Methods to Find the Cost-Effectiveness of Funding Air Quality Projects

For Evaluating Motor Vehicle Registration Fee Projects and Congestion Mitigation and Air Quality Improvement (CMAQ) Projects

Emission Factor Tables
September 2024

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Contents

Preface

This document contains updated emission factors to be used with the "Methods to Find the Cost-Effectiveness of Funding Air Quality Projects" document published in May 2005 (the Methods document). The emission factors below are the latest available as of the publication date. In most cases, it is based on the California Air Resources Board's on-road emission factor model EMFAC, or in the case of off-road emissions data, the Board's emission rate model OFFROAD.

Please note that even though the emission factors have changed since the original publication of the Methods document, the actual methods to apply the rates in that document remain valid.

Summary of Changes

Table 1	Updated emission rates to reflect EMFAC2021 for Calendar Year 2023.
Table 3	Updated emission rates to reflect EMFAC2021 for Calendar Year 2023.
Table 4	Updated emission rates to reflect EMFAC2021 for Calendar Year 2023.
Table 5	Updated emission rates to reflect EMFAC2021 for Calendar Year 2023.

Table 1A. Before Project – Diesel Bus Emission Factors

(Through Model Year 2023)

Pollutant	Calendar Year	Model Year	Emission Factor (gram/mile) Average	Emission Factor (gram/mile) 45 MPH
ROG	2023	Entire Fleet	0.083	0.043
	2023	2007 - 2011	0.156	0.057
	2023	2012 - 2016	0.070	0.041
	2023	2017 - 2021	0.066	0.042
	2023	2022 - 2023	0.055	0.039
CO	2023	Entire Fleet	0.097	0.041
	2023	2007 - 2011	0.191	0.061
	2023	2012 - 2016	0.081	0.039
	2023	2017 - 2021	0.076	0.040
	2023	2022 - 2023	0.059	0.035
NOx	2023	Entire Fleet	0.788	0.266
	2023	2007 - 2011	2.819	1.311
	2023	2012 - 2016	0.407	0.113
	2023	2017 - 2021	0.360	0.108
	2023	2022 - 2023	0.281	0.093
PM2.5 - Exhaust[1]	2023	Entire Fleet	0.007	0.006
	2023	2007 - 2011	0.007	0.006
	2023	2012 - 2016	0.007	0.006
	2023	2017 - 2021	0.007	0.006
	2023	2022 - 2023	0.005	0.005
PM2.5 – Tire Wear	All Years	All Years	0.008	Not Speed Dependent
PM2.5 – Brake Wear	All Years	All Years	0.038	Not Speed Dependent
PM2.5 – Road Dust[2]	All Years	All Years	0.028	Not Speed Dependent

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

[PM2.5 = 0.15*PM10]

[1] Statewide average annual PM2.5 emission factor, weighted by VMT per road category.

[2] The PM2.5 road dust emission factor was calculated using *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011*), and *ARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust (updated Jan. 2013)*.

Table 1B. After Project – Natural Gas Bus Emission Factors

(Through Model Year 2023)

Pollutant	Calendar Year	Model Year	Emission Factor (gram/mile) Average	Emission Factor (gram/mile) 45 MPH
ROG	2023	Entire Fleet	0.038	0.028
	2023	2007 - 2011	0.023	0.008
	2023	2012 - 2016	0.025	0.012
	2023	2017 - 2021	0.055	0.042
	2023	2022 - 2023	0.063	0.045
CO	2023	Entire Fleet	36.634	19.854
	2023	2007 - 2011	28.271	8.689
	2023	2012 - 2016	30.073	8.116
	2023	2017 - 2021	44.247	28.504
	2023	2022 - 2023	51.785	32.939
NOx	2023	Entire Fleet	0.520	0.104
	2023	2007 - 2011	0.721	0.168
	2023	2012 - 2016	0.779	0.182
	2023	2017 - 2021	0.170	0.052
	2023	2022 - 2023	0.119	0.017
PM2.5 - Exhaust[3]	2023	Entire Fleet	0.000	0.001
	2023	2007 - 2011	0.000	0.000
	2023	2012 - 2016	0.000	0.001
	2023	2017 - 2021	0.001	0.001
	2023	2022 - 2023	0.000	0.000
PM2.5 – Tire Wear	All Years	All Years	0.008	Not Speed Dependent
PM2.5 – Brake Wear	All Years	All Years	0.038	Not Speed Dependent
PM2.5 – Road Dust[4]	All Years	All Years	0.028	Not Speed Dependent

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

[PM2.5 = 0.15*PM10]

[3] Statewide average annual PM2.5 emission factor, weighted by VMT per road category.

[4] The PM2.5 road dust emission factor was calculated using *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011*), and *ARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust (updated Jan. 2013)*.

Table 1C. After Project – Electric Bus Emission Factors

(Through Model Year 2023)[5]

Pollutant	Calendar Year	Model Year	Emission Factor (gram/mile) Average	Emission Factor (gram/mile) 45 MPH
PM2.5 – Tire Wear	All Years	All Years	0.008	Not Speed Dependent
PM2.5 – Brake Wear	All Years	All Years	0.019	Not Speed Dependent
PM2.5 – Road Dust[6]**	All Years	All Years	0.028	Not Speed Dependent

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

[PM2.5 = 0.15*PM10]

[5] All-electric vehicles and PHEVs running only on electricity have zero tailpipe emissions.

[6] The PM2.5 road dust emission factor was calculated using *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011*), and *ARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust (updated Jan. 2013)*.

Table 2 Emission Factors for Cleaner Vehicles for Light-Duty and Medium-Duty Trucks/SUVs (Chassis-Certified)

Baseline (Older) Technology Vehicles

Average New Truck in 2010 (note: emission factor units are grams/mile and weight units are pound)

Weight[7]	ROG	NOx	PM2.5 Exhaust	PM2.5 Total[8]	CO
Up to 8,500	0.051	0.060	0.010	0.056	2.1
8,501-10,000	0.148	0.195	0.068	0.132	6.2
10,001-14,000	0.173	0.390	0.068	0.137	7.1

Replacement (Newer) Technology Cleaner Vehicles

Projected Average New Trucks in 2020 (note: emission factor units are grams per mile)

Weight[7]	ROG	NOx	PM2.5 Exhaust	PM2.5 Total[8]	CO
Up to 8,500	0.043	0.054	0.003	0.049	1.8
8,501-10,000	0.104	0.149	0.008	0.072	5.7
10,001-14,000	0.155	0.245	0.010	0.079	6.4

Replacement (Newer) Technology Cleaner Vehicles

Zero-emission light-duty and medium-duty vehicles (ZEV) (note: emission factor units are grams per mile)

Weight[7]	ROG	NOx	PM2.5 Exhaust	PM2.5 Total[8]	CO
Up to 8,500	0	0	0	0.046	0
8,501-10,000	0	0	0	0.064	0
10,001-14,000	0	0	0	0.069	0

See notes on next page.

