

Chapter 3

Emissions and Transportation

Summary Statistics

Table

3.5	Transportation share of carbon dioxide emissions from fossil fuel consumption	
	<i>1984</i>	30.5%
	<i>1990</i>	32.1%
	<i>1996</i>	32.1%
3.6	Carbon dioxide emissions from Transportation energy use, 1996	
	<i>Motor gasoline</i>	61.1%
	<i>Liquified petroleum gas</i>	0.1%
	<i>Jet fuel</i>	13.4%
	<i>Distillate fuel</i>	18.8%
	<i>Residual fuel</i>	3.7%
	<i>Lubricants</i>	0.3%
	<i>Aviation gas</i>	0.1%
	<i>Natural gas</i>	2.2%
	<i>Electricity</i>	0.1%
	Transportation share of emissions of criteria pollutants, 1996	
3.9	<i>Carbon Monoxide</i>	78.7%
3.10	<i>Nitrogen oxidies</i>	50.4%
3.12	<i>Voltile organic compounds</i>	41.5%
3.13	<i>PM-10</i>	2.8%
3.16	<i>Lead</i>	14.6%



Table 3.1
International Anthropogenic Emissions of All Greenhouse Gases, 1990-94^a

	1990 (gigagrams)	1991	1992	1993	1994
		(percentage relative to 1990, 1990=100)			
Australia	465,305	b	b	b	b
Austria	75,286	b	b	b	b
Bulgaria (1990)	123,755	b	b	b	b
Bulgaria (1988) ^c	141,345	b	b	b	b
Canada	577,954	99%	102%	103%	106%
Czech Republic	196,551	b	b	b	b
Denmark	65,517	117%	108%	111%	119%
Denmark ^d	71,770	104%	103%	103%	103%
Estonia	46,479	96%	73%	55%	57%
Finland	67,114	100%	91%	92%	102%
France	494,032	104%	101%	99%	b
Germany	1,241,509	94%	90%	90%	b
Greece	94,888	b	b	b	b
Hungary (1990)	88,674	b	b	b	b
Hungary (1985-1987) ^c	104,082	b	b	b	b
Iceland	3,227	95%	92%	94%	b
Ireland	63,757	b	b	b	b
Italy	563,117	b	b	b	b
Japan	1,206,523	102%	103%	101%	b
Latvia	27,640	b	b	b	b
Liechtenstein	265	b	b	b	b
Luxembourg	12,123	b	b	b	b
Monaco	71	b	b	b	b
Netherlands	213,946	105%	103%	104%	105%
Netherlands ^c	220,346	102%	102%	101%	103%
New Zealand	80,266	99%	101%	99%	100%
Norway	52,235	96%	92%	96%	100%
Poland (1990)	614,300	b	73%	b	b
Poland (1988) ^c	572,257	b	78%	b	b
Portugal	51,045	b	b	b	b
Romania (1990)	253,152	84%	72%	75%	b
Romania (1989) ^c	276,859	77%	66%	68%	b
Russian Federation	3,078,892	b	b	b	b
Slovakia	71,900	b	b	b	b
Spain	310,070	b	b	b	b
Sweden	75,573	b	91%	b	95%
Switzerland	58,196	103%	100%	98%	97%
United Kingdom	724,754	101%	97%	94%	94%
United States	5,842,371	99%	101%	102%	103%

Source:

United Nations Framework Convention on Climate Change, FCCC/CP/1996/12/Add.1, June 1996.

(Additional resources: <http://www.unfccc.de>)

^aExcluding land-use change and forestry.

^bData are not available.

^cSome parties with economies in transition have chosen different base years than 1990.

^dAll figures are adjusted for electricity trade.

^eAll figures are adjusted for temperature.



Table 3.2
International Anthropogenic Emissions of Carbon Dioxide, 1990–94^a

	1990	1991	1992	1993	1994
	(gigagrams)	(percentage relative to 1990, 1990=100)			
Australia	288,965	b	b	b	b
Austria	59,200	108%	100%	b	b
Bulgaria (1990)	82,990	b	b	b	b
Bulgaria (1988) ^c	96,878	b	b	b	b
Canada	462,643	98%	101%	102%	105%
Czech Republic	165,792	94%	86%	84%	b
Denmark	52,025	121%	110%	114%	121%
Denmark ^d	58,278	105%	104%	103%	101%
Estonia	37,797	97%	74%	55%	57%
Finland	53,900	100%	96%	97%	108%
France	366,536	106%	102%	100%	b
Germany	1,014,155	96%	91%	90%	b
Greece	82,100	b	b	b	b
Hungary (1990)	71,673	b	b	b	b
Hungary (1985–1987) ^c	83,676	b	b	b	b
Iceland	2,172	96%	101%	106%	b
Ireland	30,719	b	b	b	b
Italy	428,941	b	b	b	b
Japan	1,155,000	102%	103%	101%	107%
Latvia	22,976	b	b	b	b
Liechtenstein	208	b	b	b	b
Luxembourg	11,343	b	b	b	b
Monaco	71	b	b	b	b
Netherlands	167,600	104%	103%	104%	105%
Netherlands ^e	174,000	100%	101%	100%	102%
New Zealand	25,476	102%	110%	107%	108%
Norway	35,514	95%	96%	101%	106%
Poland (1990)	414,930	96%	90%	b	b
Poland (1988) ^c	478,880	83%	78%	b	b
Portugal	42,148	b	b	b	b
Romania (1990)	171,103	83%	72%	70%	b
Romania (1989) ^c	198,479	71%	62%	61%	b
Russian Federation	2,388,720	b	b	b	b
Slovakia	58,278	b	b	b	b
Spain	227,322	b	b	b	b
Sweden	61,256	89%	92%	90%	95%
Switzerland	45,070	103%	101%	98%	96%
United Kingdom	577,012	102%	99%	97%	96%
United States	4,957,022	99%	100%	103%	103%

Source:

United Nations Framework Convention on Climate Change, FCCC/CP/1996/12/Add.1, June 1996.

(Additional resources: <http://www.unfccc.de>)

^aExcluding land-use change and forestry.

^bData are not available.

^cSome parties with economies in transition have chosen different base years than 1990.

^dAll figures are adjusted for electricity trade.

^eAll figures are adjusted for temperature.



Table 3.3
International Anthropogenic Emissions of Nitrogen Oxides, 1990-94

	1990	1991	1992	1993	1994
	(gigagrams)	(percentage relative to 1990, 1990=100)			
Australia	60.1	a	a	a	a
Austria	4.1	a	a	a	a
Bulgaria (1990)	22.5	a	a	a	a
Bulgaria (1988) ^b	30.8	a	a	a	a
Canada	95.5	99%	103%	105%	116%
Czech Republic	24.0	a	a	a	a
Denmark	10.3	104%	103%	105%	106%
Estonia	2.4	96%	75%	58%	54%
Finland	22.0	100%	45%	50%	50%
France	176.7	101%	99%	97%	a
Germany	211.0	91%	94%	91%	a
Greece	13.7	a	a	a	a
Hungary (1990)	11.4	a	a	a	a
Hungary (1985-1987) ^b	12.9	a	a	a	a
Iceland	0.6	100%	100%	100%	a
Ireland	42.3	a	a	a	a
Italy	120.3	a	a	a	a
Japan	55.2	97%	97%	98%	a
Latvia	2.4	a	a	a	a
Liechtenstein	0.1	a	a	a	a
Luxembourg	0.6	a	a	a	a
Monaco	a	a	a	a	a
Netherlands	51.5	117%	116%	113%	113%
New Zealand	17.1	99%	103%	109%	112%
Norway	15.0	100%	87%	93%	93%
Poland (1990)	156.0	a	32%	a	a
Poland (1988) ^b	58.9	a	85%	a	a
Portugal	10.5	a	a	a	a
Romania (1990)	106.8	85%	64%	92%	a
Romania (1989) ^b	66.7	a	a	a	a
Russian Federation	89.6	a	a	a	a
Slovakia	16.0	a	a	a	a
Spain	93.9	a	a	a	a
Sweden	15.2	a	132%	a	161%
Switzerland	15.6	101%	101%	100%	104%
United Kingdom	108.3	99%	84%	75%	87%
United States	411.4	97%	97%	97%	87%

Source:

United Nations Framework Convention on Climate Change, FCCC/CP/1996/12/Add.1, June 1996.

