



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
February 2024***

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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

For tables 1 to 5, emission rates are updated using EMFAC2021 for Calendar Year 2022. Table 6 is updated based on CARB's 2017 Emission Factors for Off-road Diesel Equipment, which are available through an Excel-based tool.

Table 1A. Before Project - Diesel Bus Emission Factors
(Through Model Year 2022)

Pollutant	Calendar Year	Model Year	Emission Factor (gram/mile) Average	Emission Factor (gram/mile) 45 MPH
ROG	2022	Entire Fleet	0.086	0.044
	2022	2007 - 2011	0.163	0.061
	2022	2012 - 2016	0.070	0.040
	2022	2017 - 2021	0.066	0.042
	2022	2022	0.052	0.038
CO	2022	Entire Fleet	0.101	0.043
	2022	2007 - 2011	0.200	0.068
	2022	2012 - 2016	0.081	0.039
	2022	2017 - 2021	0.076	0.039
	2022	2022	0.054	0.033
NOx	2022	Entire Fleet	0.873	0.381
	2022	2007 - 2011	3.026	1.748
	2022	2012 - 2016	0.406	0.113
	2022	2017 - 2021	0.359	0.108
	2022	2022	0.258	0.089
PM2.5 - Exhaust¹	2022	Entire Fleet	0.007	0.006
	2022	2007 - 2011	0.008	0.006
	2022	2012 - 2016	0.007	0.006
	2022	2017 - 2021	0.007	0.006
	2022	2022	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 Dust²	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 2022)

Pollutant	Calendar Year	Model Year	Emission Factor (gram/mile) Average	Emission Factor (gram/mile) 45 MPH
ROG	2022	Entire Fleet	0.035	0.025
	2022	2007 - 2011	0.023	0.008
	2022	2012 - 2016	0.025	0.012
	2022	2017 - 2021	0.055	0.042
	2022	2022	0.064	0.043
CO	2022	Entire Fleet	35.069	17.428
	2022	2007 - 2011	28.533	9.255
	2022	2012 - 2016	29.936	7.649
	2022	2017 - 2021	44.246	28.503
	2022	2022	52.361	31.210
NOx	2022	Entire Fleet	0.563	0.118
	2022	2007 - 2011	0.721	0.177
	2022	2012 - 2016	0.776	0.177
	2022	2017 - 2021	0.170	0.051
	2022	2022	0.129	0.016
PM2.5 - Exhaust³	2022	Entire Fleet	0.000	0.001
	2022	2007 - 2011	0.000	0.000
	2022	2012 - 2016	0.000	0.001
	2022	2017 - 2021	0.001	0.001
	2022	2022	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 Dust⁴	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 2022)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)

Weight⁷	ROG	NOx	PM2.5 Exhaust	PM2.5 Total⁸	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)

Weight³	ROG	NOx	PM2.5 Exhaust	PM2.5 Total²	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)

Weight³	ROG	NOx	PM2.5 Exhaust	PM2.5 Total²	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 PM_{2.5} 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 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 (2021-2025)	6-10 Years (2021-2030)	11-15 Years (2021-2035)	16-20 Years (2021-2040)
ROG				
VMT (g/mile)	0.061	0.055	0.051	0.047
commute trip ends (g/trip end)	0.652	0.564	0.499	0.449
average trip ends (g/trip end)	0.590	0.517	0.461	0.418
NOx				
VMT (g/mile)	0.083	0.066	0.056	0.049
commute trip ends (g/trip end)	0.313	0.272	0.247	0.229
average trip ends (g/trip end)	0.345	0.303	0.275	0.256
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)	1.066	0.929	0.844	0.787
commute trip ends (g/trip end)	4.621	4.003	3.570	3.250
average trip ends (g/trip end)	3.954	3.477	3.138	2.887

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

PM_{2.5}, road dust: statewide average annual PM_{2.5} 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).

[PM_{2.5} = 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 (2021-2025)	6-10 Years (2021-2030)	11-15 Years (2021-2035)	16-20 Years (2021-2040)
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.

