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

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

Emission Factor Tables
March 2018

California Air Resources Board

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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, and in most cases are 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 by Table.

Table 1	Updated emission rates to EMFAC 2014. Updated re-entrained dust rates to reflect latest U.S. EPA and CARB methodologies.
Table 2	Updated Table 2.
Table 3/3A	Updated emission rates to EMFAC 2014. Added 2017 to project life column headings. Updated re-entrained dust rates to reflect latest U.S. EPA and CARB methodologies.
Table 4	Updated emission rates to reflect EMFAC 2014.
Table 5	Table 5 has replaced Tables 5A through 5F. EMFAC2014 is the source for the Table 5 emission rates.
Table 6	Updated rates from CARB OFFROAD program.

Other Changes

Previously, a version of the Access database tool was created for the South Coast Air Quality Management District (which calculated PM2.5), while another version was used in the remaining areas of the state (which calculated PM10). With the revisions to the CMAQ program emphasizing PM2.5 contained in the most recent highway bill signed into law, there is no longer a need to maintain a separate version of the Access database tool for PM10. The updated Access database tool now on the CARB website will calculate PM2.5 only for the remaining areas of the state; the tool will not be applicable to the South Coast Air Quality Management District.

Table 1 Diesel Bus Emission Factors

(Through model year 2017)

Pollutant	Calendar Year	Model Year	Emission Factor (g/mi) Average	45 MPH
ROG	2017	Entire Fleet	1.05	0.52
	2017	1973-83	1.69	0.66
	2017	1984-90	1.69	0.66
	2017	1991-93	1.67	0.40
	2017	1994-95	1.60	0.39
	2017	1996-2001	1.58	0.39
	2017	2002	1.57	0.39
	2017	2003 - 2006	1.42	0.08
	2017	2007 - 2009	0.02	0.004
	2017	2010 - 2017	0.02	0.004
	2017	2017	0.02	N/A***
CO	2017	Entire Fleet	11.75	5.52
	2017	1973-83	16.83	8.08
	2017	1984-90	15.72	7.59
	2017	1991-93	10.13	3.17
	2017	1994-95	12.55	2.12
	2017	1996-2001	13.53	1.67
	2017	2002	15.14	1.67
	2017	2003 - 2006	17.86	2.15
	2017	2007 - 2009	5.44	0.38
	2017	2010 - 2017	5.78	0.38
	2017	2017	6.28	N/A***
NOx	2017	Entire Fleet	17.65	24.83
	2017	1973-83	45.07	30.60
	2017	1984-90	41.42	28.34
	2017	1991-93	25.21	21.47
	2017	1994-95	25.88	25.13
	2017	1996-2001	24.52	25.09
	2017	2002	20.11	17.18
	2017	2003 - 2006	11.36	3.64
	2017	2007 - 2009	1.03	0.73
	2017	2010 - 2017	0.94	0.73
	2017	2017	0.81	N/A***
PM2.5 – Exhaust*	2017	Entire Fleet	0.28	0.37
	2017	1973-83	0.83	0.50
	2017	1984-90	0.81	0.49
	2017	1991-93	0.66	0.22
	2017	1994-95	0.53	0.27
	2017	1996-2001	0.35	0.22
	2017	2002	0.16	0.11
	2017	2003 - 2006	0.05	0.08
	2017	2007 - 2009	0.004	0.006
	2017	2010 - 2017	0.004	0.006
	2017	2017	0.003	N/A***
PM2.5 - Tire Wear	All Years	All Years	0.003	Not Speed Dependent
PM2.5 - Brake Wear	All Years	All Years	0.361	Not Speed Dependent
PM2.5 - Road Dust**	All Years	All Years	0.028	Not Speed Dependent

See notes next page.

Notes for Table 1 - Diesel Bus Emission Factors:

Source: EMFAC2014 V1.0.7, average annual emissions, statewide urban diesel bus fleet, running exhaust emissions only, humidity 50%, temperature 75 degrees F.