(Additional resources: <http://www.unfccc.de>)

^aData are not available.

^bSome parties with economies in transition have chosen different base years than 1990.



Table 3.4
Estimated U.S. Emissions of Greenhouse Gases, 1989-96

Greenhouse gas	Unit of measure ^a	1989	1990	1991	1992	1993	1994	1995	1996
Carbon dioxide	million metric tons of gas	5,091.8	5,037.1	4,987.3	5,059.8	5,175.9	5,256.1	5,296.9	5,484.9
	million metric tons of carbon	1,389.0	1,374.0	1,360.0	1,380.0	1,412.0	1,433.0	1,445.0	1,496.0
Methane	million metric tons of gas	31.3	31.6	31.6	31.7	30.8	31.4	30.9	30.9
	million metric tons of carbon (gwp) ^b	179.0	181.0	181.0	182.0	177.0	180.0	177.0	177.0
Nitrous oxide	million metric tons of gas	0.4	0.4	0.5	0.5	0.5	0.5	0.5	0.4
	million metric tons of carbon (gwp) ^b	38.0	38.0	38.0	38.0	39.0	40.0	38.0	38.0
Carbon monoxide	million metric tons of gas	94.8	87.6	89.3	86.3	86.4	90.4	81.4	80.6
Nitrogen oxide	million metric tons of gas	21.8	21.6	21.6	21.9	22.2	22.6	21.7	21.2
Nonmethane VOCs ^c	million metric tons of gas	20.3	19.0	19.1	18.8	19.0	19.5	18.7	17.3
CFC-11,12,113 ^c	million metric tons of gas	0.3	0.2	0.2	0.2	0.1	0.1	0.1	0.1
HCFC-22 ^c	million metric tons of gas	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HCFC-23 and PFCs ^c	million metric tons of gas	^d							
	million metric tons of carbon (gwp) ^b	26.0	25.0	26.0	28.0	27.0	31.0	36.0	42.0

Source:

U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1996*, Washington, DC, October 1997, p. x. (Additional resources: <http://www.eia.doe.gov>)

Criteria pollutants (CO, NO_x, VOC) - U.S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996*, 1997, pp. A-6, A-11, A-18. (Additional resources: <http://www.epa.gov/oar/oaqps>)

^aGases that contain carbon can be measured either in terms of the full molecular weight of the gas or just in terms of their carbon content. See Appendix B, Table B.5 for details.

^bBased on global warming potential.

^cVOC=volatile organic compounds. CFC=chlorofluorocarbons. HCFC=hydrochlorofluorocarbons. HFC=hydrofluorocarbons.

PFC=perfluorocarbons.

^dData are not available.





Gases which contain carbon can be measured in terms of the full molecular weight of the gas or just in terms of their carbon content. This table presents carbon content. The ratio of the weight of carbon to carbon dioxide is 0.2727.

Table 3.5
U.S. Carbon Dioxide Emissions from Fossil Energy Consumption
by End-Use Sector, 1984-96^a
(million metric tons of carbon)

End use	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996
Energy consumption sectors													
Residential	241.1	245.8	244.0	251.0	264.8	267.5	253.0	257.1	255.9	271.6	268.3	269.7	286.8
Commercial	188.8	189.6	190.4	197.2	207.6	210.1	206.8	206.5	205.5	212.0	213.8	218.3	230.3
Industrial	434.4	424.1	409.0	422.7	444.1	450.4	453.8	442.4	458.8	458.2	467.0	464.9	476.9
Transportation	379.0	384.4	399.1	411.1	427.5	432.7	432.1	424.5	431.4	439.1	452.2	458.5	469.0
Percentage	30.5%	30.9%	32.1%	32.1%	31.8%	31.8%	32.1%	31.9%	31.9%	31.8%	32.3%	32.5%	32.1%
Total energy	1,243.3	1,243.9	1,242.5	1,282.0	1,344.0	1,360.9	1,345.8	1,330.6	1,351.5	1,380.9	1,401.3	1,411.4	1,463.0
Electric utility sector													
Electric utility	427.9	438.9	435.4	452.6	475.9	484.0	477.0	473.7	472.9	490.3	494.0	493.7	516.8

Source:

U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1996*, Washington, DC, October 1997, p. 8, and annual. (Additional resources: <http://www.eia.doe.gov>)

^aIncludes energy from petroleum, coal, and natural gas. Electric utility emissions are distributed across consumption sectors.

Table 3.6
U.S. Carbon Dioxide Emissions from Energy Use in the Transportation Sector, 1980–96
 (million metric tons of carbon)

Fuel	1980		1985		1990		1995		1996	
	Emissions	Percentage	Emissions	Percentage	Emissions	Percentage	Emissions	Percentage	Emissions	Percentage
Petroleum										
Motor gasoline	238.1	62.9%	245.1	63.8%	260.9	60.4%	282.2	61.5%	286.7	61.1%
LPG ^a	0.3	0.1%	0.5	0.1%	0.4	0.1%	0.6	0.1%	0.6	0.1%
Jet fuel	42.0	11.1%	48.0	12.5%	60.1	13.9%	60.0	13.1%	62.7	13.4%
Distillate fuel	55.3	14.6%	63.3	16.5%	75.7	17.5%	83.8	18.3%	88.2	18.8%
Residual fuel	30.0	7.9%	16.7	4.3%	21.9	5.1%	18.5	4.0%	17.3	3.7%
Lubricants	1.8	0.5%	1.6	0.4%	1.8	0.4%	1.7	0.4%	1.6	0.3%
Aviation gas	1.2	0.3%	0.9	0.2%	0.8	0.2%	0.7	0.2%	0.7	0.1%
Total	368.7	97.4%	376.1	97.8%	421.5	97.5%	447.5	97.6%	457.9	97.6%
Other energy										
Natural gas	9.4	2.5%	7.5	2.0%	9.8	2.3%	10.4	2.3%	10.5	2.2%
Electricity	0.3	0.1%	0.7	0.2%	0.7	0.2%	0.6	0.1%	0.7	0.1%
Total	378.4	100.0%	384.4	100.0%	432.1	100.0%	458.5	100.0%	469.0	61.1%

Source:

U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States, 1996*, Washington, DC, October 1997, p. 20, and annual. (Additional resources: <http://www.eia.doe.gov>)

^aLiquified petroleum gas.



Global Warming Potentials (GWP) were developed to allow comparison of each greenhouse gas' ability to trap heat in the atmosphere relative to carbon dioxide. Extensive research has been performed and it has been discovered that the effects of various gases on global warming are too complex to be precisely summarized by a single number. Further understanding of the subject also causes frequent changes to estimates. Despite that, the scientific community has developed approximations, which are shown below. Most analysts use the 100-year time horizon.

Table 3.7
Numerical Estimates of Global Warming Potentials Compared With Carbon Dioxide
(kilogram of gas per kilogram of carbon dioxide)

Gas	Lifetime (years)	Direct effect for time horizons of		
		20 years	100 years	500 years
Carbon Dioxide	Variable	1	1	1
Methane	12 ± 3	56	21	7
Nitrous Oxide	120	280	310	170
HFCs, PFCs, and other gases				
HFC-23	264	9,200	12,100	9,900
HFC-125	33	4,800	3,200	11
HFC-134a	15	3,300	1,300	420
HFC-152a	2	460	140	42
HFC-227ea	37	4,300	2,900	950
Perfluoromethane	50,000	4,400	6,500	10,000
Perfluoroethane	10,000	6,200	9,200	14,000
Sulfur hexafluoride	3,200	16,300	23,900	34,900

Source:

U.S. Department of Energy, Energy Information Administration, *Emissions of Greenhouse Gases in the United States 1996*, Washington, DC, October 1997, p. 7. Original source: Intergovernmental Panel on Climate Change. (Additional resources: <http://www.eia.doe.gov>, <http://www.ipcc.ch>)

Note:

The typical uncertainty for global warming potentials is estimated by the Intergovernmental Panel on Climate Change at ± 35 percent.



