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EDITION 15

Stacy C. Davis

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Stacy C. Davis
Oak Ridge National Laboratory
P. O. Box 2008
Bldg. 5500A, MS 6366
Oak Ridge, Tennessee 37831-6366
Telephone: (615) 574-5957
FAX: (615) 574-3851
Email: DAVISSC@ornl.gov

Philip D. Patterson
Office of Transportation Technologies
Department of Energy, EE-30
Forrestal Building, Room 6B-094
1000 Independence Avenue, S.W.
Washington, D.C. 20585
Telephone: (202) 586-9121
FAX (202) 586-1637
Email: PHILIP.PATTERSON@hq.doe.gov

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ABSTRACT

The Transportation Energy Data Book: Edition 15 is a statistical compendium prepared and published by Oak Ridge National Laboratory (ORNL) under contract with the Office of Transportation Technologies in the Department of Energy (DOE). Designed for use as a desk-top reference, the data book represents an assembly and display of statistics and information that characterize transportation activity, and presents data on other factors that influence transportation energy use. The purpose of this document is to present relevant statistical data in the form of tables and graphs. Each of the major transportation modes is treated in separate chapters or sections. Chapter 1 compares U.S. transportation data with data from other countries. Aggregate energy use and energy supply data for all modes are presented in Chapter 2. The highway mode, which accounts for over three-fourths of total transportation energy consumption, is dealt with in Chapter 3. Topics in this chapter include automobiles, trucks, buses, fleet vehicles, federal standards, fuel economies, and high-occupancy vehicle lane data. Household travel behavior characteristics are displayed in Chapter 4. Chapter 5 contains information on alternative fuels and alternative fuel vehicles. Chapter 6 covers the major nonhighway modes: air, water, and rail. The last chapter, Chapter 7, presents data environmental issues relating to transportation.

INTRODUCTION

In January 1976, the Transportation Energy Conservation (TEC) Division of the Energy Research and Development Administration contracted with Oak Ridge National Laboratory (ORNL) to prepare a Transportation Energy Conservation Data Book to be used by TEC staff in their evaluation of current and proposed conservation strategies. The major purposes of the data book were to draw together, under one cover, transportation data from diverse sources, to resolve data conflicts and inconsistencies, and to produce a comprehensive document. The first edition of the TEC Data Book was published in October 1976. With the passage of the Department of Energy (DOE) Organization Act, the work being conducted by the former Transportation Energy Conservation Division fell under the purview of the DOE's Office of Transportation Programs (now the Office of Transportation Technologies). DOE, through the Office of Transportation Technologies, has supported the compilation of Editions 3 through 15.

Policymakers and analysts need to be well-informed about activity in the transportation sector. The organization and scope of the data book reflect the need for different kinds of information. For this reason, Edition 15 updates much of the same type of data that is found in previous editions.

Chapter 1 contains information which compares U.S. transportation data with data from selected countries in Asia, Europe, and North America. Chapter 2, Transportation Energy Characteristics, presents aggregate energy use data for each of the major transportation modes (i.e., highway, air, water, pipeline, and rail), as well as related statistics on the price and supply of transportation fuels. Chapter 3 covers detailed statistics on three major highway modes: automobiles, trucks, and buses. Also contained in this chapter is information on fleets, federal standards, fuel economies of highway vehicles, and high-occupancy vehicle lanes. Household travel behavior characteristics are displayed in Chapter 4. Chapter 5 presents data on alternative fuels and alternative fuel vehicles, and Chapter 6 consists of data for the major nonhighway modes: air, water, and rail. Chapter 7 contains information on environmental issues which are pertinent to the transportation industry. Sources used represent the latest available data.

In any attempt to compile a comprehensive set of statistics on transportation activity, numerous instances of inadequacies and inaccuracies in the basic data are encountered. Where such problems occur, estimates are developed by ORNL. To minimize the misuse of these statistics, an appendix (Appendix A) is included in this edition to document the estimation procedures. The attempt is to provide sufficient information for the conscientious user to evaluate the estimates and to form his or her own opinions as to their utility. Clearly, the accuracy of the estimates cannot exceed the accuracy of the primary data, an accuracy which in most instances is unknown. In cases where data accuracy is known or substantial errors are strongly suspected in the data, the reader is alerted. In all cases it should be recognized that the estimates are not precise.

The majority of the statistics contained in the data book are taken directly from published sources, although these data may be reformatted for presentation by ORNL. Consequently, neither ORNL nor DOE endorses the validity of these data.

CHAPTER 1

INTERNATIONAL TRANSPORTATION STATISTICS

This chapter includes statistics related to the transportation sector of selected countries. Countries were included based on data availability, geographical distribution, and transportation fuel use as a percentage of total refined petroleum consumption. The statistics presented for the United States in this chapter are from international sources and are only for use in international comparisons. The numbers may differ slightly from data presented in other chapters of the book.

In 1950, 76% of the world's automobiles were registered in the United States; by 1992, that percentage had dropped to 30.7% (Table 1.1). The U.S. had a lower annual growth rate in automobile registrations from 1950 to 1990 than any of the other listed countries except Sweden, for which data are not available for the years 1950 to 1970. The U.S. also accounts for 32.1% of the world's truck and bus registrations. Japan has experienced the largest growth in truck and bus registrations since 1950, 12.2% annually (Table 1.2).

The data on gasoline prices indicate that Italy has had the highest gasoline prices since 1978, while the U.S. has had the lowest of the listed countries (Table 1.3). Italy's high gasoline prices in 1993 were mainly due to the gasoline tax (Figure 1.2). In 1993 over 50% of the diesel price could be attributed to tax in four countries - Italy, France, the United Kingdom, and West Germany (Figure 1.3).

Data from the Lawrence Berkeley Laboratory (LBL) are contained in Tables 1.5 through 1.12. These data are generated by LBL using sources from various countries; a listing of these sources, along with a brief explanation, can be found in Appendix C. Often, additional data from the country will result in changes for the entire data series; such changes are noted in Appendix C. Details on the methodology for compiling these data can be found in "Energy Efficiency and Human Activity," by Lee Schipper, Steve Meyers, et. al., Cambridge University Press, Cambridge, MA, 1992, the "Proceedings of the ACEEE Conference on Automobiles and the Greenhouse Effect," and "New Car Test and Actual Fuel Economy: Yet Another Gap?" by Lee Schipper and Wienke Tax, 1993.

LBL has recently generated some vehicle-mile and passenger-mile data by trip purpose using national travel surveys performed by the United States, West Germany, Sweden, the United

Kingdom, Norway, Holland, and Denmark (Tables 1.11 and 1.12). As with most international data, caution should be used when comparing between countries because of differences in survey methodologies, definitions, etc.

Table 1.1
Automobile Registrations for Selected Countries, 1950-92
(thousands)

Year	Japan	France	Italy	Sweden	United Kingdom	West Germany	Canada	United States	U.S. percentage of world	All other countries[a]	World total
1950	43	[b]	342	[b]	2,307	[b]	1,913	40,339	76.0%	8,107	53,051
1955	153	[b]	861	[b]	3,609	1,821	2,961	52,145	71.4%	11,486	73,036
1960	457	4,950	1,976	[b]	5,650	4,559	4,104	61,671	62.7%	14,938	98,305
1965	2,181	8,320	5,473	[b]	9,131	9,043	5,279	75,258	53.8%	25,091	139,776
1970	8,779	11,860	10,181	[b]	11,802	13,299	6,602	89,244	46.1%	41,712	193,479
1975	17,236	15,180	15,060	2,760	14,061	16,764	8,870	106,706	41.0%	63,564	260,201
1980	23,660	18,440	17,686	2,883	15,438	21,455	10,256	121,601	38.0%	88,971	320,390
1981	24,612	19,130	18,603	2,893	15,633	21,812	10,199	123,098	37.2%	94,819	330,799
1982	25,539	19,750	19,616	2,936	17,644	22,086	10,530	123,702	36.4%	98,463	340,266
1983	26,385	20,300	20,389	3,007	18,108	22,624	10,732	126,444	35.9%	104,043	352,032
1984	27,114	20,600	20,888	3,081	18,532	23,193	10,781	128,158	35.1%	112,758	365,105
1985	27,845	20,800	22,495	3,151	18,953	23,777	11,118	131,864	35.2%	115,480	374,483
1986	28,654	21,090	23,495	3,253	19,415	24,700	11,586	135,431	35.1%	118,726	386,350
1987	29,478	21,500	24,320	3,367	20,108	25,558	11,686	137,324	34.9%	120,689	394,030
1988	30,776	21,970	25,290	3,483	20,977	26,228	12,086	141,252	34.2%	130,845	412,907
1989	32,621	22,520	26,267	3,578	21,919	26,914	12,380	143,081	33.7%	135,086	424,366
1990	34,924	23,010	27,300	3,601	22,528	27,218	12,622	143,550	32.3%	150,147	444,900
1991	37,076	23,550	28,200	3,619	22,744	27,484	13,061	142,956	31.3%	157,343	456,033
1992	38,963	24,020	29,497	3,587	23,008	28,092	13,322	144,213	30.7%	165,241	469,943
					Average annual percentage change						
1950-92	17.6%	5.1%[c]	11.2%	[b]	5.6%	7.7%[d]	4.7%	3.1%		7.4%	5.3%
1970-92	7.0%	3.3%	5.0%	1.6%[e]	3.1%	3.5%	3.2%	2.2%		6.5%	4.1%
1982-92	4.3%	2.0%	4.2%	2.0%	2.7%	2.4%	2.4%	1.5%		5.3%	3.3%

Source:
Motor Vehicle Manufacturers Association, World Motor Vehicle Data, 1994 Edition, Detroit, MI, 1994, pp. 26-28, 163, and annual.

[a]Automobile registrations for all other countries were calculated by subtracting listed countries' registrations from the world total.
[b]Data not available.
[c]Average annual percentage change is for 1960-92.
[d]Average annual percentage change is for 1955-92.
[e]Average annual percentage change is for 1975-92.

Table 1.2
Truck and Bus Registrations for Selected Countries, 1950-92
(thousands)

Year	Japan	France	Italy	Sweden	United Kingdom	West Germany	Canada	United States	U.S. percentage of world	All other countries[a]	World total
1950	170	[b]	235	[b]	1,060	[b]	643	8,823	50.9%	6,418	17,349
1955	285	[b]	335	[b]	1,244	760	952	10,544	46.1%	8,740	22,860
1960	832	1,540	455	[b]	1,534	1,079	1,056	12,186	42.6%	9,901	28,583
1965	3,968	1,770	664	[b]	1,748	1,690	1,232	15,100	39.6%	11,946	38,118
1970	8,470	1,850	929	[b]	1,769	2,298	1,481	19,175	36.2%	16,927	52,899
1975	10,270	2,210	1,193	171	1,934	2,725	2,158	26,243	38.8%	20,794	67,698
1980	13,407	2,550	1,429	194	1,920	3,385	2,955	34,195	37.7%	30,557	90,592
1981	14,187	2,575	1,547	199	1,890	3,501	3,192	35,188	36.5%	34,126	96,405
1982	14,947	2,716	1,642	207	3,022	3,584	3,293	35,941	36.4%	33,435	98,787
1983	15,667	2,890	1,764	215	3,106	3,725	3,363	37,306	35.9%	35,852	103,888
1984	16,471	3,230	1,792	224	3,230	3,878	3,099	38,091	35.3%	37,910	107,925
1985	17,371	3,310	1,910	231	3,278	4,032	3,149	39,790	35.2%	39,953	113,024
1986	18,341	3,980	2,008	244	3,336	4,270	3,213	40,760	35.9%	37,284	113,436
1987	19,397	4,200	2,069	260	3,452	4,534	3,576	41,714	34.4%	41,974	121,176
1988	20,588	4,370	2,191	281	3,621	4,795	3,766	43,145	34.0%	44,125	126,882
1989	21,326	4,570	2,311	309	3,754	5,140	3,889	44,179	33.3%	47,088	132,566
1990	21,567	4,748	3,427	324	3,774	5,453	3,931	45,106	32.7%	50,752	138,082
1991	21,572	4,910	2,521	324	3,685	5,926	3,744	45,416	32.6%	51,176	139,274
1992	21,380	5,040	2,763	319	3,643	6,403	3,688	46,149	32.1%	54,202	143,587
					Average annual percentage change						
1950-92	12.2%	2.9%[c]	6.0%	[b]	3.0%	5.1%[d]	4.2%	3.9%		5.2%	5.2%
1970-92	4.3%	4.7%	5.1%	3.7%[e]	3.3%	4.8%	4.2%	3.8%		5.4%	4.6%
1982-92	3.6%	6.4%	5.3%	4.4%	1.9%	6.0%	1.1%	5.0%		4.9%	3.8%

Source:
Individual countries - Motor Vehicle Manufacturers Association, World Motor Vehicle Data, 1994 Edition, Detroit, MI, 1994, pp. 26-28, 77, 163.

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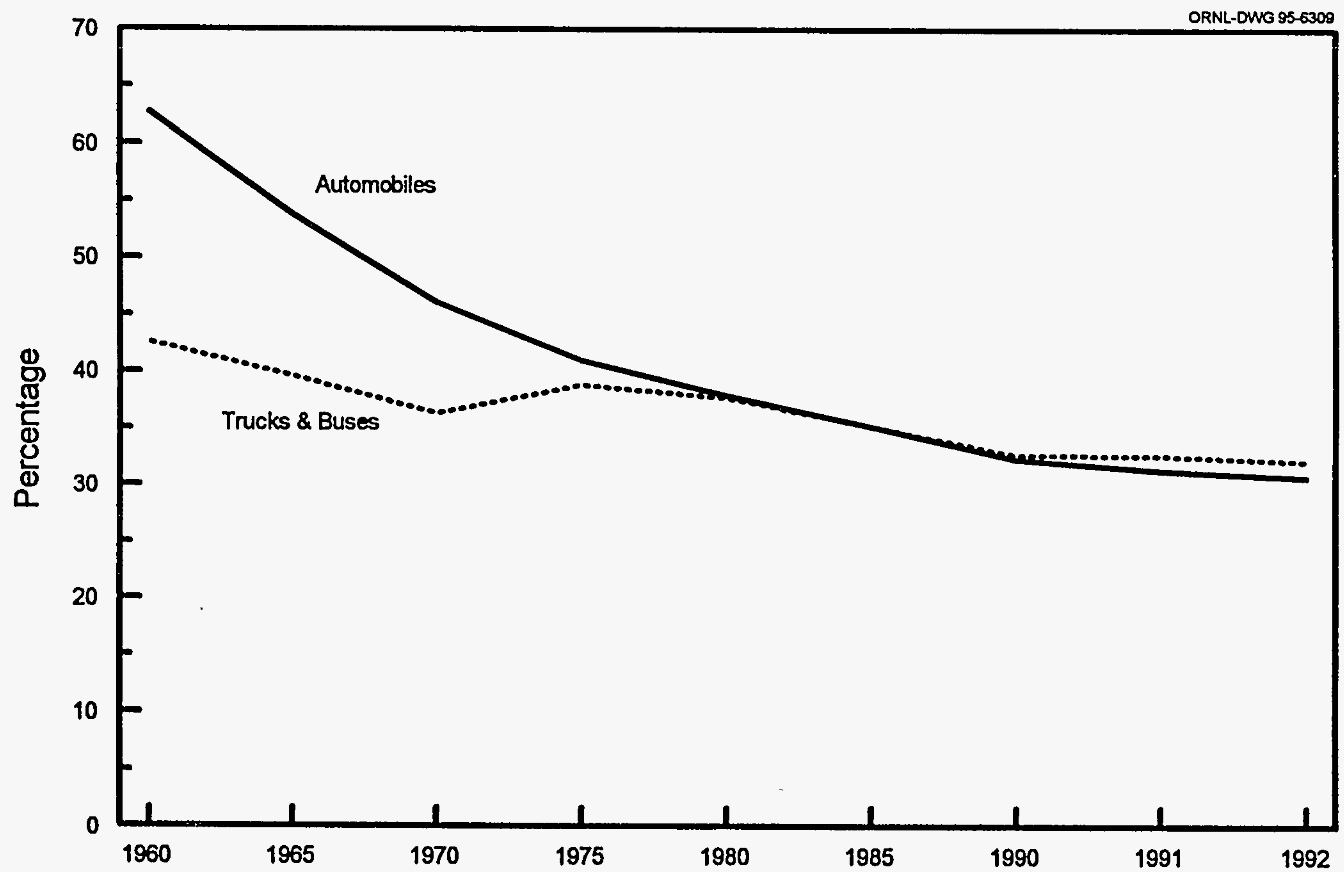
[a]Truck and bus registrations for all other countries were calculated by subtracting listed countries' registrations from the world total.
[b]Data are not available.
[c]Average annual percentage change is for 1960-92.
[d]Average annual percentage change is for 1955-92.
[e]Average annual percentage change is for 1975-92.

Figure 1.1. United States Automobile and Truck & Bus Registrations as a Percent of World Registrations, 1960-92



Source: See Tables 1.1 and 1.2.

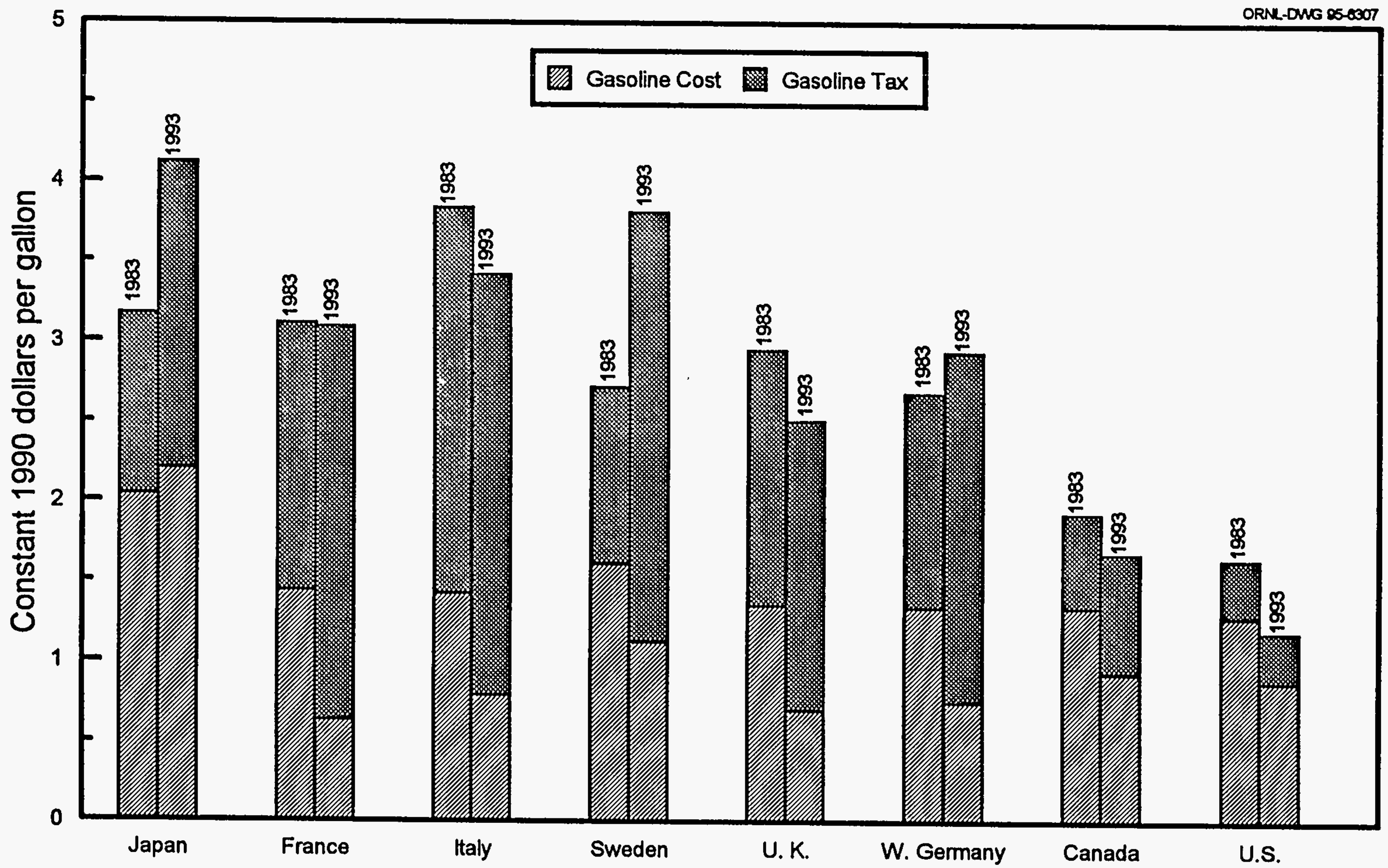
Table 1.3
Gasoline Prices for Selected Countries, 1978-93

	Current dollars per gallon							Average annual percentage change	
	1978[a]	1982[a]	1986[a]	1990[b]	1991[b]	1992[b]	1993[b]	1978-93	1982-93
Japan	2.00[c]	2.60[c]	2.79[c]	3.05[c]	3.90[c]	3.78[c]	4.55	5.6%	5.2%
France	2.15	2.56	2.58	3.40	3.86	3.69	3.41	3.1%	2.6%
Italy	2.23	2.88	3.26	4.27	5.10	4.81	3.77	3.6%	2.5%
Sweden	1.56	2.40	2.20	3.23	4.45	4.28	4.20	6.8%	5.2%
United Kingdom	1.22	2.42	2.07	2.55	2.55	3.28	2.77	5.6%	1.2%
West Germany	1.75	2.17	1.88	2.72	2.87	3.84	3.25	4.2%	3.7%
Canada	0.69[c]	1.37[c]	1.31[c]	1.92[c]	2.06[c]	2.11[c]	1.85	6.8%	2.8%
United States[d]	0.66[c]	1.32[c]	0.93[c]	1.04[c]	1.43[c]	1.07[c]	1.31	4.7%	-0.1%
	Constant 1990 dollars[e] per gallon							Average annual percentage change	
	1978[a]	1982[a]	1986[a]	1990[b]	1991[b]	1992[b]	1993[b]	1978-93	1982-93
Japan	4.01[c]	3.52[c]	3.33[c]	3.05[c]	3.74[c]	3.52[c]	4.12	0.2%	1.4%
France	4.31	3.47	3.07	3.40	3.70	3.44	3.09	-2.2%	-1.0%
Italy	4.47	3.90	3.89	4.27	4.89	4.48	3.42	-1.8%	-1.2%
Sweden	3.12	3.25	2.62	3.23	4.27	3.98	3.81	1.3%	1.5%
United Kingdom	2.44	3.28	2.47	2.55	2.45	3.05	2.51	0.2%	-2.4%
West Germany	3.51	2.94	2.24	2.72	2.75	3.58	2.94	-1.2%	0.0%
Canada	1.38[c]	1.85[c]	1.56[c]	1.92[c]	1.98[c]	1.96[c]	1.68	1.3%	-0.9%
United States[d]	1.32[c]	1.79[c]	1.11[c]	1.04[c]	1.37[c]	1.00[c]	1.19	-0.7%	-3.6%

Source:
U.S. Department of Energy, Energy Information Administration, International Energy Annual 1993, Washington, DC, January 1994, pp. 159, 160, and annual.

[a]Prices represent the retail prices (including taxes) for premium leaded gasoline. Prices are representative for each country based on quarterly data averaged for the year.
[b]Prices represent the retail prices (including taxes) for premium leaded gasoline on January 1 of the year.
[c]Unleaded regular gasoline.
[d]These estimates are for international comparisons only and do not necessarily correspond to gasoline price estimates in other sections of the book.
[e]Adjusted by the U.S. Consumer Price Inflation Index.

Figure 1.2. Gasoline Prices for Selected Countries, 1983 and 1993



Source:
International Energy Agency, Energy Prices and Taxes, Fourth Quarter, 1993 Edition, Paris, France, 1994, and Table 1.3.

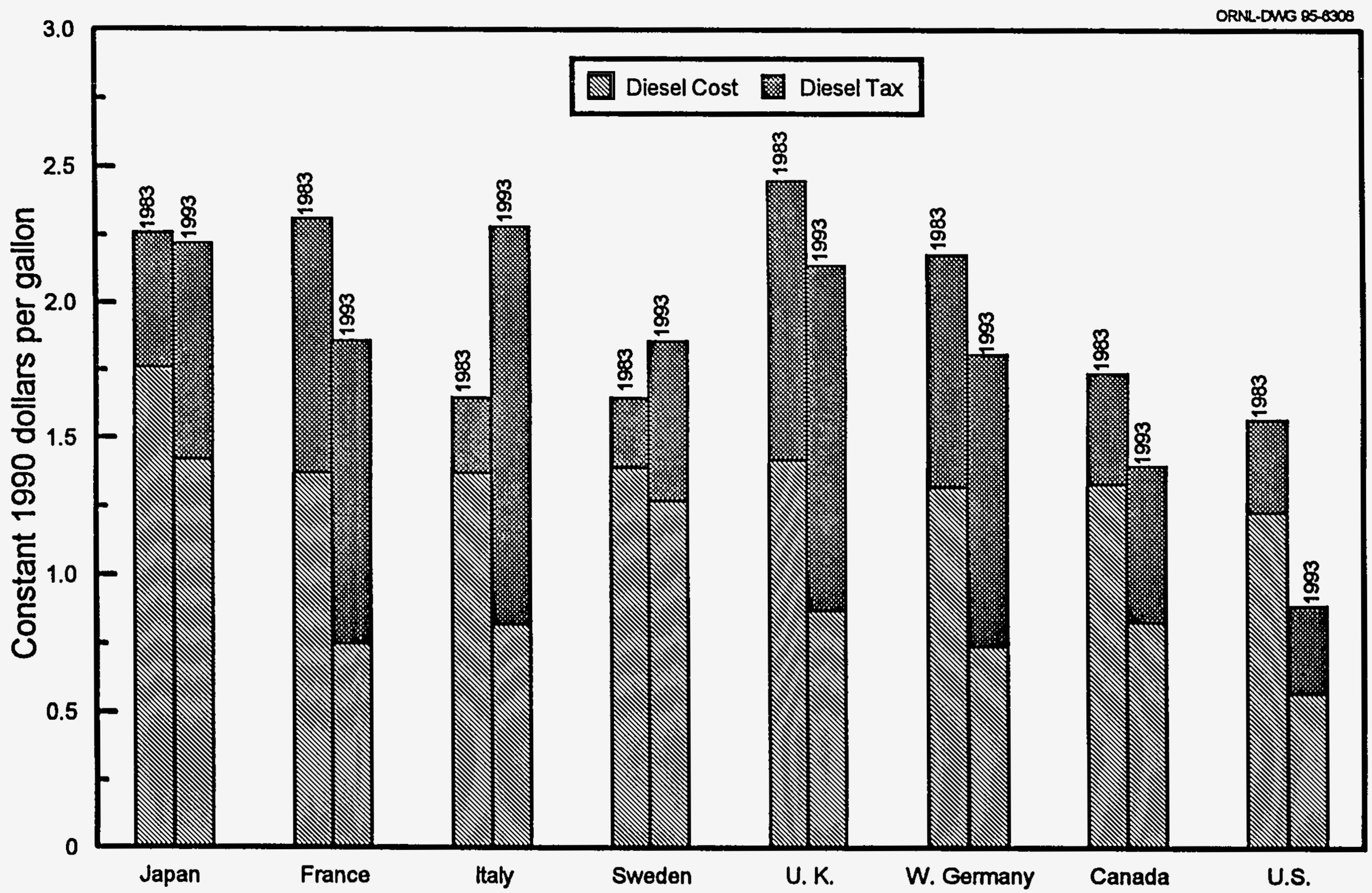
Table 1.4
Diesel Fuel Prices for Selected Countries, 1978-93

	Current dollars per gallon							Average annual percentage change	
	1978[a]	1982[a]	1986[a]	1990[b]	1991[b]	1992[b]	1993[b]	1978-93	1982-93
Japan	[c]	1.78	1.90	1.75	2.4	[c]	2.45	[c]	2.9%
France	1.30	1.88	1.69	1.78	[c]	[c]	2.05	3.1%	0.8%
Italy	0.64	1.19	1.31	2.34	3.77	[c]	2.52	9.6%	7.1%
Sweden	0.62	1.41	1.24	2.30	3.58	[c]	2.05	8.3%	3.5%
United Kingdom	1.24	2.05	1.71	2.04	[c]	[c]	2.36	4.4%	1.3%
West Germany	1.48	1.81	1.51	2.72	2.69	2.81	2.20	2.7%	1.8%
Canada	[c]	1.27	1.27	1.55	1.98	1.78	1.55	[c]	1.8%
United States[d]	0.54	1.16	0.94	0.99	0.91	1.06	0.98	4.1%	-1.5%
	Constant 1990 dollars[e] per gallon							Average annual percentage change	
	1978[a]	1982[a]	1986[a]	1990[b]	1991[b]	1992[b]	1993[b]	1978-93	1982-93
Japan	[c]	2.41	2.26	1.75	2.30	[c]	2.22	[c]	-0.7%
France	2.60	2.55	2.01	1.78	[c]	[c]	1.86	-2.2%	-2.8%
Italy	1.28	1.61	1.56	2.34	3.62	[c]	2.28	3.9%	3.2%
Sweden	1.24	1.91	1.48	2.30	3.43	[c]	1.86	2.7%	-0.2%
United Kingdom	2.48	2.78	2.04	2.04	[c]	[c]	2.14	-1.0%	-2.4%
West Germany	2.96	2.45	1.80	2.72	2.58	2.62	1.81	-3.2%	-2.7%
Canada	[c]	1.72	1.51	1.55	1.90	1.66	1.40	[c]	-1.9%
United States[d]	1.08	1.57	1.12	0.99	0.87	0.99	0.89	-1.3%	-5.0%

Source:
U.S. Department of Energy, Energy Information Administration, International Energy Annual 1993, Washington, DC, January 1994, pp. 159, 160, and annual.

[a]Prices represent the retail prices (including taxes) for premium leaded gasoline. Prices are representative for each country based on quarterly data averaged for the year.
[b]Prices represent the retail prices (including taxes) for premium leaded gasoline on January 1 of the year.
[c]Data are not available.
[d]These estimates are for international comparisons only and do not necessarily correspond to gasoline price estimates in other sections of the book.
[e]Adjusted by the U.S. Consumer Price Inflation Index.

Figure 1.3. Diesel Fuel Prices for Selected Countries, 1983 and 1993



Source:
International Energy Agency, <u>Energy Prices and Taxes, 1993 Edition</u>, Paris, France, 1994, and Table 1.4.

*According to the best available data, new cars in Denmark have the highest fuel economy of the listed countries. Caution should be used, however, when comparing fuel economy data between countries because each country may use different methods of calculating new car fuel economy. The data, therefore, may not be **directly** comparable.*

Table 1.5
New Gasoline Car Fuel Economy for Selected Countries, 1973-92
(miles per gallon)

Year	Japan	France	Italy	Sweden	Norway	Denmark	West Germany	United States
1973	22.6	[a]	[a]	[a]	[a]	[a]	23.0	13.0
1974	22.1	[a]	[a]	[a]	[a]	[a]	[a]	13.9
1975	21.2	27.5	[a]	[a]	24.8	28.1	[a]	15.3
1976	22.6	28.0	[a]	[a]	25.3	[a]	[a]	16.8
1977	24.9	28.3	[a]	[a]	25.6	30.2	[a]	17.7
1978	26.6	28.5	[a]	25.3	25.9	[a]	25.0	18.6
1979	27.3	29.0	[a]	25.6	26.1	30.7	25.3	18.7
1980	28.2	30.2	28.2	26.1	26.7	[a]	26.6	22.5
1981	28.9	31.8	28.7	27.0	27.4	31.5	28.0	24.1
1982	30.6	33.0	29.4	27.4	28.3	[a]	29.0	24.7
1983	30.1	33.6	31.8	27.4	29.0	33.6	29.2	24.6
1984	30.1	34.3	32.7	27.7	30.2	[a]	31.2	24.6
1985	29.2	34.9	32.7	27.7	30.3	35.1	31.8	25.0
1986	28.2	35.1	33.7	28.0	31.1	[a]	32.6	25.7
1987	27.8	35.5	34.1	28.7	31.2	34.5	31.6	25.9
1988	27.3	35.9	34.1	28.3	32.3	[a]	30.4	25.8
1989	26.8	36.1	[a]	28.3	30.6	35.6	29.8	25.5
1990	27.1	36.1	[a]	28.3	31.8	35.5	29.8	25.2
1991	30.8	36.1	[a]	25.3	31.8	30.7	[a]	25.3
1992	[a]	31.3	[a]	22.8	31.8	32.7	[a]	25.2

Sources:
International Energy Studies, Energy Analysis Program, Lawrence Berkeley Laboratory, Berkeley, CA, 1994. Data were compiled from country sources, such as oil companies, energy economics institutes, and government ministries. See Appendix C.

Note: Revisions in the data series are the result of newly available data.

[a]Data are not available.

Because each country may use different methods of calculating fuel economies, caution should be used when comparing fuel economy data among countries. The data for the United States were generated specifically for international comparisons and should be used only for that purpose; they are not consistent with other domestic fuel economy figures.

Table 1.6
Fuel Economy of the Gasoline Automobile Population for Selected Countries, 1970-92
(miles per gallon)

Year	Japan	France	Italy	Sweden	Finland	Norway	Denmark	United Kingdom	West Germany	United States
1970	21.7	27.7	[a]	22.7	24.6	22.8	[b]	23.8	23.0	13.2
1971	20.7	27.7	[b]	22.5	24.9	22.8	[b]	23.9	22.0	13.3
1972	21.9	27.7	[b]	22.3	25.5	22.8	23.2	22.4	21.4	13.1
1973	21.3	26.8	27.8	22.1	26.2	22.8	[b]	22.1	21.9	13.0
1974	21.0	27.7	[b]	22.7	26.6	23.1	[b]	22.2	22.1	13.2
1975	21.4	27.2	[b]	22.2	26.6	23.1	26.7	22.9	21.9	13.3
1976	21.2	26.3	[b]	22.0	27.6	23.1	26.1	23.0	21.8	13.3
1977	21.0	26.4	[b]	21.8	27.9	23.1	26.5	22.8	21.6	13.5
1978	20.8	26.1	[b]	21.6	28.3	23.1	26.5	22.5	21.4	13.8
1979	20.4	26.5	27.8	21.6	27.1	23.3	27.5	22.0	21.7	14.1
1980	20.4	25.7	27.8	21.6	27.6	23.3	27.5	23.0	21.5	15.0
1981	20.8	25.5	28.0	21.6	27.8	23.5	27.3	23.9	21.6	15.4
1982	21.1	25.2	28.0	21.7	27.8	23.8	27.0	24.1	21.6	16.1
1983	21.1	25.3	28.2	21.8	27.3	24.3	27.0	23.7	21.6	16.5
1984	21.5	25.6	28.7	21.8	27.1	24.8	28.0	23.7	21.6	17.0
1985	21.9	25.8	28.9	22.0	26.9	25.3	27.4	24.0	21.6	17.3
1986	22.0	26.0	29.4	22.4	25.6	25.9	27.2	24.0	21.6	17.3
1987	22.4	26.1	29.9	22.8	25.9	25.9	27.5	24.4	21.8	17.9
1988	22.5	26.1	30.1	23.1	26.5	25.9	27.2	24.9	22.0	18.7
1989	22.5	26.5	30.6	23.3	26.6	25.9	27.3	26.0	22.4	19.1
1990	22.3	26.5	31.1	23.5	27.0	26.1	26.4	25.7	22.6	19.5
1991	21.8	26.5	31.3	23.8	[b]	26.1	26.4	25.3	22.8	20.0
1992	22.0	26.5	31.3	24.0	[b]	26.1	26.6	25.4	23.0	19.9

Sources:
International Energy Studies, Energy Analysis Program, Lawrence Berkeley Laboratory, Berkeley,CA, 1994. Data were compiled from country sources, such as oil companies, energy economics institutes, and government ministries. See Appendix C.

Note: Revisions in the data series are the result of newly available data.

[a]Data are not available.

FUEL ECONOMY GAP

Concerns about the difference between on-road fuel economy and tested fuel economy have resulted in related data collection and analysis. "There is a relatively consistent shortfall or gap between tested fuel economy and that actually achieved by consumers on the road ... a gap which changes over time."

The International Energy Studies Program at Lawrence Berkeley Laboratory (LBL) has studied this gap for six countries. They discovered in the study that "despite differences in test measurement methods and data collection and analysis techniques, significant similarities exist between countries on the gap problem."

"The gap arises for several reasons. The effects of these variations tend to cause test values to deviate further and further from actual conditions.

- The formulae used to construct the 'real' cycle from road test data typically under represent the proportion of city to urban highway driving;
- The actual conditions in all parts of the cycle, including hills, weather, road curvature, road surface, etc., are themselves worse than modeled, leading to increased actual fuel consumption. Generally these factors cannot be accounted for by adjusting the dynamometer tests, although road tests could be adjusted;
- Driver behavior, i.e., speed, acceleration, frequency of cold starts, reflects patterns that themselves are more fuel-intensive than the patterns used in tests. Lack of maintenance of the vehicle may also decrease fuel economy ;
- The tests do not reflect seasonal differences in fuel consumption; this was noted particularly in Sweden, Canada, and France; and
- The test values do not represent cars actually sold, either because the cars tested are somehow optimized for testing or because cars actually bought contain more fuel-intensive features (larger engines, turbocharging, more accessories) than is reflected in either the tests or the sales-weightings.

Additionally, the gap may be large if the vehicles counted in the weightings do not accurately represent the entire new-car fleet[a]."

The results of the LBL gap study are presented in Table 1.7.

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[a]Schipper, Lee and Wienke Tax, "New Car Test and Actual Fuel Economy: Yet Another Gap?" Lawrence Berkeley Laboratory, Berkeley, CA, Fall 1993.

Table 1.7
Fuel Economy Gap for Selected Countries
(liters per 100 kilometers)

Country	Year	Test	Actual	Average Gap	Percent Gap	Comments
Canada	1988	8.0	10.0	2.0	20	Actual fuel efficiency from driver surveys. Test from laboratory test.
Individual car models	1985	8.6	10.7	2.1	19.6	
France	1988	6.5	8.4	1.9	23	Travel diaries compared to 1/3 city, 1/3 highway, 1/3 road test values.
Germany	1987	7.7	9.8	2.1	21.4	DIN (test) vs. DIW (actual)
Sweden	1987	8.2	8.5	0.3	3.5	KOV compared with consumer reported survey data.
U.S.	1985					
Cars		9.7	11.9	2.2	18.5	RTECS survey vs. EPA fleet average
Trucks		11.6	14.5	2.9	20	from dynamometer test.
U.K.	1989	7.2	9.3	2.1	22.6	Test value for registration-weighted average.

Sources:
Schipper, Lee and Wienke Tax, "New Car Test and Actual Fuel Economy: Yet Another Gap?" Lawrence Berkeley Laboratory, Berkeley, CA, Fall 1993.

Note: DIN = Deutsches Institut fur Normug
DIW = Deutsches Institut fur Wirtschaftsforschung
KOV = Kosumentverket
RTECS = Residential Transportation Consumption Survey
EPA = Environmental Protection Agency

Table 1.8
Annual Vehicle Miles per Vehicle Traveled by Personal Vehicles[a]
for Selected Countries, 1970-92

Year	Japan	France	Italy	Sweden	Finland	Norway	Denmark	United Kingdom	West Germany	United States
1970	9,290	8,415	7,394	8,912	12,231	7,782	9,863	8,489	8,963	11,173
1971	8,864	8,397	6,930	8,974	12,261	7,781	10,031	8,655	8,825	11,402
1972	7,948	8,415	6,780	9,172	12,853	7,781	10,180	8,694	8,577	11,606
1973	7,845	8,639	6,965	9,310	13,000	7,721	10,144	8,629	8,392	11,463
1974	6,973	8,129	6,401	8,638	11,800	7,724	9,489	8,333	8,141	10,730
1975	6,906	8,204	6,666	8,910	12,784	8,343	10,070	8,335	8,512	10,746
1976	6,748	8,135	6,467	8,805	12,607	8,590	10,038	8,564	8,378	10,920
1977	6,896	8,067	6,316	8,830	12,305	8,653	10,033	8,726	8,242	11,044
1978	6,828	8,036	6,619	8,985	12,132	8,468	10,089	9,095	8,182	11,115
1979	6,820	7,906	6,961	8,987	11,899	8,596	10,008	8,733	8,026	10,660
1980	6,714	8,092	6,898	9,147	11,511	8,288	9,663	9,035	7,971	10,604
1981	6,599	8,247	6,873	9,051	11,243	8,108	9,618	9,065	7,404	10,622
1982	6,589	7,850	6,934	9,109	11,105	8,049	9,695	9,150	7,590	10,820
1983	6,454	7,843	6,827	9,088	10,905	8,052	9,838	9,232	7,697	10,920
1984	6,403	7,980	6,902	9,159	10,763	8,241	10,018	9,259	7,738	10,968
1985	6,451	7,937	7,077	9,021	10,697	8,426	9,720	9,250	7,537	10,997
1986	6,481	8,160	7,235	9,321	10,542	8,551	9,991	9,451	7,763	11,108
1987	6,469	8,247	7,443	9,484	10,729	8,637	10,110	9,907	7,949	11,355
1988	6,505	8,378	7,636	9,444	10,931	8,733	10,250	10,049	8,104	11,776
1989	6,442	8,254	7,689	9,439	11,001	8,845	10,403	10,696	8,052	12,029
1990	6,464	8,451	7,792	9,030	10,869	8,953	10,549	10,574	8,135	12,243
1991	6,447	8,499	7,958	9,077	10,735	8,786	10,629	10,555	8,055	12,381
1992	6,439	8,667	8,173	9,205	[b]	8,664	10,714	10,344	7,958	13,031

Sources:
International Energy Studies, Energy Analysis Program, Lawrence Berkeley Laboratory, Berkeley, CA, 1994. Data were compiled from country sources, such as oil companies, energy economics institutes, and government ministries. See Appendix C.

Note: Revisions in the data series are the result of newly available data.

[a]Calculated as total vehicle miles of travel divided by the number of vehicles **in use**. Includes privately owned automobiles and light trucks.

Table 1.9
Passenger Travel by Personal Vehicles[a] for Selected Countries, 1970-92
(billion passenger-miles)

Year	Japan	France	Italy	Sweden	Finland	Norway	Denmark	United Kingdom	West Germany	United States
1970	379	189	146	38	15	11	23	180	217	2,123
1971	401	199	169	40	15	13	24	191	231	2,209
1972	422	211	186	41	17	14	26	200	234	2,305
1973	438	237	189	42	18	15	26	209	241	2,336
1974	449	224	176	40	17	15	24	203	237	2,222
1975	458	233	190	44	19	17	27	201	251	2,254
1976	456	248	196	46	20	17	25	211	258	2,326
1977	457	248	203	45	20	18	27	218	267	2,370
1978	479	258	221	44	20	19	28	231	277	2,439
1979	497	264	220	45	21	18	27	232	287	2,360
1980	499	281	218	44	21	19	26	245	290	2,322
1981	504	291	226	43	21	19	25	249	274	2,330
1982	512	291	241	43	22	19	25	252	283	2,370
1983	524	297	227	44	23	20	26	255	291	2,417
1984	530	306	242	45	23	20	27	269	297	2,476
1985	546	307	254	44	25	23	27	274	296	2,531
1986	556	321	268	46	25	23	28	289	314	2,593
1987	574	332	291	48	26	26	29	311	327	2,686
1988	601	345	317	48	27	26	29	333	342	2,807
1989	628	355	328	50	28	26	29	361	347	2,874
1990	665	364	362	49	29	26	29	365	366	2,918
1991	693	372	370	49	29	26	30	364	370	2,923
1992	711	384	387	49	[b]	26	30	364	375	3,007

Sources:

International Energy Studies, Energy Analysis Program, Lawrence Berkeley Laboratory, Berkeley, CA, 1994. Data were compiled from country sources, such as oil companies, energy economics institutes, and government ministries. See Appendix C.

Note: Revisions in the data series are the result of newly available data.

[a]Includes privately owned automobiles and light trucks.

Table 1.10
Energy Use by Personal Vehicles[a] for Selected Countries, 1970-92
(trillion Btu)

Year	Japan	France	Italy	Sweden	Finland	Norway	Denmark	United Kingdom	West Germany	United States
1970	491	431	b	99	39	30	52	501	629	9,230
1971	589	454	b	104	41	32	55	531	701	9,777
1972	594	480	b	111	45	34	60	600	742	10,509
1973	676	534	379	117	48	36	b	640	753	10,936
1974	672	511	b	110	46	35	b	622	737	10,491
1975	706	540	b	122	53	40	59	609	803	10,759
1976	747	573	b	126	53	45	62	635	839	11,332
1977	825	593	b	130	53	49	62	653	882	11,555
1978	887	627	b	133	54	49	65	692	935	11,880
1979	959	636	473	133	57	51	63	705	961	11,403
1980	982	688	493	133	57	51	58	719	991	10,667
1981	984	704	512	132	58	51	56	705	933	10,588
1982	1,005	720	536	134	60	53	56	725	968	10,509
1983	1,017	732	538	135	63	54	58	752	1,000	10,604
1984	1,015	743	550	140	65	56	58	793	1,029	10,659
1985	1,035	739	574	140	68	59	60	801	1,022	10,825
1986	1,062	766	594	146	74	62	63	845	1,089	11,191
1987	1,077	780	620	151	78	63	64	896	1,142	11,319
1988	1,118	808	655	154	82	64	66	944	1,195	11,505
1989	1,189	818	671	157	87	64	66	978	1,204	11,660
1990	1,286	831	714	153	88	65	69	1,005	1,246	11,700
1991	1,391	842	708	151	87	63	70	1,018	1,246	11,585
1992	1,446	863	784	153	b	63	71	1,013	1,251	12,028

Sources:
International Energy Studies, Energy Analysis Program, Lawrence Berkeley Laboratory, Berkeley, CA, 1994. Data were compiled from country sources, such as oil companies, energy economics institutes, and government ministries. See Appendix C.

Note: Revisions in the data series are the result of newly available data.

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[a]Includes privately owned automobiles and light trucks.
[b]Data are not available.

Table 1.11
Vehicle Travel per Automobile
for Selected Countries by Trip Purpose

	Work	Work related	Total work	Family & personal	Civic & educational	Total family & civic	Social & recreational	Total
				Number of weekly vehicle trips per automobile				
United States	3.49	0.24	3.73	6.01	0.70	6.72	2.71	13.15
Germany	2.81	0.61	3.41	1.83	0.19	2.02	2.26	7.69
Sweden	2.32	0.83	3.15	2.56	0.07	2.62	4.29	10.06
United Kingdom	1.71	0.56	2.27	2.79	0.24	3.03	1.59	6.88
Holland	2.03	1.05	3.08	1.82	0.14	1.96	3.85	8.89
Norway	2.29	0.62	2.91	5.06	0.11	5.17	3.54	11.62
Denmark	3.01	0.08	3.09	3.66	0.00	3.66	3.35	10.10
				Weekly vehicle miles traveled per automobile				
United States	98.22	11.27	109.49	104.02	13.71	117.73	119.49	346.70
Germany	72.03	48.09	120.12	22.59	5.69	28.28	66.20	214.60
Sweden	45.20	40.79	86.00	32.82	1.72	34.54	108.28	228.82
United Kingdom	39.64	26.49	66.13	38.74	2.74	41.48	46.01	153.62
Holland	56.78	33.01	89.79	18.70	4.73	23.43	89.11	202.33
Norway	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Denmark	82.17	2.86	85.02	46.36	0.00	46.36	115.27	246.65

Sources:
Compiled by Lawrence Berkeley Lab from: U. S. National Personal Transportation Survey (NPTS) for year 1990; United Kingdom National Travel Survey 1989/91; Swedish Travel Patterns Survey, Resvaneundersokningen, 1984; The German Kontiv, 1987; Dutch National Mobility Survey, De Mobiliteit van de Nederlandse bevolking, 1992 RVU Denmark. See Appendix C.

Notes:
The U. S. NPTS survey excludes people under 5 years old (7.6% of the U. S. population for 1990); German Kontiv excludes children under 6 years (5% of total Pop. by 1989); Dutch NTS excludes children under 12 years (19% of Dutch Pop. by 1990); Danish NTS excludes persons under 15 years of age (17% of Pop. by 1992); Swedish NTS excludes persons under 15 years of age (18% of Pop. by 1984).
Special Note: The way in which the Norwegian Travel Survey data was arranged in its final report did not report VMT values by mode and purpose.

[a]Data are not available.

Table 1.12
Travel per Automobile Passenger
for Selected Countries by Trip Purpose

	Work	Work related	Total work	Family & personal	Civic & educational	Total family & civic	Social & recreational	Total
				Number of weekly trips by automobile as a passenger				
United States	0.34	0.03	0.37	1.94	0.76	2.70	1.71	4.77
Germany	0.30	0.05	0.35	0.51	0.10	0.61	1.15	2.12
Sweden	0.37	0.11	0.48	0.84	0.05	0.89	2.04	3.41
United Kingdom	0.46	0.08	0.53	1.83	0.29	2.12	1.66	4.31
Holland	0.35	0.14	0.49	0.70	0.07	0.77	2.03	3.29
Norway	0.27	0.05	0.31	0.79	0.05	0.85	1.48	2.64
Denmark	0.41	0.00	0.42	0.48	0.00	0.48	1.11	2.02
				Weekly miles traveled per automobile passenger				
United States	9.93	2.40	12.33	48.49	9.80	58.29	100.63	171.24
Germany	7.46	1.75	9.21	8.60	1.68	10.28	42.10	61.59
Sweden	6.55	6.69	13.24	14.55	1.08	15.63	64.30	93.17
United Kingdom	8.32	3.98	12.30	29.48	2.74	32.22	56.42	100.94
Holland	11.60	5.52	17.12	10.03	2.25	12.28	65.68	95.08
Norway	[a]	[a]	[a]	[a]	[a]	[a]	[a]	[a]
Denmark	11.50	0.41	11.91	9.28	0.00	9.28	40.32	61.51

Sources:
Compiled by Lawrence Berkeley Lab from: U. S. National Personal Transportation Survey (NPTS) for year 1990; United Kingdom National Travel Survey 1989/91; Swedish Travel Patterns Survey, Resvaneundersokningen, 1984; The German Kontiv, 1987; Dutch National Mobility Survey, De Mobiliteit van de Nederlandse bevolking, 1992 RVU Denmark. See Appendix C.

Notes:
The U. S. NPTS survey excludes people under 5 years old (7.6% of the U. S. population for 1990); German Kontiv excludes children under 6 years (5% of total Pop. by 1989); Dutch NTS excludes children under 12 years (19% of Dutch Pop. by 1990); Danish NTS excludes persons under 15 years of age (17% of Pop. by 1992); Swedish NTS excludes persons under 15 years of age (18% of Pop. by 1984.
Special Note: The way in which the Norwegian Travel Survey data was arranged in its final report did not report VMT values by mode and purpose.

[a]Data are not available.

CHAPTER 2

TRANSPORTATION ENERGY CHARACTERISTICS

The U.S. was responsible for more than one-quarter of the world's petroleum consumption in 1993. Domestic crude oil production declined below seven million barrels per day for the first time in the 24 year series. While domestic crude oil production has declined 24% from 1985 to 1993, the amount of crude oil imported has more than doubled in that time period to meet the domestic demand. Imported oil and petroleum products in 1993 accounted for nearly 50% of U.S. petroleum consumption (Table 2.2).

Most of the petroleum consumed in the U.S. was in the transportation sector, 65.6% (on an energy basis) (Table 2.3). This accounted for 27.2% of total energy use in 1993 (Table 2.5). While the transportation sector depended primarily on petroleum, the residential and commercial sector depended heavily on electricity (Table 2.4).

The fuels used in the transportation sector include gasoline, distillate fuel oil (diesel fuel), jet fuel, residual fuel oil, natural gas, and electricity. Gasoline, however, accounted for the majority of transportation energy consumption in 1993 (Figure 2.6). Of total transportation energy use in 1993, 76% was consumed by the highway mode while the nonhighway mode (which includes water, air, pipeline, and rail transportation) accounted for 20.9%. The remaining 3.1% of transportation energy use was consumed by the off-highway mode (Table 2.9).

The results of a study sponsored by the Office of Energy Demand Policy, U.S. Department of Energy, are presented in Tables 2.17-2.23. The study of Transportation Energy Trends Analysis uses a mathematical technique known as Divisia analysis to decompose energy use trends. Further discussion of this study is found on page 2-27.

The average price for all types of gasoline jumped 10 cents from 1989 to 1990 (in 1990 dollars), but has fallen 15.5 cents from 1990 to 1993. Unleaded regular gasoline prices (in 1990 dollars) experienced an average decline of 4.7% annually from 1983 to 1993 (Table 2.24). The refiner sales prices for other transportation fuels such as propane, aviation gasoline and jet fuel have also shown declines since 1990 (Table 2.25). Crude oil price changes contribute to fuel price fluctuations. The price per barrel of crude went from $18.94 in 1989 to $22.22 in 1990, then back down to $14.85 in 1993 (constant 1990 dollars) (Table 2.26).

Transportation's share of the gross national product (GNP) remained just over 16% in 1993 (Table 2.27). Total personal consumption expenditures (PCE) more than doubled from 1970 to 1993. Transportation PCE grew 88% in that same time period. Transportation expenditures accounted for 11.5% of total PCE in 1993 (Table 2.28).

Consumers in 1993 spent more than four times more for a used car than they would have in 1970 (Table 2.29). The average price of a new car in 1993 reached $18,328 (in current dollars); after adjusting for inflation, that was a decline in price from 1992. The average price for an import car has been more than the average price for a domestic car since 1982. Before then, imports were priced less than domestics, on average (Table 2.30). The cost of operating a car (in 1990 dollars) declined to 40.85 cents per mile in 1993. This was down 1.78 cents from the 1992 cost. Gas and oil, once as much as one-quarter of the total cost to operate a car, accounted for only 13.3% of the total cost in 1993 (Table 2.32).

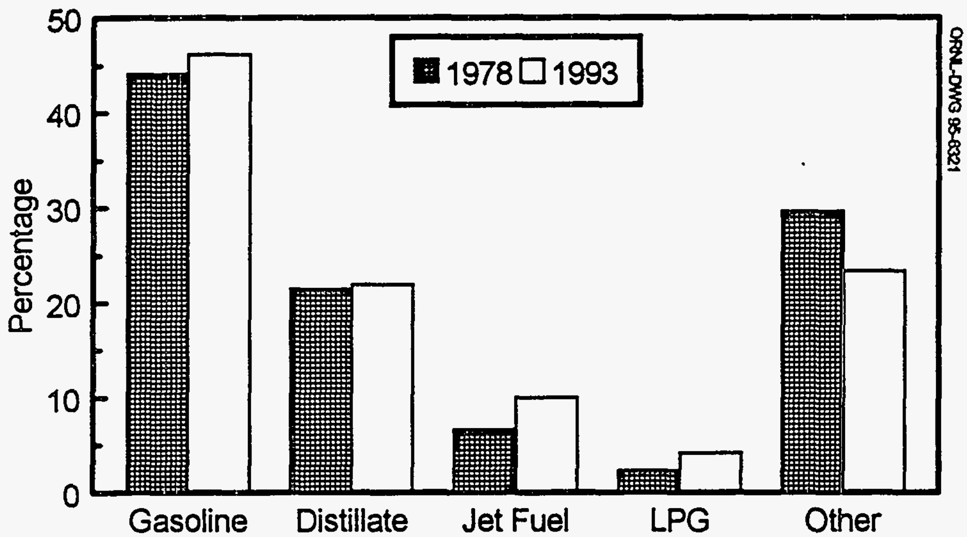
Section 2.1.
Energy Consumption and Supply

Table 2.1
Refinery Yield of Petroleum Products from a Barrel of Crude Oil, 1978-93[a]
(percentage)

Year	Motor Gasoline	Distillate fuel oil	Jet fuel	Liquified petroleum gas	Other[b]
1978	44.1	21.4	6.6	2.3	29.6
1979	43.0	21.5	6.9	2.3	30.3
1980	44.5	19.7	7.4	2.4	30.0
1981	44.8	20.5	7.6	2.4	28.7
1982	46.4	21.5	8.1	2.2	26.2
1983	47.6	20.5	8.5	2.7	24.8
1984	46.7	21.5	9.1	2.9	24.2
1985	45.6	21.6	9.6	3.1	24.6
1986	45.7	21.2	9.8	3.2	24.8
1987	46.4	20.5	10.0	3.4	24.5
1988	46.0	20.8	10.0	3.6	24.4
1989	45.7	20.8	10.1	4.0	24.2
1990	45.6	20.9	10.7	3.6	24.1
1991	45.7	21.3	10.3	3.8	24.1
1992	46.0	21.2	9.9	4.3	24.0
1993	46.1	21.9	10.0	4.1	23.3

Source:
Department of Energy, Energy Information Administration, Petroleum Supply Annual 1993, Vol. 1, June 1994, Table 19, p. 54, and annual.

Figure 2.1. Refinery Yield of Petroleum Products from a Barrel of Crude Oil, 1978 and 1993



Source: See Table 2.1.

[a]Products sum greater than 100% due to processing gain. The processing gain for years 1978 to 1980 is assumed to be 4%.

[b]Includes aviation gasoline, kerosene, naphtha and other oils for petrochemical feedstock use, special naphthas, lubricants, waxes, petroleum coke, asphalt and road oil, still gas, and miscellaneous products.

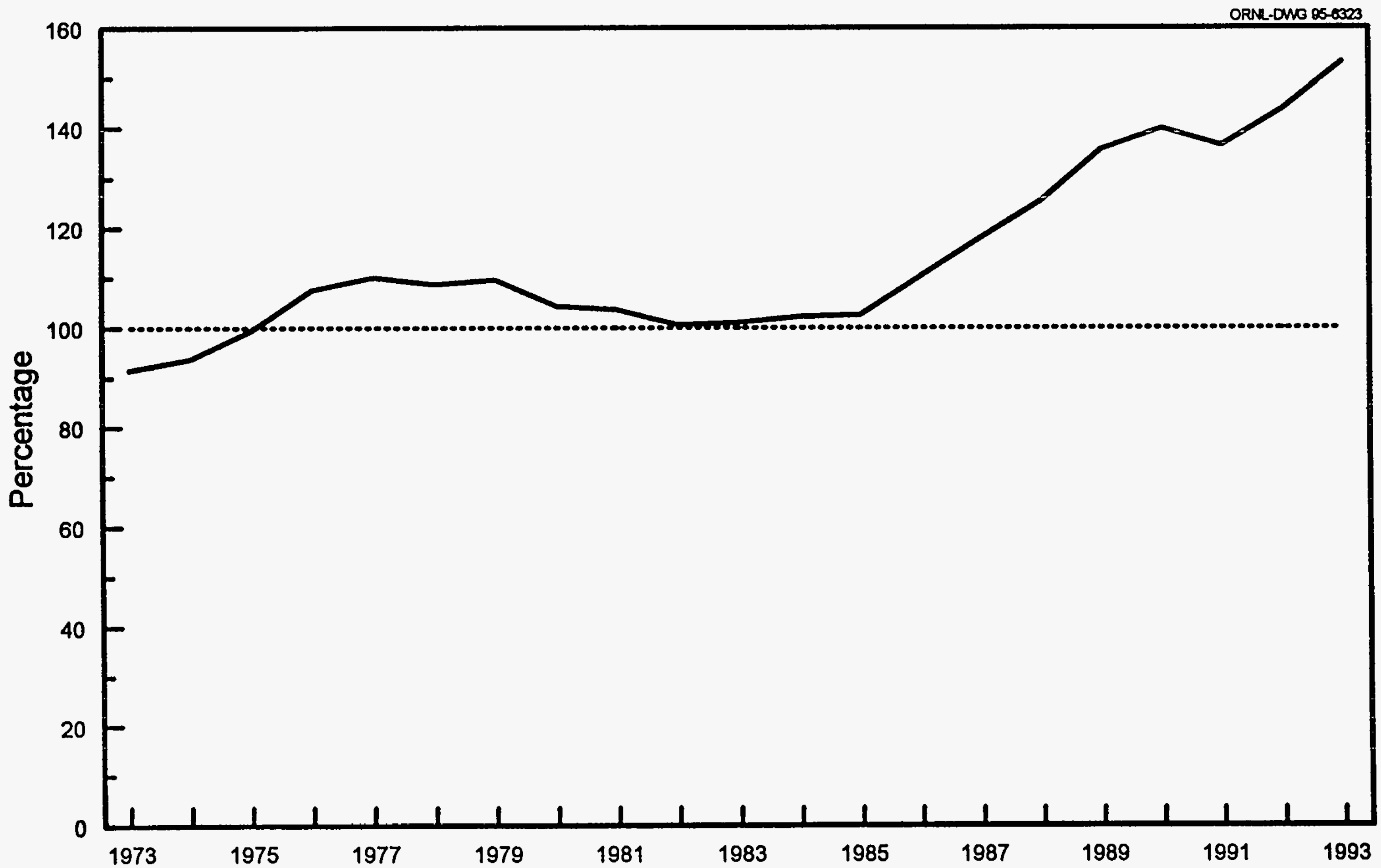
Table 2.2
United States Petroleum Production and Consumption, 1970-93
(million barrels per day)

Year	Domestic crude oil production	Gross imports			U.S. petroleum consumption[a]	World petroleum consumption	Imports as a percentage of U.S. petroleum consumption	Petroleum products as a percentage of gross imports	U.S. petroleum consumption as a percentage of world consumption	Transportation petroleum use as a percentage of domestic production[b]
		Crude oil	Petroleum products	Total						
1970	9.64	1.32	2.10	3.42	14.70	46.38	23.3%	61.4%	31.7%	[c]
1971	9.46	1.68	2.25	3.93	15.21	50.00	25.8%	57.3%	30.4%	[c]
1972	9.44	2.22	2.53	4.75	16.37	52.42	29.0%	53.3%	31.2%	[c]
1973	9.21	3.24	3.01	6.25	17.31	56.39	36.1%	48.2%	30.7%	91.5%
1974	8.77	3.48	2.64	6.12	16.65	55.91	36.8%	43.1%	29.8%	93.7%
1975	8.37	4.10	1.95	6.05	16.32	55.48	37.1%	32.2%	29.4%	99.4%
1976	8.13	5.29	2.03	7.32	17.46	58.74	41.9%	27.7%	29.7%	107.6%
1977	8.25	6.61	2.19	8.80	18.43	61.63	47.7%	24.9%	29.9%	110.2%
1978	8.71	6.36	2.01	8.37	18.85	63.30	44.4%	24.0%	29.8%	108.7%
1979	8.55	6.52	1.94	8.46	18.51	65.17	45.7%	22.9%	28.4%	109.6%
1980	8.60	5.26	1.65	6.91	17.06	63.07	40.5%	23.9%	27.0%	104.4%
1981	8.57	4.40	1.60	6.00	16.06	60.87	37.4%	26.7%	26.4%	103.7%
1982	8.65	3.49	1.63	5.12	15.30	59.50	33.5%	31.8%	25.7%	100.6%
1983	8.69	3.33	1.72	5.05	15.23	58.74	33.2%	34.1%	25.9%	101.1%
1984	8.88	3.43	2.01	5.44	15.73	59.84	34.6%	36.9%	26.3%	102.3%
1985	8.97	3.20	1.87	5.07	15.73	60.10	32.2%	36.9%	26.2%	102.6%
1986	8.68	4.18	2.05	6.23	16.28	61.76	38.3%	32.9%	26.4%	110.3%
1987	8.35	4.67	2.00	6.68	16.67	63.01	40.0%	30.0%	26.5%	118.1%
1988	8.14	5.11	2.30	7.40	17.28	64.83	42.8%	31.1%	26.7%	125.4%
1989	7.61	5.84	2.22	8.06	17.33	66.03	46.5%	27.5%	26.2%	135.7%
1990	7.36	5.89	2.12	8.02	16.99	66.16	47.2%	26.4%	25.7%	140.0%
1991	7.42	5.78	1.84	7.63	16.71	66.71	45.7%	24.1%	25.0%	136.6%
1992	7.17	6.08	1.81	7.89	17.03	66.74	46.3%	22.9%	25.5%	143.7%
1993	6.84	6.73	1.80	8.53	17.19	[c]	49.6%	21.1%	[c]	153.1%
					Average annual percentage change					
1970-93	-1.5%	7.3%	-0.7%	4.1%	0.7%	1.7%[d]				
1983-93	-2.4%	7.3%	0.5%	5.4%	1.2%	1.4%[d]				

Sources:
U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, March 1994, pp. 40-41.
World petroleum consumption - U.S. Department of Energy, Energy Information Administration, International Energy Annual 1992, January 1994, p. 24.

[a]Best estimate for U.S. petroleum consumption is the amount of petroleum produts supplied to the U.S. in a given year.
[b]Transportation petroleum use can be found on Table 2.3.
[c]Data are not available.
[d]Average annual percentage change is for years 1970-92 and 1983-92.

Figure 2.2. Transportation Petroleum Consumption as a Percentage of Total United States Crude Oil Production, 1973-93



Source: See Table 2.2.

Each year since 1990, the transportation sector has consumed at least 65% of the petroleum used in the U.S. Total petroleum use declined slightly from 1990 to 1991, but rose again in 1992 and 1993.

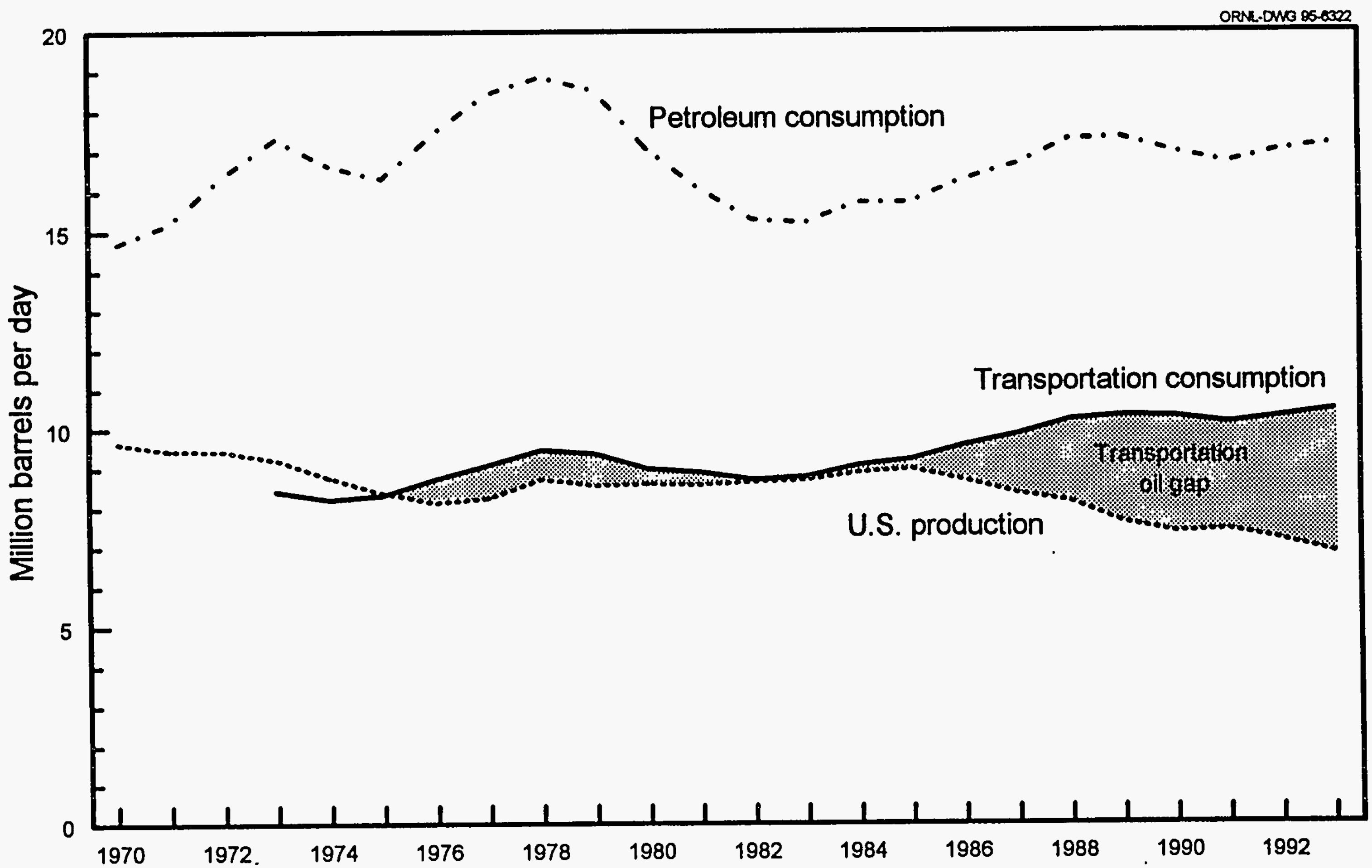
Table 2.3
Consumption of Petroleum by End-Use Sector, 1973-93
(quadrillion Btu)

Year	Transportation	Percentage transportation of total	Residential and commercial	Industrial	Electric utilities	Total	Total in million barrels per day[a]
1973	17.83	51.2%	4.39	9.10	3.52	34.84	16.46
1974	17.40	52.0%	4.00	8.69	3.37	33.46	15.81
1975	17.61	53.8%	3.81	8.15	3.17	32.74	15.47
1976	18.51	52.6%	4.18	9.01	3.48	35.18	16.62
1977	19.24	51.8%	4.21	9.77	3.90	37.12	17.53
1978	20.04	52.8%	4.07	9.87	3.99	37.97	17.94
1979	19.83	53.4%	3.45	10.57	3.28	37.13	17.54
1980	19.01	55.6%	3.04	9.53	2.63	34.21	16.16
1981	18.81	58.9%	2.63	8.29	2.20	31.93	15.08
1982	18.42	60.9%	2.45	7.79	1.57	30.23	14.28
1983	18.59	61.9%	2.50	7.42	1.54	30.05	14.19
1984	19.22	61.9%	2.54	8.01	1.29	31.06	14.67
1985	19.50	63.1%	2.52	7.81	1.09	30.92	14.61
1986	20.27	63.0%	2.56	7.92	1.45	32.20	15.21
1987	20.87	63.5%	2.59	8.15	1.26	32.87	15.53
1988	21.63	62.2%	2.60	8.43	1.56	34.22	16.16
1989	21.87	63.9%	2.53	8.13	1.69	34.22	16.16
1990	21.81	65.0%	2.17	8.32	1.25	33.55	15.85
1991	21.46	65.3%	2.15	8.06	1.18	32.85	15.52
1992	21.81	65.0%	2.13	8.64	0.95	33.53	15.84
1993	22.16	65.6%	2.13	8.43	1.05	33.77	15.95
		Average annual percentage change					
1973-93	1.1%		-3.6%	-0.4%	-5.9%	-0.2%	-0.2%
1983-93	1.8%		-1.6%	1.3%	-3.8%	1.2%	1.2%

Source:
U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, March 1994, pp. 25, 27, 29, 31.

