Chapter 4
Criteria Pollutants

Summary Statistics from Tables in this Chapter

, Source		
Table 4.1	Transportation's share of U.S. emissions, 1997	
	c o	*76.6%*
	NO_X	*49.2%*
	v o c	*39.9%*
	PM-10	*2.2%*
	PM-2.5	*7.4%*
	SO_2	*6.8%*
	NH_3	*7.6%*
Table 4.10	Transportation's share of lead emissions	
	1970	*82.3%*
	1997	*13.3%*
Table 4.11	Automobile emission standards, 1998 (grams per mile)	
	HC	*0.25*
	CO	*3.4*
	NO_X	*0.4*

Table 4.1
Total National Emissions of the Criteria Air Pollutants by Sector, 1997
(millions of short tons/percentage)

Sector	c o	NO_x	v o c	PM-10	PM-2.5	SO,	NH_3
Highway vehicles	**50.26**	**7.04**	**5.23**	**0.27**	**0.21**	**0.32**	**0.24**
	57.5%	**29.8%**	**27.2%**	**0.8%**	**2.5%**	**1.6%**	**7.6%**
Aircraft	**1.01**	**0.18**	**0.19**	**0.04**	**0.03**	**0.01**	**0.00**
	1.2%	**0.8%**	**1.0%**	**0.1%**	**0.3%**	**0.1%**	**0.0%**
Railroads	**0.12**	**0.95**	**0.05**	**0.03**	**0.00**	**0.11**	**0.00**
	0.1%	**4.0%**	**0.3%**	**0.1%**	**0.0%**	**0.6%**	**0.1%**
Vessels	**0.09**	**0.24**	**0.05**	**0.03**	**0.02**	**0.25**	**0.00**
	0.1%	**1.0%**	**0.3%**	**0.1%**	**0.3%**	**1.2%**	**0.0%**
Other off-highway	**15.54**	**3.20**	**2.14**	**0.37**	**0.36**	**0.69**	**0.00**
	17.8%	*13.6%*	*11.2%*	**1.1%**	**4.3%**	**3.4%**	**0.0%**
Transportation total	**67.01**	**11.60**	**7.66**	**0.73**	**0.62**	**1.38**	**0.24**
	76.6%	**49.2%**	**39.9%**	**2.2%**	**7.4%**	**6.8%**	**7.6%**
Stationary source fuel combustion	**4.82**	**10.72**	**0.86**	**1.10**	**0.85**	**17.26**	**0.03**
	5.5%	**45.5%**	**4.5%**	**3.3%**	**10.2%**	**84.7%**	**1.0%**
Industrial processes	**4.81**	**0.81**	**9.39**	**0.98**	**0.52**	**1.67**	**0.29**
	5.5%	**3.5%**	**48.9%**	**2.9%**	**6.3%**	**8.2%**	**9.0%**
Waste disposal and recycling total	**1.24**	**0.10**	**0.45**	**0.30**	**0.25**	**0.05**	**0.10**
	1.4%	**0.4%**	**2.3%**	**0.9%**	**3.1%**	**0.2%**	**3.1%**
Miscellaneous	*9.57*	**0.35**	**0.86**	**30.47**	**6.07**	**0.01**	**2.52**
	10.9%	**1.5%**	**4.5%**	**90.7%**	**73.0%**	**0.1%**	**79.2%**
Total of all sources	**87.45**	**23.58**	**19.22**	**33.58**	**8.31**	**20.37**	**3.18**
	100.0%	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*	*100.0%*

Source:
All other-U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997,* 1998, Appendix A. (Additional resources: http://www.epa.gov/oar/oaqps)

Note:
CO = Carbon monoxide. NO, = Nitrogen oxides. PM-10 = Particulate matter less than 10 microns. PM-2.5 = Particulate matter less than 2.5 microns. SO, = Sulfur dioxide. VOC = Volatile organic compounds. NH, = Ammonia.

The transportation sector accountedfor two-thirds of the nation's carbon monoxide (CO) emissions in 1997. Highway vehicles are by far the source of the greatest amount of CO. For details on the highway emissions of CO, see Table 4.3.

Table 4.2
Total National Emissions of Carbon Monoxide, 1970-97"
(million short tons)

Source category	1970	1980	1990	1995	1996	1997	Percent of total, 1997
Highway vehicles	88.03	78.05	57.85	54.11	53.26	50.26	57.5%
Aircraft	0.51	0.74	0.90	0.94	0.95	1.01	1.2%
Railroads	0.07	0.10	0.12	0.11	0.11	0.12	0.1%
Vessels[b]	0.01	0.04	0.08	0.08	0.09	0.09	0.1%
Other off-highway	10.70	12.88	14.27	15.13	15.27	15.54	17.8%
Transportation total	99.32	91.81	73.22	70.38	69.67	67.01	76.6%
Stationary fuel combustion total	4.63	7.30	5.51	5.93	5.98	4.82	5.5%
Industrial processes total	9.84	6.95	4.77	4.61	4.62	4.81	5.5%
Waste disposal and recycling total	7.06	2.30	1.08	1.19	1.20	1.24	1.4%
Miscellaneous total	7.91,	8.34.	11.21	7.05	9.46	9.57	10.9%
Total of all sources	128.76	116.70	95.80	89.15	90.93	87.45	100.0%

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997*, 1998, pp. A-l-A-5, and annual. (Additional resources: http://www.epa/oar/oaqps)

Note:
Emission estimation methodology changes indicated by shaded areas. Transportation methodologies changed in 1970, while all others changed in 1990.

"The sums of subcategories may not equal total due to rounding.
[b]Recreational marine vessels.

Table 4.3
Emissions of Carbon Monoxide from Highway Vehicles, 1970-97[a]
(million short tons)

Source category	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	Percent of total, 1997
Gasoline powered													
Light vehicles & motorcycles	64.03	59.28	53.56	49.45	37.41	40.27	39.37	39.16	37.06	33.70	28.73	27.04	53.8%
Light trucks[b]	16.57	15.77	16.14	18.96	13.82	15.01	14.57	15.20	17.35	14.83	19.27	18.36	36.5%
Heavy vehicles	6.71	7.14	7.19	7.72	5.36	5.46	4.57	4.48	5.53	4.12	3.77	3.35	6.7%
Total	87.31	82.19	76.89	76.13	56.58	60.74	58.51	58.84	59.93	52.65	51.77	48.75	97.0%
Diesel powered													
Light vehicles	[c]	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.1%
Light trucks[b]	[c]	[c]	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.0%
Heavy vehicles	0.72	0.92	1.14	1.24	1.23	1.30	1.32	1.33	1.41	1.41	1.45	1.47	2.9%
Total	0.72	0.95	1.16	1.26	1.27	1.33	1.35	1.37	1.45	1.45	1.49	1.51	3.0%
Total													
Highway vehicle total	88.03	83.13	78.05	77.39	57.85	62.07	59.86	60.20	61.38	54.11	53.26	50.26	100.0%
Percent diesel	0.8%	1.1%	1.5%	1.6%	2.2%	2.1%	2.3%	2.3%	2.4%	2.7%	2.8%	3.0%	

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900–1997*, 1998, p. A-3 and annual.
(Additional resources: http://www.epa.gov/oar/oaqps)

[a]The sums of subcategories may not equal total due to rounding.
'Less than 8,500 pounds.
[c]Data are not available.

The transportation sector accountedfor nearly half of the nation's nitrogen oxide (NOx) emissions in 1997, with the majority coming from highway vehicles. For details on the highway emissions of NOx, see Table 4.5.

Table 4.4
Total National Emissions of Nitrogen Oxides, 1970-97"
(million short tons)

Source category	1970	1980	1990	1995	1996	1997	Percent of total, 1997
Highway vehicles	7.39	8.62	7.04	7.32	7.25	7.04	29.8%
Railroads	0.50	0.73	0.93	0.99	0.92	0.95	4.0%
Other off-highway	1.69	3.29	3.31	3.52	3.56	3.61	15.3%
Transportation total	9.57	12.64	11.28	11.83	11.72	11.60	49.2%
Stationary fuel combustion total	10.06	11.32	10.89	10.83	10.52	10.72	45.5%
Industrial processes total	0.78	0.56	0.80	0.77	0.78	0.81	3.5%
Waste disposal and recycling total	0.44	0.11	0.09	0.10	0.10	0.10	0.4%
Miscellaneous total	0.33	'0.25	0.37	0.24	0.34	0.35	1.5%
Total of all sources	21.18	24.87	23.43	23.77	23.46	23.58	**100.0%**

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997,* 1998, pp. A-6-A-10, and annual. (Additional resources: http://www.epa/oar/oaqps)

Note:
Emission estimation methodology changes indicated by shaded areas. Transportation methodologies changed in 1970, while all others changed in 1990.

"The sums of subcategories may not equal total due to rounding.

Table 4.5
Emissions of Nitrogen Oxides from Highway Vehicles, 1970-97[a]
(million short tons)

Source category	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	Percent of total, 1997
Gasoline powered													
Light vehicles & motorcycles	4.16	4.73	4.42	3.81	3.22	3.46	3.61	3.68	3.57	3.44	2.98	2.88	40.9%
Light trucks[b]	1.28	1.46	1.41	1.53	1.26	1.34	1.36	1.42	1.66	1.52	1.95	1.90	27.0%
Heavy vehicles	0.28	0.32	0.30	0.33	0.33	0.33	0.31	0.32	0.35	0.33	0.33	0.33	4.6%
Total	5.71	6.51	6.13	5.67	4.80	5.13	5.28	5.42	5.58	5.30	5.26	5.10	72.5%
Diesel powered													
Light vehicles	[c]	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.5%
Light trucks[b]	[c]	[c]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.2%
Heavy vehicles	1.68	2.12	2.46	2.39	2.19	2.20	2.12	2.05	2.04	1.98	1.94	1.89	26.8%
Total	1.68	2.14	2.49	2.42	2.24	2.24	2.16	2.09	2.09	2.03	1.99	1.93	27.5%
Total													
Highway vehicle total	**7.39**	8.65	8.62	8.09	7.04	7.37	7.44	7.51	7.67	7.32	7.25	7.04	**100.0%**
Percent diesel	22.7%	24.8%	28.9%	30.0%	31.8%	30.4%	29.1%	27.9%	27.3%	27.7%	27.4%	27.5%	

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends,* 1900-1997, 1998, p. A-10 and annual.
(Additional resources: http://www.epa.gov/oar/oaqps)

[a]The sums of subcategories may not equal total due to rounding.
[b]Less than 8,500 pounds.
[c]Data are not available.

The transportation sector accountedfor nearly 40% of the nation's volatile organic compound (VOC) emissions in 1997, with the majority coming from highway vehicles. For details on the highway emissions of VOC, see Table 4.7.

Table 4.6
Total National Emissions of Volatile Organic Compounds, 1970-97"
(million short tons)

Source category	1970	1980	1990	1995	1996	1997	Percent of total, 1997
Highway vehicles	12.97	8.98	6.31	5.70	5.49	5.23	27.2%
Off-highway	1.71	2.14	2.50	2.41	2.40	2.43	12.6%
Transportation total	14.69	11.12	8.82	8.11	7.89	7.66	39.9%
Stationary fuel combustion total	0.72	1.05	1.01	1.07	1.08	0.86	4.5%
Industrial processes total	12.33	12.10	9.01	9.71	9.05	9.39	48.9%
Waste disposal and recycling total	1.98	0.76	0.99	1.07	0.43	0.45	2.3%
Miscellaneous total	1.10	1.13	1.16	0.60	0.85	0.86	4.5%
Total of all sources	30.82	26.17	20.98	20.56	19.29	19.22	**100.0%**

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997,* 1998, pp. A-l 1-A-17, and annual. (Additional resources: http://www.epa.gov/oar/oaqps)

Note:
Emission estimationmethodology changes indicated by shaded areas. Transportation methodologies changed in 1970, while all others changed in 1990.