Table 3.8
Total National Emissions of the Criteria Air Pollutants by Sector, 1996
(millions of short tons/percentage)

Sector	CO	NO _x	VOC	PM-10	SO ₂
Highway vehicles	52.94	7.17	5.50	0.27	0.31
	59.6%	30.7%	28.8%	0.9%	1.6%
Aircraft	0.95	0.17	0.18	0.04	0.01
	1.1%	0.7%	0.9%	0.1%	0.1%
Railroads	0.11	0.92	0.05	0.03	0.24
	0.1%	3.9%	0.3%	0.1%	1.2%
Vessels	0.08	0.23	0.05	0.03	0.11
	0.1%	1.0%	0.3%	0.1%	0.6%
Other off-highway	15.86	3.29	2.15	0.49	0.01
	17.9%	14.1%	11.3%	1.6%	0.0%
Transportation total	69.95	11.78	7.93	0.87	0.68
	78.7%	50.4%	41.5%	2.8%	3.5%
Stationary source fuel combustion	5.96	10.49	1.08	1.19	16.79
	6.7%	44.9%	5.6%	3.8%	87.8%
Industrial processes	4.62	0.78	9.05	0.94	1.60
	5.2%	3.3%	47.4%	3.0%	8.4%
Waste disposal and recycling total	1.20	0.10	0.43	0.29	0.05
	1.4%	0.4%	2.3%	0.9%	0.3%
Miscellaneous	7.10	0.24	0.60	28.02	0.01
	8.0%	1.0%	3.1%	89.5%	0.0%
Total of all sources	88.83	23.29	19.08	31.30	19.11
	100.0%	100.0%	100.0%	100.0%	100.0%

Source:

All other—U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900–1996, 1997*, Appendix A. (Additional resources: <http://www.epa.gov/oar/oaqps>)

Note:

CO = Carbon monoxide. NO_x = Nitrogen oxides. PM-10 = Particulate matter less than 10 microns.
SO₂ = Sulfur dioxide. VOC = Volatile organic compounds.



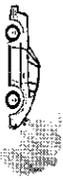


Table 3.9
Total National Emissions of Carbon Monoxide, 1940-96^a
(million short tons)

Source category	1940	1950	1960	1970	1980	1990	1994	1995	1996	Percent of total, 1996
Highway vehicles	30.12	45.20	64.27	88.03	78.05	57.85	61.83	54.11	52.94	59.6%
Aircraft	0.00	0.93	1.76	0.51	0.74	0.90	0.92	0.94	0.95	1.1%
Railroads	4.08	3.08	0.33	0.07	0.10	0.12	0.11	0.11	0.11	0.1%
Vessels ^b	0.06	0.12	0.52	0.01	0.04	0.08	0.08	0.08	0.08	0.1%
Other off-highway	3.91	7.48	8.96	10.70	12.88	15.01	15.76	15.70	15.86	17.9%
Transportation total	38.17	56.81	69.87	99.32	91.81	73.97	78.71	70.95	69.95	78.7%
Stationary fuel combustion total	15.33	11.32	7.02	4.63	7.30	5.51	5.52	5.93	5.96	6.7%
Industrial processes total	7.28	11.64	10.28	9.84	6.95	4.77	4.61	4.61	4.62	5.2%
Waste disposal and recycling total	3.63	4.72	5.60	7.06	2.30	1.08	1.23	1.19	1.20	1.4%
Miscellaneous total	29.21	18.14	11.01	7.91	8.34	11.21	9.61	7.05	7.10	8.0%
Total of all sources	93.62	102.61	109.75	128.76	116.70	96.54	99.68	89.72	88.83	100.0%

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996, 1997*, pp. A-2-A-6, 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.

^aThe sums of subcategories may not equal total due to rounding.

^bRecreational marine vessels.

Table 3.10
Total National Emissions of Nitrogen Oxides, 1940-96^a
(million short tons)

Source category	1940	1950	1960	1970	1980	1990	1994	1995	1996	Percent of total, 1996
Highway vehicles	1.33	2.14	3.98	7.39	8.62	7.04	7.67	7.32	7.17	30.7%
Railroads	0.66	0.99	0.77	0.50	0.73	0.93	0.95	0.99	0.92	3.9%
Other off-highway	0.33	0.55	0.67	2.15	3.29	3.66	4.00	3.69	3.69	15.8%
Transportation total	2.32	3.68	5.43	10.03	12.64	11.63	12.62	12.00	11.78	50.4%
Stationary fuel combustion total	3.73	5.16	7.37	10.06	11.32	10.89	11.02	10.83	10.49	44.9%
Industrial processes total	0.22	0.38	0.57	0.78	0.56	0.80	0.77	0.77	0.78	3.3%
Waste disposal and recycling total	0.11	0.22	0.33	0.44	0.11	0.09	0.11	0.10	0.10	0.4%
Miscellaneous total	0.99	0.67	0.44	0.33	0.25	0.37	0.38	0.24	0.24	1.0%
Total of all sources	7.37	10.09	14.14	21.64	24.88	23.79	24.89	23.93	23.39	100.0%

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996, 1997*, pp. A-7-A-11, 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.

^aThe sums of subcategories may not equal total due to rounding.





Table 3.11
Emissions of Nitrogen Oxides from Highway Vehicles, 1970-96^a
(million short tons)

Source category	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	Percent of total, 1996
Gasoline powered												
Light-duty vehicles & motorcycles	4.16	4.73	4.42	3.81	3.22	3.46	3.61	3.68	3.57	3.44	3.40	47.4%
Light-duty trucks ^b	1.28	1.46	1.41	1.53	1.26	1.34	1.36	1.42	1.66	1.52	1.51	21.1%
Heavy-duty vehicles	0.28	0.32	0.30	0.33	0.33	0.33	0.31	0.32	0.35	0.33	0.33	4.5%
Total	5.71	6.51	6.13	5.67	4.80	5.13	5.28	5.42	5.58	5.30	5.24	73.0%
Diesel powered												
Light-duty vehicles	^c	0.02	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.5%
Light-duty trucks ^b	^c	^c	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.1%
Heavy-duty vehicles	1.68	2.12	2.46	2.39	2.19	2.20	2.12	2.05	2.04	1.98	1.88	26.3%
Total	1.68	2.14	2.49	2.42	2.24	2.24	2.16	2.09	2.09	2.03	1.93	27.0%
Total												
Highway vehicle total	7.39	8.65	8.62	8.09	7.04	7.37	7.44	7.51	7.67	7.32	7.17	100.0%
Percent diesel	22.7%	24.8%	28.9%	30.0%	31.8%	30.4%	29.1%	27.9%	27.3%	27.7%	27.0%	

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996*, 1997, p. A-10 and annual.

(Additional resources: <http://www.epa.gov/oar/oaqps>)

^aThe sums of subcategories may not equal total due to rounding.

^bLess than 8,500 pounds.

^cData are not available.

Table 3.12
Total National Emissions of Volatile Organic Compounds, 1940-96^a
(million short tons)

Source category	1940	1950	1960	1970	1980	1990	1994	1995	1996	Percent of total, 1996
Highway vehicles	4.82	7.25	10.51	12.97	8.98	6.31	6.40	5.70	5.50	28.8%
Off-highway	0.78	1.21	1.22	1.71	2.14	2.50	2.62	2.43	2.43	12.7%
Transportation total	5.60	8.46	11.73	14.69	11.12	8.82	9.02	8.13	7.93	41.5%
Stationary fuel combustion total	1.98	1.44	0.88	0.72	1.05	1.01	0.99	1.07	1.08	5.6%
Industrial processes total	4.52	7.40	8.73	12.33	12.10	9.01	9.69	9.71	9.05	47.4%
Waste disposal and recycling total	0.99	1.10	1.55	1.98	0.76	0.99	1.05	1.07	0.43	2.3%
Miscellaneous total	4.08	2.53	1.57	1.10	1.13	1.16	0.80	0.60	0.60	3.1%
Total of all sources	17.16	20.94	24.46	30.82	26.17	20.98	21.55	20.59	19.08	100.0%

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996, 1997*, pp. A-12-A-18, 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.

