection and maintenance (I/M)
- Drive a Clean Machine (DACM) repair and replacement programs
- Energy Efficiency (EE) and Renewable Energy (RE) programs at Austin Energy
- Texas Lehigh Cement Company's Voluntary NO_X Reduction Efforts

The following table summarizes the total NO_X emissions reductions programs estimated for each program analyzed.

Table E-1-1: Estimated NO_X Emissions by Measure, 2008-2016 (tpd)

Year	TERP	I/M	DACM Repair	DACM Replacement	EE/RE	Texas Lehigh	TOTAL
2008	1.1036	3.8191	0.0209	0.3199	0.0775	0.0000	5.3410
2009	1.5258	3.6195	0.0309	0.4245	0.0841	0.5078	6.1926
2010	1.8290	3.5584	0.0313	0.4922	0.0850	0.0000	5.9959
2011	2.0126	3.3075	0.0175	0.4209	0.1285	0.0000	5.8871
2012	2.0294	3.1490	0.0299	0.3202	0.0959	0.0000	5.6245
2013	1.8334	2.9516	0.0262	0.2286	0.1308	0.5078	5.6785
2014	1.8113	2.7974	0.0230	0.1394	0.1138	0.5078	5.3928
2015	1.6345	2.5144	0.0133	0.0826	0.2493	0.5078	5.0020
2016	1.5085	2.2621	0.0057	0.0599	0.2286	0.5078	4.5726

Note: CAPCOG updated the DACM emission estimates after initially finalizing this report in January 2018 after obtaining a complete quarterly summary of the number of repairs and replacements from the Texas Commission on Environmental Quality (TCEQ) on February 1, 2018.

Table of Contents

1 Introduction

The Capital Area Council of Governments (CAPCOG) is 10-county regional planning commission in Central Texas that includes Bastrop, Blanco, Burnet, Caldwell, Fayette, Hays, Lee, Llano, Travis, and Williamson Counties. Five of these counties – Bastrop, Caldwell, Hays, Travis, and Williamson Counties – make up the Austin-Round Rock Metropolitan Statistical Area (MSA) and participate in CAPCOG's Central Texas Clean Air Coalition (CAC). The purpose of this project was to quantify the magnitude and spatial and temporal characteristics of the emissions reduction measures that have been implemented within the Austin-Round Rock MSA as a part of the region's Ozone Advance Program (OAP) Action Plan and earlier under the 8-Hour Ozone Flex Plan. These data will be helpful in CAPCOG's research and analysis of the costs and benefits of the region's air quality planning efforts under Task 1.5 and other planning activities.

CAPCOG's primary interest was in characterizing emission reductions that occurred between 2008 and 2010 and 2014 and 2016, since the ground-level ozone (O_3) levels in these years were used by the U.S. Environmental Protection Agency (EPA) as the basis for the designation of all five counties in the Austin-Round Rock MSA as attainment/unclassifiable for the 2008 and 2015 Ozone National Ambient Air Quality Standards (NAAQS), respectively. However, CAPCOG also includes estimates of emission reductions for 2011-2013 as well.

This report includes emission reduction estimates for the following emission reduction measures:

- Texas Emission Reduction Plan (TERP) grants
- The vehicle emissions inspection and maintenance (I/M) program in Travis and Williamson Counties
- The Drive a Clean Machine (DACM) program
- Energy Efficiency and Renewable Energy (EE/RE) measures implemented by Austin Energy (AE)
- Texas Lehigh's voluntarily implemented NO_X emissions reduction initiative on predicted high-ozone days

There are a host of other measures that have been implemented by CAC members over this time frame that CAPCOG did not directly quantify.

2 Texas Emission Reduction Plan (TERP) Grants

TERP grants constitute one of the largest sources of NO_X reductions within the Austin-Round Rock MSA, based on analyses CAPCOG has previously conducted for our annual air quality reports. As an incentive-based strategy for reducing emissions, it is a voluntary program and requires active participation within the community in order to achieve emission reductions.

Between 2008 and 2016, TERP included a number of different grant programs, including:

- The Diesel Emission Reduction Incentive (DERI) program:
    - Funds the replacement, repower, and retrofitting of older diesel vehicles and equipment
    - 2001 – present

- The Texas Clean Fleet Program (TCFP):
  - Funds the replacement of fleets of conventionally fueled heavy-duty vehicles with alternative-fueled vehicles
  - 2009 – present
- The Texas Natural Gas Vehicle Grant Program (TNGVGP):
  - Funds the replacement of older conventionally fueled heavy-duty vehicles with compressed natural gas (CNG)
  - FY 2012 – present
- The Light-Duty Motor Vehicle Purchase or Lease Incentive Program:
  - FY 2014 – 2015
- The Clean Transportation Triangle (CTT) Grant Program:
  - Funds natural gas fueling infrastructure in the counties bounded by I-10, I-45, I-20, and I35
  - FY 2012 – 2017, merged with AFFP program starting September 1, 2017
- The Alternative Fueling Facilities (AFFP) Program:
  - Funds various alternative fuel refueling infrastructure in nonattainment areas (merging with CTT as of September 1, 2017)
  - FY 2012 – present
- The Texas Clean School Bus (TCSB) Program:
  - Through 8/31/2017, funded retrofits of school buses to reduce particulate matter (PM) emissions; after 9/1/2017, funded
  - FY 2005 – present
- The New Technology Implementation Grants (NTIG) Program:
  - Funds energy efficiency and other new-technology emission reductions at stationary sources
  - FY 2011 – present
- The Drayage Truck Incentive Program (DTIP):
  - Funds the replacement of drayage trucks in port areas
  - FY 2013 – present

2.1 Diesel Emission Reduction Incentive (DERI) Grants

The Diesel Emission Reduction Grant (DERI) program includes the competitive Emission Reduction Incentive Grant (ERIG) program and the first-come, first-served rebate grant program. A report provided by TCEQ to CAPCOG listed all of the DERI projects funded between 2001 and August 31, 2016. This included 10,698 grants covering 17,629 activities across the state. The data included:

- Project ID number
- Name
- Area (Austin, Beaumont/Port Arthur, Corpus Christi, Dallas-Fort Worth, El Paso, Houston-Galveston-Brazoria, San Antonio, Tyler/Longview, and Victoria)
- Project type (demonstration, lease, on-site infrastructure, on-vehicle infrastructure, purchase, refueling infrastructure, replacement, retrofit/add-on, and use of qualifying fuel)

- Emissions source (locomotive, marine, non-road, on-road, stationary)
- Number of activities
- Project description
- Activity life
- Grant amount
- Total NO_X reductions
- Project start date
- Project end date

CAPCOG screened the data to only include projects in the Austin area. This left 966 grants for 1,414 projects. These grants totaled $69,389,846.20 and achieved 8,796.46 tons of NO_X emission reductions within this timeframe. CAPCOG divided the total NO_X emissions reduced for each project by that project's activity life in order to obtain the annual NO_X emissions reduction for each project. CAPCOG then divided the annual NO_X emissions reduction by 365 in order to obtain the average daily NO_X emissions reduction for each project.

This method of calculating the daily NO_X emissions reduced differs from the method TCEQ uses in its TERP reports, since TCEQ divides the annual NO_X emissions reduction by 260 rather than 365. The 260 number TCEQ uses for its report is equivalent to 52 weeks times five weekdays per week. TCEQ's number, therefore, reflects the average weekday NO_X emissions reduction if you assume that all of the vehicle or non-road engine activity occurs on weekdays.

During the time frame covered by this report (2008-2016), older DERI projects expired and new ones came on-line. Therefore, in order to estimate the NO_X emissions reductions that would be occurring on any given day, CAPCOG needed to calculate the cumulative total of daily NO_X emissions reductions from all grants with start dates prior to a particular date and subtract the cumulative total of daily NO_X emission reductions from all grants that had expired prior to that date.

Table 2-1. Unadjusted Average Ozone Season Day NO_X Emissions Reductions from DERI Projects by Year and Project Type (tpd)

Project Type	2008	2009	2010	2011	2012	2013	2014	2015	2016
On-Road Transit Bus	0.0788	0.0788	0.0788	0.0788	0.0788	0.0788	0.0178	0.0000	0.0000
On-Road School Bus	0.0072	0.0117	0.0117	0.0146	0.0137	0.0129	0.0140	0.0115	0.0068
On-Road Refuse Truck	0.0018	0.0178	0.0342	0.0354	0.0374	0.0357	0.0357	0.0357	0.0320
On-Road Single Unit Short-Haul Truck	0.0060	0.0158	0.0171	0.0185	0.0185	0.0201	0.0277	0.0270	0.0239
On-Road Combination Truck	0.5874	0.7891	1.0288	1.1512	1.2264	1.0852	1.0239	0.9135	0.8015
Agricultural Tractors	0.0031	0.0291	0.0530	0.0595	0.0891	0.0905	0.1483	0.1609	0.2957
Agricultural Sprayer	0.0000	0.0000	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009	0.0009
Construction & Mining Equipment	0.3293	0.4491	0.4453	0.4196	0.3269	0.2650	0.2776	0.2424	0.1743
Industrial Equipment	0.0271	0.0452	0.0491	0.0558	0.0546	0.0537	0.0500	0.0355	0.0088
TOTAL	1.0407	1.4367	1.7190	1.8344	1.8463	1.6428	1.5958	1.4272	1.3438

2.1.1 Temporal Allocation of On-Road Vehicles

Table 12-2 of the MOVES2014a technical report for population and activity shows the month VMT fraction used in MOVES.[1]

Table 2-2. MOVES Monthly VMT Distribution

Month	Flat Distribution	MOVES Distribution	Relative to Flat
January	**0.0849**	0.0731	0.861
February	**0.0767**	0.0697	0.909
March	**0.0849**	0.0817	0.962
April	**0.0822**	0.0823	1.001
May	**0.0849**	0.0875	1.030
June	**0.0822**	0.0883	1.074
July	**0.0849**	0.0923	1.087
August	**0.0849**	0.0934	1.100
September	**0.0822**	0.0847	1.031
October	**0.0849**	0.0865	1.018
November	**0.0822**	0.0802	0.976
December	**0.0849**	0.0802	0.944

The average adjustment factor for May – September 2016 relative to a flat distribution would be 1.064. Table 12-4 provides the VMT fractions by day type and road type. CAPCOG calculated the adjustment factors that would be needed relative to a flat distribution and averaged the urban and rural distribution for this analysis.