"The sum of subcategories may not equal total due to rounding. The EPA's definition of volatile organic compounds excludes methane, ethane, and certain other nonphotochemically reactive organic compounds.

Table 4.7
Emissions of Volatile Organic Compounds from Highway Vehicles, 1970-97[a]
(thousand short tons)

Source category	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	Percent of total, 1997
Gasoline powered													
Light vehicles&motorcycles	9,193	7,248	5,907	5,864	3,947	4,069	3,832	3,812	3,748	3,426	2,875	2,755	52.7%
Light trucks[b]	2,770	2,289	2,059	2,425	1,622	1,688	1,588	1,647	1,909	1629	2060	1968	37.6%
Heavy vehicles	743	657	611	716	432	423	334	326	414	327	293	268	5.1%
Total	12,706	10,194	8,577	9,005	6,001	6,180	5,754	5,785	6,071	5,382	5,228	4,991	95.4%
Diesel powered													
Light vehicles	[c]	15	8	8	13	12	13	13	13	14	12	12	0.2%
Light trucks[b]	[c]	[c]	2	2	3	3	3	3	4	4	5	5	0.1%
Heavy vehicles	266	335	392	360	297	304	302	301	313	302	245	221	4.2%
Total	266	350	402	370	313	319	318	317	330	320	262	238	4.6%
Total													
Highway vehicle total	12,972	10,544	8,979	9,375	6,314	6,499	6,072	6,102	6,401	5,702	5,490	5,229	100.0%
Percent diesel	2.1%	3.3%	4.5%	3.9%	5.0%	4.9%	5.2%	5.2%	5.2%	5.6%	4.8%	4.6%	

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997,* 1998, p. A-16 and annual.
(Additional resources: http://www.epa.gov/oar/oaqps)

[a]The sums of subcategories may not equal total due to rounding.
[b]Less than 8,500 pounds.
[c]Data are not available.

The transportation sector accounted for only 2% of the nation's particulate matter (PM-1 0) emissions in 1997. For details on the highway emissions of PM-IO, see Table 4.9.

Table 4.8
Total National Emissions of Particulate Matter (PM-lo), 1970–97[a]
(million short tons)

Source category	1970	1980	1990	1995	1996	1997	Percent of total, 1997
Highway vehicles	0.44	0.40	0.34	0.29	0.27	0.27	0.8%
Off-highway	0.26	0.57	0.50	0.46	0.46	0.47	1.4%
Transportation total	0.70	0.96	0.83	0.75	0.73	0.73	2.2%
Stationary fuel combustion total	2.87	2.45	1.20	1.18	1.19	1.10	3.3%
Industrial processes total	7.67	2.75	1.04	0.95	0.94	0.98	2.9%
Waste disposal and recycling total	1.00	0.27	0.27	0.29	0.29	0.30	0.9%
Miscellaneous total	0.84	0.85	26.51	23.60	30.03	30.47	90.7%
Total of all sources	13.08	‘7.29	29.84	26.76	33.19	33.58	**100.0%**

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997,* 1998, pp. A-22-A-26, and annual. (Additional resources: http:/www.epa.gov/oar/oaqps)

Note:
Emission estimation methodology changes indicated by shaded areas. Transportation methodologies changed in 1970, while all others changed in 1990.

“Fine particle matter less than 10 microns. The sums of subcategories may not equal total due to rounding.

Table 4.9
Emissions of Particulate Matter (PM-10) from Highway Vehicles, 1970-97
(thousand short tons)

Source category	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	Percent of total, 1997
Gasoline powered													
Light vehicles & motorcycles	225 70	207 72	120 55	43 77	30 61	32 63	31 64	31 65	35 62	62 32	41 55	40 56	21.0%
Light trucks[b]													15.0%
Heavy vehicles	13	15	15	14	10	10	9	10	10	9	9	9	3.4%
Total	308	294	190	134	101	105	104	106	107	103	105	105	39.3%
Diesel powered													
Light vehicles	[c]	10	12	8	9	9	9	8	8	8	7	6	2.2%
Light trucks[b]	[c]	[c]	2	1	1	2	2	2	2	2	2	2	0.7%
Heavy vehicles	136	166	194	219	224	234	228	205	204	181	168	154	57.7%
Total	136	177	209	228	235	245	239	215	213	190	177	163	60.7%
Total													
Highway vehicle total	443	471	397	363	336	349	343	321	320	293	282	268	**100.0%**
Percent diesel	30.7%	37.4%	52.4%	62.8%	69.6%	70.2%	69.7%	67.0%	66.9%	65.2%	62.8%	60.7%	

Source:
U. S. Enviromnental Protection Agency, *National Air Pollutant Emission Trends, 19004997,* 1998, p. A-25 and annual.
(Additional resources: http://www.epa.gov/oar/oaqps)

[a]The sums of subcategories may not equal total due to rounding.
[b]Less than 8,500 pounds.
'Data are not available.

The transportation sector accountedfor only 7% of the nation's particulate matter (PM-2.5) emissions in 1997. For details on the highway emissions of PM-2.5, see Table 4.11.

Table 4.10
Total National Emissions of Particulate Matter (PM-2.5), 1990-97
(million short tons)

Source category	1990	1991	1992	1993	1994	1995	1996	1997	Percent of total, 1997
Highway vehicles	0.28	**0.29**	0.28	0.26	0.26	0.23	0.22	0.21	2.5%
Off-highway	0.44	0.43	0.43	0.43	0.42	0.40	0.40	0.41	4.9%
Transportation total	0.71	0.72	0.71	0.68	0.68	0.63	0.62	0.62	7.4%
Stationary fuel combustion total	0.91	0.89	0.93	0.85	0.84	0.90	0.94	0.85	10.2%
Industrial processes total	0.56	0.57	0.58	0.50	0.50	0.50	0.50	0.52	6.3%
Waste disposal and recycling total	0.23	0.24	0.24	0.29	0.27	0.25	0.25	0.25	3.1%
Miscellaneous total	5.55	5.31	5.19	4.96	5.66	4.80	5.98	6.07	73.0%
Total of all sources	7.96	7.74	7.65	7.29	7.95	7.08	8.29	8.31	**100.0%**

Source:
U.S. Environmental Protection Agency, *National Air Pollutant Emission Trends,* 1900-1997, 1998, pp. A-27-A-31, and annual (Additional resources: http://www.epa.gov/oar/oaqps)

Diesel vehicles are responsiblefor the majority ofhighway vehicle PM-2.5 emissions. Nearly two-thirds of the PM-2.5 emissions are from heavy diesel trucks.

Table 4.11
Emissions of Particulate Matter (PM-2.5) from Highway Vehicles, 1990–97[a]
(thousand short tons)

Source category	1990	1991	1992	1993	1994	1995	1996	1997	Percent of total, 1997
Gasoline powered									
Light vehicles & motorcycles	37	38	38	38	36	36	32	32	15.5%
Light trucks[b]	19	21	20	20	23	20	25	25	12.1%
Heavy vehicles	7	6	6	7	7	6	6	6	2.9%
Total	63	65	64	65	66	62	63	63	30.4%
Diesel powered									
Light vehicles	8	8	8	7	7	7	6	6	2.9%
Light trucks[b]	1	1	2	1	2	2	2	2	1.0%
Heavy vehicles	203	212	206	183	182	161	149	136	65.7%
Total	212	221	216	192	190	169	157	144	69.6%
Total									
Highway vehicle total	275	286	280	257	256	231	221	207	**100.0%**
Percent diesel	77.1%	77.3%	77.1%	74.6%	74.3%	73.3%	71.4%	69.6%	

Source:
U.S. Environmental Protection Agency, *National Air Pollutant Emission Trends,* 1900-1997, 1998, p. A-30 and annual. (Additional resources: http://www.epa.gov/oar/oaqps)

[a] The sums of subcategories may not equal total due to rounding.
[b] Less than 8,500 pounds.

Historically the transportation sector, highway vehicles in particular, have been a major source of lead emissions in the U.S. Regulatory action in 1978 required a gradual reduction of the lead content of all gasoline over a period of many years. The transportation sector accounts for only 13% of lead emissions in 1997.

Table 4.12
National Lead Emission Estimates, 1970-97[a]
(thousand short tons per year)

Source category	1970	1975	1980	1985	1990	1995	1996	1997	Percent of total, 1997
Highway vehicles	171.96	130.21	60.50	18.05	0.42	0.02	0.02	0.02	0.5%
Off-highway	9.74	6.13	4.21	0.92	0.78	0.54	0.51	0.50	12.8%
Transportation total	181.70	136.34	64.71	18.97	1.20	0.56	0.53	0.52	13.3%
Stationary source fuel combustion	10.62	10.35	4.30	0.52	0.50	0.49	0.49	0.50	12.7%
Industrial processes	26.36	11.38	3.94	2.53	2.47	2.27	2.27	2.25	57.5%
Waste disposal and recycling total	2.20	1.60	1.21	0.87	0.80	0.60	0.62	0.65	16.5%
Total of all sources	220.87	159.66	74.15	22.89	4.98	3.92	3.91	3.92	**100.0%**

Source:
U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1997,* 1998, pp. A-34-A-35, and annual. (Additional resources: http://www.epa.gov/oar/oaqps)

[a]The sums of subcategories may not equal due to rounding.

Table 4.13
State-level Emissions for Criteria Pollutants, 1997
(thousand short tons)

State	Carbon monoxide	Nitrogen oxides[a]	Volatile organic compounds[a]	Sulfur dioxide	Particulate matter (PM-10)
Alabama	2,392	627	427	811	585
Alaska	486	42	64	5	183
Arizona	1,627	453	297	256	302
Arkansas	1,141	257	240	138	500
California	6,000	1,236	1,494	200	1,600
Colorado	1,259	414	293	141	476
Connecticut	747	153	165	90	101
District of Columbia	111	19	21	9	4
Delaware	207	68	53	98	38
Florida	4,610	916	859	879	764
Georgia	3,917	691	595	639	1,017
Hawaii	212	49	30	34	33
Idaho	811	114	116	41	690
Illinois	3,046	1,129	851	1,190	1,007
Indiana	2,384	912	567	1,370	660
Iowa	997	329	257	273	580
Kansas	2,127	528	414	180	1,639
Kentucky	1,412	690	406	806	336
Louisiana	2.316	758	437	414	440
Maine	'529	95	109	101	156
Maryland	1,160	331	243	387	208
Massachusetts	1,212	275	294	255	285
Michigan	2,996	839	705	653	530
Minnesota	1,476	463	398	168	962
Mississippi	1,565	351	339	235	479
Missouri	2,002	523	444	506	1,350
Montana	768	183	110	67	1,143
Nebraska	785	252	205	102	632
Nevada	545	135	98	65	150
New Hampshire	359	80	77	164	54
New Jersey	1,362	435	425	265	303
New Mexico	938	297	152	207	4,948
New York	3,116	667	767	663	818
N. Carolina	2,759	643	685	610	480
N. Dakota	317	239	99	308	412
Ohio	3,812	1,185	709	1,966	663
Oklahoma	1,733	470	350	239	999
Oregon	1,758	215	258	44	661
Pennsylvania	3,332	935	674	1,349	593
Rhode Island	203	31	50	13	27
S. Carolina	1,606	364	340	299	410
S. Dakota	317	120	78	57	311
Tennessee	2,391	797	610	840	384
Texas	6,479	1,843	1,615	1,151	3,307
Utah	1,029	233	170	83	248
Vermont	232	43	48	17	79
Virginia	2,082	564	492	486	445
Washington	2,062	325	431	150	392
W. Virginia	843	516	157	759	158
Wisconsin	1,517	469	418	408	381
Wyoming	363	275	68	179	659
Total	**87,451**	23,575	19,204	20,369	33,581

Source:
U.S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 19004997,* 1998, p. A-38.
(Additional resources: http://www.epa.gov/oar/oaqps)

Note:
The sums of the States may not equal national totals due to rounding.