^aThe 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 3.13
Total National Emissions of Particulate Matter (PM-10), 1940-96^a
 (million short tons)

Source category	1940	1950	1960	1970	1980	1990	1994	1995	1996	Percent of total, 1996
Highway vehicles	0.21	0.31	0.55	0.44	0.40	0.34	0.32	0.29	0.27	0.9%
Off-highway	2.48	1.79	0.20	0.37	0.57	0.60	0.65	0.59	0.59	1.9%
Transportation total	2.69	2.10	0.76	0.81	0.96	0.93	0.97	0.88	0.87	2.8%
Stationary fuel combustion total	4.01	3.75	3.56	2.87	2.45	1.20	1.11	1.18	1.19	3.8%
Industrial processes total	5.90	8.85	9.24	7.67	2.75	1.04	0.91	0.95	0.94	3.0%
Waste disposal and recycling total	0.39	0.51	0.76	1.00	0.27	0.27	0.31	0.29	0.29	0.9%
Miscellaneous total	2.97	1.93	1.24	0.84	0.85	26.51	27.62	23.60	28.02	89.5%
Total of all sources	15.96	17.13	15.56	13.19	7.29	29.95	30.92	26.89	31.30	100.0%

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996, 1997*, pp. A-23-A-27, 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.

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

Table 3.14
Emissions of Particulate Matter (PM-10) from Highway Vehicles, 1970-96^a
(thousand short tons)

Source category	1970	1975	1980	1985	1990	1991	1992	1993	1994	1995	1996	Percent of total, 1996
Gasoline powered												
Light-duty vehicles & motorcycles	225	207	120	77	61	63	64	65	62	62	63	23.0%
Light-duty trucks ^b	70	72	55	43	30	32	31	31	35	32	31	11.3%
Heavy-duty vehicles	13	15	15	14	10	10	9	10	10	9	9	3.3%
Total	308	294	190	134	101	105	104	106	107	103	103	37.6%
Diesel powered												
Light-duty vehicles ^c		10	12	8	9	9	9	8	8	8	8	2.9%
Light-duty trucks ^b			2	1	1	2	2	2	2	2	2	0.7%
Heavy-duty vehicles	136	166	194	219	224	234	228	205	204	181	162	59.1%
Total	136	176	208	228	234	245	239	215	214	191	172	62.8%
Total												
Highway vehicle total	443	471	397	363	336	349	343	321	320	293	274	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%	

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996, 1997*, p. A-26 and annual.
 (Additional resources: <http://www.epa.gov/oar/oaqps>)

^aThe sums of subcategories may not equal total due to rounding.

^bLess than 8,500 pounds.

^cData are not available.



Table 3.15
Estimates of Particulate Matter, 1990
PM_{2.5} versus PM₁₀ (tons)

Source category	PM _{2.5}	PM ₁₀	PM _{2.5} / PM ₁₀ Ratio
Electric utility-coal	99,402	268,779	37%
Electric utility-oil & gas	6,539	11,413	57%
Fuel combustion-industrial	176,607	248,974	71%
Fuel combustion-commercial & institutional	14,763	35,079	42%
Residential wood combustion	477,431	477,431	100%
Chemical & allied product manufacturing	41,811	61,537	68%
Metals processing	96,429	138,096	70%
Petroleum & related industries	20,797	30,112	69%
Other industrial processes ^a	250,536	408,632	61%
Solvent use	1,807	2,134	85%
Storage & transport (oil/chemicals)	26,489	64,319	41%
Waste disposal & recycling ^b	197,251	226,085	87%
Highway vehicles-gasoline	66,467	106,720	62%
Highway vehicles-diesel	226,207	250,018	90%
Nonroad gas engines	35,034	42,141	83%
Nonroad diesel engines	170,787	185,638	92%
Boats, aircraft & railroads	86,303	108,564	79%
Agricultural & prescribed burning	464,836	541,570	86%
Other combustion ^c	563,643	624,825	90%
Wind erosion-agricultural lands	777,715	8,184,785	15%
Paved roads	1,497,964	8,991,858	25%
Unpaved roads	1,700,367	11,335,782	15%
Construction	1,662,280	8,311,402	20%
Agricultural tilling	1,382,009	6,910,045	20%
Agricultural feedlots	60,257	401,715	15%
Miscellaneous fugitive dust	667	3,571	19%
Biogenic	0	0	0%
Total	10,122,486	41,991,504	24%

Source:

E. H. Pechan & Associates, *National PM Study: OPPE Particulate Programs Implementation Evaluation System*, Final Report to EPA, September 1994; and E.H. Pechan & Associates, *Updates to Fugitive Emission Components of the National Particulate Inventory*, January 1996.
 (Additional resources: <http://www.pechan.com>)

Note: Selected source categories appear in this table, therefore, total is not the sum of the column.

^aOther Industrial Processes includes the wood, pulp and paper industry, and mineral products industries, and other categories.

^bWaste Disposal and Recycling includes incineration and open burning.

^cOther Combustion includes wildfires and prescribed burning.



Table 3.16
National Lead Emission Estimates, 1970-96^a
(thousand short tons per year)

Source category	1970	1975	1980	1985	1990	1994	1995	1996	Percent of total, 1996
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	0.53	0.55	0.55	14.1%
Transportation total	181.70	136.34	64.71	18.97	1.20	0.54	0.56	0.56	14.6%
Stationary source fuel combustion	10.62	10.35	4.30	0.52	0.50	0.49	0.49	0.49	12.7%
Industrial processes	26.36	11.38	3.94	2.53	2.47	2.18	2.27	2.17	56.2%
Waste disposal and recycling total	2.20	1.60	1.21	0.87	0.80	0.83	0.62	0.64	16.5%
Total of all sources	220.87	159.66	74.15	22.89	4.98	4.04	3.94	3.87	100.0%

Source:

U. S. Environmental Protection Agency, *National Air Pollutant Emission Trends, 1900-1996*, 1997, pp. A-28-A-29, and annual.
 (Additional resources: <http://www.epa.gov/oar/oaqps>)

^aThe sums of subcategories may not equal due to rounding.



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

The results 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-duty 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). 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 3.17 and 3.18

Emissions acronyms (both tables)

VOC - volatile organic compounds
 CO - carbon monoxide
 NO_x - nitrogen oxides
 PM₁₀ - particulate matter measuring 10 microns or less
 SO_x - sulfur oxides
 GHGs - greenhouse gases
 CH₄ - methane
 N₂O - nitrous oxide
 CO₂ - carbon dioxide

Near-term technology acronyms (Table 3.17)

FRFG2	Federal Phase 2 reformulated gasoline
CARFG2	California Phase 2 reformulated gasoline
Conv. CI: CD	Conventional compression ignition engines fueled with conventional diesel
CIDI: CD	Compression ignition, direct injection engines fueled with conventional diesel
CNG: bi-fuel	Bi-fuel CNG vehicles
CNG: dedicated	Dedicated CNG vehicles
MeOH FFV: M85	Methanol flexible-fuel vehicles fueled with M85
LPG: converted, NG	Aftermarket converted LPG vehicles fueled with LPG produced from natural gas
LPG: converted, crude	Aftermarket converted LPG vehicles fueled with LPG produced from crude
EtOH FFV, E85, corn	Ethanol flexible-fueled vehicles fueled with E85, ethanol produced from corn
E10, corn	Gasoline vehicles fueled with E10, ethanol produced from corn
EV: U.S. mix	Electric vehicles with the U.S. electric generation mix
EV: CA mix	Electric vehicles with the California electric generation mix
EV: U.S. NE mix	Electric vehicles with the northeast U.S. electric generation mix
Grid C. HEV: FRFG2, US mix	Grid-connected hybrid electric vehicles with federal Phase 2 reformulated gasoline and the U.S. electric generation mix
Grid C. HEV: CARFG2, CA mix	Grid-connected hybrid electric vehicles with California Phase 2 reformulated gasoline and the California electric generation mix
Grid I. HEV, FRFG2	Grid-independent hybrid electric vehicles with federal Phase 2 reformulated gasoline
Grid I. HEV, CD	Grid-independent hybrid electric vehicles with conventional diesel



Long-term technology acronyms (Table 3.18)

