

APPENDIX E

EMISSION REDUCTIONS CALCULATION METHODOLOGIES FOR THE DRAFT PEA

INTRODUCTION

Appendix E summarizes the ~~methodology~~ methodologies for used to calculate the emissions baseline and reductions (e.g., air quality benefits) at the release of the Draft PEA. See Appendix E-1 for the revised air quality benefits methodologies on a rule-specific basis. A separate appendix was prepared so the revised emission benefits estimates could be more easily evaluated.

LDV / MDV METHODOLOGIES

For light- and medium-duty vehicles (LDV/MDV), the California Air Resources Board (CARB) Low Emission Vehicle (LEV I/II) regulations require vehicle manufacturers to produce various emission-based categories of vehicles, according to a specific set of hydrocarbon (HC), carbon monoxide (CO), and oxides of nitrogen (NO_x) emission standards assigned to each category. These categories, in descending order of emissions are Tier 1, transitional low-emission, low-emission (LEV), ultra-low-emission (ULEV), super-ultra-low-emission (SULEV), and zero-emission vehicles (ZEV). The CARB LEV I/II regulations achieve emission reductions by requiring manufacturers to sell progressively cleaner mixes of vehicles over time. The proposed fleet vehicle rules causes affected vehicle fleets to purchase a cleaner mix of vehicles than they would have otherwise purchased, on average, by requiring vehicle purchases to be LEV or cleaner for the 2001 through 2003 time frame and ULEV or cleaner for the 2004 through 2010 time frame. This is shown in Tables E-12 through E-34, which present CARB's vehicle manufacturer sales projections by vehicle weight category and the expected fleet purchases of vehicles in these categories as a result of proposed fleet vehicle rules implementation. An implicit assumption in this analysis is that fleet purchases in the absence of proposed fleet vehicle rules would on average correspond to the mix of vehicles projected to by CARB be sold by the vehicle manufacturers complying with LEV I/II.

To quantify annual emission reductions for LDVs/MDVs (shown in Table E-1), the following equation (EQ #1) was utilized, based on the estimated difference in emission rates that would occur between the cleaner mix of vehicles purchased by fleet operators to comply with proposed fleet vehicle rules, and the vehicles the fleet operators would have purchased in the absence of the proposed fleet vehicle rules.

$$B \frac{\text{tons}}{\text{year}} = \left(E_1 \frac{\text{grams}}{\text{mile}} - E_2 \frac{\text{grams}}{\text{mile}} \right) \times \text{VMT} \frac{\text{miles}}{\text{year}} \times P \times C \frac{\text{tons}}{\text{gram}} \times F$$

Where :

B = Emissions benefit per pollutant.

E₁ = Composite fleet average by pollutant based on CARB LEV I/II standards.

See Table E - 4 for emission rates.

E₂ = Composite fleet average by pollutant based on PR 1190 projection of vehicle fleet purchases. See Table E - 4 for emission rates.

VMT = Assumed average mile accumulation per year for each vehicles, which is 10,000 miles per year for passenger cars through medium - duty vehicles.

P = Average annual vehicles purchased by fleet operators, which is estimated for each vehicle category by dividing the vehicle population in Table E - 5 by the estimated average vehicle life of seven years (e.g., number of years vehicle is owned/operated by fleet operator).

C = Conversion factors of 454 grams per pound and 2000 pounds per ton

F = Adjustment factor of 0.6 to account for the consumption of CARB LEV I/II statewide emission credits in the SCAQMD's jurisdiction, generated by vehicle manufacturers through the sale of additional lower emitting vehicles from compliance with the PRs 1191 and 1194. The adjustment factor F is based on an estimated 40 percent of those statewide credits being consumed in the SCAQMD's jurisdiction, using the ratio of vehicle population between the SCAQMD and the entire state.

Table E-1 shows the SCAQMD's estimated LDV/MDV air quality benefits for PRs 1191 and 1194 and the project alternatives using EQ #1 above. Tables E-2 through E-6 provide the input parameters used by the SCAQMD to estimate the LDV/MDV air quality benefits.