* Statewide average annual PM2.5 emission factor, weighted by VMT per road category.

** 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 CARB's Miscellaneous Process Methodology 7.9, Entrained Paved Road Travel, Paved Road Dust (updated November 2016). [PM2.5=0.15*PM10]

*** No data available

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 milligrams/mile					
Weight (lb)[1]	**ROG**	**NOx**	**PM2.5**		**CO**
			Exhaust	Total[2]	
Up to 8500	51	60	10	56	2,100
8501-10,000	148	195	68	132	6,200
10,001-14,000	173	390	68	137	7,100

Replacement (Newer) Technology Cleaner Vehicles:

Projected Average New Trucks in 2018. NOTE: Emission factor units are milligrams per mile					
Weight (lb)[1]	**ROG**	**NOx**	**PM2.5**		**CO**
			Exhaust	Total[2]	
Up to 8500	46	58	3	49	1,800
8501-10,000	114	164	8	72	6,200
10,001-14,000	172	279	10	79	7,000

Zero-emission light-duty and medium-duty vehicle (ZEV) NOTE: Emission factor units are milligrams per mile					
Weight (lb)[1]	**ROG**	**NOx**	**PM2.5**		**CO**
			Exhaust	Total[2]	
Up to 8500	0	0	0	46	0
8501-10,000	0	0	0	64	0
10,001-14,000	0	0	0	69	0

See notes after table
Notes for Table 2, Emission Factors for Cleaner Vehicles:

1 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.

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

Sources:

Baseline is California Vehicle Exhaust Standards ("LEV II") for average chassis-certified trucks for model year 2010. Factors assume emissions at 50,000 mile standard for the first 50,000 miles of the car's life (assumed to be 120,000 miles) and emission 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 2018.

The PM2.5 factors have been adjusted from total PM by the fraction of the size distribution less than 2.5 µm. These were taken from EPA size distribution measurements tabulated in EPA's PART5 model. See the EMFAC 2000 Technical Support Document Table 4.12-5. 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 silt loading and other parameters for the equation came from MRI, 1996. Improvement of Specific Emission Factors, (BACM Project No 1). 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. The road dust PM factor, however, 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 EMFAC 2011 Technical Documentation).

Table 3 Average Auto Emission Factors

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

Analysis Period or Project Life	1-5 Years (2016-2020)	6-10 Years (2016-2025)	11-15 Years (2016-2030)	16-20 Years (2016-2035)
ROG				
VMT (g/mile)	0.119	0.102	0.087	0.084
commute trip ends (g/trip end)	0.400	0.318	0.256	0.225
average trip ends (g/trip end)	0.368	0.296	0.241	0.216
NOx				
VMT (g/mile)	0.114	0.091	0.074	0.067
commute trip ends (g/trip end)	0.125	0.095	0.074	0.063
average trip ends (g/trip end)	0.175	0.132	0.103	0.088
PM2.5				
VMT (g/mile)	0.053	0.053	0.053	0.053
Running exhaust only (g/mile)	0.002	0.002	0.002	0.002
Tire and brake wear (g/mile)	0.024	0.024	0.024	0.024
Road dust (g/mile)	0.028	0.028	0.028	0.028
Commute trip ends (g/trip end)	0.005	0.005	0.004	0.004
Average trip ends (g/trip end)	0.003	0.002	0.002	0.002
CO				
VMT (g/mile)	1.170	0.974	0.812	0.760
Commute trip ends (g/trip end)	2.967	2.384	1.929	1.719
Average trip ends (g/trip end)	2.448	1.943	1.569	1.408

Source: EMFAC2014 V1.0.7, statewide average annual emissions.

Output runs use 50% relative humidity and 75 degrees Fahrenheit temperature.