SIDI: FRFG2	Spark ignition, direction injection engines fueled with federal Phase 2 reformulated gasoline
SIDI: CARFG2	Spark ignition, direction injection engines fueled with California Phase 2 reformulated gasoline
Conv. CI: RFD	Conventional compression ignition engines fueled with reformulated diesel
CIDI; RFD	Compression ignition, direct injection engines fueled with reformulated diesel
CIDI: FTD50	Compression ignition, direct injection engines fueled with the blend of 50% Fischer-Tropsch diesel and 50% conventional diesel
CIDI: BD20	Compression ignition, direct injection engines fueled with blend of 20% biodiesel and 80% of conventional diesel
CIDI: DME	Compression ignition, direct injection engines fueled with dimethyl ether
CNG: dedicated	Dedicated CNG vehicles
LNG	Liquefied natural gas vehicles
MeOH dedicated: M95	Methanol dedicated vehicles fueled with M95
LPG: OEM, NG	OEM-produced LPG vehicles fueled with LPG produced from natural gas
LPG: OEM, crude	OEM-produced LPG vehicles fueled with LPG produced from crude
Dedi. E95, corn	Ethanol dedicated vehicles fueled with E95, ethanol produced from corn
Dedi. E95, W. biomass	Ethanol dedicated vehicles fueled with E95, ethanol produced from woody biomass
Dedi. E95, H. biomass	Ethanol dedicated vehicles fueled with E95, ethanol produced from herbaceous biomass
EV: U.S. mix	Electric vehicles with the U.S. electric generation mix
EV: CA mix	Electric vehicles with the California electric generation mix
EV: U.S. NE mix	Electric vehicles with the northeast U.S. electric generation mix
Grid C. HEV: FRFG2, US mix	Grid-connected hybrid electric vehicles with federal Phase 2 reformulated gasoline and the U.S. electric generation mix
Grid C. HEV: CARFG2, CA mix	Grid-connected hybrid electric vehicles with California Phase 2 reformulated gasoline and the California electric generation mix
Grid C. HEV: NG, US mix	Grid-connected hybrid electric vehicles with natural gas and the U.S. electric generation mix
Grid C. HEV: NG, CA mix	Grid-connected hybrid electric vehicles with natural gas and the California electric generation mix
Grid I. HEV, FRFG2	Grid-independent hybrid electric vehicles with federal Phase 2 reformulated gasoline
Grid I. HEV, NG	Grid-independent hybrid electric vehicles with natural gas
Grid I. HEV, FRFG2	Grid-independent hybrid electric vehicles with reformulated diesel
H2 FCV, NG	Hydrogen fuel-cell vehicles, hydrogen from natural gas
H2 FCV, solar	Hydrogen fuel-cell vehicles, hydrogen from solar energy
MeOH FCV	Methanol fuel-cell vehicles
FRFG2 FCV	Fuel-cell vehicles fueled with federal Phase 2 reformulated gasoline
EtOH FCV, corn	Ethanol fuel-cell vehicles, ethanol produced from corn
EtOH FCV, W. biomass	Ethanol fuel-cell vehicles, ethanol produced from woody biomass
EtOH FCV, H. biomass	Ethanol fuel-cell vehicles, ethanol produced from herbaceous biomass
NG FCV	Natural gas fuel-cell vehicles



Table 3.17
Changes in Per-Mile, Fuel-Cycle Energy Use and Emissions for Passenger Cars using Near-Term Technologies
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	FRFG2	CARFG2	Conv. CI: CD	CIDI: CD	CNG: bi-fuel	CNG: dedicated	MeOH FFV: M85	LPG: converted, NG	LPG: converted, crude
Total energy	2.6%	2.6%	-13.6%	-30.9%	3.3%	1.1%	18.5%	-9.6%	-8.6%
Fossil fuels	2.5%	2.5%	-13.5%	-30.8%	2.0%	-0.1%	19.2%	-9.2%	-8.6%
Petroleum	1.4%	1.4%	-11.5%	-29.2%	-99.3%	-99.4%	-72.6%	-98.2%	-5.0%
VOC: Total	-23.3%	-24.2%	-25.2%	-26.1%	-56.6%	-86.7%	-20.7%	-53.7%	-52.1%
VOC: Urban	-25.2%	-26.2%	-23.6%	-23.8%	-56.7%	-89.2%	-19.8%	-52.1%	-52.8%
CO: Total	-19.7%	-27.6%	-81.5%	-81.7%	-51.0%	-58.9%	-43.2%	-20.0%	-19.9%
CO: Urban	-20.0%	-28.0%	-82.2%	-82.2%	-51.7%	-59.7%	-44.0%	-20.0%	-20.0%
NOx: Total	-1.9%	-9.7%	82.7%	79.6%	-12.9%	-29.5%	2.9%	-8.4%	-6.0%
NOx: Urban	-4.9%	-14.7%	110.3%	110.0%	-28.5%	-48.4%	-0.4%	0.1%	0.2%
PM10: Total	2.4%	2.4%	172.1%	167.7%	-34.7%	-35.1%	-27.4%	-44.0%	-34.1%
PM10: Urban	-1.7%	-1.7%	261.3%	261.0%	-32.8%	-32.9%	-21.4%	-31.7%	-31.6%
SOx: Total	-8.4%	-15.6%	-23.4%	-38.7%	-38.2%	-39.5%	-55.9%	-77.1%	-56.3%
SOx: Urban	-58.4%	-83.0%	-5.4%	-24.4%	-95.8%	-95.9%	-70.0%	-97.9%	-97.8%
GHGs	0.7%	0.7%	-8.9%	-26.3%	-10.7%	-12.2%	-3.0%	-12.3%	-11.9%
CH4	1.4%	1.4%	-29.1%	-42.8%	307.8%	303.2%	2.1%	27.3%	-3.4%
N2O	1.5%	1.5%	-3.7%	-5.4%	-46.6%	-42.5%	-6.5%	-8.1%	-4.1%
CO2	0.6%	0.6%	-8.7%	-27.0%	-16.3%	-18.0%	-3.0%	-13.5%	-12.5%

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



Table 3.17 (continued)
Changes in Per-Mile, Fuel-Cycle Energy Use and Emissions for Passenger Cars using Near-Term Technologies
 (Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	EtOH FFV,		EV: U.S.	EV: CA	EV: U.S.	Grid C.	Grid C.	Grid I.	Grid I.
	E85, corn	E10, corn	mix	mix	NE mix	HEV: FRFG2, US mix	HEV: CARFG2, CA mix	HEV: FRFG2	HEV: CD
Total energy	19.9%	2.2%	-26.6%	-28.1%	-26.1%	-30.1%	-30.6%	-31.6%	-42.4%
Fossil fuels	-40.2%	-3.2%	-48.5%	-72.7%	-53.7%	-36.7%	-44.0%	-31.6%	-42.3%
Petroleum	-73.6%	-6.2%	-98.5%	-99.6%	-97.3%	-52.2%	-52.6%	-32.4%	-41.0%
VOC: Total	11.1%	6.9%	-98.1%	-98.8%	-98.0%	-44.3%	-44.5%	-21.2%	-40.8%
VOC: Urban	-14.5%	5.1%	-99.9%	-99.8%	-99.7%	-44.2%	-44.2%	-20.4%	-39.0%
CO: Total	-24.0%	-31.3%	-99.2%	-99.4%	-99.1%	-54.9%	-55.0%	-35.9%	-85.3%
CO: Urban	-27.9%	-32.0%	-99.9%	-99.8%	-99.8%	-55.2%	-55.1%	-36.0%	-85.8%
NOx: Total	36.0%	5.5%	-14.8%	-80.2%	-46.4%	-19.5%	-39.0%	-21.5%	44.1%
NOx: Urban	-26.2%	0.3%	-97.8%	-96.1%	-95.3%	-43.5%	-43.0%	-20.2%	68.0%
PM10: Total	49.3%	6.0%	68.7%	-32.2%	18.2%	11.4%	-18.3%	-13.1%	123.4%
PM10: Urban	-18.0%	0.3%	-34.8%	-33.0%	-31.5%	-15.8%	-15.3%	-7.7%	201.4%
SOx: Total	162.7%	15.2%	395.3%	-17.3%	201.0%	88.0%	-38.7%	-38.9%	-49.0%
SOx: Urban	-78.4%	-6.7%	-93.4%	-98.1%	-83.6%	-90.1%	-91.6%	-72.3%	-37.0%
GHGs	-22.2%	-1.6%	-35.5%	-74.5%	-49.7%	-33.2%	-45.0%	-32.2%	-38.7%
CH4	31.8%	2.4%	20.0%	-39.6%	2.5%	-14.2%	-32.1%	-28.8%	-52.4%
N2O	167.8%	15.3%	21.0%	-82.0%	-32.8%	-8.1%	-38.8%	-20.6%	-24.1%
CO2	-33.8%	-2.6%	-39.9%	-74.9%	-51.8%	-35.0%	-45.6%	-33.0%	-39.2%

Source:

Wang, Michael Q., GREET Model Results, Argonne National Laboratory, Argonne, IL, September 1998.