TABLE E-1
Light- & Medium-Duty Vehicle Emission Benefits (tons/yr)
Estimates For PRs 1191 and 1194 And Project Alternatives (tons/yr)

Proposed Fleet Vehicle Rules			
Year	HC¹	CO	NO_x
2001	~ ²	~	~
2002	~	~	~
2003	~	~	~
2004	2	65	1
2005	3	124	1
2006	4	174	2
2007	5	218	2
2008	6	258	2
2009	7	291	2
Year	8	318	2
Alternative B			
Year	HC	CO	NO_x
2001	~	~	~
2002	~	~	~
2003	~	~	~
2004	2	65	1
2005	3	124	1
2006	4	174	2
2007	5	218	2
2008	6	258	2
2009	7	291	2
2010	8	318	2
Alternative C			
Year	HC	CO	NO_x
2001	0	0	0
2002	~	~	~
2003	~	~	~
2004	2	65	1
2005	3	124	1
2006	4	174	2
2007	5	218	2
2008	6	258	2
2009	7	291	2
2010	8	318	2

TABLE E-1 (Continued)
Light- & Medium-Duty Vehicle Emission Benefits (tons/yr)
Estimates PRs 1191 and 1194 And Project Alternatives

Alternative D			
Year	HC	CO	NO_x
2001	~	~	~
2002	~	~	~
2003	~	~	~
2004	2	60	0
2005	3	116	1
2006	4	162	1
2007	5	204	2
2008	6	241	2
2009	6	272	2
2010	7	298	2
Alternative E			
Year	HC	CO	NO_x
2001	~	~	~
2002	~	~	~
2003	~	~	~
2004	2	65	1
2005	3	124	1
2006	4	174	2
2007	5	218	2
2008	6	258	2
2009	7	291	2
2010	8	318	2
Alternative F			
Year	HC	CO	NO_x
2001	~	~	~
2002	~	~	~
2003	~	~	~
2004	2	65	1
2005	3	124	1
2006	4	174	2
2007	5	218	2
2008	6	258	2
2009	7	291	2
2010	8	318	2

¹ HC = Hydrocarbon

² ~ = Small unquantified emission benefit due to restriction on the purchase of Tier I vehicles and TLEVs by fleets in years 2001 through 2003.

TABLE E-2
PRs 1191 and 1194 Projected PC / LDT(1) Purchase Distribution

Year	Percentage of PC & LDT(1) Purchases by Emission Categories									
	CARB Sales Distribution Projection				PRs 1191 and 1194 Purchase Requirement		PRs 1191 and 1194 Purchase Distribution Projection			
	LEV	ULEV	SULEV	ZEV ¹	LEV or cleaner	ULEV or cleaner	LEV ²	ULEV	SULEV	ZEV ³
2001	86	14	0	0	100	0	86	14	0	0
2002	80	20	0	0	100	0	80	20	0	0
2003	75	15	0	10	100	0	75	15	0	10
2004	52	33	5	10	0	100	0	78	12	10
2005	46	34	10	10	0	100	0	71	19	10
2006	36	44	10	10	0	100	0	70	20	10
2007	31	45	14	10	0	100	0	67	23	10
2008	28	42	20	10	0	100	0	62	28	10
2009	22	48	20	10	0	100	0	64	26	10
2010	18	47	25	10	0	100	0	60	30	10

¹ Years 2001 and 2002 were adjusted based on CARB's elimination of mandatory ZEV sales requirements.

² For 2004 and subsequent years, the percentage of LEVs from the CARB implementation schedule are prorated between the ULEV and SULEV categories, for compliance with proposed fleet vehicle rules purchase requirements.

³ Assumes that ZEV purchases by fleets is the same as the CARB overall vehicle manufacturer sales percentage.