Table 2-3. MOVES Day of Week VMT Distribution

Data Point	Rural	Urban	Avg.
Weekday	0.721	0.762	0.742
Weekend Day	0.279	0.238	0.258
Weekend Adjustment Factor	1.035	1.283	1.149
Weekend Day Adjustment Factor	0.976	0.832	0.904

CAPCOG applied these seasonal and day type adjustment factors to the average daily NOX emissions reductions calculated as described above.

2.1.2 Temporal Allocation of Non-Road Equipment Categories

Not all classes of non-road equipment are included among the DERI grants – only construction & mining equipment, industrial equipment, and agricultural equipment. The following table shows the default weekday/weekend allocation factors in the TexN "SEASON.DAT" packet for these equipment categories, which shows that each category is assumed to have at least some weekend activity.

[1] EPA. "Population and Activity of On-Road Vehicles in MOVES 2014." EPA-420-R-16-003, January 2016. Available online at: https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100O7VJ.pdf

Table 2-4. Weekday and Weekend Day Activity Allocation Fractions in the SEASON.DAT packet in the TexN Model

Non-Road Equipment Category	Weekday	Weekend Day
Construction	0.1800000	0.0500000
Industrial	0.1666667	0.0833334
Agricultural	0.1542871	0.1128696

In order to translate an average day into a weekday or weekend day, the following adjustment factors are needed:

- Construction:
  - Weekday: 1.260
  - Weekend day: 0.350
- Industrial:
  - Weekday: 1.167
  - Weekend day: 0.583
- Agricultural:
  - Weekday: 1.083
  - Weekend day: 0.792

The SEASON.DAT file also contains monthly activity allocations, which further complicates the analysis. TERP grants have not been targeted at all equipment types, just construction & mining, industrial, and agricultural. The following table shows the allocation factors to each month for these equipment types. For the purposes of this analysis, an ozone season day is assumed to be any day between May 1 and September 30. Therefore, the last column represents the average monthly allocation for May – September.

Table 2-5. TexN Monthly Allocation Factors for Selected Non-Road Equipment

Equipment Type	Dec.-Feb.	Mar.-May	Jun.-Aug.	Sep.-Nov.	May-Sep.
Construction & Mining	0.075	0.084	0.091	0.084	**0.088**
Industrial	0.083	0.083	0.083	0.083	**0.083**
Agricultural Tractors	0.057	0.097	0.107	0.073	**0.098**
Agricultural Sprayer	0.013	0.150	0.130	0.040	**0.116**

Relative to a flat distribution, then, the following ozone season adjustments were applied to construction and mining projects, industrial projects, agricultural tractors, and agricultural sprayers:

- Construction & Mining: 1.056
- Industrial: 1.000
- Agricultural Tractors: 1.176
- Agricultural Sprayers: 1.393

2.1.3 Temporally Adjusted NO_X Emissions Reduction Estimates

The following tables show the temporally adjusted NO_X emission reduction estimates by year and project type.

Table 2-6. Seasonally Adjusted Average Ozone Season Day NO_X Emissions Reductions from DERI Projects by Year and Project Type (tpd)

Project Type	2008	2009	2010	2011	2012	2013	2014	2015	2016
On-Road Transit Bus	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0189	0.0000	0.0000
On-Road School Bus	0.0077	0.0124	0.0124	0.0155	0.0146	0.0137	0.0149	0.0122	0.0072
On-Road Refuse Truck	0.0019	0.0189	0.0365	0.0376	0.0399	0.0380	0.0380	0.0380	0.0341
On-Road Single Unit Short-Haul Truck	0.0064	0.0169	0.0182	0.0197	0.0197	0.0214	0.0295	0.0287	0.0255
On-Road Combination Truck	0.6253	0.8400	1.0952	1.2254	1.3054	1.1551	1.0899	0.9724	0.8531
Agricultural Tractors	0.0037	0.0342	0.0623	0.0700	0.1047	0.1065	0.1745	0.1892	0.3477
Agricultural Sprayer	0.0000	0.0000	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Construction & Mining Equipment	0.3478	0.4743	0.4702	0.4431	0.3452	0.2798	0.2931	0.2559	0.1840
Industrial Equipment	0.0271	0.0452	0.0491	0.0558	0.0546	0.0537	0.0500	0.0355	0.0088
TOTAL	1.1036	1.5258	1.8290	1.9524	1.9692	1.7534	1.7099	1.5331	1.4617

Table 2-7. Seasonally Adjusted Ozone Season Weekday NO_X Emissions Reductions from DERI Projects by Year and Project Type (tpd)

Project Type	2008	2009	2010	2011	2012	2013	2014	2015	2016
On-Road Transit Bus	0.0964	0.0964	0.0964	0.0964	0.0964	0.0964	0.0217	0.0000	0.0000
On-Road School Bus	0.0088	0.0143	0.0143	0.0178	0.0167	0.0158	0.0171	0.0140	0.0083
On-Road Refuse Truck	0.0022	0.0218	0.0419	0.0432	0.0458	0.0436	0.0436	0.0436	0.0392
On-Road Single Unit Short-Haul Truck	0.0073	0.0194	0.0209	0.0227	0.0227	0.0246	0.0339	0.0330	0.0293
On-Road Combination Truck	0.7185	0.9652	1.2584	1.4081	1.5000	1.3273	1.2523	1.1173	0.9803
Agricultural Tractors	0.0040	0.0370	0.0675	0.0758	0.1134	0.1153	0.1889	0.2049	0.3766
Agricultural Sprayer	0.0000	0.0000	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014	0.0014
Construction & Mining Equipment	0.4382	0.5976	0.5925	0.5583	0.4349	0.3525	0.3693	0.3225	0.2319
Industrial Equipment	0.0316	0.0528	0.0573	0.0651	0.0637	0.0627	0.0584	0.0415	0.0102
TOTAL	1.3069	1.8044	2.1505	2.2889	2.2950	2.0396	1.9866	1.7781	1.6771

Table 2-8. Seasonally Adjusted Ozone Season Weekend Day NO_X Emissions Reductions from DERI Projects by Year and Project Type (tpd)

Project Type	2008	2009	2010	2011	2012	2013	2014	2015	2016
On-Road Transit Bus	0.0758	0.0758	0.0758	0.0758	0.0758	0.0758	0.0171	0.0000	0.0000
On-Road School Bus	0.0069	0.0112	0.0112	0.0140	0.0132	0.0124	0.0135	0.0110	0.0065
On-Road Refuse Truck	0.0017	0.0171	0.0329	0.0340	0.0360	0.0343	0.0343	0.0343	0.0308
On-Road Single Unit Short-Haul Truck	0.0058	0.0152	0.0164	0.0178	0.0178	0.0194	0.0266	0.0259	0.0230
On-Road Combination Truck	0.5651	0.7592	0.9898	1.1076	1.1798	1.0440	0.9850	0.8788	0.7710
Agricultural Tractors	0.0029	0.0271	0.0494	0.0554	0.0829	0.0843	0.1382	0.1498	0.2754
Agricultural Sprayer	0.0000	0.0000	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010	0.0010
Construction & Mining Equipment	0.1217	0.1660	0.1646	0.1551	0.1208	0.0979	0.1026	0.0896	0.0644
Industrial Equipment	0.0158	0.0264	0.0286	0.0325	0.0318	0.0313	0.0292	0.0207	0.0051
TOTAL	0.7958	1.0980	1.3698	1.4933	1.5593	1.4005	1.3474	1.2112	1.1773

2.2 Texas Clean Fleet Program

Since 2010, TCEQ has awarded six grants to replace 163 vehicles in the Austin area under the Texas Clean Fleet Program, amounting to $14,332,481.29 and achieving 148.13 tons of NO_X reductions, translating into a $96,756.10 per ton of NO_X reduced ratio.

Based on the 5-year project lifespan, CAPCOG assumed that

- Projects awarded in 2010 reduced emissions in 2011, 2012, 2013, 2014, and 2015
- Projects awarded in 2012 reduced emissions in 2013, 2014, 2015, 2016, and 2017
- Projects awarded in 2014 reduced emissions in 2015, 2016, 2017, 2018, and 2019
- Projects awarded in 2016 reduced emissions in 2017, 2018, 2019, 2020, and 2021

Using the Texas Clean Fleet program active project list through August 31, 2016, CAPCOG calculated the daily NO_X emissions, applying the same 1.064 seasonal adjustment factor that was used for the DERI program in order to estimate ozone season day NO_X emission reductions. The following table shows the average ozone season day NO_X emissions reductions in the Austin area estimated for each year by vehicle type for this program.

Table 2-9. TCFP NO_X Emissions Reductions by Year and Vehicle Type (tpd)

Year	School Bus	Transit Bus	Refuse Truck	Single-Unit Short-Haul Bus	TOTAL
2010	0.0160	0.0000	0.0270	0.0172	0.0602
2011	0.0160	0.0000	0.0270	0.0172	0.0602
2012	0.0160	0.0000	0.0468	0.0172	0.0800
2013	0.0160	0.0000	0.0468	0.0172	0.0800
2014	0.0160	0.0000	0.0468	0.0172	0.0800
2015	0.0000	0.0000	0.0198	0.0000	0.0198
2016	0.0064	0.0000	0.0198	0.0000	0.0262

2.3 Texas Natural Gas Vehicle Grant Program (TNGVGP)

Since 2012, there have been a total of four TNGVGP grants awarded for 24 replacement projects in the Austin area totaling $1,128,000 and achieving 35.66 tons of NO_X reductions over the lifetime of the project, a ratio of $31,623.08 per ton of NO_X reduced. These projects have four-year project lives, and are done on a reimbursement basis, meaning that grants awarded in 2014 would have already been implemented. Therefore, CAPCOG assumed that any grants awarded in 2014 would have benefits in 2014, 2015, 2016, and 2017, etc.