Note:

See previous pages for acronym definitions.

Table 3.18
Changes in Per-Mile, Fuel-Cycle Energy Use and Emissions for Passenger Cars using Long-Term Technologies
(Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	FRFG2	CARFG2	Conv. CI: CD	CIDI: CD	CNG: bi- fuel	CNG: dedicated	MeOH FFV: M85	LPG: converted, NG	LPG: converted, crude
Total energy	2.6%	2.6%	-13.6%	-30.9%	3.3%	1.1%	18.5%	-9.6%	-8.6%
Fossil fuels	2.5%	2.5%	-13.5%	-30.8%	2.0%	-0.1%	19.2%	-9.2%	-8.6%
Petroleum	1.4%	1.4%	-11.5%	-29.2%	-99.3%	-99.4%	-72.6%	-98.2%	-5.0%
VOC: Total	-23.3%	-24.2%	-25.2%	-26.1%	-56.6%	-86.7%	-20.7%	-53.7%	-52.1%
VOC: Urban	-25.2%	-26.2%	-23.6%	-23.8%	-56.7%	-89.2%	-19.8%	-52.1%	-52.8%
CO: Total	-19.7%	-27.6%	-81.5%	-81.7%	-51.0%	-58.9%	-43.2%	-20.0%	-19.9%
CO: Urban	-20.0%	-28.0%	-82.2%	-82.2%	-51.7%	-59.7%	-44.0%	-20.0%	-20.0%
NOx: Total	-1.9%	-9.7%	82.7%	79.6%	-12.9%	-29.5%	2.9%	-8.4%	-6.0%
NOx: Urban	-4.9%	-14.7%	110.3%	110.0%	-28.5%	-48.4%	-0.4%	0.1%	0.2%
PM10: Total	2.4%	2.4%	172.1%	167.7%	-34.7%	-35.1%	-27.4%	-44.0%	-34.1%
PM10: Urban	-1.7%	-1.7%	261.3%	261.0%	-32.8%	-32.9%	-21.4%	-31.7%	-31.6%
SOx: Total	-8.4%	-15.6%	-23.4%	-38.7%	-38.2%	-39.5%	-55.9%	-77.1%	-56.3%
SOx: Urban	-58.4%	-83.0%	-5.4%	-24.4%	-95.8%	-95.9%	-70.0%	-97.9%	-97.8%
GHGs	0.7%	0.7%	-8.9%	-26.3%	-10.7%	-12.2%	-3.0%	-12.3%	-11.9%
CH4	1.4%	1.4%	-29.1%	-42.8%	307.8%	303.2%	2.1%	27.3%	-3.4%
N2O	1.5%	1.5%	-3.7%	-5.4%	-46.6%	-42.5%	-6.5%	-8.1%	-4.1%
CO2	0.6%	0.6%	-8.7%	-27.0%	-16.3%	-18.0%	-3.0%	-13.5%	-12.5%

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



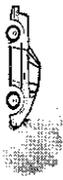


Table 3.18 (continued)
Changes in Per-Mile, Fuel-Cycle Energy Use and Emissions for Passenger Cars using Long-Term Technologies
 (Percentage relative to conventional gasoline vehicles fueled with conventional gasoline)

	EtOH FFV, E85, corn	E10, corn	EV: U.S. mix	EV: CA mix	EV: U.S. NE mix	Grid C. HEV: FRFG2, US mix	Grid C. HEV: CARFG2, CA mix	Grid I. HEV: FRFG2	Grid I. HEV: CD
Total energy	19.9%	2.2%	-26.6%	-28.1%	-26.1%	-30.1%	-30.6%	-31.6%	-42.4%
Fossil fuels	-40.2%	-3.2%	-48.5%	-72.7%	-53.7%	-36.7%	-44.0%	-31.6%	-42.3%
Petroleum	-73.6%	-6.2%	-98.5%	-99.6%	-97.3%	-52.2%	-52.6%	-32.4%	-41.0%
VOC: Total	11.1%	6.9%	-98.1%	-98.8%	-98.0%	-44.3%	-44.5%	-21.2%	-40.8%
VOC: Urban	-14.5%	5.1%	-99.9%	-99.8%	-99.7%	-44.2%	-44.2%	-20.4%	-39.0%
CO: Total	-24.0%	-31.3%	-99.2%	-99.4%	-99.1%	-54.9%	-55.0%	-35.9%	-85.3%
CO: Urban	-27.9%	-32.0%	-99.9%	-99.8%	-99.8%	-55.2%	-55.1%	-36.0%	-85.8%
NOx: Total	36.0%	5.5%	-14.8%	-80.2%	-46.4%	-19.5%	-39.0%	-21.5%	44.1%
NOx: Urban	-26.2%	0.3%	-97.8%	-96.1%	-95.3%	-43.5%	-43.0%	-20.2%	68.0%
PM10: Total	49.3%	6.0%	68.7%	-32.2%	18.2%	11.4%	-18.3%	-13.1%	123.4%
PM10: Urban	-18.0%	0.3%	-34.8%	-33.0%	-31.5%	-15.8%	-15.3%	-7.7%	201.4%
SOx: Total	162.7%	15.2%	395.3%	-17.3%	201.0%	88.0%	-38.7%	-38.9%	-49.0%
SOx: Urban	-78.4%	-6.7%	-93.4%	-98.1%	-83.6%	-90.1%	-91.6%	-72.3%	-37.0%
GHGs	-22.2%	-1.6%	-35.5%	-74.5%	-49.7%	-33.2%	-45.0%	-32.2%	-38.7%
CH4	31.8%	2.4%	20.0%	-39.6%	2.5%	-14.2%	-32.1%	-28.8%	-52.4%
N2O	167.8%	15.3%	21.0%	-82.0%	-32.8%	-8.1%	-38.8%	-20.6%	-24.1%
CO2	-33.8%	-2.6%	-39.9%	-74.9%	-51.8%	-35.0%	-45.6%	-33.0%	-39.2%

Source:

Wang, Michael Q., GREET Model Results, Argonne National Laboratory, Argonne, IL, September 1998.

Note:

See previous pages for acronym definitions.

The Clean Air Act of 1963 and its subsequent amendments set national air quality standards for all new cars and light trucks sold. The most recent amendments in 1990 established more restrictive emission control standards which became effective in 1994.

Table 3.19
Federal Emission Control Requirements for
Automobiles and Light Trucks, 1968-98^a
(grams per mile)

Model Year	Automobiles				Light trucks ^b			
	Hydrocarbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO _x)	Particulates ^c	Hydrocarbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO _x)	Particulates ^c
1968-71	4.10	34.0	d	d	8.0	102.0	3.6	d
1972-74	3.00	28.0	3.1	d	8.0	102.0	3.6	d
1975-76	1.50	15.0	3.1	d	2.0	20.0	3.1	d
1977-78	1.50	15.0	2.0	d	2.0	20.0	3.1	d
1979	1.50	15.0	2.0	d	1.7	18.0	2.3	d
1980	0.41	7.0	2.0	d	1.7	18.0	2.3	d
1981	0.41	3.4	1.0	d	1.7	18.0	2.3	d
1982-83	0.41	3.4	1.0	0.60	1.7	18.0	2.3	0.60
1984-86	0.41	3.4	1.0	0.60	0.8	10.0	2.3	0.60
1987	0.41	3.4	1.0	0.20	0.8	10.0	2.3	0.26
1988-93	0.41	3.4	1.0	0.20	0.8	10.0	1.2 ^e	0.26
1994	0.25	3.4	0.4	0.08	0.25	3.4 ^e	1.2 ^e	0.26
1995-on	0.25	3.4	0.4	0.08	0.25	3.4 ^e	0.4 ^f	0.08

Source:

1968-75: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '85*, 1985, p. 88.