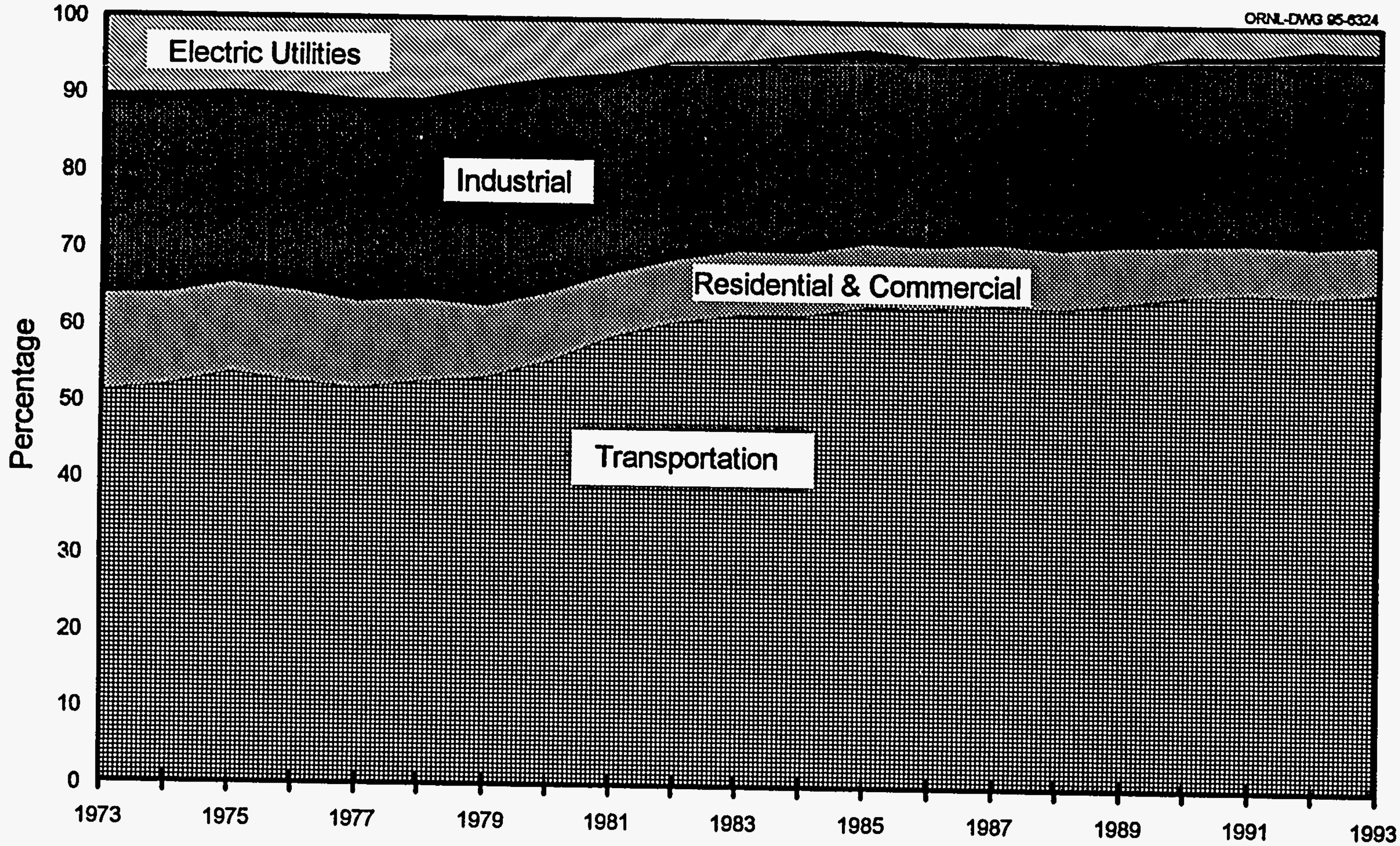
[a]Calculated from Total column. One million barrels per day of petroleum equals 2.117 quadrillion Btu per year.

Figure 2.3. United States Petroleum Production and Consumption, 1970-93



Source: See Tables 2.2 and 2.3.

Figure 2.4. Petroleum Use by End-Use Sector, 1973-93



Source: See Table 2.3.

Pipeline fuel, which is included in the transportation sector energy use, has grown at an annual rate of 2.5% from 1983-93. Natural gas vehicle fuel consumption was first reported in 1990 and may grow in future years.

Table 2.4 Natural Gas Consumption in the United States, 1970-93
(quadrillion Btu)

			Delivered to consumers						
Year	Lease and plant fuel	Pipeline fuel	Residential	Commercial	Industrial	Vehicle fuel	Electric utilities	Total	Total consumption
1970	1.428	0.737	4.939	2.449	8.016	[b]	4.014	19.418	21.583
1975	1.426	0.595	5.028	2.561	7.115	[a]	3.224	17.927	19.948
1980	1.048	0.648	4.852	2.666	7.322	[a]	3.759	18.599	20.295
1981	0.947	0.656	4.642	2.573	7.277	[a]	3.717	18.208	19.811
1982	1.133	0.609	4.730	2.660	5.954	[a]	3.293	16.637	18.379
1983	0.999	0.500	4.473	2.484	5.761	[a]	2.972	15.689	17.188
1984	1.099	0.540	4.651	2.577	6.283	[a]	3.177	16.688	18.327
1985	0.986	0.514	4.526	2.483	6.025	[a]	3.108	16.143	17.644
1986	0.942	0.495	4.405	2.367	5.696	[a]	2.657	15.125	16.562
1987	1.174	0.530	4.405	2.481	6.078	[a]	2.904	15.869	17.572
1988	1.119	0.627	4.728	2.727	6.517	[a]	2.691	16.663	18.408
1989	1.092	0.643	4.881	2.775	6.959	[a]	2.846	17.461	19.196
1990	1.262	0.674	4.484	2.678	7.166	0.000	2.845	17.172	19.108
1991	1.153	0.614	4.651	2.786	7.383	0.000	2.848	17.668	19.435
1992	1.195	0.600	4.789	2.862	7.685	0.001	2.824	18.159	19.955
1993	1.205	0.637	5.061	2.972	8.109	0.001	2.739	18.882	20.724
				Average annual percentage change					
1970-93	-0.7%	-0.6%	0.1%	0.8%	0.1%	[a]	-1.6%	-0.1%	-0.2%
1983-93	1.9%	2.5%	1.2%	1.8%	3.5%	[a]	-0.8%	1.9%	1.9%

Source:
U. S. Department of Energy, Energy Information Administration, Natural Gas Annual 1993, Washington, DC, Table 101, p. 214.

Note: All volumes are shown on a pressure base of 14.73 psia at 60 degrees Fahrenheit.

[b]Data are not available.

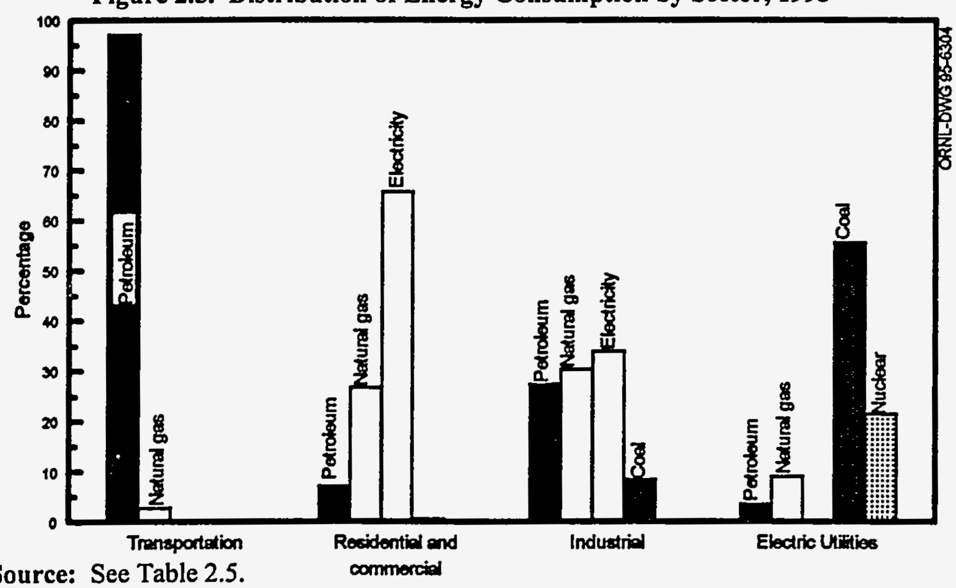
While other sectors have shifted between energy sources in the past twenty years, the transportation sector continues to consume energy from the same sources. Energy use from petroleum, which is clearly the transportation sector's main source, is declining amoung the other sectors.

Table 2.5
Distribution of Energy Consumption by Source, 1973 and 1993
(percentage)

Energy source	Transportation		Residential and Commercial		Industrial		Electric utilities	
	1973	1993	1973	1993	1973	1993	1973	1993
Petroleum	95.8	97.1	18.2	7.0	28.9	27.4	17.7	3.5
Natural gas[a]	4.0	2.7	31.6	26.7	32.9	30.3	18.9	9.0
Coal	0.0	0.0	1.1	0.5	12.8	8.3	43.6	55.6
Hydroelectric	0.0	0.0	0.0	0.0	0.1	0.1	15.0	9.9
Nuclear	0.0	0.0	0.0	0.0	0.0	0.0	4.6	21.4
Electricity[b]	0.2	0.2	49.2	65.7	25.2	33.9	0.0	0.0
Other[c]	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.6
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source:
U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, March 1994, Washington, DC, pp. 25, 27, 29, 31.

Figure 2.5. Distribution of Energy Consumption by Sector, 1993



Source: See Table 2.5.

[a]Includes supplemental gaseous fuels. Transportation sector includes pipeline fuel only.
[b]Includes electrical system energy losses.
[c]Energy generated from geothermal, wood, waste, wind, photovoltaic, and solar thermal energy sources.

Total energy consumption rose to nearly 84 quads in 1993 despite declines in 1990 and 1991. The transportation sector continues to account for more than 27% of total energy use.

Table 2.6
Consumption of Total Energy by End-Use Sector, 1970-93[a]
(quadrillion Btu)

Year	Transportation	Percentage transportation of total	Residential and commercial	Industrial	Total
1970	16.07	24.2%	21.71	28.65	66.43
1971	16.70	24.6%	22.59	28.59	67.88
1972	17.70	24.8%	23.69	29.88	71.27
1973	18.61	25.1%	24.14	31.53	74.28
1974	18.12	25.0%	23.73	30.69	72.54
1975	18.24	25.9%	23.90	28.40	70.54
1976	19.10	25.7%	25.02	30.24	74.36
1977	19.82	26.0%	25.39	31.08	76.29
1978	20.61	26.4%	26.08	31.39	78.09
1979	20.47	25.9%	25.81	32.62	78.90
1980	19.70	25.9%	25.66	30.61	75.96
1981	19.51	26.4%	25.24	29.24	73.99
1982	19.07	26.9%	25.63	26.15	70.85
1983	19.13	27.1%	25.63	25.76	70.52
1984	19.80	26.7%	26.47	27.87	74.14
1985	20.07	27.1%	26.70	27.21	73.98
1986	20.81	28.0%	26.85	26.63	74.30
1987	21.45	27.9%	27.62	27.83	76.89
1988	22.31	27.8%	28.93	28.99	80.22
1989	22.56	27.7%	29.40	29.35	81.33
1990	22.54	27.7%	28.79	29.94	81.27
1991	22.12	27.3%	29.42	29.57	81.12
1992	22.46	27.3%	29.10	30.58	82.14
1993	22.83	27.2%	30.35	30.77	83.96
		Average annual percentage change			
1970-93	1.5%		1.5%	0.3%	1.0%
1983-93	1.8%		1.7%	1.8%	1.8%

Source:
U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, March 1994, Washington, DC, Table 2.2, p. 23.

[a]Electrical energy losses have been distributed among the sectors.

Table 2.7
Domestic Consumption of Transportation Energy by Mode and Fuel Type, 1993[a]
(trillion Btu)

	Gasoline	Diesel fuel	Liquified petroleum gas	Jet fuel	Residual fuel oil	Natural gas	Electricity	Methanol
HIGHWAY	**14,168.0**	**3,345.7**	**8.2**			**1.2**	**0.9**	**0.4**
Automobiles	**9,266.7[b]**	**124.9**				**0.9**		**0.1**
Motorcycles	**24.7**							
Buses	**38.7**	**141.6**	**0.2**			**0.2**	**0.9**	**0.3**
Transit	4.6	81.6	0.2			0.2	0.9	0.3
Intercity[c]		22.1						
School[c]	34.1	37.9						
Trucks	**4,837.9**	**3,079.2**	**8.0**			**0.1**		
Light trucks[d]	4,202.9	159.3	3.0			0.0		
Other trucks	635.0	2,919.9	4.8			0.1		
OFF-HIGHWAY	**136.4**	**570.1[e]**						
Construction	**30.7**	**178.5[e]**						
Agriculture	**105.7**	**391.6[e]**						
NONHIGHWAY	**288.4**	**686.7**		**1,958.2**	**938.6**	**643.7**	**305.2**	
Air	**37.7**			**1,958.2**				
General aviation	37.7			67.0				
Domestic air carriers				1,613.6				
International air carriers[f]				277.6				
Water	**250.7**	**283.5**			**938.6**			
Freight		283.5			938.6			
Domestic		219.7			87.3			
Foreign		63.8			851.3			
Recreational	250.7							
Pipeline						643.7	245.4	
Natural gas						643.7	33.3	
Crude petroleum[g]							91.0	
Petroleum product[g]							67.4	
Coal Slurry[h]							3.7	
Water[h]							50.0	
Rail		**403.2**					**59.8**	
Freight		381.6						
Passenger		21.6					59.8	
Transit							42.2	
Commuter		8.3					13.1	
Intercity		13.3					4.5	
TOTAL	**14,592.8**	**4,602.5**	**8.2**	**1,958.2**	**938.6**	**644.9**	**306.1**	**0.4**

Source:
See Appendix A for Table 2.7.

[a]Civilian consumption only. Totals may not include all possible uses of fuels for transportation (e.g. snowmobiles).
[b]Includes gasohol.
[c]1992 data; 1993 data are not yet available.
[d]Two-axle, four-tire trucks.
[e]1985 data.
[f]Represents an estimate of energy purchased in the U.S. for international air carrier consumption.
[g]1981 data.
[h]1977 data.

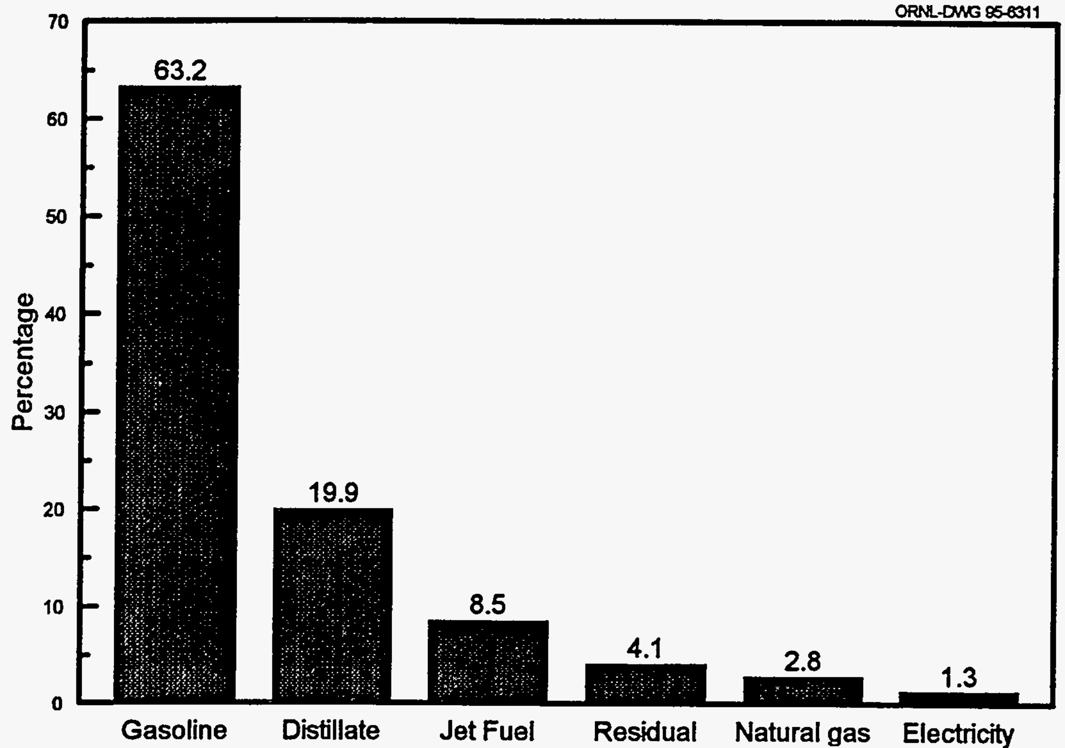
Table 2.8
Domestic Consumption of Transportation Energy by Mode and Fuel Type, 1993[a]
(Percentage)

	Gasoline	Diesel fuel	Liquified petroleum gas	Jet fuel	Residual fuel oil	Natural gas	Electricity	Methanol
HIGHWAY	**97.1%**	**72.7%**	**100.0%**			**0.2%**	**0.3%**	**100.0%**
Automobiles	**63.5%[b]**	**2.7%**				**0.1%**		**25.0%**
Motorcycles	**0.2%**							
Buses	**0.3%**	**3.1%**				**0.0%**	**0.3%**	**75.0%**
Transit		1.8%				0.0%	0.3%	75.0%
Intercity[c]		0.5%						
School[c]	0.2%	0.8%						
Trucks	**33.2%**	**66.9%**	**97.6%**			**0.0%**		
Light trucks[d]	28.8%	3.5%	39.0%			0.0%		
Other trucks	4.4%	63.4%	58.5%			0.0%		
OFF-HIGHWAY	**0.9%**	**12.4%[e]**						
Construction	**0.2%**	**3.9%[e]**						
Agriculture	**0.7%**	**8.5%[e]**						
NONHIGHWAY	**2.0%**	**14.9%**		**100.0%**	**100.0%**	**99.8%**	**99.7%**	
Air	**0.3%**			**100.0%**				
General aviation	0.3%			3.4%				
Domestic air carriers				82.4%				
International air carriers[f]				14.2%				
Water	**1.7%**	**6.2%**			**100.0%**			
Freight		6.2%			100.0%			
Domestic		4.8%			9.3%			
Foreign		1.4%			90.7%			
Recreational	1.7%							
Pipeline						**99.8%**	**80.2%**	
Natural gas						99.8%	10.9%	
Crude petroleum[g]							29.7%	
Petroleum product[g]							22.0%	
Coal Slurry[h]							1.2%	
Water[h]							16.3%	
Rail		**8.8%**					**19.5%**	
Freight		8.3%						
Passenger		0.5%					19.5%	
Transit							13.8%	
Commuter		0.2%					4.3%	
Intercity		0.3%					1.5%	
TOTAL	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source:
See Appendix A for Table 2.7.

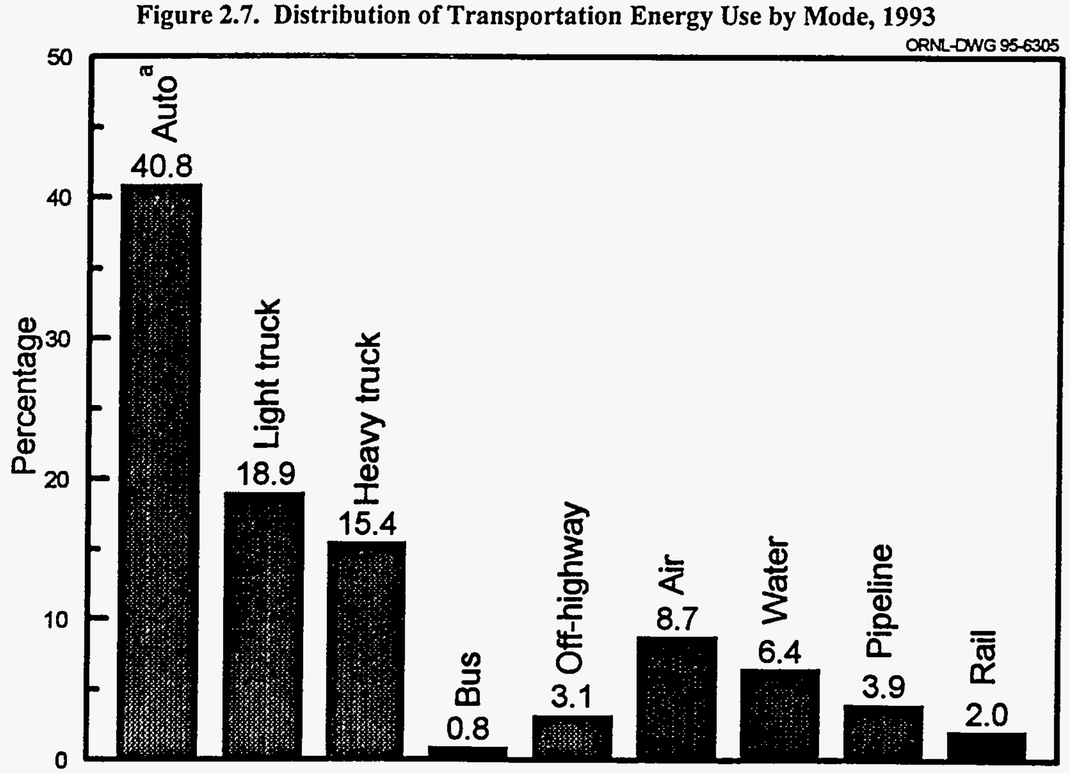
[a]Civilian consumption only. Totals may not include all possible uses of fuels for transportation (e.g. snowmobiles).
[b]Includes gasohol.
[c]1992 data; 1993 data are not yet available.
[d]Two-axle, four-tire trucks.
[e]1985 data.
[f]Represents an estimate of energy purchased in the U.S. for international air carrier consumption.
[g]1981 data.
[h]1977 data.

Figure 2.6. Distribution of Transportation Energy Use by Fuel Type, 1993



Source: See Table 2.8.

Figure 2.7. Distribution of Transportation Energy Use by Mode, 1993



Source: See Table 2.9.

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[a]Includes motorcycles.

Table 2.9
Transportation Energy Use by Mode, 1992-93[a]

	Trillion Btu		Thousand barrels per day crude oil equivalent[b]		Percentage of total	
	1992	1993	1992	1993	1992	1993
HIGHWAY	16,977.0	17,254.4	8,019.4	8,277.9	73.6%	76.0%
Automobiles	9,240.5	9,392.6	4,364.9	4,436.8	40.0%	40.7%
Motorcycles	23.8	24.7	11.2	11.7	0.1%	0.1%
Buses	174.2	181.9	82.3	85.9	0.8%	0.8%
Transit	81.0	87.8	38.3	41.5	0.4%	0.4%
Intercity[c]	22.6	22.1	10.7	10.4	0.1%	0.1%
School[c]	70.6	72.0	33.3	34.0	0.3%	0.3%
Trucks	7,538.5	7,925.2	3,560.9	3,743.6	32.7%	34.4%
Light trucks[d]	4,156.3	4,365.4	1,963.3	2,062.1	18.0%	18.9%
Other trucks	3,382.2	3,559.8	1,597.6	1,681.5	14.7%	15.4%
OFF-HIGHWAY	665.2	706.5	314.2	333.7	2.9%	3.1%
Construction	209.9	209.2	99.1	98.8	0.9%	0.9%
Agriculture	455.3	497.3	215.1	234.9	2.0%	2.2%
NONHIGHWAY	4,967.1	4,820.8	2,346.3	2,277.2	21.5%	20.9%
Air	1,970.8	1,995.9	930.9	942.8	8.5%	8.7%
General aviation	104.7	104.7	49.5	49.5	0.5%	0.5%
Domestic air carriers	1,588.0	1,613.6	750.1	762.2	6.9%	7.0%
International air carriers[e]	278.1	277.6	131.4	131.1	1.2%	1.2%
Water	1,641.3	1,472.8	775.3	695.7	7.1%	6.4%
Freight	1,388.4	1,222.1	655.8	577.3	6.0%	5.3%
Domestic	341.0	307.0	161.1	145.0	1.5%	1.3%
Foreign	1,047.4	915.1	494.8	432.3	4.5%	4.0%
Recreational	252.9	250.7	119.5	118.4	1.1%	1.1%
Pipeline	849.3	889.1	401.2	420.0	3.7%	3.9%
Natural gas	637.2	677.0	301.0	319.8	2.8%	2.9%
Crude petroleum[f]	91.0	91.0	43.0	43.0	0.4%	0.4%
Petroleum product[f]	67.4	67.4	31.8	31.8	0.3%	0.3%
Coal Slurry[g]	3.7	3.7	1.7	1.7	0.0%	0.0%
Water[g]	50.0	50.0	23.6	23.6	0.2%	0.2%
Rail	505.7	463.0	238.9	218.7	2.2%	2.0%
Freight	425.4	381.6	200.9	180.3	1.8%	1.7%
Passenger	80.3	81.4	37.9	38.5	0.3%	0.4%
Transit	40.9	42.2	19.3	19.9	0.2%	0.2%
Commuter	22.0	21.4	10.4	10.1	0.1%	0.1%
Intercity	17.4	17.8	8.2	8.4	0.1%	0.1%
TOTAL	**23,081.1**	**23,051.7**	**10,902.7**	**10,888.9**	**100.0%**	**100.0%**

Source: See Appendix A for Table 2.7.

[a]Civilian consumption only. Totals may not include all possible uses of fuels for transportation (e.g. snowmobiles).
[b]Thousand barrels per day crude oil equivalents based on Btu content of a barrel of crude oil.
[c]1992 data; 1993 data are not yet available.
[d]Two-axle, four-tire trucks.
[e]This figure represents an estimate of the energy purchased in the U.S. for international air carrier consumption.
[f]1981 data.
[g]1977 data.

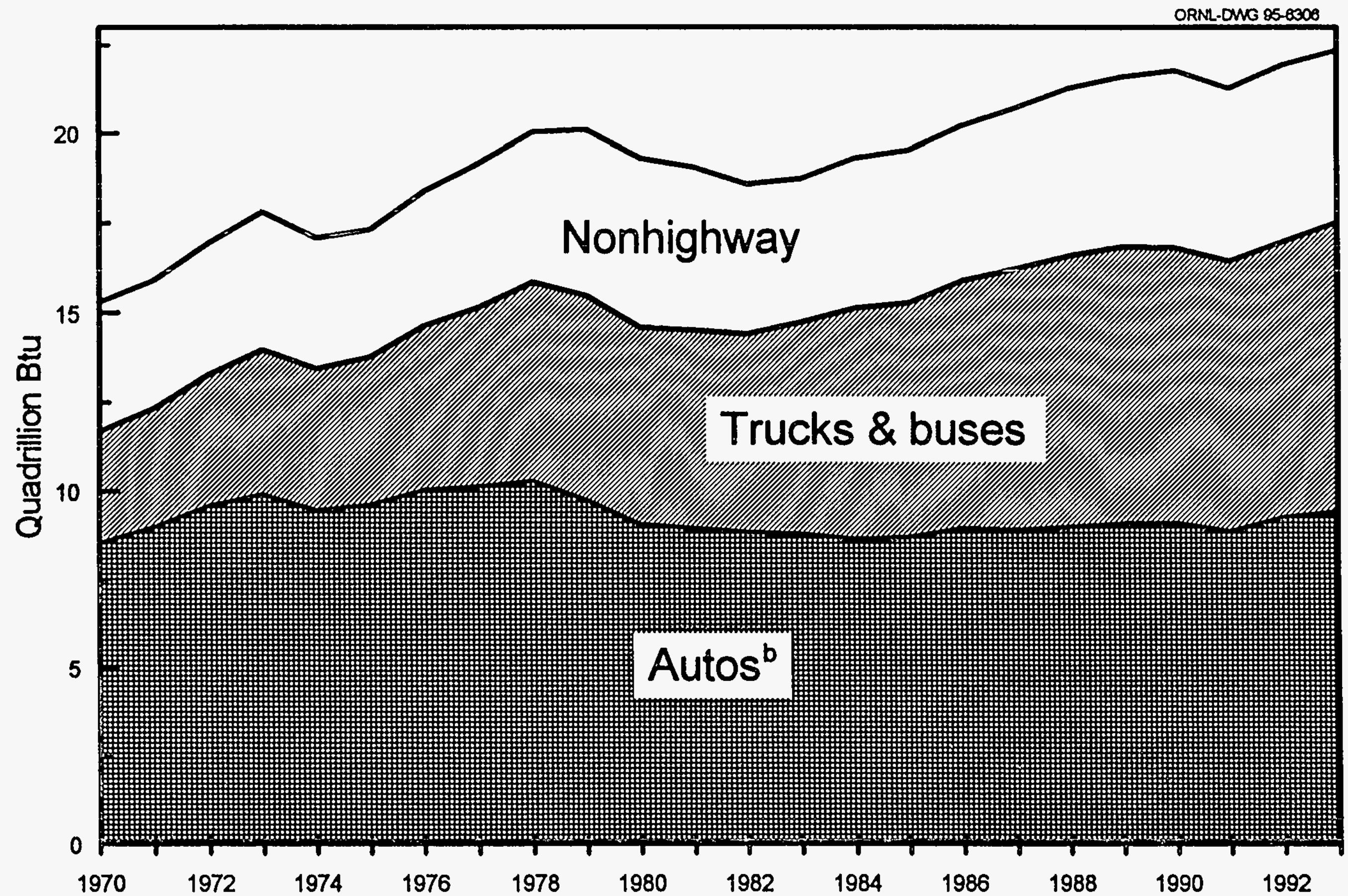
Table 2.10
Transportation Energy Consumption by Mode, 1970-93
(trillion Btu)

Year	Automobiles	Motorcycles	Buses	Light trucks[a]	Other trucks	Total highway	Air	Water	Pipeline	Rail	Total nonhighway	Total transportation[b]
1970	8,526	8	109	1,540	1,502	11,685	1,307	753	985	575	3,620	15,305
1971	8,971	9	108	1,686	1,568	12342	1,304	698	1,007	556	3,565	15,907
1972	9,583	11	106	1,895	1,684	13,279	1,314	703	1,039	614	3,670	16,949
1973	9,890	13	109	2,105	1,844	13,961	1,377	827	996	652	3,852	17,813
1974	9,440	14	113	2,083	1,791	13,441	1,254	804	932	657	3,647	17,088
1975	9,611	14	119	2,240	1,789	13,773	1,274	851	835	596	3,556	17,329
1976	10,020	15	129	2,522	1,949	14,635	1,333	1,001	803	617	3,754	18,389
1977	10,108	16	132	2,738	2,155	15,149	1,411	1,103	781	627	3,922	19,071
1978	10,267	18	135	3,008	2,420	15,848	1,467	1,311	781	628	4,187	20,035
1979	9,719	22	137	3,094	2,510	15,482	1,568	1,539	856	656	4,619	20,101
1980	9,037	26	139	2,951	2,425	14,578	1,528	1,677	889	645	4,739	19,317
1981	8,927	27	143	2,964	2,461	14,522	1,455	1,562	899	627	4,543	19,065
1982	8,814	25	146	2,982	2,430	14,397	1,468	1,290	853	581	4,192	18,589
1983	8,762	22	145	3,196	2,599	14,724	1,505	1,187	738	574	4,004	18,728
1984	8,613	22	154	3,500	2,836	15,125	1,633	1,251	780	520	4,185	19,310
1985	8,673	23	161	3,630	2,924	15,411	1,678	1,311	758	501	4,248	19,659
1986	8,917	24	154	3,785	3,007	15,886	1,823	1,295	738	487	4,343	20,229
1987	8,863	25	157	4,032	3,137	16,214	1,894	1,326	775	496	4,491	20,704
1988	8,969	25	159	4,109	3,310	16,572	1,978	1,338	878	512	4,706	21,278
1989	9,054	26	163	4,147	3,440	16,830	1,981	1,376	895	516	4,768	21,598
1990	9,066	24	163	4,156	3,387	16,797	2,059	1,487	928	507	4,981	21,778
1991	8,845	23	174	4,080	3,302	16,424	1,926	1,567	864	480	4,837	21,261
1992	9,241	24	174	4,156	3,382	16,977	1,971	1,641	849	506	4,967	21,944
1993	9,393	25	182	4,365	3,560	17,524	1,996	1,473	889	463	4,821	22,345
					Average annual percentage change							
1970-93	0.4%	5.1%	2.3%	4.6%	3.8%	1.8%	1.9%	3.0%	-0.4%	-0.9%	1.3%	1.7%
1983-93	0.7%	1.3%	2.3%	3.2%	3.2%	1.8%	2.9%	2.2%	1.9%	-2.1%	1.9%	1.8%

Source:
See Appendix A for Table 2.10.

[a] Light trucks include only those trucks which have 2-axles and 4-tires.
[b] Total transportation figures do not include military and off-highway energy use and may not include all possible uses of fuel for transportation (e.g. snowmobiles).

Figure 2.8. Transportation Energy Consumption by Mode, 1970-93[a]



Source: See Table 2.10.

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[a] Does not include military or off-highway energy use.
[b] Includes motorcycles.

Highway fuel use rose by 3% from 1992 to 1993. The Federal Highway Administration cautions, however, that some states have improved reporting procedures for 1993 data; therefore, those data components would not be directly comparable.

Table 2.11
Highway Usage of Gasoline and Special Fuels, 1973-93
(million gallons)

Year	Gasoline	Gasohol	Total Gasoline and Gasohol	Special fuels[a]	Percent special fuels	Total highway fuel use
1973	[b]	[b]	100,636	9,837	8.9%	110,473
1974	[b]	[b]	96,505	9,796	9.2%	106,301
1975	[b]	[b]	99,354	9,631	8.8%	108,985
1976	[b]	[b]	104,978	10,721	9.3%	115,699
1977	[b]	[b]	107,978	11,646	9.7%	119,624
1978	[b]	[b]	112,239	12,828	10.3%	125,067
1979	[b]	[b]	108,126	13,989	11.5%	122,115
1980	100,686	497	101,183	13,777	12.0%	114,960
1981	98,884	713	99,597	14,856	13.0%	114,453
1982	96,220	2,259	98,479	14,905	13.1%	113,384
1983	95,852	4,254	100,106	15,975	13.8%	116,081
1984	95,996	5,420	101,416	17,320	14.6%	118,736
1985	95,567	8,004	103,571	17,751	14.6%	121,322
1986	98,618	8,138	106,756	18,427	14.7%	125,183
1987	101,790	6,912	108,702	19,046	14.9%	127,748
1988	101,678	8,138	109,816	20,070	15.5%	129,886
1989	103,691	6,941	110,632	21,232	16.1%	131,864
1990	102,645	7,539	110,184	21,399	16.3%	131,583
1991	99,304	8,644	107,948	20,676	16.1%	128,624
1992	102,119	8,831	110,950	21,988	16.5%	132,938
1993	103,417	10,287	113,704	23,490	17.1%	137,194
			Average annual percentage change			
1973-93	-	-	0.6%	4.4%		1.1%
1983-93	0.8%	9.2%	1.3%	3.9%		1.7%

Source:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, pp. I-6, I-7, I-9, and annual.
Total highway fuel use - calculated as the sum of gasoline and special fuels.

[a]Special fuels consist primarily of diesel fuel, with small quantities of liquified petroleum gas.
[b]Data for gasoline and gasohol cannot be separated in this year.

Table 2.12
Estimated Fuel Used for Off-Highway Recreation by State, 1992
(thousand gallons)

State	Light truck	Motorcycle[a]	ATV[b]	Snowmobile	Total	State share
Alabama	29,613	1,617	2,484	0	33,714	*2.3%*
Alaska	4,223	354	1,125	162	5,864	*0.4%*
Arizona	34,864	1,481	1,478	17	37,839	*2.6%*
Arkansas	31,214	1,038	3,086	0	35,338	*2.4%*
California	87,502	14,972	7,643	152	110,269	*7.6%*
Colorado	35,748	1,882	903	431	38,963	*2.7%*
Connecticut	13,288	1,068	557	60	14,972	*1.0%*
Delaware	1,926	195	201	3	2,325	*0.2%*
District of Columbia	385	14	0	0	399	*0.0%*
Florida	63,415	4,160	2,515	0	70,091	*4.8%*
Georgia	34,258	2,685	2,827	0	39,769	*2.7%*
Hawaii	6,741	[c]	[c]	0	6,741	*0.5%*
Idaho	14,041	1,422	856	904	17,223	*1.2%*
Illinois	30,495	2,655	1,638	895	35,683	*2.5%*
Indiana	23,437	1,817	1,666	279	27,200	*1.9%*
Iowa	10,332	956	922	450	12,660	*0.9%*
Kansas	17,298	726	641	0	18,665	*1.3%*
Kentucky	23,677	1,139	1,636	0	26,452	*1.8%*
Louisiana	31,260	991	2,484	0	34,735	*2.4%*
Maine	9,417	561	833	1,950	12,760	*0.9%*
Maryland	17,644	1,440	886	4	19,974	*1.4%*
Massachusetts	11,223	1,729	873	190	14,014	*1.0%*
Michigan	47,068	3,098	3,824	4,155	58,144	*4.0%*
Minnesota	16,814	1,522	1,951	4,445	24,732	*1.7%*
Mississippi	19,719	602	1,887	0	22,208	*1.5%*
Missouri	33,166	1,316	2,193	0	36,675	*2.5%*
Montana	12,817	826	667	347	14,657	*1.0%*
Nebraska	9,331	490	766	19	10,605	*0.7%*
Nevada	7,933	790	504	0	9,227	*0.6%*
New Hampshire	7,635	673	632	735	9,675	*0.7%*
New Jersey	28,300	2,112	1,269	46	31,727	*2.2%*
New Mexico	34,684	844	525	19	36,072	*2.5%*
New York	27,404	3,794	3,549	1,589	36,336	*2.5%*
N. Carolina	29,540	2,525	2,366	0	34,431	*2.4%*
N. Dakota	6,370	301	320	212	7,203	*0.5%*
Ohio	28,777	3,080	2,699	237	34,793	*2.4%*
Oklahoma	35,622	1,540	1,145	0	38,307	*2.6%*
Oregon	17,418	1,842	1,647	310	21,216	*1.5%*
Pennsylvania	42,419	3,670	4,360	976	51,425	*3.5%*
Rhode Island	3,919	295	85	5	4,304	*0.3%*
S. Carolina	24,611	1,133	890	0	26,635	*1.8%*
S. Dakota	6,679	325	353	80	7,436	*0.5%*
Tennessee	30,991	1,935	2,789	0	35,715	*2.5%*
Texas	129,027	5,664	4,307	0	138,997	*9.6%*
Utah	13,153	1,434	1,339	297	16,224	*1.1%*
Vermont	4,012	242	356	968	5,578	*0.4%*
Virginia	31,832	2,136	1,484	0	35,451	*2.4%*
Washington	23,274	2,991	1,448	627	28,341	*2.0%*
W. Virginia	21,493	985	1,875	0	24,353	*1.7%*
Wisconsin	18,605	1,593	1,734	3,596	25,527	*1.8%*
Wyoming	9,517	413	407	436	10,774	*0.7%*
Total	1,254,126	91,069	82,627	24,597	1,452,419	*100.0%*

Source:

Hu, Patricia S., David Trumble, and An Lu, Fuel Used for Off-Highway Recreation, ORNL-6794, Oak Ridge National Laboratory, July 1994, Oak Ridge, TN, pp. 79-80.

[a]Estimates are based on an annual fuel use of 59 gallons per motorcycle.

[b]ATV=all terrain vehicle. Estimates are based on an annual fuel use of 55.5 gallons per ATV.

[c]Data are not available.

Section 2.2.
Energy Efficiency and Intensity

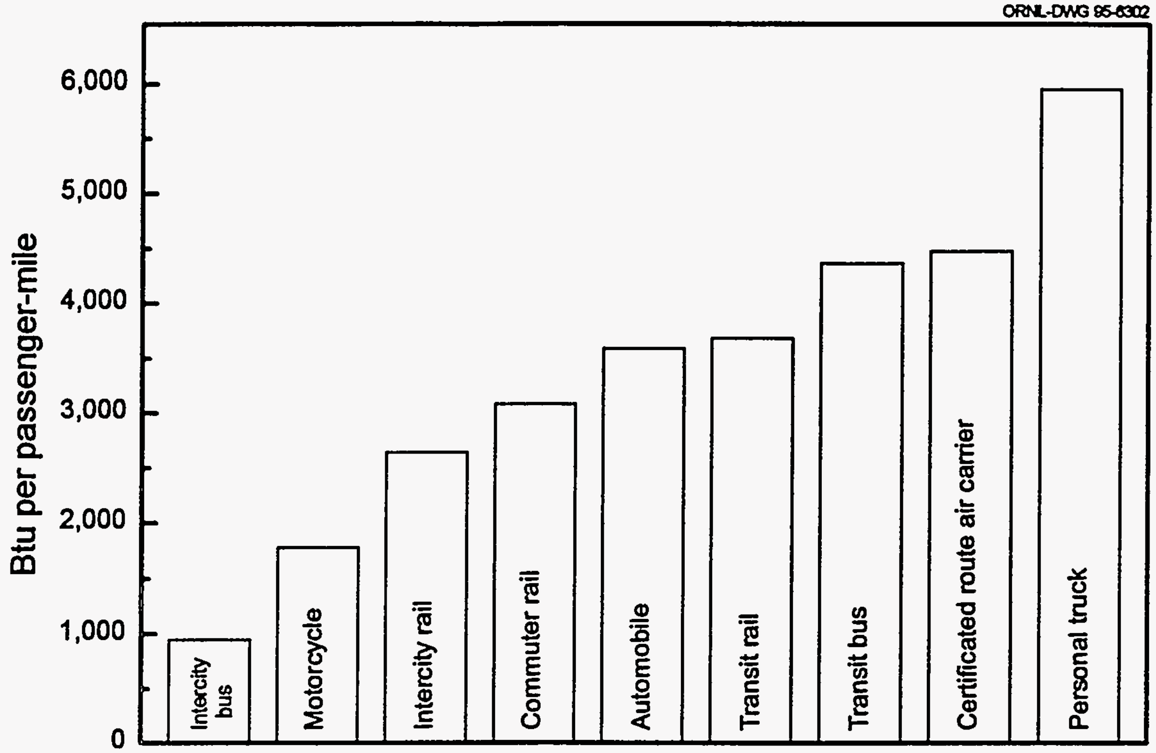
Table 2.13
Passenger Travel and Energy Use in the United States, 1993

	Number of vehicles (thousands)	Vehicle-miles (millions)	Passenger-miles (millions)	Load factor (persons/vehicle)	Energy intensities (Btu per vehicle-mile)	Energy intensities (Btu per passenger-mile)	Energy use (trillion Btu)
Automobiles	**146,314.3**	**1,633,861**	**2,614,178**	**1.6**	**5,748**	**3,593**	**9,391.6**
Personal Trucks	**28,746.7**	**315,411**	**473,117**	**1.5**	**8,938**	**5,958**	**2,819.0**
Motorcycles	**3,977.9**	**9,889**	**12,849**	**1.4**	**2,498**	**1,784**	**24.7**
Buses	**618.6**	**7,506**	**137,475**	**18.3**	**24,247**	**1,324**	**182.0**
Transit	64.6	2,206	20,075	9.1	39,801	4,374	87.8
Intercity	19.1	1,000	23,200	23.2	22,100	953	22.1[a]
School	534.9	4,300	94,200	21.9	16,767	765	72.1[a]
Air[a]	[b]	**7,086**	**366,490**	**51.7**	**238,880**	**4,619**	**1,692.7**
Certificated route (domestic)	[b]	3,954	354,290	89.6	401,619	4,482	1,588.0
General aviation	184.4	3,132[c]	12,200	3.9	33,429	8,582	104.7
Recreational boats	**10,299.0**	[b]	[b]	[b]	[b]	[b]	**250.7**
Rail	**11,292.7**	**1,080**	**24,583**	**22.8**	**74,074**	**3,254**	**80.0**
Intercity[d]	2.2[e]	303[f]	6,199[g]	20.5	54,125	2,646	16.4
Transit[h]	11,286.0	553	11,445	20.7	76,311	3,687	42.2
Commuter	4.5	224	6,939	31.0	95,536	3,084	21.4

Source:
See Appendix A for Table 2.13.

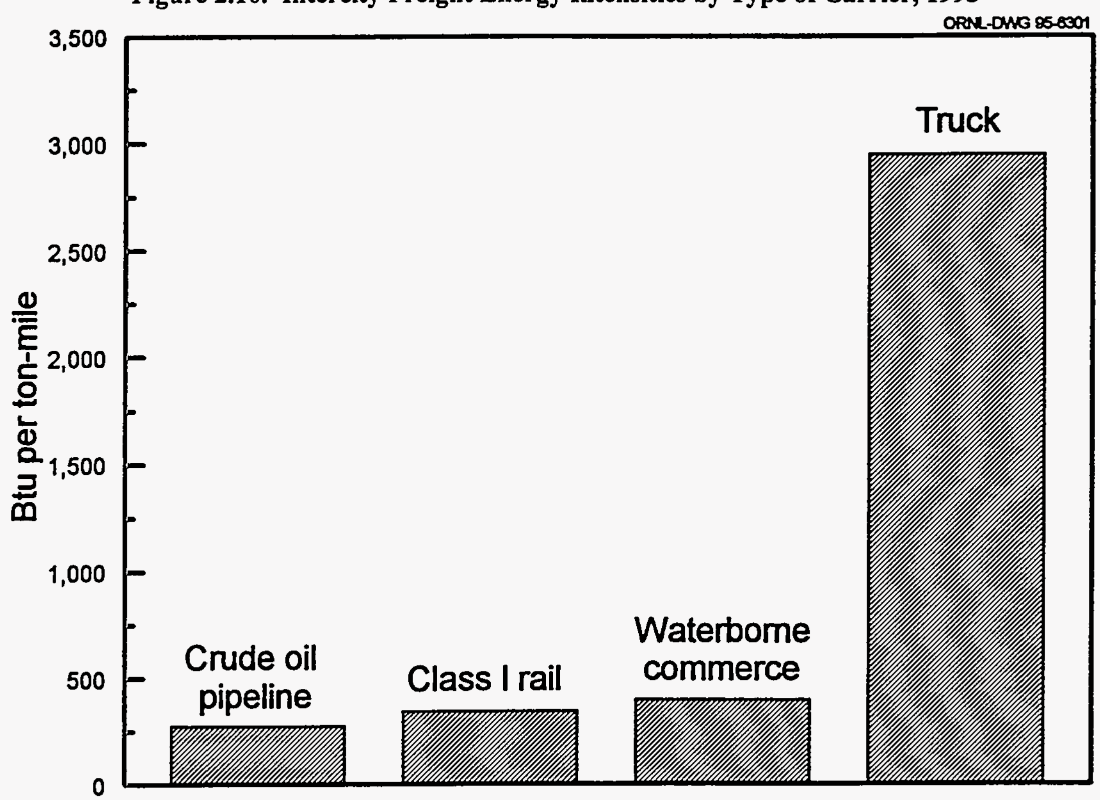
[a]1992 data; 1993 data are not yet available.
[b]Data are not available.
[c]Nautical miles.
[d]Amtrak only.
[e]Sum of passenger train cars and locomotive units.
[f]Passenger train car-miles.
[g]Revenue passenger miles.
[h]Light and heavy rail.

Figure 2.9 Passenger Energy Intensities by Type of Carrier, 1993



Source: See Table 2.13

Figure 2.10. Intercity Freight Energy Intensities by Type of Carrier, 1993



Source: See Table 2.14

Table 2.14
Intercity Freight Movement and Energy Use in the United States, 1993

	Number of vehicles (thousands)	Vehicle-miles (millions)	Ton-miles (millions)	Tons shipped (millions)	Average length of haul (miles)	Energy intensity (Btu/ton-mile)	Energy use (trillion Btu)
Truck	**4,436**	**148,136**	**880,000**	**3,079**	**611**[a]	**2,946**	**2,592.2**
Waterborne commerce[b]	**39**	c	**856,685**	**1,090**	**786**	**398**	**341.0**
Coastal	c	c	502,311	285	1,762	c	c
Lakewise	c	c	55,784	107	519	c	c
Internal and local	c	c	293,480	709	470[d]	c	c
Pipeline	c	c	c	**1,532**	c	c	**865.4**
Natural gas	c	c	c	452	c	c	677.0
Crude oil and products	c	c	575,000	1,080	c	276	158.4
Class I Railroads[e]	**633**	**26,883**	**1,109,309**	**2,047**	**794**	**344**	**381.6**

Source:
See Appendix A for Table 2.14.

[a]For general freight (less than truckload). Based on data from the Eno Transportation Foundation, the average length of haul for specialized freight (truckload) was 283 miles.
[b]Includes commerce by foreign and domestic carriers in the U.S. 1992 data; 1993 data are not yet available.
[c]Data are not available.
[d]Internal only. Average length of haul for local was 13 miles.
[e]Railroad measures are: Number vehicles = Number freight cars, Vehicle-miles = car-miles, Ton miles = revenue ton-miles.

Table 2.15
Energy Intensities of Passenger Modes, 1970-93

Year	Automobiles (Btu per vehicle-mile)	Automobiles (Btu per passenger-mile)	Buses: Transit[a] (Btu per vehicle-mile)	Buses: Transit[a] (Btu per passenger-mile)	Buses: Intercity (Btu per passenger-mile)	Buses: School (Btu per vehicle-mile)	Air: Certificated air carriers (Btu per passenger-mile)	Air: General aviation (Btu per passenger-mile)	Rail: Intercity Amtrak (Btu per passenger-mile)	Rail: Rail transit (Btu perpassenger-mile)
1970	9,301	5,471	31,796	2,472	1,051	17,857	10,351	10,374	[b]	2,453
1971	9,284	5,461	30,255	2,475	1,039	17,857	10,103	9,957	[b]	2,595
1972	9,383	5,519	30,352	2,454	1,016	16,956	9,017	10,340	[b]	2,540
1973	9,455	5,562	30,657	2,597	981	16,957	8,919	8,449	3,756	2,460
1974	9,372	5,513	31,516	2,518	949	16,980	7,917	9,054	3,240	2,840
1975	9,295	5,468	33,748	2,814	976	17,040	7,883	10,658	3,677	2,962
1976	9,293	5,467	34,598	2,896	996	17,051	7,481	10,769	3,397	2,971
1977	9,113	5,360	35,120	2,889	961	16,983	7,174	11,695	3,568	2,691
1978	8,955	5,268	36,603	2,883	953	17,018	6,333	11,305	3,683	2,210
1979	8,727	5,134	36,597	2,795	963	16,980	5,858	10,787	3,472	2,794
1980	8,130	4,782	36,553	2,813	1,169	16,379	5,837	11,497	3,176	3,008
1981	7,894	4,644	37,745	3,027	1,155	16,385	5,743	11,123	2,957	2,946
1982	7,558	4,446	38,766	3,237	1,149	16,296	5,147	13,015	3,156	3,069
1983	7,314	4,302	37,962	3,177	1,174	16,236	5,107	11,331	2,957	3,212
1984	7,031	4,136	37,507	3,204	1,247	14,912	5,031	11,912	3,027	3,732
1985	6,880	4,047	38,862	2,421	1,323	16,531	5,679	11,339	2,800	3,461
1986	6,853	4,031	39,869	3,512	869	15,622	5,447	11,935	2,574	3,531
1987	6,530	3,841	38,557	3,542	939	15,615	4,753	11,218	2,537	3,534
1988	6,275	3,598	39,121	3,415	965	15,585	4,814	11,966	2,462	3,585
1989	6,095	3,809	36,583	3,711	963	15,575	4,796	10,984	2,731	3,397
1990	5,983	3,739	36,647	3,735	944	16,368	4,811	10,146	2,609	3,453
1991	5,767	3,604	36,939	3,811	962	16,419	4,560	9,556	2,503	3,710
1992	5,738	3,586	37,071	3,970	954	16,386	4,482	8,582	2,610	3,575
1993	5,748	3,593	39,081	4,374	[b]	[b]	[b]	[b]	2,646	3,687
					Average annual percentage change					
1970-93	-2.1%	-1.8%	1.0%	2.5%	-0.4%[c]	-0.4%[c]	-3.7%[c]	-0.9%[c]	-1.7%[d]	1.8%
1983-93	-2.4%	-1.8%	0.5%	3.7%	-1.8%[c]	0.1%[c]	-1.4%[c]	-4.1%[c]	-0.9%	1.4%

Source:
See Appendix A for Table 2.15.

[a]Series not continuous between 1983 and 1984 because of a change in data source by the American Public Transit Association (APTA).
[b]Data are not available.
[c]Average annual percentage change is for years 1970-92 and 1982-92.
[d]Average annual percentage change is for years 1973-93.

All freight modes experienced energy efficiency improvements from 1970 to 1993. Domestic waterborne commerce, however, reversed this trend from 1982 to 1992 with a 2.5% decline in energy efficiency.

Table 2.16
Energy Intensities of Freight Modes, 1970-93

	Trucks			Class I freight railroad		Domestic waterborne commerce (Btu per ton-mile)
Year	Light truck[a] (Btu per vehicle-mile)	Other trucks (Btu per vehicle-mile)	Total trucks (Btu per vehicle-mile)	(Btu per freight car-mile)	(Btu per ton-mile)	
1970	12,491	24,142	16,399	16,748	655	545
1971	12,229	23,685	15,945	17,655	696	506
1972	12,099	23,350	15,646	18,087	706	522
1973	11,909	23,251	15,417	18,046	662	576
1974	11,398	22,555	14,669	18,422	665	483
1975	11,161	21,997	14,286	18,604	682	549
1976	11,167	22,644	14,335	18,843	677	468
1977	10,926	22,679	14,157	19,180	667	458
1978	10,765	22,887	14,093	18,802	637	383
1979	10,599	23,027	13,978	19,113	616	457
1980	10,143	22,352	13,489	18,585	592	358
1981	10,002	22,640	13,394	18,582	571	360
1982	9,741	22,736	13,103	18,224	547	310
1983	9,755	22,967	13,146	17,719	521	319
1984	9,777	22,884	13,147	17,740	508	346
1985	9,730	23,100	12,851	17,131	487	446
1986	9,729	23,106	13,082	16,855	474	463
1987	9,705	23,136	13,010	16,307	443	402
1988	9,350	23,387	12,767	16,436	434	361
1989	9,081	23,128	12,532	16,525	427	403
1990	8,904	22,581	12,230	16,254	411	388
1991	8,632	21,917	11,843	15,577	384	386
1992	8,692	22,134	11,947	16,281	399	398
1993	8,780	22,332	12,070	14,195	344	[b]
		Average annual percentage change				
1970-93	-1.5%	-0.3%	-1.3%	-0.7%	-2.8%	-1.4%[c]
1983-93	-1.0%	-0.3%	-0.9%	-1.0%	-4.1%	2.5%[c]

Source:
See Appendix A for Table 2.16.

[a]All two-axle, four-tire trucks.
[b]Data are not available.
[c]Average annual percentage changes are for years 1970-92 and 1982-92.

Transportation Energy Trends Analysis

Since the first oil price shock in October of 1973, important changes have occurred in the way energy is used in the U.S. transportation system. Knowing how and how much transportation energy use has changed is important to understanding how the system responds to energy challenges and how it is evolving as a result of long-term social, economic, and technological trends. As a first level of analysis, changes in transportation energy use can be decomposed into changes due to: 1) growth in transportation activity, 2) changes in the distribution of activity across modes, and 3) changes in the energy intensiveness of transport modes. A mathematical technique known as Divisia analysis can be used to rigorously decompose energy use trends (see, e.g., Greene and Fan, 1994). This technique is used here to look at the sector as a whole, at a high level of generality, and to look in increasing detail at passenger and freight movements, and the highway, air, and rail modes. The modal structure and components analyzed in each of the six Divisia decompositions are summarized in Table 2.17.

For each analysis a table and figure are displayed. The tables show actual energy use by year in the first column, followed by the level of energy use that would have been required for that year if the actual level of transportation activity had taken place at 1972 average energy intensity (the "trended energy use"). Next comes the total change in energy use from the previous year, followed by the components of change. The components will add up to the total change, except for rounding. Note that the components will tend to increase in absolute value over time, all else equal, as activity levels increase. Finally, the level of activity is shown. In the figures, trended energy use and actual energy use are plotted as dashed and solid lines, respectively. Below are bars showing the individual components, factors tending to increase energy use project above zero, those tending to decrease it project below zero. The sum of the bars in each year exactly equals the difference between the trended and actual energy use.

This work was performed by Oak Ridge National Laboratory for the U.S. Department of Energy, Office of Energy Demand Policy.

Table 2.17
Modal Structure and Components for Each Divisia Analysis Group

Analysis	Mode	Components
Transportation	Automobile Light Truck Bus Passenger Rail Commercial Air General Aviation Single-unit Heavy Truck Combination Heavy Truck Rail Freight Pipeline Domestic Waterborne International Waterborne Military	Activity Modal Structure Energy Intensity
Passenger	Automobile Light Truck Bus Passenger Rail Commercial Air General Aviation	Growth of Passenger-miles Modal Structure Energy Intensity
Highway Passenger	Passenger Car Light Truck Bus General Aviation	Growth of Passenger-miles Vehicle Type Vehicle Occupancy Energy Intensity/Vehicle-mile
Air Passenger	Commercial Air	Growth of Passenger-mile Load Factor Energy Intensity/Seat-mile
Freight	Single-unit Heavy Truck Combination Heavy Truck Rail Freight Domestic Waterborne Pipeline	Growth of Ton-miles Modal Structure Energy Intensity
Rail Freight		Growth of Ton-miles Load Factor Energy Intensity/Car-mile

Source:
Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

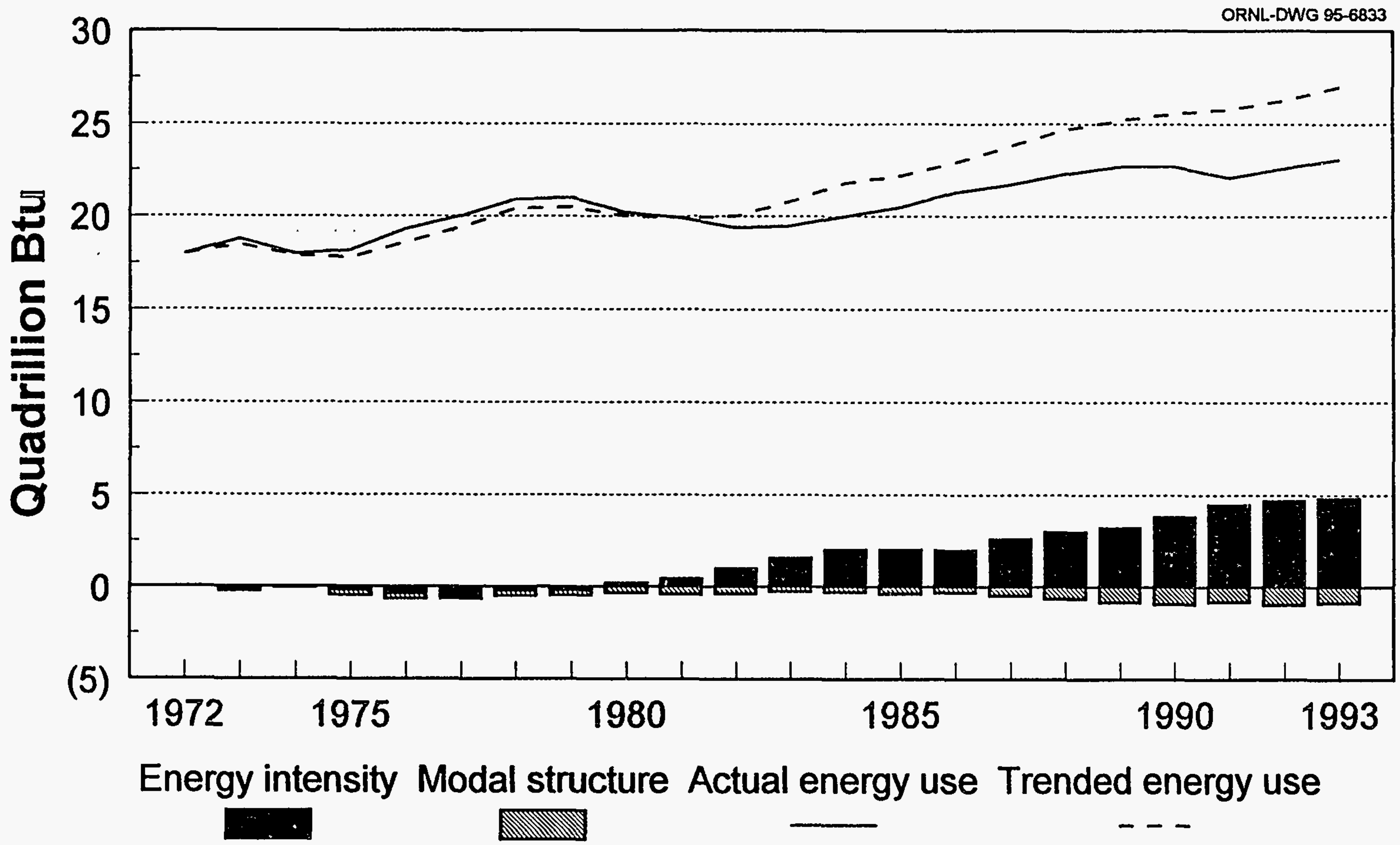
Overall transportation energy use increased by five quads from 1972 to 1993, from 18.0 to 23.1 quads. Energy use would have been 4 quads (17%) higher, had energy intensiveness not been reduced. Note that there is little difference between actual and trended energy use in the first decade from 1972 to 1982, and that the two curves diverge thereafter. This implies that the energy intensity of transportation changed very little during the first decade following the initial oil price shock of 1973-74. The changes in transportation energy use during that period were due primarily to changes in the amount of transportation activity. In other words, response to the initial price shock came largely in the form of traveling less and shipping less. The fact that energy efficiency improvements did not come until after the second price shock in 1979-80, is largely due to the fact that it takes a long time to change the energy using technology embodied in transportation equipment. Not only do transportation vehicles last a decade and often considerably more, but it takes additional time for manufacturers to redesign and retool to produce more efficient vehicles.

Table 2.18
Changes in Transportation Energy Use, 1972-93
Modal Energy Intensity And Modal Structure Effects

Year	Actual energy use (Quads)	Trended energy use (Quads)	Components of energy savings (Quads)			Activity (billion 1987 dollars)
			Total	Modal energy intensity	Modal structure	
1972	18.0	18.0	0.00	0.00	0.00	679
1973	18.8	18.5	-0.28	-0.13	-0.14	697
1974	18.0	17.9	-0.07	-0.02	-0.05	674
1975	18.2	17.8	-0.46	-0.23	-0.23	670
1976	19.3	18.6	-0.67	-0.42	-0.25	701
1977	20.0	19.4	-0.67	-0.49	-0.17	731
1978	20.9	20.4	-0.50	-0.25	-0.25	771
1979	21.0	20.5	-0.48	-0.21	-0.26	775
1980	20.2	20.0	-0.13	0.22	-0.35	756
1981	19.9	19.9	0.03	0.45	-0.42	751
1982	19.4	20.0	0.62	1.01	-0.39	754
1983	19.5	20.8	1.34	1.59	-0.25	785
1984	20.0	21.8	1.77	2.04	-0.27	822
1985	20.5	22.2	1.68	2.05	-0.37	835
1986	21.3	22.9	1.66	1.99	-0.33	864
1987	21.7	23.8	2.15	2.61	-0.46	898
1988	22.3	24.7	2.37	3.00	-0.63	931
1989	22.7	25.2	2.42	3.23	-0.81	948
1990	22.7	25.6	2.91	3.84	-0.93	964
1991	22.1	25.8	3.69	4.48	-0.79	973
1992	22.6	26.3	3.75	4.70	-0.95	992
1993	23.1	27.0	3.97	4.83	-0.86	1,019

Source:
Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

Figure 2.11. Changes in Transportation Energy Use, 1972-93
Modal Energy Intensity And Modal Structure Effects



Source: See Table 2.18.

The decomposition of energy use in passenger travel looks very similar to that of total transportation. This is because, 1) passenger travel accounts for 70% of total transportation energy use, and 2) there appears to have been little overall change in freight energy intensity, as is shown in the following material. Although energy use for passenger travel is 3.4 quads (21%) less than it would have been at 1972 energy intensities, the efficiency improvement component declined in 1993, for the first time since 1977. It may be that the actual and trended curves are no longer diverging, and that energy use in U.S. passenger travel is becoming less, rather than more energy efficient.