[7] Gross vehicle weights can be associated with payload capacity as follows: 5751-8500 lb, roughly 1-ton payload; 8501-10,000 lb, roughly 1.8-ton payload; 10,001-14,000 lb, 2.5-ton payload.

[8] Total PM2.5 factors include motor vehicle exhaust, tire wear, brake wear, and entrained road dust.

Sources:

The baseline is California Vehicle Exhaust Standards ("LEV II") for average chassis-certified trucks for model year 2010. Factors assume emissions at the 50,000 mile standard for the first 50,000 miles of the car's life (assumed to be 120,000 miles) and emissions at the 120,000 mile standard for the last 70,000 miles of the car's life.

Cleaner Vehicle Emission Factors are from the California Vehicle Exhaust Standards for MYs after 2016 ("LEV III") evaluated for calendar year 2020.

The road dust portion of the PM2.5 emission factor was calculated from equation 1 of Chapter 13.2.1.3 of *AP-42 Compilation of Air Pollutant Emission Factors Vol 5*. US EPA Jan 1995. The equation's silt loading and other parameters came from Improvement of Specific Emission Factors (BACM Project No 1) provided by the Midwest Research Institute, 1996. Vehicle Trip reductions may have little if any effect on road dust emissions from high-volume facilities thought to be in equilibrium, i.e., the dust is fully entrained due to the heavy traffic. However, the road dust PM factor may be multiplied by the total VMT reductions as it has been scaled down to reflect emissions from lower-volume local and collector roads only. The brake wear emission factors came from a review of recent non-asbestos brake emissions (Section 9 of the EMFAC2011 Technical Documentation).

Table 3A. Average Auto Emission Factors - Gasoline

(Fleet of Light-Duty Passenger Vehicles, Light-Duty Trucks, and Motorcycles)

Analysis Period or Project Life	1-5 Years (2022-2026)	6-10 Years (2022-2031)	11-15 Years (2022-2036)	16-20 Years (2022-2041)
ROG				
VMT (g/mile)	0.058	0.052	0.049	0.046
commute trip ends (g/trip end)	0.609	0.530	0.471	0.425
average trip ends (g/trip end)	0.555	0.489	0.438	0.398
NOx				
VMT (g/mile)	0.074	0.060	0.051	0.045
commute trip ends (g/trip end)	0.291	0.257	0.235	0.220
average trip ends (g/trip end)	0.323	0.287	0.263	0.246
$PM_{2.5}$				
VMT (g/mile)	0.034	0.034	0.034	0.034
running exhaust only (g/mile)	0.001	0.001	0.001	0.001
tire and brake wear (g/mile)	0.005	0.005	0.005	0.005
road dust (g/mile)	0.028	0.028	0.028	0.028
commute trip ends (g/trip end)	0.003	0.003	0.003	0.002
average trip ends (g/trip end)	0.002	0.002	0.002	0.002
CO				
VMT (g/mile)	0.991	0.876	0.804	0.755
commute trip ends (g/trip end)	4.312	3.764	3.377	3.091
average trip ends (g/trip end)	3.717	3.293	2.989	2.764

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

PM2.5, road dust: statewide average annual PM2.5 emission factor is based on *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011*, and *CARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust* (updated Nov. 2016).

[PM2.5 = 0.15*PM10]

Table 3B. Average Auto Emission Factors – Electric

(Fleet of Light-Duty Passenger Vehicles, Light-Duty Trucks, and Motorcycles)[9]

Analysis Period or Project Life	1-5 Years (2022-2026)	6-10 Years (2022-2031)	11-15 Years (2022-2036)	16-20 Years (2022-2041)
$PM_{2.5}$				
VMT (g/mile)	0.031	0.031	0.031	0.031
running exhaust only (g/mile)	0.000	0.000	0.000	0.000
tire and brake wear (g/mile)	0.004	0.004	0.004	0.004
road dust (g/mile)	0.028	0.028	0.028	0.028

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

PM2.5, road dust: statewide average annual PM2.5 emission factor is based on *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011*, and *CARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust* (updated Nov. 2016).

[9] All-electric vehicles and PHEVs running only on electricity have zero tailpipe emissions.

Table 3C. Average Auto Emission Factors - Gasoline

(Fleet of Light-Duty Passenger Vehicles, Light-Duty Trucks, and Motorcycles)

Analysis Period or Project Life	**1 Year 2023**	**1 Year 2024**	**1 Year 2025**
ROG			
VMT (g/mile)	0.060	0.057	0.055
commute trip ends (g/trip end)	0.648	0.605	0.567
average trip ends (g/trip end)	0.587	0.553	0.521
NOx			
VMT (g/mile)	0.081	0.072	0.065
commute trip ends (g/trip end)	0.310	0.289	0.270
average trip ends (g/trip end)	0.342	0.321	0.302
$PM_{2.5}$			
VMT (g/mile)	0.034	0.034	0.034
running exhaust only (g/mile)	0.001	0.001	0.001
tire and brake wear (g/mile)	0.005	0.005	0.005
road dust (g/mile)	0.028	0.028	0.028
commute trip ends (g/trip end)	0.003	0.003	0.003
average trip ends (g/trip end)	0.002	0.002	0.002
CO			
VMT (g/mile)	1.053	0.980	0.919
commute trip ends (g/trip end)	4.589	4.282	4.003
average trip ends (g/trip end)	3.929	3.693	3.481

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

PM2.5, road dust: statewide average annual PM2.5 emission factor is based on *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011)*, and *CARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust* (updated Nov. 2016).

