

# **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 2019***



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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 reflect EMFAC2017. Eliminated model year ranges with no vehicles.
Table 2	Updated Table 2.
Table 3/3A	Updated emission rates to reflect EMFAC2017.
Table 4	Updated emission rates to reflect EMFAC2017.
Table 5	Updated emission rates to reflect EMFAC2017.

**Table 1 Diesel Bus Emission Factors**  
(through Model Year 2018)

Pollutant	Calendar Year	Model Year	Emission Factor (gram/mile) Average	Emission Factor (gram/mile) 45 MPH
ROG	2018	Entire Fleet	0.004	0.004
	2018	2003 - 2006	0.011	0.004
	2018	2007 - 2009	0.008	0.008
	2018	2010 - 2014	0.003	0.003
	2018	2015 - 2018	0.002	0.002
	2018	2018	0.001	0.002
CO	2018	Entire Fleet	0.26	0.14
	2018	2003 - 2006	0.75	0.41
	2018	2007 - 2009	0.56	0.13
	2018	2010 - 2014	0.14	0.05
	2018	2015 - 2018	0.13	0.04
	2018	2018	0.13	0.04
NOx	2018	Entire Fleet	2.29	1.69
	2018	2003 - 2006	8.24	4.55
	2018	2007 - 2009	5.83	3.51
	2018	2010 - 2014	0.79	0.13
	2018	2015 - 2018	0.79	0.12
	2018	2018	0.78	0.12
PM2.5 - Exhaust*	2018	Entire Fleet	0.007	0.008
	2018	2003 - 2006	0.01	0.008
	2018	2007 - 2009	0.01	0.007
	2018	2010 - 2014	0.006	0.008
	2018	2015 - 2018	0.006	0.007
	2018	2018	0.006	0.007
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

Source: EMFAC2017 V1.0.2, 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 PM10 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).

[PM2.5 = 0.15\*PM10]

## 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)

Weight <sup>1</sup>	ROG	NOx	PM2.5 Exhaust	PM2.5 Total <sup>2</sup>	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 2019 (note: emission factor units are grams per mile)

Weight <sup>1</sup>	ROG	NOx	PM2.5 Exhaust	PM2.5 Total <sup>2</sup>	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 vehicle (ZEV) (note: emission factor units are grams per mile)

Weight <sup>1</sup>	ROG	NOx	PM2.5 Exhaust	PM2.5 Total <sup>2</sup>	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 next page

<sup>1</sup> 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.

<sup>2</sup> 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 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 2019.

The PM<sub>2.5</sub> factors have been adjusted from total PM by the fraction of the size distribution less than 2.5  $\mu\text{m}$ . 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 PM<sub>2.5</sub> 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).

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**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 (2017-2021)	6-10 Years (2017-2026)	11-15 Years (2017-2031)	16-20 Years (2017-2036)
<b>ROG</b>				
VMT (g/mile)	0.092	0.080	0.068	0.066
commute trip ends (g/trip end)	0.361	0.294	0.239	0.213
average trip ends (g/trip end)	0.560	0.466	0.384	0.350
<b>NOx</b>				
VMT (g/mile)	0.100	0.076	0.060	0.054
commute trip ends (g/trip end)	0.108	0.083	0.065	0.056
average trip ends (g/trip end)	0.289	0.243	0.202	0.189
<b>PM<sub>2.5</sub></b>				
VMT (g/mile)	0.047	0.047	0.047	0.047
running exhaust only (g/mile)	0.002	0.002	0.001	0.001
tire and brake wear (g/mile)	0.018	0.018	0.018	0.018
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)	0.002	0.002	0.002	0.001
<b>CO</b>				
VMT (g/mile)	1.230	1.013	0.844	0.798
commute trip ends (g/trip end)	2.646	2.153	1.752	1.570
average trip ends (g/trip end)	2.718	2.504	2.193	2.169

Source: EMFAC2017 V1.0.2, statewide average annual emissions output runs use 50% relative humidity and 75 degrees Fahrenheit temperature.

PM<sub>2.5</sub>, road dust: statewide average annual PM<sub>2.5</sub> 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<sub>2.5</sub> = 0.15\*PM<sub>10</sub>]



**Table 3A Average Auto Emission Factors**  
(Fleet of Light-Duty Passenger Vehicles, Light-Duty Trucks and Motor Cycles)