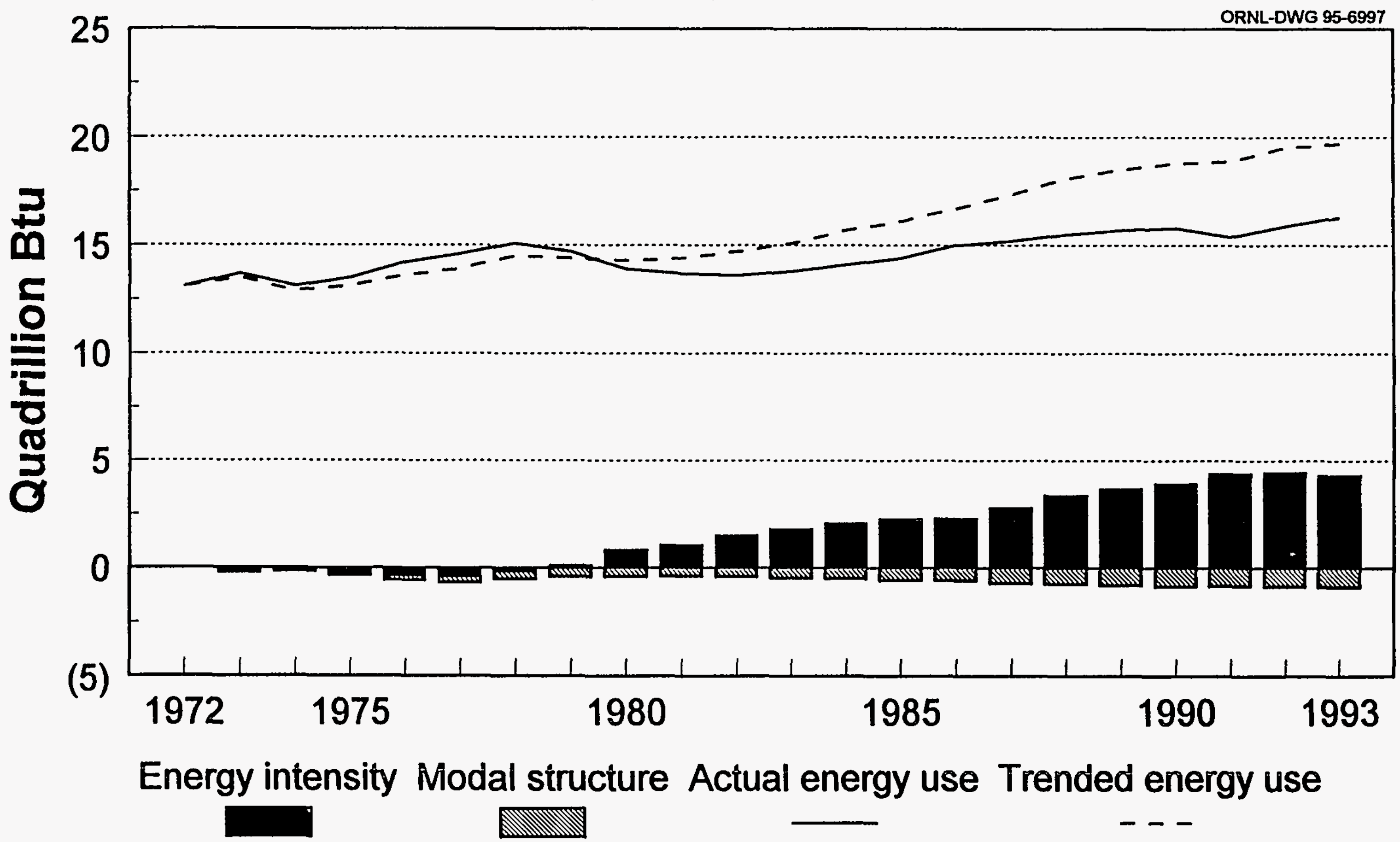
Table 2.19
Changes in Passenger Transportation Energy Use, 1972-93
Modal Energy Intensity And Modal Structure Effects

Year	Actual energy use (Quads)	Trended energy use (Quads)	Components of energy savings (Quads)			Activity (billion passenger-miles)
			Total	Modal energy intensity	Modal structure	
1972	13.1	13.1	0.00	0.00	0.00	2,717
1973	13.7	13.5	-0.25	-0.14	-0.11	2,784
1974	13.1	12.9	-0.19	-0.06	-0.13	2,671
1975	13.5	13.1	-0.38	-0.22	-0.16	2,704
1976	14.2	13.6	-0.61	-0.40	-0.21	2,810
1977	14.6	13.9	-0.69	-0.42	-0.27	2,875
1978	15.1	14.5	-0.54	-0.17	-0.37	3,007
1979	14.7	14.4	-0.30	0.12	-0.42	2,986
1980	13.9	14.3	0.43	0.83	-0.41	2,958
1981	13.7	14.4	0.65	1.05	-0.40	2,970
1982	13.6	14.7	1.05	1.48	-0.42	3,031
1983	13.8	15.1	1.31	1.79	-0.48	3,119
1984	14.1	15.7	1.54	2.06	-0.52	3,238
1985	14.4	16.1	1.67	2.26	-0.60	3,324
1986	15.0	16.7	1.70	2.29	-0.59	3,444
1987	15.2	17.3	2.05	2.78	-0.73	3,577
1988	15.5	18.1	2.58	3.34	-0.76	3,746
1989	15.7	18.5	2.84	3.65	-0.81	3,833
1990	15.8	18.8	3.03	3.90	-0.87	3,897
1991	15.4	18.9	3.52	4.37	-0.85	3,911
1992	15.9	19.5	3.58	4.44	-0.86	4,033
1993	16.3	19.7	3.38	4.28	-0.90	4,074

Source:

Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

Figure 2.12. Changes in Passenger Transportation Energy Use, 1972-93
Modal Energy Intensity And Modal Structure Effects



Source: See Table 2.19.

The most interesting aspect of trends in highway passenger energy use is the fact that very large potential gains due to vehicle fuel economy have been cut more than in half by decreasing vehicle occupancy rates. Highway passenger energy use would have been 6.7 (48%) higher had there been no improvement in vehicle miles per gallon. A persistent, gradual trend of fewer passengers per vehicle offset 3.9 quads (58%) of the potential energy savings due to vehicle fuel economy. The vehicle occupancy data come from the Nationwide Personal Transportation Survey conducted approximately every five years. Thus, true year-to-year changes cannot be captured. Nonetheless, the trend of steadily declining vehicle occupance rates is clearly reflected in every survey. Changes in the distribution of travel among vehicle types has also tended to increase energy intensiveness, though by less than 5%. Increasing popularity of light trucks is largely responsible. Energy savings over 1972 decreased in 1993 for the second year in a row.

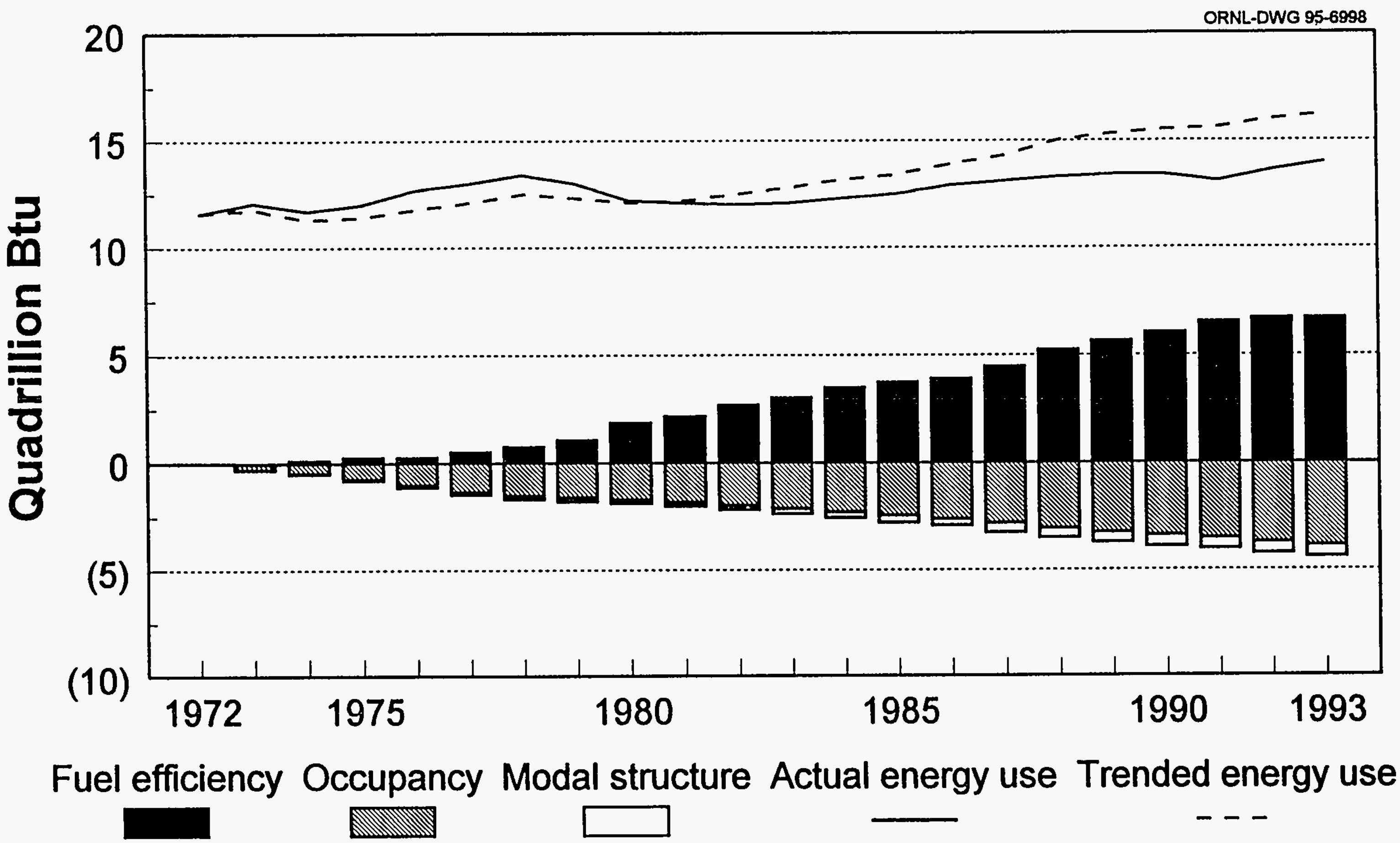
Table 2.20
Changes in Highway Passenger Transportation Energy Use, 1972-93
Efficiency, Occupancy and Vehicle Type Effects

			Components of energy savings (Quads)				
Year	Actual energy use (Quads)	Trended energy use (Quads)	Total	Fuel efficiency	Occupancy	Modal structure	Activity (billion passenger-miles)
1972	11.6	11.6	0.00	0.00	0.00	0.00	25,337
1973	12.1	11.8	-0.32	-0.04	-0.24	-0.04	25,774
1974	11.7	11.3	-0.38	0.14	-0.48	-0.04	24,627
1975	12.0	11.4	-0.56	0.26	-0.74	-0.07	24,973
1976	12.7	11.8	-0.86	0.27	-1.04	-0.09	25,839
1977	13.0	12.1	-0.94	0.53	-1.35	-0.12	26,346
1978	13.4	12.5	-0.92	0.78	-1.52	-0.17	27,338
1979	13.0	12.3	-0.72	1.07	-1.60	-0.19	26,770
1980	12.2	12.1	-0.02	1.86	-1.70	-0.18	26,519
1981	12.1	12.2	0.18	2.18	-1.83	-0.18	26,741
1982	12.0	12.5	0.51	2.69	-1.98	-0.20	27,254
1983	12.1	12.8	0.64	3.03	-2.14	-0.24	27,902
1984	12.3	13.2	0.91	3.48	-2.30	-0.26	28,842
1985	12.5	13.4	0.96	3.74	-2.45	-0.33	29,381
1986	12.9	13.9	0.98	3.91	-2.62	-0.31	30,295
1987	13.1	14.3	1.21	4.46	-2.83	-0.42	31,228
1988	13.3	15.0	1.71	5.21	-3.06	-0.44	32,717
1989	13.4	15.3	1.93	5.65	-3.24	-0.48	33,469
1990	13.4	15.5	2.09	6.01	-3.39	-0.52	33,869
1991	13.1	15.6	2.49	6.53	-3.53	-0.51	34,104
1992	13.6	16.0	2.43	6.67	-3.73	-0.50	35,025
1993	14.0	16.2	2.25	6.67	-3.88	-0.54	35,438

Source:

Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

Figure 2.13. Changes in Highway Passenger Transportation Energy Use, 1972-93
Efficiency, Occupancy and Vehicle Type Effects



Source: See Table 2.20.

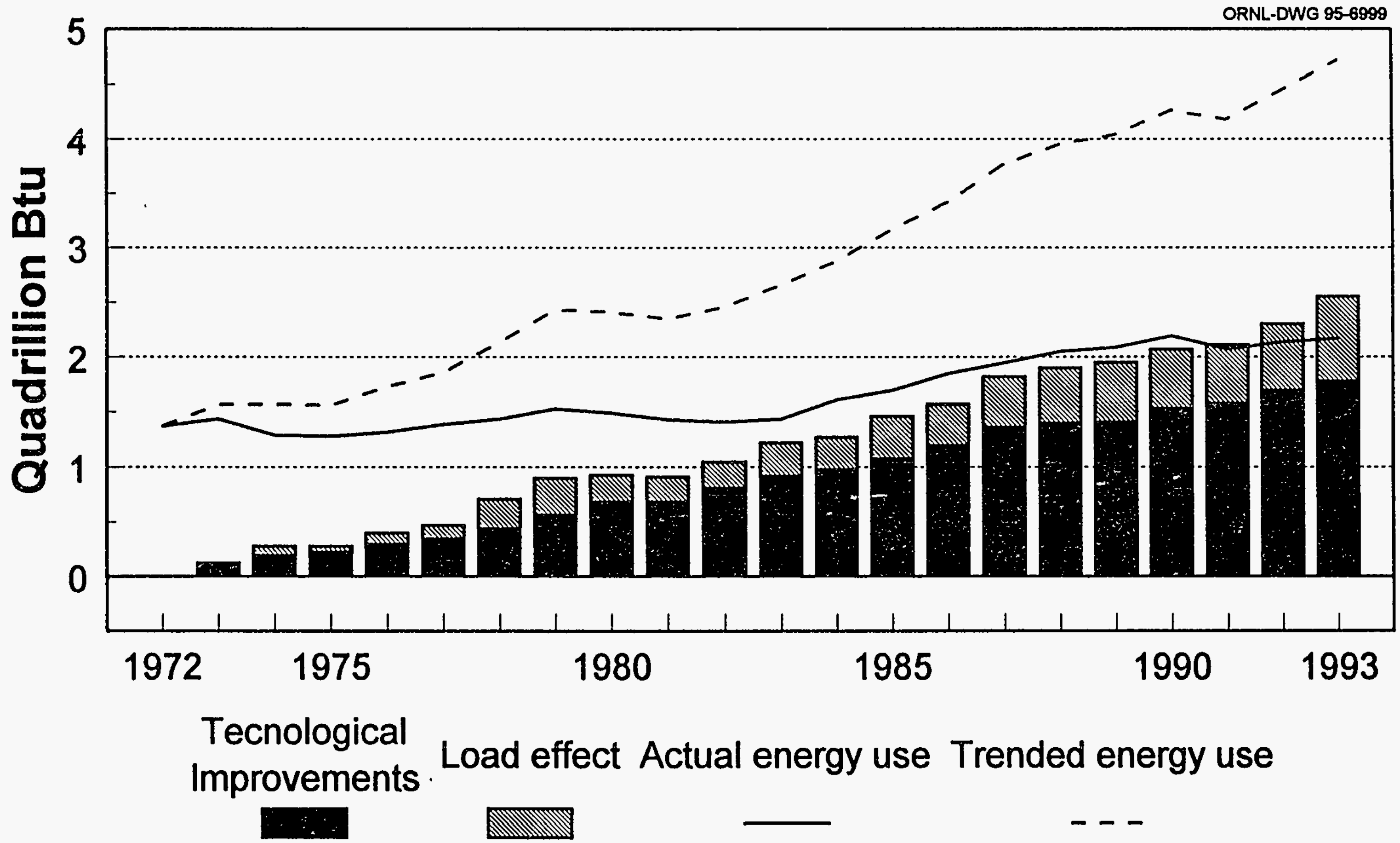
Had there been no reduction in the energy intensity of air travel since 1972, commercial airlines would be using twice as much jet fuel as they are today: 4.4 instead of 2.2 quads. This remarkable increase in the energy efficiency of air travel was achieved through a combination of aircraft and load factor improvements. Reduced energy use per seat-mile, accomplished by simultaneously reducing energy use per aircraft mile and increasing aircraft size (average number of seats per aircraft), accounted for nearly three quarters of the reduction in energy use per passenger. Higher load factors (average seat occupancy rates) provided the rest of the savings.

Table 2.21
Changes in Air Passenger Transportation Energy Use, 1972-93
Seat-Miles Efficiency and Load Factor Effects

Year	Actual energy use (Quads)	Trended energy use (Quads)	Components of energy savings (Quads)			Activity (billion passenger-miles)
			Total	Technological improvements	Load effect	
1972	1.37	1.37	0.00	0.00	0.00	152
1973	1.44	1.57	0.13	0.10	0.03	174
1974	1.29	1.57	0.28	0.20	0.08	174
1975	1.28	1.56	0.28	0.23	0.05	173
1976	1.32	1.73	0.41	0.30	0.10	192
1977	1.39	1.86	0.47	0.35	0.12	206
1978	1.44	2.14	0.70	0.44	0.27	237
1979	1.53	2.43	0.90	0.57	0.33	270
1980	1.49	2.41	0.92	0.69	0.24	268
1981	1.43	2.35	0.92	0.69	0.22	260
1982	1.41	2.46	1.05	0.81	0.24	272
1983	1.44	2.66	1.22	0.92	0.30	295
1984	1.61	2.88	1.27	0.98	0.29	320
1985	1.70	3.17	1.46	1.08	0.38	351
1986	1.85	3.42	1.57	1.20	0.37	379
1987	1.95	3.77	1.82	1.36	0.46	418
1988	2.05	3.95	1.90	1.40	0.50	438
1989	2.09	4.04	1.95	1.41	0.54	447
1990	2.19	4.26	2.07	1.53	0.54	472
1991	2.07	4.18	2.11	1.58	0.53	463
1992	2.14	4.45	2.30	1.70	0.60	493
1993	2.17	4.72	2.55	1.78	0.77	523

Source:
Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

Figure 2.14. Changes in Air Passenger Transportation Energy Use, 1972-93
Seat-Miles Efficiency and Load Factor Effects



Source: See Table 2.21.

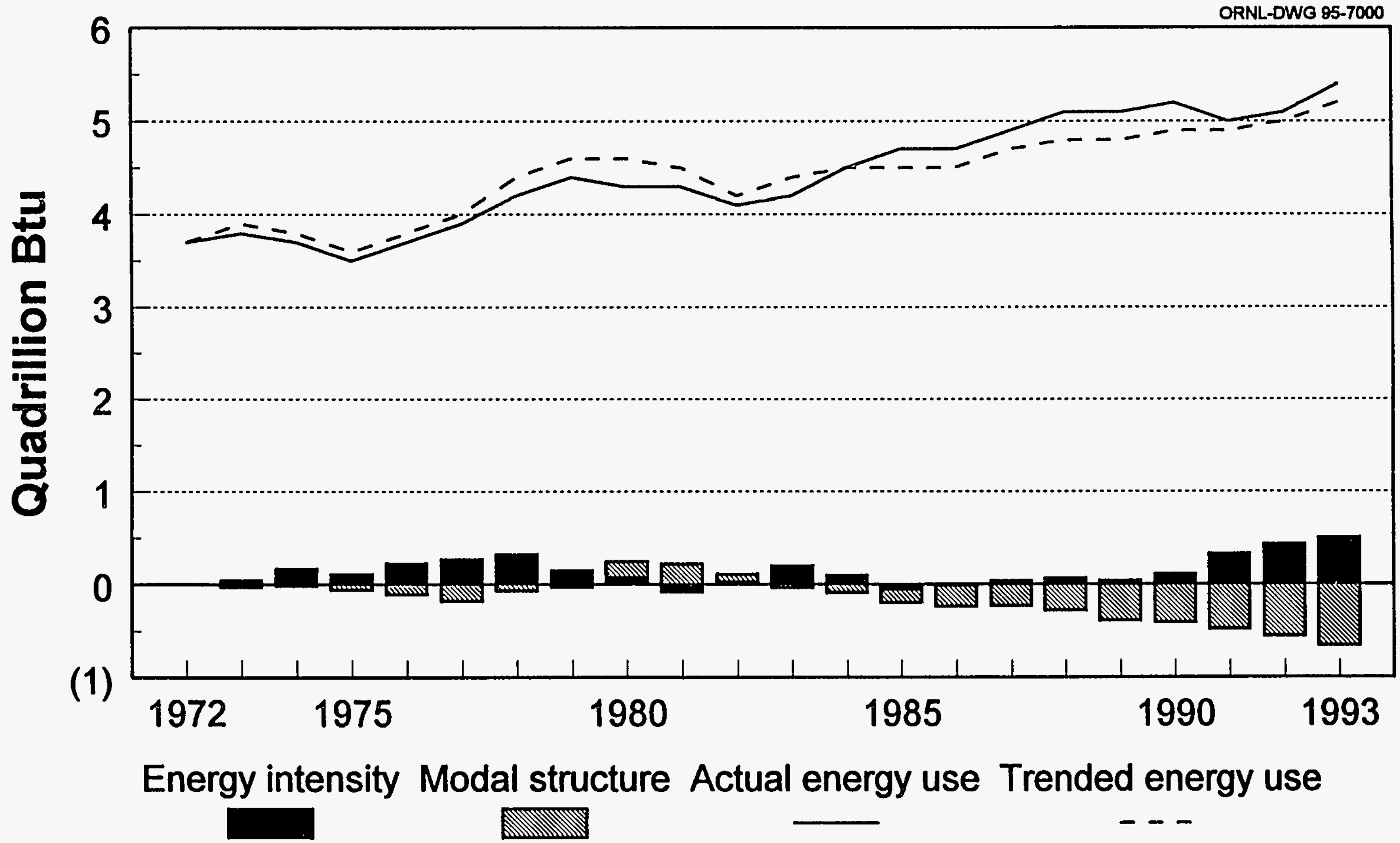
Before reviewing the freight transportation energy decomposition, we note that the quality of estimates of freight ton-miles tends to be poor, especially for the highway mode which is by far the largest energy user. Since energy use per ton-mile is the basic measure of energy intensity, this argues for caution in drawing firm conclusions about the freight sector Divisia analysis. With that in mind, the data indicate that at 1972 energy intensities, 1993 freight movements would have required essentially the same amount of energy as was actually used in 1993. That is, no overall improvement in energy intensity is indicated. A 10% improvement in energy use per ton-mile within individual modes appears to have been wiped out by a gradual shift in traffic to the more energy intensive modes (highway and air).

Table 2.22
Changes in Freight Transportation Energy Use, 1972-93
Modal Energy Intensity And Modal Structure Effects

Year	Actual energy use (Quads)	Trended energy use (Quads)	Components of energy savings (Quads)			Activity (billion ton-miles)
			Total	Modal energy intensity	Modal structure	
1972	3.7	3.7	0.00	0.00	0.00	2,871
1973	3.8	3.9	0.02	0.05	-0.03	3,019
1974	3.7	3.8	0.14	0.17	-0.02	2,986
1975	3.5	3.6	0.05	0.11	-0.06	2,812
1976	3.7	3.8	0.12	0.23	-0.11	2,968
1977	3.9	4.0	0.09	0.27	-0.18	3,099
1978	4.2	4.4	0.25	0.32	-0.07	3,471
1979	4.4	4.6	0.12	0.15	-0.03	3,571
1980	4.3	4.6	0.25	0.08	0.17	3,568
1981	4.3	4.5	0.14	-0.08	0.22	3,507
1982	4.1	4.2	0.11	0.03	0.08	3,312
1983	4.2	4.4	0.17	0.20	-0.04	3,412
1984	4.5	4.5	0.01	0.10	-0.09	3,563
1985	4.7	4.5	-0.20	-0.06	-0.14	3,511
1986	4.7	4.5	-0.24	-0.01	-0.23	3,511
1987	4.9	4.7	-0.19	0.04	-0.23	3,670
1988	5.1	4.8	-0.21	0.07	-0.28	3,795
1989	5.1	4.8	-0.34	0.04	-0.39	3,764
1990	5.2	4.9	-0.30	0.11	-0.41	3,810
1991	5.0	4.9	-0.15	0.33	-0.48	3,812
1992	5.1	5.0	-0.13	0.43	-0.56	3,902
1993	5.4	5.2	-0.17	0.50	-0.66	4,066

Source:
Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

Figure 2.15. Changes in Freight Transportation Energy Use, 1972-93
Modal Energy Intensity And Modal Structure Effects



Source: See Table 2.22.

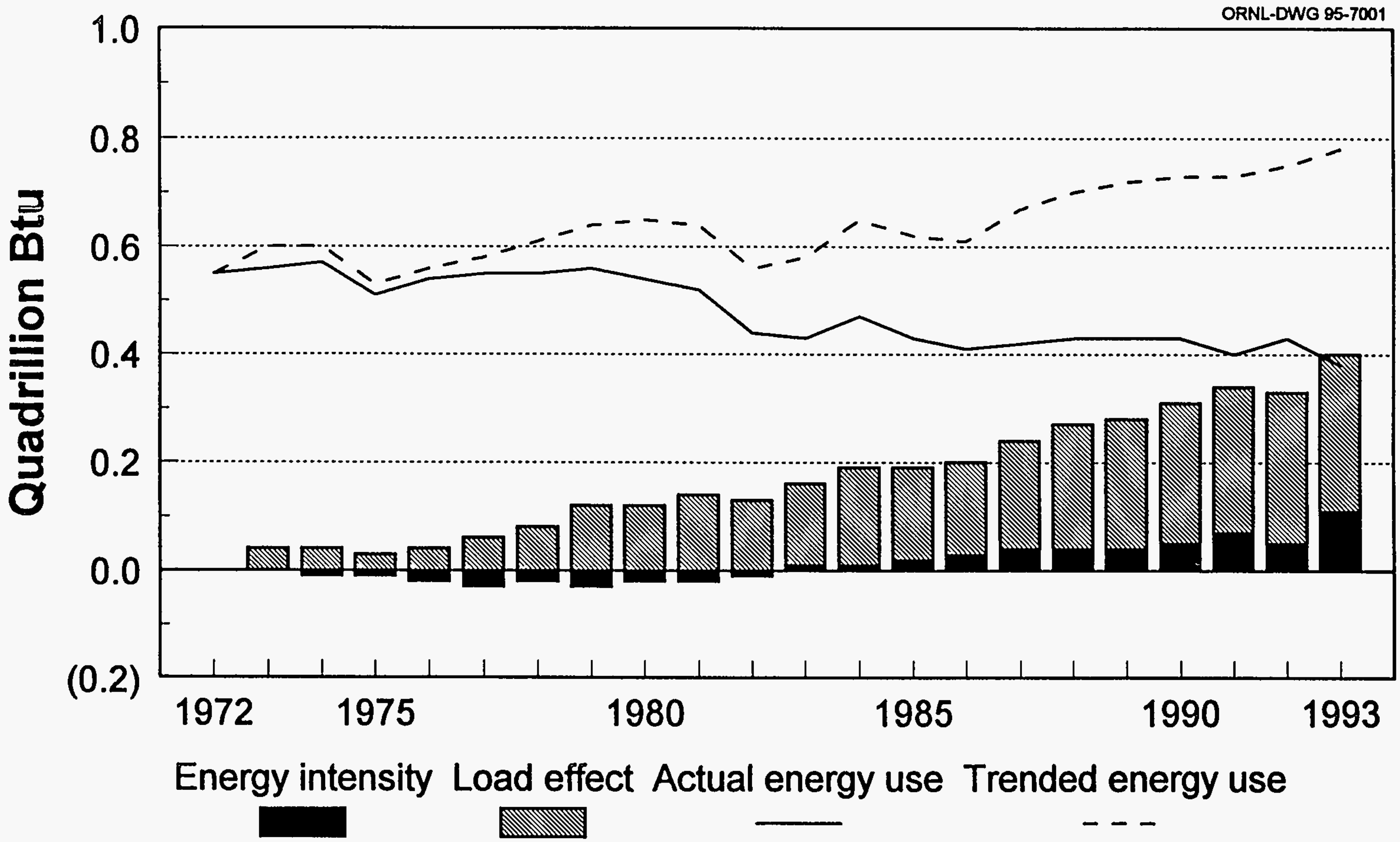
In sharp contrast to overall freight energy intensity trends, rail energy use per ton-mile has been dramatically improved. At 1972 energy intensity per ton-mile, 1993 rail freight movements would have required more than twice as much energy (0.78 quads versus 0.38 quads actually used). Higher car-loadings are primarily responsible. More than any other mode, rail freight appears to have increased its energy efficiency by improving the efficiency of operations. Energy use per car-mile was also reduced, however, despite the increase in ton-miles per car-mile. Unlike other modes, rail freight energy intensity improved once again in 1993.

Table 2.23
Changes in Rail Freight Transportation Energy Use, 1972-93
Efficiency and Load Factor Effects

Year	Actual energy use (Quads)	Trended energy use (Quads)	Components of energy savings (Quads)			Activity (billion ton-miles)
			Total	Modal energy intensity	Load effect	
1972	0.55	0.55	0.00	0.00	0.00	777
1973	0.56	0.60	0.04	0.00	0.04	852
1974	0.57	0.60	0.03	-0.01	0.04	851
1975	0.51	0.53	0.02	-0.01	0.03	754
1976	0.54	0.56	0.02	-0.02	0.04	794
1977	0.55	0.58	0.03	-0.03	0.06	826
1978	0.55	0.61	0.06	-0.02	0.08	858
1979	0.56	0.64	0.08	-0.03	0.12	914
1980	0.54	0.65	0.10	-0.02	0.12	919
1981	0.52	0.64	0.12	-0.02	0.14	910
1982	0.44	0.56	0.13	-0.01	0.13	798
1983	0.43	0.58	0.15	0.01	0.15	828
1984	0.47	0.65	0.18	0.01	0.18	922
1985	0.43	0.62	0.19	0.02	0.17	877
1986	0.41	0.61	0.20	0.03	0.17	868
1987	0.42	0.67	0.25	0.04	0.20	944
1988	0.43	0.70	0.27	0.04	0.23	996
1989	0.43	0.72	0.28	0.04	0.24	1,014
1990	0.43	0.73	0.30	0.05	0.26	1,034
1991	0.40	0.73	0.33	0.07	0.27	1,039
1992	0.43	0.75	0.33	0.05	0.28	1,067
1993	0.38	0.78	0.40	0.11	0.29	1,109

Source:
Greene, David L. and Yuehui Fan, Transportation Energy Efficiency Trends, 1972-1992, Oak Ridge National Laboratory, Oak Ridge, TN, December 1994.

Figure 2.16. Changes in Rail Freight Transportation Energy Use, 1972-93 Efficiency and Load Factor Effects



Source: See Table 2.23.

Section 2.3.
Economics

The retail price of gasoline (all types) has been declining since 1990. Prices for alternative fuels can be found in Chapter 5.

Table 2.24
Retail Prices for Motor Fuel, 1978-93
(cents per gallon, including tax)

Year	Diesel Fuel[a]		Unleaded regular gasoline[b] (87 to 88.9 octane)		Unleaded premium gasoline[b] (91 octane and above)		Average for all gasoline types[b]	
	Current	Constant 1990[c]	Current	Constant 1990[c]	Current	Constant 1990[c]	Current	Constant 1990[c]
1978	[d]	[d]	67.0	134.2	[d]	[d]	65.2	130.6
1979	[d]	[d]	90.3	162.6	[d]	[d]	88.2	158.8
1980	101.0	160.2	124.5	197.4	[d]	[d]	122.1	193.6
1981	118.0	169.5	137.8	198.0	147.0	211.2	135.3	194.4
1982	116.0	157.0	129.6	175.5	141.5	191.6	128.1	173.4
1983	120.0	157.4	124.1	162.8	138.3	181.4	122.5	160.7
1984	122.0	153.5	121.2	152.5	136.6	171.9	119.8	150.7
1985	122.0	148.2	120.2	146.0	134.0	162.8	119.6	145.3
1986	94.0	112.0	92.7	110.5	108.5	129.3	93.1	111.0
1987	96.0	110.4	94.8	109.0	109.3	125.7	95.7	110.0
1988	95.0	104.9	94.6	104.5	110.7	122.3	96.3	106.4
1989	102.0	107.5	102.1	107.6	119.7	126.2	106.0	111.7
1990	99.0	99.0	116.4	116.4	134.9	134.9	121.7	121.7
1991	91.0	87.3	114.0	109.3	132.1	126.7	119.6	114.7
1992	106.0	98.7	112.7	104.9	131.6	122.5	119.0	110.8
1993	98.0	88.7	110.8	100.3	130.2	117.8	117.3	106.2
				Average annual percentage change				
1978-93	-0.2%	-4.4%[e]	3.4%	-1.9%	-1.0%[e]	-4.7%[f]	4.0%	-1.4%
1983-93	-2.0%	-5.6%	-1.1%	-4.7%	-0.6%	-4.2%	-0.4%	-4.1%

Sources:
Gasoline - U.S. Department of Energy, Energy Information Administration, Monthly Energy Review March 1994, Washington, DC, Table 9.4, p. 112.
Diesel - U.S. Department of Energy, Energy Information Administration, International Energy Annual 1992, Washington, DC, January 1994, pp. 153.

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[a]Collected from a survey of prices on January 1 of the current year.
[b]These prices were collected from a sample of service stations in 85 urban areas selected to represent all urban consumers. Urban consumers make up about 80% of the total U.S. population.
[c]Adjusted by the Consumer Price Inflation Index.
[d]Data are not available.
[e]Average annual percentage change is for years 1981-93.

The fuel prices shown here are ***refiner sales prices*** *of transportation fuels to end users, excluding tax. Sales to end users are those made directly to the ultimate consumer, including bulk consumers. Bulk sales to utility, industrial, and commercial accounts previously included in the wholesale category are now counted as sales to end users. Prices for alternative fuels are found in Chapter 5.*

Table 2.25
Prices for Selected Transportation Fuels, 1978-93
(cents per gallon, excluding tax)

	Propane[f]		Finished aviation gasoline		Kerosene-type jet fuel		No. 2 diesel fuel	
Year	Current	Constant 1990[g]	Current	Constant 1990	Current	Constant 1990[b]	Current	Constant 1990[b]
1978	33.5	67.1	51.6	103.4	38.7	77.5	37.7	75.5
1979	35.7	64.3	68.9	124.0	54.7	98.5	58.5	105.3
1980	48.2	76.4	108.4	171.9	86.6	137.3	81.8	129.7
1981	56.5	81.2	130.3	187.2	102.4	147.1	99.5	143.0
1982	59.2	80.1	131.2	177.6	96.3	130.4	94.2	127.5
1983	70.9	93.0	125.5	164.6	87.8	115.2	82.6	108.4
1984	73.7	92.7	123.4	155.3	84.2	105.9	82.3	103.5
1985	71.7	87.1	120.1	145.9	79.6	96.7	78.9	95.9
1986	74.5	88.8	101.1	120.5	52.9	63.0	47.8	57.0
1987	70.1	80.6	90.7	104.3	54.3	62.4	55.1	63.4
1988	71.4	78.9	89.1	98.4	51.3	56.7	50.0	55.3
1989	61.5	64.8	99.5	104.9	59.2	62.4	58.5	61.7
1990	74.5	74.5	112.0	112.0	76.6	76.6	72.5	72.5
1991	73.0	70.0	104.7	100.4	65.2	62.6	64.8	62.1
1992	66.2	61.6	102.7	95.6	61.0	58.3	61.8	57.5
1993	66.0	59.7	99.0	89.6	57.9	52.4	60.3	54.6
				Average annual percentage change				
1978-93	4.6%	-0.8%	4.4%	-1.0%	2.7%	-2.6	3.2%	-2.1%
1983-93	-0.7%	-4.3%	-2.3%	-5.9%	-4.1%	-7.6	-3.1%	-6.6%

Sources:
U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, March 1994, Washington, DC, Table 9.7, p. 115.

[f]Consumer grade.
[g]Adjusted by the Consumer Price Inflation Index.

The average price of a barrel of crude oil (in constant 1990 dollars) declined by 33% from 1990 to 1993, while the average price of a gallon of gasoline declined only 17.5% in this same time period. There could be many reasons for this difference—for example, Federal and State gasoline tax increases and differences in crude oil processing cost.

Table 2.26
Prices for a Barrel of Crude Oil and a Gallon of Gasoline, 1978-93

	Crude Oil[h] (dollars per barrel)		Gasoline[i] (cents per gallon)	
Year	Current	Constant 1990[j]	Current	Constant 1990[c]
1978	12.46	24.96	65.2	130.6
1979	17.72	31.90	88.2	158.8
1980	28.07	44.52	122.1	193.6
1981	35.24	50.63	135.3	194.4
1982	31.87	43.15	128.1	173.4
1983	28.99	38.03	122.5	160.7
1984	28.63	36.02	119.8	150.7
1985	26.75	32.50	119.6	145.3
1986	14.55	17.34	93.1	111.0
1987	17.90	20.58	95.7	110.0
1988	14.67	16.21	96.3	106.4
1989	17.97	18.94	106.0	111.7
1990	22.22	22.22	121.7	121.7
1991	19.06	18.28	119.6	114.7
1992	18.43	17.16	119.0	110.8
1993	16.41	14.85	110.9	100.4
		Average annual percentage change		
1978-93	1.9%	-3.4%	3.6%	-1.7%
1983-93	-5.5%	-9.0%	-1.0%	-4.6%

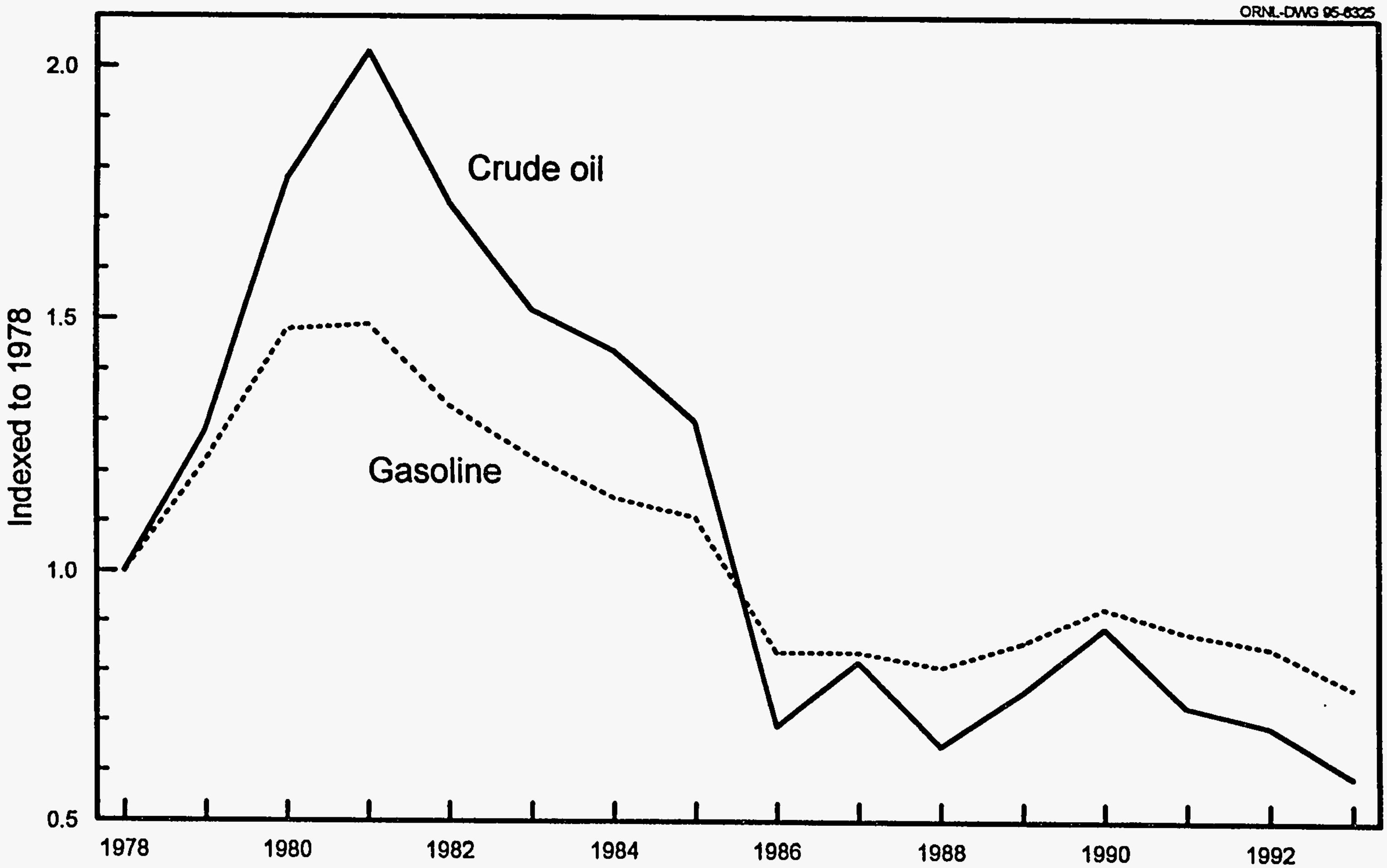
Sources:
Crude Oil - U.S. Department of Energy, Energy Information Administration, Monthly Energy Review, March 1994, Washington, DC, Table 9.1, p. 109.
Gasoline - U.S. Department of Energy, Energy Information Administration Monthly Energy Review, March 1994, Washington, DC, Table 9.4, p. 112.

[h]Refiner acquisition cost of composite (domestic and import) crude oil.

[i]Average for all types. These prices were collected from a sample of service stations in 85 urban areas selected to represent all urban consumers. Urban consumers make up about 80% of the total U.S. population.

[j]Adjusted by the Consumer Price Inflation Index.

Figure 2.17. Crude Oil and Gasoline Price Indices, 1978-93
(based on constant 1990 dollars)



Source: See Table 2.26.

Transportation's share of the Gross National Product (GNP) remains just over 16% in 1993. GNP has been growing at an average rate of 2.8% from 1970 to 1993, while transportation outlays have grown an average of 2.0% annually, in constant 1990 dollars.

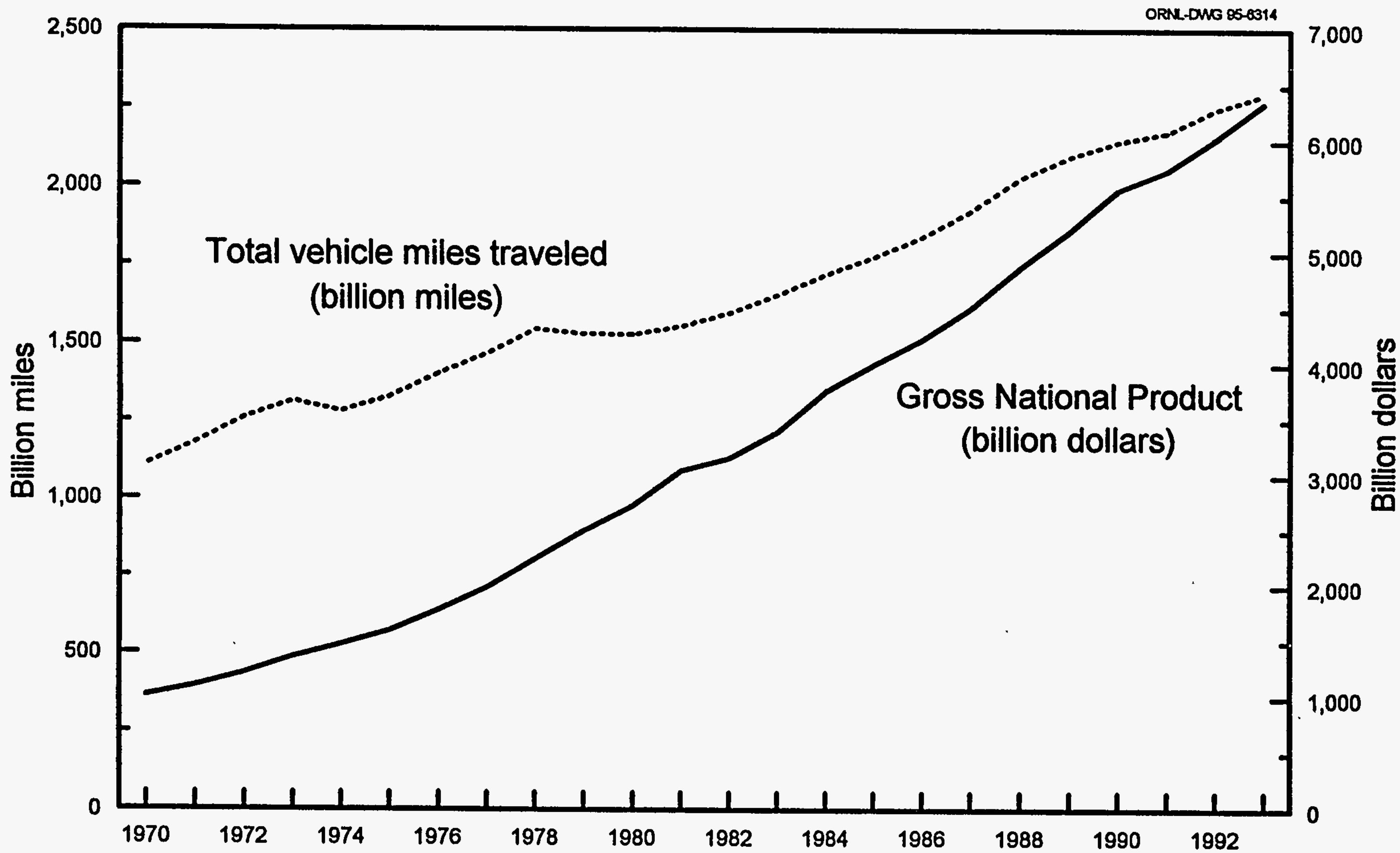
Table 2.27
Gross National Product (GNP) as Related to Transportation, 1970-93

	Gross National Product (billion dollars)		Total transportation outlays (billion dollars)		
Year	Current	Constant 1990	Current	Constant 1990[k]	Transportation as a percent of GNP
1970	1,015.5	3,031.3	195.2	582.7	19.2%
1971	1,102.7	3,127.8	222.0	629.7	20.1%
1972	1,212.8	3,304.5	242.3	660.2	20.0%
1973	1,359.3	3,499.9	266.5	686.2	19.6%
1974	1,472.8	3,490.0	282.6	669.7	19.2%
1975	1,598.4	3,463.9	298.9	647.8	18.7%
1976	1,782.8	3,671.3	351.1	723.0	19.7%
1977	1,990.5	3,871.3	400.9	779.7	20.1%
1978	2,249.7	4,076.6	453.4	821.6	20.2%
1979	2,508.2	4,182.2	503.0	838.7	20.1%
1980	2,732.0	4,167.4	524.9	800.7	19.2%
1981	3,052.6	4,259.0	592.5	826.7	19.4%
1982	3,166.0	4,163.3	591.4	777.7	18.7%
1983	3,405.7	4,308.3	643.2	813.7	18.9%
1984	3,772.2	4,573.5	715.5	867.5	19.0%
1985	4,010.3	4,730.4	753.1	888.3	18.8%
1986	4,235.0	4,861.8	760.9	873.5	18.0%
1987	4,515.6	5,053.2	807.5	903.6	17.9%
1988	4,873.7	5,268.1	868.9	939.2	17.8%
1989	5,200.8	5,416.5	915.2	953.2	17.6%
1990	5,567.8	5,567.8	964.9	964.9	17.3%
1991	5,740.8	5,488.2	951.8	909.9	16.6%
1992	6,025.8	5,567:8	996.3	920.6	16.5%
1993	6,347.8	5,751.1	1,025.4	929.0	16.2%
		Average annual percentage change			
1970-93	8.3%	2.8%	7.5%	2.0%	
1983-93	6.4%	2.9%	4.8%	1.3%	

Sources:
1970-86 GNP - U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States 1988, p.410.
1987-93 GNP - U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, July 1994, Table 1.9, p.57, and annual.
Transportation Outlays - Eno Transportation Foundation, Transportation in America, Twelfth Edition, Washington, DC, 1994, p.38.

[k]Adjusted by the implicit GNP price deflator.

Figure 2.18. Gross National Product and Vehicle Miles Traveled, 1970-93



Source: See Table 2.27 and Table 3.2.

Personal consumption expenditures (PCE) have more than doubled from 1970 to 1993. Transportation PCE have grown 88% in that same time period. Transportation expenditures accounted for 11.5% of total PCE in 1993.

Table 2.28
Personal Consumption Expenditures (PCE) as Related to Transportation, 1970-93

Year	Personal Consumption Expenditures (billion dollars) Current	Personal Consumption Expenditures (billion dollars) Constant 1990[m]	Transportation Personal Consumption Expenditures[1] (billion dollars) Current	Transportation Personal Consumption Expenditures[1] (billion dollars) Constant 1990[b]	Transportation PCE as a percent of total PCE
1970	640.0	1,910.4	81.5	243.3	12.7%
1971	691.6	1,961.7	95.2	270.0	13.8%
1972	757.6	2,064.2	105.8	288.3	14.0%
1973	837.2	2,155.6	116.0	298.7	13.9%
1974	916.5	2,171.8	119.8	283.9	13.1%
1975	1,012.8	2,194.9	131.2	284.3	13.0%
1976	1,129.3	2,325.6	157.1	323.5	13.9%
1977	1,257.2	2,445.1	181.5	353.0	14.4%
1978	1,403.5	2,543.2	199.9	362.2	14.2%
1979	1,566.8	2,612.5	222.0	370.2	14.2%
1980	1,732.6	2,642.9	238.5	363.8	13.8%
1981	1,915.1	2,672.0	261.5	364.8	13.7%
1982	2,050.7	2,696.7	267.6	351.9	13.0%
1983	2,234.5	2,826.7	295.4	373.7	13.2%
1984	2,430.5	2,946.8	329.5	399.5	13.6%
1985	2,629.0	3,101.1	359.5	424.1	13.7%
1986	2,797.4	3,211.4	366.3	420.5	13.0%
1987	3,009.4	3,367.7	379.7	424.9	12.6%
1988	3,296.1	3,562.9	413.2	446.6	12.5%
1989	3,523.1	3,669.2	437.3	455.4	12.4%
1990	3,761.2	3,761.2	453.9	453.7	12.1%
1991	3,902.4	3,730.7	433.6	414.5	11.1%
1992	4,136.9	3,822.5	466.3	430.9	11.3%
1993	4,378.2	3,966.6	504.2	456.8	11.5%
		Average annual percentage change			
1970-93	8.7%	3.2%	8.2%	2.8%	
1983-93	7.0%	3.4%	5.5%	2.0%	

Sources:

1970-86 data - U.S. Department of Commerce, Bureau of Census, Statistical Abstract of the United States 1988, p.412.

1987-93 data - U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, July 1994, Table 2.4, p. 64, and annual.

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[1]Transportation Personal Consumption Expenditures include user operating expenses (new and used auto purchases, gas and oil, repair, greasing, washing, parking, storage, rental, other motor vehicles, tires, tubes and other parts, insurance premiums); purchased intercity transportation; and purchased local transportation.

[m]Adjusted by the implicit GNP price deflator.

The Consumer Price Index (CPI) for transportation has more than tripled from 1970 to 1993; and the Used Car CPI continued to grow at a much faster rate than did the New Car CPI. This means that while consumers paid for a new automobile in 1993 more than double what they did in 1970, they paid over four times more to buy a used car in 1993 than in 1970.

Table 2.29
Statistical Indices as Related to Transportation, 1970-93
(1970 = 1.000)

Year	Consumer Price Index	Transportation Consumer Price Index[a]	New car Consumer Price Index	Used car Consumer Price Index	Gross National Product
1970	1.000	1.000	1.000	1.000	1.000
1971	1.043	1.052	1.041	1.057	1.086
1972	1.077	1.064	1.032	1.059	1.194
1973	1.144	1.098	1.033	1.128	1.339
1974	1.270	1.222	1.092	1.175	1.450
1975	1.386	1.336	1.186	1.404	1.574
1976	1.466	1.469	1.261	1.610	1.756
1977	1.561	1.572	1.328	1.753	1.960
1978	1.680	1.646	1.429	1.788	2.215
1979	1.869	1.881	1.543	1.927	2.470
1980	2.122	2.216	1.667	1.995	2.690
1981	2.342	2.484	1.768	2.463	3.006
1982	2.486	2.587	1.836	2.842	3.118
1983	2.566	2.648	1.883	3.161	3.354
1984	2.675	2.766	1.938	3.602	3.715
1985	2.770	2.838	2.000	3.640	3.954
1986	2.824	2.728	2.087	3.487	4.176
1987	2.927	2.811	2.162	3.625	4.447
1988	3.046	2.899	2.206	3.782	4.799
1989	3.193	3.043	2.249	3.859	5.121
1990	3.365	3.213	2.283	3.769	5.483
1991	3.508	3.301	2.364	3.785	5.653
1992	3.614	3.373	2.423	3.949	5.934
1993	3.721	3.477	2.481	4.292	6.251

Sources:
U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Washington, DC, March 1994, p. S-6, and annual.
Gross National Product - Indexed to 1970 from Table 2.20.

[a]Transportation Consumer Price Index includes new and used cars, gasoline, auto insurance rates, intracity mass transit, intracity bus fare, and airline fares.

After adjusting for inflation, the average price of all new cars declined from 1992 to 1993. This was a result of a decline in average domestic car prices; average import car prices continued to increase. Average domestic car prices in 1970 were $3567 ***more*** *than imports (in constant 1990 dollars), but in 1993, domestic car prices were $4,636* ***less*** *than imports.*

Table 2.30
Average Price of a New Car, 1970-93

Year	Domestic		Import		Total		Estimated Average New Car Price for a 1967 "Comparable Car"	
	Current dollars	Constant 1990 dollars[o]	Current dollars	Constant 1990 dollars[o]	Current dollars	Constant 1990 dollars[o]	With added safety & emissions equipment[p]	Without added safety & emissions equipment[q]
1970	3,708	12,479	2,648	8,912	3,542	11,920	3,601	3,459
1971	3,919	12,645	2,769	8,935	3,742	12,074	3,777	3,601
1972	4,034	12,601	2,994	9,352	3,879	12,117	3,789	3,570
1973	4,181	12,295	3,344	9,834	4,052	11,915	3,903	3,572
1974	4,524	11,988	4,206	11,146	4,440	11,766	4,237	3,779
1975	5,084	12,344	4,384	10,645	4,950	12,019	4,686	4,103
1976	5,506	12,640	4,923	11,301	5,418	12,438	4,988	4,362
1977	5,985	12,906	5,072	10,938	5,814	12,538	5,272	4,593
1978	6,478	12,976	5,934	11,886	6,379	12,778	5,687	4,944
1979	6,889	12,403	6,704	12,070	6,847	12,327	6,176	5,337
1980	7,609	12,067	7,482	11,886	7,574	12,012	6,863	5,764
1981	8,912	12,805	8,896	12,782	8,910	12,802	7,700	6,115
1982	9,865	13,356	9,957	13,480	9,890	13,390	8,078	6,350
1983	10,559	13,850	10,873	14,262	10,640	13,956	8,387	6,544
1984	11,172	14,056	12,354	15,543	11,450	14,405	8,685	6,742
1985	11,733	14,253	12,875	15,640	12,022	14,604	8,984	6,958
1986	12,526	14,929	13,815	16,465	12,894	15,368	9,395	7,259
1987	13,239	15,223	14,602	16,790	13,657	15,703	9,743	7,518
1988	14,029	15,498	15,537	17,164	14,468	15,983	9,995	7,668
1989	14,947	15,746	16,126	16,999	15,272	16,105	10,248	7,825
1990	15,638	15,638	17,538	17,538	16,157	16,157	10,581	7,938
1991	16,487	15,811	17,795	17,065	16,838	16,148	11,152	8,224
1992	17,252	16,062	20,552	19,134	18,078	16,831	11,462	8,427
1993	17,263	15,263	21,988	19,899	18,328	16,587	11,809	8,633
				Average annual percentage change				
1970-93	7.2%	1.1%	9.6%	3.4%	7.6%	1.5%	5.3%	4.1%
1983-93	5.0%	1.0%	7.3%	3.4%	5.6%	1.7%	3.5%	2.8%

Source: American Automobile Manufacturers Association, Motor Vehicle Facts and Figures '94, Detroit, MI, 1994, p.58.

[o]Adjusted by the Consumer Price Inflation Index.

[p]1967 "Average Transaction Price" plus the value of added safety and emissions equipment as determined by the U.S. Bureau of Labor Statistics (BLS), all inflated to current dollars, using the U.S. BLS, "New Car Consumer Price Index - All Urban Consumers." For example, 1969 is equal to the 1968 value plus the BLS stated value of added safety and emissions equipment for the 1969 model year multiplied by 1968-1969 monthly changes in the New Car Consumer Price Index.

[q]1967 "Average Transaction Price" inflated to current dollars.

Table 2.31
Motor Vehicle Manufacturing Employment Statistics, 1972-93

Year	Motor vehicle manufacturing employees (thousands)	Domestic automobile sales (thousands)	Domestic light truck[r] sales (thousands)	Employees per hundred vehicles sold	Expenditure per new domestic vehicle	Total domestic vehicle expenditures (millions)	Employees per million dollar expenditure (current)	Employees per million dollars (constant 1990[s])
1972	415	9,327	2,096	3.6	$4,034	$46,080	9.0	3.3
1973	462	9,676	2,512	3.8	$4,181	$50,958	9.1	3.5
1974	416	7,454	2,163	4.3	$4,524	$43,507	9.6	4.0
1975	375	7,053	2,053	4.1	$5,084	$46,295	8.1	3.7
1976	416	8,611	2,720	3.7	$5,506	$62,388	6.7	3.2
1977	442	9,109	3,108	3.6	$5,985	$73,119	6.0	3.1
1978	470	9,312	3,473	3.7	$6,478	$82,821	5.7	3.1
1979	463	8,341	2,844	4.1	$6,889	$77,053	6.0	3.6
1980	368	6,581	1,959	4.3	$7,609	$64,981	5.7	3.7
1981	359	6,209	1,745	4.5	$8,912	$70,886	5.1	3.6
1982	318	5,759	2,062	4.1	$9,865	$77,154	4.1	3.1
1983	349	6,795	2,518	3.7	$10,559	$98,336	3.5	2.8
1984	392	7,952	3,257	3.5	$11,172	$125,227	3.1	2.6
1985	409	8,205	3,691	3.4	$11,733	$139,576	2.9	2.5
1986	400	8,215	3,671	3.4	$12,526	$148,884	2.7	2.3
1987	381	7,081	3,785	3.5	$13,239	$143,855	2.6	2.4
1988	357	7,526	4,195	3.0	$14,029	$164,434	2.2	2.0
1989	350	7,073	4,108	3.1	$14,947	$167,122	2.1	2.0
1990	329	6,897	3,948	3.0	$15,638	$169,594	1.9	1.9
1991	316	6,137	3,595	3.2	$16,487	$160,451	2.0	2.1
1992	314	6,277	4,231	3.0	$17,252	$181,284	1.7	1.9
1993	319	6,734	4,987	2.7	$17,263	$202,340	1.6	1.7
				Average annual percentage change				
1972-93	-1.2%	-1.5%	4.2%	-1.4%	7.2%	7.3%	-7.9%	-3.1%
1983-93	-0.9%	-0.1%	7.1%	-3.1%	5.0%	7.5%	-7.5%	-4.9%

Sources:

Employees - American Automobile Manufacturers Association, Economic Indicators, Fourth Quarter,1994, Detroit, MI, 1995, p. 16.

Sales and expenditures - American Automobile Manufacturers Association, Motor Vehicle Facts and Figures '94, Detroit, MI, 1994, pp. 20, 21, 58, and annual.

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[r]Less than 10,000 pounds gross vehicle weight.
[s]Adjusted by the implicit Gross National Product price deflator.

The total cost of operating an automobile is the sum of the fixed cost (depreciation, insurance, finance charge, and license fee) and the variable cost, which is related to the amount of travel. The cost of operating a car in 1993 (constant 1990 dollars) was approximately 41 cents per mile, nearly two cents cheaper than 1992. From 1985 to 1993 the fixed costs have risen an average of 4.2% per year while the variable costs have declined at an average annual rate of 2.1%.

Table 2.32
Automobile Operating Costs, 1975-93

	Variable costs (Constant 1990 cents per mile[t])				Constant 1990 dollars per 10,000 miles[a]			
Year[v]	Gas and oil	Percentage gas and oil of total cost	Maintenance	Tires	Variable cost	Fixed cost	Total cost	Total cost per mile[u] (Constant 1990 cents[a])
1975	11.70	26.3%	2.36	1.60	1,566	2,880	4,446	44.46
1977	8.86	20.3%	2.22	1.42	1,251	3,103	4,354	43.54
1979	7.40	17.1%	1.98	1.17	1,055	3,260	4,315	43.15
1980	9.29	21.0%	1.78	1.01	1,208	3,224	4,433	44.33
1981	9.01	19.6%	1.70	1.03	1,174	3,413	4,586	45.86
1982	9.12	21.5%	1.35	0.97	1,133	3,145	4,243	42.43
1983	8.71	19.9%	1.36	0.89	1,097	3,287	4,384	43.84
1984	7.79	19.8%	1.31	0.79	989	2,952	3,940	39.40
1985	7.48	22.6%	1.49	0.79	977	2,328 [w]	3,304 [d]	33.04
1986	5.34	15.1%	1.63	0.80	777	2,750 [d]	3,577 [d]	35.27
1987	5.52	14.7%	1.84	0.92	828	2,925 [d]	3,753 [d]	37.53
1988	5.74	15.6%	1.77	0.88	840	2,851 [d]	3,691 [d]	36.91
1989	5.48	13.6%	2.00	0.84	833	3,194 [d]	4,027 [d]	40.27
1990	5.40	13.2%	2.10	0.90	840	3,256 [d]	4,096 [d]	40.96
1991	6.43	15.4%	2.11	0.86	940	3,245 [d]	4,185 [d]	41.85
1992	5.59	13.1%	2.05	0.84	847	3,414 [d]	4,261 [d]	42.61
1993	5.43	13.3%	2.17	0.81	842	3,244 [d]	4,085 [d]	40.85
			Average annual percentage change					
1975-84	-4.4%		-6.3%	-7.5%	-5.0%	0.3%	-1.3%	-1.3%
1985-93	-3.9%		4.8%	0.3%	-2.1%	4.2%	2.7%	2.7%

Source:
American Automobile Association, "Your Driving Costs," 1994 Edition, Falls Church, VA, and annual.

[t]Adjusted by the Consumer Price Inflation Index.
[u]Based on 10,000 miles per year.
[v]Data for 1976 and 1978 are not available.
[w]Fixed and total operating costs preceeding 1985 are not comparable with figures after 1985. Fixed cost depreciation from 1975-84 was based on four years or 60,000 miles. After 1984, the depreciation was based on six years or 60,000 miles.

CHAPTER 3

HIGHWAY MODE

This chapter presents data on highway transportation and is organized into seven sections. The first Section compares data for all types of highway transportation modes. Section 3.2 presents statistics on automobiles. Truck data are presented in Section 3.3, bus data in Section 3.4, and fleet data in Section 3.5. Federal regulations and standards on fuel economy are included in Section 3.6, and high-occupancy vehicle (HOV) lanes are the subject of Section 3.7.

Highway energy use represented 78.4% of transportation energy use in 1993. Of the highway modes, automobiles had the greatest share of energy use, 42.1% (Table 3.1). The automobiles were also responsible for the majority of vehicle miles traveled in 1993. Light trucks with two axles and four tires have experienced the largest increase in vehicle miles traveled, an average of 6.3% annually from 1970 to 1993 (Table 3.2).

The number of automobiles and trucks in use are reported by both the Federal Highway Administration and R. L. Polk and Company (Table 3.4). According to R. L. Polk, the number of automobiles in the U. S. declined from 1991 to 1992. A discussion of this decline and of differences between the two sets of estimates can be found on page 3-9. New data on automobile scrappage rates are in Table 3.6.

Automobile sales which had been declining since 1988 rose in 1992 and again in 1993. Imports accounted for 20.9% of sales in 1993, declining from a high of 31.1% in 1987 (Table 3.9). Fuel economy for the automobile population has increased from 13.5 miles per gallon in 1970 to 21.6 miles per gallon in 1993 (Table 3.12). As the older autos are scrapped, they are replaced with newer, more fuel efficient autos which help to raise the population fuel economy. The sales-weighted fuel economy for new automobiles was at 27.8 mpg for the 1993 sales period (Table 3.17).

Truck travel data are based mainly on the Truck Inventory and Use Survey (TIUS) conducted by the U.S. Bureau of the Census. As part of the nation's economic surveys, TIUS is required by law to be conducted every 5 years for the years ending in 2 and 7 to provide data on the physical and operational characteristics of the nation's truck population. The survey is based on a probability sample of private and commercial trucks registered (or licensed) in each state. The most recent survey for which results are available was conducted in 1987; results for the 1991 survey are expected this summer. In addition to trucks, the following types of vehicles were also included in the 1987 survey: minivans, vans, station wagons, and jeep-like vehicles. The 1977 and 1982 surveys did not include those vehicle types. The estimated number of trucks that were within the scope of the TIUS and registered in the U.S. as of July 1, 1987 was 44.6 million. These trucks were estimated to have been driven a total of 529,315 million miles during 1987, an increase of 40.3% from 1982. The average annual miles traveled per truck was estimated at 11,900 miles.

Tables 3.31-3.34 present data from a study on fleet vehicles in the U. S. The study, sponsored by the Office of Transportation Technologies and the Office of Policy, Planning, and Analysis of the Department of Energy, summarized available data pertaining to fleet vehicles.

Although the **average** Corporate Average Fuel Economy (CAFE) of automobiles and light trucks has met the CAFE standard each year except 1984, there are still manufacturers who fall short of meeting the standard. The domestic automobile CAFE estimate did not meet the 1992 standard, but the import estimate exceeded the standard, pulling the combined automobile CAFE estimate above the standard (Table 3.35). The fines collected for model year 1992 violations totalled more than 38 million dollars (Table 3.36). Since 1986 the Gas Guzzler tax has been assessed on automobiles with a fuel economy rating of less than 22.5 miles per gallon. These tax rates, which remained constant from 1986 to 1990, doubled in 1991 (Table 3.38).

Section 3.1.
Highway Vehicle Characteristics

Table 3.1
Highway Energy Use by Mode, 1970-93

Year	Autos[a]	Light trucks	Other trucks	Buses	Total highway	Transportation energy use[b] (trillion Btu)
	(percentage of total)					
1970	55.8%	10.1%	9.8%	0.7%	76.3%	**15,305**
1971	56.5%	10.6%	9.9%	0.7%	77.6%	**15,907**
1972	56.6%	11.2%	9.9%	0.6%	78.3%	**16,949**
1973	55.6%	11.8%	10.4%	0.6%	78.4%	**17,813**
1974	55.3%	12.2%	10.5%	0.7%	78.7%	**17,088**
1975	55.5%	12.9%	10.3%	0.7%	79.5%	**17,329**
1976	54.6%	13.7%	10.6%	0.7%	79.6%	**18,389**
1977	53.1%	14.4%	11.3%	0.7%	79.4%	**19,071**
1978	51.3%	15.0%	12.1%	0.7%	79.1%	**20,035**
1979	48.5%	15.4%	12.5%	0.7%	77.0%	**20,101**
1980	46.9%	15.3%	12.6%	0.7%	75.5%	**19,317**
1981	47.0%	15.5%	12.9%	0.8%	76.2%	**19,065**
1982	47.5%	16.0%	13.1%	0.8%	77.4%	**18,589**
1983	46.9%	17.1%	13.9%	0.8%	78.6%	**18,728**
1984	44.7%	18.1%	14.7%	0.8%	78.3%	**19,310**
1985	44.2%	18.5%	14.9%	0.8%	78.4%	**19,659**
1986	44.2%	18.7%	14.9%	0.8%	78.5%	**20,229**
1987	42.9%	19.5%	15.2%	0.8%	78.3%	**20,704**
1988	42.3%	19.3%	15.5%	0.8%	77.9%	**21,278**
1989	42.0%	19.2%	15.9%	0.8%	77.9%	**21,598**
1990	41.6%	19.1%	15.6%	0.8%	77.1%	**21,778**
1991	41.7%	19.2%	15.5%	0.8%	77.3%	**21,261**
1992	42.2%	18.9%	15.4%	0.8%	77.4%	**21,944**
1993	42.1%	19.5%	15.9%	0.8%	78.4%	**22,345**

Source:
See Appendix A for Table 2.10.

[a]Includes motorcycles.
[b]Does not include off-highway and military transportation energy use.

Although automobiles continued to be responsible for the majority of highway travel, two-axle, four-tire trucks had the fastest average growth in vehicle miles from 1970-93 and 1982-93.