TABLE E-3
Proposed Fleet Vehicle Rules PRs 1191 and 1194 Projected LDT(2) Purchase Distribution

Year	Percentage of LDT(2) Purchases by Emission Categories								
	CARB Sales Distribution Projection			PRs 1191 and 1194 Purchase Requirement		PRs 1191 and 1194 Fleet Purchase Distribution			
	LEV	ULEV	SULEV	LEV or cleaner	ULEV or cleaner	LEV ¹	ULEV	SULEV	
2001	95	5	0	100	0	95	5	0	
2002	90	10	0	100	0	90	10	0	
2003	85	15	0	100	0	85	15	0	
2004	91	19	0	0	100	0	100	0	
2005	74	26	0	0	100	0	100	0	
2006	54	42	4	0	100	0	91	9	
2007	47	48	5	0	100	0	91	9	
2008	36	54	10	0	100	0	84	16	
2009	28	62	10	0	100	0	86	14	
2010	21	64	15	0	100	0	81	19	

¹ For 2004 and subsequent years, the percentage of LEVs from the CARB implementation schedule are prorated between the ULEV and SULEV categories, for compliance with proposed fleet vehicle rules purchase requirements.

TABLE E-4
Proposed Fleet Vehicle Rules PRs 1191 and 1194 Projected MDV Purchase Distribution

Year	Percentage of MDV ¹ Purchases by Emission Categories					
	CARB Sales Requirement		PRs 1191 and 1194 Purchase Requirement		PRs 1191 and 1194 Fleet Purchase Distribution	
	LEV	ULEV	LEV or cleaner	ULEV or cleaner	LEV	ULEV
2001	80	20	100	0	80	20
2002	70	30	100	0	70	30
2003	60	40	100	0	60	40
2004	40	60	0	100	0	100
2005	40	60	0	100	0	100
2006	40	60	0	100	0	100
2007	40	60	0	100	0	100
2008	40	60	0	100	0	100
2009	40	60	0	100	0	100
2010	40	60	0	100	0	100

¹ Covers MDV(2), MDV(3), MDV(4), and MDV(5).

TABLE E-5
CARB 50,000 Mile Emission Standards

EXHAUST MASS EMISSION STANDARDS (grams/mile)							
Vehicle Type	Emission Category	LEV-I (current)			LEV-II ⁶ (starting 2004)		
		NMOG	CO	NO _x	NMOG	CO	NO _x
All PC & LDT(1)	LEV	0.075	3.4	0.2	0.075	3.4	0.05
	ULEV	0.040	1.7	0.2	0.04	1.7	0.05
	SULEV ¹	0.010	1.0	0.02	0.01	1.0	0.02
LDT(2) ²	LEV	0.100	4.4	0.4	0.075	3.4	0.05
	ULEV	0.050	2.2	0.4	0.04	1.7	0.05
	SULEV ¹	0.010	1.0	0.02	0.01	1.0	0.02
MDV(2) ²	LEV	0.160	4.4	0.4	0.075	3.4	0.05
	ULEV	0.100	4.4	0.4	0.04	1.7	0.05
	SULEV ¹	0.050	2.2	0.2	0.01	1.0	0.02
MDV(3) ²	LEV	0.195	5.0	0.6	0.075	3.4	0.05
	ULEV	0.117	5.0	0.6	0.04	1.7	0.05
	SULEV ¹	0.059	2.5	0.3	0.01	1.0	0.02

TABLE E-5 (Continued)
CARB 50,000 Mile Emission Standards

EXHAUST MASS EMISSION STANDARDS (grams/mile)							
Vehicle Type	Emission Category	LEV-I (current)			LEV-II⁶ (starting 2004)		
		NMOG	CO	NOx	NMOG	CO	NOx
MDV(4) ^{3,5}	LEV	0.230	5.5	0.7	0.163	5.2	0.14
	ULEV	0.138	5.5	0.7	0.104	5.2	0.14
	SULEV	0.069	2.8	0.35	0.069	2.6	0.07
MDV(5) ^{3,5}	LEV	0.300	7.0	1.0	0.163	5.9	0.29
	ULEV	0.180	7.0	1.0	0.104	5.9	0.29
	SULEV	0.09	3.5	0.5	0.085	3.0	0.14

¹ SULEV emission standards for PC, LDT(1), MDV(2), & MDV(3) are for 120,000 miles.

² The LEV-I emission standards for LDV(2), MDV(2), and MDV(2) are assumed to correspond to LEV-II standards for PC and LDT (<8,500 lbs GVW).