[PM2.5 = 0.15*PM10]

Table 3D. Average Auto Emission Factors - Electric

(Fleet of Light-Duty Passenger Vehicles, Light-Duty Trucks, and Motorcycles)[10]

Analysis Period or Project Life	**1 Year 2022**	**1 Year 2023**	**1 Year 2024**
$PM_{2.5}$			
VMT (g/mile)	0.031	0.031	0.031
running exhaust only (g/mile)	0.000	0.000	0.000
tire and brake wear (g/mile)	0.004	0.004	0.004
road dust (g/mile)	0.028	0.028	0.028

Source: EMFAC2021 V1.0.2, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 °F.

PM2.5, road dust: statewide average annual PM2.5 emission factor is based on *US EPA's Compilation of Air Pollutant Emission Factors, Vol. 5 (AP-42, Chapter 13.2.1, Jan. 2011)*, and *CARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust* (updated Nov. 2016).

[PM2.5 = 0.15*PM10]

[10] All-electric vehicles and PHEVs running only on electricity have zero tailpipe emissions.

Table 4A. Emission Factors (grams per mile) by Speed (mph) – Aggregated

Project Life 1-5 years (2022-2026)

Speed	ROG[11]	CO	NOx	PM2.5 Ex[12]	Speed	ROG	CO	NOx	PM2.5 Ex
5	**0.1236**	**2.1989**	**0.5818**	**0.0102**	*48*	0.0148	0.9342	0.1233	0.0019
6	0.1134	2.1369	0.5510	0.0094	*49*	0.0147	0.9223	0.1225	0.0019
7	0.1041	2.0767	0.5218	0.0087	***50***	**0.0145**	**0.9106**	**0.1218**	**0.0019**
8	0.0955	2.0182	0.4941	0.0081	*51*	0.0146	0.9004	0.1225	0.0020
9	0.0876	1.9613	0.4679	0.0075	*52*	0.0146	0.8903	0.1232	0.0020
10	**0.0804**	**1.9060**	**0.4431**	**0.0069**	*53*	0.0146	0.8804	0.1239	0.0020
11	0.0742	1.8553	0.4153	0.0064	*54*	0.0146	0.8705	0.1246	0.0021
12	0.0686	1.8060	0.3892	0.0060	***55***	**0.0147**	**0.8608**	**0.1253**	**0.0021**
13	0.0633	1.7580	0.3647	0.0056	*56*	0.0148	0.8529	0.1275	0.0022
14	0.0585	1.7112	0.3418	0.0052	*57*	0.0150	0.8451	0.1296	0.0022
15	**0.0540**	**1.6657**	**0.3203**	**0.0048**	*58*	0.0152	0.8374	0.1318	0.0023
16	0.0504	1.6288	0.3073	0.0045	*59*	0.0154	0.8298	0.1340	0.0024
17	0.0471	1.5928	0.2948	0.0042	***60***	**0.0156**	**0.8222**	**0.1363**	**0.0024**
18	0.0440	1.5575	0.2828	0.0040	*61*	0.0159	0.8166	0.1397	0.0025
19	0.0411	1.5231	0.2713	0.0037	*62*	0.0163	0.8110	0.1433	0.0026
20	**0.0384**	**1.4894**	**0.2603**	**0.0035**	*63*	0.0166	0.8054	0.1469	0.0027
21	0.0363	1.4600	0.2509	0.0033	*64*	0.0170	0.7999	0.1506	0.0028
22	0.0343	1.4312	0.2418	0.0032	***65***	**0.0174**	**0.7944**	**0.1544**	**0.0028**
23	0.0324	1.4030	0.2331	0.0030	*66*	0.0177	0.7929	0.1550	0.0029
24	0.0307	1.3754	0.2247	0.0029	*67*	0.0179	0.7914	0.1555	0.0029
25	**0.0290**	**1.3483**	**0.2166**	**0.0027**	*68*	0.0182	0.7899	0.1561	0.0029
26	0.0277	1.3238	0.2092	0.0026	*69*	0.0184	0.7884	0.1567	0.0029
27	0.0265	1.2998	0.2021	0.0025	***70***	**0.0187**	**0.7869**	**0.1572**	**0.0030**
28	0.0253	1.2762	0.1952	0.0024	*71*	0.0187	0.7869	0.1572	0.0030
29	0.0241	1.2530	0.1886	0.0023	*72*	0.0187	0.7869	0.1572	0.0030
30	**0.0230**	**1.2302**	**0.1821**	**0.0022**	*73*	0.0187	0.7869	0.1572	0.0030
31	0.0222	1.2094	0.1765	0.0022	*74*	0.0187	0.7869	0.1572	0.0030
32	0.0214	1.1890	0.1710	0.0021	***75***	**0.0187**	**0.7869**	**0.1572**	**0.0030**
33	0.0206	1.1689	0.1657	0.0021	*76*	0.0187	0.7869	0.1572	0.0030
34	0.0199	1.1492	0.1606	0.0020	*77*	0.0187	0.7869	0.1572	0.0030
35	**0.0191**	**1.1298**	**0.1556**	**0.0019**	*78*	0.0187	0.7869	0.1572	0.0030
36	0.0186	1.1120	0.1517	0.0019	*79*	0.0187	0.7869	0.1572	0.0030
37	0.0181	1.0946	0.1478	0.0019	***80***	**0.0187**	**0.7869**	**0.1572**	**0.0030**
38	0.0176	1.0775	0.1441	0.0019	*81*	0.0187	0.7869	0.1572	0.0030
39	0.0171	1.0606	0.1404	0.0018	*82*	0.0187	0.7869	0.1572	0.0030
40	**0.0166**	**1.0439**	**0.1368**	**0.0018**	*83*	0.0187	0.7869	0.1572	0.0030
41	0.0163	1.0289	0.1345	0.0018	*84*	0.0187	0.7869	0.1572	0.0030
42	0.0160	1.0141	0.1322	0.0018	***85***	**0.0187**	**0.7870**	**0.1572**	**0.0030**
43	0.0157	0.9994	0.1300	0.0018	*86*	0.0187	0.7870	0.1572	0.0030
44	0.0155	0.9850	0.1278	0.0018	*87*	0.0187	0.7870	0.1572	0.0030

[11] ROG includes running exhaust and running evaporative emissions.
[12] PM2.5 Ex includes running exhaust emissions only.