1976-93: *Code of Federal Regulations 40CFR86*, "Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Certification and Testing Procedures," July 1, 1987 edition, p. 264.

1994-on: Clean Air Act Amendments of 1990.

^a California standards not included.

^b Applies to trucks under 6,000 pounds gross vehicle weight rating (GVWR) until model year 1978 and under 8,500 pounds GVWR beginning in model year 1979.

^c Applies to diesel engines only.

^d No standard was set for this year.

^e Applies to light trucks up to and including 3,750 pounds loaded vehicle weight (LVW).

^f Applies to light trucks up to and including 3,750 pounds LVW. Does not apply to diesel-fueled light trucks.



Table 3.20
Federal Emission Control Requirements for
Heavy-Duty Gasoline Trucks, 1974-98^a
(grams per brake horsepower hour)

Model Year	Hydrocarbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO _x)	Hydrocarbons + nitrogen oxides (HC + NO _x)
1974-78	b	40.0	b	16.0
1979-83	1.5	25.0	b	10.0
1984	1.3	15.5	10.7	b
1985-86	2.5	40.0	10.7	b
1987-89	1.9	37.1	10.6	b
1990	1.9	37.1	6.0	b
1991-93	1.9	37.1	5.0	b
1994	1.9 ^c	37.1	5.0 ^c	b
1995-97	1.9 ^c	37.1 ^c	5.0 ^c	b
1998-on	1.9 ^c	37.1 ^c	4.0 ^c	b

Source:1974-75: MVMA, *Motor Vehicle Facts & Figures '85*, 1985, p. 88.1976-93: *Code of Federal Regulations*, 40CFR86, "Control of Air Pollution from New Motor Vehicles and New Motor Vehicles Engines: Certification and Testing Procedures," July 1, 1987, p. 264.

1994-on: Clean Air Act Amendments of 1990.

Table 3.21
Federal Emission Control Requirements for
Heavy-Duty Diesel Trucks, 1976-98^d
(grams per brake horsepower hour)

Model Year	Hydrocarbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO _x)	Hydrocarbons + nitrogen oxides (HC + NO _x)	Particulates
1976-78	b	40.0	b	16.0	b
1979-83	1.5	25.0	b	10.0	b
1984	1.3	15.5	10.7	5.0	b
1985-87	1.3	15.5	10.7	b	b
1988-89	1.3	15.5	10.7	b	0.60
1990	1.3	15.5	6.0	b	0.60
1991-93	1.3	15.5	5.0	b	0.25
1994-97	1.3 ^c	15.5	5.0	b	0.10
1998-on	1.3 ^c	15.5 ^c	4.0 ^c	b	0.10 ^c

Source:1976-93: *Code of Federal Regulations*, 40CFR86, "Control of Air Pollution from New Motor Vehicles and New Motor Vehicle Engines: Certification and Testing Procedures," July 1, 1987, p. 264.

1994-on: Clean Air Act Amendments of 1990.

^aApplies to trucks greater than 6,000 pounds gross vehicle weight until model year 1978, greater than 8,500 pounds gross vehicle weight for model years 1979-1986, and greater than 14,000 pounds gross vehicle weight starting in 1987.

^bNo standard was set for this year.

^cHeavy-duty trucks must meet these standards or standards which reflect the greatest degree of emission reduction achievable through the application of the technology available.

^dApplies to trucks greater than 6,000 pounds gross vehicle weight through model year 1978 and to trucks greater than 8,500 pounds gross vehicle weight beginning in model year 1979.



Table 3.22
Light-Duty Vehicles and Trucks Federal Emission Certification Standards
(grams/mile)

Vehicle Type	Emission Category	Vehicle Useful Life											
		5 Years / 50,000 Miles						10 Years / 100,000 Miles					
		THC ^a	NMHC ^b	NMOG ^c	CO	NO _x	PM	THC ^a	NMHC ^b	NMOG ^c	CO	NO _x	PM
LDV	Tier 0	0.41	0.34 ^d	—	3.4	1.0	0.20 ^e	—	0.31	—	4.2	0.6 ^g	0.10
	Tier 1	0.41	0.25	—	3.4	0.4 ^f	0.08	—	0.31	—	4.2	0.6 ^g	0.10
LDT1	Tier 0	—	—	—	—	—	—	0.80	0.67 ^d	—	10	1.2	0.26 ^e
	Tier 1	—	0.25	—	3.4	0.4 ^f	0.08	0.80 ^h	0.31	—	4.2	0.6 ^g	0.10
LDT2	Tier 0	—	—	—	—	—	—	0.80	0.67 ^d	—	10	1.7	0.13 ^e
	Tier 1	—	0.32	—	4.4	0.7 ⁱ	0.08	0.80 ^h	0.40	—	5.5	0.97	0.10
LDT3	Tier 0	—	—	—	—	—	—	0.80	0.67 ^d	—	10	1.7	0.26 ^e
	Tier 1	—	0.32	—	4.4	0.7 ⁱ	—	0.80	0.46	—	6.4	0.98	0.10
LDT4	Tier 0	—	—	—	—	—	—	0.80	0.67 ^d	—	10	1.7	0.13 ^e
	Tier 1	—	0.39	—	5.0	1.1 ⁱ	—	0.80	0.56	—	7.3	1.53	0.12

Source:

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

Note:

California standards, supplemental Federal Test Procedure standards, and Implementation schedules can be found on the Internet: <http://www.epa.gov/OMSWWW/stds-ld.htm>;
 LDV = passenger car or passenger car derivative; LDT1 = light-duty truck up through 3,750 lbs. loaded vehicle weight; LDT2 = light-duty truck greater than 3,750 lbs. loaded vehicle weight; LDT3 = light-duty truck with GVWR ≥ 6,000 lbs. and adjusted loaded vehicle weight ≤ 5,750 lbs.; LDT4 = light-duty truck with GVWR ≥ 6,000 lbs. and adjusted loaded vehicle weight ≥ 5,750 lbs.

^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 CNG vehicles only.

^e Applies to diesel-fueled vehicles only.

^f 1.0 for diesel-fueled vehicles through 2003 model year.

^g 1.25 for diesel-fueled vehicles through 2003 model year.

^h Standards apply at a useful life of 11 years / 120,000 miles.

ⁱ Does not apply to diesel-fueled vehicles.



California's Low-Emission Vehicle regulations provide for 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 3.23
California Vehicle Emission Reduction for
Passenger Cars and Light-Duty Trucks

	Emission reduction from the basic California standards ^a		
	HC	CO	NO _x
Transitional Low-Emission Vehicle (TLEV)	50%	=	=
Low-Emission Vehicle (LEV)	70%	=	50%
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.

^aCalifornia standards can be found on the Internet: <http://www.epa.gov/OMSWWW/stds-ld.htm>



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 3.24
California Air Resources Board Requirements for Meeting Emission Standards

Year	Percent of manufacturers' fleet	Vehicle type ^a
1989	100	CV
1993	100	CV
1994	90	CV
	10	TLEV
1995	85	CV
	15	TLEV
1996	80	CV
	20	TLEV
1997	73	CV
	25	LEV
	2	ULEV
1998-2000	48	CV
	48	LEV
	2	ULEV
	^b	ZEV
2001-2002	90	LEV
	5	ULEV
	^b	ZEV
2003 ^c	75	LEV
	15	ULEV
	10	ZEV

Source:

California Air Resources Board, Mobile Sources Division, El Monte, CA, 1996.

(Additional resources: <http://www.arb.ca.gov>)

- ^aCV = Conventional vehicles
TLEV = Transitional low-emission vehicles
LEV = Low-emission vehicles
ULEV = Ultra-low-emission vehicles
ZEV = Zero emission vehicles

^bAccording to revised regulations, the marketplace is to determine the amount of ZEVs that are offered for sale.