Table 2-10. TNGVGP NO_X Emissions Reductions by Year and Vehicle Type (tpd)

Year	On-Road Haul Trucks	Transit Bus	Refuse Truck	Single-Unit Short-Haul Bus	TOTAL
2014	0.0204	0.0000	0.0000	0.0000	**0.0204**
2015	0.0204	0.0000	0.0000	0.0000	**0.0204**
2016	0.0260	0.0000	0.0000	0.0000	**0.0260**

These estimates were calculated as follows:

ID Number 2014-00-0050-NV:

- 14.8 tons lifetime NO_X reductions
- 3.7 annual NO_X reductions over 4-year project life (14.8/4)
- 0.0101 tpd avg. daily NO_X reductions over 4-year project life (3.7/365)
- 0.0108 tpd avg. summertime daily NO_X reductions (0.0101 x 1.064 adj. factor)
- Benefits in 2014, 2015, 2016, and 2017

ID Number 2014-00-0067-NV:

- 4.93 tons lifetime NO_X reductions
- 1.23 annual NO_X reductions over 4-year project life (4.93/4)
- 0.0034 tpd avg. daily NO_X reductions over 4-year project life (1.23/365)
- 0.0036 tpd avg. summertime daily NO_X reductions (0.0034 x 1.064 adj. factor)
- Benefits in 2014, 2015, 2016, and 2017

ID Number 2014-00-0081-NV:

- 8.22 tons lifetime NO_X reductions
- 2.06 annual NO_X reductions over 4-year project life (8.22/4)
- 0.0056 tpd avg. daily NO_X reductions over 4-year project life (2.06/365)
- 0.0060 tpd avg. summertime daily NO_X reductions (0.0056 x 1.064 adj. factor)
- Benefits in 2014, 2015, 2016, and 2017

ID Number 2016-00-0006-NV:

- 7.71 tons lifetime NO_X reductions
- 1.93 annual NO_X reductions over 4-year project life (7.71/4)
- 0.0053 tpd avg. daily NO_X reductions over 4-year project life (1.93/365)
- 0.0056 tpd avg. summertime daily NO_X reductions (0.0053 x 1.064 adj. factor)
- Benefits in 2016, 2017, 2018, and 2019

Benefit for 2014 and 2015: 0.0108 tpd + 0.0036 tpd + 0.0060 tpd = 0.0204 tpd

Benefit for 2016: 0.0204 tpd + 0.0056 tpd = 0.0260 tpd

2.4 Light Duty Motor Vehicle Purchase or Lease Incentive (LDPLI) Program

A report provided by TCEQ to CAPCOG dated June 22, 2015, lists 349 grants amounting to $795,625 awarded within the Austin-Round Rock MSA under the LDPLI program prior to its expiration. The earliest project start date was May 23, 2014, and the latest project start date was June 18, 2015. Each grant had 1 year to complete the acquisition of the new vehicle.

In order to estimate the NO_X emissions reductions from these grants, CAPCOG first calculated the lifetime NO_X emissions reductions that would be expected from the use of a Tier 2, bin 1-4 vehicle relative to the lifetime NO_X emissions from a Tier 2, bin 5 vehicle, which was the fleet-wide average required for light-duty vehicles. The table below shows the calculated lifetime emissions reductions for each bin. EPA's standards assume 120,000 miles as the full useful life of light duty vehicles, so CAPCOG used that as the basis for estimating lifetime NO_X reductions.[2] Other literature suggests that lifetime mileage may be somewhat higher – 152,137 from a U.S. Department of Transportation study.[3]

Table 2-11. NO_X Emissions Rates for Tier 2, bins 1-5

Bin	NO_X Rate (g/mile)	Lifetime Miles per Vehicle	Lifetime NO_X per Vehicle (grams)	Lifetime NO_X Relative to Bin 5 (tons)
1	0.00	120,000	0	-0.009259
2	0.02	120,000	2,400	-0.006614
3	0.03	120,000	3,600	-0.005291
4	0.04	120,000	4,800	-0.003968
5	0.07	120,000	8,400	0.000000

CAPCOG then calculated the total number of vehicles for each make and model identified in TCEQ's report, looked up the Tier 2 bin number for those vehicles, and then calculated the total NO_X emissions reductions estimated for each make and model within the Austin-Round Rock MSA. The table below shows these calculations. CAPCOG used information available at www.fueleconomy.gov and assumed a 2014 model year for all vehicles. Where there was ambiguity in the applicable standard, CAPCOG used the least restrictive certification.[4]

Table 2-12. Austin-Round Rock MSA NO_X Emission Reduction Estimate for Light-Duty Vehicles funded under LDPLI Program

Make	Model	Qty.	Tier 2 Bin	NO_X Rate (g/mile)	Lifetime NO_X Change per vehicle (tons)	Total NO_X Reduction (tons)
BMW	i3	44	1	0.00	-0.009259	-0.407414
BMW	i3 Rex	10	5	0.07	0.000000	0.000000
Cadillac	ELR[5]	2	3	0.03	-0.005291	-0.010582
Chevrolet	Volt	65	3	0.03	-0.005291	-0.343921
Ford	C Max Energi	21	3	0.03	-0.005291	-0.111113
Ford	Focus BEV	3	1	0.00	-0.009259	-0.064816
Ford	Fusion Energi	17	3	0.03	-0.005291	-0.100531
Mercedes Benz	Smart CE	1	1	0.00	-0.005291	-0.009259
Mitsubishi	i-MiEV	2	1	0.00	-0.009259	-0.018519

[2] US EPA. "Light-Duty Vehicles, Light-Duty Trucks, and Medium-Duty Passenger Vehicles: Tier 2 Exhaust Emission Standards and Implementation Schedule." EPA-420-B17-028. September 2017. https://nepis.epa.gov/Exe/ZyPDF.cgi/P100SMQA.PDF?Dockey=P100SMQA.PDF

[3] US DOT. "Vehicle Survivability and Travel Mileage Schedules." Springfield, VA, January 2006. DOT HS 809 952. Available online at https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/809952.

[4] TCEQ. "Light Duty Motor Vehicle Purchase or Lease Incentive Program Eligible Vehicle List." August 29, 2014. https://www.tceq.texas.gov/assets/public/implementation/air/terp/ld/2014_ld_list.pdf

[5] There are two certifications listed – one for Tier 2, bin 4, and one for Tier 2, bin 3. CAPCOG used the bin 3 certification for this analysis.

Make	Model	Qty.	Tier 2 Bin	NO_X Rate (g/mile)	Lifetime NO_X Change per vehicle (tons)	Total NO_X Reduction (tons)
Nissan	Leaf	178	1	0.00	-0.009259	-1.648175
TOTAL	**n/a**	**349**	**n/a**	**n/a**	**-0.006652**	**-2.714331**

Given the total cost of $795,625 awarded for these grants, this translates into a cost/benefit ratio of $293,120.15 per ton of NO_X reduced.

CAPCOG repeated this analysis for the other pollutants covered by the Tier 2 light duty vehicle standards in order to provide a full set of emission reduction estimates from this program. For GHG emissions, CAPCOG compared the tailpipe CO2 emissions to the projected fleet-wide emissions compliance levels under the footprint-based CO2 standards in the final 2012-2016 light-duty GHG standards.[6]

Table 2-13. Estimated NO_X, NMOG, CO, PM, HCHO, and GHG Reductions from LDPLI Program in the Austin-Round Rock MSA

Pollutant	Total Reduction (tons)	Annual Reduction (tons)	Avg. Daily Reduction (tons)
NO_X	2.7143	0.3393	0.0009
NMOG	3.0450	0.3806	0.0010
CO	158.6137	19.8267	0.0543
PM	0.3069	0.0384	0.0001
HCHO	0.6515	0.0814	0.0002
GHG	9,946.7253	1,243.3407	3.4064

2.5 Other TERP Grant Programs

CAPCOG is not including an estimate of the emission reductions from the other TERP grant programs based on the lack of NO_X emission reduction data for these programs.

- The Texas Clean School Bus program has, until September 1, 2017, only focused on retrofitting school buses to reduce PM emissions
- The Alternative Fueling Facilities Program and the Clean Transportation Triangle Program do not directly reduce emissions, since they provide funding for fueling infrastructure. To the extent that increased availability of alternative fuels increases the willingness of a vehicle owner to replace an older conventionally-fueled vehicle with a newer alternative-fueled vehicle that meets more stringent emissions standards, these grants can indirectly reduce NOX emissions. However, CAPCOG is not aware of any data that quantify any such benefit, and the pairing of these programs with the Texas Natural Gas Vehicle Grant Program suggests that at least some of the emission reductions that such infrastructure might achieve may already be accounted for in the replacement of vehicles under the TNGVGP.

[6] https://www.gpo.gov/fdsys/pkg/FR-2010-05-07/pdf/2010-8159.pdf, see table I.B.2-4.

- The New Technology Implementation Grant (NTIG) program has awarded 2 grants for the Austin area totaling $2.5 million to fund electricity storage projects within the region. TCEQ estimates that these projects will achieve 6.5596 tons of NO_X reductions over five years once they become operational.[7] This works out to $381,123.32 per ton of NO_X reduced, and 0.003595 tpd of NO_X reduced, on average, over the five-year period TCEQ analyzed. Based on the status reports available on TCEQ's website, these projects are still in the implementation phase and therefore have not yet achieved any emission reductions.[8]
- The Austin area is not eligible for Drayage Truck Incentive Program (DTIP) grants

2.6 Summary of TERP Grant NO_X Reductions

[7] TCEQ. *NTIG Projects Through 2016-08-31 CAPCOG request.xlsx*. E-mailed from Amanda Guthrie to Andrew Hoekzema 10/24/2017.
[8] https://www.tceq.texas.gov/airquality/terp/ntig-fiscal-2014-15-applicants

Table 2-14. Summary of Quantified TERP OSD NO_X Emissions Reductions by Grant Program, Vehicle/Equipment Type, and Year (tpd)