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)

[PM10] = 0.15*[PM2.5]

Table 3A Average Auto Emission Factors

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

Analysis Period or Project Life	1 Year 2016	1 Year 2017	1 Year 2018
ROG			
VMT (g/mile)	0.145	0.129	0.116
Commute trip ends (g/trip end)	0.503	0.444	0.392
Average trip ends (g/trip end)	0.459	0.407	0.361
NOx			
VMT (g/mile)	0.145	0.127	0.111
Commute trip ends (g/trip end)	0.163	0.141	0.122
Average trip ends (g/trip end)	0.230	0.199	0.172
$PM_{2.5}$			
VMT (g/mile)	0.053	0.053	0.053
Running exhaust only (g/mile)	0.002	0.002	0.002
Tire and brake wear (g/mile)	0.024	0.024	0.024
Road dust (g/mile)	0.028	0.028	0.028
Commute trip ends (g/trip end)	0.005	0.005	0.005
Average trip ends (g/trip end)	0.003	0.002	0.002
CO			
VMT (g/mile)	1.453	1.285	1.142
Commute trip ends (g/trip end)	3.726	3.284	2.903
Average trip ends (g/trip end)	3.085	2.723	2.403

Source: EMFAC2014 V1.0.7, statewide average annual emissions
Output runs use 50% relative humidity and 75 degrees Fahrenheit temperature.

PM2.5, road dust: statewide average annual PM2.5 emission factor, 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).

[PM10 = 0.15*PM2.5]

Table 4 Emission Factors by Speed

Project Life 1-5 years (2016-2020)

				Grams per Mile					
Speed					**Speed**				
(mph)	**ROG**	**CO**	**NOx**	**PM2.5 Ex**	**(mph)**	**ROG**	**CO**	**NOx**	**PM2.5 Ex**
5	**0.34**	**2.74**	**1.14**	**0.02**	***35***	**0.05**	**1.30**	**0.39**	**0.005**
6	0.31	2.66	1.10	0.02	*36*	0.05	1.28	0.39	0.005
7	0.29	2.57	1.06	0.02	*37*	0.05	1.26	0.38	0.004
8	0.27	2.49	1.02	0.02	*38*	0.05	1.24	0.38	0.004
9	0.25	2.41	0.98	0.02	*39*	0.05	1.22	0.37	0.004
10	**0.23**	**2.34**	**0.94**	**0.01**	***40***	**0.04**	**1.21**	**0.37**	**0.004**
11	0.21	2.27	0.89	0.01	*41*	0.04	1.19	0.37	0.004
12	0.19	2.20	0.84	0.01	*42*	0.04	1.18	0.37	0.004
13	0.18	2.13	0.79	0.01	*43*	0.04	1.16	0.36	0.004
14	0.16	2.07	0.75	0.01	*44*	0.04	1.15	0.36	0.004
15	**0.15**	**2.00**	**0.70**	**0.01**	***45***	**0.04**	**1.13**	**0.36**	**0.004**
16	0.14	1.95	0.67	0.01	*46*	0.04	1.12	0.36	0.004
17	0.13	1.90	0.64	0.01	*47*	0.04	1.11	0.35	0.004
18	0.12	1.85	0.61	0.01	*48*	0.04	1.10	0.35	0.004
19	0.11	1.80	0.58	0.01	*49*	0.04	1.09	0.35	0.004
20	**0.10**	**1.76**	**0.55**	**0.01**	***50***	**0.04**	**1.07**	**0.35**	**0.004**
21	0.10	1.72	0.53	0.01	*51*	0.04	1.07	0.35	0.004
22	0.09	1.68	0.52	0.01	*52*	0.04	1.06	0.35	0.004
23	0.09	1.64	0.50	0.01	*53*	0.04	1.05	0.35	0.004
24	0.08	1.60	0.48	0.01	*54*	0.04	1.05	0.35	0.004
25	**0.08**	**1.57**	**0.47**	**0.01**	***55***	**0.04**	**1.04**	**0.35**	**0.004**
26	0.08	1.54	0.46	0.01	*56*	0.04	1.04	0.35	0.005
27	0.07	1.51	0.45	0.01	*57*	0.04	1.03	0.35	0.005
28	0.07	1.48	0.44	0.01	*58*	0.04	1.03	0.35	0.005
29	0.07	1.45	0.43	0.01	*59*	0.04	1.03	0.35	0.005
30	**0.06**	**1.42**	**0.42**	**0.01**	***60***	**0.04**	**1.02**	**0.35**	**0.005**
31	0.06	1.40	0.41	0.01	*61*	0.04	1.03	0.35	0.005
32	0.06	1.37	0.41	0.005	*62*	0.04	1.03	0.35	0.005
33	0.06	1.35	0.40	0.005	*63*	0.04	1.03	0.36	0.005
34	0.05	1.32	0.40	0.005	*64*	0.04	1.04	0.36	0.005
					65	**0.04**	**1.04**	**0.36**	**0.005**