PM_{2.5}, road dust: statewide average annual PM_{2.5} 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 2021	1 Year 2022	1 Year 2023
ROG			
VMT (g/mile)	0.069	0.064	0.060
commute trip ends (g/trip end)	0.745	0.693	0.648
average trip ends (g/trip end)	0.665	0.624	0.587
NOx			
VMT (g/mile)	0.104	0.091	0.081
commute trip ends (g/trip end)	0.363	0.335	0.310
average trip ends (g/trip end)	0.393	0.366	0.342
PM_{2.5}			
VMT (g/mile)	0.034	0.034	0.034
running exhaust only (g/mile)	0.002	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)	0.004	0.004	0.003
average trip ends (g/trip end)	0.002	0.002	0.002
CO			
VMT (g/mile)	1.239	1.136	1.053
commute trip ends (g/trip end)	5.305	4.927	4.589
average trip ends (g/trip end)	4.476	4.189	3.929

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

PM_{2.5}, road dust: statewide average annual PM_{2.5} 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).

[PM_{2.5} = 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 2021	1 Year 2022	1 Year 2023
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.

PM_{2.5}, road dust: statewide average annual PM_{2.5} 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).

[PM_{2.5} = 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 (2021-2025)

Speed	ROG ¹¹	CO	NO _x	PM2.5 Ex ¹²	Speed	ROG	CO	NO _x	PM2.5 Ex
5	0.1401	2.3850	0.6113	0.0110	50	0.0165	0.9848	0.1402	0.0021
6	0.1286	2.3171	0.5802	0.0101	51	0.0165	0.9741	0.1409	0.0021
7	0.1181	2.2511	0.5508	0.0094	52	0.0165	0.9635	0.1417	0.0022
8	0.1085	2.1870	0.5228	0.0087	53	0.0165	0.9531	0.1424	0.0022
9	0.0997	2.1247	0.4963	0.0081	54	0.0166	0.9427	0.1432	0.0023
10	0.0915	2.0641	0.4711	0.0075	55	0.0166	0.9325	0.1439	0.0023
11	0.0845	2.0088	0.4427	0.0069	56	0.0168	0.9244	0.1461	0.0024
12	0.0780	1.9550	0.4160	0.0065	57	0.0170	0.9164	0.1484	0.0024
13	0.0720	1.9025	0.3910	0.0060	58	0.0172	0.9085	0.1506	0.0025
14	0.0665	1.8515	0.3674	0.0056	59	0.0174	0.9007	0.1529	0.0026
15	0.0614	1.8019	0.3453	0.0052	60	0.0176	0.8929	0.1553	0.0026
16	0.0573	1.7616	0.3317	0.0049	61	0.0180	0.8874	0.1588	0.0027
17	0.0535	1.7223	0.3187	0.0046	62	0.0184	0.8820	0.1625	0.0028
18	0.0500	1.6838	0.3062	0.0043	63	0.0189	0.8766	0.1663	0.0029
19	0.0467	1.6462	0.2942	0.0041	64	0.0193	0.8713	0.1701	0.0029
20	0.0436	1.6094	0.2827	0.0038	65	0.0197	0.8659	0.1740	0.0030
21	0.0412	1.5775	0.2730	0.0036	66	0.0200	0.8647	0.1747	0.0031
22	0.0390	1.5461	0.2636	0.0035	67	0.0203	0.8635	0.1753	0.0031
23	0.0368	1.5154	0.2545	0.0033	68	0.0206	0.8622	0.1759	0.0031
24	0.0348	1.4854	0.2458	0.0031	69	0.0209	0.8610	0.1765	0.0031
25	0.0329	1.4559	0.2374	0.0030	70	0.0212	0.8598	0.1771	0.0032
26	0.0315	1.4293	0.2298	0.0029	71	0.0212	0.8598	0.1771	0.0032
27	0.0300	1.4033	0.2225	0.0027	72	0.0212	0.8598	0.1771	0.0032
28	0.0287	1.3777	0.2154	0.0026	73	0.0212	0.8598	0.1771	0.0032
29	0.0274	1.3526	0.2085	0.0025	74	0.0212	0.8598	0.1771	0.0032
30	0.0262	1.3279	0.2019	0.0024	75	0.0212	0.8598	0.1771	0.0032
31	0.0252	1.3055	0.1961	0.0024	76	0.0212	0.8598	0.1771	0.0032
32	0.0243	1.2834	0.1906	0.0023	77	0.0212	0.8598	0.1771	0.0032
33	0.0234	1.2617	0.1851	0.0023	78	0.0212	0.8598	0.1771	0.0032
34	0.0226	1.2404	0.1798	0.0022	79	0.0212	0.8598	0.1771	0.0032
35	0.0217	1.2194	0.1747	0.0021	80	0.0212	0.8598	0.1771	0.0032
36	0.0211	1.2004	0.1707	0.0021	81	0.0212	0.8598	0.1771	0.0032
37	0.0205	1.1816	0.1668	0.0021	82	0.0212	0.8598	0.1771	0.0032
38	0.0200	1.1632	0.1629	0.0021	83	0.0212	0.8598	0.1771	0.0032
39	0.0194	1.1450	0.1592	0.0020	84	0.0212	0.8598	0.1771	0.0032
40	0.0189	1.1271	0.1555	0.0020	85	0.0212	0.8598	0.1771	0.0032
41	0.0185	1.1110	0.1531	0.0020	86	0.0212	0.8598	0.1771	0.0032
42	0.0182	1.0951	0.1508	0.0020	87	0.0212	0.8599	0.1771	0.0032
43	0.0179	1.0795	0.1485	0.0020	88	0.0212	0.8599	0.1771	0.0032
44	0.0175	1.0641	0.1462	0.0020	89	0.0212	0.8599	0.1771	0.0032
45	0.0172	1.0489	0.1440	0.0020	90	0.0212	0.8599	0.1771	0.0032