Grant	Vehicle/Equipment Type	2008	2009	2010	2011	2012	2013	2014	2015	2016
DERI	On-Road Transit Bus	0.0839	0.0839	0.0839	0.0839	0.0839	0.0839	0.0189	0.0000	0.0000
DERI	On-Road School Bus	0.0077	0.0124	0.0124	0.0155	0.0146	0.0137	0.0149	0.0122	0.0072
DERI	On-Road Refuse Truck	0.0019	0.0189	0.0365	0.0376	0.0399	0.0380	0.0380	0.0380	0.0341
DERI	On-Road Single Unit Short-Haul Truck	0.0064	0.0169	0.0182	0.0197	0.0197	0.0214	0.0295	0.0287	0.0255
DERI	On-Road Combination Truck	0.6253	0.8400	1.0952	1.2254	1.3054	1.1551	1.0899	0.9724	0.8531
DERI	Non-Road Agricultural Tractors	0.0037	0.0342	0.0623	0.0700	0.1047	0.1065	0.1745	0.1892	0.3477
DERI	Non-Road Agricultural Sprayer	0.0000	0.0000	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
DERI	Non-Road Construction & Mining Equipment	0.3478	0.4743	0.4702	0.4431	0.3452	0.2798	0.2931	0.2559	0.1840
DERI	Non-Road Industrial Equipment	0.0271	0.0452	0.0491	0.0558	0.0546	0.0537	0.0500	0.0355	0.0088
TCFP	On-Road School Bus				0.0160	0.0160	0.0160	0.0160	0.0160	0.0000
TCFP	On-Road Short-Haul Single Unit Truck				0.0172	0.0172	0.0172	0.0172	0.0172	0.0000
TCFP	On-Road Refuse Truck				0.0270	0.0270	0.0468	0.0468	0.0468	0.0198
TCFP	On-Road Transit Bus				0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
TNGVGP	On-Road Single-Unit Short Haul Truck							0.0204	0.0204	0.0260
LDPLI	On-Road Passenger Cars							0.0010	0.0010	0.0010
TOTAL	**TOTAL**	**1.1036**	**1.5258**	**1.8290**	**2.0126**	**2.0294**	**1.8334**	**1.8113**	**1.6345**	**1.5085**

3 Vehicle Emissions Inspection and Maintenance Program

The vehicle emissions inspection and maintenance (I/M) program in Travis and Williamson Counties requires all gasoline-powered vehicles aged 2-24 years old registered in those counties, other than motorcycles, to pass an annual emissions inspection. Model year 1995 and older vehicles must pass a two-speed idle (TSI) test, and model year 1996 and newer vehicles must pass an on-board diagnostic (OBD) test.

The MOVES2014a model includes emissions factors derived from I/M and non-I/M areas for light-duty vehicles (GVWR <=8,500 lbs). When modeling emissions for an I/M county, it applies the I/M county reference case emissions rates, while modeling emissions for a non-I/M county, it applies that emissions rate. MOVES does not currently have the ability to model an I/M emissions benefit for vehicles with GVWR > 8,500 lbs.

A 2015 study commissioned by CAPCOG and conducted by ERG estimated the NO_X, VOC, and CO emission reduction benefits from the I/M program in Travis and Williamson Counties, including the benefits from testing heavy-duty vehicles[9]. This study estimated the following summer weekday emission reductions for 2012 and 2018.

Table 3-1. I/M Benefit Estimated in 2015 Study for 2012 Summer Weekdays (tpd)

Vehicle Type	CO	NO_X	VOC
Light Duty Vehicles	27.47	3.04	2.41
Heavy Duty Vehicles	5.59	0.67	0.25
TOTAL	**33.06**	**3.71**	**2.66**

Table 3-2. I/M Benefit Estimated in 2015 Study for 2018 Summer Weekdays (tpd)

Vehicle Type	CO	NO_X	VOC
Light Duty Vehicles	23.41	1.41	1.70
Heavy Duty Vehicles	3.10	0.20	0.12
TOTAL	**26.51**	**1.61**	**1.82**

3.1 Light-Duty Vehicle Analysis

The following tables show the percentage emission reductions for 2012 and 2018 by vehicle type for light-duty vehicles (GVWR <=8,500 lbs)

Table 3-3. Percentage Emission Reduction by Gasoline-Powered Light-Duty Vehicle Type, 2012

Vehicle Type	CO	NO_X	VOC
Passenger Cars	12.95%	11.43%	11.82%
Passenger Trucks	11.60%	11.44%	11.35%
Light Commercial Trucks	9.64%	9.53%	10.13%
TOTAL	**12.19%**	**11.22%**	**11.51%**

[9] http://www.capcog.org/documents/airquality/reports/2015/Austin_Area_I-M_Benefit_Analysis_2015_revised_2015_12_16.pdf

Table 3-4. Percentage Emission Reduction by Gasoline-Powered Vehicle Type, 2018

Vehicle Type	CO	NOX	VOC
Passenger Cars	13.83%	12.03%	12.37%
Passenger Trucks	13.46%	11.28%	12.94%
Light Commercial Trucks	11.12%	9.45%	11.64%
TOTAL	**13.47%**	**11.47%**	**12.46%**

A 2010 study commissioned by TCEQ and conducted by ERG also includes emission benefit estimates for the Austin area on an annual basis.[10] This study found nearly identical NOX and VOC emission reduction benefits for light-duty vehicles for 2012 (11.3% and 11.4%, respectively), and slightly lower benefits for CO (11.5%). The table below summarizes these results.

Table 3-5. I/M Emission Reductions for Light Duty Vehicles from 2010 Study

Pollutant	2012	2014	2016	2017
HC	11.4%	12.2%	13.0%	13.5%
CO	11.5%	11.6%	11.8%	11.9%
NO_X	11.3%	11.4%	11.4%	11.6%

Due to the similarity of these data and the absence of data for prior to 2012, CAPCOG used the 2012 data from its 2015 study for 2008, 2009, 2010, 2011, 2012, and 2013, and used the 2010 study's 2014 data for 2014 and 2015, and used the 2010 study's 2016 data for 2016. The table below summarizes this.

Table 3-6. I/M Emissions Reductions for Light Duty Vehicles by Year (%)

Year	CO	NO_X	VOC
2008	12.19%	11.22%	11.51%
2009	12.19%	11.22%	11.51%
2010	12.19%	11.22%	11.51%
2011	12.19%	11.22%	11.51%
2012	12.19%	11.22%	11.51%
2013	12.19%	11.22%	11.51%
2014	11.63%	11.38%	12.20%
2015	11.63%	11.38%	12.20%
2016	11.78%	11.44%	13.02%

Using TCEQ's annual "trends" emissions inventories for 2008-2016, CAPCOG calculated the following average ozone season day emission reduction for light-duty vehicles attributable to the I/M program.[11]

[10] https://www.tceq.texas.gov/assets/public/implementation/air/ms/IM/2010ElimTailTstRpt.pdf
[11] ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/mvs14_trends/

Table 3-7. I/M Emissions Reductions for Light Duty Vehicles by Year (tpd)

Year	CO	NO_X	VOC
2008	32.2510	3.7971	2.6139
2009	29.1180	3.5986	2.5239
2010	28.8261	3.5379	2.5222
2011	27.3416	3.2888	2.3786
2012	26.7447	3.1312	2.1807
2013	25.8226	2.9372	2.0598
2014	24.0770	2.7858	2.1134
2015	23.2581	2.5052	1.9745
2016	22.0178	2.2548	1.9468

3.2 Heavy-Duty Vehicle Analysis

ERG's 2015 report for CAPCOG includes an analysis of the emission reduction benefits from heavy-duty gasoline vehicles being subject to the I/M program. Since the MOVES model does not include the ability to estimate this directly, ERG used I/M program data instead to produce these estimates. One area in which there was a high degree of uncertainty was the number of heavy-duty gasoline vehicles in the region. TCEQ's estimate for the number of HDGVs in the Austin-Round Rock MSA in 2012 was 4,796, while the program's database lists 27,767 heavy-duty gasoline vehicles. The low estimates in the table below show an adjustment to reflect this difference – 4796/27767.

Table 3-8. Range of Emission Reduction Estimates for HDGV I-M Benefits

Pollutant	Low or High	2012	2018
CO	Low	9.17%	8.33%
CO	High	53.12%	48.20%
NOX	Low	1.51%	0.63%
NOX	High	8.76%	3.62%
VOC	Low	4.01%	6.15%
VOC	High	23.19%	35.60%

The following table shows the lowest of these estimates applied to the TCEQ trends emissions inventories.

Table 3-9. I/M Emissions Reductions for Heavy-Duty Vehicles by Year (tpd)

Year	CO	NO_X	VOC
2008	1.1948	0.0221	0.0164
2009	1.0652	0.0209	0.0154
2010	1.0338	0.0206	0.0154
2011	0.9514	0.0187	0.0142
2012	0.9089	0.0178	0.0129
2013	0.8106	0.0144	0.0128
2014	0.7282	0.0116	0.0124
2015	0.6550	0.0092	0.0118
2016	0.5953	0.0073	0.0115

3.3 Summary for I/M

The following table summarizes the CO, NO_X, and VOC emission reduction benefits from the I/M program by year for 2008-2016, including both heavy-duty and light-duty vehicles.

Table 3-10. I/M Emissions Reductions by Year (tpd)

Year	CO	NO_X	VOC
2008	33.4458	3.8191	2.6303
2009	30.1831	3.6195	2.5393
2010	29.8599	3.5584	2.5376
2011	28.2930	3.3075	2.3928
2012	27.6536	3.1490	2.1936
2013	26.6333	2.9516	2.0726
2014	24.8052	2.7974	2.1258
2015	23.9131	2.5144	1.9864
2016	22.6130	2.2621	1.9583

4 Drive a Clean Machine Program

The Drive a Clean Machine (DACM) program provides financial assistance to low-income and moderate-income residents of Travis and Williamson Counties to:

1. Help pay for the cost of repairs needed to pass an emissions test
2. Help pay for a new vehicle if the resident's existing vehicle fails an emissions test
3. Help pay for a new vehicle if the resident's existing vehicle is 10 or more years old

The program achieves emission reduction benefits in the following ways:

1. Improves the compliance rate for the I/M program
2. Accelerates the replacement of higher-emission personal vehicles with lower-emission vehicles

4.1 DACM Program Data FY 2008-2018

On February 1, 2018, TCEQ staff provided CAPCOG with a comprehensive report of the number of repair and replacement vouchers redeemed for Travis and Williamson Counties by state fiscal quarter dating back to state fiscal year (FY) 2008, quarter 2 (Dec. 1, 2007 – Feb. 28, 2008).[12] TCEQ staff further clarified that due to changes in the program that were implemented in December 2007, program records from before December 2007 are not reliable.[13] Since the first quarter of the state fiscal year is September 1 – November 30, CAPCOG December 1, 2007 – November 30, 2008, and each subsequent 12-month period in order to most closely match each analysis year. The following table summarize the number of repair and replacement vouchers redeemed by year.