[a] Excluding biogenics.

The Greenhouse Gases, Regulated Emissions, and Energy Use in Transportation (GREET) Model

The energy and criteria pollutant estimates of the most recent version (Version 1.4) of the GREET model are displayed in the next two tables. The model estimates the full fuel-cycle emissions and energy use associated with various transportation fuels and advanced transportation technologies for light vehicles. It calculates fuel-cycle emissions of **five criteria pollutants** (volatile organic compounds, carbon monoxide, nitrogen oxides, sulfur oxides, and particulate matter measuring 10 microns or less) and three greenhouse gases (carbon dioxide, methane, and nitrous oxide). See Chapter 3 for the greenhouse gas data from GREET. The model also calculates the total fuel-cycle energy consumption, fossil fuel consumption, and petroleum consumption using various transportation fuels. The fuel cycles that are included in the GREET model are:

- petroleum to conventional gasoline, reformulated gasoline, conventional diesel, reformulated diesel, liquefied petroleum gas, and electricity via residual oil;
- natural gas to compressed natural gas, liquefied natural gas, liquefied petroleum gas, methanol, Fischer-Tropsch diesel, dimethyl ether, hydrogen, and electricity;
- coal to electricity;
- uranium to electricity;
- renewable energy (hydropower, solar energy, and wind) to electricity;
- corn, woody biomass, and herbaceous biomass to ethanol;
- soybeans to biodiesel; and
- landfill gases to methanol.

Near-term technologies are ones which may be applied to 2000 model-year cars and ***long-term*** technologies are ones which may be applied to 2010 model-year cars.

For additional information about the GREET model, contact:

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Acronyms Used on Tables 4.14 and 4.15

Emissions acronyms

v o c	volatile organic compounds
c o	carbon monoxide
NOx	nitrogen oxides
PM10	particulate matter measuring 10 microns or less
s o x	sulfur oxides

Technologies acronyms

BD20	mixture of 20% biodiesel and 80% conventional diesel (by volume)
CARFG2	California Phase 2 reformulated gasoline
CD	conventional diesel
CIDI	compression ignition, direct injection
CNG	compressed natural gas
CNGV	compressed natural gas vehicle
Dedi.	dedicated
DME	dimethyl ether
E10	mixture of 10% ethanol and 90% gasoline (by volume)
E85	mixture of 85% ethanol and 15% gasoline (by volume)
E90	mixture of 90% ethanol and 10% gasoline (by volume)
ETBE	ethyl tertiary butyl ether
EtOH	ethanol
EtOHV	ethanol vehicle
EV	electric vehicle
FCV	fuel-cell vehicle
FFV	flexible fuel vehicle
FRFG2	federal Phase 2 reformulated gasoline
FG	flared gas
FT50	mixture of 50% Fischer-Tropsch diesel and 50% conventional diesel (by volume)
GC	grid-connected
GI	grid-independent
GHGs	greenhouse gases
GV	gasoline vehicle
H_2	hydrogen
HB	herbaceous biomass
HEV	hybrid electric vehicle
LFG	land-fill gas
LNG	liquefied natural gas
LNGV	liquefied natural gas vehicle
LPG	liquefied petroleum gas
LPGV	liquefied petroleum gas vehicle
M85	mixture of 85% methanol and 15% gasoline by volume
M90	mixture of 90% methanol and 10% gasoline by volume
MeOH	methanol
MeOHV	methanol vehicle
MTBE	methyl tertiary butyl ether
NE	northeast
NG	natural gas
RFD	reformulated diesel
SI	spark ignition
SIDI	spark-ignition, direct-injection
WB	woody biomass

Table 4.14

Near-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GV: FRFG2, MTBE	GV: CARFG2, ETBE	GV: CARFG2, EtOH	CIDI: CD	Bi-fuel CNGV	Dedi. CNGV	Dedi LPGV: crude	Dedi. LPGV: NG	M85 FFV: NG
Total energy	**0.0%**	0.8%	0.4%	**-29.7%**	6.7%	3.3%	-8.6%	**-9.6%**	14.5%
Fossil fuels	**0.0%**	-3.1%	-2.6%	**-29.6%**	5.7%	2.3%	-8.6%	**-9.3%**	15.0%
Petroleum	-11.0%	-10.1%	-2.5%	-26.7%	-99.4%	-99.4%	-3.4%	**-98.2%**	-72.6%
VOC: Total	-15.1%	-5.5%	8.6%	-60.9%	-48.7%	-71.2%	-58.2%	-64.1%	-19.8%
VOC: Urban	-19.7%	-19.4%	5.3%	-62.8%	-45.8%	-74.8%	-63.1%	-60.3%	-20.3%
CO: Total	-19.1%	-18.9%	-19.4%	-79.5%	-34.8%	-42.7%	-39.3%	-39.7%	-37.4%
CO: Urban	-20.0%	-19.9%	-20.0%	-80.5%	-35.5%	-43.5%	-39.9%	-39.9%	-40.0%
NOx: Total	0.4%	14.6%	2.6%	51.8%	26.6%	18.6%	-17.7%	-22.4%	0.5%
NOx: Urban	-4.2%	-2.9%	-4.2%	111.4%	25.2%	14.7%	-9.1%	-9.3%	-12.0%
PM10: Total	-1.8%	78.2%	38.5%	154.8%	-35.9%	-37.8%	-34.1%	-43.0%	-26.5%
PM10: Urban	-1.4%	-0.4%	-1.3%	258.5%	-30.4%	-32.3%	-31.3%	-31.3%	-22.8%
SOx: Total	-28.9%	-0.4%	-16.3%	-3 1.4%	-37.5%	-39.5%	-57.3%	-77.4%	-58.7%
SOx: Urban	-82.7%	-82.8%	-83.0%	-3.9%	-96.1%	-96.2%	-98.0%	-98.1%	-73.7%

Table continued on next page. See previous pages for acronym definitions.

Table 4.14 (continued)

Near-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	E10 GV: corn	E85 FFV: corn	E85 FFV: WB	E85 FFV: HB	EV: US mix	EV: NE mix	EV: CA mix	GC SIDI HEV: ETBE, CA mix	GC SIDI HEV: EtOH, CA mix
Total energy	2.1%	17.9%	**90.4%**	79.1%	-14.7%	-14.0%	-16.9%	**-35.9%**	-36.0%
Fossil fuels	-3.4%	-41.8%	-81.8%	-72.7%	-34.7%	-46.0%	-68.6%	**-52.9%**	-52.7%
Petroleum	-6.3%	-73.8%	-71.2%	-73.2%	-98.4%	-96.9%	-99.5%	**-64.9%**	-62.0%
VOC: Total	14.4%	54.0%	4.5%	0.4%	-88.0%	-90.6%	-95.2%	-48.2%	-36.7%
VOC: Urban	10.7%	-16.0%	-16.1%	-16.1%	-99.6%	-99.4%	-99.5%	-50.8%	-33.3%
CO: Total	-35.0%	-37.4%	-30.3%	-31.7%	-98.0%	-98.0%	-98.7%	-54.7%	-54.9%
CO: Urban	-35.9%	-39.8%	-39.8%	-39.8%	-99.9%	-99.9%	-99.9%	-55.2%	-55.2%
NOx: Total	9.9%	101.9%	125.7%	139.8%	64.5%	11.5%	-51.3%	-21.6%	-26.3%
NOx: Urban	0.8%	-1.1%	-2.4%	-1.7%	-94.7%	-90.9%	-93.2%	-28.6%	-29.1%
PM10: Total	57.2%	615.2%	139.9%	124.4%	48.5%	10.5%	-3 1.7%	13.3%	-2.1%
PM10: Urban	0.6%	-15.0%	-15.5%	-15.2%	-35.4%	-33.4%	-34.7%	-5.8%	-6.1%
SOx: Total	15.7%	168.8%	-151.8%	-95.8%	462.8%	217.2%	-13.9%	-35.4%	-41.6%
SOx: Urban	-6.7%	-78.6%	-79.1%	-78.9%	-96.9%	-90.7%	-99.0%	-93.0%	-93.1%

Source:
Wang, Michael Q., GREET Model Results, Argonne National Laboratory, Argonne, IL, August 1999.

Note:
See page preceding table for acronym definitions.

Table 4.15

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	Dedi. CNGV	Dedi. LNGV	Dedi. LPGV: crude	Dedi. LPGV: NG	Dedi. MeOHV: M90, NG	Dedi. MeOHV: M90, FG	Dedi. MeOHV: M90, LFG	Dedi. EtOHV: E90, corn	Dedi. EtOHV: E90, WB	Dedi. EtOHV: E90, HB	SIDI: FRFG2, MTBE
Total energy	-8.6%	-5.7%	-16.8%	-17.7%	8.8%	13.8%	-1.8%	10.0%	57.7%	44.4%	-20.0%
Fossil fuels	-9.5%	-5.1%	-16.9%	-17.4%	9.4%	-45.4%	-61.0%	-50.1%	-82.2%	-78.2%	-20.0%
Petroleum	-99.4%	-96.0%	-1.3%	-98.2%	-78.1%	-78.1%	-78.7%	-81.5%	-79.3%	-81.1%	-20.0%
VOC: Total	-62.6%	-55.8%	-48.6%	-56.2%	-15.8%	-156.0%	-35.9%	74.4%	4.9%	-0.1%	-11.0%
VOC: Urban	-55.1%	-56.8%	-49.0%	-45.3%	-11.1%	-11.1%	-15.0%	-8.9%	-9.0%	-9.0%	-7.3%
CO: Total	-19.9%	-18.2%	-20.6%	-21.3%	1.5%	-0.9%	-14.9%	2.1%	11.7%	9.5%	-1.0%
CO: Urban	-19.4%	-20.1%	-19.9%	-20.0%	-0.2%	-0.2%	-5.6%	0.0%	0.0%	0.0%	-0.1%
NOx: Total	26.5%	67.7%	-32.1%	-39.9%	-4.8%	-74.3%	-24.7%	147.0%	223.2%	228.4%	-16.6%
NOx: Urban	102.8%	-11.5%	-2.8%	-3.7%	-17.2%	-17.2%	-48.5%	9.4%	4.9%	6.2%	-5.2%
PM10: Total	-34.2%	-30.4%	-31.1%	-39.0%	-25.4%	-36.7%	-265.9%	409.1%	59.4%	46.8%	1.5%
PM10: Urban	-24.6%	-26.0%	-25.1%	-25.2%	-14.5%	-14.5%	-197.8%	-12.2%	-12.4%	-12.3%	11.9%
SOx: Total	-34.1%	-76.7%	-48.4%	-71.8%	-60.0%	-60.4%	50.8%	120.0%	-90.2%	-70.0%	-20.0%
SOx: Urban	-80.6%	-98.3%	-91.3%	-91.5%	-77.9%	-77.9%	-234.2%	-82.9%	-83.7%	-83.3%	-20.0%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars

(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	SIDI: FRFG2, ETBE	SIDI: FRFG2 EtOH	SIDI: CARFG2, ETBE	SIDI: CARFG2, EtOH	Dedi. MeOH SIDI: NG	Dedi. MeOH SIDI: M90, FG	Dedi. MeOH SIDI: M90, LFG	Dedi EtOH SIDI: E90, corn	Dedi. EtOH SIDI: E90, WB	Dedi. EtOH SIDI: E90, HB	GI SIDI HEV: FRFG2, MTBE
Total energy	-20.0%	-20.0%	-20.0%	-20.0%	-6.7%	-2.3%	-16.1%	-3.2%	38.7%	27.1%	-47.4%
Fossil fuels	-20.0%	-20.0%	-19.0%	-19.3%	-6.2%	-68.4%	-68.1%	-56.1%	-84.4%	-80.8%	-47.4%
Petroleum	-20.0%	-20.0%	-17.2%	-14.2%	-82.1%	-82.1%	-82.6%	-83.7%	-81.8%	-83.4%	-47.4%
VOC: Total	-12.0%	-8.7%	-12.0%	-8.7%	-24.6%	-148.0%	-42.3%	57.4%	-3.8%	-8.1%	-28.0%
VOC: Urban	-7.4%	-3.0%	-7.4%	-3.0%	-15.8%	-15.8%	-19.3%	-13.9%	-14.0%	-14.0%	-32.2%
CO: Total	-1.1%	-0.9%	-1.1%	-0.9%	0.4%	-1.8%	-14.0%	1.3%	9.8%	7.8%	-2.4%
CO: Urban	-0.1%	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	-5.0%	0.0%	0.0%	0.0%	-0.1%
NOx: Total	-17.2%	-16.7%	-17.2%	-16.7%	-22.5%	-83.6%	-39.9%	119.3%	186.4%	191.0%	-39.3%
NOx: Urban	-6.2%	-5.3%	-6.2%	-5.3%	-18.3%	-18.3%	-45.8%	5.3%	1.3%	2.5%	-12.4%
PM10: Total	-7.7%	-4.4%	-7.7%	-4.4%	-23.1%	-33.1%	-234.7%	359.2%	51.4%	40.3%	-12.2%
PM10: Urban	11.6%	11.9%	11.6%	11.9%	-2.1%	-2.1%	-163.4%	0.0%	-0.2%	-0.1%	4.8%
SOx: Total	-20.0%	-20.0%	-20.0%	-20.0%	-76.3%	-76.7%	21.2%	93.6%	-91.4%	-73.6%	-47.4%
SOx: Urban	-20.0%	-20.0%	-20.5%	-20.5%	-80.6%	-80.6%	-218.1%	-85.0%	-85.7%	-85.3%	-47.4%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars

(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GI SIDI HEV: FRFG2, ETBE	GI SIDI HEV: FRFG2, EtOH	GI SI HEV: CNG	GI SI HEV: LNG	GI SI HEVs: LPG, crude	GI SI HEVs: LPG, NG	GI SIDI HEVs: M90, NG	GI SIDI HEVs: M90, FG	GI SIDI HEVs: M90 LFG	GI SIDI HEVs: E90, corn	GI SIDI HEVs: E90, WB
Total energy	-47.4%	-47.4%	-43.5%	-41.7%	-46.2%	-46.7%	-37.0%	-34.1%	-43.2%	-36.3%	-8.7%
Fossil fuels	-47.4%	-47.4%	-44.1%	-41.4%	-46.2%	-46.6%	-36.7%	-68.4%	-77.4%	-71.1%	-89.7%
Petroleum	-47.4%	-47.4%	-99.6%	-97.5%	-36.1%	-98.8%	-87.3%	-87.3%	-87.7%	-89.3%	-88.0%
VOC: Total	-30.2%	-26.3%	-65.5%	-61.3%	-55.2%	-60.1%	-35.0%	-116.2%	-46.7%	16.3%	-24.0%
VOC: Urban	-32.3%	-23.6%	-56.2%	-57.2%	-50.7%	-48.3%	-25.7%	-25.7%	-28.0%	-24.3%	-24.3%
CO: Total	-2.5%	-2.1%	-21.5%	-20.4%	-21.8%	-22.2%	-1.2%	-2.7%	-10.7%	-0.7%	4.9%
CO: Urban	-0.2%	-0.1%	-19.7%	-20.1%	-20.0%	-20.0%	-0.2%	-0.2%	-3.4%	-0.1%	-0.1%
NOx: Total	-40.8%	-39.5%	-15.4%	10.1%	-50.0%	-55.1%	-37.8%	-78.0%	-49.2%	50.0%	94.1%
NOx: Urban	-14.7%	-12.5%	53.5%	-17.1%	-11.1%	-11.7%	-21.0%	-21.0%	-39.1%	-4.9%	-7.6%
PM1 0: Total	-27.2%	-21.8%	-34.5%	-32.1%	-32.0%	-37.1%	-27.5%	-34.1%	-166.8%	216.1%	13.6%
PM10: Urban	4.4%	4.8%	-16.5%	-17.4%	-16.8%	-16.8%	-7.1%	-7.1%	-113.2%	-5.6%	-5.7%
SOx: Total	-47.4%	-47.4%	-59.3%	-85.6%	-66.6%	-81.7%	-76.8%	-77.1%	-12.7%	27.4%	-94.3%
SOx: Urban	-47.4%	-47.4%	-88.0%	-98.9%	-94.4%	-94.5%	-87.2%	-87.2%	-177.7%	-90.1%	-90.6%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GI SIDI HEVs: E90, HB	GCSIDI HEV: FRFG2, MTBE, US mix	GCSIDI HEV: FRFG2, ETBE, US mix	GCSIDI HEV: FRFG2, EtOH, US mix	GCSIDI HEV: FRFG2, MTBE, CAmix	GCSIDI HEV: FRFG2, ETBE, CAmix	GCSIDI HEV: FRFG2, EtOH, CAmix	GC SI HEV: CNG, US mix	GC SI HEV: CNG, CAmix	GC SI HEV: LNG, US mix	GC SI HEV: LNG, CAmix
Total energy	-16.4%	-43.7%	-43.8%	-43.7%	-43.9%	-44.0%	-43.9%	-40.8%	-41.0%	-39.5%	-39.7%
Fossil fuels	-87.4%	-48.2%	-47.1%	-47.3%	-55.5%	-54.8%	-54.9%	-45.7%	-53.0%	-43.8%	-51.1%
Petroleum	-89.1%	-60.7%	-60.4%	-61.4%	-61.0%	-60.7%	-61.7%	-99.4%	-99.6%	-97.8%	-98.1%
VOC: Total	-26.9%	-46.1%	-47.9%	-45.0%	-48.2%	-49.8%	-47.0%	-72.6%	-74.8%	-69.6%	-71.7%
VOC: Urban	-24.4%	-43.8%	-43.9%	-40.8%	-43.8%	-43.9%	-40.8%	-69.2%	-69.2%	-70.0%	-70.0%
CO: Total	3.6%	-30.9%	-31.0%	-30.7%	-31.2%	-31.3%	-31.0%	-44.3%	-44.5%	-43.5%	-43.8%
CO: Urban	-0.1%	-30.1%	-30.1%	-30.1%	-30.1%	-30.1%	-30.0%	-43.8%	-43.7%	-44.1%	-44.1%
NOx: Total	97.1%	4.4%	-7.7%	2.9%	-37.8%	-42.2%	-38.3%	21.7%	-20.4%	40.1%	-2.0%
NOx: Urban	-6.8%	-32.7%	-34.6%	-32.7%	-31.1%	-33.1%	-31.1%	14.9%	16.5%	-36.0%	-34.5%
PM10: Total	6.3%	-2.9%	-28.2%	-19.1%	-19.2%	-37.6%	-31.0%	-18.6%	-34.9%	-16.9%	-33.2%
PM10: Urban	-5.7%	-6.3%	-6.8%	-6.3%	-6.2%	-6.7%	-6.2%	-21.2%	-21.1%	-21.9%	-21.7%
SOx: Total	-82.6%	81.0%	53.4%	68.0%	-40.0%	-44.3%	-42.1%	72.6%	-48.5%	53.6%	-67.5%
SOx: Urban	-90.4%	-59.2%	-59.2%	-59.2%	-61.3%	-61.4%	-61.4%	-88.1%	-90.3%	-96.0%	-98.2%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GC SI HEV: LPG, crude, US mix	GC SI HEV: LPG, NG, US mix	GC SI HEV: LPG, crude, CA mix	GC SIDI HEVs: LPG, CAmix	GC SIDI HEV: M90, NG, US mix	GC SIDI HEV: M90, FG, US mix	GC SIDI HEV: M90, LFG, US mix	GC SIDI HEV: M90, NG, CAmix	GC SIDI HEV: M90, FG, CAmix	GC SIDI HEV: M90, LFG, CAmix	GC SIDI HEV: E90, corn, US mix
Total energy	-42.7%	-43.1%	-42.9%	-43.3%	-36.2%	-34.1%	-40.6%	-36.4%	-34.3%	-40.8%	-35.8%
Fossil fuels	-47.2%	-47.5%	-54.6%	-54.8%	-40.5%	-63.3%	-69.8%	-47.8%	-70.7%	-77.1%	-64.7%
Petroleum	-53.6%	-98.8%	-53.8%	-99.0%	-90.5%	-90.5%	-90.7%	-90.8%	-90.8%	-91.0%	-91.9%
VOC: Total	-65.9%	-68.8%	-67.4%	-70.9%	-51.1%	-109.5%	-59.5%	-53.3%	-111.6%	-61.7%	-14.4%
VOC: Urban	-66.3%	-63.6%	-65.3%	-63.6%	-47.9%	-47.9%	-49.5%	-47.8%	-47.8%	-49.5%	-46.9%
CO: Total	-44.7%	-44.8%	-44.8%	-45.1%	-30.1%	-31.1%	-36.9%	-30.3%	-31.4%	-37.2%	-29.7%
CO: Urban	-44.0%	-44.0%	-44.0%	-44.0%	-30.1%	-30.1%	-32.4%	-30.1%	-30.1%	-32.4%	-30.0%
NOx: Total	-2.1%	-6.9%	-45.4%	-49.0%	5.5%	-23.4%	-2.7%	-36.6%	-65.5%	-44.9%	67.5%
NOx: Urban	-32.0%	-32.1%	-30.1%	-30.5%	-38.8%	-38.8%	-51.9%	-37.3%	-37.3%	-50.3%	-27.2%
PM10: Total	-16.0%	-20.5%	-33.1%	-36.8%	-13.8%	-18.5%	-113.9%	-30.1%	-34.8%	-130.2%	152.1%
PM10: Urban	-21.6%	-21.4%	-21.3%	-21.3%	-14.7%	-14.7%	-91.0%	-14.6%	-14.6%	-90.9%	-13.6%
SOx: Total	67.3%	56.4%	-53.8%	-64.7%	59.9%	59.7%	106.0%	-61.2%	-61.4%	-15.1%	121.8%
SOx: Urban	-92.7%	-92.8%	-94.9%	-95.0%	-87.6%	-87.6%	-152.6%	-89.8%	-89.8%	-154.8%	-89.6%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GC SIDI HEV: E90, WB, US mix	GC SIDI HEV: E90, HB, US mix	GC SIDI HEV: E90, corn, CA mix	GC SIDI HEV: E90, WB, CA mix	GC SIDI HEV: E90, HB, CA mix	CIDI: RFD	CIDI: DME, NG	CIDI: DME, FG	CIDI: FT50, NG	CIDI: FT50, FG	CIDI: BD20
Total energy	-15.9%	-21.5%	-36.0%	-16.1%	-21.7%	-35.1%	-17.7%	-14.4%	-21.3%	-13.2%	-31.4%
Fossil fuels	-78.1%	-76.4%	-72.3%	-85.7%	-84.0%	-35.0%	-17.2%	-67.4%	-21.1%	-38.6%	-31.6%
Petroleum	-91.0%	-91.8%	-92.2%	-91.3%	-92.0%	-25.0%	-97.9%	-97.9%	-59.9%	-59.9%	-36.7%
VOC: Total	-43.3%	-45.4%	-16.4%	-45.3%	-47.4%	-61.9%	-74.3%	-192.5%	-67.4%	-135.9%	-38.0%
VOC: Urban	-46.9%	-46.9%	-46.8%	-46.9%	-46.9%	-63.4%	-76.0%	-76.0%	-65.0%	-65.0%	-61.3%
CO: Total	-25.6%	-26.6%	-29.9%	-25.9%	-26.8%	-2.4%	-0.5%	-3.1%	-2.1%	-3.1%	-0.2%
CO: Urban	-30.0%	-30.0%	-30.0%	-30.0%	-30.0%	-0.1%	-0.3%	-0.3%	-0.2%	-0.2%	0.5%
NOx: Total	99.2%	101.4%	26.1%	57.8%	60.0%	-24.4%	-23.2%	-90.0%	-32.7%	-64.7%	17.7%
NOx: Urban	-29.1%	-28.5%	-25.5%	-27.4%	-26.9%	43.1%	32.6%	32.6%	38.2%	38.2%	78.5%
PM10: Total	6.5%	1.2%	140.2%	-5.4%	-10.6%	-13.7%	-36.0%	-47.9%	-28.6%	-33.0%	-7.0%
PM10: Urban	-13.6%	-13.6%	-13.4%	-13.5%	-13.5%	-1.4%	-12.0%	-12.0%	-8.3%	-8.3%	-0.8%
SOx: Total	34.3%	42.7%	11.7%	-75.8%	-67.4%	-34.1%	-82.2%	-83.3%	-58.4%	-58.0%	-32.6%
SOx: Urban	-90.0%	-89.8%	-91.8%	-92.2%	-92.0%	6.8%	-95.7%	-95.7%	-42.2%	-42.2%	-9.6%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GI CIDI HEV: RFD	GI CID1 HEV: DME, NG	GI CIDI HEV: DME, FG	GI CIDI HEV: FT50, NG	GI CIDI HEV: FT50, FG	GI CID1 HEV: BD20	GC CIDI HEV: RFD, US mix	GC CIDI HEV: RFD, CA mix	GC CIDI HEV: DME, NG, US mix	GC CIDI HEV: DME, FG, US mix	GC CJDI HEV: DME, NG, CA mix
Total energy	-57.7%	-46.3%	-44.2%	-43.3%	-48.7%	-55.3%	-53.5%	-53.3%	-42.2%	-40.7%	-42.4%
Fossil fuels	-57.6%	-46.0%	-78.7%	-43.1%	-57.6%	-55.4%	-65.2%	-57.8%	-46.5%	-70.5%	-53.9%
Petroleum	-51.1%	-98.6%	-98.6%	-73.8%	-73.8%	-58.7%	-67.3%	-67.1%	-98.6%	-98.6%	-98.9%
VOC: Total	-67.0%	-77.5%	-154.6%	-115.3%	-70.6%	-51.4%	-76.2%	-74.1%	-80.9%	-137.4%	-83.1%
VOC: Urban	-41.2%	-48.6%	-48.6%	-65.6%	-65.6%	-63.2%	-75.2%	-75.2%	-83.3%	-83.3%	-83.3%
CO: Total	-3.3%	-2.1%	-3.8%	-3.8%	-3.1%	-1.9%	-31.9%	-31.7%	-30.6%	-3 1.9%	-30.9%
CO: Urban	-0.1%	-0.1%	-0.1%	-0.2%	-0.2%	0.2%	-30.2%	-30.2%	-30.2%	-30.2%	-30.1%
NOx: Total	-40.4%	-39.6%	-83.1%	-66.7%	-45.8%	-12.9%	-40.3%	1.8%	4.4%	-27.5%	-37.8%
NOx: Urban	6.5%	5.3%	5.3%	35.1%	35.1%	61.3%	-2.1%	-3.7%	-2.2%	-2.2%	-0.6%
PM10: Total	-21.0%	-37.7%	-45.5%	-35.0%	-32.2%	-17.3%	-26.2%	-9.9%	-21.0%	-26.7%	-37.3%
PM10: Urban	-1.9%	-11.4%	-11.4%	-8.6%	-8.6%	-2.7%	-11.7%	-11.8%	-18.2%	-18.2%	-18.1%
SOx: Total	-57.0%	-88.4%	-89.1%	-72.6%	-72.9%	-56.1%	-49.3%	71.8%	51.7%	51.2%	-69.4%
SOx: Urban	-4.7%	-14.9%	-14.9%	-62.3%	-62.3%	-41.1%	-54.9%	-52.7%	-94.7%	-94.7%	-96.9%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