<b>Analysis Period or Project Life</b>	<b>1 Year 2017</b>	<b>1 Year 2018</b>	<b>1 Year 2019</b>
<b>ROG</b>			
VMT (g/mile)	0.109	0.098	0.090
commute trip ends (g/trip end)	0.445	0.396	0.355
average trip ends (g/trip end)	0.667	0.607	0.554
<b>NO<sub>x</sub></b>			
VMT (g/mile)	0.132	0.113	0.096
commute trip ends (g/trip end)	0.141	0.122	0.106
average trip ends (g/trip end)	0.341	0.313	0.287
<b>PM<sub>2.5</sub></b>			
VMT (g/mile)	0.047	0.047	0.047
running exhaust only (g/mile)	0.002	0.002	0.002
tire and brake wear (g/mile)	0.018	0.018	0.018
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)	0.002	0.002	0.002
<b>CO</b>			
VMT (g/mile)	1.528	1.350	1.201
commute trip ends (g/trip end)	3.284	2.903	2.592
average trip ends (g/trip end)	2.924	2.810	2.709

Source: EMFAC2017 V1.0.2, statewide average annual emissions output runs use 50% relative humidity and 75 degrees Fahrenheit temperature.

PM<sub>2.5</sub>, road dust: statewide average annual PM<sub>2.5</sub> 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<sub>2.5</sub> = 0.15\*PM<sub>10</sub>]

**Table 4 Emission Factors (Grams per Mile) by Speed (mph)**

**Project Life 1-5 years (2017-2021)**

Speed	ROG	CO	NOx	PM2.5 Ex	Speed	ROG	CO	NOx	PM2.5 Ex
<b>5</b>	<b>0.34</b>	<b>2.84</b>	<b>0.94</b>	<b>0.02</b>	<b>35</b>	<b>0.05</b>	<b>1.39</b>	<b>0.35</b>	<b>0.005</b>
6	0.32	2.75	0.90	0.02	36	0.05	1.37	0.34	0.005
7	0.29	2.67	0.87	0.02	37	0.05	1.35	0.34	0.005
8	0.27	2.59	0.84	0.02	38	0.04	1.33	0.33	0.005
9	0.25	2.51	0.80	0.02	39	0.04	1.31	0.33	0.005
<b>10</b>	<b>0.23</b>	<b>2.43</b>	<b>0.77</b>	<b>0.02</b>	<b>40</b>	<b>0.04</b>	<b>1.29</b>	<b>0.32</b>	<b>0.005</b>
11	0.21	2.36	0.73	0.02	41	0.04	1.28	0.32	0.005
12	0.19	2.29	0.69	0.01	42	0.04	1.26	0.31	0.005
13	0.18	2.22	0.66	0.01	43	0.04	1.24	0.31	0.005
14	0.16	2.16	0.62	0.01	44	0.04	1.23	0.31	0.005
<b>15</b>	<b>0.15</b>	<b>2.10</b>	<b>0.59</b>	<b>0.01</b>	<b>45</b>	<b>0.04</b>	<b>1.21</b>	<b>0.31</b>	<b>0.005</b>
16	0.14	2.04	0.57	0.01	46	0.04	1.20	0.30	0.005
17	0.12	1.99	0.55	0.01	47	0.04	1.19	0.30	0.005
18	0.11	1.94	0.53	0.01	48	0.04	1.17	0.30	0.005
19	0.11	1.89	0.51	0.01	49	0.04	1.16	0.30	0.005
<b>20</b>	<b>0.10</b>	<b>1.85</b>	<b>0.49</b>	<b>0.01</b>	<b>50</b>	<b>0.04</b>	<b>1.15</b>	<b>0.30</b>	<b>0.005</b>
21	0.09	1.81	0.48	0.01	51	0.04	1.14	0.30	0.005
22	0.09	1.77	0.46	0.01	52	0.04	1.13	0.30	0.006
23	0.08	1.73	0.45	0.01	53	0.04	1.12	0.30	0.006
24	0.08	1.70	0.44	0.01	54	0.04	1.11	0.30	0.006
<b>25</b>	<b>0.07</b>	<b>1.66</b>	<b>0.43</b>	<b>0.01</b>	<b>55</b>	<b>0.04</b>	<b>1.10</b>	<b>0.30</b>	<b>0.006</b>
26	0.07	1.63	0.42	0.01	56	0.04	1.10	0.31	0.006
27	0.07	1.60	0.41	0.01	57	0.04	1.09	0.31	0.006
28	0.06	1.57	0.40	0.01	58	0.04	1.09	0.31	0.006
29	0.06	1.54	0.39	0.01	59	0.04	1.09	0.32	0.006
<b>30</b>	<b>0.06</b>	<b>1.51</b>	<b>0.38</b>	<b>0.01</b>	<b>60</b>	<b>0.04</b>	<b>1.08</b>	<b>0.32</b>	<b>0.006</b>
31	0.06	1.49	0.37	0.01	61	0.04	1.08	0.32	0.007
32	0.05	1.46	0.37	0.006	62	0.04	1.08	0.33	0.007
33	0.05	1.44	0.36	0.005	63	0.04	1.08	0.33	0.007
34	0.05	1.42	0.35	0.005	64	0.04	1.08	0.34	0.007
					<b>65</b>	<b>0.04</b>	<b>1.08</b>	<b>0.34</b>	<b>0.007</b>