[12] E-mail from David Serrins, TCEQ, to Andrew Hoekzema, CAPCOG, February 1, 2018.
[13] E-mail from Morris Brown, TCEQ, to Andrew Hoekzema, CAPCOG, March 6, 2018.

Table 4-1. DACM Repairs and Replacements in Travis and Williamson Counties, 2008-2017

Year	Repairs	Replacements	Total Vehicles
2008	230	964	**1,194**
2009	421	933	**1,354**
2010	443	624	**1,067**
2011	279	310	**589**
2012	510	75	**585**
2013	466	204	**670**
2014	433	199	**632**
2015	252	165	**417**
2016	138	156	**294**
2017	99	145	**244**
TOTAL	**3,271**	**3,775**	**7,046**

4.2 I/M Compliance Factor Benefits

The compliance rate is one of three components of the "compliance factor" used in modeling on-road emissions in EPA's MOVES model:

$$Compliance\ Factor = Compliance\ Rate\ \times (1 - Waiver\ Rate) \times Regulatory\ Class\ Coverage\ Factor$$

The compliance factor represents the fraction of vehicles within a given source use type (SUT) that are in compliance with an I/M program.

The regulatory class coverage factor is a number from 0-1 that represents the fraction of vehicles in a given source use type that is subject to I/M testing. EPA's assumption in the MOVES model is that vehicles with gross vehicle weight ratings of 8,501 or more are exempt from I/M testing, although this is not the case in Travis and Williamson Counties. However, since EPA only has reference emissions rates for vehicles subject to I/M programs that have this exemption level, MOVES is not able to model emission impacts from an I/M program on vehicles with GVWR of 8,501 or more. The default regulatory class coverage factors for personal vehicles are shown below:

- Passenger Cars: 100%
- Passenger Trucks: 94%

The waiver rate is the percentage of vehicles that fail an emissions test that are issued a waiver to continue operating despite the test failure. EPA's default assumption is that the wavier rate is 3%. The higher the waiver rate, the lower the emission reduction benefit is from an I/M program. By providing a mechanism for avoiding issuing waivers, the DACM program helps keep the waiver rate low.

In Texas, there are several types of waivers and extensions available:[14]

[14] https://www.tceq.texas.gov/airquality/mobilesource/vim/waivers.html

- Individual vehicle waivers: a vehicle owner has spent at least $600 on emission-related repairs and is still unable to pass an emissions inspection or qualify for another type of waiver
- Low-mileage waivers: available if the vehicle fails both an initial test and free retest, is driven less than 5,000 miles a year, and the owner incurred at least $100 of emissions-related repairs
- Low-income time extensions: available : available if the motorists' income is below the national poverty level; available every other year
- Parts availability time extensions: available if there is difficulty in obtaining an uncommon part

Actual program data from Travis and Williamson Counties has shown the waiver rate to be far lower – just 0.27% in 2012. Out of the 149 waivers issued in 2012, 92 were for individual vehicle waivers, 39 for low-income time extensions, 18 for low-mileage waivers, and 0 for parts availability waivers. During FY 2012, Travis County and Williamson County issued a total of 466 repair vouchers. It can be assumed that these vehicle owners would otherwise have qualified for the individual vehicle waiver, the low-mileage waiver, or the low-income time extension.

The third component of the compliance factor is the compliance rate. The compliance rate represents the percentage of vehicles subject to the I/M program that actually participate (legally) in the program, whether or not they pass their emissions test. EPA's default assumption is a 96% compliance rate. However, a study by ERG on the emission reduction benefits of the I/M program in 2015 found lower compliance rates and accounted for incidence of fraud. The compliance rate calculated by ERG included both a "participation rate" and a "fraud rate:"[15]

- Participation Rate: 86.17%
- Fraud Rate for On-Board Diagnostic (OBD) testing: 0.89%
- Compliance Rate for Vehicles Subject to Two-Speed Idle (TSI) testing: 86.17%
- Compliance Rate for Vehicles Subject to OBD testing: 85.40%

The participation rate represents the percentage of vehicles that actually came in for an emissions inspection test within the time frame it was required to. By providing a mechanism for funding emission repairs that may be needed, the DACM program may also be increasing the participation rate to the extent that a motorist may simply avoid bringing in his or her vehicle for inspection if he or she fears (or is certain) that their vehicle would not pass an emissions test. It would also tend to decrease the incidence of fraud.

ERG used remote sensing data and program data to estimate this percentage by dividing the number of vehicles identified subject to testing that came in for a test by the total number of vehicles subject to testing. The MOVES model is able to generate emissions estimates for an area with and without an I/M program by comparing reference rates from areas that had I/M programs to areas that did not. The full benefit represents the I/M benefit that would be expected if there was 100% regulatory class coverage, 0% wavier rate, and 100% compliance rate. The compliance factor, therefore, represents the percentage of the I/M benefit that a particular area receives from subjecting that vehicle source use type to

[15] http://www.capcog.org/documents/airquality/reports/2015/Austin_Area_I-M_Benefit_Analysis_2015_revised_2015_12_16.pdf

emissions testing. While it is possible (and perhaps likely) that a vehicle that is not participating in the I/M program is more likely to fail a test, and therefore there might be non-linear impacts from increasing or decreasing the compliance factor, this is not the case in the MOVES model.

4.3 Repair Assistance Emission Reduction Benefits

The I/M program primarily achieves emissions benefits by compelling motorists to repair failing emissions-related components on their vehicles. The existence of an I/M program may cause motorists to complete these repairs prior to an initial test, but it is difficult to figure out exactly how many vehicles this behavior would impact. However, program data do provide information on the number of vehicles that fail an initial test and subsequent retests. It is possible to assign the emission reduction benefit associated with the I/M program to the number of vehicles that failed an initial test and subsequently passed a test.

Table 4-2. Initial Emission Test Failure Data for Autos, LDT1, and LDT2

Year	Initial Tests	Initial Failures	Initial Failure Rate
2008	696,650	41,837	6.01%
2009	728,380	49,079	6.74%
2010	771,107	50,112	6.50%
2011	803,587	52,339	6.51%
2012	817,343	53,359	6.53%
2013	839,728	52,174	6.21%
2014	880,501	52,344	5.94%
2015	817,840	47,369	5.79%
2016	999,478	54,213	5.42%

Based on the average daily emission reductions calculated for light duty vehicles in the previous section and the number of initial failures listed above, the following table shows the average daily emission reduction benefit of the I/M program per vehicle failing an emissions test.

Table 4-3. Avg. I/M Program Daily Emission Reduction Benefit Per Failing Light-Duty Vehicle (lbs)

Year	CO	NO_X	VOC
2008	1.5417	0.1815	0.1250
2009	1.1866	0.1466	0.1029
2010	1.1505	0.1412	0.1007
2011	1.0448	0.1257	0.0909
2012	1.0024	0.1174	0.0817
2013	0.9899	0.1126	0.0790
2014	0.9200	0.1064	0.0808
2015	0.9820	0.1058	0.0834
2016	0.8123	0.0832	0.0718

If you then multiply this benefit by the number of repair vouchers that were issued, you are able to obtain an estimate of the CO, NO_X, and VOC emission reduction benefits from the repair assistance part of the DACM program.

Table 4-4. DACM Repair Assistance CO, NO_X, and VOC Reduction Benefits by Year

Year	CO (lbs/day)	NO_X (lbs/day)	VOC (lbs/day)
2008	1.5417	0.1815	0.1250
2009	1.1866	0.1466	0.1029
2010	1.1505	0.1412	0.1007
2011	1.0448	0.1257	0.0909
2012	1.0024	0.1174	0.0817
2013	0.9899	0.1126	0.0790
2014	0.9200	0.1064	0.0808
2015	0.9820	0.1058	0.0834
2016	0.8123	0.0832	0.0718

CAPCOG then multiplied the daily emission reduction benefit by the number of repair vouchers issued. The totals are shown below

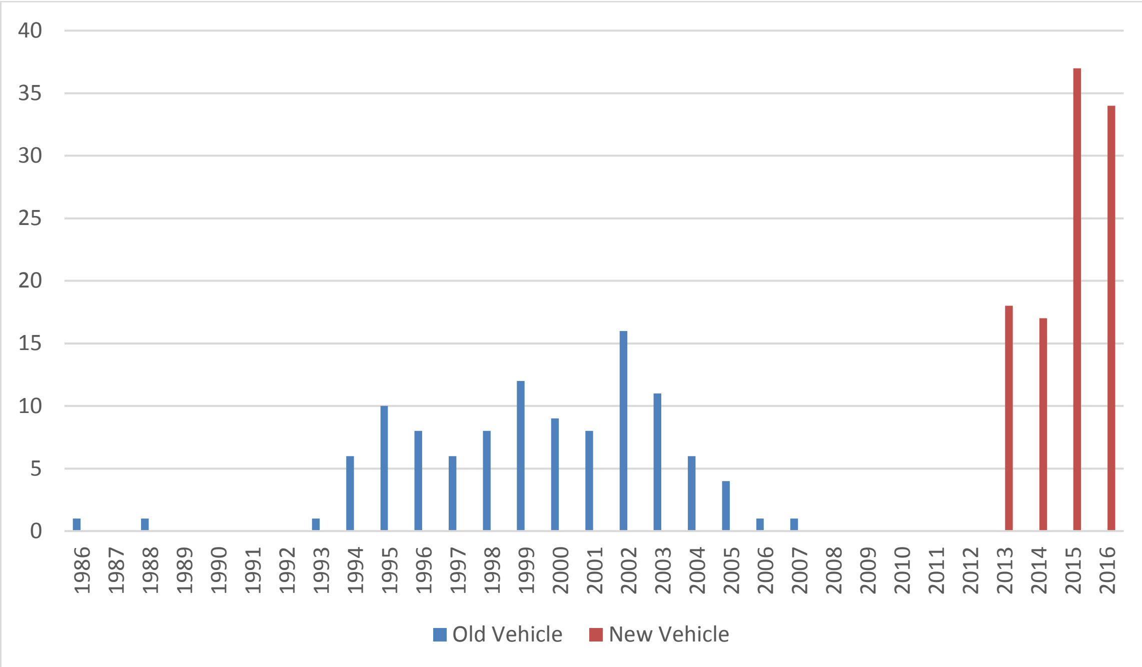
Table 4-5. DACM Repair Assistance CO, NO_X, and VOC Reduction Benefits by Year

Year	CO (tpd)	NO_X (tpd)	VOC (tpd)
2008	0.1773	0.0209	0.0144
2009	0.2498	0.0309	0.0217
2010	0.2548	0.0313	0.0223
2011	0.1457	0.0175	0.0127
2012	0.2556	0.0299	0.0208
2013	0.2306	0.0262	0.0184
2014	0.1992	0.0230	0.0175
2015	0.1237	0.0133	0.0105
2016	0.0560	0.0057	0.0050

4.4 Replacement Assistance

The second type of voucher under the DACM program is a replacement voucher. This voucher provides up to $3,000 for a new, recent model-year vehicle (or up to $3,500 for certain lower-emission vehicles) if a vehicle fails an emissions test or is at least 10 years old. The replacement vehicle must be no more than 2-3 years old, depending on the vehicle type. The following figure shows the age distribution of vehicles that were replaced and the replacement vehicles for FY 2016 Q1 – Q3.