Speed	ROG[11]	CO	NOx	PM2.5 Ex[12]		Speed	ROG	CO	NOx	PM2.5 Ex
45	**0.0152**	**0.9708**	**0.1256**	**0.0018**		*88*	0.0187	0.7870	0.1572	0.0030
46	0.0150	0.9585	0.1248	0.0018		*89*	0.0187	0.7870	0.1572	0.0030
47	0.0149	0.9463	0.1240	0.0018		***90***	**0.0187**	**0.7870**	**0.1572**	**0.0030**

Table 4B. Emission Factors (grams per mile) by Speed (mph) – Aggregated

Project Life 6-10 years (2022-2031)

Speed	ROG[13]	CO	NOx	PM2.5 Ex[14]	Speed	ROG	CO	NOx	PM2.5 Ex
5	**0.1025**	**1.9155**	**0.5458**	**0.0089**	*48*	0.0122	0.8208	0.1016	0.0017
6	0.0939	1.8626	0.5154	0.0082	*49*	0.0121	0.8101	0.1008	0.0017
7	0.0861	1.8111	0.4867	0.0076	***50***	**0.0119**	**0.7997**	**0.1000**	**0.0017**
8	0.0790	1.7611	0.4596	0.0070	*51*	0.0120	0.7905	0.1007	0.0018
9	0.0724	1.7125	0.4340	0.0065	*52*	0.0120	0.7814	0.1013	0.0018
10	**0.0664**	**1.6652**	**0.4098**	**0.0060**	*53*	0.0120	0.7724	0.1019	0.0018
11	0.0613	1.6217	0.3826	0.0056	*54*	0.0120	0.7635	0.1025	0.0019
12	0.0565	1.5794	0.3572	0.0052	***55***	**0.0120**	**0.7547**	**0.1031**	**0.0019**
13	0.0522	1.5381	0.3335	0.0048	*56*	0.0122	0.7475	0.1051	0.0020
14	0.0482	1.4979	0.3113	0.0045	*57*	0.0123	0.7403	0.1071	0.0021
15	**0.0444**	**1.4588**	**0.2907**	**0.0042**	*58*	0.0125	0.7332	0.1091	0.0021
16	0.0415	1.4270	0.2782	0.0039	*59*	0.0126	0.7262	0.1111	0.0022
17	0.0388	1.3959	0.2662	0.0037	***60***	**0.0128**	**0.7192**	**0.1132**	**0.0022**
18	0.0362	1.3655	0.2548	0.0035	*61*	0.0131	0.7138	0.1165	0.0023
19	0.0338	1.3358	0.2439	0.0032	*62*	0.0133	0.7083	0.1198	0.0024
20	**0.0316**	**1.3067**	**0.2334**	**0.0031**	*63*	0.0136	0.7030	0.1232	0.0025
21	0.0299	1.2812	0.2244	0.0029	*64*	0.0139	0.6976	0.1267	0.0025
22	0.0282	1.2563	0.2158	0.0028	***65***	**0.0143**	**0.6923**	**0.1303**	**0.0026**
23	0.0267	1.2319	0.2075	0.0026	*66*	0.0145	0.6907	0.1307	0.0027
24	0.0252	1.2079	0.1995	0.0025	*67*	0.0147	0.6891	0.1312	0.0027
25	**0.0239**	**1.1844**	**0.1918**	**0.0024**	*68*	0.0149	0.6875	0.1316	0.0027
26	0.0228	1.1631	0.1847	0.0023	*69*	0.0151	0.6858	0.1321	0.0027
27	0.0218	1.1421	0.1779	0.0022	***70***	**0.0153**	**0.6842**	**0.1325**	**0.0027**
28	0.0208	1.1216	0.1713	0.0021	*71*	0.0153	0.6842	0.1325	0.0027
29	0.0199	1.1014	0.1649	0.0020	*72*	0.0153	0.6842	0.1325	0.0027
30	**0.0190**	**1.0815**	**0.1588**	**0.0019**	*73*	0.0153	0.6842	0.1325	0.0027
31	0.0183	1.0633	0.1533	0.0019	*74*	0.0153	0.6842	0.1325	0.0027
32	0.0176	1.0455	0.1481	0.0018	***75***	**0.0153**	**0.6842**	**0.1325**	**0.0027**
33	0.0170	1.0279	0.1430	0.0018	*76*	0.0153	0.6842	0.1325	0.0027
34	0.0164	1.0106	0.1380	0.0017	*77*	0.0153	0.6842	0.1325	0.0027
35	**0.0158**	**0.9936**	**0.1333**	**0.0017**	*78*	0.0153	0.6842	0.1325	0.0027
36	0.0153	0.9780	0.1294	0.0017	*79*	0.0153	0.6843	0.1325	0.0027
37	0.0149	0.9627	0.1257	0.0017	***80***	**0.0153**	**0.6843**	**0.1325**	**0.0027**
38	0.0145	0.9476	0.1220	0.0016	*81*	0.0153	0.6843	0.1325	0.0027
39	0.0141	0.9327	0.1185	0.0016	*82*	0.0153	0.6843	0.1325	0.0027
40	**0.0137**	**0.9181**	**0.1151**	**0.0016**	*83*	0.0153	0.6843	0.1325	0.0027
41	0.0134	0.9048	0.1128	0.0016	*84*	0.0153	0.6843	0.1325	0.0027
42	0.0132	0.8917	0.1105	0.0016	***85***	**0.0153**	**0.6843**	**0.1325**	**0.0027**
43	0.0130	0.8788	0.1083	0.0016	*86*	0.0153	0.6843	0.1325	0.0027
44	0.0127	0.8660	0.1061	0.0016	*87*	0.0153	0.6843	0.1325	0.0027

[13] ROG includes running exhaust and running evaporative emissions.
[14] PM2.5 Ex includes running exhaust emissions only.