Source: EMFAC2014 V1.0.7, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 degrees F. ROG includes running exhaust and running evaporative emissions. PM2.5 Ex includes running exhaust emissions only.

Table 4 Emission Factors by Speed (Continued)

Project Life 6-10 years (2016-2025)

				Grams per Mile					
Speed					***Speed***				
(mph)	**ROG**	**CO**	**NOx**	**PM2.5 Ex**	***(mph)***	**ROG**	**CO**	**NOx**	**PM2.5 Ex**
5	**0.28**	**2.26**	**1.09**	**0.02**	***35***	**0.04**	**1.08**	**0.30**	**0.003**
6	0.26	2.20	1.04	0.02	*36*	0.04	1.06	0.29	0.003
7	0.24	2.13	1.00	0.01	*37*	0.04	1.05	0.29	0.003
8	0.22	2.06	0.96	0.01	*38*	0.04	1.03	0.28	0.003
9	0.20	2.00	0.92	0.01	*39*	0.04	1.02	0.28	0.003
10	**0.19**	**1.94**	**0.88**	**0.01**	***40***	**0.04**	**1.00**	**0.28**	**0.003**
11	0.17	1.88	0.83	0.01	*41*	0.04	0.99	0.27	0.003
12	0.16	1.82	0.77	0.01	*42*	0.03	0.97	0.27	0.003
13	0.15	1.77	0.72	0.01	*43*	0.03	0.96	0.27	0.003
14	0.13	1.72	0.68	0.01	*44*	0.03	0.95	0.27	0.003
15	**0.12**	**1.66**	**0.63**	**0.01**	***45***	**0.03**	**0.93**	**0.26**	**0.003**
16	0.11	1.62	0.59	0.01	*46*	0.03	0.92	0.26	0.003
17	0.11	1.58	0.56	0.01	*47*	0.03	0.91	0.26	0.003
18	0.10	1.54	0.53	0.01	*48*	0.03	0.90	0.26	0.003
19	0.09	1.50	0.50	0.01	*49*	0.03	0.89	0.26	0.003
20	**0.09**	**1.46**	**0.47**	**0.01**	***50***	**0.03**	**0.89**	**0.26**	**0.003**
21	0.08	1.43	0.45	0.01	*51*	0.03	0.88	0.26	0.003
22	0.08	1.40	0.43	0.01	*52*	0.03	0.87	0.25	0.003
23	0.07	1.36	0.41	0.01	*53*	0.03	0.86	0.25	0.003
24	0.07	1.33	0.39	0.005	*54*	0.03	0.86	0.25	0.003
25	**0.06**	**1.30**	**0.37**	**0.005**	***55***	**0.03**	**0.85**	**0.25**	**0.003**
26	0.06	1.28	0.36	0.005	*56*	0.03	0.85	0.25	0.003
27	0.06	1.25	0.35	0.004	*57*	0.03	0.84	0.25	0.003
28	0.06	1.23	0.34	0.004	*58*	0.03	0.84	0.25	0.003
29	0.05	1.20	0.33	0.004	*59*	0.03	0.84	0.25	0.003
30	**0.05**	**1.18**	**0.33**	**0.004**	***60***	**0.03**	**0.83**	**0.25**	**0.003**
31	0.05	1.16	0.32	0.004	*61*	0.03	0.84	0.26	0.003
32	0.05	1.14	0.31	0.004	*62*	0.03	0.84	0.26	0.003
33	0.05	1.12	0.31	0.004	*63*	0.03	0.84	0.26	0.004
34	0.04	1.10	0.30	0.004	*64*	0.04	0.84	0.26	0.004
					65	**0.04**	**0.84**	**0.26**	**0.004**