Figure 4-1. Age Distribution of Old and New Vehicles under DACM Replacement Program, FY 2016 Q1 – Q3



The average model year for an old vehicle was 1999, while the average model year for a new vehicle was 2015.

Using a 2018 by-model-year emissions inventory developed by ERG for CAPCOG in 2015, CAPCOG calculated the average change in the emissions rate using model year-specific rates and the average model year. These rate changes and associated calculations are shown below.

Approach 1: multiply number of vehicles in each model year by that model year's emissions rate and calculate weighted averages for old and new vehicles

- Avg. old vehicle emissions rate using detailed approach: 1.6143 grams NO_X/mile
- Avg. new vehicle emissions rate using detailed approach: 0.0505 grams NO_X/mile
- Average change using detailed approach: -1.5639 grams NO_X/mile

Approach 2: compare emissions rate for average model years for old and new vehicles

- 1999 vehicle emissions rate: 1.7662 grams NO_X/mile
- 2015 vehicle emissions rate: 0.0413 grams NO_X/mile
- Change in vehicle emissions rate: -1.7249 grams NO_X/mile

Since approach 1 is more accurate and provides a more conservative estimate, CAPCOG decided to use this approach. The rates below represent the emissions rates using the 2018 inventory for 2013-2016, shifting the vehicle counts by 1 model year for each analysis year. CAPCOG used the 2012 inventory for 2008-2012.

Table 4-6. Change in Vehicle Emissions Rate by Year (grams NO_X/mile)

Year	Old Vehicle Rate	New Vehicle Rate	Difference
2008	3.4626	0.3341	-3.1285
2009	3.3185	0.2260	-3.0925
2010	3.1557	0.1604	-2.9953
2011	2.9348	0.1208	-2.8140
2012	2.6689	0.0870	-2.5820
2013	2.4718	0.0794	-2.3924
2014	2.2001	0.0694	-2.1307
2015	1.8895	0.0591	-1.8304
2016	1.6143	0.0491	-1.5652

Based on an average annual mileage of 12,000 and the number of vehicle replacements each year, CAPCOG calculated the incremental change in daily NO_X emissions from vouchers redeemed in that year are shown below. If you assume that these replacements achieved up to 5 years of benefits (in light of the standard replacement voucher being for $3,000, compared to the standard repair voucher being for $600), it is possible to calculate multi-year benefits from the program. CAPCOG was not able to locate data on replacements for 2006 or 2007 (the region started implementing the program at the beginning of FY 2006), and so we used the 2008 replacement vouchers as the estimate of the number of replacement vouchers redeemed in 2006 and 2007 and calculated the marginal emission reduction impact from these years.

- 2006: -2.9447 g NO_X/mile
- 2007: -3.0838 g NO_X/mile

Table 4-7. NO_X Emissions from DACM Replacement Vouchers Issued in Each Year (grams)

Year	Replacements	Incremental NO_X Impact (tpd)	Cumulative NO_X Impact (tpd)
2006	964	-0.1029	-0.1029
2007	964	-0.1077	-0.2106
2008	964	-0.1093	-0.3199
2009	933	-0.1046	-0.4245
2010	624	-0.0677	-0.4922
2011	310	-0.0316	-0.4209
2012	75	-0.0070	-0.3202
2013	204	-0.0177	-0.2286
2014	199	-0.0154	-0.1394
2015	165	-0.0109	-0.0826
2016	156	-0.0088	-0.0599

Due to the labor-intensive nature of this particular analysis, CAPCOG only calculated the NO_X reduction benefits for this project, but plans to use this same approach for developing estimates of emission benefits for other pollutants using this same methodology.

4.5 Summary for DACM

The following table summarizes the NO_X emissions reductions from the DACM program from 2008-2016.

Table 4-8. DACM Summary (tpd NO_X)

Year	Repair	Replacement (cumulative)	Combined
2008	0.0209	0.3199	0.3408
2009	0.0309	0.4245	0.4553
2010	0.0313	0.4922	0.5235
2011	0.0175	0.4209	0.4385
2012	0.0299	0.3202	0.3502
2013	0.0262	0.2286	0.2549
2014	0.0230	0.1394	0.1625
2015	0.0133	0.0826	0.0960
2016	0.0057	0.0599	0.0656

5 Energy Efficiency and Renewable Energy Measures Implemented by AE

Austin Energy (AE) is one of the largest public electric utilities in the country and has implemented a wide array of energy efficiency (EE) and renewable energy (RE) measures throughout the years. Both of these types of measures can help reduce emissions from point source electric generating units (EGUs) within the Electric Reliability Council of Texas (ERCOT) grid by reducing the demand for electricity from fossil fuel power plants. EE measures reduce overall demand, while RE measures displace electricity generated from fossil fuel plants with electricity generated by wind or solar power. CAPCOG obtained the estimated energy efficiency savings, the wind power capacity, the utility-scale solar capacity, and the rooftop solar panel installations attributable to AE's programs. These data were obtained from AE's annual performance reports for 2011 and 2015.[16] Data for 2016 is not yet available on AE's website.

CAPCOG used EPA's AVoided Emissions and geneRation Tool (AVERT)[17] in order to model the emission reduction benefits from these measures. AVERT represents the dynamics of electricity dispatch based on the historical patterns of actual generation in a selected year. EPA currently has data available for 2007-2016. AVERT's statistical module uses "prepackaged" data from EPA's Air Markets Program Data (AMPD) and National Emissions Inventory (NEI) to perform statistical analysis on actual behavior of past generation, heat input, $PM_{2.5}$, SO_2, NO_X, and CO_2 emissions data given various regional demand levels. AVERT's statistical module produces regional data files that are input files used in AVERT's Excel-based main module. AVERT's main module prompts users to select one of 10 AVERT Regional Data Files (including ERCOT) and enter EE/RE impacts (MWhs or MW) from a selection of options. The AVERT main module performs emissions displacement calculations based on the hourly electric generating unit information in the regional data files and the EE/RE impacts entered into the tool.

[16] https://austinenergy.com/ae/about/reports-and-data-library/corporate-reports
[17] https://www.epa.gov/statelocalenergy/avoided-emissions-and-generation-tool-avert

Since the tool uses actual historical electricity dispatch, CAPCOG entered the values identified in AE's reports for each year as negative values in order to estimate the increase in emissions that would have occurred had these measures not been implemented. This number is not the same as entering a positive value, which would be the estimate of additional energy efficiency savings or renewable energy power.

Table 5-1. AVERT Model Inputs for Austin Energy

Year	Energy Efficiency Savings (GWh)	Wind (MW)	Utility Solar (MW)	Rooftop Solar (MW)
2008	-132.3	-273.2	0.0	-2.3
2009	-102.1	-438.2	0.0	-3.5
2010	-89.1	-438.2	0.0	-4.6
2011	-117.3	-438.2	-30.0	-6.2
2012	-108.6	-633.9	-30.0	-8.3
2013	-117.2	-850.9	-30.0	-13.5
2014	-127.7	-840.9	-30.0	-22.3
2015	-152.7	-1,340.6	-30.0	-27.5
2016[18]	-152.7	-1,340.6	-30.0	-27.5

CAPCOG then ran the AVERT module for each calendar year from 2008-2016 using all of the inputs identified above simultaneously.

Table 5-2. AVERT Annual Outputs Statewide

Year	Energy Generated (MWh)	SO_2 (lbs)	NO_X (lbs)	CO_2 (tons)	$PM_{2.5}$ (lbs)
2008	953,830	1,465,420	739,930	660,970	55,500
2009	1,407,910	2,278,670	1,134,070	927,000	79,680
2010	1,399,030	2,339,570	936,410	949,470	102,170
2011	1,482,310	2,076,940	1,045,330	969,360	90,380
2012	2,057,280	2,709,130	1,257,060	1,419,950	131,850
2013	2,715,790	4,227,060	1,908,560	1,836,520	193,290
2014	2,700,520	3,940,540	1,799,660	1,754,110	187,740
2015	4,224,370	5,968,500	2,752,370	2,956,850	324,900
2016	4,235,220	7,083,160	2,863,030	3,131,880	343,130

Table 5-3. AVERT Annual Outputs Austin-Round Rock MSA

Year	Energy Generated (MWh)	SO_2 (lbs)	NO_X (lbs)	CO_2 (tons)	$PM_{2.5}$ (lbs)
2008	57,270	890	41,820	35,130	3,550
2009	93,110	380	53,220	47,480	4,670
2010	102,180	660	57,400	49,790	5,060
2011	106,440	720	71,450	52,590	4,860
2012	114,870	3,710	51,940	57,710	5,420

[18] Used 2015 data

Year	Energy Generated (MWh)	SO_2 (lbs)	NO_X (lbs)	CO_2 (tons)	$PM_{2.5}$ (lbs)
2013	141,240	3,340	61,690	71,460	6,260
2014	117,310	1,110	47,950	56,860	4,340
2015	204,700	1,080	118,220	104,790	7,820
2016	146,810	880	100,560	77,850	5,550

Table 5-4. AVERT Ozone Season Outputs Austin-Round Rock MSA

Year	SO_2 (lbs)	NO_X (lbs)	$PM_{2.5}$ (lbs)
2008	630	23,730	1,660
2009	170	25,740	2,290
2010	300	26,000	2,260
2011	290	39,310	2,280
2012	3,330	29,360	2,550
2013	3,010	40,030	3,110
2014	440	34,830	2,020
2015	560	76,280	3,530
2016	450	69,960	3,270

Table 5-5. OSD NO_X Emissions Impact from AE EE/RE Measures in the Austin-Round Rock MSA by County (tpd)

Year	Bastrop	Hays	Travis	TOTAL
2008	0.0237	0.0025	0.0513	0.0775
2009	0.0288	0.0031	0.0522	0.0841
2010	0.0413	0.0040	0.0397	0.0850
2011	0.0476	0.0042	0.0767	0.1285
2012	0.0318	0.0046	0.0596	0.0959
2013	0.0479	0.0053	0.0776	0.1308
2014	0.0348	0.0044	0.0746	0.1138
2015	0.0783	0.0043	0.1667	0.2493
2016	0.0842	0.0053	0.1391	0.2286

Since AE's corporate report also included estimates of CO_2, NO_X, and SO_2 and emission reduction estimates from its EE/RE measures using different methods, CAPCOG compared these emissions impacts in the table below.