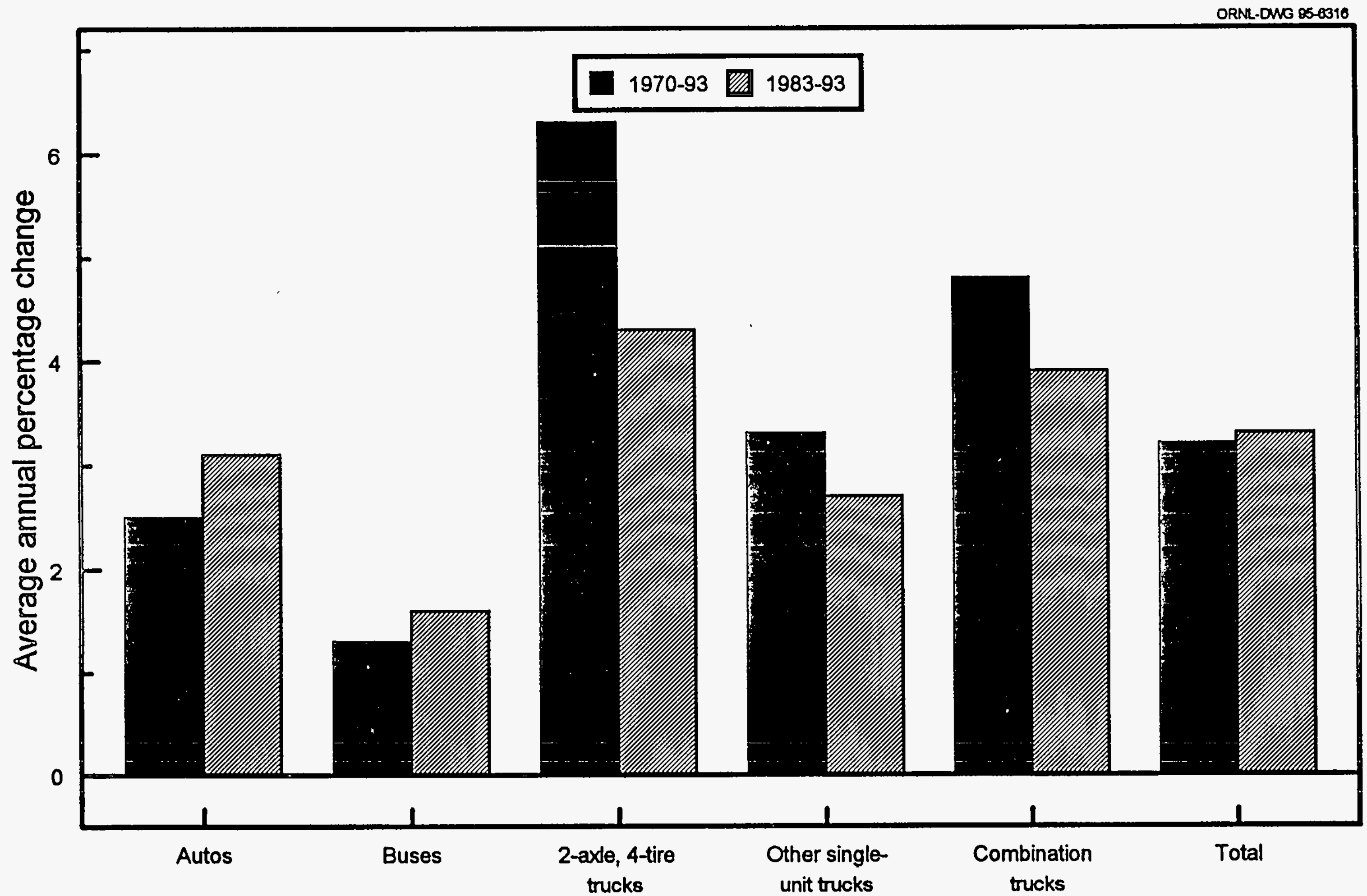
Table 3.2
Highway Vehicle Miles Traveled by Mode, 1970-93
(million miles)

Year	Automobiles[a]	Two-axle, four-tire trucks	Other single-unit trucks	Combination trucks	Buses[b]	Total
1970	919,679	123,286	27,081	35,134	4,544	1,109,724
1971	969,947	137,870	28,985	37,217	4,792	1,178,811
1972	1,025,696	156,622	31,414	40,706	5,348	1,259,786
1973	1,051,175	176,833	33,661	45,649	5,792	1,313,110
1974	1,012,696	182,757	33,441	45,966	5,684	1,280,544
1975	1,039,579	200,700	34,606	46,724	6,055	1,327,664
1976	1,084,218	225,834	36,390	49,680	6,258	1,402,380
1977	1,115,592	250,591	39,339	55,682	5,823	1,467,027
1978	1,153,666	279,414	42,747	62,992	5,885	1,544,704
1979	1,122,277	291,905	42,012	66,992	5,947	1,529,133
1980	1,121,810	290,935	39,813	68,678	6,059	1,527,295
1981	1,141,517	296,343	39,568	69,134	6,241	1,552,803
1982	1,176,166	306,141	40,212	66,668	5,823	1,595,010
1983	1,206,783	327,643	43,409	69,754	5,199	1,652,788
1984	1,233,703	357,999	46,560	77,367	4,640	1,720,269
1985	1,269,651	373,072	46,980	79,600	4,876	1,774,179
1986	1,312,921	389,123	48,413	82,696	5,087	1,838,240
1987	1,364,836	415,449	49,537	86,064	5,318	1,921,204
1988	1,439,603	439,496	51,239	90,158	5,466	2,025,962
1989	1,488,140	454,339	52,969	95,349	5,659	2,096,456
1990	1,522,741	466,092	53,443	96,367	5,719	2,144,362
1991	1,542,730	472,848	53,787	96,942	5,743	2,172,050
1992	1,610,396	478,193	53,691	99,112	5,759	2,247,151
1993	1,633,861	497,201	56,693	102,709	6,121	2,296,585
		Average annual percentage change				
1970-93	2.5%	6.3%	3.3%	4.8%	1.3%	3.2%
1983-93	3.1%	4.3%	2.7%	3.9%	1.6%	3.3%

Source:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table VM-1, p. V-115, and annual.

[a]Includes motorcycles.
[b]The data do not correspond with vehicle miles of travel presented in the Bus section of this chapter due to differing data sources.

Figure 3.1. Annual Growth Rates of Highway Vehicle Miles Traveled by Mode, 1970-93 and 1983-93



Source: See Table 3.2.

Table 3.3
Vehicle Stock and New Sales in United States, 1993 Calendar Year

	Vehicle Stock[a] (thousands)	New Sales Domestic (thousands)	Import[b] (thousands)	Total (thousands)
Autos[c]	**121,055**	**6,734 (79.1%)**	**1,783 (20.9%)**	**8,518 (100.0%)**
Two seaters	2,686	27 (35.1%)	50 (64.9%)	77 (100.0%)
Minicompact	2,677	0 (0.0%)	77 (100.0%)	77 (100.0%)
Subcompact	30,744	1,152 (60.2%)	763 (39.8%)	1,915 (100.0%)
Compact	31,324	2,222 (80.8%)	528 (19.2%)	2,750 (100.0%)
Midsize	35,987	2,148 (86.3%)	341 (13.7%)	2,489 (100.0%)
Large	17,637	1,185 (98.1%)	23 (1.9%)	1,208 (100.0%)
Fleets of ten or more	7,699	d	d	d
Personal autos	113,356	d	d	d
Motorcycles	**3,850[e]**	**243 (49.8%)**	**245 (50.2%)**	**488 (100.0%)**
Recreational vehicles	d	**429 (100.0%)**	**0 (0.0%)**	**429 (100.0%)**
Trucks	**65,260**	**5,287 (93.1%)**	**394 (6.9%)**	**5,681 (100.0%)**
Light (0-10,000 lbs)	59,974	4,987 (93.2%)	365 (6.8%)	5,352 (100.0%)
Medium (10,001-19,500 lbs)	1,501	43 (67.2%)	21 (32.8%)	64 (100.0%)
Light-heavy (19,501-26,000 lbs)	1,109	22 (81.5%)	5 (18.5%)	27 (100.0%)
Heavy-heavy (26,001 lbs and over)	2,676	235 (98.7%)	3 (1.3%)	238 (100.0%)

Source:
See Appendix A for Table 3.3

[a]Vehicle stock as of July 1.
[b]Includes domestic-sponsored imports.
[c]These figures represent only those automobiles that could be matched to the Environmental Protection Agency size classes.
[d]Data are not available.
[e]Includes mostly on-highway motorcycles. Many states do not require registration for off-highway vehicles.

VEHICLES IN USE

Both the Federal Highway Administration (FHWA) and R. L. Polk and Company report figures on the automobile and truck population each year. The two estimates, however, differ by as much as 25.6% for trucks. The differences can be attributed to several factors.

(1) The FHWA data include all vehicles which have been registered at any time throughout the calendar year. Therefore, the data include vehicles which were retired during the year and may double count vehicles which have been registered twice in different or the same states. The R. L. Polk data include only those vehicles which are registered on July 1 of the given year.

(2) In many states mini-vans, station wagons on truck chassis, and utility vehicles (e.g., jeep-like vehicles) are classified as passenger cars and are included in the FHWA automobile data. The R. L. Polk data included passenger vans in the automobile count until 1970; since 1980 all vans have been counted as trucks.

According to the R. L. Polk statistics, the number of passenger cars in use in the U.S. declined from 1991 to 1992. This is the first decline in vehicle stock since the figures were first reported in 1924. However, the data should be viewed with caution. A redesign of Polk's approach in 1992 allowed a national check for duplicate registrations which was not possible in earlier years. Polk estimates that due to processing limitations, it's vehicle population counts may have been inflated by as much as 1½ percent. Assuming that percentage is correct, the number of passenger cars in use would have declined from 1991 to 1992 under the previous Polk method.

The Federal Highway Administration estimates indicated growth in both the number of passenger cars and trucks from 1991 to 1992, raising the differences between FHWA and Polk for both vehicle types (20% for passenger cars, -26% for trucks). It is apparent that the method for classifying vehicles as passenger cars or trucks is different for the two sources, since the difference in total vehicles has been less than 5% each year since 1990.

Table 3.4
Automobiles and Trucks in Use, 1970-93
(thousands)

Years	Automobiles			Trucks			Total		
	FHWA	R.L. Polk	Percentage Difference	FHWA	R.L. Polk	Percentage Difference	FHWA	R.L. Polk	Percentage Difference
1970	89,244	80,448	11.0%	18,797	17,688	6.3%	108,041	98,136	10.1%
1971	92,718	83,138	11.5%	19,871	18,462	7.6%	112,589	101,600	10.8%
1972	97,082	86,439	12.3%	21,308	19,773	7.8%	118,390	106,212	11.5%
1973	101,985	89,805	13.6%	23,244	21,412	8.6%	125,229	111,217	12.6%
1974	104,856	92,608	13.2%	24,630	23,312	5.7%	129,486	115,920	11.7%
1975	106,704	95,241	12.0%	25,781	24,813	3.9%	132,485	120,054	10.4%
1976	110,189	97,818	12.6%	27,876	26,560	5.0%	138,065	124,378	11.0%
1977	112,288	99,904	12.4%	29,314	28,222	3.7%	141,602	128,126	10.5%
1978	116,573	102,957	13.2%	31,336	30,565	2.5%	147,909	133,522	10.8%
1979	118,429	104,677	13.1%	32,914	32,583	1.0%	151,343	137,260	10.3%
1980	121,601	104,564	16.3%	33,667	35,268	-4.5%	155,268	139,832	11.0%
1981	123,098	105,839	16.3%	34,644	36,069	-4.0%	157,742	141,908	11.2%
1982	123,902	106,867	15.9%	35,382	36,987	-4.3%	159,284	143,854	10.7%
1983	126,444	108,961	16.0%	36,723	38,143	-3.7%	163,167	147,104	10.9%
1984	128,158	112,019	14.4%	37,507	40,143	-6.6%	165,665	152,162	8.9%
1985	131,864	114,662	15.0%	39,196	42,387	-7.5%	171,060	157,049	8.9%
1986	135,431	117,268	15.5%	40,069	44,826	-10.6%	175,500	162,094	8.3%
1987	137,208	119,849	14.5%	41,144	47,344	-13.1%	178,352	167,193	6.7%
1988	141,252	121,519	16.2%	42,529	50,221	-15.3%	183,781	171,740	7.0%
1989	143,026	122,758	16.5%	43,609	53,202	-18.0%	186,635	175,960	6.1%
1990	143,453	123,276	16.4%	44,717	56,023	-20.2%	188,170	179,299	4.9%
1991	142,569	123,268	15.7%	44,936	58,179	-22.8%	187,505	181,438	3.3%
1992	144,213	120,347	19.8%	45,504	61,172	-25.6%	189,717	181,519	4.5%
1993	146,314	121,055	20.9%	47,095	65,260	-27.8%	193,409	186,315	3.8%

Sources:

FHWA - U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table VM-1, p. V-115, and annual.

R. L. Polk - R. L. Polk and Company, Detroit, Michigan. **FURTHER REPRODUCTION PROHIBITED.**

The average age of automobiles and trucks continued to rise in 1993. The average age gap between autos and trucks stayed at 0.3 years in 1993.

Table 3.5
Average Age of Automobiles and Trucks in Use, 1970-93
(years)

Calendar Year	Automobile		Trucks	
	Mean	Median	Mean	Median
1970	5.6	4.9	7.3	5.9
1971	5.7	5.1	7.4	6.1
1972	5.7	5.1	7.2	6.0
1973	5.7	5.1	6.9	5.8
1974	5.7	5.2	7.0	5.6
1975	6.0	5.4	6.9	5.8
1976	6.2	5.5	7.0	5.8
1977	6.2	5.6	6.9	5.7
1978	6.3	5.7	6.9	5.8
1979	6.4	5.9	6.9	5.9
1980	6.6	6.0	7.1	6.3
1981	6.9	6.0	7.5	6.5
1982	7.2	6.2	7.8	6.8
1983	7.4	6.5	8.1	7.2
1984	7.5	6.7	8.2	7.4
1985	7.6	6.9	8.1	7.6
1986	7.6	7.0	8.0	7.7
1987	7.6	6.9	8.0	7.8
1988	7.6	6.8	7.9	7.1
1989	7.6	6.5	7.9	6.7
1990	7.8	6.5	8.0	6.5
1991	7.9	6.7	8.1	6.8
1992	8.1	7.0	8.4	7.2
1993	8.3	7.3	8.6	7.5

Source:
R. L. Polk and Co., Detroit, MI. **FURTHER REPRODUCTION PROHIBITED.**

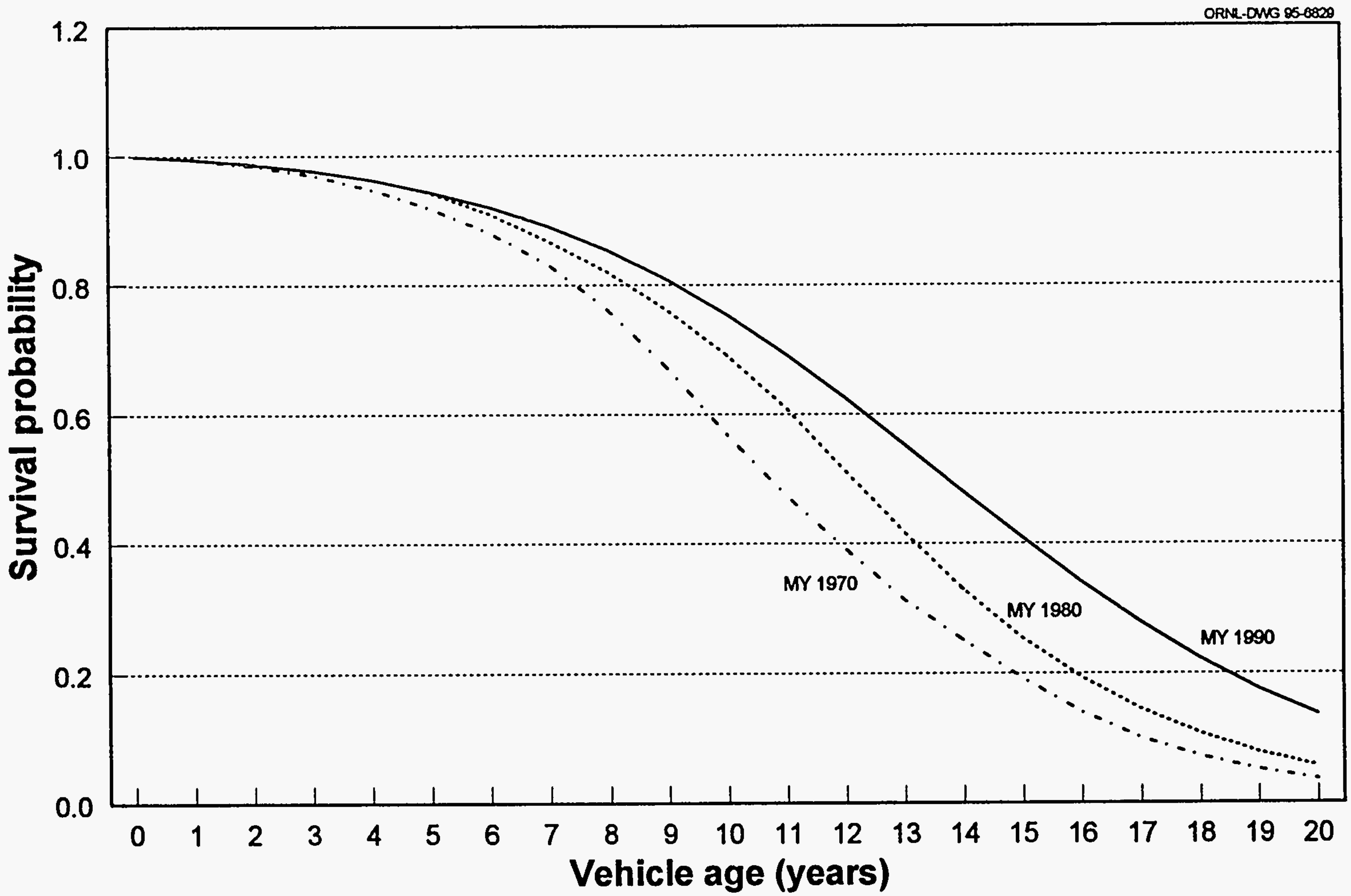
Table 3.6
Scrappage and Survival Rates for Automobiles
1970, 1980 and 1990 Model Years

Vehicle Age (Years)	1970 Model Year Scrappage Rate[a]	1970 Model Year Survival Rate[b]	1980 Model Year Scrappage Rate[a]	1980 Model Year Survival Rate[b]	1990 Model Year Scrappage Rate[a]	1990 Model Year Survival Rate[b]
0	0.000000	1.000000	0.000000	1.000000	0.000000	1.000000
1	0.006050	0.993950	0.005553	0.994447	0.005255	0.994745
2	0.009650	0.984359	0.007636	0.986854	0.007538	0.987246
3	0.014590	0.969997	0.011011	0.975988	0.010522	0.976858
4	0.022892	0.947792	0.013567	0.962746	0.014414	0.962778
5	0.030522	0.918864	0.020498	0.943011	0.019623	0.943885
6	0.040956	0.881231	0.034718	0.910272	0.025096	0.920197
7	0.057029	0.830975	0.047366	0.867156	0.032690	0.890116
8	0.084560	0.760708	0.055299	0.819204	0.042014	0.852719
9	0.118527	0.670543	0.071153	0.760915	0.053468	0.807126
10	0.151858	0.568716	0.092931	0.690202	0.066230	0.753669
11	0.166996	0.473743	0.117300	0.609241	0.081338	0.692367
12	0.171955	0.392280	0.158696	0.512557	0.096959	0.625236
13	0.201774	0.313128	0.187663	0.416369	0.114297	0.553773
14	0.198887	0.250851	0.208822	0.329422	0.131169	0.481135
15	0.233611	0.192250	0.228359	0.254196	0.149005	0.409444
16	0.271810	0.139994	0.238412	0.193592	0.166710	0.341186
17	0.283363	0.100325	0.250547	0.145088	0.183826	0.278467
18	0.283078	0.071925	0.261438	0.107157	0.199477	0.222919
19	0.287708	0.051232	0.270527	0.078168	0.211449	0.175783
20	0.292908	0.036226	0.277234	0.056497	0.223461	0.136502

Source:
Miaou, Shaw-Pin, "Factors Associated with Aggregated Car Scrappage Rate in the United States: 1966-1992," Oak Ridge National Laboratory, Oak Ridge, TN, January 1995.

[a]The probability that a 1970/80/90 model year automobile will be retired from use within a given year.
[b]The probability that a 1970/80/90 model year automobile will be in use at the end of a given year.

Figure 3.2. Survival Probabilities of Automobiles



Source: See Table 3.6.

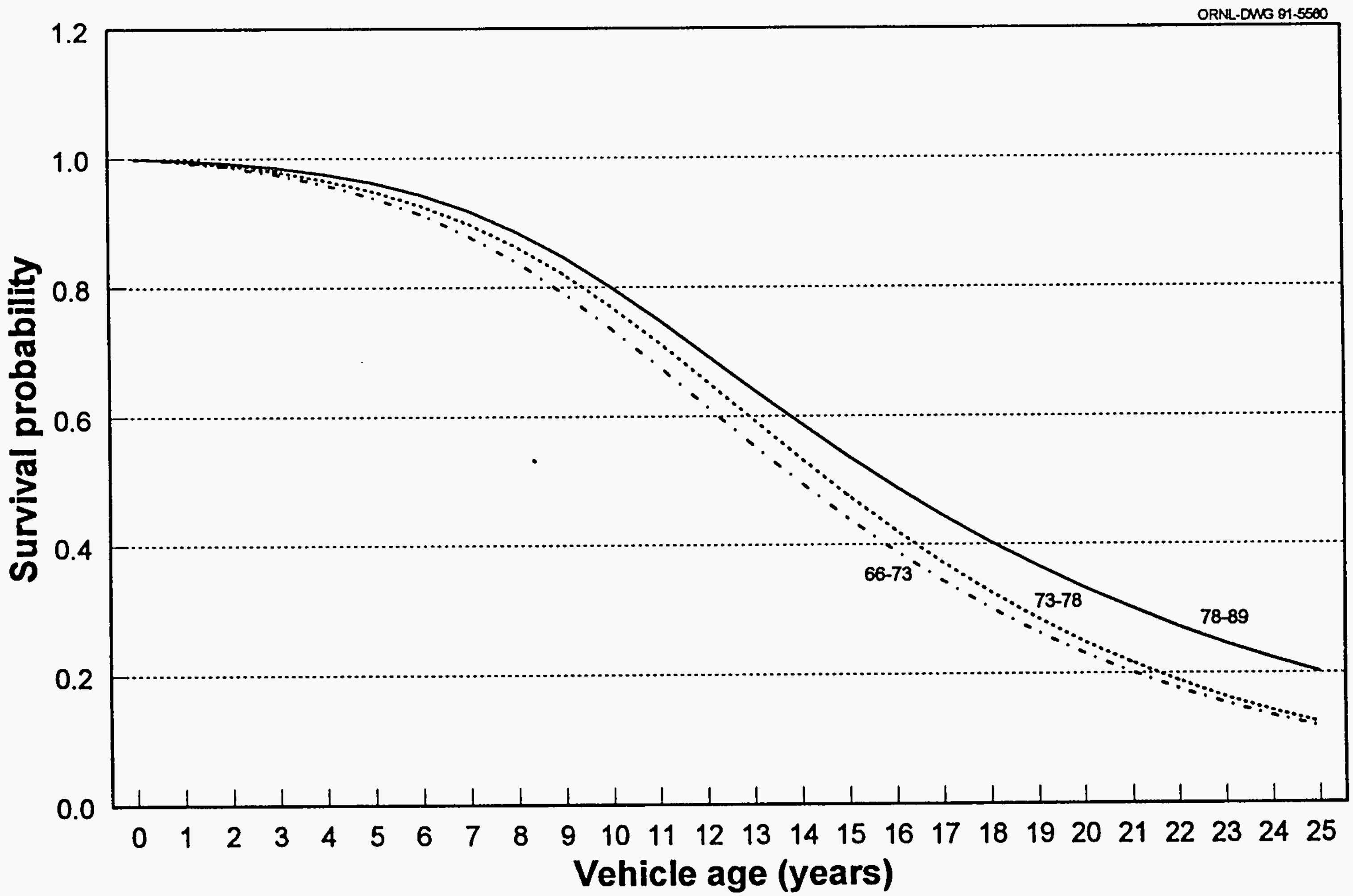
Table 3.7
Scrappage and Survival Rates for Trucks

	All Trucks						Light Trucks	
	(1966-73)[a]		(1973-78)[a]		(1978-89)[a]		(1978-89)[a]	
Vehicle Age (Years)	Scrappage Rate	Survival Rate	Scrappage Rate	Survival Rate	Scrappage Rate	Survival Rate	Scrappage Rate	Survival Rate
0	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000	0.00000	1.00000
1	0.00582	0.99418	0.00505	0.99495	0.00312	0.99688	0.00249	0.99751
2	0.00814	0.98608	0.00698	0.98801	0.00461	0.99228	0.00383	0.99369
3	0.01129	0.97495	0.00958	0.97854	0.00676	0.98557	0.00583	0.98790
4	0.01550	0.95983	0.01306	0.96576	0.00980	0.97591	0.00877	0.97923
5	0.02101	0.93967	0.01762	0.94873	0.01399	0.96226	0.01296	0.96654
6	0.02798	0.91337	0.02347	0.92647	0.01957	0.94343	0.01869	0.94848
7	0.03649	0.88005	0.03073	0.89800	0.02663	0.91830	0.02606	0.92376
8	0.04638	0.83923	0.03943	0.86260	0.03507	0.88609	0.03488	0.89154
9	0.05730	0.79114	0.04940	0.81999	0.04445	0.84671	0.04454	0.85182
10	0.06863	0.73685	0.06026	0.77058	0.05408	0.80092	0.05416	0.80569
11	0.07970	0.67812	0.07147	0.71551	0.06320	0.75030	0.06285	0.75505
12	0.08987	0.61718	0.08239	0.65656	0.07121	0.69687	0.07006	0.70215
13	0.09872	0.55625	0.09247	0.59585	0.07776	0.64268	0.07562	0.64905
14	0.10605	0.49726	0.10130	0.53548	0.08285	0.58944	0.07967	0.59734
15	0.11189	0.44162	0.10871	0.47727	0.08662	0.53838	0.08251	0.54805
16	0.11638	0.39023	0.11468	0.42254	0.08932	0.49029	0.08443	0.50178
17	0.11976	0.34349	0.11936	0.37210	0.09122	0.44557	0.08571	0.45877
18	0.12225	0.30150	0.12294	0.32636	0.09253	0.40434	0.08655	0.41907
19	0.12406	0.26410	0.12562	0.28536	0.09343	0.36656	0.08710	0.38257
20	0.12536	0.23099	0.12761	0.24894	0.09403	0.33209	0.08745	0.34911
21	0.12629	0.20182	0.12906	0.21681	0.09444	0.30073	0.08768	0.31850
22	0.12696	0.17620	0.13012	0.18860	0.09471	0.27225	0.08783	0.29052
23	0.12743	0.15374	0.13089	0.16392	0.09490	0.24641	0.08793	0.26498
24	0.12776	0.13410	0.13144	0.14237	0.09502	0.22300	0.08799	0.24166
25	0.12799	0.11694	0.13183	0.12360	0.09510	0.20179	0.08803	0.22039

Source:
Miaou, Shaw-Pin, "Study of Vehicle Scrappage Rates," Oak Ridge National Laboratory, Oak Ridge, TN, August 1990.

[a]Average scrappage and survival rates for all vehicles registered within this time period.

Figure 3.3. Survival Probabilities of Trucks



Source: See Table 3.7.

Table 3.8
Production of Automobiles and Trucks by State, Model Year 1993

State	Automobiles Number	Automobiles Percentage	Trucks Number	Trucks Percentage
California	191,320	3.1%		
Delaware	367,376	6.1%		
Georgia	357,334	5.9%		
Illinois	527,070	8.7%		
Indiana	50,471	0.8%	274,294	6.2%
Kansas	116,008	1.9%		
Kentucky	264,492	4.4%	453,335	10.3%
Louisiana			127,823	2.9%
Maryland			178,245	4.0%
Michigan	1,931,724	32.2%	864,303	19.6%
Minnesota			181,651	4.1%
Missouri	362,722	6.0%	772,468	17.5%
New Jersey			91,823	2.1%
New York			108,070	2.4%
North Carolina			21,450	0.5%
Ohio	955,851	15.9%	837,923	19.0%
Oklahoma	245,743	4.1%		
Oregon			14,250	0.3%
Pennsylvania			4,600	0.1%
South Carolina			10,850	0.2%
Tennessee	510,192	8.5%	107,834	2.4%
Texas	106,172	1.7%	7,440	0.2%
Utah			0	0.0%
Virginia			146,833	3.3%
Washington			9,350	0.2%
Wisconsin			204,086	4.6%
Total U.S.	5,990,479	100.0%	4,419,448[a]	100.0%

Source:
H. A. Stark (ed), Ward's Communications, Inc., Ward's Automotive Yearbook, Detroit, MI, 1994, pp. 187, 188.

[a]Total includes 2,820 miscellaneous medium and heavy-duty trucks.

Section 3.2.
Automobiles

Although the transplant share of new automobile sales grew from 1992 to 1993, the import share declined by nearly 3%. Domestic car sales have been rising since 1991, while import sales have been decreasing.

Table 3.9
New Retail Automobile Sales in the United States, 1970-93

Calendar Year	Domestic (thousands)	Import[a] (thousands)	Total (thousands)	Percentage imports	Percentage transplants[b] on model year basis	Percentage imports and transplants	Percentage diesel
1970	7,119	1,285	8,404	15.3%	c	c	c
1971	8,681	1,568	10,249	15.3%	c	c	0.06%
1972	9,327	1,623	10,950	14.8%	c	c	0.05%
1973	9,676	1,763	11,439	15.4%	c	c	0.06%
1974	7,454	1,399	8,853	15.8%	c	c	0.20%
1975	7,053	1,571	8,624	18.2%	c	c	0.31%
1976	8,611	1,499	10,110	14.8%	0.0%	14.8%	0.22%
1977	9,109	2,074	11,183	18.5%	0.0%	18.5%	0.34%
1978	9,312	2,002	11,314	17.7%	0.0%	17.7%	1.02%
1979	8,341	2,332	10,673	21.8%	1.3%	23.1%	2.54%
1980	6,581	2,398	8,979	26.7%	2.1%	28.8%	4.31%
1981	6,209	2,327	8,536	27.3%	1.8%	29.1%	6.10%
1982	5,759	2,223	7,982	27.9%	1.4%	29.3%	4.44%
1983	6,795	2,387	9,182	26.0%	1.3%	27.3%	2.09%
1984	7,952	2,439	10,391	23.5%	2.0%	25.5%	1.45%
1985	8,205	2,838	11,043	25.7%	2.2%	27.9%	0.82%
1986	8,215	3,238	11,453	28.3%	2.8%	31.1%	0.37%
1987	7,081	3,197	10,278	31.1%	5.2%	36.3%	0.16%
1988	7,526	3,099	10,626	29.2%	5.8%	35.0%	0.01%
1989	7,073	2,825	9,898	28.5%	7.3%	35.8%	0.13%
1990	6,897	2,404	9,301	25.8%	11.2%	37.0%	0.08%
1991	6,137	2,038	8,175	24.9%	13.7%	38.6%	0.11%
1992	6,277	1,938	8,214	23.6%	14.1%	37.7%	0.06%
1993	6,734	1,783	8,518	20.9%	14.9%	35.8%	0.10%
				Average annual percentage change			
1970-93	0.2%	1.4%	0.1%				
1982-93	-0.1%	-2.9%	-0.7%				

Sources:

Domestic and import data - American Automobile Manufacturers Association, Motor Vehicle Facts and Figures '93, Detroit, MI, 1994, p. 16, and annual.

Diesel data - H. A. Stark (ed), Ward's Communications, Inc., Ward's Automotive Yearbook, Detroit, MI, 1994, p. 44, and annual.

Transplant data - Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares Data System, Oak Ridge, TN, 1995.

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[a]Does not include import tourist deliveries.

[b]A transplant is an automobile which was built in the U.S. by a foreign firm. Also included are joint ventures which are built in the U.S.

[c]Data are not available.

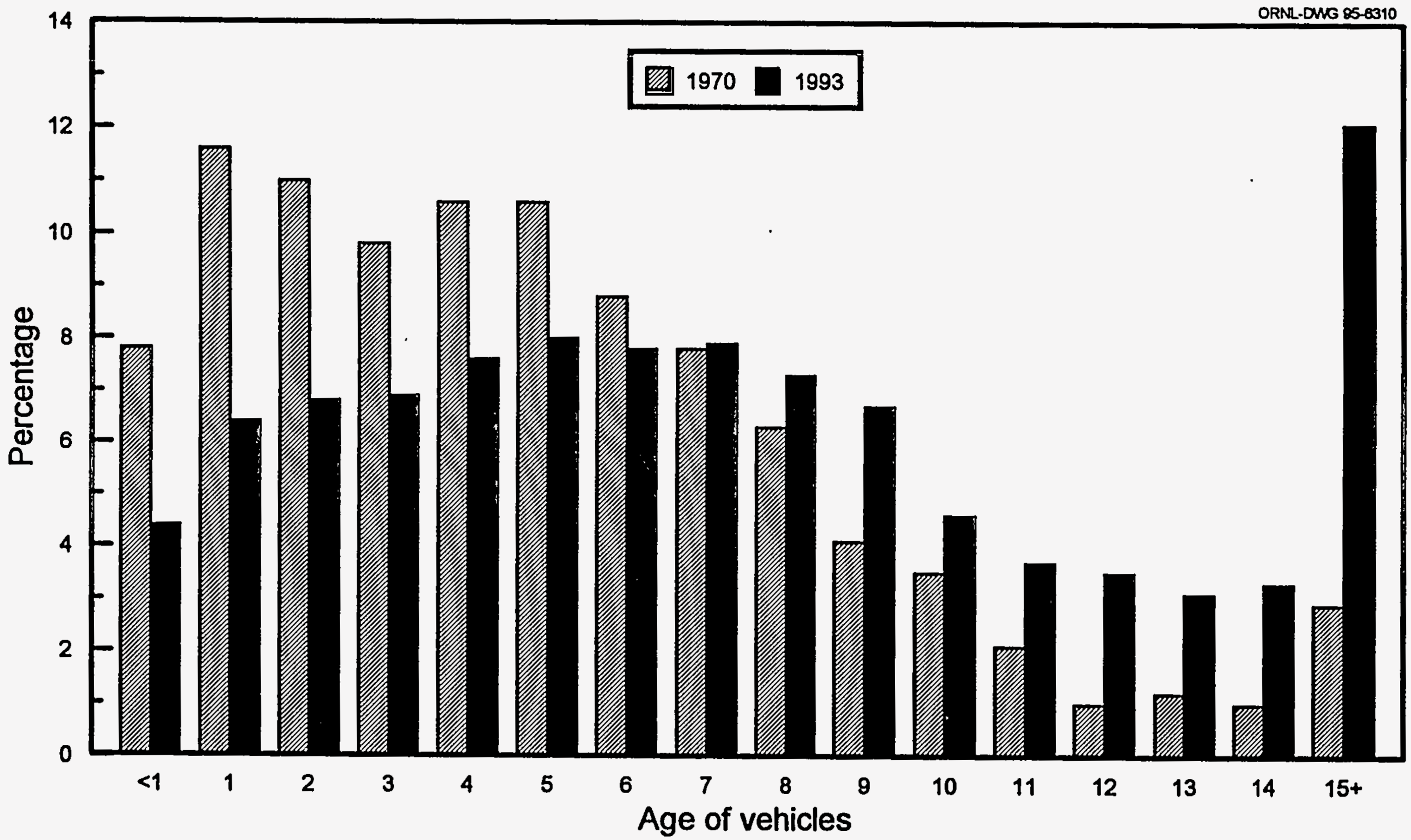
Table 3.10
Automobiles in Operation and Vehicle Travel by Age, 1970 and 1993

Age (years)	1970 Vehicles (thousands)	1970 Percentage	1970 Cumulative percentage	1993 Vehicles (thousands)	1993 Percentage	1993 Cumulative percentage	1993 Estimated vehicle travel Percentage	1993 Estimated vehicle travel Cumulative percentage
Under 1[a]	6,288	7.8%	7.8%	5,270	4.4%	4.4%	5.6%	5.6%
1	9,299	11.6%	19.4%	7,739	6.4%	10.8%	8.6%	14.2%
2	8,816	11.0%	30.3%	8,176	6.8%	17.5%	8.5%	22.7%
3	7,878	9.8%	40.1%	8,362	6.9%	24.4%	8.3%	31.0%
4	8,538	10.6%	50.8%	9,253	7.6%	32.1%	8.8%	39.8%
5	8,506	10.6%	61.3%	9,686	8.0%	40.1%	8.5%	48.3%
6	7,116	8.8%	70.2%	9,471	7.8%	47.9%	8.4%	56.7%
7	6,268	7.8%	78.0%	9,501	7.9%	55.8%	7.8%	64.5%
8	5,058	6.3%	84.3%	8,863	7.3%	63.1%	7.5%	72.1%
9	3,267	4.1%	88.3%	8,069	6.7%	69.7%	5.9%	78.0%
10	2,776	3.5%	91.8%	5,543	4.6%	74.3%	4.1%	82.1%
11	1,692	2.1%	93.9%	4,507	3.7%	78.1%	3.1%	85.2%
12	799	1.0%	94.9%	4,192	3.5%	81.5%	2.7%	88.0%
13	996	1.2%	96.1%	3,709	3.1%	84.6%	2.3%	90.2%
14	794	1.0%	97.1%	4,020	3.3%	87.9%	2.4%	92.6%
15 and older	2,336	2.9%	100.0%	14,636	12.1%	100.0%	7.4%	100.0%
Subtotal	**80,427**	**100.0%**		**120,996**	**100.0%**		**100.0%**	
Age not given	22			59				
Total	**80,449**			**121,055**				
Average age		5.5			8.3			
Median age		4.9			7.3			

Source:
R. L. Polk and Co., Detroit, MI. FURTHER REPRODUCTION PROHIBITED.
Vehicle travel - Average annual miles per auto by age were multiplied by the number of vehicles in operation by age to estimate the vehicle travel. Average annual miles per auto by age - generated by ORNL from the 1988 Residential Transportation Energy Consumption Survey public use tape, provided by the U.S. Department of Energy, Energy Information Administration, Office of Markets and End Use, Energy End Use Division, 1990.

[a]Automobiles sold as of July 1 of each year.

Figure 3.4 Automobiles in Use by Age, 1970 and 1993



Source: See Table 3.10.

Although registrations, vehicle travel, and fuel use of automobiles continued to climb in 1993 the fuel economy of the automobile population declined from 21.7 mpg in 1992 to 21.6 mpg in 1993 The fuel economy has increased significantly since 1970, largely due to older autos being scrapped and replaced with newer fuel-efficient autos, thus raising the population fuel economy.

Table 3.11
Summary Statistics for Passenger Cars, 1970-93

Year	Registrations[a] (thousands)	Vehicle travel (million miles)	Fuel use (million gallons)	Fuel economy[b] (miles per gallon)
1970	89,244	916,700	67,820	13.5
1971	92,718	966,340	71,351	13.5
1972	97,082	1,021,365	76,222	13.4
1973	101,985	1,045,981	78,668	13.3
1974	104,856	1,007,251	75,083	13.4
1975	106,704	1,033,950	76,447	13.5
1976	110,189	1,078,215	79,693	13.5
1977	112,288	1,109,243	80,397	13.8
1978	116,573	1,146,508	81,661	14.0
1979	118,429	1,113,640	77,304	14.4
1980	121,601	1,111,596	71,883	15.5
1981	123,098	1,130,827	70,954	15.9
1982	123,902	1,166,256	70,062	16.7
1983	126,444	1,198,023	69,906	17.1
1984	128,158	1,224,919	68,717	17.8
1985	131,864	1,260,565	69,268	18.2
1986	135,431	1,301,214	71,216	18.3
1987	137,208	1,355,330	70,573	19.2
1988	141,252	1,429,579	71,949	19.9
1989	143,026	1,477,769	72,749	20.3
1990	143,453	1,513,184	71,989	21.0
1991	142,569	1,533,552	70,692	21.7
1992	144,213	1,600,839	73,823	21.7
1993	146,314	1,623,972	75,059	21.6
		Average annual percentage change		
1970-93	2.2%	2.5%	0.4%	2.1%
1983-93	1.5%	3.1%	0.7%	2.4%

Source:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table VM-1, p. V-115, and annual.

[a]This number differs from R. L. Polk's estimates of "number of automobiles in use." See Table 3.4.
[b]Fuel economy for automobile population.

The data from the Nationwide Personal Transportation Study (NPTS) is based on estimates by survey respondents. The Residential Transportation Energy Consumption Survey (RTECS) data, which represents actual odometer readings of automobiles, has little bias from respondent estimations and, therefore, is the preferred data.

Table 3.12
Average Annual Miles Per Automobile by Automobile Age

Vehicle age (years)	National Personal Transportation Study[a]		Residential Transportation Energy Consumption Survey[b]			
	1983	1990	1983	1985	1988	1991
Under 1	14,200	19,800	13,400	12,700	12,900	13,400
1	17,000	16,900	13,000	13,000	13,400	14,100
2	14,000	16,300	12,700	12,600	12,600	12,600
3	12,500	14,400	12,100	12,400	12,100	13,200
4	11,400	13,800	11,300	11,100	11,500	13,300
5	11,000	12,600	9,700	10,600	10,600	12,200
6	9,900	12,900	9,700	10,000	10,800	11,200
7	9,400	12,400	9,500	9,700	10,000	10,700
8	8,700	12,300	8,700	8,900	10,300	11,400
9	8,100	11,200	8,400	8,600	8,900	10,000
10 and older	6,900	9,300	8,700	8,400	7,500	7,200
All vehicles	**10,400**	**12,600**	**9,400**	**9,900**	**10,200**	**10,600**

Sources:

Nationwide Personal Transportation Study—1983: D. Klinger and J. Richard Kuzmyak, COMSIS Corporation, Personal Travel in the United States, Volume 1: 1983-84 Nationwide Personal Travel Study, prepared for the U.S. Department of Transportation, Washington, DC, August 1986, Table 4-22, p.4-21.

1990: Generated from the 1990 Nationwide Personal Transportation Study Public Use Tape, March 1992.

Residential Transportation Energy Consumption Survey—Energy Information Agency, Office of Markets and End Use, Energy End Use Division, 1983, 1985, 1988 and 1991 Residential Transportation Energy Consumption Survey, Public Use Tapes.

[a]Includes only auto vehicles (standard auto, station wagon, taxi, and van-bus/minibus) owned by or available to the household on a regular basis.

[b]Includes all household vehicles—automobiles, station wagons, pick-up trucks, vans, and utility vehicles.

The average weight of the domestic automobile has been reduced nearly 350 pounds from 1978 to 1994, but increased slightly from 1984 to 1994. Much of the weight reduction was due to the declining use of conventional steel and iron and the increasing use of aluminum and plastics. Conventional steel, however, remained the predominant component of automobiles in 1994 with a 43.8% share of total materials. As conventional steel use has been decreasing, use of high-strength steel has increased.

Table 3.13
Average Material Consumption for a Domestic Automobile, 1978, 1984, and 1994

	1978		1984		1994	
Material	Pounds	Percentage	Pounds	Percentage	Pounds	Percentage
Conventional steel[a]	1,880.0	53.8	1,487.5	47.3	1,388.5	43.8
High-strength steel	127.5	3.6	214.0	6.8	263.0	8.3
Stainless steel	25.0	0.7	29.0	0.9	45.0	1.4
Other steels	56.0	1.6	45.0	1.4	42.5	1.3
Iron	503.0	14.4	454.5	14.5	406.0	12.8
Aluminum	112.0	3.2	137.0	4.4	182.0	5.7
Rubber	141.5	4.1	133.5	4.2	134.0	4.2
Plastics/Composites	176.0	5.0	206.5	6.6	245.5	7.7
Glass	88.0	2.5	87.0	2.8	89.0	2.8
Copper	39.5	1.1	44.0	1.4	42.0	1.3
Zinc die castings	28.0	0.8	17.0	0.5	16.0	0.5
Power metal parts	16.0	0.5	18.5	0.6	27.0	0.9
Fluids & lubricants	189.0	5.4	180.0	5.7	189.5	6.0
Other materials	112.5	3.2	88.0	2.8	99.0	3.1
Total	3,494.0	100.0	3,141.5	100.0	3,169.0	100.0

Source:
H. A. Stark (ed), Ward's Communications, Inc., Wards Automotive Yearbook, Detroit, MI, 1994, p. 27, and annual.

[a]Includes cold rolled and pre-coated steel.

Table 3.14
Sales-Weighted Engine Size of New Domestic and Import Automobiles by Size Class, Sales Periods 1976-93
(cubic inches -- 1 liter = 61.026 cubic inches)

Model year	Minicompact	Subcompact	Compact	Midsize	Large	Two seater	Fleet
76	[a]	163.1	304.9	357.0	414.2	176.2	298.5
77	120.8	166.4	292.4	333.5	367.2	171.6	278.3
78	125.5	162.8	241.0	298.6	376.3	183.8	264.4
79	113.2	146.0	228.5	268.9	339.4	168.8	230.8
80	115.8	128.2	184.8	237.9	312.3	170.0	196.5
81	96.1	124.6	134.2	221.2	304.8	151.7	182.0
82	93.5	127.2	129.3	212.0	288.4	147.2	176.1
83	97.8	133.6	134.3	210.3	302.0	153.8	182.1
84	132.7	135.3	135.1	207.3	297.1	152.4	181.2
85	118.8	139.8	138.8	205.5	283.6	150.9	178.3
86	88.4	133.6	134.6	194.9	267.3	172.5	168.3
87	90.2	133.4	134.4	182.4	266.3	157.1	163.5
88	92.5	125.0	135.1	183.1	263.4	167.9	162.2
89	155.2	127.0	128.8	183.5	263.1	171.3	163.5
90	147.7	119.6	137.5	190.7	264.3	157.0	166.1
91	132.6	120.2	135.8	192.9	268.3	163.1	166.2
92	111.9	122.5	141.9	192.9	265.2	184.4	168.6
93	115.7	126.8	138.6	192.6	260.3	210.9	169.4

Source:
Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

[a]There were no minicompact automobiles sold in 1976.

Table 3.15
Sales-Weighted Curb Weight of New Domestic and Import Automobiles by Size Class, Sales Periods 1976-93
(pounds)

Model year	Minicompact	Subcompact	Compact	Midsize	Large	Two seater	Fleet
76	[a]	2,577.2	3,608.7	4,046.1	4,562.55	2,624.1	3,608.0
77	2,228.0	2,586.3	3,549.8	3,900.3	4,025.8	2,608.1	3,424.4
78	2,199.6	2,444.3	3,137.5	3,426.8	3,955.7	2,762.5	3,196.5
79	2,120.1	2,366.7	3,048.0	3,286.7	3,763.4	2,699.1	3,000.4
80	2,154.3	2,270.4	2,812.5	3,080.9	3,667.44	2,790.3	2,790.3
81	1,919.8	2,370.3	2,381.7	2,995.7	3,671.88	2,744.3	2,744.3
82	2,002.1	2,301.7	2,421.8	2,991.9	3,702.88	2,524.8	2,729.8
83	2,072.0	2,333.9	2,441.3	3,026.5	3,779.00	2,662.5	2,787.9
84	2,375.9	2,380.4	2,453.7	2,990.0	3,733.66	2,559.3	2,787.7
85	2,210.8	2,391.8	2,464.3	2,953.6	3,575.44	2,538.6	2,743.4
86	2,120.3	2,414.8	2,431.5	2,856.7	3,451.22	2,574.5	2,675.3
87	1,959.7	2,422.5	2,474.0	2,856.8	3,483.0	2,601.8	2,688.5
88	1,932.7	2,346.3	2,558.1	2,880.3	3,487.33	2,693.0	2,716.8
89	2,575.8	2,357.3	2,517.1	2,984.5	3,495.77	2,734.9	2,759.6
90	2,650.7	2,368.4	2,637.2	3,065.3	3,593.99	2,656.3	2,827.7
91	2,583.6	2,405.8	2,652.1	3,084.7	3,649.66	2,707.3	2,848.2
92	2,358.2	2,443.7	2,669.2	3,130.5	3,670.00	2,878.7	2,878.7
93	2,396.2	2,482.8	2,651.3	3,142.0	3,615.44	2,893.4	2,893.4

Source:
Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

[a]There were no minicompact automobiles sold in 1976.

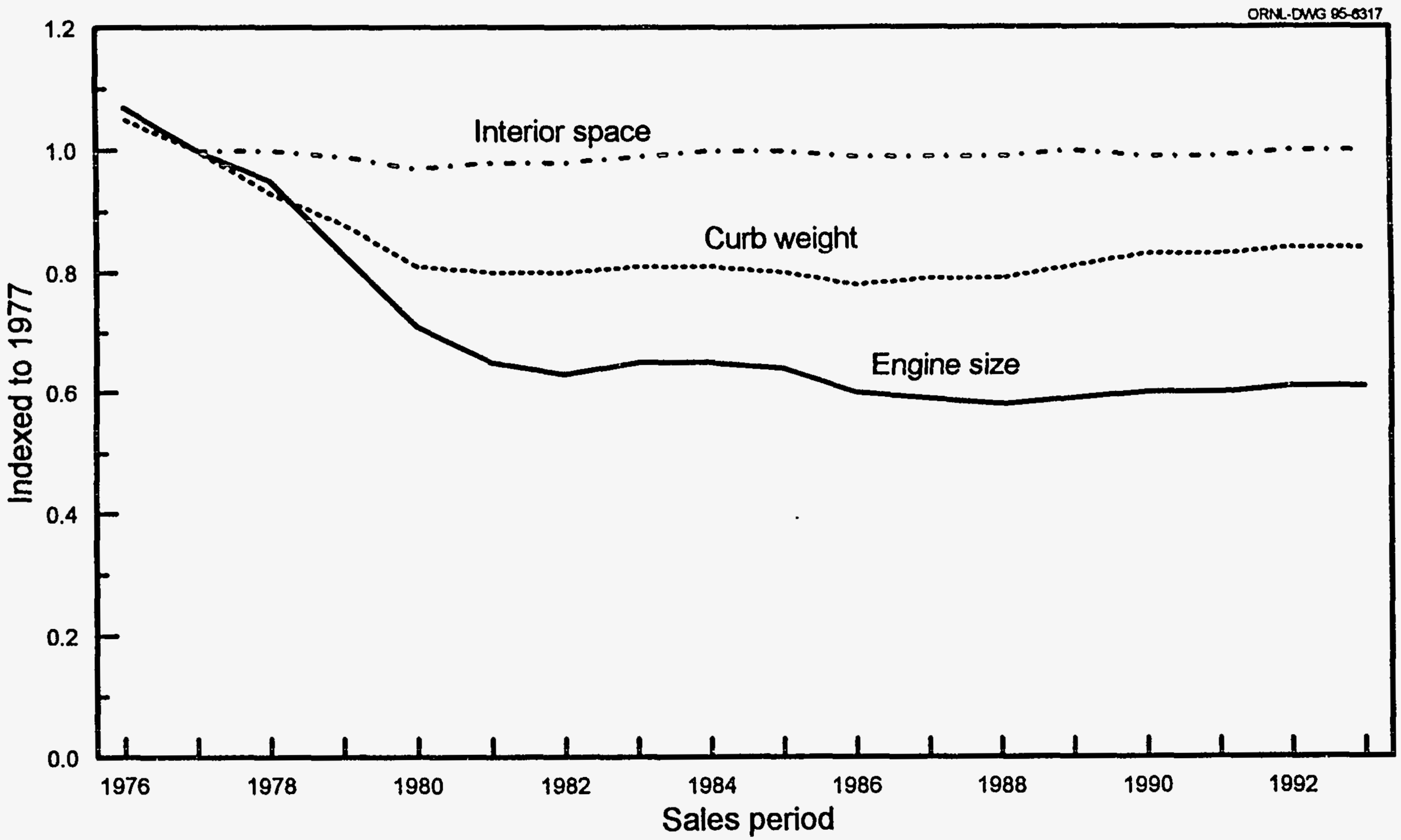
Table 3.16
Sales-Weighted Interior Space of New Domestic and Import Automobiles by Size Class, Sales Periods 1976-93
(cubic feet)

Model year	Minicompact (< 85)	Subcompact (85-99)	Compact (100-109)	Midsize (110-119)	Large (> 120)	Fleet[a]
77	78.8	89.8	107.1	113.0	128.0	107.9
78	79.4	89.8	105.3	112.9	128.5	107.9
79	80.0	90.2	105.8	113.4	130.1	106.9
80	82.4	89.9	105.4	113.5	130.8	104.9
81	83.3	90.2	103.6	113.7	130.6	105.5
82	83.1	91.3	102.9	113.9	130.4	106.0
83	82.7	93.3	103.0	113.1	131.3	107.3
84	77.0	93.8	103.0	113.3	130.4	108.0
85	77.8	94.1	103.1	113.5	129.7	107.9
86	80.1	94.5	102.8	113.8	127.6	107.0
87	81.6	93.1	103.0	113.9	127.5	106.9
88	81.0	93.5	103.3	113.6	127.2	107.0
89	75.0	93.3	102.7	113.8	127.4	107.5
90	79.9	93.9	103.2	113.8	127.8	107.3
91	79.6	94.4	103.2	113.8	128.3	107.1
92	79.7	94.0	104.2	114.0	129.1	107.6
93	79.7	94.7	103.9	114.1	128.9	108.1

Source:
Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

[a]Interior volumes of two seaters are not reported to EPA.

Figure 3.5. Engine Size, Curb Weight, and Interior Space of New Domestic and Import Automobiles, 1976-93



Source: See Tables 3.14, 3.15, and 3.16.

Table 3.17
Period Sales, Market Shares, and Sales-Weighted Fuel Economies of New Domestic and Import Automobiles, Selected Sales Periods 1976-93[a]

	1976	1980	1982	1984	1986	1988	1990	1992	1993
MINICOMPACT									
Total sales, units	[b]	428,346	221,699	41,368	191,490	84,186	76,698	100,504	77,215
Market share, %	[b]	4.7	2.9	0.4	1.7	0.8	0.8	1.2	0.9
Fuel economy, mpg	[b]	29.4	36.5	29.0	31.9	37.8	26.4	31.0	30.5
SUBCOMPACT									
Total sales, units	2,625,929	3,441,480	2,404,489	2,510,929	2,350,081	1,983,353	2,030,226	2,044,016	1,893,902
Market share, %	27.1	37.8	31.4	24.6	21.2	19.1	22.0	25.2	22.6
Fuel economy, mpg	23.5	27.3	30.2	30.5	30.7	31.7	31.3	31.8	31.9
COMPACT									
Total sales, units	2,839,603	599,423	1,300,372	2,768,056	3,829,093	4,199,638	3,156,481	2,482,187	2,708,091
Market share, %	29.3	6.6	17.0	27.1	34.5	40.5	34.2	30.6	32.3
Fuel economy, mpg	17.1	22.3	30.1	30.6	30.0	29.8	28.9	28.8	29.3
MIDSIZE									
Total sales, units	1,815,505	3,073,103	2,533,121	3,059,647	2,985,835	2,550,964	2,511,503	2,249,553	2,445,842
Market share, %	18.7	33.8	33.1	30.0	26.9	24.6	27.2	27.7	29.2
Fuel economy, mpg	15.3	21.3	24.1	24.1	25.6	26.9	25.9	25.8	25.7
LARGE									
Total sales, units	2,206,102	1,336,190	995,561	1,502,097	1,467,077	1,368,717	1,279,092	1,140,775	1,186,991
Market share, %	22.8	14.7	13.0	14.7	13.2	13.2	13.9	14.1	14.2
Fuel economy, mpg	13.9	19.3	20.6	20.2	23.8	24.2	23.5	23.7	24.0
TWO SEATER									
Total sales, units	199,716	215,964	202,929	328,968	275,470	186,127	170,465	89,965	75,367
Market share, %	2.1	2.4	2.6	3.2	2.5	1.8	1.8	1.1	0.9
Fuel economy, mpg	20.1	21.0	25.1	26.5	28.4	27.3	28.0	25.6	24.6
FLEET									
Total sales, units	9,686,855	9,094,506	7,658,171	10,211,065	11,099,046	10,372,985	9,224,465	8,107,000	8,387,408
Market share, %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fuel economy, mpg	17.2	23.2	26.3	26.3	27.9	28.5	27.6	27.7	27.8

Source:
Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

[a]These figures represent only those sales that could be matched to corresponding EPA fuel economy values.
[b]There were no minicompact automobiles sold in 1976.

Section 3.3
Trucks

Light trucks' share of light-duty vehicle sales was nearly 39% in 1993. Although domestic light truck sales increased in 1993, import sales continued to decline, evidenced by the 1.8% decline in the import share of total sales. Transplants, however, have grown to 7.1% of the 1993 light truck sales.

Table 3.18
New Retail Sales of Light Trucks in the United States, 1970-93

		Percentages					
Calendar Year	Light truck sales[a]	Import[b]	Transplants[c]	Diesel	Four-wheel drive on domestic light trucks	Light trucks of light-duty vehicle sales[d]	Light trucks of total truck sales
1970	1,463	4.5%	[e]	[f]	[e]	14.8%	80.4%
1971	1,757	4.8%	[e]	[f]	[e]	14.6%	83.4%
1972	2,239	6.4%	[e]	[f]	[e]	16.7%	83.3%
1973	2,745	8.5%	[e]	[f]	[e]	18.8%	84.2%
1974	2,338	7.5%	[e]	[f]	18.0%	20.3%	84.2%
1975	2,281	10.0%	[e]	[f]	23.4%	20.1%	87.9%
1976	2,956	8.0%	0.0%	[f]	23.8%	22.0%	89.8%
1977	3,430	9.4%	0.0%	[f]	24.6%	22.8%	89.7%
1978	3,808	8.8%	0.0%	1.0%	28.5%	24.5%	89.2%
1979	3,311	14.1%	0.0%	1.0%	29.4%	22.4%	88.7%
1980	2,440	19.7%	0.9%	3.2%	20.7%	19.8%	88.9%
1981	2,189	20.3%	0.0%	3.3%	18.6%	19.2%	89.8%
1982	2,470	16.5%	0.0%	5.0%	16.8%	23.0%	92.8%
1983	2,984	15.6%	0.0%	4.0%	28.5%	24.2%	93.6%
1984	3,863	15.7%	2.0%	3.8%	27.0%	26.9%	93.0%
1985	4,458	17.2%	2.6%	3.3%	29.1%	28.7%	93.6%
1986	4,594	20.1%	2.3%	2.6%	27.0%	28.6%	94.3%
1987	4,610	17.9%	1.7%	2.3%	32.0%	31.0%	93.9%
1988	4,800	12.6%	2.4%	2.0%	32.1%	31.1%	93.2%
1989	4,610	10.9%	2.6%	2.1%	31.4%[g]	31.8%	93.3%
1990	4,548	13.2%	3.4%	2.2%[g]	31.6%[g]	32.8%	93.9%
1991	4,123	12.8%	4.5%	2.2%[g]	34.4%[g]	33.5%	94.5%
1992	4,629	8.6%	5.5%	2.5%[g]	31.6%[g]	36.0%	94.4%
1993	5,351	6.8%	7.1%	2.3%[g]	32.6%[g]	38.6%	94.2%
			Average annual percentage change				
1970-93	7.3%						
1983-93	6.0%						

Sources:

Four-wheel drive - 1970-88: H. A. Stark (ed.), Ward's Communication, Inc., Ward's Automotive Yearbook, Detroit, MI, 1989, p. 168, and annual. 1989-93: H. A. Stark (ed.), Ward's Communications, Inc., Ward's Automotive Yearbook, Factory Installation Reports, Detroit, MI, 1994.

Transplants - Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

All other - American Automobile Manufacturers Association, Motor Vehicle Facts and Figures '94, Detroit, MI, 1994, pp. 8, 19, 20, 21, and annual.

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[a]Includes all trucks of 10,000 pounds gross vehicle weight and less sold in the U.S.

[b]Excluding transplants.

[c]Based on model year data. A transplant is a light truck which was built in the U.S. by a foreign firm. Also included are joint ventures built in the U.S.

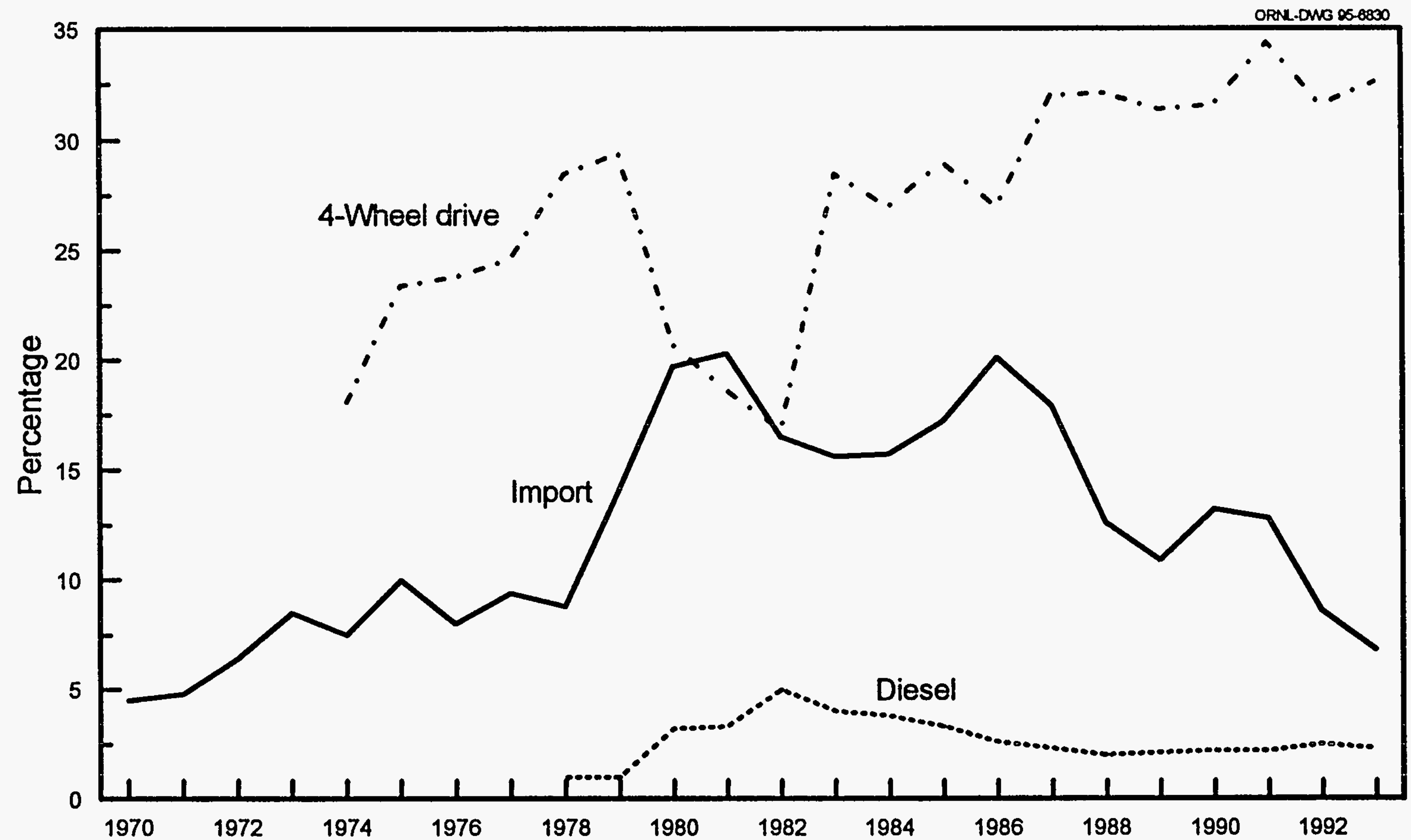
[d]Light-duty vehicles include cars and light trucks.

[e]Data are not available.

[f]Indicates less than 1 percent.

[g]Based on factory installions or factory sales.

Figure 3.6. Import, Diesel, and Four-Wheel Drive Shares of Light Truck Sales, 1970-93



Source: See Table 3.18.

Table 3.19
New Retail Domestic Truck Sales by Gross Vehicle Weight, 1970-93[a]
(thousands)

Calendar Year	Class 1 6,000 lbs. or less	Class 2 6,001-10,000 lbs.	Class 3 10,001-14,000 lbs.	Class 4 14,001-16,000 lbs.	Class 5 16,001-19,500 lbs.	Class 6 19,501-26000 lbs.	Class 7 26,001-33,000 lbs.	Class 8 33,001 lbs. and over	Total[b]
1970[c]	1,049	408	6	12	58	133	36	89	1,791
1971	1,185	488	6	15	46	140	34	99	2,013
1972	1,498	599	55	11	29	182	35	126	2,535
1973	1,754	758	50	3	16	236	37	155	3,009
1974	1,467	696	21	3	14	207	31	148	2,587
1975	1,101	952	23	1	9	159	23	83	2,351
1976	1,318	1,401	43	[d]	9	153	22	97	3,043
1977	1,306	1,803	36	3	5	163	28	141	3,485
1978	1,334	2,140	73	6	3	156	41	162	3,915
1979	1,271	1,574	15	3	3	146	50	174	3,236
1980	985	975	4	[d]	2	90	58	117	2,231
1981	896	850	1	[d]	2	72	51	100	1,972
1982	1,102	961	1	[d]	1	44	62	76	2,248
1983	1,314	1,207	[d]	[d]	1	47	59	82	2,710
1984	2,031	1,224	6	[d]	5	55	78	138	3,538
1985	2,408	1,280	11	[d]	5	48	97	134	3,983
1986	2,541	1,214	7	[d]	6	42	98	112	4,020
1987	2,697	1,175	7	[d]	6	41	98	131	4,155
1988	2,926	1,333	6	20	6	51	98	148	4,588
1989	2,809	1,297	7	26	4	34	81	145	4,403
1990	2,852	1,097	8	26	2	33	76	121	4,215
1991	2,719	876	11	23	[d]	19	67	98	3,813
1992	3,212	1,021	14	23	[d]	23	69	119	4,481
1993	3,754	1,232	14	29	[d]	22	77	158	5,287
				Average annual percentage change					
1970-93	5.7%	4.9%	3.8%	3.9%	-	-7.5%	3.4%	2.5%	4.8%
1983-93	11.1%	0.2%	-	-	-	-7.3%	2.7%	6.8%	6.9%

Source:
American Automobile Manufacturers Association, Motor Vehicle Facts and Figures '94, Detroit, MI, 1994, p. 21, and annual.

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[a]Sales include domestic-sponsored imports.
[b]Totals may not equal Motor Vehicle Manufacturers Association totals due to rounding.
[c]Data for 1970 is based on new truck registrations.
[d]Less than 500 trucks.

Table 3.20
Trucks in Operation and Vehicle Travel by Age, 1970 and 1993

Age (years)	1970			1993			1993 Estimated vehicle travel		Average annual miles per vehicle
	Vehicles (thousands)	Percentage	Cumulative percentage	Vehicles (thousands)	Percentage	Cumulative percentage	Percentage	Cumulative percentage	
Under 1[a]	1,262	7.1%	7.1%	3,393	5.2%	5.2%	6.7%	6.7%	14,901
1	1,881	10.6%	17.8%	4,380	6.7%	11.9%	9.8%	16.4%	16,853
2	1,536	8.7%	26.5%	4,305	6.6%	18.5%	9.5%	26.0%	16,719
3	1,428	8.1%	34.6%	4,232	6.5%	25.0%	9.0%	34.9%	16,074
4	1,483	8.4%	43.0%	4,859	7.5%	32.5%	9.0%	43.9%	14,005
5	1,339	7.6%	50.5%	4,829	7.4%	39.9%	8.9%	52.9%	13,952
6	1,154	6.5%	57.1%	4,298	6.6%	46.5%	7.8%	60.6%	13,687
7	975	5.5%	62.6%	4,496	6.9%	53.4%	7.5%	68.1%	12,644
8	826	4.7%	67.3%	3,858	5.9%	59.3%	5.8%	73.9%	11,387
9	621	3.5%	70.8%	3,369	5.2%	64.5%	4.7%	78.7%	10,665
10	658	3.7%	74.5%	2,111	3.2%	67.7%	1.9%	80.6%	6,960
11	583	3.3%	77.8%	1,752	2.7%	70.4%	1.6%	82.3%	6,960
12	383	2.2%	80.0%	1,580	2.4%	72.8%	1.5%	83.7%	6,960
13	417	2.4%	82.3%	1,478	2.3%	75.1%	1.4%	85.1%	6,960
14	414	2.3%	84.7%	2,569	3.9%	79.0%	2.4%	87.4%	6,960
15 and older	2,710	15.3%	100.0%	13,662	21.0%	100.0%	12.6%	100.0%	6,960
Subtotal	**17,670**	**100.0%**		**65,171**	**100.0%**		**100.0%**		
Age not given	15			89					
Total	**17,685**			**65,260**					
Average age		7.3			8.6				
Median age		5.9			7.5				

Source:

R. L. Polk and Co., Detroit, MI. **FURTHER REPRODUCTION PROHIBITED.**

Vehicle travel—The average annual vehicle miles per truck by age were multiplied by the number of trucks in operation by age to estimate the vehicle travel. Average annual miles per truck by age were generated by ORNL from the 1987 Truck Inventory and Use Survey public use tape provided by U.S. Department of Commerce, Bureau of the Census, Washington, DC, 1990.