¹¹ ROG includes running exhaust and running evaporative emissions.

¹² PM2.5 Ex includes running exhaust emissions only.

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

Project Life 6-10 years (2021-2030)

Speed	ROG ¹³	CO	NO _x	PM2.5 Ex ¹⁴	Speed	ROG	CO	NO _x	PM2.5 Ex
5	0.1135	2.0514	0.5658	0.0095	50	0.0133	0.8525	0.1121	0.0018
6	0.1042	1.9940	0.5352	0.0088	51	0.0133	0.8429	0.1128	0.0019
7	0.0956	1.9382	0.5063	0.0081	52	0.0133	0.8334	0.1134	0.0019
8	0.0877	1.8840	0.4789	0.0075	53	0.0133	0.8240	0.1141	0.0020
9	0.0805	1.8313	0.4530	0.0070	54	0.0133	0.8147	0.1147	0.0020
10	0.0738	1.7801	0.4285	0.0064	55	0.0134	0.8056	0.1154	0.0021
11	0.0682	1.7330	0.4009	0.0060	56	0.0135	0.7981	0.1174	0.0021
12	0.0629	1.6872	0.3751	0.0056	57	0.0137	0.7908	0.1195	0.0022
13	0.0581	1.6427	0.3510	0.0052	58	0.0138	0.7835	0.1216	0.0022
14	0.0536	1.5993	0.3284	0.0048	59	0.0140	0.7762	0.1237	0.0023
15	0.0495	1.5570	0.3073	0.0045	60	0.0142	0.7691	0.1258	0.0024
16	0.0462	1.5227	0.2944	0.0042	61	0.0145	0.7637	0.1291	0.0024
17	0.0431	1.4892	0.2822	0.0040	62	0.0148	0.7583	0.1326	0.0025
18	0.0403	1.4564	0.2704	0.0037	63	0.0152	0.7530	0.1361	0.0026
19	0.0376	1.4244	0.2591	0.0035	64	0.0155	0.7477	0.1396	0.0027
20	0.0351	1.3930	0.2483	0.0033	65	0.0158	0.7424	0.1433	0.0028
21	0.0332	1.3657	0.2391	0.0031	66	0.0161	0.7409	0.1438	0.0028
22	0.0314	1.3389	0.2302	0.0030	67	0.0163	0.7395	0.1443	0.0028
23	0.0297	1.3127	0.2217	0.0028	68	0.0165	0.7380	0.1448	0.0028
24	0.0281	1.2869	0.2135	0.0027	69	0.0168	0.7365	0.1453	0.0029
25	0.0265	1.2617	0.2056	0.0026	70	0.0170	0.7350	0.1458	0.0029
26	0.0253	1.2389	0.1983	0.0025	71	0.0170	0.7350	0.1458	0.0029
27	0.0242	1.2164	0.1913	0.0024	72	0.0170	0.7350	0.1458	0.0029
28	0.0231	1.1944	0.1846	0.0023	73	0.0170	0.7350	0.1458	0.0029
29	0.0221	1.1728	0.1781	0.0022	74	0.0170	0.7350	0.1458	0.0029
30	0.0211	1.1516	0.1718	0.0021	75	0.0170	0.7350	0.1458	0.0029
31	0.0203	1.1322	0.1663	0.0020	76	0.0170	0.7350	0.1458	0.0029
32	0.0196	1.1131	0.1609	0.0020	77	0.0170	0.7350	0.1458	0.0029
33	0.0189	1.0944	0.1557	0.0019	78	0.0170	0.7350	0.1458	0.0029
34	0.0182	1.0759	0.1507	0.0019	79	0.0170	0.7351	0.1458	0.0029
35	0.0175	1.0578	0.1458	0.0018	80	0.0170	0.7351	0.1458	0.0029
36	0.0170	1.0412	0.1419	0.0018	81	0.0170	0.7351	0.1458	0.0029
37	0.0166	1.0249	0.1381	0.0018	82	0.0170	0.7351	0.1458	0.0029
38	0.0161	1.0089	0.1344	0.0018	83	0.0170	0.7351	0.1458	0.0029
39	0.0157	0.9931	0.1308	0.0018	84	0.0170	0.7351	0.1458	0.0029
40	0.0152	0.9776	0.1273	0.0017	85	0.0170	0.7351	0.1458	0.0029
41	0.0149	0.9635	0.1250	0.0017	86	0.0170	0.7351	0.1458	0.0029
42	0.0147	0.9496	0.1227	0.0017	87	0.0170	0.7351	0.1458	0.0029
43	0.0144	0.9359	0.1204	0.0017	88	0.0170	0.7351	0.1458	0.0029
44	0.0141	0.9224	0.1183	0.0017	89	0.0170	0.7351	0.1458	0.0029
45	0.0139	0.9091	0.1161	0.0017	90	0.0170	0.7351	0.1458	0.0029