Table 5-6. Comparison of AE Estimate of Avoided Emissions to AVERT Estimate for 2015

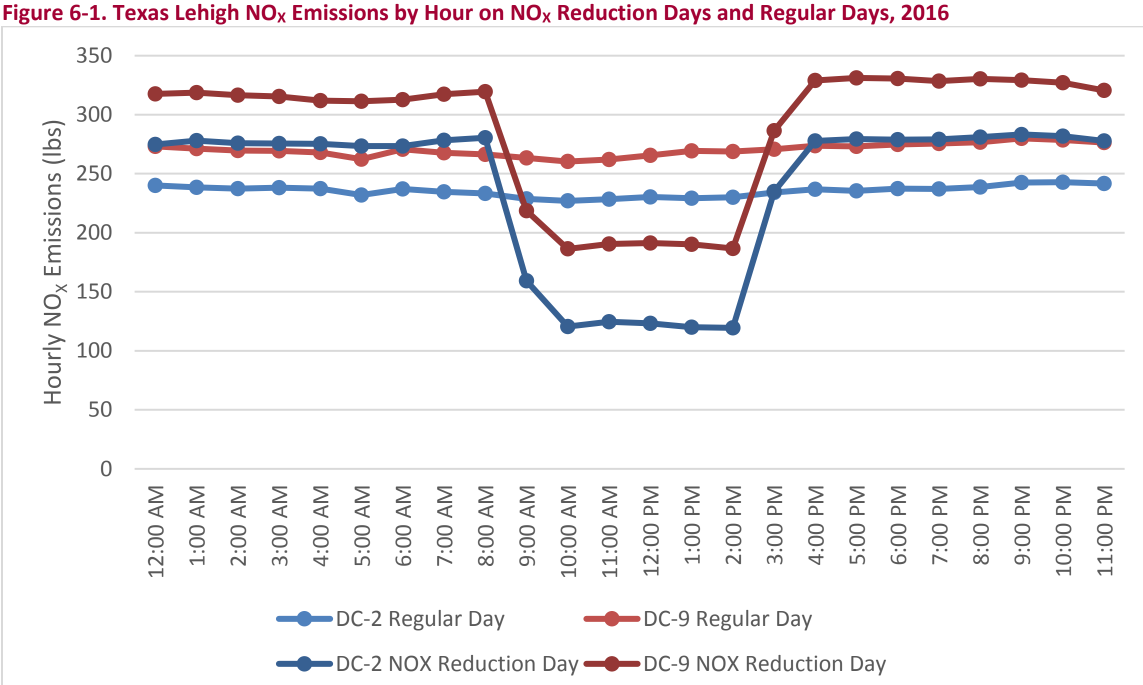
Total	AE Report	AVERT
CO_2	1,926,656	2,956,870
NO_X	1,181	1,376
SO_2	3,558	2,984

6 Texas Lehigh Cement Company NO_X Emission Reduction Measure

Texas Lehigh Cement Company operates a selective non-catalytic reduction (SNCR) NO_X control device on its cement plant in Buda in order to stay within monthly NO_X limitations, but does not typically operate the control device to its maximum NO_X reduction potential. In 2009, as part of the "Big Push" to reduce emissions during the 2009 O_3 season, Texas Lehigh agreed to voluntarily implement and episodic NO_X reduction measure that involved operating the SNCR at its maximum NO_X reduction potential between 9 am and 3 pm on predicted high ozone days. Following the 2009 O_3 season, Texas Lehigh did not again implement this measure until 2013, when the company voluntarily agreed to resume this measure following a meeting with CAPCOG staff. Texas Lehigh ultimately joined the Clean Air Coalition later in the year and has been implementing this measure ever since.

The following figure shows a comparison of the facility's NO_X emissions on a typical ozone season day in 2016 compared to the NO_X emissions on a day when the facility implemented the NO_X reduction measure.

Figure 6-1. Texas Lehigh NO_X Emissions by Hour on NO_X Reduction Days and Regular Days, 2016



This measure results in an average reduction of 0.5 tons of NO_X emitted between 9 am and 3 pm, although overall NO_X emissions for the day are about the same, since Texas Lehigh has to avoid exceeding its permitted ammonia emissions as well, and increased SNCR usage increases NH_3 emissions. CAPCOG's prior annual reports covering 2013-2016 provide details on Texas Lehigh's implementation of this measure during those years. A 2015 modeling study by CAPCOG included modeled ozone impacts of this measure.[19]

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

7 Other Quantification Methods CAPCOG Developed

Apart from the measures specifically accounted for above, there are hundreds of other individual emission reduction efforts that CAC members have undertaken over the years. While CAPCOG did not develop estimates of the emission reductions from these efforts over the years, CAPCOG did develop several frameworks that could be used to develop broad estimates of potential impacts from various categories of emission reduction categories that CAC members could undertake. This includes:

1. An updated framework for calculating emission reduction benefits from commuter reduction programs that can be incorporated into the Clean Air Partners Program reporting tool
2. An framework for providing an overall assessment of an organization's NO_X impact

CAPCOG did develop a general framework for assessing each organization's emissions impact based on high-level operational data reported by each organization, including the number of employees, electricity consumption, natural gas consumption, water consumption, and transportation fuel consumption. This framework allows for analysis of the scale of emissions impact that measures implemented by the organization might have made.

CAPCOG also developed an updated framework for quantifying emission reductions from commuter-related programs, which should help enable future quantification efforts for the Clean Air Partners Program (CAPP) and other assessments of the emissions impacts of commuter programs.

7.1 Framework for Updating CAPP Reporting Tool Commuter Emissions Reductions

The following table shows the average emissions rates for passenger vehicles for 2008-2018, based on TCEQ's "trend" emissions inventories.

Table 7-1. Average Passenger Car NO_X, VOC, and CO_2 Emissions by Year for CAPP Reporting Tool

Year	NO_X (lbs/mi.)	VOC (lbs/mi.)	CO_2 (lbs/mi.)
2008	0.001829	0.001208	0.908499
2009	0.001736	0.001173	0.906070
2010	0.001663	0.001138	0.904206
2011	0.001553	0.001078	0.902828
2012	0.001420	0.000947	0.895746
2013	0.001306	0.000874	0.887069
2014	0.001190	0.000820	0.875268
2015	0.001048	0.000751	0.863232
2016	0.000918	0.000673	0.848588
2017	0.000666	0.000586	0.832622
2018	0.000576	0.000539	0.818017

These questions and the associated output estimate the emissions reductions associated with employee commuting & education programs in the current year to a baseline year.

Table 7-2. Updates Proposed for CAPP Reporting Tool for Calculating Commuter Emission Reductions

Assumption	Existing Reporting Tool	Proposed for New Reporting Tool	Explanation/Rationale
Percentage of Employees who Commute by Driving Alone	100% of reported # of employees, unless otherwise specified	76.92% of reported # of employees, unless otherwise specified	More representative of a typical employer; Based on 2015 1-year American Community Survey Data for the Austin-Round Rock MSA
Percentage of Employees who Commute by Using CapMetro's Vanpool Groups? (associated with Q6) **RECOMMENDED QUESTION CHANGE:** **"On average, how many employees per day ride in carpool/vanpool groups with 5 or more people?"**	0% of reported # of employees, unless otherwise specified	0.05% of reported # of employees OR 0.51% of reported # of employees	0.05% represents estimated % of commuters who used CapMetro's RideShare vanpools in 2015, based on ½ of the average number of daily boardings reported in December 2015 0.51% represents the estimated % of commuters who use carpools with 5 or more people
Percentage of Employees who Commute in Carpools (associated with Q7, assumed to be 2-4 people) **RECOMMENDED QUESTION CHANGE:** **"On average, how many employees per day ride in carpool groups of 2-4 people?"**	0% of reported # of employees, unless otherwise specified	8.78% of reported # of employees	More representative of a typical employer; Based on 2015 1-year American Community Survey Data for the Austin-Round Rock MSA
Percentage of Employees who Telecommute (Q	0% of reported # of employees, unless otherwise specified	7.69% of reported # of employees	Represents % of employees who report working from home

Assumption	Existing Reporting Tool	Proposed for New Reporting Tool	Explanation/Rationale
Percentage of Employees who Commute via bike, walking, or transit? (Q9) **RECOMMENDED QUESTION CHANGE: split into 3 parts:** **% of employees who commute via bike** **% of employees who commute via walking** **% of employees who commute via transit**	0% of reported # of employees, unless otherwise specified	4.84% of reported # of employees (2.34% for public transit + 0.81% for bicycle + 1.69% for walking)	More representative of a typical employer; Based on 2015 1-year American Community Survey Data for the Austin-Round Rock MSA