[a]Trucks sold as of July 1 of each year.

Table 3.21
Sales-Weighted Engine Size of New Domestic and Import Light Trucks by Size Class
Sales Periods 1976-93
(cubic inches -- 1 liter = 61.026 cubic inches)

Model year	Small pickup	Large pickup	Small van	Large van	Small utility	Large utility	Fleet
76	116.7	339.6	120.0	328.8	329.1	303.1	318.9
77	122.8	334.4	120.0	324.7	333.4	302.1	306.7
78	123.9	332.6	120.0	322.7	310.8	329.7	306.5
79	125.3	314.1	120.0	313.3	275.7	323.3	281.7
80	125.0	308.4	120.0	306.7	261.6	329.0	264.2
81	130.4	294.1	120.0	295.5	240.6	314.3	253.4
82	142.7	304.4	109.4	300.5	237.0	321.3	258.8
83	143.7	303.5	114.3	308.6	186.0	326.1	244.2
84	145.0	301.8	136.2	308.7	171.2	329.0	235.9
85	145.5	290.8	161.9	312.6	172.7	327.5	229.8
86	148.0	285.6	169.8	313.1	169.4	338.6	222.6
87	149.0	286.0	180.8	317.8	171.1	331.0	222.6
88	156.5	285.7	192.2	318.2	191.7	336.3	232.8
89	160.8	286.9	189.5	318.3	213.6	332.8	239.9
90	177.0	274.0	200.8	318.0	206.1	334.1	239.6
91	177.6	278.9	201.0	319.3	220.9	329.6	240.4
92	187.1	278.4	202.3	322.3	225.0	308.6	243.8
93	198.2	263.9	202.0	317.7	223.4	306.5	245.7

Source:
Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

Table 3.22
Period Sales, Market Shares, and Sales-Weighted Fuel Economies of New Domestic and Import Light Trucks, Selected Sales Periods 1976-93[a]

	1976	1980	1982	1984	1986	1988	1990	1992	1993
SMALL PICKUP									
Total sales, units	170,351	516,412	579,263	1,012,2988	1,225,5700	1,026,5511	678,488	586,752	332,470
Market share, %	7.1	23.3	27.2	28.0	27.0	21.6	15.0	13.4	6.6
Fuel economy, mpg	23.9	25.5	28.1	27.2	26.1	26.1	25.2	25.0	24.9
LARGE PICKUP									
Total sales, units	1,586,020	1,115,248	1,000,772	1,218,972	1,325,547	1,453,255	1,573,729	1,452,192	1,877,806
Market share, %	66.4	50.3	46.9	33.7	29.2	30.6	34.9	33.1	37.2
Fuel economy, mpg	15.1	17	18.6	17.5	18.4	18.5	18.9	18.9	19.6
SMALL VAN									
Total sales, units	18,651	13,649	11,964	222,798	640,936	851,384	932,693	961,348	1,121,786
Market share, %	0.8	0.6	0.6	6.2	14.1	18.0	20.7	21.9	22.2
Fuel economy, mpg	19.5	19.6	22.5	25.0	23.8	22.9	23.1	22.5	22.8
LARGE VAN									
Total sales, units	574,745	328,065	379,110	545,595	510,558	486,981	398,877	350,013	388,435
Market share, %	24.1	14.8	17.8	15.1	11.3	10.3	8.8	8.0	7.7
Fuel economy, mpg	15.4	16.3	17.0	16.3	17.3	17.0	16.9	16.9	17.3
SMALL UTILITY									
Total sales, units	4,716	75,875	28,376	398,000	598,652	701,005	738,294	854,572	938,514
Market share, %	0.2	3.4	1.3	11.0	13.2	14.8	16.4	19.5	18.6
Fuel economy, mpg	15.5	16.9	20.9	23.0	21.5	22.4	21.9	20.9	21.3
LARGE UTILITY									
Total sales, units	32,427	167,288	133,355	215,271	233,625	223,824	192,544	180,576	388,993
Market share, %	1.4	7.5	6.3	6.0	5.2	4.7	4.3	4.1	7.7
Fuel economy, mpg	14.7	14.6	16.9	15.7	15.9	16.2	16.1	17.2	17.6
FLEET									
Total sales, units	2,386,910	2,216,537	2,132,840	3,612,934	4,534,888	4,743,000	4,514,625	4,385,453	5,048,004
Market share, %	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Fuel economy, mpg	15.6	18.1	20.0	20.0	20.8	20.7	20.5	20.4	20.5

Source:
Oak Ridge National Laboratory, Light-Duty Vehicle MPG and Market Shares System, Oak Ridge, TN, 1995.

[a]These figures represent only those sales that could be matched to corresponding EPA fuel economy values.

Vehicle travel for two-axle, four tire trucks in 1993 is more than three times the 1970 vehicle travel. Registrations in 1993 are not quite three times the 1970 level, indicating that the annual travel per truck has increased.

Table 3.23
Summary Statistics for Two-Axle, Four-Tire Trucks, 1970-93

Year	Registrations (thousands)	Vehicle travel (million miles)	Fuel use (million gallons)	Fuel economy (miles per gallon)
1970	14,211	123,286	12,313	10.0
1971	15,181	137,870	13,484	10.2
1972	16,428	156,622	15,150	10.3
1973	18,083	176,833	16,828	10.5
1974	19,335	182,757	16,657	11.0
1975	20,418	200,700	17,903	11.2
1976	22,301	225,834	20,164	11.2
1977	23,624	250,591	21,895	11.4
1978	25,476	279,414	24,055	11.6
1979	27,022	291,905	24,742	11.8
1980	27,876	290,935	23,594	12.3
1981	28,928	296,343	23,697	12.5
1982	29,792	306,141	23,845	12.8
1983	31,214	327,643	25,556	12.8
1984	32,106	357,999	27,687	12.9
1985	33,865	373,072	29,021	12.9
1986	34,820	389,047	30,265	12.9
1987	35,841	415,449	32,266	12.9
1988	37,096	439,496	32,803	13.4
1989	37,918	454,339	33,005	13.8
1990	38,864	466,092	32,937	14.2
1991	39,067	472,848	32,531	14.5
1992	39,533	478,193	33,127	14.4
1993	40,903	497,201	34,807	14.3
		Average annual percentage change		
1970-93	4.7%	6.3%	4.6%	1.6%
1983-93	2.7%	4.3%	3.1%	1.1%

Source:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table VM-1, p. V-115, and annual.

Table 3.24
Summary Statistics for Other Single-Unit and Combination Trucks, 1970-93

	Other single-unit trucks[a]				Combination trucks[b]			
Year	Registrations (thousands)	Vehicle travel (million miles)	Fuel use (million gallons)	Fuel economy (miles per gallon)	Registrations (thousands)	Vehicle travel (million miles)	Fuel use (million gallons)	Fuel economy (miles per gallon)
1970	3,681	27,081	3,968	6.8	905	35,134	7,347	4.8
1971	3,770	28,985	4,212	6.9	919	37,217	7,595	4.9
1972	3,918	31,414	4,560	6.9	961	40,706	8,120	5.0
1973	4,131	33,661	4,859	6.9	1,029	45,649	9,026	5.1
1974	4,211	33,441	4,687	7.1	1,085	45,966	8,800	5.2
1975	4,232	34,606	4,825	7.2	1,131	46,724	8,653	5.4
1976	4,350	36,390	5,140	7.1	1,225	49,680	9,536	5.2
1977	4,450	39,339	5,559	7.1	1,240	55,683	10,673	5.2
1978	4,518	42,727	6,106	7.0	1,342	62,992	12,113	5.2
1979	4,505	42,012	6,036	7.0	1,386	66,992	12,864	5.2
1980	4,374	39,813	5,557	7.2	1,417	68,678	12,703	5.4
1981	4,455	39,568	5,574	7.1	1,261	69,134	12,960	5.3
1982	4,325	40,212	5,661	7.1	1,265	66,668	12,636	5.3
1983	4,204	43,409	6,118	7.1	1,304	69,754	13,447	5.2
1984	4,061	46,560	6,582	7.1	1,340	77,367	14,781	5.2
1985	3,927	46,980	6,735	7.0	1,403	79,600	15,280	5.2
1986	3,850	48,308	6,929	7.0	1,399	81,833	15,716	5.2
1987	3,884	49,537	7,091	7.0	1,419	86,064	16,493	5.2
1988	3,957	51,239	7,260	7.1	1,476	90,158	17,123	5.3
1989	4,103	52,969	7,413	7.2	1,589	95,349	17,495	5.5
1990	4,243	53,443	7,294	7.3	1,611	96,367	17,469	5.5
1991	4,265	53,787	7,181	7.5	1,604	96,942	17,157	5.7
1992	4,316	53,691	7,179	7.5	1,655	99,112	17,691	5.6
1993	4,466	56,693	7,667	7.4	1,726	102,709	18,517	5.6
				Average annual percentage change				
1970-93	0.8%	3.3%	2.9%	0.4%	2.8%	4.8%	4.1%	0.7%
1983-93	0.6%	2.7%	2.3%	0.4%	2.8%	3.9%	3.3%	0.7%

Source:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table VM-1, p. V-115, and annual.

[a]Other single-unit trucks are defined as all single-unit trucks with more than two axles or more than four tires.

[b]The fuel economy for combination trucks is not the same as the fuel economy for Class 8 trucks. Fuel economy for Class 8 trucks is shown in Table 3.25.

Table 3.25
Truck Fuel Economy by Size Class, 1977, 1982, and 1987
(miles per gallon)

Size Class	Weight	1977 TIUS[a]	1982 TIUS[a]	1987 TIUS[a]
Class 1	6,000 pounds and less	13.2	14.2	15.0
Class 2	6,001-10,000 pounds	11.5	11.1	10.9
Class 3	10,000-14,000 pounds	9.4	8.1	8.1
Class 4	14,001-16,000 pounds	6.9	7.5	7.5
Class 5	16,001-19,500 pounds	7.6	7.2	7.1
Class 6	19,501-26,000 pounds	6.1	6.9	6.4
Class 7	26,001-33,000 pounds	5.3	6.2	6.1
Class 8	33,001 and over	4.8	5.2	5.3

Source:
Estimates are based on data provided on the following public use tapes: U.S. Department of Commerce, Bureau of the Census, 1977 Census of Transportation, Truck Inventory and Use Survey, Washington, DC, 1980; U.S. Department of Commerce, Bureau of the Census, 1982 Census of Transportation, Truck Inventory and Use Survey, Washington, DC, 1985; and U.S. Department of Commerce, Bureau of the Census, 1987 Census of Transportation, Truck Inventory and Use Survey, Washington, DC, 1990.

Table 3.26
Percentage of Trucks by Size Class, 1977, 1982, and 1987
(percentage)

Size Class	Weight	1977 TIUS[a]	1982 TIUS[a]	1987 TIUS[a]
Class 1	6,000 pounds and less	66.0	77.8	85.4
Class 2	6,001-10,000 pounds	17.9	11.6	6.5
Class 3	10,000-14,000 pounds	3.1	1.6	1.2
Class 4	14,001-16,000 pounds	1.3	0.9	0.5
Class 5	16,001-19,500 pounds	2.1	1.0	0.6
Class 6	19,501-26,000 pounds	3.4	2.4	1.7
Class 7	26,001-33,000 pounds	1.5	1.0	0.8
Class 8	33,001 and over	4.6	3.8	3.3

Source:
Estimates are based on data provided on the following public use tapes: U.S. Department of Commerce, Bureau of the Census, 1977 Census of Transportation, Truck Inventory and Use Survey, Washington, DC, 1980; U.S. Department of Commerce, Bureau of the Census, 1982 Census of Transportation, Truck Inventory and Use Survey, Washington, DC, 1985; and U.S. Department of Commerce, Bureau of the Census, 1987 Census of Transportation, Truck Inventory and Use Survey, Washington, DC, 1990.

[a]Truck Inventory and Use Survey.

Section 3.4
Buses

Table 3.27
Summary Statistics on Buses by Type, 1970-93

Year	Transit motor bus[a]	Intercity bus	School bus
	Number in Operation		
1970	49,700	22,000	288,700
1975	50,811	20,500	368,300
1980	59,411	21,400	418,255
1985	64,258	20,200	480,400
1990	58,714	20,680	508,261
1991	60,377	21,158	513,227
1992	63,080	19,904	525,838
1993	64,648	19,119	534,872
	Vehicle-miles (millions)		
1970	1,409	1,209	2,100
1975	1,526	1,126	2,500
1980	1,677	1,162	2,900
1985	1,863	933	3,448
1990	2,123	991	3,800
1991	2,167	1,013	4,300
1992	2,178	1,022	4,400
1993	2,206	1,000	4,300
	Passenger-miles (millions)		
1970	18,210	25,300	[b]
1975	18,300	25,400	[b]
1980	21,790	27,400	[b]
1985	21,161	23,800	[b]
1990	20,981	23,000	74,200
1991	21,090	23,500	83,300
1992	20,336	23,700	90,000
1993	20,075	23,200	94,200
	Energy Use (trillion Btu)		
1970	44.8	26.6	37.5
1975	51.5	24.8	42.6
1980	61.3	29.3	47.5
1985	72.4	31.5	57.0
1990	78.9	21.7	62.2
1991	80.6	22.6	70.6
1992	81.0	22.1	72.1
1993	87.8[c]	[b]	[b]

Source:
See Appendix A for Table 3.27.

[a]Data for Transit buses after 1983 is not comparable with prior data. Data for prior years were provided voluntarily and statistically expanded, but in 1984 reporting became mandatory.
[b]Data are not available.
[c]In 1993 data became available on alternative fuel use by transit buses.

Section 3.5
Fleets

Automobile fleet data are difficult to estimate, but progress is made each year in compiling fleet estimates. In the mid-eighties it was discovered that daily rental fleets from 1970 to 1983 had been grossly underestimated. Now, newly available data dictate changes in the number of business fleets, individually leased fleets, government fleets, and utility fleets in 1993. Since these data are not historically consistent, please use caution when comparing 1993 data to earlier years.

Table 3.28
Automobile Fleets by Use, 1982-93
(thousands)

	Cars in fleets of 10 or more								
Year	Business fleets[a]	Individual leased	Government	Utilities	Police	Taxi	Daily rental	Total cars	Cars in fleets of 4 or more
1982	3,324	1,645	500	530	223	141	[b]	6,923	10,076
1983	3,383	1,653	500	533	221	139	[b]	7,001	10,400
1984	3,422	1,657	528	540	228	140	755	7,380	10,475
1985	3,484	1,800	528	540	233	140	760	7,600	10,508
1986	3,530	1,975	535	545	238	143	790	7,868	10,560
1987	3,564	2,098	538	550	240	144	800	8,046	10,578
1988	3,689	2,160	543	553	242	144	870	8,314	10,597
1989	3,787	2,140	543	553	244	144	907	8,431	10,592
1990	3,823	2,020	538	551	249	141	990	8,427	10,607
1991	3,466	2,008	504	544	250	141	1,160	8,188	10,514
1992	3,460	2,126	516	548	264	140	1,448	8,502	10,468
1993[c]	2,607	2,400	401	386	264	140	1,501	7,699	10,359

Source:
Bobit Publishing Company, Automotive Fleet Research Department, 1994 Automotive Fleet Fact Book, Redondo Beach, CA, 1994, pp. 15, 24, and annual.

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[a]Includes driver schools.
[b]Data are not available.
[c]Newly available data resulted in changes for the 1993 data.

Table 3.29
Federal Government Vehicles by Agency, Fiscal Year 1992

Department or Agency	Autos	Buses	Light trucks[a]	Medium trucks	Heavy trucks	Total
CIVILIAN AGENCIES	**94,486**	**3,534**	**130,348**	**18,890**	**7,302**	**254,560**
Department of Agriculture	3,677	54	25,285	5,304	608	34,928
Department of Commerce	89	4	386	216	17	712
Department of Energy	1,886	235	6,910	1,928	743	11,702
Department of Health & Human	113	11	251	110	48	533
Department of Interior	1,923	132	9,747	3,963	1,829	17,594
Department of Justice	17,656	192	7,382	665	131	26,026
Department of Labor	25	9	118	7	2	161
Department of State	1,313	0	1,239	979	75	3,606
Department of Transportation	20	16	399	156	57	648
Department of Treasury	11,205	16	3,010	83	16	14,330
Department of Veterans Affairs	290	98	836	192	62	1,478
American Battle Monuments Comm.	14	0	37	11	0	62
Environmental Protection Agency	31	0	449	57	15	552
Federal Communications Comm	68	0	48	2	0	118
Federal Emergency Mgmt Agency	29	9	88	24	0	150
General Services Administration	53,425	2,666	70,541	3,717	3,280	133,629
Government Printing Office	3	0	48	0	0	51
International. Boundary & Water	0	0	17	13	23	53
International Development Corporation	310	25	479	53	16	883
Merit System Protection Board	0	0	1	0	0	1
Natl Aeronautics & Space Admin.	70	13	555	215	46	899
National Science Foundation	24	8	122	25	4	183
Panama Canal Commission	188	13	465	122	62	850
Peace Corps	97	0	353	2	0	452
Pension Benefit Guaranty Corp.	1	0	0	0	0	1
Railroad Retirement Board	1	0	0	0	0	1
Small Business Administration	1	0	1	0	0	2
Smithsonian Institute	75	4	216	57	15	367
Tennessee Valley Authority	1,507	4	1,044	963	243	3,761
U.S. Information Agency	434	17	297	20	1	769
U.S. Soldiers' & Airmen's Home	11	8	24	6	9	58
U.S. POSTAL SERVICE	**8,587**	**15**	**158,320**	**11,939**	**4,776**	**183,637**
MILITARY AGENCIES	**16,184**	**4,973**	**88,601**	**9,819**	**7,559**	**127,136**
Air Force	5,170	2,190	38,381	3,212	2,862	51,815
Army	3,340	1,305	12,936	1,894	1,330	20,805
Corps of Engineers	570	19	4,491	984	274	6,338
Marine	704	387	5,155	784	410	7,440
Navy	3,238	1,032	26,127	2,625	2,452	35,474
Other	3,162	40	1,511	320	231	5,264
TOTAL	**119,257**	**8,522**	**377,269**	**40,648**	**19,637**	**565,333**

Source:
U.S. General Services Administration, Federal Supply Service, Federal Motor Fleet Report, Washington, DC, 1994, p. 25.

[a]Includes ambulances.

The average cost per mile for the operation of sedans, trucks, and all vehicles declined in FY 1992. On average, sedans were driven nearly twice the miles that trucks were driven.

Table 3.30
Operating and Cost Data for Large Domestic Federal Fleets, 1986-92[a]

Fiscal Year	Number of Vehicles	Miles Operated (thousands)	Average Annual Miles per Vehicle	Fleet Average Cost per Mile (dollars)
		Sedans		
1986	86,069	1,130,843	13,139	0.21
1987	89,894	1,069,124	11,893	0.20
1988	85,928	1,119,343	13,027	0.19
1989	90,254	1,170,370	12,968	0.20
1990	93,510	1,226,674	13,118	0.22
1991	98,259	1,297,651	13,206	0.23
1992	97,680	1,261,954	12,940	0.20
		Trucks		
1986	292,256	2,095,079	7,168	0.43
1987	303,275	2,195,017	8,238	0.45
1988	316,443	2,242,075	7,085	0.44
1989	336,617	2,292,593	6,811	0.43
1990	354,392	2,423,131	6,837	0.44
1991	366,471	2,498,190	6,818	0.45
1992	381,721	2,645,979	6,932	0.40
		All Vehicles[b]		
1986	403,855	3,477,730	8,611	0.36
1987	414,575	3,461,332	8,349	0.37
1988	424,286	3,576,421	8,429	0.36
1989	448,836	3,681,314	8,202	0.35
1990	467,678	3,855,984	8,245	0.38
1991	484,552	3,984,175	8,222	0.38
1992	495,257	4,061,255	8,200	0.35

Source:
U.S. General Services Administrations, Federal Supply Service, Federal Motor Fleet Report, Washington, DC, 1994, pp. 29-31, 34, 38, 39.

[a]Agencies or bureaus with 2,000 or more vehicles.
[b]Includes sedans, station wagons, ambulances, buses and all trucks.

Table 3.31
Vehicle Composition by Vehicle Type
(percent)

Fleet type	Cars	Light trucks and vans	Medium trucks	Heavy trucks	Total
Business	24.2	21.1	45.8	8.9	100
Utility	22.6	39.0	15.0	23.4	100
Government	48.5	42.8	6.8	1.8	100

Table 3.32
Average Length of Time Vehicles are Kept Before Sold to Others
(months)

	Business	Utility	Government
Cars	35	68	81
Light trucks	56	60	82
Medium trucks	83	86	96
Heavy trucks	103	132	117

Table 3.33
Average Annual/Daily Vehicle Miles of Travel

	Business		Utility		Government	
Vehicle type	Miles/Yr (000)	Miles/Day @250 Days/Yr	Miles/Yr (000)	Miles/Day @250 Days/Yr	Miles/Yr (000)	Miles/Day @250 Days/Yr
Cars	29.2	117	14.5	58	13.7	55
Light trucks	26.6	106	17.5	70	13.9	56
Medium trucks	17.5	70	11.8	47	11.9	48
Heavy trucks	64.4	258	13.8	55	10.7	43

Source:
Miaou, et. al., "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices", (ORNL-6717), Oak Ridge National Laboratory, Oak Ridge, Tenn., May 1992.

Table 3.34
Fueling Practices of Five Business Fleet Types-Easton Consultants, Inc. [1991].
(percent)

Fleet Type	Have On-Site Fueling Facilities	% of Fuel Taken from Company's Own Facilities	Have Alternative Fuel Vehicles[a]
Transit Bus	97	95	18
School Bus	93	93	8
Taxi/Limo	36	74	6
Service/Heavy Delivery	65	89	18
Food/Vending	60	92	20
Routine	69	79	38
Materials	77	86	11
Other Service	46	78	22
Beverage	68	94	23
Institutional Food	80	89	10
Other Food/Grocery	67	89	12
Other Heavy Delivery	72	88	12
Repair Service	44	82	9
Appliance	36	75	5
Plumbing/Water Heating/Pool	41	77	8
Outside/Landscape/Etc.	60	78	10
Construction Trades	46	86	12
Other Repair	51	87	6

Source:
Miaou, et. al., "Fleet Vehicles in the United States: Composition, Operating Characteristics, and Fueling Practices", (ORNL-6717), Oak Ridge National Laboratory, Oak Ridge, Tenn., May 1992.

[a]Most of the alternative fuel vehicles are powered with propane.

Section 3.6
Federal Standards and Motor Vehicle Fuel Economy

Except for the automobile fuel economy in model year 1984, the sales-weighted fuel economies of automobiles and light trucks have, on average, met the fuel economy standards set by the federal government. This does not mean, however, that each manufacturer has met the standards each year. Some manufacturers still fall short, while others exceed the standards. The domestic automobile CAFE estimate did not meet the standards in 1992 and 1994, but the import estimates exceeded the standards, pulling the combined automobile CAFE estimates above the standards for those years.

Table 3.35
Corporate Average Fuel Economy (CAFE)
Standards versus Sales-Weighted Fuel Economy Estimates
for Automobiles and Light Trucks, 1978-94[a]
(miles per gallon)

	Automobiles				Light Trucks[b]			
Model Year	CAFE Standards	CAFE Estimates[c] Domestic	Import	Combined	CAFE Standards	CAFE Estimates[c] Domestic	Import	Combined
1978	18.0	18.7	27.3	19.9	[d]	[e]	[e]	[e]
1979	19.0	19.3	26.1	20.3	17.2	17.7	20.8	18.2
1980	20.0	22.6	29.6	24.3	[d]	16.8	24.3	18.5
1981	22.0	24.2	31.5	25.9	[d]	18.3	27.4	20.1
1982	24.0	25.0	31.1	26.6	17.5	19.2	27.0	20.5
1983	26.0	24.4	32.4	26.4	19.0	19.6	27.1	20.7
1984	27.0	25.5	32.0	26.9	20.0	19.3	26.7	20.6
1985	27.5	26.3	31.5	27.6	19.5	19.6	26.5	20.7
1986	26.0	26.9	31.6	28.2	20.0	19.9	25.9	21.5
1987	26.0	27.0	31.2	28.5	20.5	20.5	25.2	21.7
1988	26.0	27.4	31.5	28.8	20.5	20.6	24.6	21.3
1989	26.5	27.2	30.8	28.4	20.5	20.4	23.5	21.0
1990	27.5	26.9	29.9	28.0	20.0	20.3	23.0	20.8
1991	27.5	27.3	30.0	28.3	20.2	20.9	23.0	21.3
1992	27.5	27.0	29.1	27.8	20.2	20.5	22.4	20.8
1993	27.5	27.8	29.5	28.4	20.2	20.4	22.6	20.8
1994	27.5	27.3	29.6	28.2	20.5	[e]	[e]	20.6

Source:

U.S. Department of Transportation, NHTSA, "Summary of Fuel Economy Performance," Washington, DC, September 1994.

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[a]Only vehicles with at least 75 percent domestic content can be counted in the average domestic fuel economy for a manufacturer.

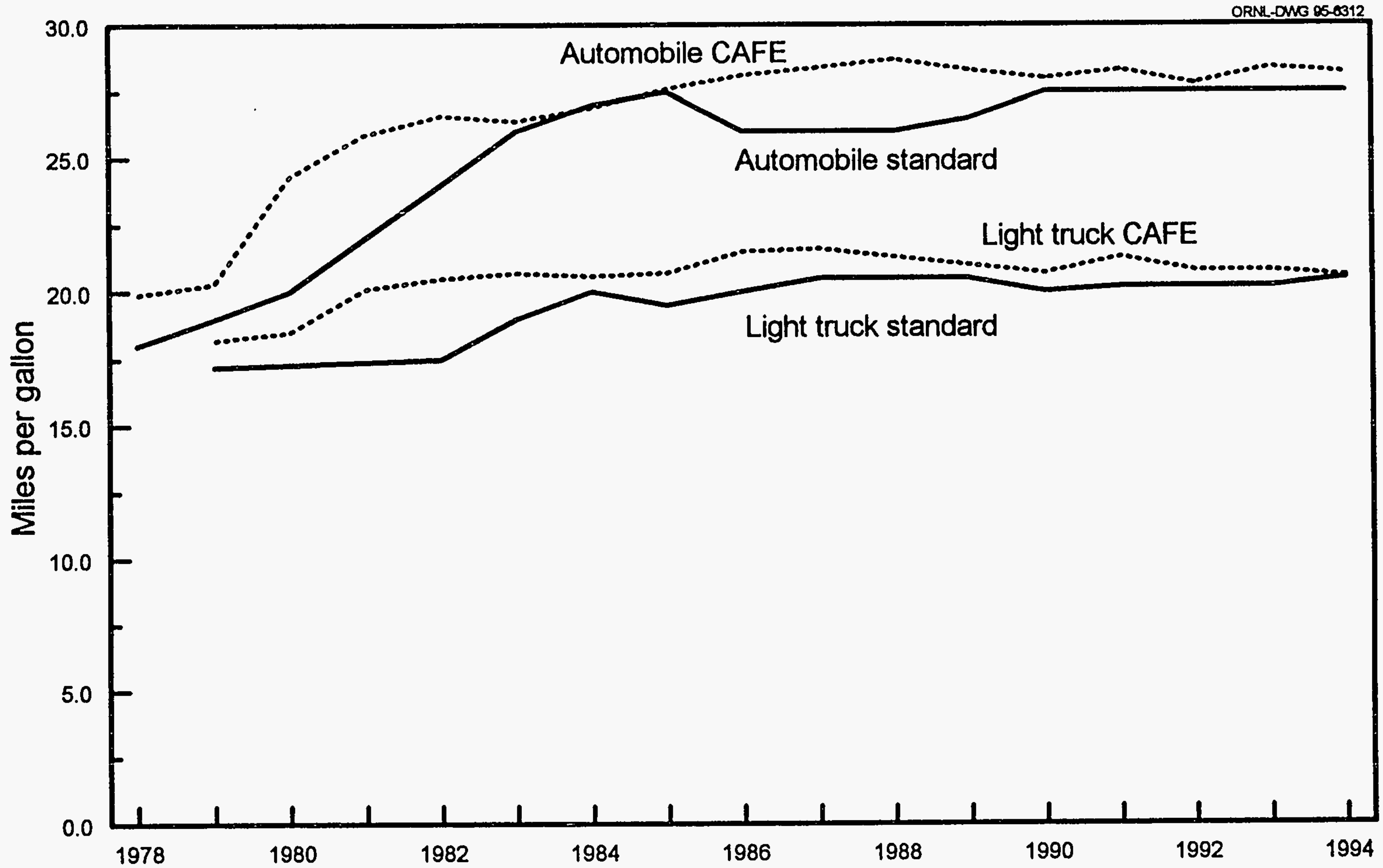
[b]Represents two- and four-wheel drive trucks combined. Gross vehicle weight of 0-6,000 pounds for model year 1979 and 0-8,500 pounds for subsequent years.

[c]All CAFE calculations are sales-weighted.

[d]Standards were set for two-wheel drive and four-wheel drive light trucks separately, but no combined standard was set in this year.

[e]Data are not available.

Figure 3.7. Corporate Average Fuel Economy Standards and Sales-Weighted Fuel Economies for Automobiles and Light Trucks, 1978-94



Source: See Table 3.35.

Table 3.36
Corporate Average Fuel Economy (CAFE) Fines Collected, 1983-93
(Thousands)

Model year	Current dollars	1990 constant dollars[a]
1983	58	76
1984	5,958	7,496
1985	15,565	18,908
1986	29,872	35,603
1987	31,261	35,945
1988	44,519	49,181
1989	47,381	49,946
1990	48,429	48,429
1991	42,241	40,509
1992	38,287	35,645
1993	20,164	18,248
Total	323,735	321,738

Source:
U.S. Department of Transportation, National Highway Traffic Safety Administration, Office of Vehicle Safety Compliance, Washington, DC, January 1995.

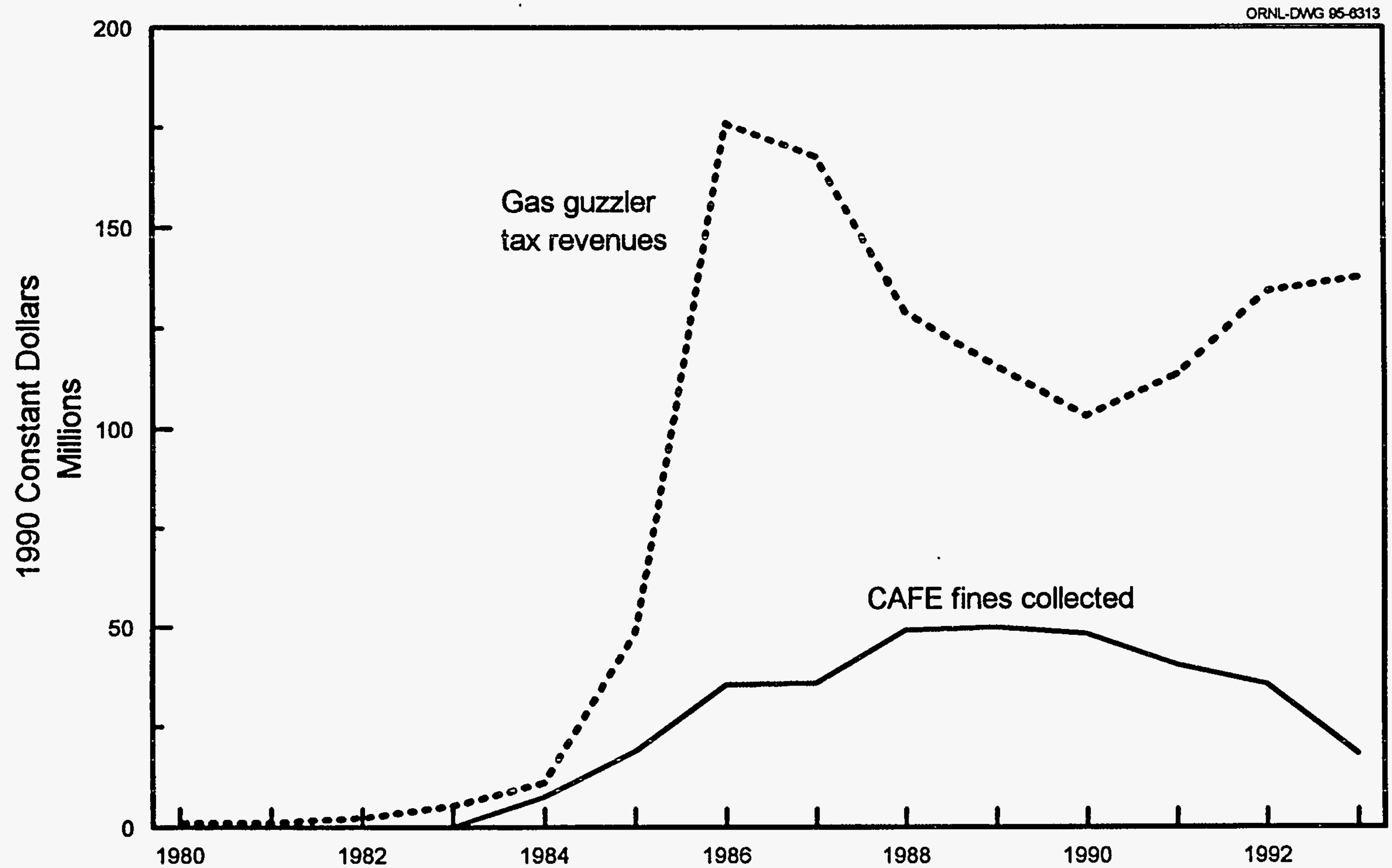
Table 3.37
Tax Receipts from the Sale of Gas Guzzlers, 1980-93
(Thousands)

Fiscal year	Current dollars	1990 constant dollars[a]
1980	740	1,174
1981	780	1,121
1982	1,720	2,329
1983	4,020	5,273
1984	8,820	11,097
1985	39,790	48,336
1986	147,660	175,987
1987	145,900	167,759
1988	116,780	129,008
1989	109,640	115,575
1990	103,200	103,200
1991	118,400	113,546
1992	144,200	134,250
1993	152,000	137,560
Total	1,093,650	1,146,214

Source:
Motor Vehicle Manufacturers Association, Motor Vehicle Facts and Figures '94, Detroit, MI, 1994, p. 85.

[a]Adjusted using the Consumer Price Inflation Index.

Figure 3.8. CAFE Fines and Gas Guzzler Tax Revenues, 1980-93



Source: See Tables 3.36 and 3.37.

Consumers must pay the Gas Guzzler Tax when purchasing an automobile that has an Environmental Protection Agency (EPA) fuel economy rating less than that stipulated in the table below. The Gas Guzzler Tax doubled in 1991 after remaining constant from 1986 to 1990.

Table 3.38
The Gas Guzzler Tax on New Cars
(dollars per vehicle)

Vehicle fuel economy (mpg)	1980	1981	1982	1983	1984	1985	1986-90	1991+
Over 22.5	0	0	0	0	0	0	0	0
22.0-22.5	0	0	0	0	0	0	500	1,000
21.5-22.0	0	0	0	0	0	0	500	1,000
21.0-21.5	0	0	0	0	0	0	650	1,300
20.5-21.0	0	0	0	0	0	500	650	1,300
20.0-20.5	0	0	0	0	0	500	850	1,700
19.5-20.0	0	0	0	0	0	600	850	1,700
19.0-19.5	0	0	0	0	450	600	1,050	2,100
18.5-19.0	0	0	0	350	450	800	1,050	2,100
18.0-18.5	0	0	200	350	600	800	1,300	2,600
17.5-18.0	0	0	200	500	600	1,000	1,300	2,600
17.0-17.5	0	0	350	500	750	1,000	1,500	3,000
16.5-17.0	0	200	350	650	750	1,200	1,500	3,000
16.0-16.5	0	200	450	650	950	1,200	1,850	3,700
15.5-16.0	0	350	450	800	950	1,500	1,850	3,700
15.0-15.5	0	350	600	800	1,150	1,500	2,250	4,500
14.5-15.0	200	450	600	1,000	1,150	1,800	2,250	4,500
14.0-14.5	200	450	750	1,000	1,450	1,800	2,700	5,400
13.5-14.0	300	550	750	1,250	1,450	2,200	2,700	5,400
13.0-13.5	300	550	950	1,250	1,750	2,200	3,200	6,400
12.5-13.0	550	650	950	1,550	1,750	2,650	3,200	6,400
Under 12.5	550	650	1,200	1,550	2,150	2,650	3,850	7,700

Source:
Internal Revenue Service, Form 6197, "Gas Guzzler Tax" and annual.

New Data by Vehicle Speed

Oak Ridge National Laboratory (ORNL) is presently conducting a study for the Federal Highway Administration (FHWA) to develop vehicle fuel consumption and emissions models and databases for use in FHWA's TRAF-NETSIM model. The goal is to thoroughly characterize 15 to 20 light-duty vehicles for their fuel consumption and emissions over most of their operating ranges. Vehicle characterizations will be represented in tables of fuel consumption and emissions as functions of vehicle speed and acceleration. To acquire the data for each vehicle ORNL staff are carrying out extensive testing of instrumented vehicles, both on-road and on a chassis dynamometer. Principal measurements of emissions are made while driving the vehicles on the dynamometer, but these data are supplemented with actual on-road emissions measurements using portable (but less accurate) emissions instruments. Tests of the first vehicle, an older Buick Regal, have been completed. With this vehicle ORNL had complete access to the car's engine computer, enabling the study of effects such as enrichment threshold parameters. Moreover, all of the experimental procedures have been developed while testing the Buick. The study also features a modeling exercise intended to generalize the results from the limited number of vehicles actually tested to a larger population of vehicles based on only minimal new measurements of additional vehicles. This effort should assure the value of these new vehicle databases for a longer period of time.

Two separate studies by the Federal Highway Administration have measured the effects of speed on the fuel economy of automobiles. (The 1984 study also included light trucks.) The fuel economy loss will vary for each individual vehicle; these data are averages for the tested vehicles. Both studies indicated that maximum fuel efficiency was achieved at speeds of 35 to 40 mph.

Table 3.39
Fuel Economy by Speed, 1973 and 1984
(miles per gallon)

Speed (miles per hour)	1973[a]	1984[b]
15	c	21.1
20	c	25.5
25	c	30.0
30	21.1	31.8
35	21.1	33.6
40	21.1	33.6
45	20.3	33.5
50	19.5	31.9
55	18.5	30.3
60	17.5	27.6
65	16.2	24.9
70	14.9	22.5
75	c	20.0
	Fuel economy loss	
55-65 mph	12.4%	17.8%
65-70 mph	8.0%	9.6%
55-70 mph	19.5%	25.7%

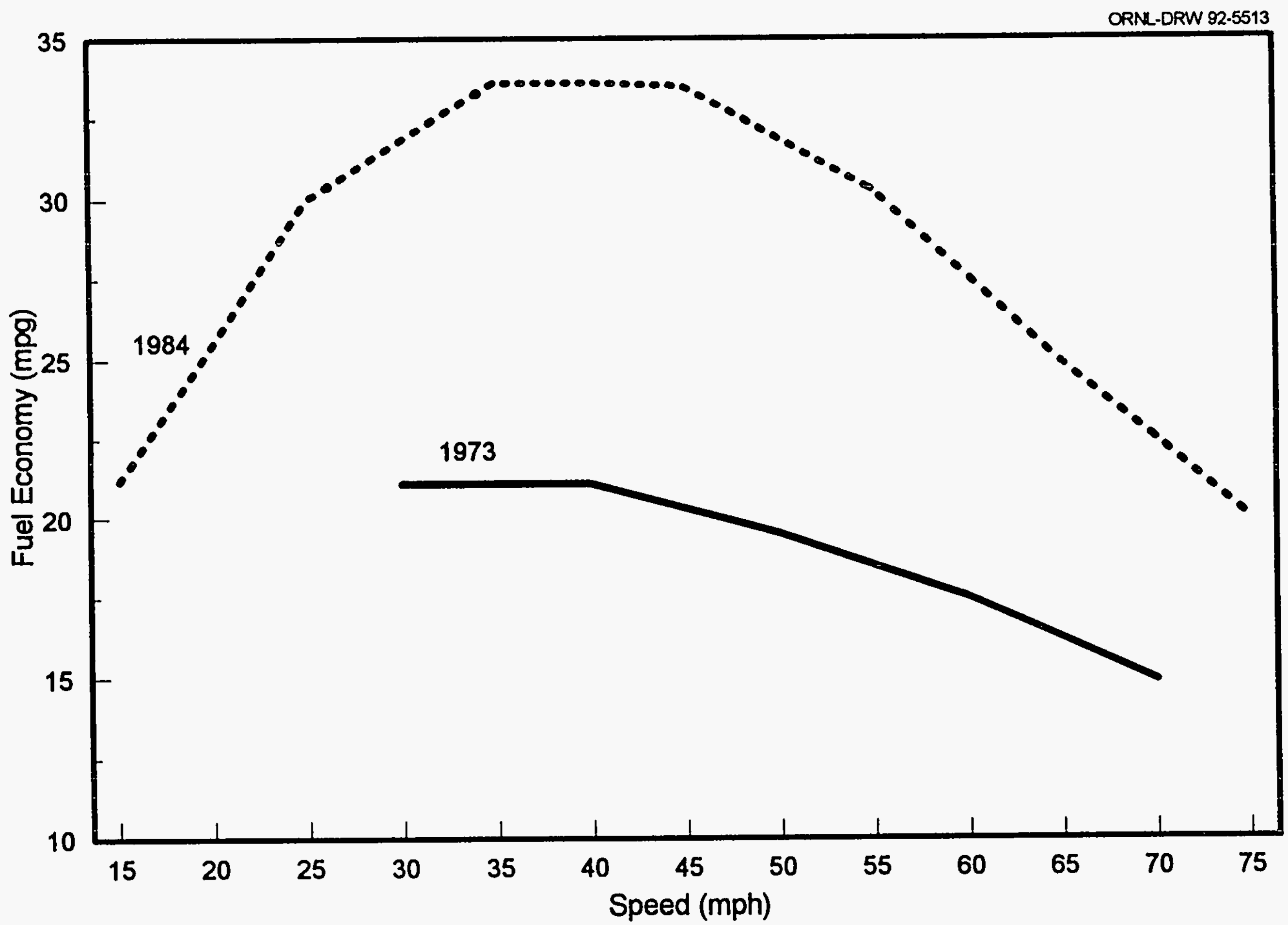
Sources:

1973- U.S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, The Effect of Speed on Automobile Gasoline Consumption Rates, Washington, DC, October 1973.

1984 - U.S. Department of Transportation, Federal Highway Administration, Fuel Consumption and Emission Values for Traffic Models, Washington, DC, May 1985.

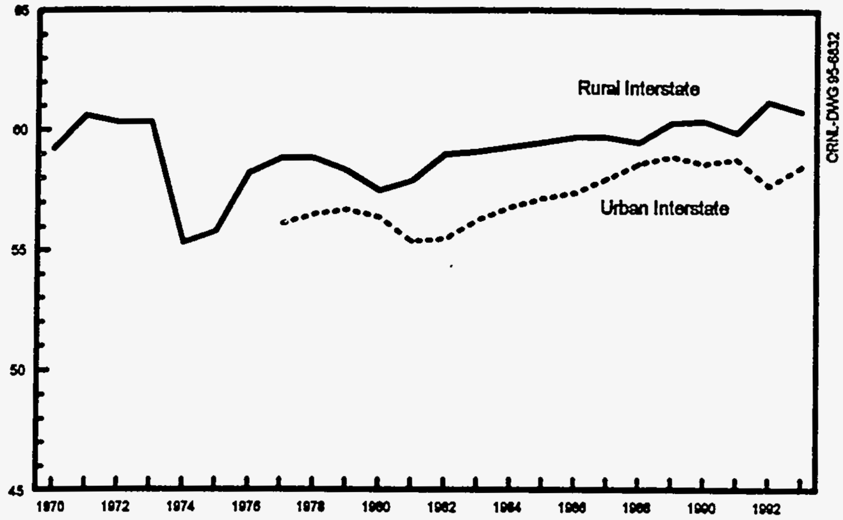
[a]Model years 1970 and earlier automobiles.
[b]Model years 1981-84 automobiles and light trucks.
[c]Data are not available.

Figure 3.9. Fuel Economy by Speed, 1973 and 1984



Source: See Table 3.39.

Figure 3.10. Average Interstate Speeds, 1970-93



Source: See Table 3.40.

Table 3.40
Average Urban and Rural Interstate Speeds, 1970-93[a]
(miles per hour)

Year	Urban Interstate	Rural Interstate
1970	[b]	59.2
1971	[b]	60.6
1972	[b]	60.3
1973	[b]	60.3
1974	[b]	55.3
1975	[b]	55.8
1976	56.1	58.2
1977	56.5	58.8
1978	56.7	58.8
1979	56.4	58.3
1980	55.4	57.5
1981	55.5	57.9
1982	56.3	59.0
1983	56.8	59.1
1984	57.2	59.3
1985	57.2	59.5
1986	57.4	59.7
1987	58.0	59.7
1988	58.6	59.5
1989	58.9	60.3
1990	58.6	60.4
1991	58.8	59.9
1992	57.7	61.2
1993	58.5	60.8

Source:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table VS-1, p. V-137, and annual.

[a]Data from 1970-79 represent only free-moving traffic, on level, straight, uncongested sections of Interstate. Beginning with fiscal year 1980, the data show the speeds of all vehicular traffic.
[b]Data are not available.

The Environmental Protection Agency (EPA) tests new vehicles to determine fuel economy ratings. The city and highway fuel economies that are posted on the windows of new vehicles are determined by testing the vehicle during these driving cycles. The driving cycles simulate the performance of an engine while driving in the city or on the highway. Once the urban cycle is completed, the engine is stopped, then started again for the 8.5 minute hot start cycle.

ORNL-DWG89-14608

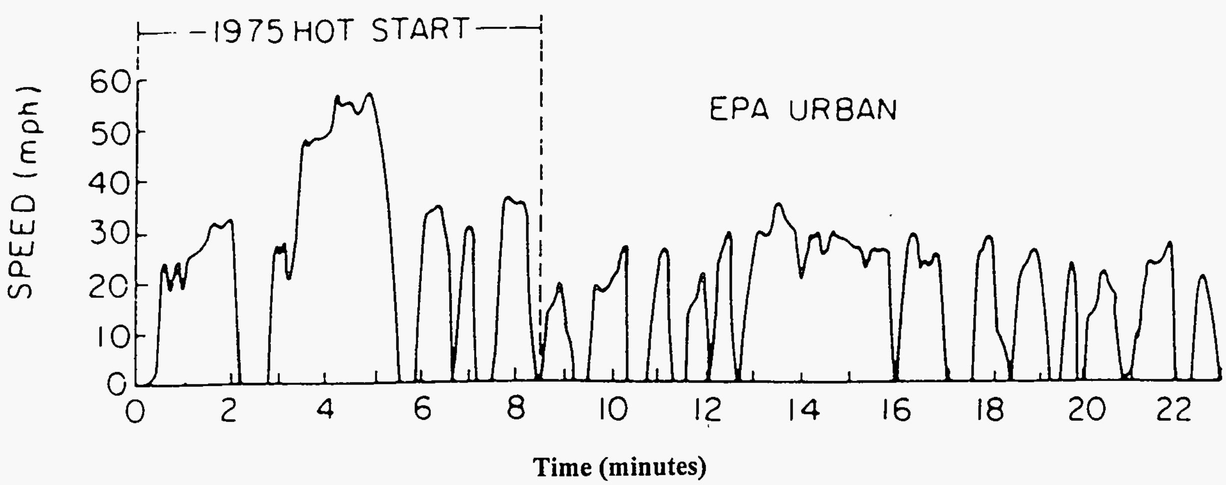


Figure 3.11. Urban Driving Cycle
Length of cycle: 1870 seconds, including idle time.
Average speed: 21.3 mph with idle; 26.5 mph without idle.

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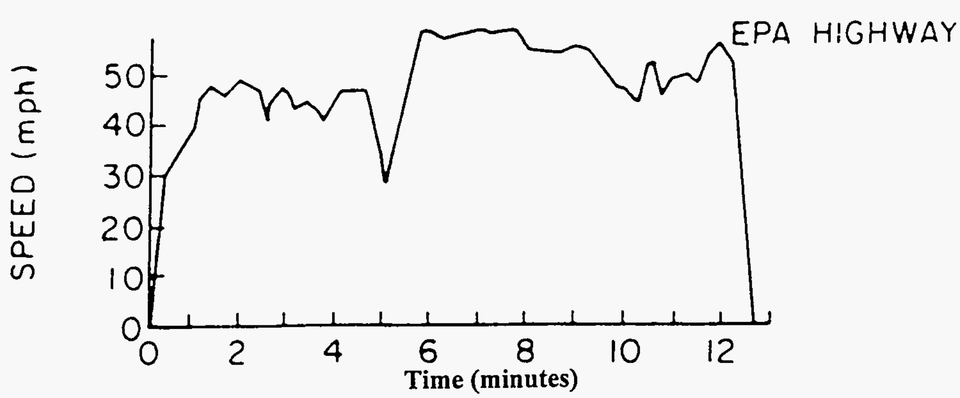
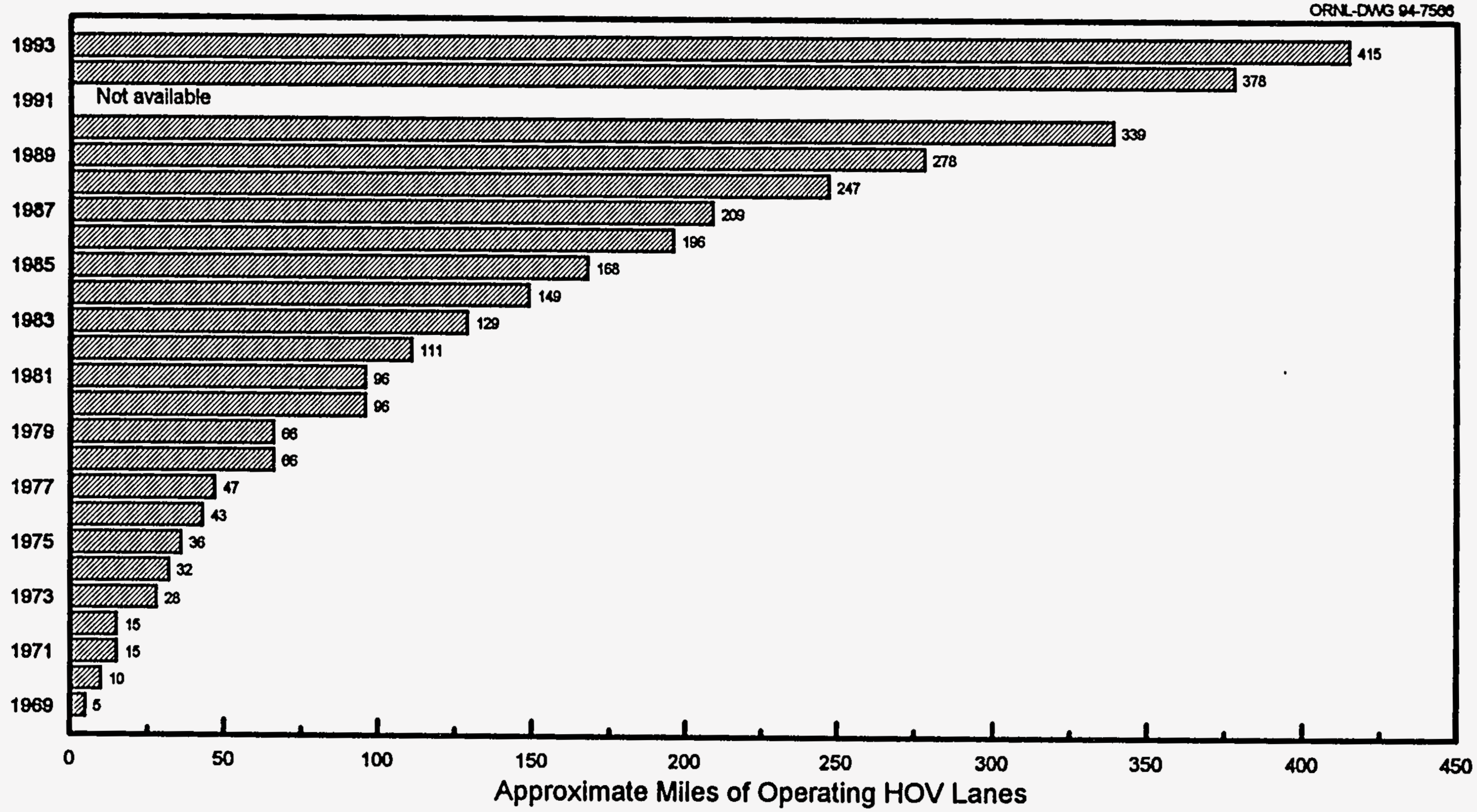


Figure 3.12. Highway Driving Cycle
Length of cycle: 765 seconds.
Average speed: 48.5 mph.

Source:
Code of Federal Regulations, 40CFR, "Subpart B - Fuel Economy Regulations for 1978 and Later Model Year Automobiles - Test Procedures," July 1, 1988 edition, p. 676.

High-occupancy vehicle (HOV) lanes are special highway lanes meant for the exclusive use of vehicles with a specified number of passengers. Vehicles that use HOV lanes are usually guaranteed a shorter and less congested trip than those using regular traffic lanes. In 1993 there were 415 miles of HOV lanes in operation in the U.S. Twenty areas had HOV facilities in 1993, and 5 more areas had HOV facilities in development at that time.

Figure 3.13. Miles of High-Occupancy Vehicle Lanes, 1969-93



Source:
Texas Transportation Institute, College Station, TX, December 1993.

CHAPTER 4

PERSONAL TRAVEL STATISTICS

From 1950 to 1993, the average annual rate of increase in the number of vehicles surpassed the increases in population, households, licensed drivers, and employed persons. Since 1985 there has been more than one vehicle for every licensed driver in the U.S. (Table 4.1). An average household spent 17.5% of total expenditures on transportation in 1993.

Results from the Residential Transportation Energy Consumption Survey (RTECS) are found in Tables 4.3-4.8. The RTECS has been conducted five times since 1978 by the Department of Energy's Energy Information Administration. The survey focuses on vehicle miles traveled, energy end-use consumption and expenditures by households for personal transportation. Vehicle travel information is collected by actual odometer readings instead of survey respondents estimates. There were no major changes in survey methodology between the 1988 and 1991 surveys, but the 1985 and previous RTECS had different estimation procedures for vehicle fuel economy and fuel prices. Therefore, caution should be used when comparing the 1988 and 1991 RTECS to previous years.

Information on household trips by trip purpose is found in the Nationwide Personal Transportation Survey (NPTS) (Table 4.10). The NPTS is a national survey designed to collect data on the nature and characteristics of personal travel. The definition of a trip in the NPTS is "any one-way travel from one address to another by private motor vehicle, public transportation, bicycle, or walking." Excluded from the survey are jogging and walking for exercise, as well as all bicycling and walking for individuals under 5 years of age. The survey collects detailed data on household trips, their purposes and the transportation modes used. The NPTS is sponsored by several agencies of the U.S. Department of Transportation and is conducted approximately every seven years. Since each of the surveys differ somewhat in terminology, survey procedure, and target population, one should be cautious when comparing statistics from one survey to the next.

The NPTS and the Decennial Census of the population both provide information on the "journey-to-work." In 1990, 73% of U.S. workers commuted to work alone in a private vehicle, which is 9% more than in 1980 (Table 4.14).

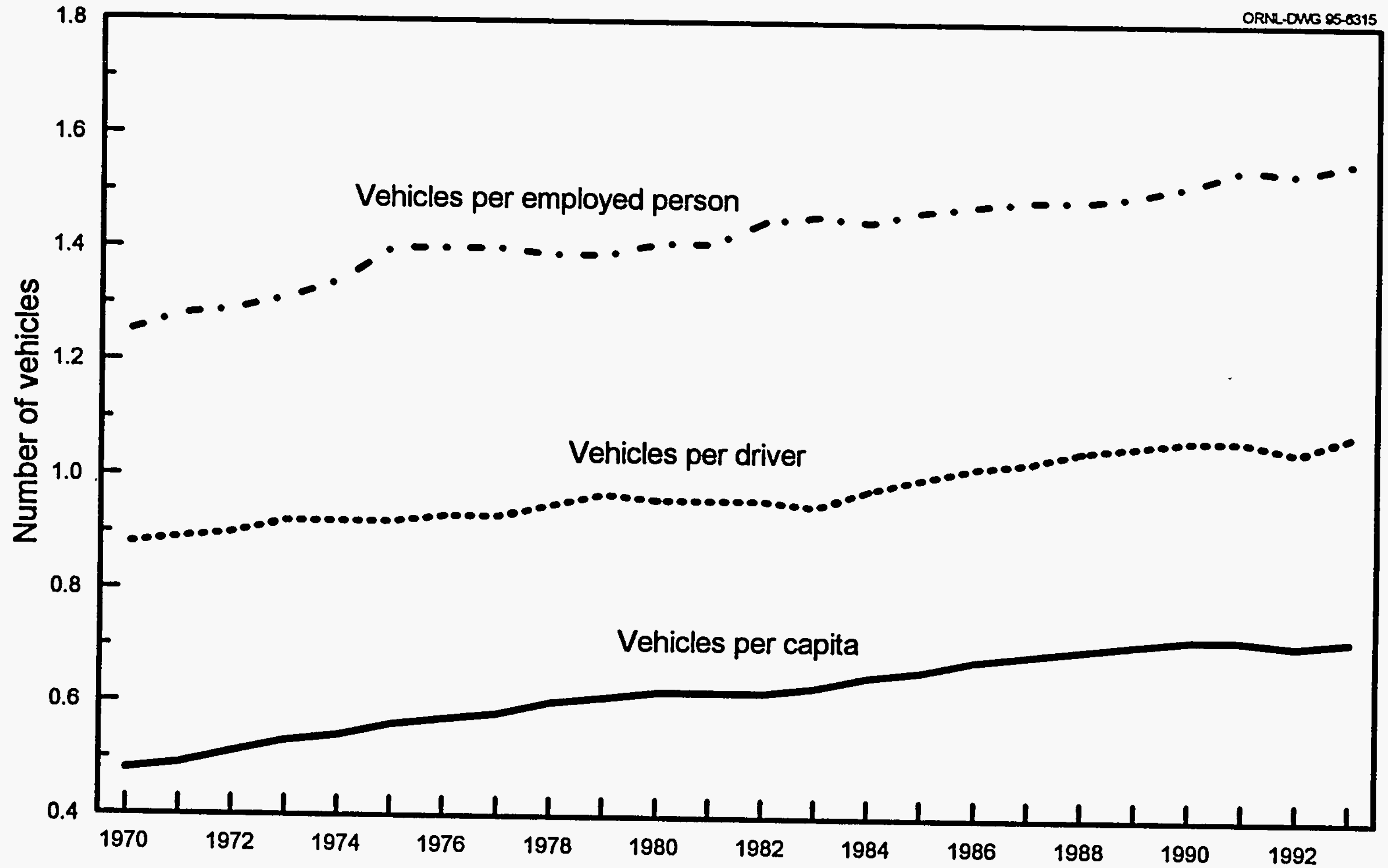
Table 4.1
Population and Vehicle Profile, 1950-93

Year	Resident population[a] (thousands)	Total households (thousands)	Number of vehicles in operation (thousands)	Number of licensed drivers (thousands)	Number of civilian employed persons (thousands)	Vehicles per capita	Vehicle miles per capita	Licensed drivers per household	Vehicles per licensed driver	Vehicles per civilian employed persons
1950	151,271	43,554	43,256	62,194	58,918	0.29	3,029	1.43	0.70	0.73
1955	165,069	47,874	55,804	74,686	62,170	0.34	3,656	1.56	0.75	0.90
1960	179,979	52,799	66,582	87,253	65,778	0.36	3,994	1.65	0.76	1.01
1965	193,526	57,251	82,067	98,502	71,088	0.42	4,587	1.72	0.83	1.15
1970	203,984	63,401	98,136	111,543	78,678	0.48	5,440	1.76	0.88	1.25
1975	215,465	71,120	120,054	129,791	85,846	0.56	6,162	1.82	0.92	1.40
1980	227,225	80,776	139,832	145,295	99,303	0.62	6,722	1.80	0.96	1.41
1981	229,466	82,368	141,908	147,075	100,397	0.62	6,767	1.79	0.96	1.41
1982	231,664	83,527	143,854	150,234	99,526	0.62	6,885	1.80	0.96	1.45
1983	233,792	83,918	147,104	154,389	100,834	0.63	7,069	1.83	0.95	1.46
1984	235,825	85,407	152,162	155,424	105,005	0.65	7,295	1.82	0.98	1.45
1985	237,924	86,789	157,048	156,868	107,150	0.66	7,457	1.81	1.00	1.47
1986	240,133	88,458	162,094	159,487	109,597	0.68	7,655	1.80	1.02	1.48
1987	242,289	89,479	167,193	161,975	112,440	0.69	7,929	1.81	1.03	1.49
1988	244,499	91,061	171,741	162,853	114,968	0.70	8,286	1.79	1.05	1.49
1989	246,819	92,830	175,960	165,555	117,342	0.71	8,494	1.78	1.06	1.50
1990	249,391	93,347	179,299	167,015	117,914	0.72	8,598	1.79	1.07	1.52
1991	252,160	94,312	181,438	168,995	116,877	0.72	8,614	1.79	1.07	1.55
1992	255,078	95,689	181,519	173,125	117,598	0.71	8,781	1.81	1.05	1.54
1993	257,908	96,391	186,315	173,149	119,306	0.72	8,905	1.80	1.08	1.56
					Average annual percentage change					
1950-93	1.2%	1.9%	3.5%	2.4%	1.7%	2.1%	2.5%	0.5%	1.0%	1.8%
1983-93	1.0%	1.4%	2.4%	1.2%	1.7%	1.3%	2.3%	-0.2%	1.3%	0.7%

Sources:
Resident population, total households, and civilian employed persons - U.S. Department of Commerce, Bureau of the Census, Statistical Abstract of the United States, 114th edition, 1994, Washington, DC, pp. 8, 58, 395, and annual.
Vehicles in operation - R. L. Polk and Company. **FURTHER REPRODUCTION PROHIBITED.**
Licensed drivers and vehicle miles - U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Table DL-1A, VM-1, and annual.

[a]Estimates as of July 1. Includes Armed Forces stationed in the United States.

Figure 4.1. Population and Vehicle Profile, 1970-93



Source: See Table 4.1.

Transportation (17.5%) is second only to housing (30.8%) as the largest expenditure for the average household. In 1993, approximately 18% of transportation expenditures were for purchasing gasoline and motor oil.

Table 4.2
Average Annual Expenditures of Households by Income, 1993[a]

		Income before taxes								
	All households	Less than $5000	$5,000-$9999	$10,000-$14999	$15,000-$19,999	$20,000-$29,999	$30,000-$39,999	$40,000-$49999	$50,000-$69,999	$70,000 and over
Total expenditures	$31,436	$13,251	$13,860	$17,890	$21,068	$25,444	$32,453	$39,176	$46,327	$70,296
	Percentage of total expenditures[b]									
Food[c]	15.3%	18.3%	19.4%	17.2%	17.5%	16.5%	15.3%	15.2%	14.5%	12.5%
Housing	30.8%	34.2%	35.7%	35.9%	31.9%	31.3%	29.3%	30.0%	29.4%	29.5%
Apparel and services	5.5%	5.9%	6.5%	5.4%	5.7%	5.5%	5.5%	5.7%	5.0%	5.2%
Transportation	17.5%	17.9%	13.9%	15.6%	18.3%	17.7%	19.6%	17.7%	17.9%	17.0%
Vehicle purchases (net outlay)	**7.4%**	**6.8%**	**5.8%**	**5.6%**	**8.1%**	**6.5%**	**9.1%**	**7.2%**	**7.8%**	**7.4%**
Gasoline and motor oil	**3.1%**	**3.7%**	**3.1%**	**3.4%**	**3.5%**	**3.9%**	**3.4%**	**3.2%**	**2.9%**	**2.4%**
Other vehicle expenditures	**6.0%**	**6.2%**	**4.2%**	**5.6%**	**5.8%**	**6.4%**	**6.4%**	**6.4%**	**6.1%**	**5.9%**
Public transportation	**1.0%**	**1.2%**	**0.7%**	**1.0%**	**0.9%**	**0.9%**	**0.7%**	**1.0%**	**1.0%**	**1.3%**
Health care	5.6%	5.6%	8.4%	8.4%	8.6%	6.8%	5.8%	5.1%	4.4%	3.8%
Entertainment	5.1%	4.5%	3.5%	4.9%	4.3%	4.7%	4.9%	5.2%	5.5%	5.7%
Personal Insurance & pensions	10.4%	1.8%	2.2%	3.4%	5.1%	7.6%	10.1%	11.7%	13.4%	15.6%
Others[d]	9.9%	11.8%	10.4%	9.2%	8.7%	9.9%	9.4%	9.4%	9.8%	10.7%

Source:
U.S. Department of Labor, Bureau of Labor Statistics, Consumer Expenditure Survey: Interview Survey, 1993, detailed computer printout, December 1994.

[a]Public assistance monies are included in reported income.

[b]Percentages may not sum to totals due to rounding.

[c]Includes alcoholic beverages.

[d]Includes personal care, reading, education, tobacco and smoking supplies, cash contributions, and miscellaneous items.

Table 4.3
Summary Statistics from the 1983, 1985, 1988, and 1991 RTECS

	RTECS Survey year				Average annual percentage change		
	1983	1985	1988	1991	1983-85	1985-88	1988-91
Number of households with vehicles (millions)	72.2	77.7	81.3	84.6	3.7%	1.5%	1.3%
Number of household vehicles (millions)	129.3	137.3	147.5	151.2	3.0%	2.4%	0.8%
Total vehicle miles traveled (billions)	1,215	1,353	1,511	1,602	5.5%	3.8%	2.0%
Vehicle miles traveled per household with vehicles	16,800	17,400	18,600	18,900	1.7%	2.2%	0.6%
Vehicle miles traveled per vehicle	9,400	9,900	10,200	10,600	2.4%	1.3%	1.3%

Source:
U.S. Department of Energy, Energy Information Administration, Household Vehicles Energy Consumption 1991, Washington, DC, December 1993, p. 15.

Table 4.4
Average Number of Vehicles and Vehicle Travel per Household, 1991 RTECS

	Average number of vehicles per household	Average vehicle miles traveled per household
Number of Drivers		
1	1.2	10,900
2	2.0	21,400
3	2.6	30,700
4 or more	3.1	36,700
Household size		
1 person	1.2	10,600
2 persons	1.8	17,700
3 persons	2.0	22,300
4 persons	2.2	26,200
5 persons	2.1	23,600
6 or more persons	1.9	22,600
Household urban status		
Urban	1.8	18,800
Central city	1.6	15,900
Suburban	1.9	20,400
Rural	1.9	19,500
Household composition		
With children	2.0	22,800
Without children	1.7	16,500
Total	**1.8**	**18,900**

Source:
U.S. Department of Energy, Energy Information Administration, Household Vehicles Energy Consumption 1991, Washington, DC, December 1993, pp. 48, 49.