Speed	ROG[13]	CO	NOx	PM2.5 Ex[14]		Speed	ROG	CO	NOx	PM2.5 Ex
45	**0.0125**	**0.8535**	**0.1040**	**0.0016**		*88*	0.0153	0.6843	0.1325	0.0027
46	0.0124	0.8424	0.1032	0.0016		*89*	0.0153	0.6843	0.1325	0.0027
47	0.0123	0.8315	0.1024	0.0017		***90***	**0.0153**	**0.6843**	**0.1325**	**0.0027**

Table 5A. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) - Gasoline

BEFORE PROJECT Baseline Emission Factors

Vehicle Type	GVWR[15] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr)	CO (g/bhp-hr[16])	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	> 33,000	2007-2009	0.087	0.957	0.547	0.042	4.0	0.022	0.239	0.137	0.0104
		2010-2012	0.085	0.933	0.509	0.042	4.0	0.021	0.233	0.127	0.0105
		2013-2015	0.043	0.785	0.168	0.037	4.0	0.0108	0.196	0.042	0.0093
		2016-2018	0.036	0.764	0.147	0.038	4.0	0.0089	0.191	0.037	0.0094
		2019-2021	0.046	0.933	0.156	0.039	4.0	0.0115	0.233	0.039	0.0098
		2022+	0.039	0.808	0.137	0.041	4.0	0.0099	0.202	0.034	0.0102
Transit Buses,[17] School Buses, and Trucks[18]	14,001-33,000	2007-2009	0.251	1.923	0.315	0.019	1.8	0.139	1.068	0.175	0.010
		2010-2012	0.154	1.584	0.202	0.019	1.8	0.085	0.880	0.112	0.010
		2013-2015	0.122	1.456	0.186	0.019	1.8	0.068	0.809	0.103	0.011
		2016-2018	0.103	1.327	0.164	0.020	1.8	0.057	0.737	0.091	0.011
		2019-2021	0.081	1.173	0.166	0.020	1.8	0.045	0.651	0.092	0.011
		2022+	0.081	1.219	0.192	0.020	1.8	0.045	0.677	0.107	0.011
Class 8 Trucks[19]	> 33,000	2007-2009	0.485	33.75	3.630	0.044	2.9	0.167	11.639	1.252	0.015
		2010-2012	0.519	34.97	3.646	0.036	2.9	0.179	12.057	1.257	0.012
		2013-2015	0.343	28.55	2.903	0.033	2.9	0.118	9.844	1.001	0.011
		2016-2018	0.364	28.17	2.873	0.036	2.9	0.126	9.714	0.991	0.012
		2019-2021	0.245	21.21	2.460	0.036	2.9	0.084	7.312	0.848	0.012
		2022+	0.205	18.05	2.249	0.036	2.9	0.071	6.226	0.776	0.012

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

[15] Gross vehicle weight rating
[16] Grams per brake horsepower-hour
[17] Other buses
[18] Medium heavy-duty trucks
[19] Heavy heavy-duty trucks

Table 5A. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) - Gasoline (Continued)

Retrofit Gasoline Vehicles

Vehicle Type	GVWR[20] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr[21])	CO (g/bhp-hr)	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	>33,000	2007-2009	0.087	0.957	0.547	0.042	4.0	0.022	0.239	0.137	0.010
		2010-2012	0.085	0.933	0.509	0.042	4.0	0.021	0.233	0.127	0.010
Transit Buses[22], School Buses, and Trucks[23]	14,001-33,000	1994-1997	2.726	25.68	4.622	0.025	1.8	1.514	14.264	2.568	0.014
		1998-2002	1.638	23.18	4.458	0.021	1.8	0.910	12.876	2.477	0.011
		2003-2006	0.501	5.116	1.081	0.019	1.8	0.278	2.842	0.601	0.010
		2007-2009	0.251	1.923	0.315	0.019	1.8	0.139	1.068	0.175	0.010
		2010-2012	0.154	1.584	0.202	0.019	1.8	0.085	0.880	0.112	0.010
Class 8 Trucks[24]	>33,000	1994-1997	3.481	39.10	15.047	0.048	2.9	1.200	13.481	5.189	0.017
		1998-2002	2.937	38.30	9.297	0.047	2.9	1.013	13.206	3.206	0.016
		2003-2006	1.001	37.23	4.653	0.045	2.9	0.345	12.839	1.605	0.016
		2007-2009	0.485	33.75	3.630	0.044	2.9	0.167	11.639	1.252	0.015
		2010-2012	0.519	34.97	3.646	0.036	2.9	0.179	12.057	1.257	0.012

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

[20] Gross vehicle weight rating
[21] Grams per brake horsepower-hour
[22] Other buses
[23] Medium heavy-duty trucks
[24] Heavy heavy-duty trucks

Table 5A. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) – Gasoline (Continued)

AFTER PROJECT Emission Factors – New Cleaner Gasoline Vehicle Purchase or Repowers

Vehicle Type	GVWR[25] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr[26])	CO (g/bhp-hr)	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	> 33,000	2013-2015	0.043	0.79	0.17	0.04	4.0	0.0108	0.196	0.042	0.0093
		2016-2018	0.036	0.76	0.15	0.04	4.0	0.0089	0.191	0.037	0.0094
		2019-2021	0.046	0.93	0.16	0.04	4.0	0.0115	0.233	0.039	0.0098
		2022+	0.039	0.81	0.14	0.04	4.0	0.0099	0.202	0.034	0.0102
Transit Buses[27], School Buses, and Trucks[28]	14,001 - 33,000	2013-2015	0.122	1.46	0.19	0.02	1.8	0.068	0.809	0.103	0.011
		2016-2018	0.103	1.33	0.16	0.02	1.8	0.057	0.737	0.091	0.011
		2019-2021	0.081	1.17	0.17	0.02	1.8	0.045	0.651	0.092	0.011
		2022+	0.081	1.22	0.19	0.02	1.8	0.045	0.677	0.107	0.011
Class 8 Trucks[29]	> 33,000	2013-2015	0.343	28.5	2.90	0.03	2.9	0.118	9.844	1.001	0.011
		2016-2018	0.364	28.2	2.87	0.04	2.9	0.126	9.714	0.991	0.012
		2019-2021	0.245	21.2	2.46	0.04	2.9	0.084	7.312	0.848	0.012
		2022+	0.205	18.1	2.25	0.04	2.9	0.071	6.226	0.776	0.012

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and formaldehyde.