Source: EMFAC2014 V1.0.7, average annual emissions, statewide vehicle fleet, 50% humidity, temperature 75 degrees F. ROG includes running exhaust and running evaporative emissions. PM2.5 Ex includes running exhaust emissions only.

Table 5. Emission Rates for Medium-Heavy and Heavy-Heavy Duty Trucks and Buses.

The source for the emission rates is EMFAC 2014 (see notes in the individual tables). Rates are provided for diesel fuel.

To use this table, find the emission rate of the model year (or certification rate, if known) of the engine that is to be replaced, expressed in the units desired. Second, find the emission rate of the new engine based on its model year or certification rate (if known) expressed in the units desired (usually the same units as for the existing engine). Calculate the cost effectiveness using the rates and appropriate method as described in the Methods document.

Table 5 Statewide Calendar Year 2017 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects

BEFORE PROJECT Baseline Emission Factors
New Diesel Vehicles

Vehicle Type	Gross Vehicle Weight Rating (lbs)	Model Year	Emission Factors (g/mi)				Conversion Factors	Emission Factors (g/bhp-hr)			
			ROG	CO	NOx	PM2.5		ROG	CO	NOx	PM2.5
Urban Transit Buses	> 33,000	2007-2009	0.02	5.44	1.03	0.0044	4.0	0.006	1.359	0.256	0.0011
		2010-2012	0.02	5.05	1.13	0.0050	4.0	0.006	1.262	0.282	0.0013
		2013+	0.02	6.28	0.81	0.0031	4.0	0.006	1.569	0.203	0.0008
Transit Buses[1], School Buses, and Trucks[2]	14,001 - 33,000	2007-2009	0.2	0.6	6.4	0.104	1.8	0.128	0.344	3.528	0.058
		2010-2012	0.05	0.2	2.0	0.005	1.8	0.028	0.129	1.138	0.003
		2013+	0.03	0.2	1.1	0.002	1.8	0.018	0.094	0.626	0.001
Class 8 Trucks[3]	> 33,000	2007-2009	0.4	1.1	12.0	0.065	2.9	0.121	0.362	4.150	0.022
		2010-2012	0.1	0.6	3.8	0.010	2.9	0.041	0.218	1.314	0.003
		2013+	0.1	0.6	1.6	0.004	2.9	0.023	0.191	0.538	0.001

Retrofit Diesel Vehicles

Vehicle Type	Gross Vehicle Weight Rating (lbs)	Model Year	Emission Factors (g/mi)				Conversion Factors	Emission Factors (g/bhp-hr)			
			ROG	CO	NOx	PM2.5		ROG	CO	NOx	PM2.5
Urban Transit Buses	> 33,000	1994-1997	1.60	11.45	30.22	0.63	4.0	0.401	2.862	7.555	0.158
		1998-2002	1.58	14.32	22.21	0.25	4.0	0.394	3.580	5.554	0.063
Transit Buses[1], School Buses, and Trucks[2]	14,001 - 33,000	1994-1997	0.50	1.31	15.33	0.19	1.8	0.280	0.729	8.518	0.105
		1998-2002	0.91	2.36	14.99	0.35	1.8	0.504	1.309	8.329	0.192
Class 8 Trucks[3]	> 33,000	1994-1997	0.76	2.84	20.44	0.27	2.9	0.263	0.980	7.048	0.092
		1998-2002	0.61	1.88	23.99	0.18	2.9	0.211	0.649	8.274	0.064