Table 4.5
Statistics for Household Vehicles by Vehicle Type, 1985, 1988, and 1991 RTECS

Type of vehicle	Number of vehicles[a] (millions)			Average annual miles per vehicle (thousands)			Average fuel economy (mpg)		
	1985	1988	1991	1985	1988	1991	1985[b]	1988	1991
Passenger car	106.6	109.3	108.3	9.9	10.4	10.6	17.2	19.7	21.1
Pickup truck	21.2	25.9	25.9	9.4	9.4	10.0	13.5	15.3	15.8
Mini van	[c]	2.2	5.1	[c]	12.7	12.7	[c]	19.4	19.6
Large van	4.7	4.7	2.6	10.5	9.8	10.1	13.2	13.1	13.7
Utility vehicle	3.7	4.8	7.3	10.6	11.8	11.6	12.7	15.4	16.2
Other[d]	1.1	0.7	[c]	6.0	4.9	[c]	9.6	8.3	[c]

Sources:

1985 and 1988 estimates are based on data provided on the following public use tapes: U.S. Department of Energy, Energy Information Administration, 1985 Residential Transportation Energy Consumption Survey, and 1988 Residential Transportation Energy Consumption Survey, Washington, DC, 1987 and 1990.

1991 estimates: U.S. Department of Energy, Energy Information Administration, Household Vehicles Energy Consumption 1991, Washington, DC, 1993, pp. 29, 46, 52.

[a]These data are survey estimates; data are not the same as R. L. Polk estimates of the number of vehicles.
[b]Fuel economy data from the 1985 RTECS is not **directly** comparable to data from later years because of a change in methodology.
[c]Data are not available.
[d]Includes motor homes.

As households owned more vehicles, the average annual miles for the most frequently driven vehicle increased. For example, the most frequently driven vehicle in five-vehicle households was driven 18% more than per year than the one in two-vehicle households (15,110 miles vs. 12,803 miles).

Table 4.6
Average Annual Miles per Vehicle by Household Vehicle Ownership, 1991 RTECS

Vehicle [a]	One-vehicle household	Two-vehicle household	Three-vehicle household	Four-vehicle household	Five-vehicle household
#1	9,245	12,803	13,756	14,837	15,110
#2	-	6,405	8,629	9,416	9,969
#3	-	-	4,200	5,839	6,966
#4	-	-	-	2,661	4,828
#5	-	-	-	-	2,469
Average	**9,245**	**9,604**	**8,862**	**8,188**	**7,868**

Source:
Generated from the Department of Energy, Energy Information Administration, "1991 Residential Transportation Energy Consumption Survey Public Use diskettes," Washington, DC, December 1993.

Table 4.7
Average Age of Vehicles by Household Vehicle Ownership, 1991 RTECS

Vehicle[a]	One-vehicle household	Two-vehicle household	Three-vehicle household	Four-vehicle household	Five-vehicle household
#1	7.64	6.05	6.33	5.58	5.52
#2	-	8.48	7.40	6.43	7.81
#3	-	-	9.45	9.15	11.09
#4	-	-	-	9.60	9.20
#5	-	-	-	-	10.70
Average	**7.64**	**7.27**	**7.73**	**7.69**	**8.87**

Source:
Generated from the Department of Energy, Energy Information Administration, "1991 Residential Transportation Energy Consumption Survey Public Use diskettes," Washington, DC, December 1993.

[a]Vehicles are ranked by descending annual miles driven.

Table 4.8
Distribution of Vehicles by Vehicle Age and Household Vehicle Ownership, 1991 RTECS

Vehicle age	One-vehicle households	Two-vehicle households	Three-vehicle households	Four-vehicle households	Five-vehicle households	Total households
			Vehicle 1			
New	2.94%	4.36%	2.42%	1.20%	0.29%	11.22%
2-5	3.94%	5.83%	2.63%	0.89%	0.37%	13.66%
6-10	4.95%	4.90%	2.31%	1.17%	0.21%	13.54%
11-15	2.90%	1.92%	1.19%	0.42%	0.14%	6.58%
16-20	1.01%	0.60%	0.29%	0.06%	0.04%	2.00%
21+	0.50%	0.32%	0.29%	0.07%	0.00%	1.18%
			Vehicle 2			
New		2.26%	1.82%	0.95%	0.11%	5.14%
2-5		4.33%	2.26%	1.02%	0.27%	7.88%
6-10		5.58%	2.83%	1.12%	0.30%	9.84%
11-15		3.69%	1.39%	0.45%	0.30%	5.83%
16-20		1.26%	0.46%	0.17%	0.06%	1.95%
21+		0.80%	0.37%	0.09%	0.02%	1.28%
			Vehicle 3			
New			1.47%	0.68%	0.08%	2.23%
2-5			1.50%	0.74%	0.15%	2.39%
6-10			2.58%	0.79%	0.29%	3.66%
11-15			2.04%	0.97%	0.36%	3.37%
16-20			0.84%	0.34%	0.08%	1.26%
21+			0.70%	0.29%	0.10%	1.09%
			Vehicle 4			
New				0.61%	0.27%	0.88%
2-5				0.78%	0.14%	0.92%
6-10				0.89%	0.22%	1.11%
11-15				0.87%	0.21%	1.08%
16-20				0.34%	0.09%	0.43%
21+				0.32%	0.12%	0.44%
			Vehicle 5			
New					0.18%	0.18%
2-5					0.19%	0.19%
6-10					0.12%	0.12%
11-15					0.27%	0.27%
16-20					0.20%	0.20%
21+					0.09%	0.09%
Total	**16.25%**	**35.85%**	**27.38%**	**15.23%**	**5.29%**	**100.00%**

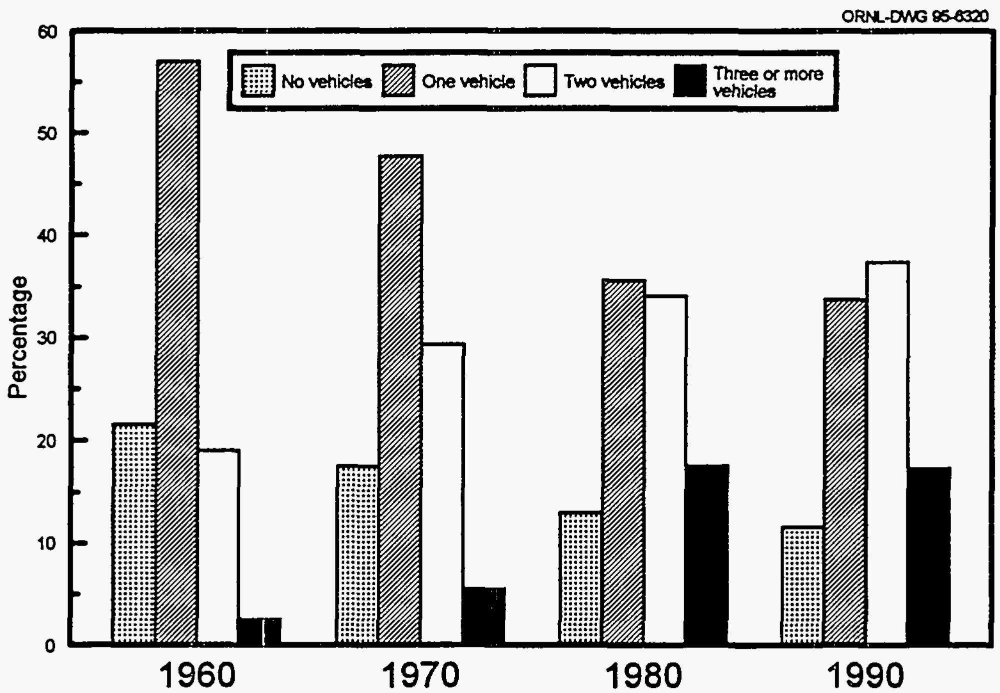
Source:
Generated from the Department of Energy, Energy Information Administration, "1991 Residential Transportation Energy Consumption Survey Public Use diskettes," Washington,DC, December 1993.

Table 4.9
Household Vehicle Ownership, 1960-90 Census
(percentage)

	No vehicles	One vehicle	Two vehicles	Three or more vehicles	Total vehicles
1960	21.53%	56.94%	19.00%	2.53%	54,766,718
1970	17.47%	47.71%	29.32%	5.51%	79,002,052
1980	12.92%	35.53%	34.02%	17.52%	129,747,911
1990	11.53%	33.74%	37.35%	17.33%	152,380,479

Source:
U. S. Department of Transportation, Volpe National Transportation Systems Center, Journey-to-Work Trends in the United States and its Major Metropolitan Area, 1960-1990, Cambridge, MA, 1994, p. 2-2.

Figure 4.2 Household Vehicle Ownership, 1960-90



Source: See Table 4.9.

> *"Both annual VMT and annual vehicle trips per household increased by 22% between 1969 and 1990. Work trips continue to account for the largest proportion of household travel, both in terms of miles and in number of trips. Average vehicle trip lengths, which had been decreasing from 1969 to 1983, showed increases in 1990. The largest increase in trip length was in work trips."* [a]

Table 4.10
Average Annual Vehicle Miles, Vehicle Trips and Trip Length
Per Household for Selected Trip Purposes
1969, 1977, 1983, and 1990 NPTS

Trip Purpose	1969	1977	1983	1990	Percent Change 69-90
Average Annual Vehicle Miles per Household					
Home to Work	4,183	3,815	3,538	4,853	16%
Shopping	929	1,336	1,567	1,743	88%
Other Family or Personal Business	1,270	1,444	1,816	3,014	137%
Social and Recreation	4,094	3,286	3,534	4,060	-1%
All[b]	**12,423**	**12,036**	**11,739**	**15,100**	**22%**
Average Annual Vehicle Trips per Household					
Home to Work	445	423	414	448	0.7%
Shopping	213	268	297	345	62%
Other Family or Personal Business	195	215	272	411	111%
Social and Recreation	312	320	335	349	12%
All[b]	**1,396**	**1,442**	**1,486**	**1,702**	**22%**
Average Vehicle Trip Length (Miles)					
Home to Work	9.4	9.1	8.5	11	17%
Shopping	4.4	5	5.3	5.1	16%
Other Family or Personal Business	6.5	6.8	6.7	7.4	14%
Social and Recreation	13.1	10.3	10.5	11.8	-10%
All[b]	**8.9**	**8.4**	**7.9**	**9.0**	**1%**

Source:
U.S. Department of Transportation, Federal Highway Administration, 1990 Nationwide Personal Transportation Survey: Summary of Travel Trends, Table 7, FHWA-PL-92-027, Washington, DC, March 1992.

[a]Reference source document, p. 18.
[b]Includes trip purposes not shown above.

Table 4.11
Average Vehicle Trip Length[a] by Vehicle Type and Trip Purpose, 1990 NPTS
(miles)

Vehicle Type	Earning a Living	Family and Personal Business	Civic, Educational and Religious	Social and Recreational	Other	**ALL**
Auto	10.9	6.2	7.5	11.4	11.5	**8.7**
Passenger Van	10.6	7.2	5.1	14.1	4.6	**9.2**
Cargo Van	17.6	9.5	14.4	14.8	10.0	**14.2**
Pickup Truck	12.1	7.4	8.1	13.1	10.6	**10.3**
Other Truck	25.0	8.6	2.0	7.8	[b]	**15.9**
RV/Motor Home	1.6	11.7	[b]	59.3	[b]	**24.8**
Motorcycle	6.2	8.1	6.6	15.5	[b]	**11.2**
Moped	8.6	2.0	0.9	2.1	[b]	**3.8**
Other POV	0.3	14.1	[b]	8.1	8.2	**12.2**
ALL	**11.2**	**6.5**	**7.5**	**11.8**	**10.8**	**9.0**

Source:
U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey, 1990 NPTS Databook, Volume II, FHWA-PL-94-010B, Washington, DC, November 1994, p. 5-59.

[a]Information based on observations that had valid trip mile information.
[b]Indicates no data reported.

Two-vehicle households accounted for 42% of all households, but 46% of vehicle trips in 1990. Over 20% of all vehicle trips were taken in vehicles 10 years or older, regardless of the number of vehicles available to the household.

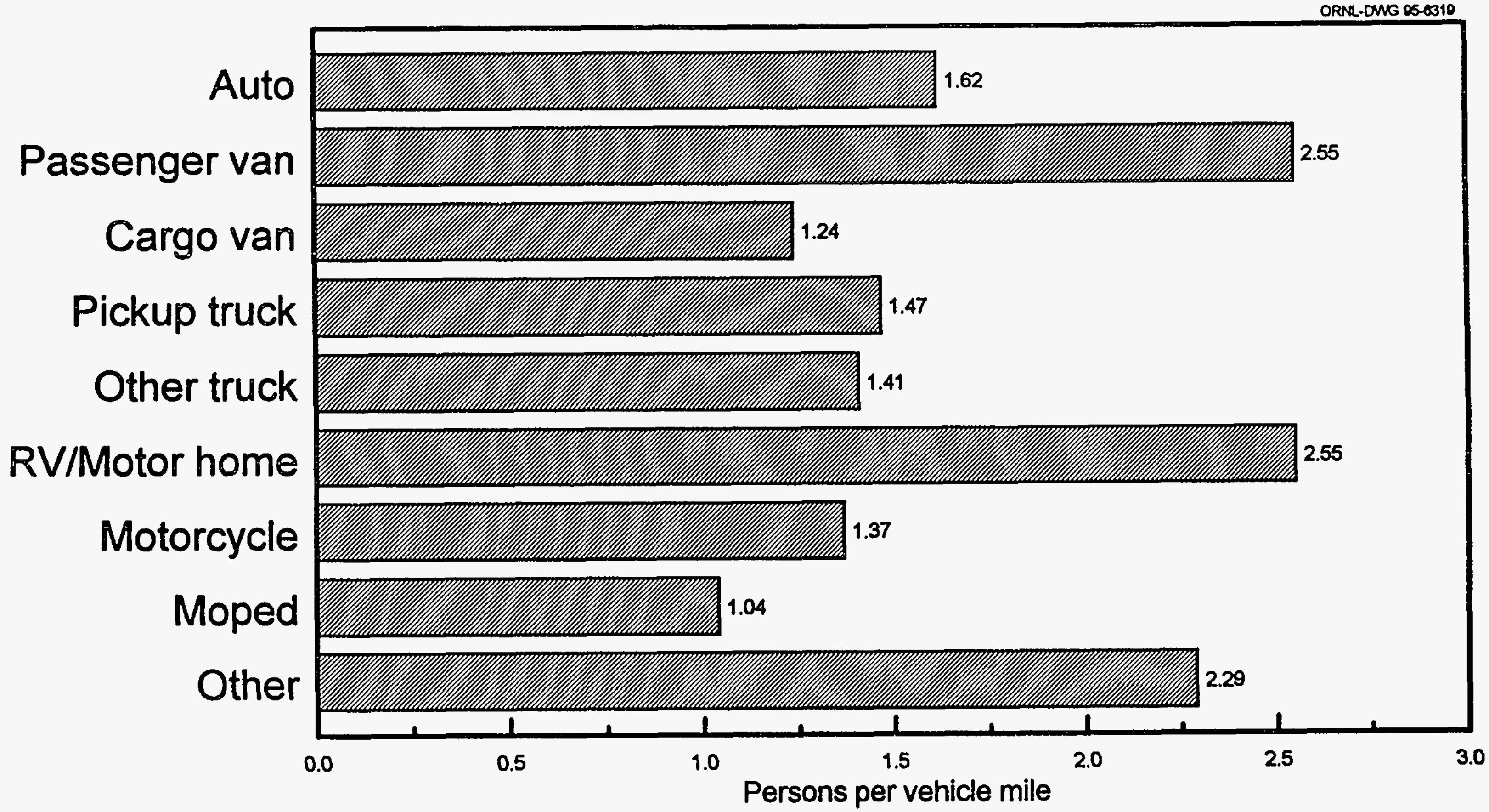
Table 4.12
Annual Vehicle Trips by Number of Household-based Vehicles[a] and Age of Vehicle, 1990 NPTS (millions)

Vehicle Age	1 Vehicle	2 Vehicles	3 or More Vehicles	TOTAL
1 Year or Less	2,334	5,876	3,716	**11,926**
2 Years	3,399	8,608	4,755	**16,762**
3 Years	3,227	8,064	4,532	**15,823**
4 Years	4,021	7,490	4,067	**15,578**
5 Years	3,806	7,600	4,559	**15,965**
6 Years	3,222	6,451	4,074	**13,747**
7 Years	2,913	5,600	3,860	**12,373**
8 Years	1,813	3,274	2,463	**7,550**
9 Years	1,433	2,710	1,983	**6,126**
10 or More Years	9,267	14,600	11,500	**35,367**
TOTAL	**36,966**	**73,144**	**48,274**	**158,927[b]**
ALL AGES	***23%***	***46%***	***30%***	***100%***
TOTAL HOUSEHOLDS	***36.3%***	***42.3%***	***21.5%***	***100.0%***

Source:
U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey, 1990 NPTS Databook, Volume II, FHWA-PL-94-010B, Washington, DC, November 1994, p. 5-43.

[a]Includes all vehicles owned by or available on a regular basis to the household.
[b]Includes trips where age of vehicle was unreported.

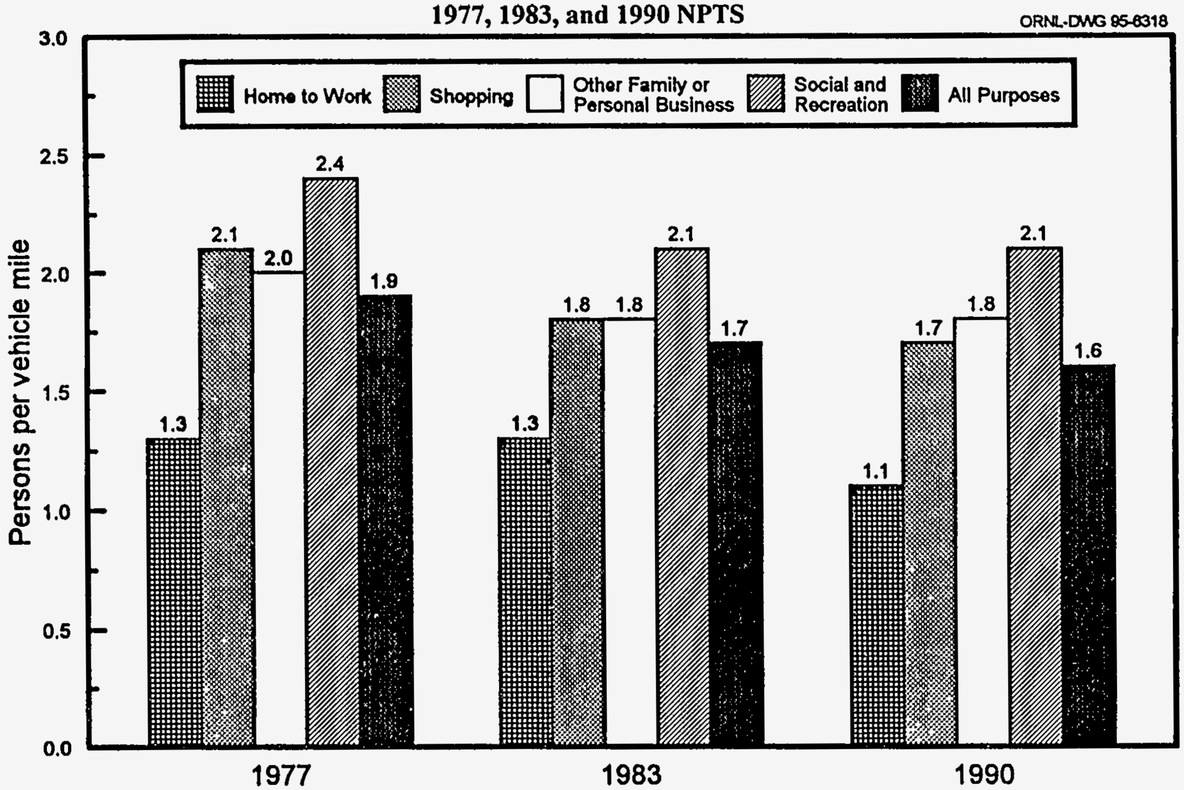
Figure 4.3 Average Vehicle Occupancy by Vehicle Type, 1990 NPTS



Source:
U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey, 1990 NPTS Databook, Volume II, FHWA-PL-94-010B, Washington, DC, November 1994, p. 7-6.

The average vehicle occupancy, calculated as person miles per vehicle mile, was at its lowest level since 1977 for every trip purpose. The increased number of vehicles per household and the decrease in average household size could have contributed to the decline.

Figure 4.4 Average Vehicle Occupancy by Trip Purpose
1977, 1983, and 1990 NPTS



Source:
U.S. Department of Transportation, Federal Highway Administration, 1990 Nationwide Personal Transportation Survey: Summary of Travel Trends, FHWA-PL-92-027, Figure 6, Washington, DC, March 1992.

The average vehicle occupancy declined from 1.3 in 1977 to 1.13 in 1990. In each of the years shown, carpooling increased as trip distance increased.

Table 4.13
Average Journey-to-Work Vehicle Occupancy[a] by Trip Length
1977, 1983, and 1990 NPTS

	Trip Length (Miles)						
	5 or Less	6-10	11-15	16-20	21-30	31 or More	All
1977[b]	1.3	1.3	1.3	1.3	1.3	1.5	1.3
1983[b]	1.2	1.1	1.2	1.3	1.3	1.7	1.2
1990	1.13	1.11	1.12	1.12	1.15	1.19	1.13

Source:
U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey, 1990 NPTS Databook Volume II, FHWA-PL-94-010B, Washington, DC, November 1994, p. 7-40.

[a]Person trips per vehicle trip.
[b]Occupancy rates from 1977 and 1983 were only calculated to tenths, not hundreths.

Less than 10% of vehicle trips to work were multi-occupant. Single-occupant automobile trips accounted for nearly 70% of all journey-to-work vehicle trips.

Table 4.14
Number of Journey-to-Work Vehicle Trips by Number of Occupants and Vehicle Type, 1990 NPTS

	Number of Persons on the Trip				
	1	2	3	4+	Total
Auto	29,143,140	2,245,724	524,413	179,100	32,092,377
	69.7%	5.4%	1.3%	0.4%	76.8%
Passenger Van	1,365,401	135,338	30,063	47,930	1,578,732
	3.3%	0.3%	0.1%	0.1%	3.8%
Pickup Truck	6,601,584	547,596	107,032	22,757	7,278,968
	15.8%	1.3%	0.3%	0.0%	17.4%
Motorcycle and Moped	137,546	[a]	[a]	[a]	137,546
	0.3%	[a]	[a]	[a]	0.3%
Other[b]	619,870	64,058	9,784	1,648	695,360
	1.5%	0.2%	0.0%	0.0%	1.7%
Total [c]	**37,876,690**	**2,992,716**	**671,291**	**251,435**	**41,792,133**
	90.6%	**7.2%**	**1.6%**	**0.6%**	**100.0%**

Source:
U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey, 1990 NPTS Databook, Volume II, FHWA-PL-94-010B, Washington, DC, November 1994, p. 7-34.

[a]Indicates no data reported.
[b]Includes cargo van, other truck, RV/motor home, and any other private vehicles not corresponding to the above classifications.
[c]Includes trips where vehicle type was unreported.

According to the U.S. Census data, the percentage of workers who carpooled has dropped from 19.7% in 1980 to 13.4% in 1990. The percent of workers using public transit declined from 6.4% to 5.3% during the same time period. The average travel time increased by 0.7 minutes from 1980 to 1990.

Table 4.15
Means of Transportation to Work for the United States, 1980 and 1990 Census

	1980 Census		1990 Census	
Means of Transportation	Number of Workers	Percentage	Number of Workers	Percentage
Private vehicle	81,258,496	84.1%	99,592,932	86.5%
Drove alone	62,193,449	64.4%	84,215,298	73.2%
Carpooled	19,065,047	19.7%	15,377,634	13.4%
Public Transportation	6,175,061	6.4%	6,069,589	5.3%
Bus or trolley bus[a]	3,924,787	1.1%	3,445,000	3.0%
Streetcar or trolley car[a]	[b]	[b]	78,130	0.1%
Subway or elevated	1,528,852	1.6%	1,755,476	1.5%
Railroad	554,089	0.6%	574,052	0.5%
Ferryboat	[b]	[b]	37,497	0.0%
Taxicab	167,133	0.2%	179,434	0.2%
Other Means	703,273	0.7%	808,582	0.7%
Motorcycle	419,007	0.4%	237,404	0.2%
Bicycle	468,348	0.5%	466,856	0.4%
Walked only	5,413,248	5.6%	4,488,886	3.9%
Worked at home	2,179,863	2.3%	3,406,025	3.0%
Total Workers	96,617,296	100.0%	115,070,274	100.0%
Average travel time (minutes)	21.7		22.4	

Source:
Data provided by the Journey-to-Work and Migration Statistics Branch, Population Division, U.S. Bureau of the Census.

[a]This category was "Bus or streetcar" in 1980.
[b]Data are not available.

Since 1970 over three-fourths of the workers in the U.S. travel to work in private vehicles. The share of workers traveling by private vehicle increased 19% from 1960 to 1990. The percentage of workers traveling by public transit declined by 8% in this same period.

Table 4.16
Workers by Major Mode of Transportation-to-Work, 1960-90 Census
(percentage)

	Private vehicle[a]	Public transit	Walked	Worked at home	Total workers
1960	69.48%	12.62%	10.37%	7.54%	64,656,805
1970	80.63%	8.48%	7.40%	3.49%	76,852,389
1980	85.92%	6.22%	5.60%	2.26%	96,617,296
1990	88.02%	5.12%	3.90%	2.96%	115,070,274

Source:
U. S. Department of Transportation, Volpe National Transportation Systems Center, Journey-to-Work Trends in the United States and its Major Metropolitan Area, 1960-1990, FHWA-PL-94-012, Cambridge, MA, 1994, p. 2-2.

[a]Includes cars, trucks, vans, bicycles, motorcycles, taxicabs, and all other means.

Table 4.17
National and Metropolitan Area Comparisons of Journey-to-Work Statistics, 1990 Census

	National	Metropolitan areas[a]
Workers per household	1.25	1.31
Workers per vehicle	0.76	0.82
Average travel time (minutes)	22.38	25.20
Commute Length (percentage)		
Less than 15 minutes	15.87%	11.45%
15 - 29 minutes	51.64%	49.22%
30 - 39 minutes	14.66%	17.48%
40 - 59 minutes	9.01%	11.77%
60 minutes or more	5.86%	7.52%
Mode (percentage)		
Drive alone	73.19%	70.75%
Percentage carpooled	13.36%	12.69%
Public transit	5.27%	8.98%
Motorcycle	0.21%	0.21%
Walk	3.90%	3.76%
Bicycle	0.41%	0.43%
Other	0.70%	0.62%
Work at home	2.96%	2.57%
Time Workers Leave Home (percentage)		
5:00 AM - 6.59 AM	26.04%	25.49%
7:00 AM - 8:29 AM	41.87%	42.44%
8:30 AM - 9:59 AM	10.28%	11.57%
All other departures	18.85%	17.93%

Source:
U. S. Department of Transportation, Volpe National Transportation Systems Center, Journey-to-Work Trends in the United States and its Major Metropolitan Area, 1960-1990, FHWA-PL-94-012, Cambridge, MA, 1994, p. 2-6.

[a]Metropolitan areas over 1 million population. There were 39 such areas in the 1990 Census.

The average commute trip length increased from 9.9 miles in 1969 to 10.6 miles in 1990. The shortest commuter trips (distancewise) each year were taken by bus, and the longest by truck.

Table 4.18
Journey-to-Work Trip Distance by Mode
1969, 1977, 1983, and 1990 NPTS

					Change	
Mode	1969	1977	1983	1990	69-90[a]	69-90[b]
	Average Commute Trip Distance (Miles)					
Auto	9.4	9.2	9.9	10.4	0.5%	11.0%
Truck[c]	14.2	10.6	11.4	13	-0.4%	-8.0%
Bus	8.7	7.2	8.6	9.3	0.3%	7.0%
ALL	**9.9**	**9.2**	**9.9**	**10.6**	**0.3%**	**7.0%**

Source:
U.S. Department of Transportation, Federal Highway Administration, 1990 Nationwide Personal Transportation Survey: Summary of Travel Trends, FHWA-PL-94-012, Table 10, Washington, DC, March 1992.

[a]Compounded annual percentage change rate.
[b]Percentage change rate.
[c]Household-based trucks, primarily pickups.

Table 4.19
Distribution of Journey-to-Work Trips by Trip Distance and Mode, 1990 NPTS
(percentage)

Trip Distance (miles)	Auto	Truck	Van	Bus	Train[a]	Walk	Other[b]	Total	Distribution by distance
Less then 1/2	45.8%	7.7%	2.3%	1.6%	1.1%	40.0%	1.6%	100.0%	7.4%
1/2 - 5	73.2%	15.1%	4.2%	2.4%	0.9%	2.5%	1.7%	100.0%	39.0%
6 - 10	74.7%	16.6%	4.0%	2.6%	1.3%	0.3%	0.6%	100.0%	21.5%
11 - 15	74.3%	18.0%	4.0%	2.1%	1.2%	0.0%	0.4%	100.0%	12.4%
16 - 20	70.3%	20.3%	5.1%	2.0%	1.9%	[c]	0.1%	100.0%	7.1%
21 - 30	69.9%	19.7%	5.9%	1.5%	2.7%	0.0%	0.3%	100.0%	6.7%
31 - 40	66.1%	23.5%	4.7%	0.9%	4.1%	[c]	0.5%	100.0%	2.9%
41 - 50	65.9%	21.0%	4.3%	1.6%	6.4%	0.0%	0.7%	100.0%	1.5%
51 - 60	55.1%	19.7%	17.1%	4.5%	2.0%	0.0%	1.6%	100.0%	0.7%
61 - 70	64.9%	23.4%	7.9%	0.0%	3.8%	0.0%	0.0%	100.0%	0.3%
71 - 80	51.4%	27.6%	10.7%	4.2%	6.1%	0.0%	0.0%	100.0%	0.2%
81 - 90	82.0%	4.9%	0.0%	0.0%	13.1%	0.0%	0.0%	100.0%	0.1%
91 - 100	59.0%	18.9%	14.4%	0.0%	7.7%	0.0%	0.0%	100.0%	0.1%
Over 100	47.7%	43.7%	5.3%	1.4%	1.9%	0.0%	0.0%	100.0%	0.2%
Total	**70.6%**	**16.4%**	**4.3%**	**2.2%**	**1.5%**	**4.0%**	**1.0%**	**100.0%**	**100.0%**

Source:
Generated from the U.S. Department of Transportation, Federal Highway Administration, 1990 Nationwide Personal Transportation Study, Public Use tape, March 1992.

[a]Includes Amtrak, commuter train, streetcar, trolley, elevated rail, and subway.
[b]Includes recreational vehicle, motorcycle, moped, bicycle, taxi, and other.
[c]Insufficient data reported.

Table 4.20
Number of Person Trips by Weekday vs. Weekend,[a] Trip Purpose, and Time of Day, 1990 NPTS

	1:00 a.m. to 6:00 a.m.	6:00 a.m. to 9:00 a.m.	9:00 a.m. to 1:00 p.m.	1:00 p.m. to 4:00 p.m.	4:00 p.m. to 7:00 p.m.	7:00 p.m. to 10:00 p.m.	10:00 p.m. to 1:00 a.m.	TOTAL[b]
				WEEKDAY				
Journey-to-Work	5.8%	33.8%	8.6%	13.3%	27.6%	5.9%	3.5%	**100.0%**
Work Related Business	1.3%	15.2%	31.7%	22.0%	17.3%	7.1%	2.8%	**100.0%**
Other	1.0%	12.0%	21.2%	23.6%	22.5%	13.0%	3.0%	**100.0%**
Subtotal	**2.2%**	**17.6%**	**18.2%**	**21.0%**	**23.7%**	**11.1%**	**3.1%**	**100.0%**
				WEEKEND				
Journey-to-Work	5.2%	17.5%	14.9%	13.4%	23.1%	15.1%	9.1%	**100.0%**
Work Related Business	2.3%	12.4%	23.3%	18.7%	20.6%	13.1%	4.4%	**100.0%**
Other	1.0%	4.4%	25.7%	20.2%	21.2%	17.2%	5.8%	**100.0%**
Subtotal	**1.4%**	**5.6%**	**24.8%**	**19.6%**	**21.3%**	**17.0%**	**6.1%**	**100.0%**
TOTAL[b]	**1.9%**	**13.9%**	**20.1%**	**20.4%**	**22.8%**	**12.8%**	**4.0%**	**100.0%**

Source:
U.S. Department of Transportation, Federal Highway Administration, Nationwide Personal Transportation Survey, 1990 NPTS Databook, Volume II, FHWA-PL-94-010B, Washington, DC, November 1994, p. 6-48.

[a]Weekday is defined as the time between 12:01a.m. Monday and 6:00p.m. Friday; weekend is defined as the time between 6:01p.m. Friday and midnight Sunday.

[b]Includes trips where time of day, weekday vs. weekend or both were unreported.

CHAPTER 5

ALTERNATIVE FUELS STATISTICS

In 1993, the transportation sector alone used 22.2 quads of petroleum fuels, accounting for 65.6% of total petroleum consumed in the United States. With decreasing domestic oil production and rising demand, the amount of imported crude oil and petroleum products has increased at an average rate of 6.5% per year since 1983. In 1993, 50% of the petroleum consumed in the U.S. was imported. These statistics suggest that reducing the transportation sector's dependence on petroleum fuels will be the key to reducing the nation's dependence on imported petroleum.

In 1988 the Alternative Motor Fuels Act (AMFA) was established to encourage the use of alternative fuels in the U.S. transportation sector. As a result of the AMFA, the Alternative Fuels Data Center (AFDC) was established by the Department of Energy. The AFDC distributes information about alternative fuel vehicles as well as data on refueling sites around the nation. Information about the AFDC, and statistics and maps generated by the AFDC, are presented in this chapter.

Since the AMFA, government and industry have made major efforts to advance our knowledge of alternative fuels and alternative fuel vehicles. The U.S. Advanced Battery Consortium (USABC) was established in January 1991 to concentrate efforts on battery development for electric vehicles. The goals of the USABC are presented in Table 5.8.

The Energy Policy Act (EPAct) of 1992 included alternative fuel mandates. Purchase requirements were set from 1993 forward for the federal and state governments, fuel providers (e.g., natural gas and electric utilities), and the private sector. The federal fleet purchase requirements have already been updated by Executive Order 12844 (see Figure 5.4). Additional rulemaking is required for the private sector alternative fuel vehicle mandates to take effect.

Fuel type abbreviations are used throughout this chapter. LPG = liquified petroleum gas. CNG = compressed natural gas. M-85 = 85% methanol, 15%gasoline. E-85 = 85% ethanol, 15% gasoline. M-100 = 100% methanol. E-95 = 95% ethanol, 5% gasoline. LNG = liquified natural gas.

THE ALTERNATIVE FUELS DATA CENTER

The Department of Energy (DOE) has established the Alternative Fuels Data Center (AFDC) in support of its work aimed at fulfilling the Alternative Motor Fuels Act (AMFA) directives. The AFDC is operated and managed by the National Renewable Energy Laboratory (NREL) in Golden, Colorado.

The purposes of the AFDC are

- to gather and analyze information on the fuel consumption, emissions, operation, and durability of alternative fuel vehicles, and
- to provide unbiased, accurate information on alternative fuels and alternative fuel vehicles to government agencies, private industry, research institutions, and other interested organizations.

The data are collected for three specific vehicle types: (1) light-duty vehicles, including automobiles, light trucks, and mini-vans; (2) heavy-duty vehicles such as tractor trailers and garbage trucks; and (3) urban transit buses. An Oracle Relational Database Management System is used to manage the data, along with a statistical software package capable of providing statistical, graphic, and textual information to users. Several tables and graphs in this chaper contain statistics which were generated by the AFDC. Future editions of the Transportation Energy Data Book will continue to present graphical and statistical information from the AFDC.

The Department of Energy is now sponsoring the **National Alternative Fuels Hotline** for Transportation Technologies in order to assist the general public and interested organizations in improving their understanding of alternative transportation fuels. The Hotline can be reached by dialing **1-800-423-1DOE**.

Table 5.1
Estimates of Non-Federal Alternative Fuel Vehicles by Ownership and Vehicle Size, 1992 and 1994

Fuel type	Private		State and local government		Total	
	1992	1994	1992	1994	1992	1994
Light-duty vehicles						
LPG	>167,600	>176,000	9,400	>10,000	>177,000	>186,000
CNG	16,500	29,900	3,700	12,700	20,200	42,600
M-85	24	54	2,390	8,378	2,414	8,432
E-85	28	59	117	338	145	397
Electricity	1,588	2,572	92	207	1,680	2,779
M-100	0	0	37	37	37	37
E-95	9	10	1	1	10	11
LNG	3	3	2	2	5	5
Total	**>185,752**	**>208,598**	**>15,739**	**>31,663**	**>201,491**	**>240,261**
Heavy-duty vehicles						
LPG	>44,000	>41,900	1,600	>1,500	>43,500	>45,500
CNG	2,500	1,300	1,000	2,800	2,300	5,300
M-85	0	3	131	252	134	252
E-85	1	1	1	1	2	2
Electricity	1	1	9	44	10	45
M-100	6	6	361	669	367	675
E-95	4	4	24	42	28	46
LNG	22	16	69	498	85	520
Total	**>46,534**	**>43,231**	**>3,195**	**>5,806**	**>46,426**	**>52,340**

Source:
U. S. Department of Energy, Energy Information Administration, Alternatives to Traditional Transportation Fuels: An Overview, Washington, DC, June 1994, p. 14.

In 1993 the Federal Fleet had 7,606 alternative fuel vehicles (AFV). Estimated acquisitions for 1994 indicate that the number of AFVs would more than double. The plans called for the purchase of 150 propane vehicles, 7,000 CNG vehicles, 3,640 M-85 vehicles, and 10 electric vehicles, totaling 10,800 additional AFVs.

Table 5.2
Federal Government
Alternative Fuel Vehicles by Fuel Type, 1992-94

Fuel type	1992	1993	Estimated purchases, 1994
Propane	20	20	150
Compressed natural gas	1,978	2,137	7,000
M-85	220	5,363	3,640
E-85	22	79	0
Electricity	0	7	10
Total	**2,240**	**7,606**	**10,800**

Source:
U. S. Department of Energy, Energy Information Administration, Alternatives to Traditional Transportation Fuels: An Overview, Washington, DC, June 1994, p. 12.

In 1994 there were 4,455 alternative refuel sites in the United States. This list includes public and private refuel sites; therefore, not all of these sites are available to the public.

Table 5.3
Number of Alternative Refuel Sites by State and Fuel Type, 1994

State	M85 Sites	E85 Sites	CNG Sites	Propane Sites	Total
Alabama	0	0	16	85	101
Alaska	0	0	0	8	8
Arizona	1	0	19	45	65
Arkansas	0	0	7	104	111
California	59	1	117	214	391
Colorado	3	0	41	48	92
Connecticut	0	0	11	19	30
Delaware	0	0	2	6	8
District of Columbia	1	1	7	0	9
Florida	1	0	38	222	261
Georgia	0	0	47	80	127
Hawaii	0	0	0	0	0
Idaho	0	0	6	20	26
Illinois	2	10	23	165	200
Indiana	0	1	39	124	164
Iowa	0	6	4	108	118
Kansas	0	0	10	38	48
Kentucky	0	0	9	35	44
Louisiana	0	0	10	44	54
Maine	0	0	0	12	12
Maryland	2	0	24	21	47
Massachusetts	0	0	12	41	53
Michigan	2	1	29	182	214
Minnesota	0	1	16	125	142
Mississippi	0	0	0	75	75
Missouri	0	0	10	83	93
Montana	0	0	11	48	59
Nebraska	0	3	10	47	60
Nevada	0	0	7	20	27
New Hampshire	0	0	1	31	32
New Jersey	0	0	18	36	54
New Mexico	0	0	15	46	61
New York	5	0	43	100	148
N. Carolina	0	0	8	72	80
N. Dakota	0	0	5	17	22
Ohio	2	0	53	98	153
Oklahoma	0	0	46	56	102
Oregon	0	0	4	21	25
Pennsylvania	1	0	50	132	183
Rhode Island	0	0	2	5	7
S. Carolina	0	0	2	43	45
S. Dakota	0	6	5	24	35
Tennessee	1	0	6	80	87
Texas	0	0	77	202	279
Utah	0	0	49	20	69
Vermont	0	0	1	33	34
Virginia	0	0	24	39	63
Washington	1	0	30	37	68
W. Virginia	1	0	37	16	54
Wisconsin	0	2	22	139	163
Wyoming	0	0	19	33	52
Total	**82**	**32**	**1,042**	**3,299**	**4,455**

Source:
National Alternative Fuels Hotline, 1995.

A comparison of fuel prices by "Natural Gas Fuels" in December 1994 showed that consumers saved anywhere from 16% to 46% by using compressed natural gas (CNG) instead of unleaded regular gasoline as a vehicle fuel.

Table 5.4
Comparison of Station Prices: Compressed Natural Gas and Regular Unleaded Gasoline, December 1994
(Dollars per gallon or equivalent gallons)

Region	Station	CNG	Unleaded gasoline	Percentage CNG to gasoline
1	Amoco/Minneapolis, MN	$0.969	$1.159	83.6%
	Exxon/Billings, MT	$0.750	$1.299	57.7%
2	Shell/Sacramento, CA	$0.660	$1.189	55.5%
	UnocalVista, CA	$0.855	$1.299	65.8%
	Total/Denver, CO	$0.809	$1.239	65.3%
	Sinclair/Salt Lake City, UT	$0.584	$1.079	54.1%
3	Mobile/Garland, TX	$0.799	$1.149	69.5%
	Shell/Houston, TX	$0.899	$1.129	79.6%
	Chevron/Houston, TX	$0.799	$1.049	76.2%
	Phillips 66/Oklahoma City, OK	$0.799	$0.929	83.9%
	Mobile/Shreveport, LA	$0.749	$1.058	70.7%
	Amoco/Topeka. KS	$0.859	$1.029	83.5%
4	Conoco/Mobile, AL	$0.799	$1.069	74.7%
	Shell/Palm Beach Gardens, FL	$0.999	$1.219	82.0%
	Amoco/Atlanta, GA	$0.749	$0.999	75.0%
	Amoco/Tucker, GA	$0.749	$0.999	75.0%
5	Amoco/Naperville, IL	$0.959	$1.239	77.4%
	Texaco/Hartford, CT	$0.929	$1.310	70.9%
	Mobile/Brooklyn, NY	$1.080	$1.359	79.5%
Canada	Petro-Canada/Van., BC	$0.307	$0.568	54.0%
	Shell/Etobicoke, Ont.	$0.338	$0.495	68.3%

Source:
"Natural Gas Fuels," January 1995, p. 15.

The Alternative Fuels Data Center collects data from more than 600 vehicles from 10 different sites. The data reflect a simple average that "does not take into consideration differences in highway and city driving, difference between the sites reporting and how the vehicles are being used.[a]" This led to large variations or standard deviations in the data.

Table 5.5
Alternative Fuel Vehicle Fuel Economies
by Vehicle Type[b]

Vehicle type	Model Year	Average MPG (gasoline)/average equivalent MPG (AFVs)	Standard deviation of MPG	Number of samples	Percentage operated on alternative fuel
CNG GMC Pickup/C2500	1992	11.8	3.9	2,747	100%
Gasoline Control GMC Pickup	1993	13.4	4.2	105	0%
M85 Ford Econoline	1992	14.6	7.5	13	48%
Gasoline Control Ford Econoline	1993	15.1	3.9	32	0%
E85 FFV[c] Chevrolet Lumina	1992	22.8	6.8	195	60%
Gasoline Control Chevrolet Lumina	1991 & 1993	24.7	5.6	549	0%
M85 FFV[c] Chevrolet Lumina	1991 & 1993	23.7	6.3	2,305	84%
M85 Control Chevrolet Lumina	1991	22.4	6.1	245	100%
CNG Dodge Van/ B200	1992	12.8	2.5	4,033	100%
Gasoline Control Dodge Van	1994	10.4	3.5	94	0%
M85 Dodge Spirit	1993	23.4	6.2	601	50%
Gasoline Control Dodge Spirit	1993	26.4	4.2	148	0%
M85 FFV[c] Ford Taurus	1991 & 1993	23.2	6.2	2,245	82%
M85 Control Ford Taurus	1991	21.5	5.0	183	100%
Gasoline Control Ford Taurus	1991 & 1993	23.2	5.4	505	0%

Source:
Alternative Fuels Data Center, Golden, CO, 1994.

[a] Lee Schrock, AFDC engineer.
[b] As of January 20, 1994.
[c] A Flexible fuel vehicle can run on any combination of either E85 and gasoline or M85 and gasoline.

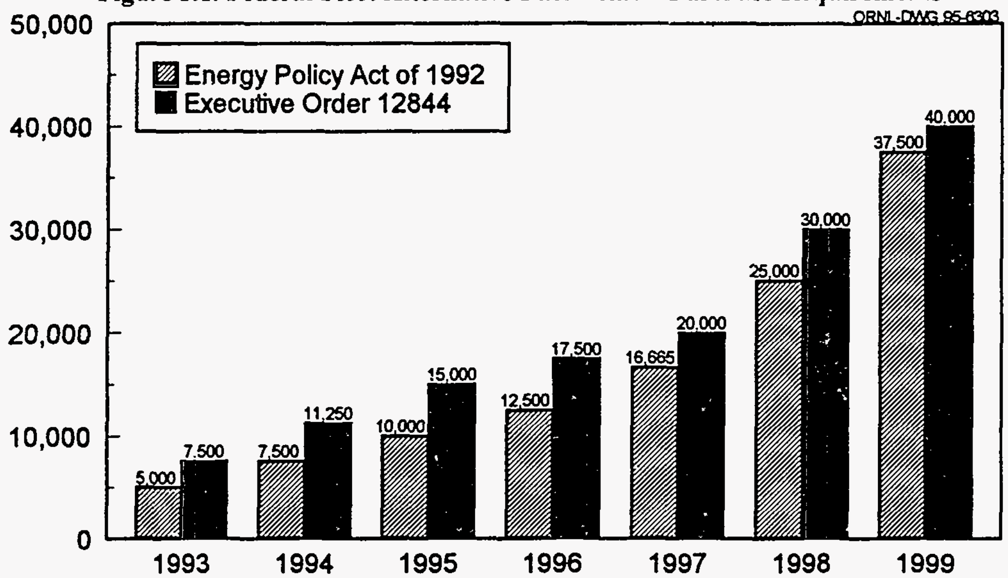
Although the Energy Policy Act of 1992 (EPAct) set alternative fuel vehicle purchase requirements for Federal and State Governments, fuel providers and the private sector, the Federal fleet requirements have since been increased by Executive Order 12844. A comparison of the two requirements is shown in the graph below.

Table 5.6
Energy Policy Act Purchase Requirements of Light-Duty Alternative Fuel Vehicles

Year	Federal	State	Fuel providers	Private[a]
1993	5,000	-	-	-
1994	7,500	-	-	-
1995	10,000	-	-	-
1996	25%	10%	30%	-
1997	33%	15%	50%	-
1998	50%	25%	70%	-
1999	75%	50%	90%	20%
2000	75%	75%	90%	20%
2001	75%	75%	90%	20%
2002	75%	75%	90%	30%
2003	75%	75%	90%	40%
2004	75%	75%	90%	50%
2005	75%	75%	90%	60%
2006 on	75%	75%	90%	70%

Source:
National Alternative Fuels Hotline for Transportation Technologies, 1993.

Figure 5.1. Federal Fleet Alternative Fuel Vehicle Purchase Requirements[b]



[a]Under the early rulemaking scenario. Additional rulemaking is required by December 15, 1996 for private AFV requirements to take effect.
[b]Based on 50,000 vehicle acquisitions per year.

U.S. ADVANCED BATTERY CONSORTIUM

Electric vehicles are the subject of intense research and development because they are required to be sold in California in 1998 (2% rising to 10% in 2003) under the California Low-Emission Vehicle (LEV) program. Other states have indicated that they will also enforce the LEV program. One of the greatest advantages in using electric vehicles is that there are no vehicle emissions. The U.S. Advanced Battery Consortium (USABC) was established in January 1991 to concentrate efforts on battery development for future electric vehicles. The USABC consists of the Big Three U.S. auto manufacturers (Chrysler, Ford, General Motors), the Electric Power Research Institute, and the U.S. Department of Energy. Five major U.S. electric utilities are also direct participants in USABC.

The USABC has established research contracts with several companies for the development of advanced batteries. Also, a series of Cooperative Research and Development Agreements (CRADAs) with several DOE National Laboratories have been established.

Table 5.7
U.S. Advanced Battery Consortium Research Agreements

Battery type	Organization
	Research contracts
Nickel-metal hydride	Ovonic Battery Corporation, Troy, MI
Sodium-sulfur	Silent Power, Salt Lake City, UT
Nickel-metal hydride	Saft America, Cockeysville, MD
Lithium-iron disulfide	Saft America, Cockeysville, MD
Lithium-polymer	W. R. Grace, Boca Raton, FL 3M, St. Paul, MN
Nickel electrode	Yardney Technical Products, Pawcatuck, CT
	CRADAs
Lithium-polymer	Lawrence Berkeley Laboratory, Berkeley, CA
Advanced battery thermal enclosure	National Renewable Energy Laboratory, Golden, CO
Nickel-metal hydride	Argonne National Laboratory, Argonne, IL
Sodium-sulfur	Argonne National Laboratory, Argonne, IL Sandia National Laboratory, Albuquerque, NM
Lithium-iron disulfide	Argonne National Laboratory, Argonne, IL
Sodium-beta sulfur	Idaho National Energy Laboratory, Idaho Falls, ID
Lithium-polymer	Sandia National Laboratory, Albuquerque, NM Idaho National Energy Laboratory, Idaho Falls, ID

Source: U.S. Adanced Battery Consortium Fact Sheet.

Today's lead acid batteries provide 30-40 watt hours per kilogram, cost betwen $50-150 per kilowatt hour and have a two- to three-year lifetime. However, current batteries do not have energy or performance sufficient to provide vehicles which are competitive with gasoline-fueled vehicles. When attained, the mid-term Advanced Battery Technology goals will effectively double the range and performance of electric vehicles compared to the range and performance possible with today's battery technology.

Table 5.8
Advanced Battery Technology Goals of the U.S. Advanced Battery Consortium

	Mid-term goal (1995-1998)	Long-term goal[a]
Power density W/L	250	600
Specific power (charge) W/kg (80% DoD/30 sec)	150-200	400
Specific power (recharge) W/kg (20% DoD/10 sec)	75	
Energy density Wh/L (C/3 discharge rate)	135	300
Specific energy Wh/kg (C/3 discharge rate)	80-100	200
Power/energy ratio	1.5-2.5	
Life (years)	5	10
Cycle life (cycles) (80% DoD)	600	1000
Power and capacity degradation (% of rated spec)	20%	20%
Ultimate price ($/kWh) (10,000 units @ 40 kWh)	<$150	<$100
Operating environment	-30 to 65° C	-40 to 85° C
Normal recharge time	<6 hours	3 to 6 hours
Fast recharge time	50% of capacity in <30 minutes	
Continuous discharge in 1 hour (no failure) energy	75% (of rated energy capacity)	75% (of rated capacity)

Note: w=watt; kg=kilogram; L=liter; DoD=depth of discharge; wh=watt-hour; kwh=kilowatt-hour

Source:
U.S. Department of Energy, Office of Transportation Technologies, Washington, DC, 1995.

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[a]Competitive with today's internal combustion engine vehicles.

Table 5.9
U.S. Production of MTBE[a] and Fuel Ethanol, 1978-94
(million gallons)

Year	Fuel ethanol	MTBE[a]
1978	20	[b]
1979	40	[b]
1980	80	[b]
1981	85	122
1982	234	132
1983	443	134
1984	567	235
1985	793	302
1986	798	359
1987	825	[b]
1988	800	[b]
1989	750	[b]
1990	756	[b]
1991	875	[b]
1992	1,080	1,542
1993	1,156	2,081
1994	1,280	2,205
	Average annual percentage change	
1978-94	29.7%	[b]
1984-94	8.5%	25.1%

Sources:
1992-93 Ethanol and MTBE - U.S. Department of Energy, Energy Information Administration, *Petroleum Supply Monthly*, January 1995, Table D1.
1978-90 Ethanol - Information Resources, Inc., Washington, DC, 1991.
1981-86 MTBE - EA-Mueller,Inc., Baltimore, MD, 1992.

[a]Methyl tertiary butyl ether.
[b]Data are not available.

Table 5.10
Federal and State Taxes on Motor Fuels[a]
(dollars per gallon or gallon equivalent)

State	Gasoline	Diesel fuel	Gasohol	Propane	CNG	Methanol	Ethanol	Electricity
Alabama	0.180	0.190	0.180	0.170	[b]	0.190	0.190	
Alaska	0.080	0.080	0.000					
Arizona	0.180	0.180	0.180	0.180	0.010			
Arkansas	0.187	0.187	0.187	0.165	0.000			
California	0.170	0.170	0.170	0.060	[b]	0.080	0.080	
Colorado	0.220	0.205	0.220	0.205	[b]	0.205	0.205	
Connecticut	0.280	0.180	0.270	0.280	0.280	0.270	0.270	
Delaware	0.190	0.190	0.190	0.190	0.190	0.190	0.190	
District of Columbia	0.200	0.200	0.200	0.200	0.200	0.200	0.200	
Florida	0.118	0.210	0.118	0.132	0.116	0.116	0.116	
Georgia	0.075	0.075	0.075	0.075	0.075	0.075	0.075	
Hawaii	0.160	0.160	0.160	0.110				
Idaho	0.210	0.210	0.210	0.210	0.190			
Illinois	0.190	0.215	0.190	0.190	0.215	0.215	0.215	
Indiana	0.150	0.160	0.150		[b]			
Iowa	0.200	0.225	0.190	0.200	0.160			
Kansas	0.180	0.200	0.180	0.170	0.170	0.200	0.200	
Kentucky	0.154	0.124	0.154	0.150	0.120			
Louisiana	0.200	0.200	0.200	0.200	0.200	0.200	0.200	
Maine	0.190	0.200	0.190	0.180	0.180	0.180	0.180	
Maryland	0.2350	0.2175	0.2350	0.2175	0.1925	0.1925	0.1925	0.1925
Massachusetts	0.210	0.210	0.210	0.097	0.087			
Michigan	0.150	0.150	0.150	0.150	0.000	0.150	0.150	
Minnesota	0.200	0.200	0.200	0.201		0.200		
Mississippi	0.182	0.182	0.182	0.170	0.180			
Missouri	0.130	0.130	0.130	0.130				
Montana	0.214	0.214	0.214	[b]	0.070			
Nebraska	0.252	0.252	0.252	0.246	0.246	0.246	0.246	
Nevada	0.204	0.270	0.240	0.230	0.245	0.245	0.245	
New Hampshire	0.186	0.186	0.186	0.180	0.180			
New Jersey	0.1050	0.1350	0.1050	0.0525	0.0525			
New Mexico	0.170	0.170	0.170	0.160	0.170	0.170	0.170	
New York	0.229	0.248	0.228	0.080	0.080			
N. Carolina	0.223	0.223	0.223	0.223	0.219	0.219	0.219	
N. Dakota	0.180	0.180	0.180	0.180	0.170	0.170	0.170	
Ohio	0.210	0.210	0.210	0.210	0.210	0.210		
Oklahoma	0.170	0.140	0.170	[b]	[b]	0.160	0.160	
Oregon	0.240	0.240	0.190	0.240	0.220	0.220		
Pennsylvania	0.224	0.224	0.224	0.235	0.224	0.224	0.224	
Rhode Island	0.260	0.260	0.260	0.260	0.260	0.260	0.260	0.260
S. Carolina	0.160	0.160	0.160	0.160	0.160	0.160	0.160	
S. Dakota	0.180	0.180	0.160	0.160	0.180		0.180	
Tennessee	0.210	0.170	0.200	0.140	0.130	0.214	0.214	
Texas	0.200	0.200	0.200	0.150	[b]	0.200	0.200	
Utah	0.190	0.190	0.190	0.190	[b]			[b]
Vermont	0.160	0.170	0.160					
Virginia	0.175	0.160	0.175	0.160	0.162	0.162	0.162	
Washington	0.230	0.230	0.207	[b]	[b]			
W. Virginia	0.2035	0.2035	0.2035	0.2035	0.2035	0.2035	0.2035	
Wisconsin	0.222	0.222	0.222	0.222	0.222	0.222	0.222	
Wyoming	0.090	0.090	0.050		0.000			
Federal	**0.184**	**0.244**	**0.013**	**0.183**	**0.000**	**0.0805**	**0.0865**	

Source:
Gasoline, diesel, gasohol, and propane: U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, p. IV-50.
All else: J. E. Sinor Consultants, Inc., "The Clean Fuels Report," February 1993, pp. 69, 70.

[a]All prices are per gallon or gallon equivalent. In some states, a state or local sales tax may be added.
[b]Annual flat fee.

As of October 1993, only seven states offered tax exemptions to encourage the use of gasohol for transportation purposes. This list is quite short compared to the 30 states which offered gasohol tax exemptions ten years ago. Still, the Federal Government encourages gasohol use via a 5.4¢ difference in the Federal tax rates of gasoline and gasohol (see Table 5.10).

Table 5.11
State Tax Exemptions for Gasohol
November 1994

State	Exemption (cents/gallon of gasohol)
Alaska	8.0
Connecticut	1.0
Idaho	2.1
Iowa	1.0
South Dakota	2.0
Washington	2.7
Wyoming	4.0

Source:
U.S. Department of Transportation, Federal Highway Administration, "Monthly Motor Fuel Reported by the States, August 1994," December 1994, Washington, DC, Table MF-121T.

Table 5.12
Gasohol Consumption by Reporting States, 1980-93[a]
(thousands of gallons)

	1980	1990	1992	1993	Total Ethanol Used in Gasohol,1993
Alabama		197,856	280,700	140,774	14,077
Alaska					
Arizona	2,798			32,062	2,844
Arkansas	8,250	62,004	24,541	16,152	1,615
California	147,795	479,716	59,488	360,112	20,526
Colorado	3	97,263	141,984	251,889	21,878
Connecticut	15,849		50,379	58,359	5,836
Delaware	1,512				
District of Columbia	124				
Florida	14,359	77,558	86,268	46,671	4,667
Georgia	11,063	88,672	22,973	40,391	4,039
Hawaii	1,095				
Idaho		70,199	43,997	6,536	654
Illinois	15,088	1,341,148	1,567,122	1,472,573	147,257
Indiana		638,337	642,291	638,673	63,867
Iowa	155,947	374,897	514,418	575,515	57,552
Kansas	37,786	73,971	62,979	51,939	5,194
Kentucky	4,763	355,987	364,841	218,231	21,823
Louisiana		38,760	83,603	78,727	7,873
Maine	2,634				
Maryland	18,549				
Massachusetts	16,209			8	1
Michigan	29,924	510,447	514,813	574,747	57,475
Minnesota	11,776	244,336	651,008	1,293,107	115,162
Mississippi				49,747	4,980
Missouri		267,408	252,984	274,217	27,422
Montana	158	1,423	5,005	5,491	542
Nebraska	30,067	300,632	371,792	288,206	28,821
Nevada	641	49,167	71,687	94,880	8,140
New Hampshire	3,642				
New Jersey	6,567			11,743	961
New Mexico		156,935	108,560	22,406	2,111
New York				33,806	2,960
N. Carolina	10,688		29,312	29,422	2,793
N. Dakota	13,491	35,821	55,769	52,331	5,233
Ohio	16,726	1,072,040	1,249,017	1,675,801	167,580
Oklahoma	28,910				
Oregon			191,196	339,128	31,230
Pennsylvania				82,460	7,761
Rhode Island	1,763				
S. Carolina	11,608	62,549			
S. Dakota	10,507	60,000	159,474	168,193	16,819
Tennessee		246,713	194,319	211,883	21,188
Texas		247,384	247,821	53,829	5,349
Utah		485	2,530	7,137	693
Virginia	1,991	161,202	103,384	19,273	1,839
Washington	14,063	86,847	422,804	804,150	69,457
W. Virginia	692		41,979	23,114	2,311
Wisconsin		82,961	160,048	127,117	12,712
Wyoming	611	9,513	51,682	55,717	5,572
Total	497,222	7,492,231	8,830,768	10,286,567	978,814

Sources:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1994, Table MF-33E, p. I-9, and annual.

[a]The data reflect gallons of gasohol reported by the distributors in each of the selected states. Blanks indicate data were not reported for the state that year.

CHAPTER 6

NONHIGHWAY MODES

This chapter presents statistics for four major nonhighway transportation modes: air, water, pipeline, and rail. The combined energy use for these four modes accounted for over 22% of the total energy use in the transportation sector in 1992 (Table 6.1). Air transportation accounted for the largest share (41%) of nonhighway transportation energy consumption (Figure 6.1).

Section 6.1 discusses data on air transportation. Statistics on water transportation are included in Section 6.2; and rail data in Section 6.3.

Table 6.1
Nonhighway Energy Use by Mode, 1970-93

Year	Air	Water	Pipeline	Rail	Nonhighway transportation energy use	Transportation energy use[a] (trillion Btu)
	(percent of total transportation)					
1970	8.5%	4.9%	6.4%	3.8%	23.7%	15,305
1971	8.2%	4.4%	6.3%	3.5%	22.4%	15,907
1972	7.8%	4.1%	6.1%	3.6%	21.7%	16,949
1973	7.7%	4.6%	5.6%	3.7%	21.6%	17,813
1974	7.3%	4.7%	5.5%	3.8%	21.3%	17,088
1975	7.4%	4.9%	4.8%	3.4%	20.5%	17,329
1976	7.2%	5.4%	4.4%	3.4%	20.4%	18,389
1977	7.4%	5.8%	4.1%	3.3%	20.6%	19,071
1978	7.3%	6.5%	3.9%	3.1%	20.9%	20,035
1979	7.8%	7.7%	4.3%	3.3%	23.0%	20,101
1980	7.9%	8.7%	4.6%	3.3%	24.5%	19,317
1981	7.6%	8.2%	4.7%	3.3%	23.8%	19,065
1982	7.9%	6.9%	4.6%	3.1%	22.6%	18,589
1983	8.0%	6.3%	3.9%	3.1%	21.4%	18,728
1984	8.5%	6.5%	4.0%	2.7%	21.7%	19,310
1985	8.5%	6.7%	3.9%	2.5%	21.6%	19,659
1986	9.0%	6.4%	3.6%	2.4%	21.5%	20,229
1987	9.2%	6.4%	3.7%	2.4%	21.7%	20,704
1988	9.3%	6.3%	4.1%	2.4%	22.1%	21,278
1989	9.2%	6.4%	4.1%	2.4%	22.1%	21,598
1990	9.5%	6.8%	4.3%	2.3%	22.8%	21,778
1991	9.1%	7.4%	4.1%	2.3%	22.7%	21,261
1992	9.0%	7.5%	3.9%	2.3%	22.6%	21,944
1993	8.9%	6.6%	4.0%	2.1%	21.6%	22,345

Source:
See Appendix A for Table 2.10.

[a]Does not include off-highway and military transportation energy use.

Section 6.1
Air

Air transportation activities can be categorized into two types: air carrier and general aviation. General aviation aircraft serve a variety of purposes, such as business and flight instruction, and include all aircraft which do not belong to the air carrier fleet. Since most of the aircraft in this category are used for personal activities, they do not provide commercial passenger or freight services. Although general aviation aircraft account for the majority of the number of aircraft in operation and fly almost five times as many hours as their counterparts in the air carrier category, the lower speeds and the smaller loads of general aviation aircraft resulted in a significantly smaller share of total aircraft energy use than that of the air carrier fleet, 4.7% and 95.3%, respectively (Tables 6.2 and 6.3).

Domestic and international[a] certificated route air carriers experienced declines in all activities from 1990 to 1991--aircraft-miles, passenger-miles, available seat-miles and cargo ton-miles, but these activities increased in 1992. Nearly three-quarters of total air carrier energy use was consumed by domestic carriers in 1992, although the domestic share has been declining since 1986 when it was 81.4%. Average passenger trip length has increased by 130 miles in the last 22 years.

Intercity passenger travel by general aviation continued to decline in 1992 to 12.2 billion passenger-miles from a high in 1989 of 13.1 billion passenger-miles. In 1992 the number of hours flown by general aviation was at its lowest point in twenty years. Following the decline in hours flown, energy use declined by 13% from 1991 to 1992.

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[a]Operating outside the territory of the U.S., including operations between the U.S. and foreign countries and the U.S. and its territories or possessions.

Table 6.2
Summary Statistics for Domestic and International Certificated Route Air Carriers (Combined Totals), 1970-92

Year	Revenue aircraft-miles (millions)	Average passenger trip length[a] (miles)	Revenue passenger-miles (millions)	Available seat-miles (millions)	Available seats per aircraft[b]	Passenger load factor (percentage)[c]	Revenue cargo ton-miles (millions)	Energy use (trillion Btu)[d]	Percent domestic of total energy use (percentage)
1970	2,383	678	131,719[e]	264,904[e]	111	49.7%[e]	4,994	1,363.4	[f]
1971	2,344	681	135,658[e]	279,823	119	48.5%[e]	5,120	1,370.5	[f]
1972	2,337	685	152,406[e]	287,411	122	53.0%[e]	5,506	1,374.3	[f]
1973	2,402	689	174,352	322,992	129	54.0%	6,046	1,444.5	[f]
1974	2,351	684	174,052	310,130	126	56.1%	6,133	1,289.8	[f]
1975	2,241	698	173,324	315,823	135	54.9%	5,944	1,283.4	[f]
1976	2,320	704	191,823	338,349	139	56.7%	6,222	1,324.1	[f]
1977	2,418	704	206,082	361,172	143	57.1%	6,587	1,386.2	[f]
1978	2,608	719	236,998	381,113	147	62.2%	7,395	1,436.3	82.0%
1979	2,859	714	269,719	425,411	146	63.4%	7,580	1,534.8	82.5%
1980	2,924	736	267,722	448,479	148	59.7%	7,515	1,489.6	82.4%
1981	2,703	749	260,063	438,778	157	59.3%	7,917	1,429.3	[f]
1982	2,804	766	272,435	455,938	157	59.8%	7,807	1,406.6	81.1%
1983	2,923	765	295,144	480,977	159	61.4%	8,497	1,439.2	84.4%
1984	3,264	759	319,504	534,104	164	59.8%	9,328	1,607.4	[f]
1985	3,462	758	351,073	565,677	163	62.1%	9,048	1,701.5	[f]
1986	3,873	767	378,923	623,073	161	60.8%	10,987	1,847.1	81.4%
1987	4,182	779	417,830	670,871	160	62.3%	13,130	1,945.4	80.4%
1988	4,355	786	437,649	696,337	160	62.9%	14,633	2,049.4	78.5%
1989	4,442	792	447,480	703,888	158	63.6%	16,347	2,087.4	77.0%
1990	4,724	803	472,236	753,211	159	62.7%	16,411	2,191.3	75.9%
1991	4,661	806	463,296	738,030	158	62.8%	16,149	2,069.2	74.5%
1992	4,856	808	493,163	771,788	159	63.9%	17,143	2,144.2	74.1%
				Average annual percentage change					
1970-92	3.3%	0.8%	6.2%	5.0%	1.6%		5.8%	2.1%	
1982-92	5.6%	0.5%	6.1%	5.4%	0.1%		8.2%	4.3%	

Sources:

U.S. Department of Transportation, Federal Aviation Administration, FAA Statistical Handbook of Aviation, 1992 Edition, Washington, DC, 1994, pp. 5-3, 6-4, 6-7, and annual.

1970-81 Energy Use - Department of Transportation, Civil Aeronautics Board, Fuel Cost and Consumption, Washington, DC, 1981, and annual.

1982-92 Energy Use - Department of Transportation, Research and Special Programs Administration, "Fuel Cost and Consumption Tables," Washington, DC, monthly. Annual totals are derived by summing monthly totals for domestic and international air carriers.

[a]Scheduled services of domestic operations only. The average passenger trip length for international operations is approximately three times longer than for domestic operations.
[b]Available seats per aircraft is calculated as the ratio of available seat-miles to revenue aircraft-miles.
[c]Passenger load factor is calculated as the ratio of revenue passenger-miles to available seat-miles for scheduled and nonscheduled services.
[d]Energy use includes fuel purchased abroad for international flights.
[e]Scheduled services only.
[f]Data are not available.