[25] Gross vehicle weight rating
[26] Grams per brake horsepower-hour
[27] Other buses
[28] Medium heavy-duty trucks
[29] Heavy heavy-duty trucks

Table 5B. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) - Diesel

BEFORE PROJECT Baseline Emission Factors

Vehicle Type	GVWR[30] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr)	CO (g/bhp-hr[31])	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	> 33,000	2007-2009	0.233	0.290	4.995	0.054	4.0	0.058	0.072	1.249	0.0134
		2010-2012	0.074	0.087	0.441	0.054	4.0	0.018	0.022	0.110	0.0135
		2013-2015	0.069	0.080	0.396	0.053	4.0	0.0172	0.020	0.099	0.0133
		2016-2018	0.068	0.077	0.375	0.053	4.0	0.0169	0.019	0.094	0.0133
		2019-2021	0.065	0.075	0.350	0.052	4.0	0.0164	0.019	0.087	0.0131
		2022+	0.052	0.054	0.258	0.049	4.0	0.0130	0.014	0.064	0.0122
Transit Buses[32], School Buses, and Trucks[33]	14,001-33,000	2007-2009	0.151	0.419	5.866	0.043	1.8	0.084	0.233	3.259	0.024
		2010-2012	0.038	0.300	3.009	0.030	1.8	0.021	0.167	1.672	0.017
		2013-2015	0.011	0.228	1.442	0.024	1.8	0.006	0.127	0.801	0.013
		2016-2018	0.009	0.199	0.969	0.022	1.8	0.005	0.110	0.539	0.012
		2019-2021	0.008	0.176	0.839	0.022	1.8	0.005	0.098	0.466	0.012
		2022+	0.009	0.176	0.715	0.022	1.8	0.005	0.098	0.397	0.012
Class 8 Trucks[34]	> 33,000	2007-2009	0.231	0.701	9.346	0.082	2.9	0.080	0.242	3.223	0.028
		2010-2012	0.126	0.846	5.594	0.076	2.9	0.044	0.292	1.929	0.026
		2013-2015	0.060	0.787	2.928	0.070	2.9	0.021	0.271	1.010	0.024
		2016-2018	0.056	0.722	2.199	0.065	2.9	0.019	0.249	0.758	0.023
		2019-2021	0.051	0.642	1.910	0.056	2.9	0.017	0.222	0.659	0.019
		2022+	0.058	0.772	1.786	0.051	2.9	0.020	0.266	0.616	0.017

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)
Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and also, formaldehyde.

[30] Gross vehicle weight rating
[31] Grams per brake horsepower-hour
[32] Other buses
[33] Medium heavy-duty trucks
[34] Heavy heavy-duty trucks

Table 5B. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) – Diesel (Continued)

Retrofit Diesel Vehicles

Vehicle Type	GVWR[35] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr[36])	CO (g/bhp-hr)	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	>33,000	2007-2009	0.233	0.290	4.995	0.054	4.0	0.058	0.072	1.249	0.013
		2010-2012	0.074	0.087	0.441	0.054	4.0	0.018	0.022	0.110	0.014
Transit Buses[37], School Buses, and Trucks[38]	14,001-33,000	1994-1997	0.540	1.697	15.15	0.234	1.8	0.300	0.943	8.417	0.130
		1998-2002	0.433	1.358	15.27	0.194	1.8	0.241	0.754	8.484	0.108
		2003-2006	0.151	0.503	9.550	0.088	1.8	0.084	0.280	5.306	0.049
		2007-2009	0.151	0.419	5.866	0.043	1.8	0.084	0.233	3.259	0.024
		2010-2012	0.038	0.300	3.009	0.030	1.8	0.021	0.167	1.672	0.017
Class 8 Trucks[39]	>33,000	1994-1997	0.147	0.468	18.98	0.113	2.9	0.051	0.161	6.546	0.039
		1998-2002	0.115	0.346	21.65	0.106	2.9	0.040	0.119	7.466	0.036
		2003-2006	0.078	0.288	12.54	0.116	2.9	0.027	0.099	4.324	0.040
		2007-2009	0.231	0.701	9.346	0.082	2.9	0.080	0.242	3.223	0.028
		2010-2012	0.126	0.846	5.594	0.076	2.9	0.044	0.292	1.929	0.026

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and also, formaldehyde.

[35] Gross vehicle weight rating
[36] Grams per brake horsepower-hour
[37] Other buses
[38] Medium heavy-duty trucks
[39] Heavy heavy-duty trucks

Table 5B. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) – Diesel (Continued)

AFTER PROJECT Emission Factors – New Cleaner Diesel Vehicle Purchase or Repowers

Vehicle Type	GVWR[40] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr[41])	CO (g/bhp-hr)	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	> 33,000	2013-2015	0.069	0.08	0.40	0.05	4.0	0.0172	0.020	0.099	0.0133
		2016-2018	0.068	0.08	0.38	0.05	4.0	0.0169	0.019	0.094	0.0133
		2019-2021	0.065	0.08	0.35	0.05	4.0	0.0164	0.019	0.087	0.0131
		2022+	0.052	0.05	0.26	0.05	4.0	0.0130	0.014	0.064	0.0122
Transit Buses[42], School Buses, and Trucks[43]	14,001 - 33,000	2013-2015	0.011	0.23	1.44	0.02	1.8	0.006	0.127	0.801	0.013
		2016-2018	0.009	0.20	0.97	0.02	1.8	0.005	0.110	0.539	0.012
		2019-2021	0.008	0.18	0.84	0.02	1.8	0.005	0.098	0.466	0.012
		2022+	0.009	0.18	0.72	0.02	1.8	0.005	0.098	0.397	0.012
Class 8 Trucks[44]	> 33,000	2013-2015	0.060	0.79	2.93	0.07	2.9	0.021	0.271	1.010	0.024
		2016-2018	0.056	0.72	2.20	0.07	2.9	0.019	0.249	0.758	0.023
		2019-2021	0.051	0.64	1.91	0.06	2.9	0.017	0.222	0.659	0.019
		2022+	0.058	0.77	1.79	0.05	2.9	0.020	0.266	0.616	0.017

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and also, formaldehyde.