Data needed to calculate employee commuting emissions

1. On a typical work day, how many total employees per day (including temporary/seasonal workers) worked at your location?
2. On a typical work day, what percentage of all employees that commuted to work by car, truck, or van and drove alone? (NOTE: THIS WAS CALCULATED IN THE OLD SPREADSHEET; default = 76.92%)
3. On typical work day, what is the percentage of all employees that commuted to work by car, truck, or van in a carpool or vanpool with 2-4 people in it? (corresponds to old Question # 6; default = 8.78%)
4. On a typical work day, what is the percentage of all employees that commuted to work by car, truck, or van in a carpool or vanpool with 5 or more people in it? (corresponds to old Question #7, default = 0.51%)
5. On a typical work day, what is the percentage of all employees that commuted to work by public transit (one component of old Question #9; default = 2.34%)
6. On a typical work day, what is the percentage of all employees that commuted to work by taxicab (not included in old questions; default = 0.07%)
7. On a typical work day, what is the percentage of all employees that commuted to work by motorcycle (not included in old questions; default = 0.29%)
8. On a typical work day, what is the percentage of all employees that commuted to work by bicycle (one component of old question #9, default = 0.81%)

9. On a typical work day, what is the percentage of all employees that commuted to work by walking (one component of old question #9; default = 1.69%)
10. On a typical work day, what is the percentage of all employees that worked at home (corresponds to question # 8, default = 7.69%)
11. On a typical work day, what is the percentage of all employees that commutes to work by some other means (not included in old questions; default = 0.90%)
12. During a typical week, what percentage of all employees are full-time employees who worked a compressed work schedule of 4 days a week rather than 5 days a week? (corresponds to old question 2; default = 0%)
13. During a typical two-week period, what percentage of all employees worked a full-time employees worked a scheduled that enabled them to work 9 days rather than 10 days? (corresponds to old question 3; default = 0%)

[# Employees (Q1)] * [% Employees who Drove Alone (Q2)] * [1 vehicle per person for Employees who Drove Alone] * [Average Round-Trip Commute Distance Per Day] * [% of Employees who Do Not Work Compressed Schedules] * [240 work days per year] * [NO_X emissions rate for passenger vehicles in terms of lbs/mile] = **lbs of NO_X emissions for single-occupancy vehicle commuters working a normal schedule**

[# Employees (Q1)] * [% Employees who Drove Alone (Q2)] * [1 vehicle per person for Employees who Drove Alone] * [Average Round-Trip Commute Distance Per Day] * [% of Employees who work 4 days out of 5 (Q12)] * [240 work days per year] * [80% of work days worked] * [NO_X emissions rate for passenger vehicles in terms of lbs/mile] = **lbs of NO_X emissions for single-occupancy vehicle commuters working a four day/ten-hour schedule**

[# Employees (Q1)] * [% Employees who Drove Alone (Q2)] * [1 vehicle per person for Employees who Drove Alone] * [Average Round-Trip Commute Distance Per Day] * [% of Employees who work 9 days out of 10 (Q12)] * [240 work days per year] * [90% of work days worked] * [NO_X emissions rate for passenger vehicles in terms of lbs/mile] = **lbs of NO_X emissions for single-occupancy vehicle commuters working a four-ten schedule**

[# Employees (Q1)] * [% Employees who Commuted in 2-4-Person Carpools (Q3)] * [1 vehicle per person for Employees who Drove Alone] * [Average Round-Trip Commute Distance Per Day] * [% of Employees who Do Not Work Compressed Schedules] * [240 work days per year] * [NO_X emissions rate for passenger vehicles in terms of lbs/mile] = lbs of NO_X emissions for single-occupancy vehicle commuters working a normal schedule

[# Employees (Q1)] * [% Employees who Commuted in 2-4-Person Carpools (Q3)] * = # of Employees who Drove in 2-4-Person Carpools

[# Employees (Q1)] * [% Employees who Commuted

7.1.1 Existing Assumptions

The following information reflects the existing equations and assumptions in the model:

EmployeesPerYear*NOxVehicleEmissionsFactor*CommuteDistance*WorkDaysPerYear = Baseline NO_X

EmployeesPerYear*VOCVehicleEmissionsFactor*CommuteDistance*WorkDaysPerYear = Baseline VOC

- NOxVehicleEmissionsFactor = 0.001601 lbs/mile (2005-2007 avg. from Mobile6 CAMPO factors from October 2004)
- VOCVehicleEmissionsFactor = 0.001549 lbs/mile (2005-2007 avg. from Mobile6 CAMPO factors from October 2004)
- CommuteDistance: 22.6 miles
- WorkRelatedTravelDistance: 13.56 miles (commute distance *0.6)
- PersonalErrandTravelDistance: 13.56 miles (commute distance*0.6)
- WorkDaysPerYear = 240 (260 weekdays minus 10 holidays and 10 days of vacation/sick leave)
- FlexSchedBenefit: 0.5%
- TelecommuteBenefit: 100%
- VanpoolBenefit: 80% (assuming avg. vanpool size of 5 people)
- CarpoolBenefit: 60% (assuming avg. carpool size of 2.5 people)
- BikeWalkBusBenefit: 100%
- Four10SchedulePercentBenefit: 20% (1 out of every 5 days not working)
- Nine9SchedulePercentBenefit: 10% (1 out of every 10 days not working)
- HybridVehicleBenefit: 50%
- VehicleEducationBenefit: 0.1%

This approach assumes 100% of employees commute by single-occupancy vehicle unless otherwise reported above and uses outdated NO_X and VOC emissions rates.

7.1.2 New Data

7.1.2.1 Emission Rates

The following table shows updates NO_X and VOC rates and also includes CO_2 rates for 2008-2018.

Table 7-3. Average Passenger Car NO_X, VOC, and CO_2 Emissions by Year for CAPP Reporting Tool

Year	NO_X (lbs/mi.)	VOC (lbs/mi.)	CO_2 (lbs/mi.)
2008	0.001829	0.001208	0.908499
2009	0.001736	0.001173	0.906070
2010	0.001663	0.001138	0.904206
2011	0.001553	0.001078	0.902828
2012	0.001420	0.000947	0.895746
2013	0.001306	0.000874	0.887069
2014	0.001190	0.000820	0.875268
2015	0.001048	0.000751	0.863232

Year	NO_X (lbs/mi.)	VOC (lbs/mi.)	CO_2 (lbs/mi.)
2016	0.000918	0.000673	0.848588
2017	0.000666	0.000586	0.832622
2018	0.000576	0.000539	0.818017

Source:
ftp://amdaftp.tceq.texas.gov/pub/EI/onroad/mvs14_trends/ei_tables/mvs14_trends.annual_by_sut_fuel.zip

- Note:
  - the estimated average NO_X emissions rate for 2005-2007 is 0.002618 lbs NO_X/mile
  - the estimated average VOC emissions rate for 2005-2007 is 0.004461 lbs VOC/mile

7.1.2.2 Commuting Mode

One of the problems with the existing reporting tool is that it assumes that the baseline for calculating emission reductions from commuting is 100% single-occupancy vehicle (SOV) commuting. This fails to account for the fact that, within the region, 23.08% of commuters use some other mode to get to work, and so a company could get "credit" for having just 10% of its employees use alternatives to SOV commuting, even though this is 13.08% lower than the average for all employees region-wide. The table below outlines the basis for an alternative baseline.

Table 7-4. Austin-Round Rock MSA Commuting Data – 2015 ACS 1-Year Data[20]

Commuting Mode	Number	Percentage
Car-Drove Alone	795,865	76.92%
Carpooled	96,104	9.29%
Public Transportation	24,249	2.34%
Taxicab	757	0.07%
Motorcycle	2,964	0.29%
Bicycle	8,387	0.81%
Walked	17,450	1.69%
Worked at Home	79,566	7.69%
Other Means	9,263	0.90%
TOTAL	**1,034,605**	**100.00%**

7.1.2.3 Avg. Carpool Size

CAPCOG also updated the assumed carpool size based on American Community Survey data. The existing assumption was that regular carpools are 2-4 people

Number of People in Carpool	Commuters	Vehicles	Vehicles/Carpooler
2	74,333	37,166.5	0.500
3	12,496	4,165.3	0.333
4	3,966	991.5	0.250
TOTAL	**90,795**	**42,323.3**	**0.466**

[20] ACS_15_1YR_B08301_with_ann

7.2 Framework for Assessing Organization-Wide Emissions Impact

For CAPCOG's 2015 annual report, CAPCOG developed organization-wide NO_X emissions impacts for each CAC member based on some key top-level data, such as employment, electricity consumption, fuel consumption, and others.

- Commuting: 5.206620 lbs NO_X/employee/year
- Natural gas: 0.000100 lbs NO_X/CF consumed
- Electricity: 0.000616 lbs NO_X/kWh consumed
- Water: 3.193587 lbs NO_X/million gallons consumed
- Diesel: 0.095687 lbs NO_X/gallon consumed
- B20: 0.093791 lbs NO_X/gallon consumed
- Gasoline: 0.025983 lbs NO_X/gallon
- E85: 0.034988 lbs NO_X/gallon
- LPG: 0.043273 lbx NO_X/gallon
- CNG: 0.064562 lbs NO_X/GGE

CAPCOG is in the process of developing a supplemental report that will fully document each of these estimates and provide additional estimates for all years from 2008-2016.

8 Summary

The following table summarizes the NO_X reduction benefits from the programs analyzed in this report.

Table 8-1. Quantified NO_X Reductions by Year and Program (tpd)

Year	TERP	I/M	DACM Repair	DACM Replacement	EE/RE	Texas Lehigh	TOTAL
2008	1.1036	3.8191	0.0209	0.3199	0.0775	0.0000	**5.3410**
2009	1.5258	3.6195	0.0309	0.4245	0.0841	0.5078	**6.1926**
2010	1.8290	3.5584	0.0313	0.4922	0.0850	0.0000	**5.9959**
2011	2.0126	3.3075	0.0175	0.4209	0.1285	0.0000	**5.8871**
2012	2.0294	3.1490	0.0299	0.3202	0.0959	0.0000	**5.6245**
2013	1.8334	2.9516	0.0262	0.2286	0.1308	0.5078	**5.6785**
2014	1.8113	2.7974	0.0230	0.1394	0.1138	0.5078	**5.3928**
2015	1.6345	2.5144	0.0133	0.0826	0.2493	0.5078	**5.0020**
2016	1.5085	2.2621	0.0057	0.0599	0.2286	0.5078	**4.5726**