^cFleet average of non-methane organic gases = 0.062 in 2003.



Clean Cities is a locally-based government/industry partnership, coordinated by the U.S. Department of Energy to expand the use of alternatives to gasoline and diesel fuel. By combining the decision-making with voluntary action by partners, the "grass-roots" approach of Clean Cities departs from traditional "top-down" Federal programs. It establishes a plan, carried out at the local level, for creating a sustainable, nationwide alternative fuels market.

Table 3.25
List of Clean Cities as of 4/24/98

1.	Atlanta, GA - 9/8/93	33.	New London, CT - 11/22/94
2.	Denver, CO - 9/13/93	34.	Peoria, IL - 11/22/94
3.	Philadelphia, PA - 9/22/93	35.	Kansas - SW Area - 3/30/95
4.	Wilmington, DE - 10/12/93	36.	Central New York - 6/15/95
5.	Las Vegas, NV - 10/18/93	37.	Dallas/Ft. Worth, TX - 7/25/95
6.	Washington, DC - 10/21/93	38.	Honolulu, HI - 8/29/95
7.	Boston, MA - 3/18/94	39.	Missoula, MT - 9/21/95
8.	Austin, TX - 4/18/94	40.	New Haven, CT - 10/5/95
9.	Florida Gold Coast - 5/3/94	41.	Central Arkansas - 10/25/95
10.	Chicago, IL - 5/13/94	42.	Paso Del Norte - 11/17/95
11.	Albuquerque, NM - 6/1/94	43.	Pittsburgh, PA - 12/5/95
12.	Wisconsin - SE Area - 6/30/94	44.	S. California Assn. Gov. - 3/1/96
13.	Colorado Springs, CO - 7/13/94	45.	Los Angeles, CA - 3/22/96
14.	Long Beach, CA - 8/31/94	46.	Coachella Valley, CA - 4/22/96
15.	Lancaster, CA - 9/22/94	47.	Weld/Larimer/Rocky Mountain National Park - 5/21/96
16.	Salt Lake City, UT - 10/3/94	48.	Central Oklahoma - 5/29/96
17.	White Plains, NY - 10/4/94	49.	Hampton Roads, VA - 10/4/96
18.	Baltimore, MD - 10/7/94	50.	Long Island, NY - 10/18/96
19.	Louisville, KY - 10/18/94	51.	San Diego, CA 12/12/96
20.	State of WV - 10/18/94	52.	Detroit, MI/Toronto, ON - 12/18/96
21.	Sacramento, CA - 10/21/94	53.	Cincinnati, OH - 1/29/97
22.	Oakland, CA - 10/21/94	54.	Evansville, IL - 1/30/97
23.	San Joaquin Valley, CA - 10/21/94	55.	Red River Valley/Grand Forks, ND [postponed]
24.	San Francisco, CA - 10/21/94	56.	Houston, TX - 9/4/97
25.	South Bay (San Jose), CA - 10/21/94	57.	Portland, ME - 9/4/97
26.	Western New York - 11/4/94	58.	Tulsa, OK - 9/22/97
27.	Rogue Valley, OR - 11/10/94	59.	Maricopa Assn. of Govts. - 10/8/97
28.	Portland, OR - 11/10/94	60.	Riverside, CA - 10/24/97
29.	St. Louis, MO - 11/18/94	61.	North Jersey, NJ - 10/31/97
30.	Norwalk, CT - 11/21/94	62.	Corpus Christi, TX - 3/30/98
31.	Waterbury, CT - 11/21/94		
32.	Norwich, CT - 11/22/94		

For more information, contact the Clean Cities Hotline at (800) CCITIES, or write to: U.S. Department of Energy, EE-33, Clean Cities Program, 1000 Independence Avenue SW, Washington, DC 20585.

Source:

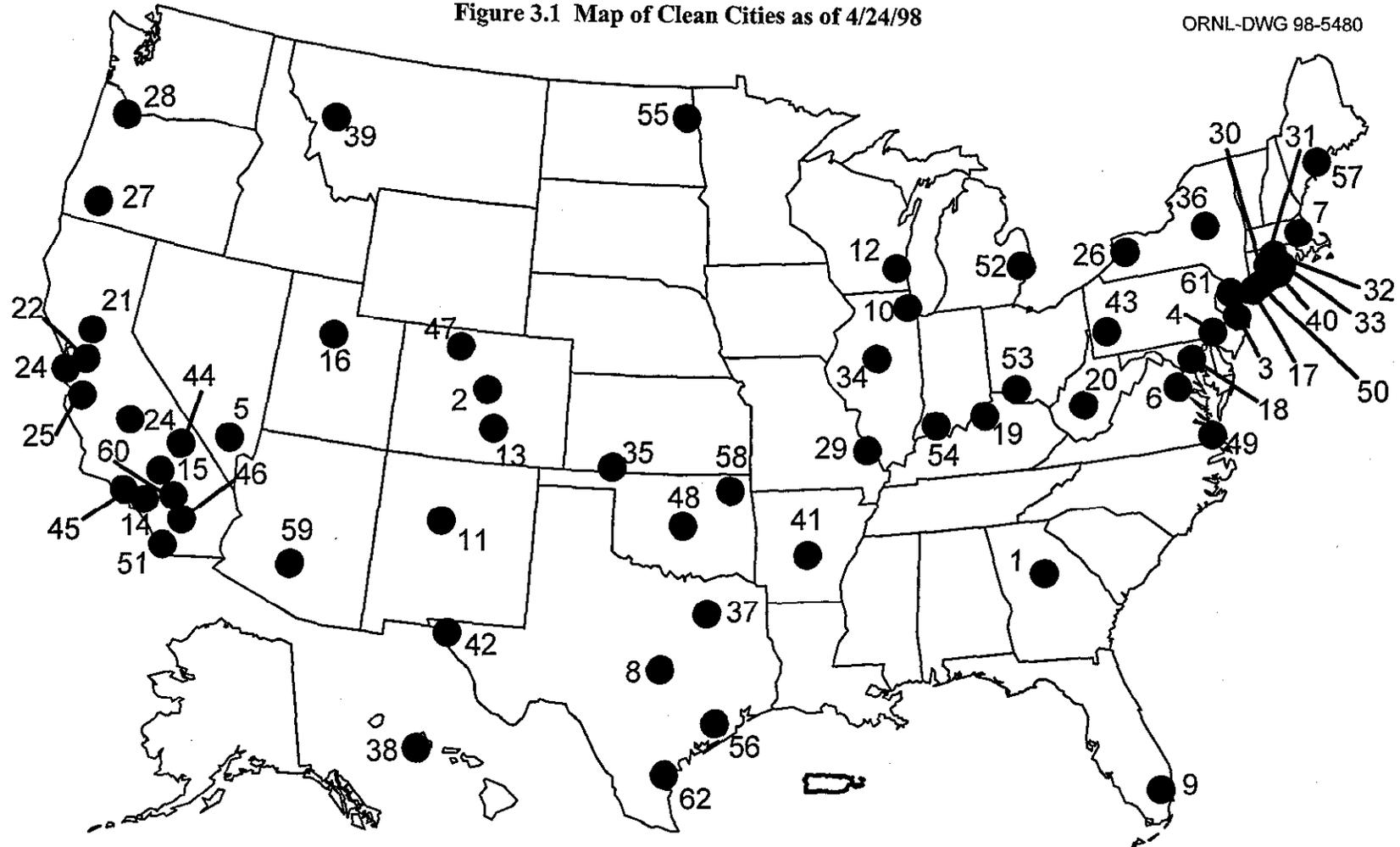
U.S. Department of Energy, Alternative Fuel Information, *Clean Cities: Guide to Alternative Fuel Vehicle Incentives & Laws*, Washington, DC, November 1996, and updates from web site, April 1998.

(Additional resources: <http://www.cities.doe.gov>)



Figure 3.1 Map of Clean Cities as of 4/24/98

ORNL-DWG 98-5480



Source:

U.S. Department of Energy, Alternative Fuel Information, *Clean Cities: Guide to Alternative Fuel Vehicle Incentives & Laws*, Washington, DC, November 1996, and updates from the web site, April 1998.
(Additional resources: <http://www.cities.doe.gov>)