³ The LEV-I emission standards for MDV(4) are assumed to correspond to LEV-II standards for MDV (8,500 to 10,000 lbs GVW).

⁴ The LEV-I emission standards for MDV(5) are assumed to correspond to LEV-II standards for MDV (10,000 to 14,000lbs GVW).

⁵ Estimated equivalent 50,000 emission standards based on ratios of 50,000 to 120,000 standards by pollutant for PC & LDT(1) LEV-II emission standards.

⁶ LEV II emission standards are phased in according to the following schedule: 25% in 2004; 50% in 2005; 75% in 2006; and 100% in 2007.

TABLE E-6
PRs 1191 and 1194 Unscaled Fleet Vehicle Population

Estimated Vehicle Population Profile	
Vehicle Category	Vehicles
Passenger Car	49,080
LDT(1)	7,256
LDT(2)	8,452
MDV(2)	5,026
MDV(3)	5,026
MDV(4)	228
MDV(5)	(negligible)
Total	75,068

HDV METHODOLOGIES

Unlike light- and medium-duty vehicles, emission standards for heavy-duty vehicles actually apply to the engine that is used to power the vehicle. CARB has basically established engine-specific emission standards for two categories of engines -- urban bus engines and all other heavy-duty engines. The emission benefits are based on fleets purchasing cleaner vehicles/engines than they would have otherwise purchased in the absence of proposed fleet vehicle rules. This results from the proposed fleet vehicle rules vehicle purchase requirement that allow fleets to only purchase vehicles powered by engines that emit particulate matter (PM) at or below 0.031 grams per brake horsepower-hour (g/bhp-hr). Compliance by the fleet operator with proposed fleet vehicle rules is determined by comparing the engine certification emission level submitted to CARB for that engine as part of the CARB engine certification procedure with the 0.031 g/bhp-hr PM threshold. It should be noted that the current applicable PM emission standard (for diesel engines) is 0.1 g/bhp-hr. The emission benefits include minimum PM reductions, based on the difference between 0.1 g/bhp-hr and 0.031 g/bhp-hr. Corresponding maximum PM reductions are based on the difference between 0.1 g/bhp-hr and 0.0045 g/bhp-hr, as suggested by recently generated PM emission data from natural-gas powered vehicles using the central business district test cycle (Presentation made by CARB to Municipal Waste Management Association, November 18, 1999). Besides this explicit PM emission benefit, there is assumed to be a NO_x benefit because it is anticipated that compliant engines will be natural gas powered, and these engines have lower NO_x emissions compared to other engines meeting the current mandatory NO_x emission standard of 4 g/bhp-hr. In addition, it is anticipated that compliant natural gas powered engines will have lower NO_x emissions compared to corresponding diesel engines subsequent to the October 2002 implementation of the 2.5 g/bhp-hr NMHC + NO_x standard.

To quantify annual emission reductions, the following equation (EQ #2) was utilized, based on the estimated difference in emission rates that would occur between the vehicle fleet purchase of heavy-duty vehicles powered by cleaner proposed fleet vehicle rules compliant engines and engines meeting mandatory emission emissions standards (see table 6 for specific assumptions used in this equation to develop the emission benefits).

$$B \frac{\text{tons}}{\text{year}} = \left(E_1 \frac{\text{grams}}{\text{bhp - hour}} - E_2 \frac{\text{grams}}{\text{bhp - hour}} \right) \times K \frac{\text{bhp - hour}}{\text{mile}} \times \text{VMT} \frac{\text{miles}}{\text{year}} \times P \times C \frac{\text{tons}}{\text{gram}}$$

Where :

B = Emissions benefit per pollutant.

E₁ = Applicable CARB emission standard by pollutant. See Table E - 8.

E₂ = Assumed emission rated by pollutant for PR 1190 compliant engines.

See Table E - 8.

K = Assumed conversion factor used to convert grams per brake horsepower (bhp) to grams per mile. See Table E - 8.

VMT = Assumed average mile accumulation per year for fleet vehicles.

See Table E - 8.

P = Average annual vehicles purchased by fleet operators, which is estimated for each vehicle category by dividing the vehicle population in Table E - 8 by the estimated average vehicle life of seven years (e.g., number of years vehicle is owned/operated by fleet operator).