Source: EMFAC2017 V1.0.2, 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 (Grams per Mile) by Speed (mph) (continued)**

**Project Life 6-10 years (2017-2026)**

<b>Speed</b>	<b>ROG</b>	<b>CO</b>	<b>NOx</b>	<b>PM2.5 Ex</b>	<b>Speed</b>	<b>ROG</b>	<b>CO</b>	<b>NOx</b>	<b>PM2.5 Ex</b>
<b>5</b>	<b>0.26</b>	<b>2.31</b>	<b>0.83</b>	<b>0.02</b>	<b>35</b>	<b>0.04</b>	<b>1.14</b>	<b>0.27</b>	<b>0.004</b>
6	0.24	2.24	0.79	0.02	36	0.04	1.12	0.26	0.004
7	0.22	2.17	0.76	0.01	37	0.03	1.11	0.25	0.004
8	0.20	2.11	0.73	0.01	38	0.03	1.09	0.25	0.003
9	0.18	2.04	0.70	0.01	39	0.03	1.07	0.24	0.003
<b>10</b>	<b>0.17</b>	<b>1.98</b>	<b>0.67</b>	<b>0.01</b>	<b>40</b>	<b>0.03</b>	<b>1.06</b>	<b>0.24</b>	<b>0.003</b>
11	0.16	1.92	0.63	0.01	41	0.03	1.04	0.23	0.003
12	0.14	1.87	0.60	0.01	42	0.03	1.03	0.23	0.003
13	0.13	1.81	0.56	0.01	43	0.03	1.02	0.23	0.003
14	0.12	1.76	0.53	0.01	44	0.03	1.00	0.22	0.003
<b>15</b>	<b>0.11</b>	<b>1.71</b>	<b>0.50</b>	<b>0.01</b>	<b>45</b>	<b>0.03</b>	<b>0.99</b>	<b>0.22</b>	<b>0.003</b>
16	0.10	1.67	0.48	0.01	46	0.03	0.98	0.22	0.004
17	0.09	1.62	0.47	0.01	47	0.03	0.97	0.22	0.004
18	0.09	1.58	0.45	0.01	48	0.03	0.96	0.22	0.004
19	0.08	1.55	0.43	0.01	49	0.03	0.95	0.22	0.004
<b>20</b>	<b>0.07</b>	<b>1.51</b>	<b>0.41</b>	<b>0.01</b>	<b>50</b>	<b>0.03</b>	<b>0.94</b>	<b>0.21</b>	<b>0.004</b>
21	0.07	1.48	0.40	0.01	51	0.03	0.93	0.22	0.004
22	0.07	1.45	0.39	0.01	52	0.03	0.92	0.22	0.004
23	0.06	1.42	0.38	0.01	53	0.03	0.91	0.22	0.004
24	0.06	1.39	0.37	0.005	54	0.03	0.91	0.22	0.004
<b>25</b>	<b>0.06</b>	<b>1.36</b>	<b>0.35</b>	<b>0.005</b>	<b>55</b>	<b>0.03</b>	<b>0.90</b>	<b>0.22</b>	<b>0.004</b>
26	0.05	1.33	0.34	0.004	56	0.03	0.89	0.22	0.004
27	0.05	1.31	0.33	0.004	57	0.03	0.89	0.22	0.004
28	0.05	1.29	0.32	0.004	58	0.03	0.88	0.23	0.004
29	0.05	1.26	0.31	0.004	59	0.03	0.88	0.23	0.004
<b>30</b>	<b>0.04</b>	<b>1.24</b>	<b>0.30</b>	<b>0.004</b>	<b>60</b>	<b>0.03</b>	<b>0.87</b>	<b>0.23</b>	<b>0.005</b>
31	0.04	1.22	0.30	0.004	61	0.03	0.87	0.24	0.005
32	0.04	1.20	0.29	0.004	62	0.03	0.87	0.24	0.005
33	0.04	1.18	0.28	0.004	63	0.03	0.87	0.25	0.005
34	0.04	1.16	0.27	0.004	64	0.03	0.87	0.25	0.005
					<b>65</b>	<b>0.03</b>	<b>0.87</b>	<b>0.25</b>	<b>0.005</b>

Source: EMFAC2017 V1.0.2, 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 Statewide Calendar Year 2018 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (Grams per Mile)**