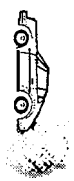

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars

(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	GCCIDI HEV: DME, FG, CA mix	GC CIDI HEVs: FT50, NG, US mix	GCCIDI HEVs: FT50, FG, US mix	GCCIDI HEV: FT50, NG, CA mix	GC CID1 HEV: FT50, FG, CA mix	GCCIDI HEV: BD20, US mix	GCCIDI HEV: BD20, CA mix	EV: US mix	EV:NE mix	EV: CA mix	H2 FCV: NG, C. gaseous
Total energy	-40.9%	**-43.9%**	-40.1%	-44.1%	-40.3%	-48.8%	**-49.0%**	-38.4%	**-39.7%**	**-39.0%**	**-59.7%**
Fossil fuels	-77.8%	-48.3%	-56.7%	-55.7%	-64.0%	-53.4%	-60.7%	-53.4%	-57.2%	**-77.9%**	-60.3%
Petroleum	-98.9%	-80.5%	-80.5%	-80.7%	-80.7%	-69.4%	-69.7%	-98.7%	-98.2%	**-99.6%**	-99.7%
VOC: Total	-139.5%	-76.1%	-108.8%	-78.2%	-111.0%	-62.0%	-64.2%	-89.6%	-92.5%	**-96.7%**	-95.8%
VOC: Urban	-83.3%	-75.8%	-75.8%	-75.8%	-75.8%	-74.1%	-74.0%	-99.7%	-99.5%	**-99.7%**	-98.3%
CO: Total	-32.1%	-31.4%	-31.9%	-31.7%	-32.1%	-30.5%	-30.8%	-97.5%	-97.3%	**-98.5%**	-97.1%
CO: Urban	-30.1%	-30.1%	-30.1%	-30.1%	-30.1%	-29.8%	-29.8%	-99.9%	-99.8%	**-99.9%**	-99.5%
NOx: Total	-69.6%	-0.2%	-15.5%	-42.3%	-57.6%	23.9%	-18.3%	103.6%	44.7%	-36.8%	-41.5%
NOx: Urban	-0.6%	0.5%	0.5%	2.1%	2.1%	19.7%	21.3%	-80.8%	-60.2%	-75.5%	-23.4%
PM10: Total	-43.0%	-17.0%	-19.1%	-33.3%	-35.4%	-6.2%	-22.5%	17.7%	-8.2%	-36.7%	-47.4%
PM10: Urban	-18.1%	-15.7%	-15.7%	-15.6%	-15.6%	-11.5%	-11.3%	-32.4%	-30.5%	-32.0%	-32.2%
SOx: Total	-69.9%	63.1%	63.3%	-58.0%	-57.8%	75.4%	-45.7%	377.4%	147.0%	-26.2%	-66.0%
SOx: Urban	-96.9%	-69.2%	-69.2%	-71.4%	-71.4%	-53.6%	-55.8%	-89.3%	-78.7%	-96.5%	-99.0%

Table continued on next page. See page preceding Table 4.14 for acronym definitions.

Table 4.15 (continued)

Long-Term Technology

Changes in Per-Mile, Fuel-Cycle Energy Use and Criteria Pollutant Emissions for Passenger Cars

(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	H2 FCV: NG, station gaseous	H2 FCV: solar gas	H2 FCV: solar, liquid	H2 FCV: NG, liquid	FCV: MeOH, NG	FCV: MeOH, FG	FCV: MeOH, LFG	FCV: FRFG2	EtOH FCV: Corn	EtOH FCV: WB	EtOH FCV: HB	NG FCV: CNG
Total energy	-53.2%	-65.5%	-71.8%	-58.8%	-52.3%	-49.7%	-57.8%	-50.0%	-37.7%	-7.1%	-15.6%	-52.0%
Fossil fuels	-52.9%	-93.1%	-98.3%	-58.5%	-52.0%	-80.3%	-88.3%	-50.0%	-77.4%	-97.3%	-94.8%	-52.5%
Petroleum	-99.7%	-99.9%	-98.1%	-97.8%	-98.6%	-98.6%	-98.9%	-50.0%	-96.5%	-94.9%	-96.2%	-99.7%
VOC: Total	-94.5%	-95.8%	-92.3%	-89.8%	-72.8%	-145.1%	-83.2%	-52.9%	-5.8%	-53.0%	-56.4%	-88.5%
VOC: Urban	-94.9%	-97.6%	-97.8%	-97.7%	-73.6%	-73.6%	-75.6%	-54.1%	-72.0%	-72.0%	-72.1%	-87.9%
CO: Total	-95.9%	-98.4%	-98.8%	-96.7%	-78.0%	-79.3%	-86.5%	-78.5%	-77.2%	-71.1%	-72.5%	-78.9%
CO: Urban	-97.1%	-99.3%	-99.8%	-99.8%	-80.0%	-80.0%	-82.8%	-79.9%	-79.8%	-79.9%	-79.8%	-79.6%
NOx: Total	-30.8%	-35.8%	-71.0%	-44.6%	-63.3%	-99.1%	-73.5%	-55.1%	46.7%	96.4%	99.8%	-39.1%
NOx: Urban	93.3%	7.2%	-75.4%	-73.0%	-82.8%	-82.8%	-98.9%	-72.1%	-55.1%	-59.5%	-58.2%	-17.5%
PM10: Total	-46.4%	-46.4%	-43.6%	-38.8%	-49.5%	-55.4%	-173.5%	-38.4%	349.9%	42.2%	31.1%	-46.7%
PM 10: Urban	-25.6%	-31.4%	-30.8%	-30.6%	-34.0%	-34.0%	-128.6%	-32.8%	-31.6%	-31.8%	-31.7%	-32.5%
SOx: Total	-91.7%	-63.5%	-97.5%	-90.6%	-87.8%	-88.0%	-30.6%	-54.1%	45.9%	-102.1%	-87.9%	-66.2%
SOx: Urban	-99.4%	-98.8%	-97.2%	-97.1%	-97.0%	-97.0%	-177.6%	-94.9%	-95.8%	-96.6%	-96.1%	-99.1%

Source:

Wang, Michael Q., GREET Model Results, Argonne National Laboratory, Argonne, IL, August 1999.