C = Conversion factors of 454 grams per pound and 2000 pounds per ton

In addition to the above terms, an additional multiplicative factor should be utilized for the quantification of PM emission benefits, to account for a portion of the fleet being gasoline powered. For HDVs, not including urban buses and non-contracted school buses, this factor is estimated to be 0.95 (5 percent of fleet is gasoline powered), and for non-contracted school buses, this factor is estimated to be 0.75 (25 percent of fleet is gasoline powered). Essentially, the quantification methodology does not include any PM benefit for the portion of the vehicle fleet that is already gasoline powered, since these vehicles already have low PM emissions. It should be noted that this factor does not apply to urban buses since this fleet does not utilize gasoline engines.

Table E-7 shows the SCAQMD's estimated HDV air quality benefits for PRs 1192, 1193, 1194, 1195, 1196, and 1186.1 and the project alternatives using EQ #2 above. Table E-8 provides the input parameters used by the SCAQMD to estimate the HDV air quality benefits.

TABLE E-7
Heavy-Duty Vehicle Emission Benefits (tons/yr)
Estimates For PRs 1192, 1193, 1194, 1195, 1196, And 1186.1 And Project Alternatives

PRs 1192, 1193, 1194, 1195, 1196, And 1186.1			
Year	Min PM¹	Max PM¹	NOx
2001	4	5	99
2002	9	14	263
2003	14	22	288
2004	19	30	314
2005	24	38	339
2006	29	47	365
2007	33	55	390
2008	38	63	416
2009	43	72	441
2010	48	80	467
Alternative B			
Year	Min PM	Max PM	NOx
2001	4	5	86
2002	7	11	179
2003	11	16	193
2004	15	21	208
2005	18	26	223
2006	22	31	237
2007	22	31	252
2008	22	31	266
2009	22	31	281
2010	22	31	295
Alternative C			
Year	Min PM	Max PM	NOx
2001	0	0	0
2002	5	8	163
2003	10	17	189
2004	15	25	214
2005	20	33	240
2006	25	41	265
2007	30	50	291
2008	35	58	316
2009	40	66	342
2010	45	74	367

TABLE E-7 (Continued)
Heavy-Duty Vehicle Emission Benefits (tons/yr)
Estimates For PRs 1192, 1193, 1194, 1195, 1196, And 1186.1 And Project Alternatives

Alternative D			
Year	Min PM	Max PM	NOx
2001	3	5	91
2002	8	13	247
2003	13	21	271
2004	17	28	295
2005	22	36	320
2006	27	44	344
2007	31	52	368
2008	36	60	392
2009	41	67	417
2010	45	75	441
Alternative E			
Year	Min PM	Max PM	NOx
2001	2	3	50
2002	4	7	131
2003	9	15	157
2004	14	23	182
2005	19	32	208
2006	24	40	233
2007	29	48	259
2008	34	56	284
2009	39	65	310
2010	44	73	335
Alternative F			
Year	Min PM	Max PM	NOx
2001	2	4	69
2002	6	10	206
2003	10	17	228
2004	14	23	249
2005	17	30	271
2006	21	36	292
2007	25	43	313
2008	28	50	335
2009	32	56	356
2010	36	63	378

¹ Min PM / Max PM = Minimum / Maximum Particulate Matter

TABLE E-8
PRs 1192, 1193, 1194, 1195, 1196, And 1186.1 Vehicle Assumptions

Vehicle Category	Vehicles	Annual VMT	Vehicle Life (yr)	Emissions (g/bhp-hr)			Conversion Factor bhp-hr/mi
				Baseline NOx	Baseline PM	MY 2002 NOx	
HDV(1)	28,397	10,000	10	4	0.1	2	2.6
HDV(2)	4,650	40,000	12	4	0.05	2	4.3
HDV(3)	4,428	12,000	20	4	0.1	2	2.6

MY = Model year.

HDV(1) = Trucks & contracted school buses, EXCLUDING urban buses & non-contracted school buses.

HDV(2) = Urban Buses.

HDV(3) = Non-contracted school buses.