¹³ ROG includes running exhaust and running evaporative emissions.

¹⁴ PM2.5 Ex includes running exhaust emissions only.

Table 5A. Statewide Calendar Year 2022 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	0.086	0.938	0.516	0.042	4.0	0.021	0.234	0.129	0.0104
		2010-2012	0.075	0.904	0.345	0.040	4.0	0.019	0.226	0.086	0.0100
		2013-2015	0.039	0.772	0.159	0.037	4.0	0.0098	0.193	0.040	0.0093
		2016-2018	0.035	0.757	0.139	0.038	4.0	0.0088	0.189	0.035	0.0094
		2019-2021	0.045	0.946	0.146	0.039	4.0	0.0113	0.236	0.037	0.0098
		2022+	0.040	0.799	0.130	0.041	4.0	0.0101	0.200	0.033	0.0102
Transit Buses,¹⁷ School Buses, and Trucks¹⁸	14,001- 33,000	2007-2009	0.211	1.853	0.305	0.019	1.8	0.117	1.029	0.169	0.010
		2010-2012	0.147	1.532	0.197	0.019	1.8	0.082	0.851	0.109	0.010
		2013-2015	0.112	1.406	0.180	0.019	1.8	0.062	0.781	0.100	0.011
		2016-2018	0.100	1.298	0.161	0.020	1.8	0.055	0.721	0.089	0.011
		2019-2021	0.083	1.212	0.181	0.020	1.8	0.046	0.674	0.101	0.011
		2022+	0.079	1.194	0.185	0.020	1.8	0.044	0.664	0.103	0.011
Class 8 Trucks¹⁹	> 33,000	2007-2009	0.457	33.81	3.517	0.044	2.9	0.157	11.660	1.213	0.015
		2010-2012	0.492	35.03	3.424	0.036	2.9	0.170	12.080	1.181	0.012
		2013-2015	0.333	28.04	2.872	0.033	2.9	0.115	9.668	0.990	0.011
		2016-2018	0.342	26.80	2.749	0.036	2.9	0.118	9.242	0.948	0.012
		2019-2021	0.223	19.67	2.422	0.036	2.9	0.077	6.782	0.835	0.012
		2022+	0.197	17.13	2.110	0.036	2.9	0.068	5.907	0.728	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 2022 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	0.086	0.938	0.516	0.042	4.0	0.021	0.234	0.129	0.010
		2010-2012	0.075	0.904	0.345	0.040	4.0	0.019	0.226	0.086	0.010
Transit Buses²², School Buses, and Trucks²³	14,001- 33,000	1994-1997	2.600	24.96	4.564	0.025	1.8	1.445	13.866	2.535	0.014
		1998-2002	1.579	22.63	4.407	0.021	1.8	0.877	12.571	2.448	0.011
		2003-2006	0.433	4.994	1.056	0.019	1.8	0.240	2.774	0.587	0.010
		2007-2009	0.211	1.853	0.305	0.019	1.8	0.117	1.029	0.169	0.010
		2010-2012	0.147	1.532	0.197	0.019	1.8	0.082	0.851	0.109	0.010
Class 8 Trucks²⁴	>33,000	1994-1997	3.369	38.78	15.58 4	0.048	2.9	1.162	13.373	5.374	0.017
		1998-2002	2.911	38.21	9.281	0.047	2.9	1.004	13.175	3.200	0.016
		2003-2006	0.959	36.99	4.590	0.045	2.9	0.331	12.755	1.583	0.016
		2007-2009	0.457	33.81	3.517	0.044	2.9	0.157	11.660	1.213	0.015
		2010-2012	0.492	35.03	3.424	0.036	2.9	0.170	12.080	1.181	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 2022 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	0.039	0.77	0.16	0.04	4.0	0.0098	0.193	0.040	0.0093
		2016-2018	0.035	0.76	0.14	0.04	4.0	0.0088	0.189	0.035	0.0094
		2019-2021	0.045	0.95	0.15	0.04	4.0	0.0113	0.236	0.037	0.0098