Note:

See page preceding Table 4.14 for acronym definitions.

Table 4.16
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Light Vehicles *a,b*
(grams per mile)

Engine Type & Pollutant	Prior to control	1968-69	1970-71	1972	1973-74	1975-76	1977-79	1980	1981	1982-86	1987-93	1994+*b*	
Gasoline													
Hydrocarbons (total)	11	*c*	2.2	3.4		1.5		0.41				0.41	(*e*)
Non-methane hydrocarbons	*d*											0.25	(0.31)
Carbon monoxide	80	*c*	23	39		15		7.0	3.4			3.4	(4.2)
Cold-temp. carbon monoxide *f*	*d*											10	(*e*)
Nitrogen oxides	4				3.0	3.1	2.0		1.0			0.4	(0.6)
Particulates	*d*											0.08	(0.10)
Diesel													
Hydrocarbons (total)	11					1.5		0.41				0.41	(*e*)
Non-methane hydrocarbons	*d*											0.25	(0.31)
Carbon monoxide	80					15		7.0	3.4			3.4	(4.2)
Nitrogen oxides	4					3.1	2.0		1.0			1.0	(1.25)
Particulates	*d*									0.60	0.20	0.08	(0.10)
Test Procedure		7-mode		CVS-72		CVS-75							
Useful Life (intermediate) *b*												5 yrs/50,000 mi	
(full)		5 yrs/50,000 mi										10 yrs/100,000 mi	

Source:
40 CFR 86.085-2; 40 CFR 86.090-2; 40 CFR 86.090-s; 40 CFR 86.094-s; 40 CFR 86.096-2; 40 CFR 86.096-s; 40 CFR 86.098-8;40 CFR 86.099-s; 40 CFR 86.082-2; 40 CFR 86.000-8. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999.

[a]The test procedure for measuring exhaust emissions has changed several times over the course of vehicle emissions regulation. The 7-mode procedure was used through model year 197 1 and was replaced by the CVS-72 procedure beginning in model year 1972. The CVS-75 became the test procedure as of model year 1975. While it may appear that the total hydrocarbon and carbon monoxide standards were relaxed in 1972-74, these standards were actually more stringent due to the more stringent nature of the CVS-72 test procedure. Additional standards for carbon monoxide and composite standards for non-methane hydrocarbons and nitrogen oxides tested over the new Supplemental Federal Test Procedure will be phased-in during model years 2000-02; these standards are not shown in this table.

[b]All emission standards must be met for a useful life of 5 years/50,000 miles. Beginning in with model year 1994, a second set of emission standards must also be met for a full useful life of 10 years/100,000 miles (these standards are shown in parentheses). Tier 1 exhaust standards were phased-in during 1994-96 at a rate of 40, 80, and 100 percent, respectively.

[c]In 1968-69, exhaust emission standards were issued in parts per million (ppm) rather than grams per mile and are, therefore, incompatible with this table.

[d]No estimate available.

[e]No standard set.

[f]The cold CO emission standard is measured at 20 degrees F (rather than 75 degrees F) and is applicable for a 5-year/50,000-mile useful life.

Table 4.17
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Light Trucks (Category LDT1) *a,b,c*
(grams per mile)

Engine Type & Pollutant	Prior to control	1968-69	1970-71	1972	1973-74	1975	1976-78	1979-81	1982-83	1984	1985-86	1987	1988-93	1994	1995+
Gasoline															
Hydrocarbons (total)	11	*d*	2.2	3.4		2.0		1.7		0.80				*f* (0.80)	
Non-methane hydrocarbons	*e*													0.25 (0.31)	
Carbon monoxide	80	*d*	23	39		20		18		10				3.4 (4.2)	
Cold-temp. carbon monoxide *g*	*e*													10 (*f*)	
Nitrogen oxides	4				3.0	3.1		2.3					1.2	0.4 (0.6)	
Particulates	*e*														0.08 (0.10)
Diesel															
Hydrocarbons (total)	11						2.0	1.7		0.80				*f* (0.80)	
Non-methane hydrocarbons	*e*													0.25 (0.31)	
Carbon monoxide	80						20	18		10				3.4 (4.2)	
Nitrogen oxides	4						3.1	2.3					1.2	1.0 (1.25)	
Particulates	*e*								0.60			0.26			0.08 (0.10)
LDT1 Weight Critera *h*		GVWR up through 6,000 lbs						GVWR up through 8,500 lbs					GVWR up through 6,000 lbs; LVW up through 3,750 lbs		
Test Procedure *b*		7-mode		CVS-72		CVS-75									
Useful Life (intermediate) *c*														5 yrs/50,000 mi	
(full)		5 yrs/50,000 mi									11 yrs/120,000 mi			11 yrs/120,000 mi	

Source:
40 CFR 86.082-2; 40 CFR 86.085-2; 40 CFR 86.090-2; 40 CFR 86.090-9; 40 CFR 86.091-9; 40 CFR 86.094-9; 40 CFR 86.096-2; 40 CFR 86.096-9; 40 CFR 86.099-9; 40 CFR 86.000-9; 40 CFR 86.001-9; 40 CFR 86.004-9. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication.

[a]Light truck categories LDT1-LDT4 were not actually created until 1994. From 1968 to 1978 all trucks with a Gross Vehicle Weight Rating (GVWR) up to 6,000 lbs were classified as light trucks and were required to meet the same standards. As of 1979, the maximum weight was raised to 8,500 lbs GVWR. During 1988 through 1993, light trucks were divided into two subcategories that coincide with the current LDT1 and LDT2/3/4 categories.

[b]The test procedure for measuring exhaust emissions has changed several times over the course of vehicle emissions regulation. The 7-mode procedure was used through model year 1971 and was replaced by the CVS-72 procedure beginning in model year 1972. The CVS-75 became the test procedure as of model year 1975. While it may appear that the total hydrocarbon and carbon monoxide standards were relaxed in 1972-74, these standards were actually more stringent due to the more stringent nature of the CVS-72 test procedure. Additional standards for carbon monoxide and composite standards for non-methane hydrocarbons and nitrogen oxides tested over the new Supplemental Federal Test Procedure will be phased-in during model years 2000-02; these standards are not shown in this table.

'Emission standards had to be met for a useful life of 5 years/50,000 miles through model year 1983, and a full useful life of 11 years 120,000 miles was defined for 1985-93 (several useful life options were available for 1984). Beginning in model year 1994, emission standards were established for an intermediate useful life of 5 years/50,000 miles as well as a full useful life of 11 years/120,000 miles (these standards are shown in parentheses). Hydrocarbon standards, however, were established only for full useful life. Tier 1 exhaust standards, except PM standards, were phased-in during 1994-96 at a rate of 40, 80, and 100 percent, respectively. PM standards were phased-in at a rate of 40, 80, and 100 percent during 1995-97.

[d]In 1968-69, exhaust emission standards were issued in parts per million (ppm) rather than grams per mile and are, therefore, incompatible with this table.

[e]No estimate available.

[f]No standard set.

[g]The cold CO emission standard is measured at 20 degrees F (rather than 75 degrees F) and is applicable for a 5-year/50,000-mile useful life.

[h]Gross vehicle weight rating (GVWR) is the maximum design loaded weight. Loaded vehicle weight (LVW) is the curb weight (nominal vehicle weight) plus 300 lbs.

Table 4.18
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Light Trucks (Category LDT2) *a,b,c*
(grams per mile)

Engine Type & Pollutant	Prior to control	1968-69	1970-71	1972	1973-74	1975	1976-78	1979-81	1982-83	1984	1985-86	1987	1988-90	1991-93	1994	1995+
Gasoline																
Hydrocarbons (total)	11	*d*	2.2		3.4	12.0	1.7		0.80		0.80				*f*	(0.80)
Non-methane hydrocarbons	e														0.32	(0.40)
Carbon monoxide	80	*d*	23		39		20		18		10				4.4	(5.5)
Cold-temp. carbon monoxide *g*	*e*														12.5	*(f)*
Nitrogen oxides	4				3.0	3.1			2.3				1.7		0.7	(0.97)
Particulates	*e*														0.08	(0.10)
Diesel																
Hydrocarbons (total)	11						2.0		1.7		0.80				*f*	(0.80)
Non-methane hydrocarbons	e														0.32	(0.40)
Carbon monoxide	80						20		18		10				4.4	(5.5)
Nitrogen oxides	4						3.1		2.3				1.7		*f*	(0.97)
Particulates	*e*								0.60			0.50	0.45	0.13		0.08 (0.10)
LDT2 Weight Criteria *h*		GVWR up through 6,000 lbs						GVWR up through 8,500 lbs					GVWR up through 6,000 lbs and LVW over 3,750 lbs			
Test Procedure *b*		7-mode			CVS-72		CVS-75									
Useful Life (intermediate) *c*															5 yrs/50,000 mi	
(full)		5 yrs/50,000 mi									11 yrs/120,000 mi				11 yrs/120,000 mi	

Source:
40 CFR 86.082-2; 40 CFR 86.085-2; 40 CFR 86.090-2; 40 CFR 86.090-g; 40 CFR 86,091-g; 40 CFR 86.094-g; 40 CFR 86.096-2; 40 CFR 86.096-g; 40 CFR 86.099-g; 40 CFR 86.000-g; 40 CFR 86.001-g; 40 CFR 86.004-g. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999.

[a]Light truck categories LDT1-LDT4 were not actually created until 1994. From 1968 to 1978 all trucks with a Gross Vehicle Weight Rating (GVWR) up to 6,000 lbs were classified as light trucks and were required to meet the same standards. As of 1979, the maximum weight was raised to 8,500 lbs GVWR. During 1988-93, light trucks were divided into two subcategories that coincide with the current LDT1 and LDT2/3/4 categories. The standards for LDT1, LDT3, and LDT4 are given in tables 4-30a, 4-40c, and 4-30d.

[b]The test procedure for measuring exhaust emissions has changed several times over the course of vehicle emissions regulation. The 7-mode procedure was used through model year 1971 and was replaced by the CVS-72 procedure beginning in model year 1972. The CVS-75 became the test procedure as of model year 1975. While it may appear that the total hydrocarbon and carbon monoxide standards were relaxed in 1972-74, these standards were actually more stringent due to the more stringent nature of the CVS-72 test procedure. Additional standards for carbon monoxide and composite standards for non-methane hydrocarbons and nitrogen oxides tested over the new Supplemental Federal Test Procedure will be phased-in during model years 2000-02; these standards are not shown in this table.