[40] Gross vehicle weight rating
[41] Grams per brake horsepower-hour
[42] Other buses
[43] Medium heavy-duty trucks
[44] Heavy heavy-duty trucks

Table 5C. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) – Natural Gas

BEFORE PROJECT Baseline Emission Factors – New Natural Gas Vehicles

Vehicle Type	GVWR[45] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr)	CO (g/bhp-hr[46])	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	> 33,000	2007-2009	0.023	29.13	0.730	0.047	4.0	0.006	7.282	0.182	0.0118
		2010-2012	0.023	27.29	0.697	0.047	4.0	0.006	6.822	0.174	0.0117
		2013-2015	0.025	29.29	0.760	0.047	4.0	0.0062	7.321	0.190	0.0118
		2016-2018	0.031	31.50	0.664	0.047	4.0	0.0077	7.874	0.166	0.0117
		2019-2021	0.062	50.31	0.109	0.047	4.0	0.0156	12.578	0.027	0.0118
		2022+	0.064	52.36	0.129	0.047	4.0	0.0161	13.090	0.032	0.0119
Transit Buses[47], School Buses, and Trucks[48]	14,001-33,000	2007-2009	0.036	8.389	0.650	0.021	1.8	0.020	4.661	0.361	0.011
		2010-2012	0.049	11.53	0.834	0.021	1.8	0.027	6.408	0.463	0.012
		2013-2015	0.043	10.20	0.744	0.021	1.8	0.024	5.666	0.414	0.012
		2016-2018	0.027	6.007	0.380	0.021	1.8	0.015	3.337	0.211	0.012
		2019-2021	0.023	4.963	0.212	0.021	1.8	0.013	2.757	0.118	0.012
		2022+	0.025	5.243	0.243	0.022	1.8	0.014	2.913	0.135	0.012
Class 8 Trucks[49]	> 33,000	2007-2009	0.053	17.24	1.373	0.070	2.9	0.018	5.944	0.474	0.024
		2010-2012	0.046	16.19	1.265	0.058	2.9	0.016	5.582	0.436	0.020
		2013-2015	0.053	17.87	1.412	0.062	2.9	0.018	6.160	0.487	0.021
		2016-2018	0.032	11.79	0.848	0.059	2.9	0.011	4.065	0.292	0.020
		2019-2021	0.010	6.225	0.193	0.064	2.9	0.003	2.147	0.067	0.022
		2022+	0.012	6.291	0.225	0.059	2.9	0.004	2.169	0.077	0.020

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and also, formaldehyde.

[45] Gross vehicle weight rating
[46] Grams per brake horsepower-hour
[47] Other buses
[48] Medium heavy-duty trucks
[49] Heavy heavy-duty trucks

Table 5C. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) –Natural Gas (Continued)

Retrofit Natural Gas Vehicles

Vehicle Type	GVWR[50] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr[51])	CO (g/bhp-hr)	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	>33,000	2007-2009	0.023	29.13	0.730	0.047	4.0	0.006	7.282	0.182	0.012
		2010-2012	0.023	27.29	0.697	0.047	4.0	0.006	6.822	0.174	0.012
Transit Buses[52], School Buses, and Trucks[53]	14,001-33,000	1994-1997	0.000	0.000	0.000	0.000	1.8	0.000	0.000	0.000	0.000
		1998-2002	0.000	0.000	0.000	0.000	1.8	0.000	0.000	0.000	0.000
		2003-2006	0.000	0.000	0.000	0.000	1.8	0.000	0.000	0.000	0.000
		2007-2009	0.036	8.389	0.650	0.021	1.8	0.020	4.661	0.361	0.011
		2010-2012	0.049	11.53	0.834	0.021	1.8	0.027	6.408	0.463	0.012
Class 8 Trucks[54]	>33,000	1994-1997	1.405	1.797	33.73	0.120	2.9	0.484	0.620	11.632	0.041
		1998-2002	1.520	1.830	33.98	0.122	2.9	0.524	0.631	11.717	0.042
		2003-2006	1.501	2.435	23.65	0.163	2.9	0.517	0.840	8.155	0.056
		2007-2009	0.053	17.24	1.373	0.070	2.9	0.018	5.944	0.474	0.024
		2010-2012	0.046	16.19	1.265	0.058	2.9	0.016	5.582	0.436	0.020

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and also, formaldehyde.

[50] Gross vehicle weight rating
[51] Grams per brake horsepower-hour
[52] Other buses
[53] Medium heavy-duty trucks
[54] Heavy heavy-duty trucks

Table 5C. Statewide Calendar Year 2023 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (grams per mile) – Natural Gas (Continued)

AFTER PROJECT Emission Factors – New Cleaner Natural Gas Vehicle Purchase or Repowers

Vehicle Type	GVWR[55] (lbs)	Model Year	ROG (g/mi)	CO (g/mi)	NOx (g/mi)	PM2.5 (g/mi)	Conversion Factors	ROG (g/bhp-hr[56])	CO (g/bhp-hr)	NOx (g/bhp-hr)	PM2.5 (g/bhp-hr)
Urban Transit Buses	> 33,000	2013-2015	0.025	29.3	0.76	0.05	4.0	0.0062	7.321	0.190	0.0118
		2016-2018	0.031	31.5	0.66	0.05	4.0	0.0077	7.874	0.166	0.0117
		2019-2021	0.062	50.3	0.11	0.05	4.0	0.0156	12.578	0.027	0.0118
		2022+	0.064	52.4	0.13	0.05	4.0	0.0161	13.090	0.032	0.0119
Transit Buses[57], School Buses, and Trucks[58]	14,001 - 33,000	2013-2015	0.043	10.2	0.74	0.02	1.8	0.024	5.666	0.414	0.012
		2016-2018	0.027	6.01	0.38	0.02	1.8	0.015	3.337	0.211	0.012
		2019-2021	0.023	4.96	0.21	0.02	1.8	0.013	2.757	0.118	0.012
		2022+	0.025	5.24	0.24	0.02	1.8	0.014	2.913	0.135	0.012
Class 8 Trucks[59]	> 33,000	2013-2015	0.053	17.9	1.41	0.06	2.9	0.018	6.160	0.487	0.021
		2016-2018	0.032	11.8	0.85	0.06	2.9	0.011	4.065	0.292	0.020
		2019-2021	0.010	6.23	0.19	0.06	2.9	0.003	2.147	0.067	0.022
		2022+	0.012	6.29	0.23	0.06	2.9	0.004	2.169	0.077	0.020

Source: EMFAC2021 v1.0.2, Annual, Statewide (No pre-2003 Urban Transit Buses)

Cleaner vehicles could be compressed natural gas (CNG), liquefied natural gas (LNG), or cleaner diesel with after-treatment technology to reduce NOx and PM. The "After Project" emission factors are based on typical CNG vehicles; however, after-treatment applied to CNG vehicles has been shown to reduce even more PM and also, formaldehyde.