**BEFORE PROJECT Baseline Emission Factors – New Diesel Vehicles**

Vehicle Type	GVWR <sup>1</sup> (lbs)	Model Year	ROG	CO	NOx	PM2.5	Conversion Factors	ROG	CO	NOx	PM2.5
Urban Transit Buses	>33,000	2007-2009	0.01	0.56	5.83	0.05	4.0	0.002	0.141	1.459	0.0135
		2010-2012	0.005	0.14	0.78	0.04	4.0	0.001	0.036	0.196	0.0111
		2013+	0.002	0.13	0.79	0.04	4.0	0.0004	0.032	0.197	0.0111
Transit Buses <sup>2</sup> School Buses, and Trucks <sup>3</sup>	14,001- 33,000	2007-2009	0.3	0.9	6.1	0.2	1.8	0.176	0.501	3.389	0.117
		2010-2012	0.03	0.18	2.48	0.08	1.8	0.019	0.103	1.377	0.044
		2013+	0.01	0.13	1.37	0.07	1.8	0.005	0.071	0.762	0.039
Class 8 Trucks <sup>4</sup>	>33,000	2007-2009	0.4	1.4	10.3	0.2	2.9	0.155	0.481	3.553	0.062
		2010-2012	0.2	0.9	5.6	0.1	2.9	0.052	0.302	1.948	0.028
		2013+	0.1	0.7	2.5	0.1	2.9	0.019	0.257	0.861	0.019

**Retrofit Diesel Vehicles**

Vehicle Type	GVWR <sup>1</sup> (lbs)	Model Year	ROG	CO	NOx	PM2.5	Conversion Factors	ROG	CO	NOx	PM2.5
Urban Transit Buses	>33,000	1994-1997					4.0				
		1998-2002					4.0				
Transit Buses <sup>2</sup> School Buses, and Trucks <sup>3</sup>	14,001- 33,000	1994-1997	0.99	2.43	15.58	0.47	1.8	0.553	1.349	8.657	0.260
		1998-2002	1.06	2.56	15.46	0.46	1.8	0.589	1.422	8.587	0.258
Class 8 Trucks <sup>4</sup>	>33,000	1994-1997	1.38	4.35	20.63	0.52	2.9	0.475	1.501	7.114	0.179
		1998-2002	1.44	3.78	24.30	0.47	2.9	0.495	1.303	8.379	0.162

Source: EMFAC2017 v1.02, Annual, Statewide

1 – Gross Vehicle Weight Rating 2 – Other Buses 3 – Medium Heavy-Duty Trucks 4 – Heavy Heavy-Duty Trucks

**Table 5 Statewide Calendar Year 2018 On-Road Emission Factors for Heavy-Duty Cleaner Vehicle Projects (Grams per Mile) (Continued)**

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

Vehicle Type	GVWR <sup>1</sup> (lbs)	Model Year	ROG	CO	NOx	PM2.5	Conversion Factors	ROG	CO	NOx	PM2.5
Urban Transit Buses	>33,000	2012-2014	0.001	0.13	0.79	0.04	4.0	0.0003	0.032	0.199	0.0110
		2015+	0.002	0.13	0.79	0.04	4.0	0.0005	0.033	0.197	0.0111
Transit Buses <sup>2</sup> School Buses, and Trucks <sup>3</sup>	14,001-33,000	2012-2014	0.010	0.14	1.90	0.07	1.8	0.006	0.0787	1.056	0.040
		2015+	0.01	0.12	1.25	0.07	1.8	0.005	0.069	0.695	0.038
Class 8 Trucks <sup>4</sup>	>33,000	2012-2014	0.1	0.8	3.7	0.1	2.9	0.021	0.269	1.271	0.022
		2015+	0.1	0.7	2.1	0.1	2.9	0.019	0.254	0.736	0.017

Source: EMFAC2017 v1.02, Annual, Statewide

1 – Gross Vehicle Weight Rating 2 – Other Buses 3 – Medium Heavy-Duty Trucks 4 – 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:

$$EF_{DR} = (\text{Hrs}_{\text{Cumulative}} * \text{DR}) + \text{EF}$$

$EF_{DR}$  = Emission factor with deterioration rate (to be calculated)

$\text{Hrs}_{\text{Cumulative}}$  = 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:

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

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 EF	NOx DR	ROG EF	ROG DR	PM2.5 EF	PM2.5 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
50-119	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:  $PM_{2.5} = PM_{10} \times 0.92$   
 ([https://www.arb.ca.gov/msei/ordiesel/pm25\\_pm10reference.pdf](https://www.arb.ca.gov/msei/ordiesel/pm25_pm10reference.pdf))

**Table 6 Uncontrolled Off-Road Diesel Engines (continued)**  
**Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)**

**After Project: Cleaner Engine**

Horsepower	Tier	NOx EF	NOx DR	ROG EF	ROG DR	PM2.5 EF	PM2.5 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