Table 6.3
Summary Statistics for General Aviation, 1970-92

Calendar year	Percentage of total aircraft: Piston	Turboprop	Turbojet	Rotary wing	Other	Total number of aircraft	Hours flown (thousands)	Intercity passenger travel (billion passenger-miles)	Energy use (trillion btu)
1970	[a]	[a]	[a]	[a]	[a]	131,700[b]	26,030[c]	9.1	94.4
1971	[a]	[a]	[a]	[a]	[a]	131,100[b]	25,512[c]	9.2	91.6
1972	[a]	[a]	[a]	[a]	[a]	145,000[b]	26,974[c]	10.0	103.4
1973	[a]	[a]	[a]	[a]	[a]	148,000[b]	28,599	10.7	90.4
1974	93.9%	1.3%	1.0%	2.2%	1.6%	161,502	29,758	11.2	101.4
1975	93.4%	1.5%	1.1%	2.4%	1.7%	168,475	30,298	11.4	121.5
1976	93.3%	1.4%	1.1%	2.5%	1.8%	177,964	31,950	12.1	130.3
1977	92.7%	1.6%	1.2%	2.6%	2.0%	184,294	33,679	12.8	149.7
1978	92.5%	1.6%	1.2%	2.7%	2.0%	199,178	36,844	14.1	159.4
1979	92.0%	1.7%	1.3%	2.8%	2.3%	210,339	40,432	15.5	167.2
1980	91.5%	1.9%	1.4%	2.8%	2.3%	211,045	41,016	14.7	169.0
1981	90.7%	2.2%	1.5%	3.3%	2.4%	213,226	40,704	14.6	162.4
1982	90.2%	2.5%	1.9%	2.9%	2.5%	209,779	36,457	13.1	170.5
1983	89.8%	2.6%	1.8%	3.1%	2.8%	213,293	35,249	12.7	143.9
1984	89.4%	2.6%	2.0%	3.2%	2.8%	220,943	36,119	13.0	148.9
1985	89.3%	2.6%	2.1%	3.0%	3.0%	210,654	34,063	12.3	144.0
1986	88.9%	2.7%	2.0%	3.2%	3.2%	220,044	34,416	12.4	148.0
1987	89.5%	2.4%	2.0%	2.9%	3.1%	217,183	33,443	12.1	139.1
1988	89.2%	2.5%	2.0%	3.0%	3.3%	210,266	33,593	12.6	148.6
1989	88.2%	2.9%	2.0%	3.4%	3.5%	219,737	35,012	13.1	134.0
1990	88.5%	2.7%	2.1%	3.5%	3.3%	212,211	34,756	13.0	131.9
1991	88.3%	2.5%	2.2%	3.2%	3.8%	198,475	30,067	12.6	120.4
1992	87.9%	2.6%	2.2%	3.1%	4.2%	184,433	26,493	12.2	104.7
					Average Annual Percentage Change				
1970-92						2.0%	0.7%	1.6%	1.2%
1982-92						-0.6%	-2.1%	-0.4%	-3.8%

Sources:

Aircraft and hours flown - U.S. Department of Transportation, Federal Aviation Administration, FAA Statistical Handbook of Aviation, Calendar Year 1992, Washington, DC, 1994, pp. 8-4, 8-6, and annual.

Intercity passenger miles - Eno Foundation for Transportation, Transportation in America, 11th edition, Washington, DC, 1993, p.47.

Energy use - U.S. Department of Transportation, Federal Aviation Administration, General Aviation Activity and Avionics Survey: Calendar Year 1992, Table 5.1, p. 5-7.

[a]Data are not available.
[b]Active fixed-wing general aviation aircraft only.
[c]Include rotocraft.

Section 6.2
Water

Domestic marine traffic includes all movements between points in the United States, Puerto Rico, and the Virgin Islands. All movements between the United States and foreign countries are classified as foreign traffic. Foreign trade has grown from 37.9% of total waterbourne trade in 1970 to 48.6% in 1992. The combined foreign and domestic tonnage in 1992 was just over 2.1 billion tons (Table 6.4).

Ton-miles in domestic waterborne commerce have risen to 857 billion miles in 1992, up from the recent low in 1989 of 816 billion miles. In that same time period, the number of tons shipped declined slightly (Table 6.5).

The commodities most often moved by domestic commerce in 1992 were petroleum and products (39.2%), coal and coke (20.4%), and crude materials (20.4%). The longest average haul for a known product in total domestic commerce in 1992 was manufactured equipment and products, which had an average of 1,189 miles (Table 6.6).

In the early seventies, domestic waterbourne commerce accounted for over 60% of total tonnage, but by 1992 foreign tonnage grew to nearly half of all waterbourne tonnage.

Table 6.4
Tonnage Statistics for Domestic and International Waterborne Commerce, 1970-92
(million tons shipped)

Year	Foreign and domestic total	Foreign total[a]	Domestic total[b]	Percent domestic of total
1970	1,532	581	951	62.1%
1971	1,513	566	947	62.6%
1972	1,617	630	987	61.0%
1973	1,762	767	994	56.4%
1974	1,747	764	983	56.3%
1975	1,695	749	946	55.8%
1976	1,835	856	979	53.4%
1977	1,908	935	973	51.0%
1978	2,021	946	1,075	53.2%
1979	2,073	993	1,080	52.1%
1980	1,999	921	1,077	53.9%
1981	1,942	887	1,054	54.3%
1982	1,777	820	957	53.9%
1983	1,708	751	957	56.0%
1984	1,836	803	1,033	56.3%
1985	1,788	774	1,014	56.7%
1986	1,874	837	1,037	55.3%
1987	1,967	891	1,076	54.7%
1988	2,088	976	1,112	53.3%
1989	2,140	1,038	1,103	51.5%
1990	2,164	1,042	1,122	51.8%
1991	2,092	1,014	1,079	51.6%
1992	2,132	1,037	1,095	51.4%
	Average annual percentage change			
1970-92	1.5%	2.4%	1.4%	
1982-92	1.8%	2.7%	0.6%	

Source:
U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Calendar Years 1991 and 1992, Part 5: National Summaries, New Orleans, Louisiana, 1994, Table 1-1, p. 1-3.

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[a]All movements between the U.S. and foreign countries and between Puerto Rico and Virgin Islands and foreign countries are classified as foreign trade.

[b]All movements between U.S. ports, continental and noncontiguous, and on the inland rivers, canals, and connecting channels of the U.S., Puerto Rico, and the Virgin Islands, excluding the Panama Canal.

Although the number of tons shipped in domestic waterbourne commerce declined slightly from 1990 to 1992, ton-miles increased in this period.

Table 6.5
Summary Statistics for Domestic Waterborne Commerce, 1970-92

Year	Number of vessels[a]	Ton-miles (billions)	Tons shipped[b] (millions)	Average length of haul (miles)	Energy intensity (Btu/ton-mile)	Energy use (trillion Btu)
1970	25,832	596	949	628.2	545	324.8
1971	26,063	593	944	628.1	506	300.0
1972	27,347	604	985	612.8	522	315.1
1973	28,431	585	990	590.7	576	337.0
1974	29,328	586	979	599.1	483	283.3
1975	31,666	566	944	599.9	549	311.0
1976	33,204	592	976	606.3	468	277.3
1977	35,333	599	969	618.0	458	274.3
1978	35,723	827	1,072	771.6	383	316.6
1979	36,264	829	1,076	770.0	457	378.7
1980	38,792	922	1,074	856.4	358	329.8
1981	42,079	929	1,051	884.0	360	334.5
1982	42,079	886	954	929.0	310	274.9
1983	41,784	920	953	964.6	319	293.7
1984	41,784	888	1,029	862.5	346	307.3
1985	41,672	893	1,011	883.5	446	398.6
1986	40,308	873	1,033	845.3	463	404.0
1987	40,000	895	1,072	835.0	402	370.7
1988	39,192	890	1,106	804.3	361	321.3
1989	39,209	816	1,097	743.2	403	328.6
1990	39,233	834	1,118	745.7	388	323.2
1991	39,233	848	1,074	789.9	386	327.5
1992	39,210	857	1,090	785.7	398	341.0
			Average annual percentage change			
1970-92	1.9%	1.7%	0.6%	1.0%	-1.4%	0.2%
1982-92	-0.7%	-0.3%	1.3%	-1.7%	2.5%	2.2%

Sources:

Number of Vessels - U.S. Department of the Army, Corps of Engineers, "Summary of U.S. Flag Passenger and Cargo Vessels, 1992," New Orleans, LA, 1993, and annual.

Ton-miles, tons shipped, average length of haul - U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Calendar Years 1991 and 1992, Part 5: National Summaries, New Orleans, LA, 1994, Table 1-4, pp. 1-6,1-7, and annual.

Energy Use - See Appendix A for Table 2.7.

[a]Grand total for self-propelled and non-self-propelled.

[b]These figures are not consistent with the figures on Table 6.4 because intra-territory tons are not included in this table. Intra-territory is traffic between ports in Puerto Rico and the Virgin Islands.

Sixty percent of all domestic marine cargo in 1992 were energy-related products (petroleum, coal, coke). The majority of the energy-related products were shipped internal and local (61%). Barge traffic accounted for 95% of all internal and local waterborne commerce.

Table 6.6
Breakdown of Domestic Marine Cargo by Commodity Class, 1992

Commodity class	Coastwise		Lakewise		Internal and local		Total domestic		
	Tons shipped (millions)	Average haul[a] (miles)	Tons shipped (millions)	Average haul[a] (miles)	Tons shipped (millions)	Average haul[a] (miles)	Tons shipped (millions)	Percentage	Average haul[a] (miles)
Petroleum and products	223	1,884	2	205	204	195	429	39.2	1,072
Chemicals and related products	14	2,036	[b]	388	56	532	70	6.4	834
Crude materials	13	765	83	524	128	260	223	20.4	387
Coal and coke	13	712	18	550	192	442	223	20.4	466
Primary manufactured goods	5	1,080	3	306	17	700	26	2.3	725
Food and farm products	8	1,994	1	845	96	1,017	105	9.6	1,088
Manufactured equipment &	8	1,581	[b]	-	3	156	11	1.0	1,189
Waste and scrap	[b]	-	[b]	-	6	123	6	0.5	123
Unknown	1	830	[b]	-	[b]	-	1	0.1	767
Total	285	1,763	107	553	702	414	1,095	100.0	782
Barge traffic (million tons)	90.1		6.5		668.7		765.4		
Percentage by barge	31.6%		6.1%		95.3%		69.0%		

Source:
U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Calendar Years 1991 and 1992, Part 5: National Summaries, New Orleans, Louisiana, 1994, Tables 2-2, 2-4, and 2-6, pp. 2-4, 2-5, 2-6, 2-10, 2-11, 2-12, 2-16.

Note:
Coastwise applies to domestic traffic receiving a carriage over the ocean or between the Great Lakes ports and seacoast ports when having a carriage over the ocean.
Lakewise applies to traffic between United States ports on the Great Lakes. Internal applies to traffic between ports or landing wherein the entire movement takes place on inland waterways. Local applies to movements of freight within the confines of a port.

[a]Calculated as ton-miles divided by tons shipped.
[b]Negligible.

Section 6.3
Railroad

Thirteen railroad systems in 1993 were designated by the Interstate Commerce Commission (ICC) as Class I freight railroads (Table 6.7). This designation was assigned on the basis of the annual gross revenue of the railroad. A railroad whose revenues were 253.7 million dollars or more in 1992 was designated as a Class I railroad in 1993. The threshold for 1991 designation was set at 94.4 million dollars, and there were fourteen Class I railroads. The Class I designation is dropped if the railroad fails to meet the annual earnings threshold for three consecutive years. The large increase in the threshold had little effect on the Class I railroads. What it did, however, was keep the larger Class II railroads from moving into the Class I category.

The revenue ton-miles and average length of haul for Class I freight railroads have grown consistently since 1986. In 1993, train-miles rose to over 400 million miles for the first time since 1981. The number of freight cars owned by Class I railroads has been declining since 1980. Shippers are finding it more cost-effective to own their own freight cars, making it less necessary for Class I railroads to keep freight cars on hand (Table 6.8).

The railroad freight industry experienced a 19% drop in its revenue carloadings from 1974 to 1993. During this 19-year period, coal has not only remained the major commodity being hauled by the railroads, but its share of revenue carloads also increased by 17% from 1974 to 1993. Many new miscellaneous items were shipped by rail in 1993, evidenced by the 58% increase in the "other" category (Table 6.9).

Revenue passenger-miles for the National Railroad Passenger Corporation (Amtrak) continued to be more than 6 billion passenger-miles in 1993, despite a decline in 1992 (Table 6.10). The average trip length in 1993 was 280 miles.

Although transit rail vehicle-miles declined slightly in 1992, passenger-miles increased for the first time since 1989. The average trip length for transit rail passengers in 1992 was 4.8 miles. Energy use declined slightly from 1991 to 1992, possibly due to the fewer vehicle-miles and number of transit rail vehicles. (Transit rail data for 1993 are not yet available.)

The Interstate Commerce Commission designates Class I railroads on the basis of annual gross revenues. In 1993, thirteen railroads were given this classification.

Table 6.7
Class I Railroad Freight Systems in the United States
Ranked by Revenue Ton-Miles, 1993

Railroad	Revenue ton-miles (millions)	Percent
Burlington Northern Railroad Company	237,339	21.4%
Union Pacific Railroad	220,697	19.9%
CSX Transportation, Incorporation	145,100	13.1%
Norfolk Southern Corporation	111,640	10.1%
Southern Pacific Transportation Company	101,119	9.1%
Atchison, Topeka and Santa Fe Railway	93,114	8.4%
Consolidated Rail Corporation (Conrail)	86,953	7.8%
Chicago and North Western Transportation Company	32,791	3.0%
Soo Line Railroad	22,965	2.1%
Illinois Central Railroad	20,333	1.8%
Denver and Rio Grande Western Railroad	17,398	1.6%
Kansas City Southern Railway	13,688	1.2%
Grand Trunk Corporation	6,171	0.6%
Total	**1,109,309**	**100.0%**

Source:
Association of American Railroads, Analysis of Class I Railroads 1993, 1994, p. 95.

Table 6.8
Summary Statistics for Class I Freight Railroads, 1970-93

Year	Number of locomotives in service[a]	Number of freight cars (thousands)[b]	Train-miles (milions)	Car-miles (millions)	Revenue tons (millions)	Average length of haul (miles)	Revenue ton-miles (millions)	Energy intensity (Btu/ton-mile)	Energy use (trillion Btu)
1970	27,077[c]	1,424	427	29,890	2,616	515	764,809	655	500.6
1971	27,160[c]	1,422	430	29,181	2,458	507	739,723	697	515.6
1972	27,044	1,411	451	30,309	2,543	511	776,746	706	548.2
1973	27,438	1,395	469	31,248	2,701	531	851,809	662	563.9
1974	27,627	1,375	469	30,719	2,732	527	850,961	665	565.9
1975	27,855	1,359	403	27,656	2,437	541	754,252	682	514.5
1976	27,233	1,332	425	28,530	2,452	540	794,059	677	537.6
1977	27,298	1,287	428	28,749	2,439	549	826,292	667	551.4
1978	26,959	1,226	433	29,076	2,312	617	858,105	637	546.7
1979	27,660	1,217	438	29,436	2,463	611	913,669	616	562.6
1980	28,094	1,168	428	29,277	2,434	616	918,621	592	544.1
1981	27,421	1,111	408	27,968	2,386	626	910,169	571	519.7
1982	26,795	1,039	345	23,952	1,990	629	797,759	547	436.5
1983	25,448	1,007	346	24,358	1,936	641	828,275	521	431.6
1984	24,117	948	369	26,409	2,119	645	921,542	508	468.5
1985	22,548	867	347	24,920	1,985	664	876,984	487	426.9
1986	20,790	799	347	24,414	1,938	664	867,722	474	411.5
1987	19,647	749	361	25,627	1,926	688	943,747	443	417.9
1988	19,364	725	379	26,339	2,001	697	996,182	434	432.3
1989	19,015	682	383	26,196	1,988	723	1,013,841	427	432.9
1990	18,835	659	380	26,159	2,024	726	1,033,969	411	425.2
1991	18,344	633	375	25,628	1,987	751	1,038,875	384	399.3
1992	18,004	605	390	26,128	2,016	763	1,066,781	399	425.4
1993	18,161	587	405	26,883	2,047	794	1,109,309	344	381.6
				Average annual percentage change					
1970-93	-1.7%	-3.8%	-0.2%	-0.5%	-1.1%	1.9%	1.6%	-2.8%	-1.2%
1983-93	-3.3%	-5.3%	1.6%	1.0%	0.6%	2.2%	3.0%	-4.1%	-1.2%

Sources:
Association of American Railroads, Railroad Facts, 1994 Edition, Washington, DC, September 1994, pp. 27, 33, 34, 36, 48, 50.
Revenue tons - Association of American Railroads, Analysis of Class I Railroads 1993, 1994, p. 31, and annual.
Energy use - See Appendix A for Table 2.7.

[a]Does not include self-powered units. From 1972-79, the number of locomotives used in Amtrak passenger operations are subtracted from the total locomotives used in passenger and freight service to calculate the number of Class I locomotives in service.
[b]Does not include private or shipper-owned cars.
[c]Data represent total locomotives used in freight and passenger service. Separate estimates are not available.

Although revenue carloadings declined by 19% from 1974 to 1993, coal is still the commodity with the highest share of carloadings.

Table 6.9
Railroad Revenue Carloadings by Commodity Group, 1974 and 1993

Commodity group	Carloadings (thousands) 1974	Carloadings (thousands) 1993	1993 Percent distribution	Percentage change 1974-93
Coal	4,544	5,310	24.5	16.9
Farm products	3,021	1,636	7.5	-45.8
Chemicals and allied products	1,464	1,631	7.5	11.4
Nonmetallic minerals	821	1,044	4.8	27.2
Food and kindred products	1,777	1,380	6.4	-22.3
Lumber and wood products	1,930	710	3.3	-63.2
Metallic ores	1,910	443	2.0	-76.8
Stone, clay and glass	2,428	487	2.2	-79.9
Pulp, paper, and allied products	1,180	620	2.9	-47.5
Petroleum products	877	559	2.6	-36.3
Primary metal products	1,366	566	2.6	-58.6
Waste and scrap material	889	558	2.6	-37.2
Transportation equipment	1,126	1,287	5.9	14.3
Others	3,451	5,451	25.1	58.0
Total	26,784	21,683	100.0	-19.0

Sources:
1974 - Association of American Railroads, Railroad Facts, 1976 Edition, Washington, DC, 1975, p. 26.
1993 - Association of American Railroads, Railroad Facts, 1994 Edition, Washington, DC, September 1994, p. 25.

Table 6.10
Summary Statistics for the National Railroad Passenger Corporation (Amtrak), 1971-93

Year	Number of locomotives in service	Number of passenger cars	Train-miles (thousands)	Car-miles (thousands)	Revenue passenger-miles (millions)	Average trip length (miles)	Energy intensity (Btu per revenue passenger mile)	Energy use (trillion Btu)
1971	[a]	1,165	16,537	140,147	1,993	188	[a]	[a]
1972	285	1,571	26,302	213,261	3,039	183	[a]	[a]
1973	352	1,777	27,151	239,775	3,807	224	3,756	14.3
1974	457	1,848	29,538	260,060	4,259	233	3,240	13.8
1975	355	1,913	30,166	253,898	3,753	224	3,677	13.8
1976	379	2,062	30,885	263,589	4,268	229	3,397	14.5
1977	369	2,154	33,200	261,325	4,204	221	3,568	15.0
1978	441	2,084	32,451	255,214	4,154	217	3,683	15.3
1979	437	2,026	31,379	255,129	4,867	226	3,472	16.9
1980	448	2,128	29,487	235,235	4,503	217	3,176	14.3
1981	398	1,830	30,380	222,753	4,397	226	2,979	13.1
1982	396	1,929	28,833	217,385	3,993	220	3,156	12.6
1983	388	1,880	28,805	223,509	4,227	223	2,957	12.5
1984	387	1,844	29,133	234,557	4,427	227	3,027	13.4
1985	382	1,818	30,038	250,642	4,785	238	2,800	13.4
1986	369	1,793	28,604	249,665	5,011	249	2,574	12.9
1987	381	1,850	29,515	261,054	5,361	259	2,537	13.6
1988	391	1,845	30,221	277,774	5,686	265	2,462	14.0
1989	312	1,742	31,000	285,255	5,859	274	2,731	16.0
1990	318	1,863	33,000	300,996	6,057	273	2,609	15.8
1991	316	1,786	34,000	312,484	6,273	285	2,503	15.7
1992	336	1,796	34,000	307,282	6,091	286	2,610	15.9
1993	360	1,853	35,000	302,739	6,199	280	2,646	16.4
				Average annual percentage change				
1971-93	1.8% [b]	2.3%	3.5%	3.6%	5.2%	2.0%	-1.9% [c]	0.6% [c]
1983-93	-0.7%	-0.1%	2.0%	3.1%	3.9%	2.3%	-1.1%	2.8%

Sources:
1971-83 - Association of American Railroads, Economics and Finance Department, Statistics of Class I Railroads, Washington, DC, and annual.
1984-88 - Association of American Railroads, Railroad Facts, 1988 Edition, Washington, DC, December 1989, p. 61, and annual.
1989-93- Personal communication with the Corporate Accounting Office of Amtrak, Washington, D.C.
Energy use - 1971-84: Association of American Railroads, Railroad Facts, 1984 Edition, Washington, DC, 1984, and annual.
1985-93 Personal communication with the Corporate Accounting Office of Amtrak, Washington, DC.

[a] Data are not available.
[b] Average annual percentage change is for years 1972-93.
[c] Average annual percentage change is for years 1973-93.

Table 6.11
Summary Statistics for Rail Transit Operations, 1970-93[a]

Year	Number of passenger vehicles	Vehicle-miles (millions)	Passenger trips (millions) [b]	Estimated passenger-miles (millions) [c]	Average trip length (miles) [d]	Energy intensity (Btu/passenger-mile) [e]	Energy use (trillion Btu)
1970	10,548	440.8	2,116	12,273	[f]	2,453	30.1
1971	10,550	440.4	2,000	11,600	[f]	2,595	30.1
1972	10,599	417.8	1,942	11,264	[f]	2,540	28.6
1973	10,510	438.5	1,921	11,142	[f]	2,460	27.4
1974	10,471	458.8	1,876	10,881	[f]	2,840	30.9
1975	10,617	446.9	1,797	10,423	[f]	2,962	31.1
1976	10,625	428.1	1,744	10,115	[f]	2,971	30.3
1977	10,579	381.7	1,713	10,071	5.8	2,691	27.1
1978	10,459	383.0	1,810	10,722	5.9	2,210	23.7
1979	10,429	399.6	1,884	11,167	5.9	2,794	31.2
1980	10,654	402.2	2,241	10,939	4.9	3,008	32.9
1981	10,824	436.6	2,217	10,590	4.8	2,946	31.2
1982	10,831	445.2	2,201	10,428	4.6	3,069	32.0
1983	10,904	423.5	2,304	10,741	4.7	3,212	34.5
1984	10,848	452.7	2,388	10,531	4.4	3,732	39.3
1985	11,109	467.8	2,422	10,777	4.4	3,461	37.3
1986	11,083	492.8	2,467	11,018	4.5	3,531	38.9
1987	10,934	508.6	2,535	11,603	4.6	3,534	41.0
1988	11,370	538.3	2,462	11,836	4.8	3,565	42.2
1989	11,261	553.4	2,704	12,539	4.6	3,397	42.6
1990	11,332	560.9	2,521	12,046	4.8	3,453	41.6
1991	11,426	554.8	2,356	11,190	4.7	3,727	41.7
1992	11,303	554.1	2,396	11,441	4.8	3,575	40.9
1993	11,286	553.4	2,397	11,445	4.8	3,687	42.2
				Average annual percentage change			
1970-93	0.3%	1.0%	0.5%	-0.3%	-1.2% [g]	1.8%	1.5%
1983-93	0.3%	2.7%	0.4%	0.6%	0.2%	1.4%	2.0%

Sources:
American Public Transit Association, 1994-5 Transit Fact Book, Washington, DC, February 1995, pp. 28-31.
Energy use - See Appendix A for Table 2.7.

[a]Series not continuous between 1983 and 1984 because of a change in data source by the American Public Transit Association (APTA). Beginning in 1984, data provided by APTA are taken from mandatory reports filed with the Urban Mass Transit Administration (UMTA). Data for prior years were provided on a voluntary basis by APTA members and expanded statistically.
[b]1970-79 data represents total pasenger rides; after 1979, data represents unlinked pasenger trips.
[c]Estimated for years 1970-76 based on an average trip length of 5.8 miles.
[d]Calculated as the ratio of passenger miles to passenger trips.
[e]Large system-to-system variations exist within this category.
[f]Data are not available.
[g]Average annual percentage change is calculated for years 1977-92.

CHAPTER 7

EMISSIONS AND TRANSPORTATION

The combustion of fossil fuel in transportation vehicles contributes significantly to air pollution. In 1993 the transportation sector was responsible for 77% of carbon monoxide (CO) emissions and over 35% of nitrogen oxide (NO_x), lead, and volatile organic compound (VOC) emissions (Table 7.1). Highway vehicles, which are responsible for the majority of transportation CO emissions, have reduced their emissions by 32% from 1970 to 1993 (Table 7.2), despite a 107% increase in vehicle travel in that time period. Some of the emission reduction can be attributed to the Federal Motor Vehicle Control Program. This program has resulted in the widespread use of catalytic converters on automobiles to reduce not only CO emissions but also NO_x and VOC emissions.

Transportation and stationary fuel combustion account for the majority of NO_x emissions (Table 7.3). Light-duty gasoline-powered vehicles and heavy-duty diesel-powered vehicles were responsible for over half of the transportation sector's NO_x emissions in 1993 (Table 7.4). Transportation does not play a major role in the emissions of particulate matter (Table 7.6) or sulfur dioxide.

National lead emissions have declined by 98% from 1940 to 1993, mostly due to the 99% decline in transportation lead emissions (Table 7.7). This is mainly due to the fact that almost all highway vehicles are now made to use unleaded gasoline (another result of the Federal Motor Vehicle Control Program).

The estimated U.S. emissions of greenhouse gases in 1992 are presented in Table 7.8. Greenhouse gases block the outward flow of radiation more effectively than they block incoming solar radiation, causing the earth to be warmer than it would otherwise be. More than half of the carbon dioxide (CO_2) emitted from transportation sources in the U.S. comes from motor gasoline (Table 7.10).

In order to reduce the amount of emissions from mobile sources, the government has imposed standards for hydrocarbons, carbon monoxide, nitrogen oxide and particulate emissions. The Clean Air Act Amendments of 1990 set stricter standards nationwide beginning in 1994 (Tables 7.14-7.16). The California Air Resources Board developed a plan for their state to meet the tougher emission standards (Table 7.18). A discussion of ozone nonattainment areas concludes this chapter.

Table 7.1
Total National Emissions by Sector, 1993
(millions of short tons)

Sector	CO	NO_x	VOC	PM-10	SO_2	Lead[a]
Transportation						
Highway vehicles	59.99	7.44	6.09	0.20	0.44	1.38
	61.7%	31.8%	26.1%	0.4%	2.0%	28.2%
Aircraft	1.02	0.15	0.20	0.05	0.01	[b]
	1.0%	0.6%	0.9%	0.1%	0.0%	[b]
Railroads	0.12	0.95	0.04	0.05	0.07	[b]
	0.1%	4.1%	0.2%	0.1%	0.3%	[b]
Vessels	0.06	0.18	0.04	0.03	0.2	[b]
	0.1%	0.8%	0.2%	0.1%	0.9%	[b]
Other off-highway	12.88	2.04	1.91	0.27	0	0.21[c]
	13.2%	8.7%	8.2%	0.6%	0.0%	4.3%
Transportation total	**75.26**	**10.42**	**8.30**	**0.59**	**0.72**	**1.59**
	77.4%	**44.5%**	**35.6%**	**1.3%**	**3.3%**	**32.5%**
Stationary source fuel combustion	5.43	11.69	0.65	1.21	19.27	0.5
	5.5%	50.0%	2.8%	2.7%	88.0%	10.2%
Industrial processes	5.28	0.91	11.20	0.61	1.86	2.28
	5.4%	3.9%	48.0%	1.3%	8.5%	46.6%
Waste disposal and recycling total	1.73	0.08	2.27	0.25	0.04	0.52
	1.8%	0.3%	9.7%	0.5%	0.2%	10.6%
Miscellaneous	9.51	0.30	0.89	42.20	0.01	0.00
	9.8%	1.3%	3.8%	92.8%	0.0%	0.0%
Total of all sources	**97.21**	**23.40**	**23.31**	**45.49**	**21.89**	**4.89**
	100.0%	**100.0%**	**100.0%**	**100.0%**	**100.0%**	**100.0%**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, Appendix A.

Note: CO = Carbon monoxide. NO_x =Nitrogen oxides. PM-10 = Particulate matter. SO_2 = Sulfur dioxide. VOC = Volatile organic compounds.

[a]Thousands of short tons.
[b]Data are not available.
[c]Includes all off-highway and nonhighway vehicles.

Table 7.2
Total National Emissions of Carbon Monoxide, 1940-93[a]
(million short tons)

Source category	1940	1950	1960	1970	1980	1990[b]	1992[b]	1993[b]
Transportation								
Highway vehicles	27.37	41.37	58.30	88.03	78.05	62.86	59.86	59.99
Aircraft	0.00	0.93	1.76	0.51	0.74	0.97	0.98	1.02
Railroads	4.08	3.08	0.33	0.07	0.10	0.12	0.12	0.12
Vessels[c]	0.06	0.12	0.52	0.98	1.10	1.21	1.23	1.25
Other off-highway	3.90	7.48	8.96	9.06	10.74	12.35	12.57	12.88
Transportation total	35.41	52.98	69.87	98.64	90.73	77.5	74.76	75.26
Stationary fuel combustion total	15.33	11.32	7.02	4.63	7.30	6.72	6.02	5.43
Industrial processes total	7.28	11.64	10.28	9.84	6.95	5.23	5.19	5.28
Waste disposal and recycling total	3.63	4.72	5.60	7.06	2.30	1.69	1.72	1.73
Miscellaneous total	29.21	18.14	11.01	7.91	8.34	12.62	8.68	9.51
Total of all sources	**90.87**	**98.79**	**103.78**	**128.08**	**115.63**	**103.75**	**96.37**	**97.21**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, p. 3-11.

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

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

Table 7.3
Total National Emissions of Nitrogen Oxides, 1940-93[a]
(million short tons)

Source category	1940	1950	1960	1970	1980	1990[b]	1992[b]	1993[b]
Transportation								
Highway vehicles	1.52	2.45	4.42	7.39	8.62	7.49	7.44	7.44
Railroads	0.66	0.99	0.77	0.50	0.73	0.93	0.95	0.95
Other off-highway	0.33	0.55	0.67	1.13	1.69	1.91	1.94	2.04
Transportation total	2.51	3.99	5.87	9.02	11.04	10.33	10.33	10.42
Stationary fuel combustion total	3.73	5.16	7.37	10.06	11.31	11.50	11.41	11.69
Industrial processes total	0.22	0.38	0.57	0.88	0.66	0.89	0.90	0.91
Waste disposal and recycling total	0.11	0.22	0.33	0.44	0.11	0.08	0.08	0.08
Miscellaneous total	0.99	0.67	0.44	0.33	0.25	0.38	0.27	0.30
Total of all sources	**7.57**	**10.40**	**14.58**	**20.63**	**23.28**	**23.19**	**22.99**	**23.40**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, p. 3-12.

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

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

Table 7.4
Emissions of Nitrogen Oxides from Highway Vehicles, 1970-93[a]
(million short tons)

Source category	1970	1980	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Gasoline powered												
Light-duty vehicles & motorcycles	4.16	4.42	3.99	3.81	3.60	3.50	3.50	3.49	3.44	3.46	3.61	3.69
Light-duty trucks[b]	1.28	1.41	1.58	1.53	1.45	1.44	1.42	1.39	1.34	1.34	1.36	1.39
Heavy-duty vehicles	0.28	0.30	0.33	0.33	0.33	0.33	0.34	0.34	0.34	0.33	0.31	0.30
Total	5.72	6.13	5.90	5.67	5.38	5.27	5.26	5.22	5.12	5.13	5.28	5.38
Diesel powered												
Light-duty vehicles	[c]	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04
Light-duty trucks[b]	[c]	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Heavy-duty vehicles	1.68	2.46	2.45	2.39	2.35	2.35	2.37	2.42	2.33	2.20	2.12	2.01
Total	1.68	2.50	2.49	2.43	2.39	2.39	3.41	2.47	2.38	2.25	2.17	2.06
Total												
Highway vehicle total	**7.39**	**8.62**	**8.39**	**8.09**	**7.77**	**7.66**	**7.66**	**7.68**	**7.49**	**7.37**	**7.44**	**7.44**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, p. A-8.

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

Table 7.5
Total National Emissions of Volatile Organic Compounds, 1940-93[a]
(million short tons)

Source category	1940	1950	1960	1970	1980	1990[b]	1992[b]	1993[b]
Transportation								
Highway vehicles	4.77	7.17	10. 37	13.97	8.98	6.85	6.07	6.09
Off-highway	0.78	1.21	1.22	1.54	1.87	2.12	2.16	2.21
Transportation total	5.55	8.39	11.59	15.51	10.85	8.97	8.23	8.30
Stationary fuel combustion total	1.98	1.44	0.88	0.72	1.05	0.74	0.69	0.65
Industrial processes total	4.52	7.40	8.73	12.33	12.10	10.98	11.05	11.20
Waste disposal and recycling total	0.99	1.10	1.55	1.98	0.76	2.26	2.27	2.27
Miscellaneous total	4.08	2.53	1.57	1.10	1.13	1.32	0.78	0.89
Total of all sources	**17.12**	**20.86**	**24.32**	**30.65**	**25.89**	**24.28**	**23.02**	**23.31**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, p. 3-13.

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

[a]The sums 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.
[b]Preliminary.

Table 7.6
Total National Emissions of Particulate Matter (PM-10), 1940-93[a]
(million short tons)

Source category	1940	1950	1960	1970	1980	1990[b]	1992[b]	1993
Transportation								
Highway vehicles	0.21	0.31	0.55	0.24	0.28	0.24	0.21	0.20
Off-highway	2.48	1.79	0.20	0.22	0.33	0.37	0.38	0.40
Transportation total	2.69	2.10	0.76	0.46	0.60	0.61	0.59	0.59
Stationary fuel combustion total	4.01	3.75	3.56	2.87	2.45	1.45	1.30	1.21
Industrial processes total	4.90	8.85	8.85	7.67	2.75	0.60	0.60	0.61
Waste disposal and recycling total	0.39	0.51	0.76	1.00	0.27	0.24	0.25	0.25
Miscellaneous total	2.97	1.93	1.24	0.84	0.85	42.06[c]	41.25[c]	42.20[c]
Total of all sources	**15.96**	**17.13**	**15.56**	**12.84**	**6.93**	**49.16**	**48.63**	**45.49**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, p. 3-15.

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

[a]The sums of subcategories may not equal total due to rounding.
[b]Preliminary.
[c]Includes fugitive dust estimates which were not available before 1990.

Table 7.7
National Lead Emission Estimates, 1970-93
(thousand short tons per year)

Source category	1970	1975	1980	1985	1990	1992	1993
Transportation							
Highway vehicles	171.96	130.21	62.19	15.98	1.69	1.45	1.38
Off-highway	8.34	5.01	3.32	0.23	0.20	0.19	0.21
Transportation total	180.30	135.22	65.51	16.21	1.89	1.65	1.59
Stationary source fuel combustion	10.62	10.35	4.30	0.52	0.50	0.49	0.50
Industrial processes	26.35	11.38	3.94	2.53	2.44	2.19	2.28
Waste disposal and recycling total	2.20	1.60	1.21	0.87	0.80	0.42	0.52
Total of all sources	**219.47**	**158.54**	**74.96**	**20.12**	**5.64**	**4.74**	**4.89**

Source:
U. S. Environmental Protection Agency, National Air Pollutant Emission Estimates, 1900-1993, 1994, p. 3-16.

Table 7.8
Estimated U.S. Emissions of Greenhouse Gases, 1992

Greenhouse gas	Unit of measure[a]	
Carbon dioxide	million metric tons of gas	5,069.3
	million metric tons of carbon	1,383.0
Methane	million metric tons of gas	27.2
	million metric tons of carbon (gwp)[b]	163.0
Nitrous oxide	million metric tons of gas	0.4
	million metric tons of carbon (gwp)[b]	32.0
Carbon monoxide	million metric tons of gas	79.0
Nitrogen oxide	million metric tons of gas	21.0
Nonmethane VOCs[c]	million metric tons of gas	20.6
CFC-11,12,113[c]	million metric tons of gas	0.2
HCFC-22[c]	million metric tons of gas	0.1
HCFC-23 and PFCs[c]	million metric tons of gas	0.007
	million metric tons of carbon (gwp)[b]	19.0
Methyl Chloroform	million metric tons of gas	0.2

Source:
U.S. Department of Energy, Energy Information Administration, Emissions of Greenhouse Gases in the United States, 1987-1992, Washington, DC, November 1994, pp. ix, xi.

Table 7.9
U.S. Carbon Dioxide Emissions from Fossil Energy Consumption by End-Use Sector, 1985-93[d]
(million metric tons of carbon)

End use	1987	1988	1989	1990	1991	1992	1993[e]
Energy consumption sectors							
Residential	251.0	264.9	267.5	253.1	257.2	255.9	270.1
Commercial	197.2	207.6	210.0	206.7	206.4	205.5	212.1
Industrial	422.8	444.2	445.7	452.5	436.8	454.1	456.2
Transportation	412.4	428.7	433.7	433.2	425.5	432.3	437.1
Total energy	**1,283.4**	**1,345.4**	**1,356.9**	**1,345.5**	**1,325.9**	**1,347.8**	**1,375.5**
Electric utility sector							
Electric utility	452.6	475.9	483.5	476.9	473.5	472.9	489.1

Source:
U.S. Department of Energy, Energy Information Administration, Emissions of Greenhouse Gases in the United States, 1987-1992, Washington, DC, November 1994, p. 12.

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[a]Gases 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 for details.

[b]Based on global warming potential.

[c]VOC=volatile organic compounds. CFC=chlorofluorocarbons. HCFC=hydrochlorofluorocarbons. HFC=hydrofluorocarbons. PFC=perfluorocarbons.

[d]Includes energy from petroleum, coal, and natural gas. Electric utility emissions are distributed across consumption sectors.

[e]Preliminary.

Table 7.10
U.S. Carbon Dioxide Emissions from Energy Use in the Transportation Sector, 1980-93
(million metric tons of carbon)

Fuel	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993[a]
								Petroleum						
Motor Gasoline	238.1	238.1	236.6	239.9	242.1	245.6	253.2	259.4	265.2	264.2	260.9	259.5	263.2	267.6
LPG[b]	0.3	0.6	0.5	0.7	0.7	0.5	0.4	0.4	0.4	0.4	0.4	0.3	0.3	0.3
Jet Fuel	42.0	39.7	40.4	41.8	47.2	48.8	52.4	55.6	58.3	59.8	61.2	59.1	58.7	59.2
Distillate Fuel	55.3	57.4	55.1	57.4	62.1	63.3	65.3	66.9	72.9	75.8	75.7	72.6	75.3	76.5
Residual Fuel	30.0	26.1	21.7	17.5	17.2	16.7	18.5	19.2	19.6	20.8	21.9	22.0	23.0	21.4
Lubricants	1.8	1.7	1.5	1.6	1.7	1.6	1.5	1.7	1.7	1.7	1.8	1.6	1.6	1.6
Aviation Gas	1.2	1.1	0.9	0.9	0.8	0.9	1.1	0.9	0.9	0.9	0.8	0.8	0.8	0.7
Total	**368.7**	**364.6**	**356.7**	**359.7**	**371.7**	**377.4**	**392.4**	**404.0**	**418.8**	**423.6**	**422.6**	**415.9**	**422.8**	**427.4**
								Other energy						
Natural Gas	9.4	9.5	8.8	7.3	7.8	7.5	7.2	7.7	9.1	9.4	9.8	8.9	8.8	9.0
Electricity	0.3	0.3	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
Total	**378.4**	**374.4**	**366.2**	**367.5**	**380.2**	**385.6**	**400.4**	**412.4**	**428.7**	**433.7**	**433.2**	**425.5**	**432.3**	**437.1**

Source:
U.S. Department of Energy, Energy Information Administration, Emissions of Greenhouse Gases in the United States, 1987-1992, Washington, DC, November 1994, p. 102.

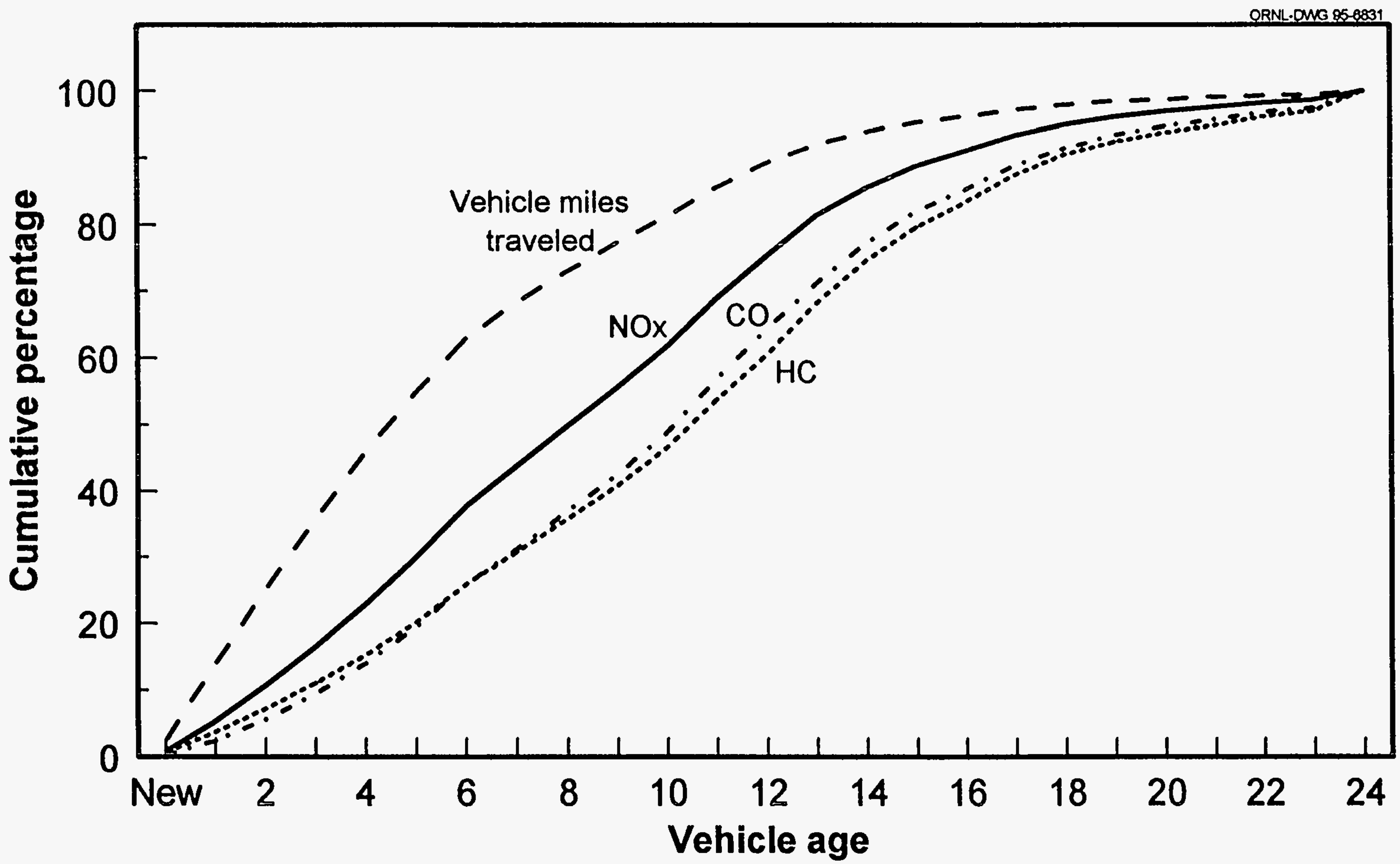
[a]Preliminary.
[b]Liquified petroleum gas.

Table 7.11
Urban Emissions from Light-Duty Vehicles by Age of Vehicle, 1993

Vehicle Age	Nitrogen oxides			Hydrocarbons			Carbon monoxide			Vehicle miles traveled	
	Thousand tons	Percentage	Cumulative percentage	Thousand tons	Percentage	Cumulative percentage	Thousand tons	Percentage	Cumulative percentage	Percentage	Cumulative percentage
New	4.202	0.86%	0.86%	4.964	0.61%	0.61%	21.316	0.32%	0.32%	2.50%	2.50%
1	22.012	4.52%	5.38%	25.299	3.11%	3.72%	142.568	2.13%	2.45%	11.45%	13.96%
2	25.979	5.34%	10.72%	29.086	3.57%	7.29%	210.873	3.15%	0.056	11.27%	25.22%
3	28.349	5.82%	16.54%	31.032	3.81%	11.10%	260.005	3.89%	9.49%	10.56%	35.78%
4	31.413	6.45%	22.99%	33.923	4.17%	15.27%	305.515	4.57%	14.06%	10.19%	45.97%
5	34.455	7.08%	30.07%	40.665	4.99%	20.26%	368.261	5.51%	19.57%	8.95%	54.93%
6	37.367	7.67%	37.74%	46.403	5.70%	25.96%	422.732	6.32%	25.89%	7.94%	62.86%
7	29.781	6.12%	43.86%	39.522	4.85%	30.81%	363.820	5.44%	31.33%	5.45%	68.31%
8	29.495	6.06%	49.92%	40.920	5.03%	35.84%	381.732	5.71%	37.04%	4.70%	73.01%
9	28.304	5.81%	55.73%	41.101	5.05%	40.89%	372.633	5.57%	42.62%	4.28%	77.27%
10	29.456	6.05%	61.78%	46.261	5.68%	46.57%	422.491	6.32%	48.93%	3.91%	81.18%
11	34.913	7.17%	68.95%	59.280	7.28%	53.85%	535.991	8.02%	56.95%	4.38%	85.57%
12	30.975	6.36%	75.31%	54.905	6.74%	60.59%	501.493	7.50%	64.45%	3.71%	89.27%
13	29.742	6.11%	81.42%	62.589	7.69%	68.28%	452.738	6.77%	71.22%	2.80%	92.07%
14	19.999	4.11%	85.53%	51.418	6.31%	74.59%	397.766	5.95%	77.17%	1.86%	93.93%
15	16.207	3.33%	88.85%	41.055	5.04%	79.63%	323.728	4.84%	82.01%	1.40%	95.33%
16	10.885	2.24%	91.09%	30.285	3.72%	83.35%	217.090	3.25%	85.26%	0.93%	96.26%
17	11.132	2.29%	93.38%	33.713	4.14%	87.49%	241.146	3.61%	88.86%	0.99%	97.25%
18	7.937	1.63%	95.01%	24.447	3.00%	90.50%	173.085	2.59%	91.45%	0.70%	97.95%
19	5.572	1.14%	96.15%	15.523	1.91%	92.40%	129.604	1.94%	93.39%	0.50%	98.46%
20	3.841	0.79%	96.94%	10.805	1.33%	93.73%	87.565	1.31%	94.70%	0.34%	98.79%
21	3.391	0.70%	97.64%	8.942	1.10%	94.83%	70.172	1.05%	95.75%	0.27%	99.07%
22	2.862	0.59%	98.22%	10.528	1.29%	96.12%	66.787	1.00%	96.75%	0.23%	99.30%
23	1.949	0.40%	98.62%	7.012	0.86%	96.98%	46.246	0.69%	97.44%	0.16%	99.45%
24	6.704	1.38%	100.00%	24.582	3.02%	100.00%	171.129	2.56%	100.00%	0.55%	100.00%
Total	**486.921**	**100.00%**		**814.257**	**100.00%**		**6,686.484**	**100.00%**		**100.00%**	

Source:
Maples, John D., Memorandum "Urban Emissions from Light-Duty Vehicles," Crofton, MD, April 1993. For detailed methodology, see Appendix A, Table 7.11.

Figure 7.1. Urban Emissions from Light-Duty Vehicles by Age of Vehicle, 1993



Source: See Table 7.11.

Table 7.12
CO_2-Equivalent Emissions of Light-Duty Internal Combustion-Engine Vehicles[a]
(grams/mile)

			Methanol from				
Source or Fuel-Cycle Stage	Reform. Gas	Std. Gas	NG[b]	Coal[c]	Diesel[d]	LPG from NG and Oil[e]	Ethanol from wood
Vehicle end use	333.7	344.5	277.4	277.4	325.0	283.6	51.0
Compression/liquefaction	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuel distribution	5.9	5.9	29.2	15.2	5.6	6.8	14.1
Fuel production	68.2[f]	51.2	84.0	401.5	23.7	12.4	-63.1
Feedstock transport	10.6	11.1	9.5	1.5	10.6	3.9	13.9
Feedstock recovery	11.8	12.4	17.6	9.2	11.8	8.1	60.7
CH_4 leaks/flares	5.1	5.4	11.3	37.3	5.1	5.7	0.0
First total	435.3	430.4	428.9	742.1	381.8	320.5	76.6
Change (%)[g]	n/a	-1.1	-1.5	70.4	-12.4	-26.4	-82.4
Car assembly	14.0	14.0	14.0	14.0	10.5[h]	14.3	14.0
Materials in cars	41.9	41.9	41.9	41.9	31.6[h]	42.8	41.9
Second total	491.2	486.3	484.8	798.0	423.9	377.6	132.5
Change (%)[g]	n/a	-1.0	-1.3	59.3	-13.7	-23.1	-73.0

Source:
DeLuchi, M. A., "Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity: Volume 1," ANL/ESD/TM-22, Center for Transportation Research, Argonne National Laboratory, 1991, pp. 57-59.

Note: CH_4=methane. NG=natural gas. LPG=liquefied petroleum gas.
See footnotes on following page.

Footnotes for Table 7.12 - CO_2-Equivalent Emissions of Light-Duty Combustion-Engine Vehicles (ICEVs).

[a]Percentage changes for light-duty vehicles (LDVs) are relative to base-case reformulated-gasoline LDVs, and percentage changes for heavy-duty vehicles (HDVs) are relative to base-case diesel HDVs. The base-case LDV in combined city/highway driving gets 30 miles per gallon (mpg) on reformulated gasoline and 30.7 mpg on standard gasoline, because of the higher density (in Btu/gal) of standard gasoline. The base-case grams/mile results for gasoline and diesel fuel for all the time horizons are:

Fuel	20-Year	100-Year (this table)	500-year
Reformulated gasoline (30 mpg, city/highway)	636.6	491.2	449.2
Diesel (6 mpg)	3,819.3	2,627.1	2,331.4

[b]100% methanol, all from remote natural gas (NG) in this base case.
[c]100% methanol, all from coal.
[d]Assumes that a diesel LDV gets 39 mpg (27% better than a comparable vehicle on standard gasoline and 30% better than a comparable vehicle on reformulated gasoline), weighs 100 lb more than a comparable gasoline vehicle, lasts 150,000 (as opposed to 108,000 miles for the gasoline vehicle), and emits non-CO_2 greenhouse gases
[e]61.4% of the liquefied petroleum gas (LPG) comes from natural gas liquids (NGL) plants and 38.6% comes from petroleum refineries.
[f]Includes emissions from the production and delivery of methanol and ethanol used to make MTBE.
[g]To make an internally consistent scenario, methanol from coal is compared with reformulated gasoline that contains methyl tertiary butyl ether (MTBE) made from coal-derived methanol. The first total for this reformulated gasoline is 445.0 g/mi; the second total is 500.9 g/mi, and the LDV + HDV total is 628.4 g/mi. These totals are higher than the totals (shown above) for reformulated gasoline that contains NG-derived MTBE. The liquified natural gas (LNG) vehicle and the diesel LDV are compared with the baseline gasoline vehicle using NG-derived MTBE.
[h]Low values are due to the long life of the diesel vehicle.

Table 7.13
CO_2-Equivalent Emissions of Battery Powered Light-Duty Electric Vehicles by Source of Electricity[a]
(grams/mile)

Source or Fuel-Cycle Stage	U.S. National ("Marginal") Power Mix[b]	Coal-Fired Plants Only	Natural Gas-Fired Plants Only	Nuclear Power Plants Only	Solar Power Plants Only
Vehicle end use	0.0	0.0	0.0	0.0	0.0
Fuel Distribution	7.6[c]	0.0	21.1[d]	0.0	0.0
Fuel Production[e]	402.8	502.7	288.5	27.6	1.3[f]
Feedstock Transport	6.7	8.6	0.0	0.0	0.0
Feedstock Recovery	8.6	6.6	8.5	1.3	0.0
CH_4 leaks/flares	19.9	27.7	16.3	0.0	0.0
First total	445.6	545.6	334.4	29.0	1.3
Change (%)	-14.5	4.7	-35.8	-94.4	-99.7
Car assembly	14.4	14.4	14.4	14.4	14.4
Materials in cars[g]	46.6	46.6	46.6	46.6	46.6
Second total	506.6	606.6	395.4	90.0	67.3
Change (%)	-12.2	5.1	-31.5	-84.4	-89.2

Source:
Deluchi, M.A., "Emissions of Greenhouse Gases from the Use of Transportation Fuels and Electricity: Volume 1," ANL/ESD/TM-22, Center for Transportation Research, Argonne National Laboratory, 1991.

Note: CH_4=methane.

[a]Because in the base case, battery-powered electric vehicles (EVs) are assumed to be used in city driving only, they are compared with reformulated-gasoline light-duty vehicles (LDV) in the city driving cycle. The reformulated-gasoline LDV that gets 30 mph in combined city/highway driving gets 24.5 mpg in city driving only. The base-case g/mi results (second total in the table) for the gasoline LDV in city driving, for all time horizons, are as follows:

Fuel	20-year	100-year	500-year
Reformulated gasoline (24.5 mpg, city driving)	727.7	577.1	533.1

The percentage changes in this table are given with respect to the value of 521.2 grams/mile found in the reformulated gasoline LDV fuel cycle.

[b]The mix of power used nationally specifically to recharge EVs.

[c]Emissions from the distribution of fuel oil to power plants.

[d]Emissions from the transmission and distribution of NG by pipeline to power plants.

[e]Emissions from power plants plus emissions from the facilities that make the fuel used at power plants plus N_2O emissions from high-voltage power lines.

[f]Emissions of N_2O formed by the corona discharge from high-voltage transmission lines.

[g]This estimate of emissions from the manufacture of materials for an EV is only approximate, assuming that the breakdown of the materials in an EV, excluding the battery, is the same as the breakdown for an internal-combustion-engine vehicle (ICEV). However, this assumption is obviously not correct, since the powertrain in an EV is very different from that in an ICEV.

The Clean Air Act Amendments of 1990 established more restrictive emission control standards. These standards became effective in 1994.

Table 7.14
Federal Emission Control Requirements for Automobiles and Light Trucks, 1976-95[a]
(grams per mile)

	Automoibles				Light trucks[b]			
Model Year	Hydro-carbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO_x)	Particulates [c]	Hydro-carbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO_x)	Particulates [c]
1976	1.50	15.0	3.1	[d]	2.0	20.0	3.1	[d]
1977	1.50	15.0	2.0	[d]	2.0	20.0	3.1	[d]
1978	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	0.41	3.4	1.0	0.60	1.7	18.0	2.3	0.60
1983	0.41	3.4	1.0	0.60	1.7	18.0	2.3	0.60
1984	0.41	3.4	1.0	0.60	0.8	10.0	2.3	0.60
1985	0.41	3.4	1.0	0.60	0.8	10.0	2.3	0.60
1986	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	0.41	3.4	1.0	0.20	0.8	10.0	1.2[e]	0.26
1989	0.41	3.4	1.0	0.20	0.8	10.0	1.2[e]	0.26
1990	0.41	3.4	1.0	0.20	0.8	10.0	1.2[e]	0.26
1991	0.41	3.4	1.0	0.20	0.8	10.0	1.2[e]	0.26
1992	0.41	3.4	1.0	0.20	0.8	10.0	1.2[e]	0.26
1993	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

Sources:
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.

The Clean Air Act Amendments of 1990 established more restrictive emission control standards. These standards became effective in 1994.

Table 7.15
Federal Emission Control Requirements for Heavy-Duty Gasoline Trucks, 1976-95[a]
(grams per brake horsepower hour)

Model Year	Hydrocarbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO_x)	Hydrocarbons + nitrogen oxides ($HC + NO_x$)
1976	b	40.0	b	16.0
1977	b	40.0	b	16.0
1978	b	40.0	b	16.0
1979	1.5	25.0	b	10.0
1980	1.5	25.0	b	10.0
1981	1.5	25.0	b	10.0
1982	1.5	25.0	b	10.0
1983	1.5	25.0	b	10.0
1984	1.3	15.5	10.7	b
1985	2.5	40.0	10.7	b
1986	2.5	40.0	10.7	b
1987	1.9	37.1	10.6	b
1988	1.9	37.1	10.6	b
1989	1.9	37.1	10.6	b
1990	1.9	37.1	6.0	b
1991	1.9	37.1	5.0	b
1992	1.9	37.1	5.0	b
1993	1.9	37.1	5.0	b
1994	1.9[c]	37.1	5.0[c]	b
1995	1.9[c]	37.1[c]	5.0[c]	b
1996	1.9[c]	37.1[c]	5.0[c]	b
1997	1.9[c]	37.1[c]	5.0[c]	b
1998-on	1.9[c]	37.1[c]	4.0[c]	b

Sources:
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 edition, p. 264.
1994-on: Clean Air Act Amendments of 1990.

[a]Applies to trucks greater than 6,000 pounds gross vehicle weight until model year 1978; greater than 8,500 pounds gross vehicle weight from model year 1979-1986; and greater than 14,000 pounds gross vehicle weight starting in 1987.

[b]No standard was set for this year.

[c]Heavy-duty trucks must meet these standards or standards which reflect the greatest degree of emission reduction achievable through the application of the technology available.

The Clean Air Act Amendments of 1990 established more restrictive emission control standards. These standards became effective in 1994.

Table 7.16
Federal Emission Control Requirements for Heavy-Duty Diesel Trucks, 1976-95[a]
(grams per brake horsepower hour)

Model Year	Hydrocarbons (HC)	Carbon monoxide (CO)	Nitrogen oxides (NO_x)	Hydrocarbons + nitrogen oxides ($HC + NO_x$)	Particulates
1976	[b]	40.0	[b]	16.0	[b]
1977	[b]	40.0	[b]	16.0	[b]
1978	[b]	40.0	[b]	16.0	[b]
1979	1.5	25.0	[b]	10.0	[b]
1980	1.5	25.0	[b]	10.0	[b]
1981	1.5	25.0	[b]	10.0	[b]
1982	1.5	25.0	[b]	10.0	[b]
1983	1.5	25.0	[b]	10.0	[b]
1984	1.3	15.5	10.7	5.0	[b]
1985	1.3	15.5	10.7	[b]	[b]
1986	1.3	15.5	10.7	[b]	[b]
1987	1.3	15.5	10.7	[b]	[b]
1988	1.3	15.5	10.7	[b]	0.60
1989	1.3	15.5	10.7	[b]	0.60
1990	1.3	15.5	6.0	[b]	0.60
1991	1.3	15.5	5.0	[b]	0.25
1992	1.3	15.5	5.0	[b]	0.25
1993	1.3	15.5	5.0	[b]	0.25
1994	1.3[c]	15.5	5.0	[b]	0.10
1995	1.3[c]	15.5[c]	5.0[c]	[b]	0.10[c]
1996	1.3[c]	15.5[c]	5.0[c]	[b]	0.10[c]
1997	1.3[c]	15.5[c]	5.0[c]	[b]	0.10[c]
1998-on	1.3[c]	15.5[c]	4.0[c]	[b]	0.10[c]

Sources:
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]Applies to trucks greater than 6,000 pounds gross vehicle weight until model year 1978; greater than 8,500 pounds gross vehicle weight beginning in model year 1979.

[b]No standard was set for this year.

[c]Heavy-duty trucks must meet these standards or standards which reflect the greatest degree of emission reduction achievable through the application of the technology available.

Table 7.17
Exhaust Emission Standards for Clean-Fuel Vehicles in the California Pilot Test Program
(50,000 mile standards in grams per mile)

	LDV & LDT ≤6,000 GVWR ≤3,750 LVW	LDT ≤6,000 GVWR >3,750 LVW ≤5,750 LVW	LDT [a] >6,000 GVWR ≤3,750 TW	LDT [a] >6,000 GVWR >3,750 TW ≤5,750 TW	LDT [a] >6,000 GVWR >5,750 TW
Conventional vehicles					
Non-methane	0.250	0.320	0.250	0.320	0.390
Carbon monoxide	3.400	4.400	3.400	4.400	5.000
Nitrogen oxides	0.400	0.700	0.400	0.700	1.100
Formaldehyde	[b]	[b]	[b]	[b]	[b]
Transition low-emission vehicles (TLEVs)					
Non-methane organic	0.125	0.160	[c]	[c]	[c]
Carbon monoxide	3.400	4.400	[c]	[c]	[c]
Nitrogen oxides	0.400	0.700	[c]	[c]	[c]
Formaldehyde	0.015	0.018	[c]	[c]	[c]
Low-emission vehicles (LEVs)					
Non-methane organic	0.075	0.100	0.125	0.160	0.195
Carbon monoxide	3.400	4.400	3.400	4.400	5.000
Nitrogen oxides	0.200	0.400	0.400	0.700	1.100
Formaldehyde	0.015	0.018	0.015	0.018	0.022
Ultra-low emission vehicles (ULEVs)					
Non-methane organic	0.040	0.050	0.075	0.100	0.117
Carbon monoxide	1.700	2.200	1.700	2.200	2.500
Nitrogen oxides	0.200	0.400	0.200	0.400	0.600
Formaldehyde	0.008	0.009	0.008	0.009	0.011
Zero-emission vehicles (ZEVs)					
Non-methane organic	0.0	0.0	0.0	0.0	0.0
Carbon monoxide	0.0	0.0	0.0	0.0	0.0
Nitrogen oxides	0.0	0.0	0.0	0.0	0.0
Formaldehyde	0.0	0.0	0.0	0.0	0.0

Source:
U.S. Environmental Protection Agency, Office of Mobile Sources, "California Pilot Test Program," Public Outreach Meeting, Ann Arbor, MI, May 17, 1991.

Note: LDV = light-duty vehicle
LDT = light-duty truck
GVWR = gross vehicle weight rating
LVW = loaded vehicle weight
TW = tare weight

[a]The clean-fuel vehicle standards are not effective until the 1998 model year.
[b]Not applicable.
[c]There is no TLEV category for this vehicle class.

The California Air Resources Board has proposed these figures for fleet mixture in order to meet the emission standards. By the year 2001 it is proposed that 90% of the vehicle manufacturer's fleet be low-emission vehicles.

Table 7.18
California Air Resources Board Proposal for Meeting Emission Standards

Year	Percent of manufacturer's 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
	2	ZEV
2001-2002	90	LEV
	5	ULEV
	5	ZEV
2003[b]	75	LEV
	15	ULEV
	10	ZEV

Source:
California Air Resources Board, Mobile Sources Division, El Monte, CA, 1990.

[a] CV = Conventional vehicles
TLEV = Transition low emission vehicles
LEV = Low emission vehicles
ULEV = Ultra low emission vehicles
ZEV = Zero emission vehicles
[b] Fleet average of non-methane organic gases = 0.062 in 2003.

Four fuels are projected as capable of meeting the requirements for the transitional low-emission vehicles, low-emission vehicles, ultra-low emission vehicles, and zero-emission vehicles. Gasoline, alcohol, compressed natural gas, and liquified petroleum gas, with fuel and vehicle improvements, are projected as capable of meeting the first three levels. Electric vehicles are phased in as ultra-low emission vehicles and are the only vehicle type expected to be zero-emission vehicles.

Table 7.19
Possible Fuel/Vehicles for Clean-Fuel Vehicles

TRANSITIONAL LOW-EMISSION VEHICLES (TLEVs)

- ***Gasoline*** - small/medium displacement engines, heated fuel preparation system, close-coupled catalyst
- ***Alcohol*** - improved close-coupled catalyst
- ***Compressed natural gas*** - underfloor catalyst
- ***Liquified petroleum gas*** - close-coupled catalyst

LOW-EMISSION VEHICLES (LEVs)

- ***Gasoline*** - electrically heated catalyst, phase 2 gasoline
- ***Alcohol*** - heated fuel preparation system, close-coupled catalyst
- ***Compressed natural gas*** - electronic fuel injection, close-coupled catalyst
- ***Liquified petroleum gas*** - electronic fuel injection, close-coupled catalyst

ULTRA-LOW EMISSION VEHICLES (ULEVs)

- ***Gasoline*** - heated fuel preparation system, electrically heated catalyst, phase 2 gasoline
- ***Alcohol*** - heated fuel preparation system, electrically heated catalyst
- ***Compressed natural gas*** - electronic fuel injection, electrically heated catalyst
- ***Electricity*** - range-extended hybrid vehicles, battery powered vehicles with auxiliary combustion heaters

ZERO-EMISSION VEHICLES (ZEVs)

- ***Electricity*** - battery-powered vehicles

Source:
U.S. Department of Energy, Office of Transportation Technologies, "Electric Vehicle Progress," Washington, DC, January 1991, p.3.

Ozone Nonattainment Areas

"In response to the Clean Air Act Amendments of 1990 (CAAA), the Environmental Protection Agency is implementing a reformulated gasoline[a] (RFG) program that will go into effect in 1995. As mandated by the CAAA, beginning January 1, 1995, gasoline sellers in the nine U.S. metropolitan areas with the worst ozone problems may only sell RFG that meets Federal standards. This requirement applies to petroleum refiners, blenders, marketers, and importers.

The nine ozone-nonattainment areas that must use Federal RFG beginning in 1995 are:

Los Angeles, California
Baltimore, Maryland
Houston-Galveston-Brazoria, Texas
Milwaukee-Racine, Wisconsin
Hartford, Connecticut
Philadelphia, Pennsylvania
San Diego, California
Chicago and surrounding areas in Illinois, Indiana, and Wisconsin
New York City and surrounding areas in New York State, New Jersey and Connecticut.

The CAAA also allow other, less severe ozone-nonattainment areas (an additional 89 urban areas) to 'opt into' the RFG program as part of their State Implementation Plans for improving air quality.[b]" Many of these areas have already "opted into" the program.

[a]Reformulated gasoline is gasoline that has had its physical or chemical characteristics changed.
[b]U.S. Department of Energy, Office of Policy, Estimating the Costs and Effects of Reformulated Gasolines, Washington, DC, December, 1994, pp. 1-2.

APPENDIX A

SOURCES

This appendix, first included in Edition 10 of the Transportation Energy Data Book, contains documentation of the estimation procedures used by ORNL. The reader can examine the methodology behind the estimates and form an opinion as to their utility.

The appendix is arranged by table number and subject heading. Only tables which contain ORNL estimations are documented in Appendix A; all other tables have sources listed at the bottom of the table. Abbreviations are used throughout the appendix; so a list of abbreviations is also included.

List of Abbreviations Used in Appendix A

AAMA	American Automobile Manufacturers Association
AAR	Association of American Railroads
APTA	American Public Transit Association
Amtrak	National Railroad Passenger Corporation
Btu	British thermal unit
DOC	Department of Commerce
DOE	Department of Energy
DOT	Department of Transportation
EIA	Energy Information Administration
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FHWA	Federal Highway Administration
gvw	gross vehicle weight
lpg	liquefied petroleum gas
MIC	Motorcycle Industry Council
mpg	miles per gallon
NHTSA	National Highway Traffic Safety Administration
NPTS	Nationwide Personal Transportation Study
ORNL	Oak Ridge National Laboratory
pmt	passenger-miles traveled
RECS	Residential Energy Consumption Survey
RTECS	Residential Transportation Energy Consumption Survey
TIUS	Truck Inventory and Use Survey
TSC	Transportation Systems Center
vmt	vehicle-miles traveled

Table 2.7
Domestic Consumption of Transportation Energy by Mode and Fuel Type, 1993

Most of the source data were given in gallons. It was converted to Btu by using the conversion factors in Appendix B.

Highway

Automobiles

Total gallons of fuel taken from DOT, FHWA, Highway Statistics 1993, Table VM-1. These were distributed as follows: 97.8% gasoline, 1.0% gasohol, and 1.2% diesel. Percentages were derived from the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Household Vehicles Energy Consumption 1991, December 1993, p. 46. Methanol use was estimated per personal communication with the California Energy Commission. Methanol estimate may contain small amounts of fuel used by school buses and heavy-duty trucks.