AFTER PROJECT Emission Factors
New Cleaner Vehicle Purchases or Repowers

Vehicle Type	Gross Vehicle Weight Rating (lbs)	Model Year	Emission Factors (g/mi)				Conversion Factors	Emission Factors (g/bhp-hr)			
			ROG	CO	NOx	PM2.5		ROG	CO	NOx	PM2.5
Urban Transit Buses	> 33,000	2012-2014	0.02	6.35	0.80	0.0030	4.0	0.006	1.586	0.199	0.0007
		2015+	0.02	6.28	0.81	0.0031	4.0	0.006	1.570	0.203	0.0008
Transit Buses[1], School Buses, and Trucks[2]	14,001 - 33,000	2012-2014	0.04	0.2	1.6	0.003	1.8	0.022	0.115	0.901	0.002
		2015+	0.03	0.2	1.0	0.002	1.8	0.017	0.088	0.545	0.001
Class 8 Trucks[3]	> 33,000	2012-2014	0.1	0.6	2.8	0.006	2.9	0.030	0.199	0.951	0.002
		2015+	0.1	0.5	1.2	0.003	2.9	0.021	0.174	0.428	0.001

Source: EMFAC2014 V1.07 (Default), Annual, Statewide

1 - Other Buses; 2 - Medium Heavy-Duty Trucks; 3 - Heavy Heavy-Duty Trucks

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.

Table 6 Off-Road Emission Factors For Cleaner Vehicle Projects (2016-2017)

In Table 6, find the horsepower (hp) and model year for the engine that best describes the engine being replaced to determine the “before project” baseline emission factors. In Table 6, find the hp and model year for the newer engine to determine the “after project” cleaner engine baseline emission factors.

To calculate an engine’s emission factor taking into account deterioration from the engine’s cumulative operating hours:

1. First multiply the engine’s cumulative operating hours by the deterioration rate (DR).

2. Then add that to the emission factor (EF).

Equation 1:

$EF_{DR} = (Hrs_{Cumulative} * DR) + EF$

EF_{DR} = Emission factor with deterioration rate (to be calculated)
$Hrs_{Cumulative}$ = Total operating hours to date
DR = Deterioration Rate (from Table 6)

For example, based on Equation 1 and data presented in Table 6, a pre-1988 25 horsepower engine that has 1,000 operating hours to date would have the following NOx emission factor:

$$6.608 = (1{,}000 * 0.000098) + 6.51$$

To estimate the reduction in annual emissions (in grams) from replacing the engine, use the equation below, obtained from the Carl Moyer Guidelines, Appendix D (https://www.arb.ca.gov/regact/2010/offroadlsi10/offroadappd.pdf):

Equation 2:

$Annual\ Reductions = (EF_{Before\ Project} - EF_{After\ Project}) * (Hours/Year) * hp * (LF)$

LF = Load Factor (unitless, see Carl Moyer Guidelines Appendix D for values https://www.arb.ca.gov/regact/2010/offroadlsi10/offroadappd.pdf)

Table 6
Uncontrolled Off-Road Diesel Engines
Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)
Before Project: Baseline Emission

Horsepower	Model Year	NOx		ROG		PM2.5	
		EF	DR	EF	DR	EF	DR
25-49	Pre-1988	6.51	0.000098	1.68	0.000210	0.503	0.0000390
	1988+	6.42	0.000097	1.64	0.000210	0.503	0.0000390
20-119	Pre-1988	12.09	0.00028	1.31	0.000061	0.557	0.0000405
	1988+	8.14	0.00019	0.90	0.000042	0.457	0.0000332
120+	Pre-1970	13.02	0.00030	1.20	0.000056	0.510	0.0000371
	1970-1979	11.16	0.00026	0.91	0.000042	0.364	0.0000265
	1980-1987	10.23	0.00024	0.80	0.000037	0.364	0.0000265
	1988+	7.60	0.00018	0.62	0.000029	0.252	0.0000183

Source: The Carl Moyer Program Guidelines 2017 Revisions, Appendix D, Table D-8

For use in calculating cost effectiveness of diesel engines: PM2.5 = PM10 X 0.92
(https://www.arb.ca.gov/msei/ordiesel/pm25_pm10reference.pdf)