[55] Gross vehicle weight rating
[56] Grams per brake horsepower-hour
[57] Other buses
[58] Medium heavy-duty trucks
[59] Heavy heavy-duty trucks

Off-Road Emission Factors for Cleaner Vehicle Projects

CARB offers a user-friendly Excel-based tool designed[60] to estimate fuel consumption and emissions for equipment in a specific year, CARB's 2017 Emission Factors for Off-road Diesel Equipment. This tool employs a methodology that averages engine certification values within a particular horsepower range and model year. This average encompasses a wide spectrum, ranging from engines surpassing the standards for that year to those utilizing various flexibility provisions (such as emission credits) to meet standards from previous years.[61]

How to Use the Tool

To utilize this tool effectively, users need to input specific parameters, including horsepower, model year, calendar year, activity measured in annual hours, and accumulated hours on the equipment. If the user only knows the age of the equipment, they can calculate accumulated hours by multiplying annual hours by the age (annual-hours × age). Additionally, users require the load factor, available in the lookup tables provided below. Exhibit 1 shows a screenshot of the input box.

Exhibit 1: Input Box (Example Numbers)

Input	Input Engine Here
Horsepower (hp)	150
Model year	1985
Calendar year	2015
Activity (annual hours)	200
Accumulated hours on equipment (estimate using annual-hours*age if you only know the age of the equipment)	(2015-1985)*200 = 6000 hours
Load factor (check the lookup table)	0.48

[60] The tool is available here: ordas_ef_fcf_2017_v8.xlsx (live.com)

[61] For more information, please see: ordas_emsfactors_2017.docx (ca.gov)

Look up tables for load factor

Equipment Category	Equipment Type	Load Factor
Agriculture equipment	Agricultural tractors	0.48
	Combine harvesters	0.44
	Forage & silage harvesters	0.44
	Cotton pickers	0.44
	Nut harvester	0.44
	Other harvesters	0.44
	Balers (self propelled)	0.50
	Bale wagons (self propelled)	0.50
	Swathers/windrowers/hay conditioners	0.48
	Hay Squeeze/Stack retriever	0.42
	Sprayers/Spray rigs	0.42
	Construction equipment	0.40
	Other non-mobile	0.48
	Forklifts	0.40
	Atvs	0.40
	Others	0.40
Portable equipment	All portable equipment	0.31
Cargo Handling Equipment	Construction equipment	0.55
	Container handling equipment	0.59
	Forklift	0.30
	Other general industrial equipment	0.51
	Rtg crane	0.20
	Yard tractor	0.39

Equipment Category	Equipment Type	Details	Load Factor
Transport Refrigeration Units (TRU)	TRU on trailers	25 HP and over, MY2012 and Older	0.46
	TRU on trailers	25 HP and over, MY2013 and Newer	0.38
	TRU on trailers	23 HP and Over, below 25 HP, All years	0.46
	TRU on trucks	Below 23 HP, All Model years	0.56
	TRU on railcars	25 HP and over, MY2012 and Older	0.33
	TRU on railcars	25 HP and over, MY2013 and Newer	0.27
	TRU on railcars	Below 25 HP, All Model years	0.33
	TRU with generators	25 HP and over, MY2012 and Older	0.46
	TRU with generators	25 HP and Over, MY2013 and Newer	0.38
	TRU with generators	23 HP and Over, below 25 HP, All Model Years	0.46

Equipment Category	Equipment Type	Load Factor
Construction and Industrial Equipment	Cranes	0.29
	Crawler Tractors	0.43
	Excavators	0.38
	Graders	0.41
	Off-Highway Tractors	0.44
	Off-Highway Trucks	0.38
	Other Construction Equipment	0.42
	Pavers	0.42
	Paving Equipment	0.36
	Rollers	0.38
	Rough Terrain Forklifts	0.40
	Rubber Tired Dozers	0.40
	Rubber Tired Loaders	0.36
	Scrapers	0.48
	Skid Steer Loaders	0.37
	Surfacing Equipment	0.30
	Tractors/Loaders/Backhoes	0.37
	Trenchers	0.50
	Aerial Lifts	0.31
	Forklifts	0.20
	Other General Industrial Equipment	0.34
	Other Material Handling Equipment	0.40
	Sweepers/Scrubbers	0.46
Oil and Drill Rigs	Drill Rig (Mobile)	0.50
	Workover Rig (Mobile)	0.50
	Bore/Drill Rigs	0.50

The Output Box provides a summary of the estimated fuel usage, NOx (Nitrogen Oxides), PM (Particulate Matter), and THC (Total Hydrocarbons) emissions for the user's equipment. Exhibit 2 shows a screenshot of the output box in the table. Upon completing the analysis, the tool provides the following results based on the input parameters provided by the user:

- Fuel Used (gallon): The total amount of fuel consumed by the equipment, measured in gallons.
- NOx Emissions (kg): The total Nitrogen Oxides emitted by the equipment, measured in kilograms.
- PM Emissions (kg): The total Particulate Matter emissions from the equipment, measured in kilograms.

- THC Emissions (kg): The total emissions of Total Hydrocarbons from the equipment, measured in kilograms.
- CO2 Emissions (kg): The total Carbon Dioxide emissions resulting from the equipment's fuel consumption, measured in kilograms.
- NOx Emission Factor (including deterioration and fuel correction factor): The emission rate of Nitrogen Oxides per brake horsepower-hour (bhp-hr) of the equipment, accounting for deterioration and fuel correction factors, measured in grams per bhp-hr.
- PM Emission Factor (including deterioration and fuel correction factor): The emission rate of Particulate Matter per brake horsepower-hour (bhp-hr) of the equipment, considering deterioration and fuel correction factors, measured in grams per bhp-hr.
- THC Emission Factor (including deterioration and fuel correction factor): The emission rate of Total Hydrocarbons per brake horsepower-hour (bhp-hr) of the equipment, factoring in deterioration and fuel correction factors, measured in grams per bhp-hr.

Exhibit 2: Output Box (Example Numbers)

Results	
Fuel Used (gallon)	743
NOx Emissions (kg)	150.7
PM Emissions (kg)	6.0
THC Emissions (kg)	11.9
CO2 Emissions (kg)	7590.2
NOx Emission Factor (including deterioration and fuel correction factor): gram/bhp-hr	10.47
PM Emission Factor (including deterioration and fuel correction factor): gram/bhp-hr	0.42
THC Emission Factor (including deterioration and fuel correction factor): gram/ bhp-hr	0.83