		2022+	0.040	0.80	0.13	0.04	4.0	0.0101	0.200	0.033	0.0102
Transit Buses²⁷, School Buses, and Trucks²⁸	14,001 - 33,000	2013-2015	0.112	1.41	0.18	0.02	1.8	0.062	0.781	0.100	0.011
		2016-2018	0.100	1.30	0.16	0.02	1.8	0.055	0.721	0.089	0.011
		2019-2021	0.083	1.21	0.18	0.02	1.8	0.046	0.674	0.101	0.011
		2022+	0.079	1.19	0.19	0.02	1.8	0.044	0.664	0.103	0.011
Class 8 Trucks²⁹	> 33,000	2013-2015	0.333	28.0	2.87	0.03	2.9	0.115	9.668	0.990	0.011
		2016-2018	0.342	26.8	2.75	0.04	2.9	0.118	9.242	0.948	0.012
		2019-2021	0.223	19.7	2.42	0.04	2.9	0.077	6.782	0.835	0.012
		2022+	0.197	17.1	2.11	0.04	2.9	0.068	5.907	0.728	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 also, 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 2022 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 Buses³², School Buses, and Trucks³³	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 Trucks³⁴	> 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 2022 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 Buses³⁷, School Buses, and Trucks³⁸	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 Trucks³⁹	>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 2022 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 Buses⁴², School Buses, and Trucks⁴³	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	0.73	0.02	1.8	0.005	0.098	0.397	0.012
Class 8 Trucks⁴⁴	> 33,000	2013-2015	0.060	0.79	2.94	0.07	2.9	0.021	0.271	1.010	0.024
		2016-2018	0.056	0.72	2.30	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 2022 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 Buses⁴⁷, School Buses, and Trucks⁴⁸	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 Trucks⁴⁹	> 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 2022 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 Buses⁵², School Buses, and Trucks⁵³	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 Trucks⁵⁴	>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 2022 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 Buses⁵⁷, School Buses, and Trucks⁵⁸	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	0.03	1.8	0.014	2.913	0.135	0.012
Class 8 Trucks⁵⁹	> 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 designed⁶⁰ 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 \(live.com\)](https://www.ordas.ca.gov/ef/fcf/2017/v8.xlsx)

⁶¹ For more information, please see: [ordas_emsfactors_2017.docx \(ca.gov\)](https://www.ordas.ca.gov/ef/emsfactors/2017.docx)

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, NO_x (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.
- NO_x 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