Table 6 (Continued)
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)
After Project: Cleaner Engine

Horsepower	Tier	NOx		ROG		PM2.5	
		EF	DR	EF	DR	EF	DR
25-49	1	5.26	0.0000980	1.32	0.000170	0.442	0.0000342
	2	4.63	0.0000930	0.22	0.000050	0.258	0.0000201
	4 (Interim)	4.55	0.0000950	0.09	0.000036	0.118	0.0000088
	4 (Final)	2.75	0.0000570	0.09	0.000036	0.008	0.0000009
50-74	1	6.54	0.0001500	0.90	0.000042	0.508	0.0000370
	2	4.75	0.0000710	0.17	0.000025	0.177	0.0000130
	3	2.74	0.0000360	0.09	0.000023	0.177	0.0000130
	4 (Interim)	2.74	0.0000360	0.09	0.000023	0.103	0.0000074
	4 (Final)	2.74	0.0000360	0.09	0.000023	0.008	0.0000008
75-99	1	6.54	0.0001500	0.90	0.000042	0.508	0.0000370
	2	4.75	0.0000710	0.17	0.000025	0.177	0.0000130
	3	2.74	0.0000360	0.09	0.000023	0.103	0.0000074
	4 (Phase-Out)	2.74	0.0000360	0.09	0.000030	0.008	0.0000008
	(Phase-In or Alt. NOx)	2.15	0.0000270	0.08	0.000021	0.008	0.0000008
	4 (Final)	0.26	0.0000035	0.05	0.000015	0.008	0.0000008
100-174	1	6.54	0.0001500	0.62	0.000029	0.280	0.0000203
	2	4.15	0.0000600	0.15	0.000023	0.118	0.0000086
	3	2.32	0.0000300	0.09	0.000030	0.103	0.0000074
	4 (Phase-Out)	2.32	0.0000300	0.09	0.000030	0.008	0.0000004
	(Phase-In or Alt. NOx)	2.15	0.0000270	0.08	0.000020	0.008	0.0000004
	4 (Final)	0.26	0.0000040	0.05	0.000011	0.008	0.0000004
175-299	1	5.93	0.0001400	0.29	0.000013	0.110	0.0000059
	2	4.15	0.0000600	0.11	0.000022	0.081	0.0000042
	3	2.32	0.0000300	0.09	0.000023	0.081	0.0000042
	4 (Phase-Out)	2.32	0.0000300	0.09	0.000023	0.008	0.0000003
	(Phase-In or Alt. NOx)	1.29	0.0000170	0.06	0.000017	0.008	0.0000003
	4 (Final)	0.26	0.0000036	0.05	0.000011	0.008	0.0000003
300-750	1	5.93	0.0000990	0.29	0.000010	0.110	0.0000059
	2	3.79	0.0000500	0.09	0.000023	0.081	0.0000040
	3	2.32	0.0000300	0.09	0.000023	0.081	0.0000040
	4 (Phase-Out)	2.32	0.0000300	0.09	0.000023	0.008	0.0000003
	(Phase-In or Alt. NOx)	1.29	0.0000170	0.06	0.000017	0.008	0.0000003
	4 (Final)	0.26	0.0000036	0.05	0.000011	0.008	0.0000003
751+	1	5.93	0.0000990	0.29	0.000010	0.110	0.0000059
	2	3.79	0.0000500	0.09	0.000023	0.081	0.0000040
	4 (Interim)	2.24	0.0000280	0.06	0.000017	0.047	0.0000019
	4 (Final)	2.24	0.0000280	0.05	0.000011	0.016	0.0000008

Source: The Carl Moyer Program Guidelines 2017 Revisions, Appendix D, Table D-9

For use in calculating cost effectiveness of diesel engines: PM2.5 = PM10 X 0.92
(https://www.arb.ca.gov/msei/ordiesel/pm25_pm10reference.pdf)