[c]Emission standards had to be met for a useful life of 5 years/50,000 miles through model year 1983, and a full useful life of 11 years 120,000 miles was defined for 1985-93 (several useful life options were available for 1984). Beginning in model year 1994, emission standards were established for an intermediate useful life of 5 years/50,000 miles as well as a full useful life of 11 years/120,000 miles (these standards are shown in parentheses). Hydrocarbon standards, however, were established only for full useful life. Tier 1 exhaust standards, except PM standards, were phased-in during 1994-96 at a rate of 40, 80, and 100 percent, respectively. PM standards were phased-in at a rate of 40, 80, and 100 percent during 1995-97.

[d]In 1968-69, exhaust emission standards were issued in parts per million (ppm) rather than grams per mile and are, therefore, incompatible with this table.

[e]No estimate available.

[f]No standard set.

[g]The cold CO emission standard is measured at 20 degrees F (rather than 75 degrees F) and is applicable for a 5-year/50,000-mile useful life.

[h]Gross vehicle weight rating (GVWR) is the maximum design loaded weight. Loaded vehicle weight (LVW) is the curb weight (nominal vehicle weight) plus 300 lbs.

Table 4.19
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Light Trucks (Category LDT3) *a,b,c*
(grams per mile)

Engine Type & Pollutant	Prior to control	1968-69	1970-71	1972	1973-74	1975	1976-78	1979-81	1982-83	1984	1985-86	1987	1988-89	1990	1991-95	1996+	
Gasoline																	
Hydrocarbons (total)	11	*d*	2.2	3.4		2.0		1.7		0.80						*f*	(0.80)
Non-methane hydrocarbons	*e*	*f*														0.32	(0.46)
Carbon monoxide	80	*d*	23	39		20		18		10						4.4	(6.4)
Cold-temp. carbon monoxide *g*	*e*	*f*														12.5	*(f)*
Nitrogen oxides	4	*f*			3.0	3.1		2.3					2.3	1.7		0.7	(0.98)
Particulates	*e*	*f*														*f*	(0.10)
Diesel																	
Hydrocarbons (total)	11	*f*					2.0	1.7		0.80						*f*	(0.80)
Non-methane hydrocarbons	*e*	*f*														0.32	(0.46)
Carbon monoxide	80	*f*					20	18		10						4.4	(6.4)
Nitrogen oxides	4	*f*					3.1	2.3					2.3	1.7		*f*	(0.98)
Particulates	*e*	*f*							0.60		0.50		0.45		0.13	*f*	(0.10)
LDT3 Weight Criteria *h*		GVWR up through 6,000 lbs						GVWR up through 8,500 lbs					Any ALW			ALW up through 5,750 lbs	
													GVWR 6,001-8,500 lbs				
Test Procedure *b*		7-mode		CVS-72		CVS-75											
Useful Life (intermediate) *c*		*f*														5 yrs/50,000 mi	
(full)		5 yrs/50,000 mi									11 yrs/120,000 mi					11 yrs/120,000	

Source:

40 CFR 86.082-2; 40 CFR 86.085-2; 40 CFR 86.090-2; 40 CFR 86.090-9; 40 CFR 86.091-9; 40 CFR 86.094-9; 40 CFR 86.096-2; 40 CFR 86.096-g; 40 CFR 86.099-g; 40 CFR 86.000-g; 40 CFR 86.001-g; 40 CFR 86.004-g. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999.

[a]Light truck categories LDT1-LDT4 were not actually created until 1994. From 1968 to 1978 all trucks with a Gross Vehicle Weight Rating (GVWR) up to 6,000 lbs were classified as light trucks and were required to meet the same standards. As of 1979, the maximum weight was raised to 8,500 lbs GVWR. During 1988-93, light trucks were divided into two subcategories that coincide with the current LDT1 and LDT2/3/4 categories.

[b]The test procedure for measuring exhaust emissions has changed several times over the course of vehicle emissions regulation. The 7-mode procedure was used through model year 1971 and was replaced by the CVS-72 procedure beginning in model year 1972. The CVS-75 became the test procedure as of model year 1975. While it may appear that the total hydrocarbon and carbon monoxide standards were relaxed in 1972-74, these standards were actually more stringent due to the more stringent nature of the CVS-72 test procedure. Additional standards for carbon monoxide and composite standards for non-methane hydrocarbons and nitrogen oxides tested over the new Supplemental Federal Test Procedure will be phased-in during model years 2002-04; these standards are not shown in this table.

'Emission standards had to be met for a full useful life of 5 years/50,000 miles through model year 1983, and a full useful life of 11 years 120,000 miles was defined for 1985-93 (several useful life options were available for 1984). Beginning in model year 1996, emission standards were established for an intermediate useful life of 5 years/50,000 miles as well as a full useful life of 11 years/120,000 miles (these standards are shown in parentheses). This applied to all pollutants except hydrocarbons and particulates for all LDT3s and NOx for diesel-powered LDT3s, which were only required to meet full useful life standards. Tier 1 exhaust standards were phased-in during 1996-97 at a rate of 50 and 100 percent, respectively.

[d]In 1968-69, exhaust emission standards were issued in parts per million (ppm) rather than grams per mile and are, therefore, incompatible with this table.

[e]No estimate available.

[f]No standard set.

[g]The cold CO emission standard is measured at 20 degrees F (rather than 75 degrees F) and is applicable for a 5-year/50,000-mile useful life.

[h]Gross vehicle weight rating (GVWR) is the maximum design loaded weight. Loaded vehicle weight (LVW) is the curb weight (nominal vehicle weight) plus 300 lbs.

Table 4.20
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Light Trucks (Category LDT4) *a,b,c*
(grams per mile)

Engine Type & Pollutant	Prior to control	1968-69	1970-71	1972	1973-74	1975	1976-78	1979-81	1982-83	1984	1985-86	1987	1988-89	1990	1991-95	1996+	
Gasoline																	
Hydrocarbons (total)	11	*d*	2.2	3.4		2.0		1.7		0.80						*f*	(0.80)
Non-methane hydrocarbons	*e*															0.39	(0.56)
Carbon monoxide	80	*d*	23	39		20		18		10						5.0	(7.3)
Cold-temp. carbon monoxide *g*	*e*															12.5	*(f)*
Nitrogen oxides	4				3.0	3.1		2.3					2.3	1.7		1.1	(1.53)
Particulates	*e*															*f*	(0.12)
Diesel																	
Hydrocarbons (total)	11						2.0	1.7		0.80						*f*	(0.80)
Non-methane hydrocarbons	*e*															0.39	(0.56)
Carbon monoxide	80						20	18		10						5.0	(7.3)
Nitrogen oxides	4						3.1	2.3					2.3	1.7		*f*	(1.53)
Particulates	*e*								0.60		0.50		0.45		0.13	*f*	(0.12)
LDT4 Weight Criteria *h*		GVWR up through 6,000 lbs						GVWR up through 8,500 lbs					Any ALVW			ALVW over 5,750 lbs	
													GVWR 6,001-8,500 lbs				
Test Procedure *b*		7-mode		CVS-72		CVS-75											
Useful Life (intermediate) *c*																5 yrs/50,000 mi	
(full)		5 yrs/50,000 mi									11 yrs/120,000 mi					11 yrs/120,000	

Source:
40 CFR 86.082-2; 40 CFR 86.085-2; 40 CFR 86.090-2; 40 CFR 86.090-g; 40 CFR 86.091-g; 40 CFR 86.094-g; 40 CFR 86.096-2; 40 CFR 86.096-g; 40 CFR 86.099-g; 40 CFR 86.000-g; 40 CFR 86.001-g; 40 CFR 86.004-g. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999.

[a]Light truck categories LDT1-LDT4 were not actually created until 1994. From 1968 to 1978 all trucks with a Gross Vehicle Weight Rating (GVWR) up to 6,000 lbs were classified as light trucks and were required to meet the same standards. As of 1979, the maximum weight was raised to 8,500 lbs GVWR. During 1988-93, light trucks were divided into two subcategories that coincide with the current LDT1 and LDT2/3/4 categories.

[b]The test procedure for measuring exhaust emissions has changed several times over the course of vehicle emissions regulation. The 7-mode procedure was used through model year 1971 and was replaced by the CVS-72 procedure beginning in model year 1972. The CVS-75 became the test procedure as of model year 1975. While it may appear that the total hydrocarbon and carbon monoxide standards were relaxed in 1972-74, these standards were actually more stringent due to the more stringent nature of the CVS-72 test procedure. Additional standards for carbon monoxide and composite standards for non-methane hydrocarbons and nitrogen oxides tested over the new Supplemental Federal Test Procedure will be phased-in during model years 2002-04; these standards are not shown in this table.

'Emission standards had to be met for a full useful life of 5 years/50,000 miles through model year 1983, and a full useful life of 11 years 120,000 miles was defined for 1985-93 (several useful life options were available for 1984). Beginning in model year 1996, emission standards were established for an intermediate useful life of 5 years/50,000 miles as well as a full useful life of 11 years/120,000 miles (these standards are shown in parentheses). This applied to all pollutants except hydrocarbons and particulates for all LDT3s and NOx for diesel-powered LDT3s, which were only required to meet full useful life standards. Tier 1 exhaust standards were phased-in during 1996-97 at a rate of 50 and 100 percent, respectively.

[d]In 1968-69, exhaust emission standards were issued in parts per million (ppm) rather than grams per mile and are, therefore, incompatible with this table.

[e]No estimate available.

[f]No standard set.

[g]The cold CO emission standard is measured at 20 degrees F (rather than 75 degrees F) and is applicable for a 5-year/50,000-mile useful life.

[h]Gross vehicle weight rating (GVWR) is the maximum design loaded weight. Adjusted loaded vehicle weight (ALVW) is the numerical average of the GVWR and the curb weight.

Table 4.21
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Light Heavy Trucks
(Grams per brake horsepower-hour)

Engine Type & Pollutant	1970-73	1974-78	1979-83	1984	1985-86	1987	1988-89	1990	1991-93	1994-97	1998-2003	2004+
Gasoline												
Hydrocarbons + nitrogen oxides (HC + NOx)	a	16	10		a							
Hydrocarbons (HC)	b	a	1.5		1.9	1.1						
Nitrogen oxides (NOx)	a				10.6			6.0	5.0		4.0	
Carbon Monoxide (CO)	b	40	25		37.1	14.4						
Diesel												
Hydrocarbons + nitrogen oxides (HC + NOx)	a	16	10		a							
Hydrocarbons (HC)	b	a	1.5		1.3							
Nitrogen oxides (NOx)	a				10.7			6.0	5.0		4.0	
Non-methane hydrocarbons + nitrogen oxides	a											2.4c
Carbon Monoxide (CO)	b	40	25		15.5							
Particulates	a						0.60		0.25	0.10		
Smoke Opacity (acceleration/lugging/peak) d	40/20/a	20/15/50										
Weight Criteria for Light Heavy Trucks e	GVWR over 6,000 lbs		GVWR over 8,500 lbs			GVWR 8,501 through 14,000 lbs						
Test Procedure (gasoline)f	9-mode steady-state				MVMA transient							
(diesel) f	13-mode steady-state				EPA transient							
Useful Life g (gasoline)	5 years/50,000 miles				8 years/l 10,000 miles							

Sources:

40 CFR 86.082-2; 40 CFR 86.085-2; 40 CFR 86.088-10; 40 CFR 86.090-2; 40 CFR 86.090-10; 40 CFR 86.090-l 1; 40 CFR 86.091-10; 40 CFR 86.091-l 1; 40 CFR 86.093-l 1; 40 CFR 86.094-l 1; 40 CFR 86.096-2; 40 CFR 86.096-10; 40 CFR 86.096-l 1; 40 CFR 86.098-10; 40 CFR 86.098-I 1; 40 CFR 86.099-10; 40 CFR 86,099-l 1; 40 CFR 86.004-l 1; 40 CFR 86.004-15. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999. Rob French, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999.

[a]No standard set.

[b]Although emission standards for hydrocarbons and carbon monoxide were in effect for these years, they were not measured in grams/brake horsepower-hour and are, therefore, incompatible with this table.

'Vehicles can meet a composite non-methane hydrocarbon and nitrogen oxide standard of 2.5, if they meet a non-methane hydrocarbon standard of no more than 0.5.

[d]Smoke opacity is expressed in percentage for acceleration, lugging, and peak modes (acceleration/lugging/peak). Lugging is when a vehicle is carrying a load.

[e]Gross vehicle weight rating (GVWR) is the maximum design loaded weight.

[f]Several testing procedures have been used during the course of exhaust emission control. A steady-state 9-mode test procedure (13-mode for diesel) was used for 1970-83 standards. For 1984, either the steady-state tests or the EPA transient test procedure could be used. For diesels, the EPA transient test was required from 1985 to the present. For gasoline-powered vehicles, either the EPA or MVMA (Motor Vehicle Manufacturers Association) transient test procedure could be used during 1985-86, and the MVMA procedure was required thereafter.

[g]Emissions standards apply to the useful life of the vehicle. Useful life was 5 years/50,000 miles through 1983, and 8 years/l 10,000 miles for model year 1985 and after. 1984 was a transitional year in which vehicles could meet the older standard (and test procedure) or the newer one. Useful life requirement for gasoline-powered trucks meeting NOx standards for 1998 and after is *10* years/l 10,000 miles. The useful life requirements for heavy diesel truck standards are more complex and vary by vehicle weight, pollutant, test procedure, and year. Consult the U.S. Code of Federal Regulations for further information.

Table 4.22
Federal Exhaust Emission Certification Standards for Gasoline- and Diesel-Powered Heavy Heavy Trucks
(Grams per brake horsepower-hour)

Engine Type & Pollutant	1970-73	1974-78	1979-83	1984	1985-86	1987	1988-89	1990	1991-93	1994-97	1998-2003	2004+
Gasoline												
Hydrocarbons + nitrogen oxides (HC + NOx)	[a]	16	10	[a]								
Hydrocarbons (HC)	*b*	[a]	1.5	1.9								
Nitrogen oxides (NOx)	[a]				10.6			6.0	5.0		4.0	
Carbon Monoxide (CO)	*b*	40	25	37.1								
Diesel												
Hydrocarbons + nitrogen oxides (HC + NOx)	[a]	16	10	[a]								
Hydrocarbons (HC)	*b*	[a]	1.5	1.3								
Nitrogen oxides (NOx)	[a]			10.7				6.0	5.0		4.0	
Non-methane hydrocarbons + nitrogen oxides	[a]											2.4*c*
Carbon Monoxide (CO)	*b*	40	25	15.5								
Particulates	[a]						0.60		0.25	0.10		
Smoke Opacity (acceleration/lugging/peak) *d*	40/20/*a*	20/15/50										
Weight Criteria for Heavy Heavy Trucks *e*	GVWR over 6,000 lbs		GVWR over 8,500 lbs			GVWR over 14,000 lbs						
Test Procedure (gasoline) *f*	13-mode steady-state				MVMA							
(diesel) *f*	13-mode steady-state			EPA transient								
Useful Life (gasoline) *g*	5 years/50,000 miles				8 years/110,000 miles							

Sources:
40 CFR 86.082-2; 40 CFR 86.085-2; 40 CFR 86.088-10; 40 CFR 86.090-2; 40 CFR 86.090-10; 40 CFR 86.090-I 1; 40 CFR 86.091-10; 40 CFR 86.091-I 1; 40 CFR 86.093-l 1; 40 CFR 86.094-I 1; 40 CFR 86.096-2; 40 CFR 86.096-10; 40 CFR 86.096-l 1; 40 CFR 86.098-10; 40 CFR 86.098-l 1; 40 CFR 86.099-10; 40 CFR 86.099-l 1; 40 CFR 86.004-l 1; 40 CFR 86.004-15. Lisa Snapp, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999. Rob French, Office of Air and Radiation, Environmental Protection Agency, Personal communication, April 1999.

[a] No standard set

[b] Although emission standards for hydrocarbons and carbon monoxide were in effect for these years, they were not measured in grams/brake horsepower-hour and are, therefore, incompatible with this table.

[c] Vehicles can meet a composite non-methane hydrocarbons and nitrogen oxides standard of 2.5, if they meet a non-methane hydrocarbon standard of no more than 0.5.

[d] Smoke opacity is expressed in percentage for acceleration, lugging, and peak modes (acceleration/lugging/peak). Lugging is when a vehicle is carrying a load.

[e] Gross vehicle weight rating (GVWR) is the maximum design loaded weight.

[f] Several testing procedures have been used during the course of exhaust emission control. A steady-state 9-mode test procedure (13-mode for diesel) was used for 1970-83 standards. For 1984, either the steady-state tests or the EPA transient test procedure could be used. For diesels, the EPA transient test was required from 1985 to the present. For gasoline-powered vehicles, either either the EPA or MVMA (Motor Vehicle Manufacturers Association) transient test procedure could be used during 1985-86, and the MVMA procedure was required thereafter.

[g] Emissions standards apply to the useful life of the vehicle. Useful life was 5 years/50,000 miles through 1983, and 8 years/l 10,000 miles for model year 1985 and after. 1984 was a transitional year in which vehicles could meet the older standard (and test procedure) or the newer one. Useful life requirement for gasoline-powered trucks meeting NOx standards for 1998 and after is IO years/l 10,000 miles. The useful life requirements for heavy diesel truck standards are more complex and vary by vehicle weight, pollutant, test procedure, and year. Consult the U.S. Code of Federal Regulations for further information.

Table 4.23
***California* Passenger Cars and Light Trucks Federal Emission Certification Standards**
(grams/mile)

Vehicle Type	Emission Category	Vehicle Useful Life: 5 Years / 50,000 Miles THC	NMHC[b]	NMOG[c]	CO	NO_x	PM	HCHO	10 Years / 100,000 Miles THC[a]	NMHC[b]	NMOG[c]	CO	NO_x	PM	HCHO
Passenger car	Tier 0	–	0.39	–	7.0	0.4	0.08[d]	0.015[e]							
	Tier 1		0.25	–	3.4	0.4	0.08[d]	0.015'	–	0.31	–	4.2	0.6	–	–
	TLEV	–		0.125	3.4	0.4	–	0.015	–	–	0.156	4.2	0.6	0.08[d]	0.018
	LEV	–		0.075	3.4	0.2	–	0.015	–	–	0.090	4.2	0.3	0.08[d]	0.018
	ULEV			0.040	1.7	0.2	–	0.008	–	–	0.055	2.1	0.3	0.04[d]	0.011
	ZEV	0.0	0.00	0.000	0.0	0.0	0.00	0.000	0.00	0.00	0.000	0.0	0.0	0.00	0.000
LDT1	Tier 0	–	0.39	–	9.0	0.4	0.08[d]	0.015'							
	Tier 1	–	0.25	–	3.4	0.4	0.08[d]	0.015'	–	0.31	–	4.2	0.6	–	–
	TLEV			0.125	3.4	0.4	–	0.015	–	–	0.156	4.2	0.6	0.08[d]	0.018
	LEV			0.075	3.4	0.2	–	0.015	–	–	0.090	4.2	0.3	0.08[d]	0.018
	ULEV			0.040	1.7	0.2	–	0.008	–	–	0.055	2.1	0.3	0.04[d]	0.011
	ZEV	0.0	0.00	0.000	0.0	0.0	0.00	0.000	0.00	0.00	0.000	0.0	0.0	0.00	0.000
LDT2	Tier 0		0.50	–	9.0	1.0	0.08[d]	0.018'							
	Tier 1		0.32	–	4.4	0.7	0.08[d]	0.018'	–	0.40	–	5.5	0.97	–	–
	TLEV			0.160	4.4	0.7	–	0.018	–	–	0.200	5.5	0.9	0.10[d]	0.023
	LEV			0.100	4.4	0.4	–	0.018	–	–	0.130	5.5	0.5	0.10[d]	0.023
	ULEV			0.050	2.2	0.4	–	0.009	–	–	0.070	2.8	0.5	0.05[d]	0.013

Source:
U.S. Environmental Protection Agency, Office of Mobile Sources, EPA 420-B-98-001. (Additional resources: http://www.epa.gov/OMSWWW)

Note:
LDT1 = light truck up through 3,750 lbs. loaded vehicle weight; LDT2 = light truck greater than 3,750 Ibs. loaded vehicle weight.

[a] THCE for methanol vehicles. Does not apply to CNG vehicles.
[b] THCE for Tier 0 methanol vehicles. NMHCE for other alcohol vehicles.
[c] NMHC for diesel-fueled vehicles.
[d] Diesel-fueled vehicles only.
[e] Ethanol- and methanol-fueled vehicles only.

California's Low-Emission Vehicle regulationsprovidefor reduced emission vehicles to be available to consumers. Vehicles meeting these standards have even lower emissions than the basic standards for all new vehicles sold in California. Currently, there is a wide array of TLEVs and LEVs, and a few ULEVs and ZEVs on the market. For a listing of the available low emission vehicles, see the California Air Resources Board web site referenced below.

Table 4.24
California Vehicle Emission Reduction for Passenger Cars and Light Trucks

	Emission reduction from the basic California standards"		
	HC	c o	NOx
Transitional Low-Emission Vehicle (TLEV)	50%	=	=
Low-Emission Vehicle (LEV)	70%	=	5 0 %
Ultra-Low-Emission Vehicle (ULEV)	85%	50%	50%
Zero-Emission Vehicles (ZEV)	100%	100%	100%

Source:
California Air Resources Board web site, http://www.arb.ca.gov/msprog/ccbg/ccbg.htm
(Additional resources: http://www.arb.ca.gov)

Note:
= indicates equivalent emissions to vehicles meeting the basic California standard.

[a]See Table 4.23.

The California Air Resources Board adopted requirements in 1991 for fleet mixture in order to meet the emission standards. By the year 2001, it is proposed that 90% of each vehicle manufacturer's fleet be low-emission vehicles. A March 1996 amendment to the plan allows the marketplace to determine the number of zero emission vehicles from 1998 to 2002.

Table 4.25
California Air Resources Board Requirements for Meeting Emission Standards

Year	Conventional vehicles	Transitional low-emission vehicles	Low-emission vehicles	Ultra-low-emission vehicles	Zero emission vehicles
1993	100%				
1994	90%	10%			
1995	85%	15%			
1996	80%	20%			
1997	73%		25%	2%	
1998	48%		48%	2%	
1999	25%		73%	2%	
2000			90%	2%	
2001			90%	5%	
2002			85%	10%	
2003			75%	15%	10%

Source:
California Air Resources Board, Mobile Sources Division, El Monte, CA, 1996.
(Additional resources: http://www.arb.ca.gov)