Motorcycles

DOT, FHWA, Highway Statistics 1993, Table VM-1. For conversion purposes, fuel for all motorcycles was assumed to be gasoline.

Buses

Transit:

APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 132-135. Non-diesel fossil fuel consumption was assumed to be used by motor buses.

Intercity:

Eno Transportation Foundation, Transportation in America, Twelfth Edition, 1994, Washington, DC, p. 56. Data for 1993 are not yet available.

School:

Eno Transportation Foundation, Transportation in America, Twelfth Edition, 1994, Washington, DC, p. 56. Data for 1993 are not yet available.

Trucks

Total:
Sum of light trucks and other trucks.

Light Trucks:
DOT, FHWA, Highway Statistics 1993, Table VM-1, for single-unit, 2-axle, 4-tire trucks. 96.6% of fuel assumed to be gasoline, 3.3% diesel, and 0.1% lpg; percentages were generated from the 1987 TIUS Public Use Tape.

Other Trucks:
DOT, FHWA, Highway Statistics 1993, Table VM-1. Total gallons for other trucks was the difference between total and 2-axle, 4-tire trucks. These gallons were distributed as follows based on data from the 1987 TIUS Public Use Tape: 19.4% of fuel assumed to be gasoline, 80.4% diesel, and 0.2% lpg.

Off Highway

Diesel:
Data supplied by Marianne Mintz, Argonne National Laboratory, from the Public Use Data Base, National Energy Accounts, DOC, OBA-NEA-10, August 1988.

Gasoline:
DOT, FHWA, Highway Statistics 1993, Table MF-24. Agriculture and Construction totals.

Non-Highway

Air

General Aviation:
DOT, FAA, General Aviation Activity and Avionics Survey: Annual Summary Report Calendar Year 1992, Table 5.1. Jet fuel was converted from gallons to Btu using 135,000 Btu/gallon (kerosene-type jet fuel). Data for 1993 are not yet available.

Domestic and International Air Carrier:
DOT, Research and Special Programs Administration, Data Administration Division, "Fuel Cost and Consumption Tables;" annual figures were obtained by summing monthly totals. Because the data for international included fuel purchased abroad, the international total was divided in half to estimate domestic fuel purchases for international flights.

Water

Freight:

Total - DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23. Adjusted sales of distillate and residual fuel oil for vessel bunkering.

Domestic and Foreign - Total freight energy use was distributed as follows:

Distillate fuel - 77.5% domestic, 22.5% foreign

Residual fuel - 9.3% domestic, 90.7% foreign

Percentages were derived from the DOC, U.S. Foreign Trade, Bunker Fuels, "Oil and Coal Laden in the U.S. on Vessels Engaged in Foreign Trade," 1988. This report was discontinued in 1989.

Recreational Boating:

Fuel use by recreational boating was calculated using the methodology developed by D. L. Greene in the report, Off-Highway Use of Gasoline in the United States (DOT, FHWA, July 1986, p. 3-22). Results from Model 1 in the report indicated an average annual consumption of 205 gallons per boat. Total consumption in gallons was then calculated using the following equation: Total = 0.95 (Gal/boat) (number of boats). An estimate of number of recreational boats in operation was found in Boating Industry Magazine, Annual Report, "The Boating Business 1993" (Communication Channels, Inc., Chicago, IL). The total was the sum of inboard, outboard and inboard/outdrive boats.

Pipeline

Natural Gas:

The amount of natural gas used to transport natural gas was defined as "pipeline fuel" as reported in DOE, EIA, Natural Gas Annual 1993, Table 1. Cubic feet were converted to Btu using 1,031 Btu/ft^3. Electricity use was estimated using the following procedure as reported on p. 5-110 of J. N. Hooker et al., End Use Energy Consumption DataBase: Transportation Sector. The energy consumption of a natural gas pipeline was taken to be the energy content of the fuel used to drive the pumps. Some 94% of the installed pumping horsepower was supplied by natural gas. The remaining 6% of the horse power was generated more efficiently, mostly by electric motors. The energy consumed by natural gas pipeline pumps that were electrically powered was not known. In order to estimate the electricity consumed, the Btu of natural gas pipeline fuel consumed was multiplied by a factor of 0.015. From this computed value, electricity efficiency and generation loss must be taken into account. The electricity energy use in Btu must be converted to kWhr, using the conversion factor 29.305 x 10^{-5} kWhr/Btu. Electricity generation and distribution efficiency was 29%. When generation and distribution efficiency are taken into account, 1 kWhr equals 11,765 Btu.

Crude petroleum and petroleum product:

J. N. Hooker, Oil Pipeline Energy Consumption and Efficiency, ORNL-5697, ORNL, Oak Ridge, TN, 1981. (Latest available data.)

Coal slurry and water:

W. F. Banks, Systems, Science and Software, Energy Consumption in the Pipeline Industry, LaJolla, CA, October 1977. (Latest available data.)

Rail

Total:

DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23. Adjusted sales of deliveries of distillate fuel oil for railroad.

Freight:

Distillate fuel oil was obtained by subtracting total passenger fuel use from total distillate as reported by EIA.

Passenger:

Transit and Commuter - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, p. 132-135. Transit was defined as the sum of "heavy rail," "light rail," and "other."

Intercity - Sum of fuel used by Amtrak and Class I passenger trains. Source for Amtrak was personal communication with the Corporate Accounting Office of Amtrak, Washington, DC. Source for fuel use by Class I passenger trains was the AAR, Statistics of Class I Railroads 1993, 1994, Items 747-750. Fuel use for Class I passenger was derived as follows: fuel use for passenger locomotive, including weighted percent of fuel for yard switching. Diesel fuel consumed by work train was not included as it was considered to be indirect energy.

Table 2.10
Transportation Energy Consumption by Mode, 1970-93

Highway

Automobiles

Total gallons of fuel for automobiles was taken from DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A; and Table VM-1 in the 1986-93 annual editions. Fuel for automobiles was distributed between fuel types for conversion into Btu's as follows:

1970-80 - 94.7% gasoline, 5.3% diesel as reported in the DOE, EIA, Office of Energy Markets and End Use, Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, June 1979 to December 1980, p. 10.

1981-82 - 94.1% gasoline, 5.9% diesel as reported in the DOE, EIA, Office of Energy Markets and End Use, Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981, pp. 11, 13.

1983-84 - 97.5% gasoline, 2.5% diesel as reported in the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1983, Jan., 1985, pp. 7, 9.

1985-87 - 98.5% gasoline, 1.5% diesel as reported in the DOE, EIA, Office of Energy Markets and End Use, Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles 1985, April 1987, pp. 25, 27.

1988-90 - 98.8% gasoline and 1.2% diesel as reported in the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Household Vehicles Energy Consumption 1988, March 1990, p. 65.

1991-93 - 97.8% gasoline, 1.0% gasohol, and 1.2% diesel as reported in the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Household Vehicles Energy Consumption 1991, December 1993, p. 46.

1993 - Methanol use was estimated per personal communication with the California Energy Commission. Methanol estimate may contain small amounts of fuel used by school buses and heavy-duty trucks.

Motorcycles

Department of Transportation, Federal Highway Administration, Highway Statistics Summary to 1985, Table VM-201A; and Table VM-1 in the 1986-93 annual editions. For conversion purposes, fuel for all motorcycles was assumed to be gasoline.

Buses

Sum of transit, intercity and school.

Transit:

APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 132-135, and annual.

Non-diesel fossil fuel consumption was assumed to be used by motor buses. For the years 1988-92, motor bus gasoline use was estimated as 5% of "other" fuels, based on personal communication with the APTA Research and Statistics Department.

Intercity:

1970-84 - American Bus Association, Annual Report, Washington, DC, annual.

1985-91 - Eno Transportation Foundation, Transportation in America, Twelfth Edition, 1994, Washington, DC, p. 56. Data for 1993 are not yet available.

School:

1970-84 - DOT, FHWA, Highway Statistics 1984, Washington, DC, Table VM-1, and annual.

1985-86 - DOT, Research and Special Programs Administration, National Transportation Statistics, Figure 2, p. 5, and annual.

1987-91 - Eno Transportation Foundation, Transportation in America, Twelfth Edition, 1994, Washington, DC, p. 56. Data for 1993 are not yet available.

Trucks

Light Trucks:

Defined as 2-axle, 4-tire trucks. Total gallons of fuel was taken from DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A, and Table VM-1 of the 1986-93 annual editions. Based on data from the 1982 TIUS Public Use Tape, fuel use for 1970-1987 was distributed among fuel types as follows: 95.3% gasoline; 3.5% diesel; and 1.2% lpg. Fuel use for 1990 was distributed based on the 1987 TIUS: 96.6% gasoline; 3.3% diesel; and 0.1% lpg.

Other Trucks:

Defined as the difference between total trucks and 2-axle, 4-tire trucks. Total gallons of fuel was taken from DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A, and Table VM-1 of the 1986-93 annual editions. Based on data from the 1982 TIUS Public Use Tape, fuel use for 1970-1987 was distributed among fuel types as follows: 39.6% gasoline; 59.4% diesel; and 1.0% lpg. Fuel use for 1988-90 was distributed based on the 1987 TIUS: 19.4% gasoline; 80.4% diesel; and 0.2% lpg.

Total Highway

Sum of autos, motorcycles, buses, light trucks, and other trucks.

Non-Highway

Air

Sum of fuel use by General Aviation and Certificated Route Air Carrier.

General Aviation:

1970-74 - DOT, TSC, National Transportation Statistics, Cambridge, MA, 1981.

1975-85 - DOT, FAA, FAA Aviation Forecasts, Washington, DC, annual.

1985-92 - DOT, FAA, General Aviation Activity and Avionics Survey: Annual Summary Report, Calendar Year 1992, Table 5.1. Jet fuel was converted from gallons to Btu using 135,000 Btu/gallon (kerosene-type jet fuel). Data for 1993 are not yet available.

Certificated Route Air Carrier:

1970-81 - DOT, Civil Aeronautics Board, Fuel Cost and Consumption, Washington, DC, annual.

1982-93 - DOT, Research and Special Programs Administration, Data Administration Division, "Fuel Cost and Consumption Tables;" annual figures were obtained by summing monthly totals. Because the data for international included fuel purchased abroad, the international total was divided in half to estimate domestic fuel purchases for international flights.

Water

Sum of vessel bunkering fuel (i.e., freight) and fuel used by recreational boats.

Freight:

Total - DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23. Adjusted sales of distillate and residual fuel oil for vessel bunkering.

Domestic and Foreign - 1970-88 - DOC, U.S. Foreign Trade, Bunker Fuels, "Oil and Coal Laden in the U.S. on Vessels Engaged in Foreign Trade," 1988, annual. In this were fuel oil (i.e., residual) and diesel oil laden in the U.S. on vessels engaged in foreign trade. The totals for residual and diesel used by foreign vessels and American vessels for foreign trade were subtracted from the EIA totals for residual and diesel deliveries to obtain the value for domestic trade.
1989-92 - Total freight energy use was distributed as follows:
Distillate fuel - 77.5% domestic, 22.5% foreign
Residual fuel - 9.3% domestic, 90.7% foreign

Percentages were derived from the DOC, U.S. Foreign Trade, Bunker Fuels, "Oil and Coal Laden in the U.S. on Vessels Engaged in Foreign Trade," 1988. This report was discontinued in 1989.

Recreational Boating:

1970-84 - DOT, FHWA, Highway Statistics, Washington, DC, Table MF-24, annual.

1985-93 - Fuel use by recreational boating was calculated using the methodology developed by D. L. Greene in the report, Off-Highway Use of Gasoline in the United States (DOT, FHWA, July 1986, p. 3-22). Results from Model 1 in the report indicated an average annual consumption of 205 gallons per boat. Total consumption in gallons was then calculated using the following equation: Total = 0.95 (Gal/boat) (number of boats). An estimate of number of recreational boats in operation was found in Boating Industry Magazine, Annual Report, "The Boating Business 1992" (Communication Channels, Inc., Chicago, IL) and annual. The total was the sum of inboard, outboard and inboard/outdrive boats.

Pipeline

Natural Gas:

The amount of natural gas used to transport natural gas was defined as "pipeline fuel" as reported in DOE, EIA, Natural Gas Annual 1993, Table 1. Cubic feet were converted to Btu using 1,031 Btu/ft^3. Electricity use was estimated using the following procedure as reported on p. 5-110 of J. N. Hooker et al., End Use Energy Consumption DataBase: Transportation Sector. The energy consumption of a natural gas pipeline was taken to be the energy content of the fuel used to drive the pumps. Some 94% of the installed pumping horsepower was supplied by natural gas. The remaining 6% of the horse power was generated more efficiently, mostly by electric motors. The energy consumed by natural gas pipeline pumps that were electrically powered was not known. In order to estimate the electricity consumed, the Btu of natural gas pipeline fuel consumed was multiplied by a factor of 0.015. From this computed value, electricity efficiency and generation loss must be taken into account. The electricity energy use in Btu must be converted to kWhr, using the conversion factor 29.305 x 10^{-5} kWhr/Btu. Electricity generation and distribution efficiency was 29%. When generation and distribution efficiency are taken into account, 1 kWhr equals 11,765 Btu.

Crude petroleum and petroleum product:

J. N. Hooker, Oil Pipeline Energy Consumption and Efficiency, ORNL-5697, ORNL, Oak Ridge, Tennessee, 1981. (Latest available data.)

Coal slurry and water:

W. F. Banks, Systems, Science and Software, Energy Consumption in the Pipeline Industry, LaJolla, California, October 1977. (Latest available data.)

Rail

Total:

DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23, and annual. Adjusted sales of distillate fuel oil for railroad.

Freight:

Distillate fuel oil was obtained by subtracting total passenger fuel use from total distillate as reported by EIA.

Passenger:

Transit and Commuter - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, p. 132-135, annual. Transit was defined as the sum of "heavy rail," "light rail," and "other."

Intercity - Sum of fuel used by Amtrak and Class I passenger trains. Source for Amtrak was personal communication with the Corporate Accounting Office of Amtrak, Washington, DC. Source for fuel use by Class I passenger trains was the AAR, Statistics of Class I Railroads 1993, 1994, Items 747-750, and annual. Fuel use for Class I passenger was derived as follows: fuel use for passenger locomotive, including weighted percent of fuel for yard switching. Diesel fuel consumed by work train was not included as it was considered to be indirect energy.

Table 2.13
Passenger Travel and Energy Use in the United States, 1993

Highway

Automobiles

Number of Vehicles - DOT, FHWA, Highway Statistics 1993, Table VM-1.
Vmt - DOT, FHWA, Highway Statistics 1993, Table VM-1.
Pmt - Calculated by ORNL (load factor times vmt).
Load Factor - DOT, FHWA, Office of Highway Information Management, 1990 NPTS, Public Use Tape, 1992.
Energy Use - Total gallons of fuel taken from DOT, FHWA, Highway Statistics 1993, Table VM-1. These were distributed as follows: 97.8% gasoline, 1.0% gasohol, and 1.2% diesel. Percentages were derived from the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Household Vehicles Energy Consumption 1991, December 1993, p. 46. Methanol use was estimated per personal communication with the California Energy Commission. Methanol estimate may contain small amounts of fuel used by school buses and heavy-duty trucks.

Personal Trucks

Number of Vehicles - Based on the 1987 TIUS, 68.6% of total 2-axle, 4-tire trucks and 11.1% of total other trucks were for personal use. Therefore, 68.6% of total 2-axle, 4-tire trucks (as reported by DOT, FHWA in Highway Statistics 1993, Table VM-1) and 11.1% of total other trucks were estimated to be for personal use.
Vmt - 62.7% of total vehicle miles traveled by 2-axle, 4-tire trucks (as reported by DOT, FHWA in Highway Statistics 1993, Table VM-1) and 2.3% of total vehicle miles traveled by other trucks were for personal use. The percentages were derived by ORNL from the 1987 TIUS public use tape.
Pmt - Calculated by ORNL as vmt multiplied by load factor.
Load Factor - DOT, FHWA, Office of Highway Information Management, 1990 NPTS, Public Use Tape, 1992.
Energy Use- Assuming that there is no difference in fuel economy (measured in miles per gallon) between personal-use trucks and non-personal use trucks, 62.7% of total fuel consumption by 2-axle, 4-tire trucks (as reported by DOT, FHWA in Highway Statistics 1993, Table VM-1) and 2.3% of total other truck fuel consumption was for personal use. These percentages were derived by ORNL from the 1987 TIUS Public Use tape. Total truck energy use was the sum of light truck and other truck energy use.

Light Trucks: DOT, FHWA, Highway Statistics 1993, Table VM-1, for single-unit, 2-axle, 4-tire trucks. 96.6% of fuel assumed to be gasoline, 3.3% diesel, and 0.1% lpg; percentages were generated from the 1987 TIUS Public Use Tape.

Other Trucks: DOT, FHWA, Highway Statistics 1993, Table VM-1. Total gallons for other trucks was the difference between total and 2-axle, 4-tire trucks. These values were distributed based on data from the 1987 TIUS Public Use Tape: 19.4% of fuel assumed to be gasoline, 80.4% diesel, and 0.2% lpg.

Motorcycles

Number of Vehicles and Vmt - DOT, FHWA, Highway Statistics 1993, Table VM-1.
Pmt - Calculated by ORNL as vmt multiplied by load factor.
Load Factor - DOT, FHWA, Office of Highway Information Management, 1990 NPTS, Publlic Use Tape, 1992.
Energy Use - DOT, FHWA, Highway Statistics 1993, Table VM-1. For conversion purposes, fuel for all motorcycles was assumed to be gasoline.

Buses

Transit:

Number of Vehicles, Vmt, Pmt, and Energy Use - Motor bus only. APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 106, 107, 110, 132-135.
Load Factor - Calculated by ORNL as pmt/vmt.

Intercity:

Number of Vehicles - Estimated by ORNL as 18% of commercial bus registrations, DOT, FHWA, Highway Statistics 1993, Table MV-10.
Pmt - Eno Transportation Foundation, Transportation in America, Twelfth Edition, Washington, DC, 1994, p. 47.
Vmt - Estimated using passenger travel and an average load factor of 23.2 persons/vehicle.
Load Factor -Estimated as 23.2 based on historical data
Energy Use - Eno Transportation Foundation, Transportation in America, Twelfth Edition, 1994, Washington, DC, p. 56.

School:

Number of Vehicles - School and other nonrevenue as reported in DOT, FHWA, Highway Statistics 1993, Table MV-10.
Energy Use - Eno Transportation Foundation, Transportation in America, Twelfth Edition, 1994, Washington, DC, p. 56.
Load Factor - Calculated by ORNL as pmt/vmt.
Vmt, Pmt - National Safety Council, Accident Facts, 1994 Edition, Chicago, IL, pp. 70-71.

Non-Highway

Air

Large Certified Route Air Carriers:

Vmt - Revenue aircraft miles flown, DOT, FAA, FAA Statistical Handbook of Aviation Calendar Year 1992, p. 6-4.

Pmt - Revenue pmt of domestic operations, scheduled and unscheduled, DOT, FAA, FAA Statistical Handbook of Aviation Calendar Year 1992, p. 6-4.

Load Factor - Calculated by ORNL as pmt/vmt.

Energy Use - DOT, Research and Special Programs Administration, Data Administration Division, "Fuel Cost and Consumption Tables;" annual figures were obtained by summing monthly totals. Because the data for international included fuel purchased abroad, the international total was divided by two to estimate domestic fuel purchases for international flights.

General Aviation:

Number of Vehicles, Vmt, Energy Use - DOT, FAA, General Aviation Activity and Avionics, Survey: Calendar Year 1992, pp. 2-8, 3-11, 5-7.

Pmt - Eno Transportation Foundation, Transportation in America, Eleventh Edition, Washington, DC, 1993, p. 47.

Load Factor - Calculated by ORNL as pmt/vmt.

Recreational Boating

Number of Vehicles - Whitney Communications, Boating Industry Magazine, Annual Report, "The Boating Business 1993." The total was the sum of inboard, outboard, and inboard/outdrive boats.

Energy Use - Fuel use by recreational boating was calculated using the methodology developed by D. L. Greene in the report, Off-Highway Use of Gasoline in the United States (DOT, FHWA, July 1986, p. 3-22). Results from Model 1 in the report indicated an average annual consumption of 205 gallons per boat. Total consumption in gallons was then calculated using the following equation: Total = 0.95 (Gal/boat) (number of boats). An estimate of number of recreational boats in operation was found in Boating Industry Magazine, Annual Report, "The Boating Business 1993" (Communication Channels, Inc., Chicago, IL). The total was the sum of inboard, outboard and inboard/outdrive boats.

Rail

Intercity:

Number of Vehicles, Vmt and Pmt - Personal communication with the Corporate Accounting Office of Amtrak, Washington, DC.

Load Factor - Calculated by ORNL as pmt/vmt.

Energy Use - Personal communication with the Accounting Division of Amtrak, Washington, DC.

Transit and Commuter:

Number of Vehicles, Vmt and Pmt - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 106, 107, 110.

Load Factor - Calculated by ORNL as pmt/vmt.

Energy Use - APTA, 1994-95 Transit Fact Book, Februray 1995, Washington, DC, pp. 132-135. Transit was defined as the sum of "heavy rail," "light rail," and "other."

Table 2.14
Intercity Freight Movement and Energy Use in the United States, 1993

Highway

Trucks

Vehicles - 7.5% of total 2-axle, 4-tire trucks (as reported by DOT, FHWA in Highway Statistics 1993, Table VM-1) and 22.1% of total other trucks were engaged in intercity freight movement. These percentages were derived by ORNL from the 1987 TIUS public use tape.

Vmt - 13.7% of total vehicle miles traveled by 2-axle, 4-tire trucks (as reported by DOT, FHWA in Highway Statistics 1993, Table VM-1) and 50.2% of total vehicle miles traveled by other trucks were used in intercity freight movement. These percentages were derived by ORNL from the 1987 TIUS public use tape.

Ton Miles, Tons Shipped and Average Length of Haul - Eno Transportation Foundation, Transportation in America, Twelfth edition, Washington, DC, 1994, pp. 44, 46, 71.

Energy Intensity - Energy use divided by ton-miles.

Energy Use - 16% of total fuel consumption by 2-axle, 4-tire trucks (as reported by DOT, FHWA in Highway Statistics 1993, Table VM-1) and 53.2% of total other truck fuel consumption were used in intercity freight movement. These percentages were derived by ORNL from the 1987 TIUS public use tape.

Non-Highway

Waterborne Commerce

Vehicles - U.S. Department of the Army, Army Corps of Engineers, "Summary of U.S. Flag Passenger and Cargo Vessels, 1992," New Orleans, LA, 1993.

Ton Miles, Tons Shipped, and Average Length of Haul - U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Calendar Year 1991 and 1992, Part 5: National Summaries, New Orleans, LA, 1994, pp. 1-6, 1-7.

Energy Intensity - Energy use divided by ton miles.

Energy Use - DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23. Adjusted sales of distillate and residual fuel oil for vessel bunkering.

Domestic freight energy use was calculated as:

Distillate fuel - 77.5% domestic, 22.5% foreign

Residual fuel - 9.3% domestic, 90.7% foreign

Percentages were derived from the DOC, U.S. Foreign Trade, Bunker Fuels, "Oil and Coal Laden in the U.S. on Vessels Engaged in Foreign Trade," 1988. This report was discontinued in 1989.

Pipeline

Natural Gas:

Tons shipped - DOE, EIA, Natural Gas Annual 1993, Washington, DC, 1994, Table 1. Total natural gas disposition divided by 44,870 ft^3/ton.

Energy use - The amount of natural gas used to transport natural gas was defined as "pipeline fuel" as reported in DOE, EIA, Natural Gas Annual 1993, Table 1. Cubic feet were converted to Btu using 1,031 Btu/ft^3. Electricity use was estimated using the following procedure as reported on p. 5-110 of J. N. Hooker et al., End Use Energy Consumption DataBase: Transportation Sector. The energy consumption of a natural gas pipeline was taken to be the energy content of the fuel used to drive the pumps. Some 94% of the installed pumping horsepower was supplied by natural gas. The remaining 6% of the horse power was generated more efficiently, mostly by electric motors. The energy consumed by natural gas pipeline pumps that were electrically powered was not known. In order to estimate the electricity consumed, the Btu of natural gas pipeline fuel consumed was multiplied by a factor of 0.015. From this computed value, electricity efficiency and generation loss must be taken into account. The electricity energy use in Btu must be converted to kWhr, using the conversion factor 29.305 x 10^{-5} kWhr/Btu. Electricity generation and distribution efficiency was 29%. When generation and distribution efficiency are taken into account, 1 kWhr equals 11,765 Btu.

Crude Oil and Petroleum Product:

Ton Miles and Tons Shipped - Eno Transportation Foundation, Transportation in America, Twelfth edition, Washington, DC, 1994, pp. 44.

Energy Use - W. F. Banks, Systems, Science, and Software, Inc., Energy Consumption in the Pipeline Industry, LaJolla, CA, 1977.

Rail

Vehicles, Vmt, Ton Miles, Average Length of Haul - AAR, Railroad Facts, 1994 Edition, Washington, DC, 1994, pp. 27, 34, 36, 50.

Tons shipped - AAR, Analysis of Class I Railroads 1993, 1994, p. 31.

Energy Use - Distillate fuel oil was obtained by subtracting total passenger fuel use from total distillate as reported by EIA.

Total - DOE, EIA, Fuel Oil and Kerosene Sales, 1993, p. 42. Adjusted sales of distillate fuel oil for railroad.

Passenger - Transit and Commuter - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 132-135. Transit was defined as the sum of "heavy rail," "light rail," and "other."

Intercity - Sum of fuel used by Amtrak and Class I passenger trains. Source for Amtrak was personal communication with the Accounting Division of Amtrak, Washington, DC. Source for fuel use by Class I passenger trains was the AAR, Analysis of Class I Railroads 1993, 1994, Items 747-750. Fuel use for Class I passenger was derived as follows: fuel use for passenger locomotive, including weighted percent of fuel for yard switching. Diesel fuel consumed by work train was not included as it was considered to be indirect energy.

Table 2.15
Energy Intensities of Passenger Modes, 1970-93

In reference to transportation, the energy intensity of a mode is the ratio of the energy inputs to a process to a measure of the useful outputs from that process; for example, Btu per pmt or Btu per ton-mile. The energy intensity ratios were calculated for each passenger mode using the following data sources:

Highway

Automobiles

Vmt - DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A, and Table VM-1 of the 1987-93 editions.
Pmt - vmt times load factor.
Energy Use - Total gallons of fuel for automobiles was taken from DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A; and Table VM-1 in the 1986-93 annual editions. Fuel for automobiles was distributed between fuel types for conversion into Btu's as follows:

1970-80 - 94.7% gasoline, 5.3% diesel as reported in the DOE, EIA, Office of Energy Markets and End Use, Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, June 1979 to December 1980, p. 10.
1981-82 - 94.1% gasoline, 5.9% diesel as reported in the DOE, EIA, Office of Energy Markets and End Use, Residential Energy Consumption Survey: Consumption Patterns of Household Vehicles, Supplement: January 1981 to September 1981, pp. 11, 13.
1983-84 - 97.5% gasoline, 2.5% diesel as reported in the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles, 1983, Jan., 1985, pp. 7, 9.
1985-87 - 98.5% gasoline, 1.5% diesel as reported in the DOE, EIA, Office of Energy Markets and End Use, Residential Transportation Energy Consumption Survey: Consumption Patterns of Household Vehicles 1985, April 1987, pp. 25, 27.
1988-90 - 98.8% gasoline and 1.2% diesel as reported in the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Household Vehicles Energy Consumption 1988, March 1990, p. 65.
1991-93 - 97.8% gasoline, 1.0% gasohol, and 1.2% diesel as reported in the DOE, EIA, Office of Markets and End Use, Energy End Use Division, Household Vehicles Energy Consumption 1991, December 1993, p. 46.
1993 - Methanol use was estimated per personal communication with the California Energy Commission. Methanol estimate may contain small amounts of fuel used by school buses and heavy-duty trucks.

Buses

Transit:

Vmt, Pmt, Energy Use - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 106, 107, 132-135, and annual.

Non-diesel fossil fuel consumption was assumed to be used by motor buses. For the years 1988-92, motor bus gasoline use was estimated as 5% of "other" fuels, based on personal communication with the APTA Research and Statistics Department.

Intercity:

Pmt - 1970-84 - American Bus Association, Annual Report, Washington, DC, annual.

1985-91 - Eno Transportation Foundation, Transportation in America, Eleventh edition, Washington, DC, 1993, p. 47.

Energy Use - 1970-1984 - American Bus Association, Annual Report, Washington, DC, annual.

1985-92 - Eno Transportation Foundation, Transportation in America, Twelfth Edition, Washington, DC, p. 56, and annual.

School:

Vmt - 1970-84 - DOT, FHWA, Highway Statistics 1984,Washington, DC, Table VM-1, p. 175, and annual.

1985-87 - DOT, TSC, National Transportation Statistics, 1989, Figure 2, p. 7, and annual.

1988-91 - National Safety Council, Accident Facts, 1992 Edition , Chicago, IL, p. 71, and annual.

Energy Use - 1970-1984 - DOT, FHWA, Highway Statistics 1984, Washington, DC, Table VM-1, and annual.

1985-86 - DOT, TSC, National Transportation Statistics, Figure 2, p. 5, and annual.

1987-92 - Eno Transportation Foundation, Transportation in America, Twelfth Edition, Washington, DC, p. 56, and annual.

Non-Highway

Air

Certificated Air Carriers:

Pmt - DOT, FAA, FAA Statistical Handbook of Aviation, Calendar Year 1992, Washington, DC, 1994, p. 6-4, and annual.

Energy Use - 1970-81 - DOT, Civil Aeronautics Board, Fuel Cost and Consumption, Washington, DC, annual.

1982-93 - DOT, Research and Special Programs Administration, Data Administration Division, "Fuel Cost and Consumption Tables;" annual figures were obtained by summing monthly totals. Because the data for international included fuel purchased abroad, the international total was divided in half to estimate domestic fuel purchases for international flights.

General Aviation:

Pmt - Eno Transportation Foundation, Transportation In America, Eleventh Edition, Washington, DC, 1993, p.47.

Energy Use - 1970-74 - DOT, TSC, National Transportation Statistics, Cambridge, MA, 1981.

1975-85 - DOT, FAA, FAA Aviation Forecasts, Washington, DC, annual.

1985-92 - DOT, FAA, General Aviation Activity and Avionics Survey: Calendar Year 1992, Table 5.1. Jet fuel was converted from gallons to Btu using 135,000 Btu/gallon (kerosene-type jet fuel).

Rail

Passenger (Amtrak):

Pmt - 1971-83 - AAR, Statistics of Class I Railroads, Washington, DC, annual.

1984-88 - AAR, Railroad Facts, 1988 Edition, Washington, DC, December 1989, p. 61, and annual.

1989-93 - Personal communication with the Corporate Accounting Office of Amtrak.

Energy Use - Personal communication with the Corporate Accounting Office of Amtrak.

Transit:

Pmt and Energy Use - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 106, 132-135. Transit was defined as the sum of "heavy rail," "light rail,"and "other."

Table 2.16
Energy Intensities of Freight Modes, 1970-93

In reference to transportation, the energy intensity of a mode is the ratio of the energy inputs to a process to a measure of the useful outputs from that process; for example, Btu per pmt or Btu per ton-mile. The energy intensity ratios were calculated for each freight mode using the following data sources:

Highway

Trucks

Vmt - DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A, and Table VM-1 of the 1987-93 editions. Light trucks were defined as 2-axle, 4-tire trucks. Other trucks were defined as the difference between total trucks and 2-axle, 4-tire trucks.

Energy Use - Light Trucks - Defined as 2-axle, 4-tire trucks. Total gallons of fuel was taken from DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A, and Table VM-1 of the 1986-93 annual editions. Based on data from the 1982 TIUS Public Use Tape, fuel use for 1970-1987 was distributed among fuel types as follows: 95.3% gasoline; 3.5% diesel; and 1.2% lpg. Fuel use for 1988-92 was distributed based on the 1987 TIUS: 96.6% gasoline; 3.3% diesel; and 0.1% lpg.

Other Trucks - Defined as the difference between total trucks and 2-axle, 4-tire trucks. Total gallons of fuel was taken from DOT, FHWA, Highway Statistics Summary to 1985, Table VM-201A, and Table VM-1 of the 1986-93 annual editions. Based on data from the 1982 TIUS Public Use Tape, fuel use for 1970-1987 was distributed among fuel types as follows: 39.6% gasoline; 59.4% diesel; and 1.0% lpg. Fuel use for 1988-92 was distributed based on the 1987 TIUS: 19.4% gasoline; 80.4% diesel; and 0.2% lpg.

Non-Highway

Water

Ton Miles - U.S. Department of the Army, Corps of Engineers, Waterborne Commerce of the United States, Calendar Year 1991 and 1992, Part 5: National Summaries, New Orleans, LA, 1994, p. 1-6, and annual.

Energy Use - Calculated as the difference between total water freight energy use and foreign water freight energy use.

Total - DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23. Adjusted sales of distillate and residual fuel oil for vessel bunkering.

Domestic and Foreign - 1970-88 - DOC, U.S. Foreign Trade, Bunker Fuels, "Oil and Coal Laden in the U.S. on Vessels Engaged in Foreign Trade," 1988, annual. In this were fuel oil (i.e., residual) and diesel oil laden in the U.S. on vessels engaged in foreign trade. The totals for residual and diesel used by foreign vessels and American vessels for foreign trade were subtracted from the EIA totals for residual and diesel deliveries to obtain the value for domestic trade.

1989-93 - Total freight energy use was distributed as follows:

Distillate fuel - 77.5% domestic, 22.5% foreign

Residual fuel - 9.3% domestic, 90.7% foreign

Percentages were derived from the DOC, U.S. Foreign Trade, Bunker Fuels, "Oil and Coal Laden in the U.S. on Vessels Engaged in Foreign Trade," 1988. This report was discontinued in 1989.

Rail

Freight Car Miles and Ton Miles - AAR, Railroad Facts, 1993 Edition, Washington, DC, 1994, pp. 27, 36, and annual.

Energy Use - Distillate fuel oil was obtained by subtracting total passenger fuel use from total distillate as reported by EIA.

Total - DOE, EIA, Fuel Oil and Kerosene Sales, 1993, Table 23. Adjusted sales of distillate fuel oil for railroad.

Passenger - Transit and Commuter - APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 132-135. Transit was defined as the sum of "heavy rail," "light rail," and "other."

Intercity - Sum of fuel used by Amtrak and Class I passenger trains. Source for Amtrak was personal communication with the Accounting Division of Amtrak, Washington, DC. Source for fuel use by Class I passenger trains was the AAR, Statistics of Class I Railroads 1993, 1994, Items 747-750. Fuel use for Class I passenger was derived as follows: fuel use for passenger locomotive, including weighted percent of fuel for yard switching. Diesel fuel consumed by work train was not included as it was considered to be indirect energy.

Table 3.3
Vehicle Stock, New Sales and New Registrations
in the United States, 1993 Calendar Year

Highway

Automobiles

Vehicle Stock:

The number of vehicles in use by EPA size class were derived as follows: Market Shares by EPA size class for new car sales from 1970-1975 were taken from the DOT, NHTSA, Automotive Characteristics Historical DataBase, Washington, DC. Market shares for the years 1976-1990 were found in Linda S. Williams and Patricia S. Hu, Highway Vehicle MPG and Market Shares Report: Model Year 1990, ORNL-6672, April 1991, and Table 7 and the ORNL MPG and Market Shares Database, thereafter. These data were assumed to represent the number of cars registered in each size class for each year. These percentages were applied to the automobiles in operation for that year as reported by R. L. Polk and Company (FURTHER REPRODUCTION PROHIBITED) and summed to calculate the total mix. This method assumed that all vehicles, large and small, were scrapped at the same rate.

Sales:

Domestic, import, and total sales were from AAMA, Facts and Figures '94, p. 16. The domestic sales were distributed by size class according to the following percentages: Two seater, 0.4%; Minicompact, 0%; Subcompact, 17.1%; Compact 33.0%; Midsize, 31.9%; and Large, 17.6%. The import sales were distributed by size class according to the following percentages: Two-seater, 2.8%; Minicompact, 4.3%; Subcompact, 42.8%; Compact, 29.6%; Midsize, 19.1%; and Large, 1.3%. These percentages were derived from the ORNL MPG and Market Shares Database and were based on the sales period instead of the calendar year. Domestic-sponsored imports (captive imports) were included in the import figure only.

See Glossary for definition of Automobile Size Classifications.

Fleet

Fleets of ten or more:

Stock - E. J. Bobit (ed.), Bobit Publishing Company, 1994 Automotive Fleet Fact Book, Redondo Beach, CA, 1994, pp. 15, 24. Vehicle stock was equal to the sum of business fleets 25 or more, business fleets 10-24, individually leased, and "other" fleets.

Personal Autos:

Stock - Calculated by ORNL as the difference between total auto and fleets.

Motorcycles

Stock -MIC, 1994 Motorcycle Statisticsl Annual, p. 14, registrations.

Sales - MIC, 1994 Motorcycle Statistical Annual, pp. 10 and 16. Sales included motorcycles, scooters, and all-terrain vehicles for on- and off-highway use. Domestic was the difference between total sales (p. 10) and imports (p. 16).

Recreational Vehicles

Sales - Recreation Vehicle Industry Association, 1993... The Year in Review, "Total Shipments."

Trucks

Stock - Vehicles in use by weight class were determined by applying the percentage in use by weight class as reported in DOC, Bureau of the Census, 1987 TIUS, (0-10,000 lbs, 91.9%; 10,001-19,500 lbs, 2.3%; 19,501-26,000 lbs, 1.7%; 26,001 lbs and over, 4.1%) to the total number of trucks in use as reported by R. L. Polk and Company (FURTHER REPRODUCTION PROHIBITED).

Sales - AAMA, Facts and Figures '94, p. 21.

Table 3.27
Summary Statistics on Buses by Type, 1970-93

Number in Operation

Transit buses:
American Public Transit Association, 1994-95 Transit Fact Book, Washington, DC, February 1995, p. 110, and annual.

Intercity buses:
1970-80 - American Bus Association, 1984 Annual Report, Washington, DC, and annual.
1985 - U.S. Department of Transportation, Transportation Systems Center, National Transportation Statistics, Cambridge, MA, August 1990, Figure 5, p. 8, and annual.
1990-93 - Estimated as 38% of commercial buses (less transit motor buses). Commercial bus total found in Highway Statistics 1993, Table MV-10, and annual.

School buses:
U.S. Department of Transportation, Federal Highway Administration, Highway Statistics 1993, Washington, DC, 1993, Table MV-10, p. 20, and annual.

Vehicle-miles and Passenger-miles

Transit buses:
American Public Transit Association, 1994-95 Transit Fact Book, Washington, DC, February 1995, pp. 106, 107, and annual.

Intercity buses:
1970-80 - American Bus Association, Annual Report, Washington, DC, annual.
1985-93 - Eno Transportation Foundation, Transportation in America, Twelfth edition, Washington, DC, 1994, p. 47.
1990-93 vehicle travel - Estimated using passenger travel and an average load factor of 23.2.

School buses:
1970-80 - U.S. Department of Transportation, Federal Highway Administration, Highway Statistics1984, Washington, DC, Table VM-1, p. 175, and annual.
1985 - U.S. Department of Transportation, Research and Special Programs Administration, National Transportation Statistics, 1989, Figure 2, p. 7, and annual.
1990-93 - National Safety Council, Accident Facts, 1993 Edition, Chicago, IL, pp. 74-75, and annual.

Energy Use

Transit buses:

APTA, 1994-95 Transit Fact Book, February 1995, Washington, DC, pp. 132-135.

Non-diesel fossil fuel consumption was assumed to be used by motor buses. For the years 1988-92, motor bus gasoline use was estimated as 5% of "other" fuels, based on personal communication with the APTA Research and Statistics Department.

Intercity buses:

1970-80 - American Bus Association, Annual Report, Washington, DC, annual.

1985-92 - Eno Transportation Foundation, Transportation in America, Twelfth edition, Washington, DC, p. 56.

School buses:

1970-80 - DOT, FHWA, Highway Statistics 1984, Washington, DC, Table VM-1, and annual.

1985 - DOT, Research and Special Programs Administration, National Transportation Statistics, Figure 2, p. 5, and annual.

1986-92 - Eno Transportation Foundation, Transportation in America, Twelfth edition, Washington, DC, p. 56.

Table 7.11
Urban Emissions from Light-Duty Vehicles by Age of Vehicle, 1993

Total light duty vehicle (LDV) **urban** ambient emissions were estimated for 1993 using vehicle emissions estimates generated from EPA's MOBILE5[a] model and urban travel data from FHWA, Highway Statistics, 1991. This study was a comparative analysis to investigate the effects of differing VMT estimates on mobile emissions. Follow-on studies have **not** been conducted using MOBILE5A emissions data and latest urban travel data.

Lois Platte, U.S. EPA, supplied the MOBILE5 1993 vehicle emissions data for automobiles and light trucks age 1 to 25 years old. Light truck emissions data were segregated into two classifications: light trucks less than or equal to 6,000 pounds gross vehicle weight (gvw), and light trucks 6,001 to 8,500 pounds gvw. Vehicle emissions data, in grams/mile, were estimated for hydrocarbons (HC), carbon monoxide (CO), and nitrous oxide (NO_x). The total vehicle emissions estimates for HC include tailpipe (BEF4), evaporative (Evapor), running (Running), and resting (Resting). Refueling emissions are not included in the total grams/mile (Total Vehicle) estimates or total annual urban emissions estimates (Total Tons). Tampering offsets that are due to vehicles with some disabled emission control components are included in all total vehicle emissions estimates.

1993 **urban** vehicle miles traveled are assumed to equal 1.2 trillion miles for LDVs[b]. Automobiles account for 79.4% of LDV urban travel, light trucks less than or equal to 6,000 lbs gvw account for 14% of LDV urban travel, and light trucks 6,000 to 8,500 lbs gvw account for 6.6% of LDV urban travel. A cautionary note concerning the calculation of total urban emissions: there is a discrepancy between the shares of urban travel used to estimate total urban emissions and the shares of total travel used by MOBILE5 to estimate total vehicle emissions per mile traveled. The MOBILE5 model assumes automobiles account for 64% of **total** travel, light trucks less than or equal to 6,000 lbs gvw account for 17.4% of total travel, and light trucks 6,001 to 8,000 lbs gvw account for 8.3%

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[a]MOBILE5 modeling runs were completed by Lois Platte, U.S. EPA. This scenario assumes vehicles are operating in the Federal Test Procedure cycle for city driving.

[b]1993 total urban miles traveled are assumed to equal 1991 urban miles of travel. FHWA, Highway Statistics, 1991, Table VM-1, p. 193. Automobile urban travel equals 958.2 billion miles, light truck (2-axle 4-tire) urban travel equals 264.6 billion miles.

of total travel. The urban travel shares used to estimate to urban emissions give much greater weight to automobile emissions.

Estimates of the share of total urban travel by vehicle age were assumed to equal the share of total VMT by vehicle age shown in the MOBILE5 output.

Total 1993 urban emissions were calculated by multiplying vehicle emissions by urban miles traveled, see formula below.

$$LDVUE = \sum_{i=1}^{25} [(VE_{ai} \times UVMT_{ai}) + (VE_{lt1i} \times UVMT_{lt1i}) + (VE_{lt2i} \times UVMT_{lt2i})]$$

Where:
LDVUE = light duty vehicle urban emissions
VE = vehicle emissions
UVMT = urban vehicle miles traveled
i = age of vehicle
a = automobiles
lt1 = light trucks less than or equal to 6,000 lbs gvw
lt2 = light trucks 6,001 to 8,500 lbs gvw.

APPENDIX B

CONVERSIONS

A Note About Heating Values

The heat content of a fuel is the quantity of energy released by burning a unit amount of that fuel. However, this value is not absolute and can vary according to several factors. For example, empirical formulae for determining the heating value of liquid fuels depend on the fuels' American Petroleum Institute (API) gravity. The API gravity varies depending on the percent by weight of the chemical constituents and impurities in the fuel, both of which are affected by the combination of raw materials used to produce the fuel and by the type of manufacturing process. Temperature and climatic conditions are also factors.

Because of these variations, the heating values in Table B.1 may differ from values in other publications. The figures in this report are representative or average values, not absolute ones. The gross heating values used here agree with those used by the Energy Information Administration (EIA).

Heating values fall into two categories, gross and net. If the products of fuel combustion are cooled back to the initial fuel-air or fuel-oxidizer mixture temperature and the water formed during combustion is condensed, the energy released by the process is the higher (gross) heating value. If the products of combustion are cooled to the initial fuel-air temperature, but the water is considered to remain as a vapor, the energy released by the process is lower (net) heating value. Usually the difference between the gross and net heating values for fuels used in transportation is around 5 to 8 percent; however, it is important to be consistent in their use.

Table B.1
Approximate Heat Content for Various Fuels

Automotive gasoline	125,000 Btu/gal(gross) = 115,400 Btu/gal(net)
Diesel motor fuel	138,700 Btu/gal (gross) = 128,700 Btu/gal (net)
Methanol	64,600 Btu/gal (gross) = 56,560 Btu/gal (net)
Ethanol	84,600 Btu/gal (gross) = 75,670 Btu/gal (net)
Gasohol	120,900 Btu/gal (gross) = 112,417 Btu/gal (net)
Aviation gasoline	120,200 Btu/gal (gross) = 112,000 Btu/gal (net)
Propane	91,300 Btu/gal (gross) = 83,500 Btu/gal (net)
Butane	103,000 Btu/gal (gross) = 93,000 Btu/gal (net)
Jet fuel (naphtha)	127,500 Btu/gal (gross) = 118,700 Btu/gal (net)
Jet fuel (kerosene)	135,000 Btu/gal (gross) = 128,100 Btu/gal (net)
Lubricants	144,400 Btu/gal (gross) = 130,900 Btu/gal (net)
Waxes	131,800 Btu/gal (gross) = 120,200 Btu/gal (net)
Asphalt and road oil	158,000 Btu/gal (gross) = 157,700 Btu/gal (net)
Petroleum coke	143,400 Btu/gal (gross) = 168,300 Btu/gal (net)
Natural gas	
Wet	1,112 Btu/ft^3
Dry	1,031 Btu/ft^3
Compressed	20,551 Btu/pound
Liquid	90,800 Btu/gal (gross) = 87,600 Btu/gal (net)
Crude petroleum	138,100 Btu/gal (gross) = 131,800 Btu/gal (net)
Fuel Oils	
Residual	149,700 Btu/gal (gross) = 138,400 Btu/gal (net)
Distillate	138,700 Btu/gal (gross) = 131,800 Btu/gal (net)
Coal	
Anthracite	23.268 x 10^6 Btu/short ton
Bituminous and lignite	21.772 x 10^6 Btu/short ton
Production average	21.776 x 10^6 Btu/short ton
Consumption average	21.266 x 10^6 Btu/short ton

Table B.2
Fuel Equivalents

1 million bbl/day crude oil	= 0.3650 billion bbl/year crude oil = 5.800 trillion Btu/day = 2.117 quadrillion Btu/year = 90.09 million short tons coal/year = 2.074 trillion ft^3 natural gas/year = 22.33 x 10^{11} MJ/year
1 billion bbl/year crude oil	= 2.740 million bbl/day crude oil = 15.89 trillion Btu/day = 5.800 quadrillion Btu/year = 246.8 million short ton coal/year = 5.68 trillion ft^3/year natural gas/day = 61.19 x 10^{11} MJ/year
1 trillion Btu/day	= 172.4 thousand bbl/day crude oil = 62.93 million bbl/year crude oil = 0.3650 quadrillion Btu/year = 15.53 million short tons coal/year = 357.5 billion ft^3 natural gas/year = 38.51 x 10^{10} MJ/year
1 quadrillion Btu/year	= 0.4724 million bbl/day crude oil = 172.4 million bbl/year crude oil = 2.740 trillion Btu/day = 42.55 million short tons coal/year = 979.4 billion ft^3 natural gas/year = 10.55 x 10^{11} MJ/year
1 billion short tons coal/year	= 11.10 million bbl/day crude oil = 4.052 billion bbl/year crude oil = 64.38 trillion Btu/day = 23.50 quadrillion Btu/year = 23.02 trillion ft^3 natural gas/year = 24.79 x 10^{12} MJ/year
1 trillion ft^3 natural gas/year	= 0.4823 million bbl/day crude oil = 0.1760 billion bbl/year crude oil = 2.797 trillion Btu/day = 1.021 quadrillion Btu/year = 43.45 million short tons coal/year = 10.77 x 10^{11} MJ/year
1 mega joule/year	= 44.78 x 10^{-8} bbl/day crude oil = 16.34 x 10^{-5} bbl/year crude oil = 2.597 Btu/day = 947.9 Btu/year = 4.034 x 10^{-5} short tons coal/year = 0.9285 ft^3 natural gas/year

Table B.3
Energy Unit Conversions

1 Btu	= 778.2 ft-lb	1 kWhr	= 3412 Btu[a]
	= 107.6 kg-m		= 2.655×10^6 ft-lb
	= 1055 J		= 3.671×10^5 kg-m
	= 39.30×10^{-5} hp-h		= 3.600×10^6 J
	= 39.85×10^{-5} metric hp-h		= 1.341 hp-h
	= 29.31×10^{-5} kWhr		= 1.360 metric hp-h
1 kg-m	= 92.95×10^{-4} Btu	1 Joule	= 94.78×10^{-5} Btu
	= 7.233 ft-lb		= 0.7376 ft-lb
	= 9.806 J		= 0.1020 kg-m
	= 36.53×10^{-7} hp-h		= 37.25×10^{-8} hp-h
	= 37.04×10^{-7} metric hp-h		= 37.77×10^{-8} metric hp-h
	= 27.24×10^{-7} kWhr		= 27.78×10^{-8} kWhr
1 hp-h	= 2544 Btu	1 metric hp-h	= 2510 Btu
	= 1.98×10^6 ft-lb		= 1.953×10^6 ft-lb
	= 2.738×10^6 kgm		= 27.00×10^4 kg-m
	= 2.685×10^6 J		= 2.648×10^6 J
	= 1.014 metric hp-h		= 0.9863 hp-h
	= 0.7475 kWhr		= 0.7355 kWhr

[a]This figure does not take into account the fact that electricity generation and distribution efficiency is approximately 29%. If generation and distribution efficiency are taken into account, 1 kWhr = 11,765 Btu.

Table B.4
Distance and Velocity Conversions

1 in.	$= 83.33 \times 10^{-3}$ ft	1 ft	= 12.0 in.
	$= 27.78 \times 10^{-3}$ yd		= 0.33 yd
	$= 15.78 \times 10^{-6}$ mile		$= 189.4 \times 10^{-3}$ mile
	$= 25.40 \times 10^{-3}$ m		= 0.3048 m
	$= 0.2540 \times 10^{-6}$ km		$= 0.3048 \times 10^{-3}$ km
1 mile	= 63360 in.	1 km	= 39370 in.
	= 5280 ft		= 3281 ft
	= 1760 yd		= 1093.6 yd
	= 1609 m		= 0.6214 mile
	= 1.609 km		= 1000 m

1 ft/sec = 0.3048 m/s = 0.6818 mph = 1.0972 km/h
1 m/sec = 3.281 ft/s = 2.237 mph = 3.600 km/h
1 km/h = 0.9114 ft/s = 0.2778 m/s = 0.6214 mph
1 mph = 1.467 ft/s = 0.4469 m/s = 1.609 km/h

Table B.5
Alternative Measures of Greenhouse Gases

1 pound methane, measured in carbon units (CH_4)	=	1.333 pounds methane, measured at full molecular weight (CH_4)
1 pound carbon dioxide, measured in carbon units (CO_2-C)	=	3.6667 pounds carbon dioxide, measured at full molecular weight (CO_2)
1 pound carbon monoxide, measured in carbon units (CO-C)	=	2.333 pounds carbon monoxide, measured at full molecular weight (CO)
1 pound nitrous oxide, measured in nitrogen units (N_2O-N)	=	1.571 pounds nitrous oxide, measured at full molecular weight (N_2O)

Table B.6
Volume and Flow Rate Conversions[a]

1 U.S. gal	= 231 in.^{3}	1 liter	= 61.02 in.^{3}
	= 0.1337 ft^3		= 3.531 x 10^{-2} ft^3
	= 3.785 liters		= 0.2624 U.S. gal
	= 0.8321 imperial gal		= 0.2200 imperial gal
	= 0.0238 bbl		= 6.29 x 10^{-3} bbl
	= 0.003785 m^3		= 0.001 m^3
A U.S. gallon of gasoline weighs 6.2 pounds			
1 imperial gal	= 277.4 in.^{3}	1 bbl	= 9702 in.^{3}
	= 0.1606 ft^3		= 5.615 ft^3
	= 4.545 liters		= 158.97 liters
	= 1.201 U.S. gal		= 42 U.S. gal
	= 0.0286 bbl		= 34.97 imperial gal
	= 0.004546 m^3		= 0.15897 m^3
1 U.S. gal/hr	= 3.209 ft^3/day		= 1171 ft^3/year
	= 90.84 liter/day		= 33157 liter/year
	= 19.97 imperial gal/day		= 7289 imperial gal/year
	= 0.5712 bbl/day		= 207.92 bbl/year
For Imperial gallons, multiply above values by 1.201			
1 liter/hr	= 0.8474 ft^3/day		= 309.3 ft^3/year
	= 6.298 U.S. gal/day		= 2299 U.S. gal/year
	= 5.28 imperial gal/day		= 1927 imperial gal/year
	= 0.1510 bbl/day		= 55.10 bbl/year
1 bbl/hr	= 137.8 ft^3/year		= 49187 ft^3 year
	= 1008 U.S. gal/day		= 3.679 x 10^5 U.S. gal/year
	= 839.3 imperial gal/day		= 3.063 x 10^5 imperial gal/year
	= 3815 liter/day		= 1.393 x 10^6 liter/day

[a]The conversions for flow rates are identical to those for volume measures, if the time units are identical.

Table B.7
Power Conversions

FROM	TO					
	Horsepower	Kilowatts	Metric horsepower	Ft-lb per sec	Kilocalories per sec	Btu per sec
Horsepower	1	0.7457	1.014	550	0.1781	0.7068
Kilowatts	1.341	1	1.360	737.6	0.239	0.9478
Metric horsepower	0.9863	0.7355	1	542.5	0.1757	0.6971
Ft-lb per sec	1.36×10^{-3}	1.356×10^{-3}	1.84×10^{-3}	1	0.3238×10^{-3}	1.285×10^{-3}
Kilocalories per sec	5.615	4.184	5.692	3088	1	3.968
Btu per sec	1.415	1.055	1.434	778.2	0.2520	1

Table B.8
Mass Conversions

	TO				
FROM	Pound	Kilogram	Short ton	Long ton	Metric ton
Pound	1	0.4536	5.0×10^{-4}	4.4643×10^{-4}	4.5362×10^{-4}
Kilogram	2.205	1	1.1023×10^{-3}	9.8425×10^{-4}	1.0×10^{-3}
Short ton	2000	907.2	1	0.8929	0.9072
Long ton	2240	1016	1.12	1	1.016
Metric ton	2205	1000	1.102	0.9842	1

Table B.9
Fuel Efficiency Conversions[a]

MPG	Miles/liter	Kilometers/L	L/100 kilometers
10	2.64	4.25	23.52
15	3.96	6.38	15.68
20	5.28	8.50	11.76
25	6.60	10.63	9.41
30	7.92	12.75	7.84
35	9.25	14.88	6.72
40	10.57	17.00	5.88
45	11.89	19.13	5.23
50	13.21	21.25	4.70
55	14.53	23.38	4.28
60	15.85	25.51	3.92
65	17.17	27.63	3.62
70	18.49	29.76	3.36
75	19.81	31.88	3.14
80	21.13	34.01	2.94
85	22.45	36.13	2.77
90	23.77	38.26	2.61
95	25.09	40.38	2.48
100	26.42	42.51	2.35
105	27.74	44.64	2.24
110	29.06	46.76	2.14
115	30.38	48.89	2.05
120	31.70	51.01	1.96
125	33.02	53.14	1.88
130	34.34	55.26	1.81
135	35.66	57.39	1.74
140	36.98	59.51	1.68
145	38.30	61.64	1.62
150	39.62	63.76	1.57

[a]To convert fuel efficiency from miles per gallon (mpg) to liters per hundred kilometers, divide mpg into 235.24.

Table B.10
SI Prefixes and Their Values

	Value	Prefix	Symbol
One million million millionth	10^{-18}	atto	a
One thousand million millionth	10^{-15}	femto	f
One million millionth	10^{-12}	pico	p
One thousand millionth	10^{-9}	nano	n
One millionth	10^{-6}	micro	µ
One thousandth	10^{-3}	milli	m
One hundredth	10^{-2}	centi	c
One tenth	10^{-1}	deci	
One	10^{0}		
Ten	10^{1}	deca	
One hundred	10^{2}	hecto	
One thousand	10^{3}	kilo	k
One million	10^{6}	mega	M
One billion[a]	10^{9}	giga	G
One trillion[a]	10^{12}	tera	T
One quadrillion[a]	10^{15}	peta	P
One quintillion[a]	10^{18}	exa	E

[a]Care should be exercised in the use of this nomenclature, especially in foreign correspondence, as it is either unknown or carries a different value in other countries. A "billion," for example, signifies a value of 10^{12} in most other countries.

Table B.11
Metric Units and Abbreviations

Quantity	Unit name	Symbol
Energy	joule	J
Specific energy	joule/kilogram	J/kg
Specific energy consumption	joule/kilogram•kilometer	
J/(kg•km)		
Energy consumption	joule/kilometer	J/km
Energy economy	kilometer/kilojoule	km/kJ
Power	kilowatt	Kw
Specific power	watt/kilogram	W/kg
Power density	watt/meter^3	W/m^3
Speed	kilometer/hour	km/h
Acceleration	meter/second^2	m/s^2
Range (distance)	kilometer	km
Weight	kilogram	kg
Torque	newton•meter	N•m
Volume	meter^3	m^3
Mass; payload	kilogram	kg
Length; width	meter	m
Brake specific fuel consumption	kilogram/joule	kg/J
Fuel economy (heat engine)	liters/100 km	L/100 km
Air pressure		

Conversion of Constant Dollar Values

Many types of information in this data book are expressed in dollars. Generally, constant dollars are used--that is, dollars of a fixed value for a specific year, such as 1990 dollars. Converting current dollars to constant dollars, or converting constant dollars for one year to constant dollars for another year, requires conversion factors (Table B.12 and B.13). Table B.12 shows conversion factors for the Consumer Price Index inflation factors. Table B.13 shows conversion factors using the Gross National Product inflation factors.

Table B.12
Consumer Price Inflation (CPI) Index

From	To																							
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1970	1.000	1.043	1.078	1.144	1.270	1.386	1.466	1.561	1.680	1.869	2.122	2.342	2.486	2.566	2.675	2.770	2.824	2.927	3.046	3.193	3.365	3.508	3.614	3.721
1971	0.958	1.000	1.033	1.097	1.217	1.328	1.405	1.496	1.609	1.791	2.035	2.245	2.382	2.458	2.563	2.654	2.708	2.806	2.921	3.061	3.227	3.364	3.465	3.567
1972	0.928	0.968	1.000	1.062	1.179	1.286	1.361	1.448	1.559	1.735	1.971	2.174	2.307	2.381	2.482	2.571	2.620	2.717	2.828	2.963	3.124	3.256	3.354	3.453
1973	0.874	0.911	0.941	1.000	1.110	1.211	1.281	1.364	1.467	1.633	1.856	2.047	2.173	2.243	2.338	2.421	2.469	2.558	2.662	2.790	2.941	3.065	3.158	3.251
1974	0.787	0.821	0.848	0.901	1.000	1.091	1.154	1.229	1.322	1.472	1.672	1.844	1.956	2.019	2.105	2.180	2.224	2.305	2.399	2.514	2.650	2.762	2.846	2.930
1975	0.721	0.752	0.777	0.826	0.916	1.000	1.058	1.126	1.212	1.349	1.532	1.690	1.792	1.850	1.929	1.997	2.038	2.112	2.198	2.303	2.428	2.531	2.607	2.684
1976	0.682	0.712	0.736	0.781	0.866	0.945	1.000	1.065	1.145	1.275	1.449	1.598	1.696	1.750	1.824	1.889	1.926	1.997	2.078	2.178	2.296	2.393	2.465	2.538
1977	0.641	0.668	0.690	0.733	0.814	0.888	0.939	1.000	1.076	1.198	1.361	1.501	1.594	1.645	1.715	1.776	1.809	1.876	1.952	2.046	2.156	2.248	2.316	2.384
1978	0.595	0.621	0.642	0.682	0.756	0.825	0.873	0.929	1.000	1.113	1.265	1.395	1.479	1.527	1.592	1.648	1.681	1.742	1.813	1.900	2.003	2.088	2.151	2.214
1979	0.535	0.558	0.576	0.612	0.679	0.741	0.784	0.835	0.898	1.000	1.135	1.253	1.330	1.373	1.431	1.482	1.511	1.566	1.630	1.708	1.800	1.877	1.933	1.990
1980	0.471	0.491	0.508	0.539	0.598	0.653	0.690	0.735	0.791	0.881	1.000	1.103	1.171	1.209	1.260	1.305	1.331	1.379	1.436	1.504	1.586	1.653	1.703	1.753
1981	0.427	0.445	0.460	0.489	0.542	0.592	0.626	0.666	0.717	0.798	0.907	1.000	1.062	1.096	1.142	1.183	1.206	1.250	1.301	1.363	1.437	1.498	1.543	1.588
1982	0.402	0.420	0.434	0.460	0.511	0.558	0.590	0.628	0.676	0.752	0.853	0.942	1.000	1.032	1.075	1.114	1.136	1.178	1.226	1.284	1.354	1.411	1.454	1.497
1983	0.390	0.406	0.420	0.446	0.495	0.540	0.571	0.608	0.655	0.728	0.827	0.913	0.970	1.000	1.043	1.080	1.100	1.141	1.187	1.244	1.312	1.367	1.409	1.450
1984	0.374	0.390	0.403	0.428	0.475	0.518	0.548	0.584	0.628	0.699	0.793	0.876	0.930	0.960	1.000	1.036	1.056	1.094	1.139	1.194	1.258	1.311	1.351	1.391
1985	0.361	0.376	0.389	0.413	0.458	0.500	0.529	0.564	0.606	0.675	0.766	0.846	0.898	0.926	0.966	1.000	1.019	1.057	1.100	1.152	1.215	1.266	1.304	1.343
1986	0.354	0.369	0.382	0.405	0.450	0.491	0.519	0.553	0.595	0.662	0.751	0.829	0.880	0.909	0.947	0.981	1.000	1.037	1.079	1.131	1.192	1.242	1.280	1.318
1987	0.342	0.356	0.368	0.391	0.434	0.474	0.501	0.533	0.574	0.639	0.725	0.800	0.849	0.876	0.914	0.946	0.964	1.000	1.041	1.091	1.150	1.199	1.235	1.271
1988	0.328	0.342	0.354	0.376	0.417	0.455	0.481	0.512	0.552	0.614	0.697	0.769	0.816	0.842	0.878	0.909	0.927	0.961	1.000	1.048	1.105	1.152	1.186	1.221
1989	0.313	0.327	0.337	0.358	0.398	0.434	0.459	0.489	0.526	0.586	0.665	0.734	0.779	0.804	0.838	0.868	0.884	0.917	0.954	1.000	1.054	1.099	1.132	1.165
1990	0.297	0.310	0.320	0.340	0.377	0.412	0.436	0.464	0.499	0.555	0.631	0.696	0.739	0.762	0.795	0.823	0.839	0.870	0.905	0.949	1.000	1.042	1.074	1.106
1991	0.285	0.297	0.307	0.326	0.362	0.395	0.418	0.445	0.479	0.533	0.605	0.668	0.709	0.731	0.762	0.790	0.805	0.834	0.868	0.910	0.959	1.000	1.030	1.061
1992	0.277	0.289	0.298	0.317	0.351	0.384	0.406	0.432	0.465	0.517	0.587	0.648	0.688	0.710	0.740	0.767	0.781	0.810	0.843	0.883	0.931	0.971	1.000	1.030
1993	0.269	0.280	0.290	0.308	0.341	0.373	0.394	0.419	0.452	0.502	0.570	0.630	0.668	0.690	0.719	0.745	0.759	0.787	0.819	0.858	0.905	0.943	0.971	1.000

Source:
U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Washington, DC, monthly.

Table B.13
Gross National Product (GNP) Implicit Price Deflator

From	To																							
	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
1970	1.000	1.051	1.095	1.159	1.260	1.377	1.448	1.534	1.646	1.789	1.953	2.141	2.270	2.356	2.454	2.531	2.600	2.667	2.763	2.867	2.985	3.120	3.230	3.294
1971	0.951	1.000	1.041	1.101	1.198	1.310	1.377	1.457	1.566	1.701	1.859	2.035	2.157	2.241	2.334	2.412	2.475	2.535	2.625	2.724	2.836	2.966	3.070	3.131
1972	0.913	0.960	1.000	1.058	1.150	1.257	1.323	1.400	1.504	1.634	1.786	1.955	2.072	2.151	2.240	2.315	2.375	2.435	2.522	2.617	2.725	2.849	2.949	3.007
1973	0.863	0.908	0.945	1.000	1.087	1.188	1.250	1.323	1.421	1.544	1.688	1.848	1.958	2.033	2.118	2.189	2.242	2.301	2.383	2.473	2.575	2.692	2.787	2.842
1974	0.794	0.834	0.869	0.920	1.000	1.094	1.150	1.218	1.307	1.421	1.551	1.700	1.802	1.871	1.948	2.014	2.062	2.117	2.193	2.276	2.370	2.477	2.564	2.614
1975	0.726	0.763	0.795	0.841	0.915	1.000	1.051	1.114	1.195	1.299	1.418	1.554	1.648	1.711	1.782	1.841	1.887	1.936	2.006	2.081	2.167	2.265	2.344	2.391
1976	0.691	0.726	0.756	0.800	0.871	0.952	1.000	1.058	1.137	1.235	1.350	1.478	1.566	1.628	1.696	1.752	1.795	1.840	1.906	1.978	2.059	2.153	2.228	2.272
1977	0.652	0.686	0.714	0.756	0.822	0.898	0.945	1.000	1.074	1.167	1.273	1.396	1.479	1.536	1.600	1.654	1.695	1.738	1.800	1.868	1.945	2.033	2.105	2.146
1978	0.608	0.639	0.665	0.704	0.766	0.837	0.880	0.931	1.000	1.087	1.187	1.300	1.378	1.432	1.492	1.542	1.580	1.619	1.677	1.740	1.812	1.894	1.961	1.999
1979	0.559	0.588	0.612	0.648	0.704	0.770	0.810	0.857	0.920	1.000	1.092	1.196	1.268	1.317	1.372	1.418	1.453	1.490	1.543	1.601	1.667	1.743	1.804	1.840
1980	0.512	0.539	0.560	0.592	0.645	0.705	0.741	0.784	0.842	0.915	1.000	1.095	1.160	1.206	1.256	1.298	1.332	1.363	1.412	1.465	1.525	1.595	1.651	1.683
1981	0.467	0.491	0.512	0.541	0.588	0.643	0.677	0.717	0.770	0.837	0.912	1.000	1.061	1.100	1.146	1.184	1.214	1.247	1.291	1.340	1.395	1.459	1.510	1.540
1982	0.441	0.464	0.483	0.511	0.556	0.607	0.639	0.676	0.726	0.789	0.861	0.944	1.000	1.040	1.082	1.118	1.145	1.175	1.217	1.263	1.315	1.375	1.423	1.451
1983	0.424	0.446	0.464	0.491	0.534	0.584	0.614	0.651	0.698	0.759	0.828	0.907	0.962	1.000	1.040	1.075	1.104	1.130	1.171	1.215	1.265	1.322	1.368	1.396
1984	0.408	0.428	0.445	0.471	0.514	0.562	0.589	0.624	0.670	0.728	0.797	0.870	0.922	0.961	1.000	1.035	1.059	1.083	1.122	1.164	1.212	1.267	1.312	1.338
1985	0.395	0.415	0.433	0.458	0.498	0.544	0.572	0.606	0.645	0.707	0.772	0.846	0.897	0.931	0.944	1.000	1.027	1.054	1.092	1.133	1.180	1.233	1.276	1.302
1986	0.385	0.404	0.421	0.446	0.485	0.530	0.557	0.590	0.633	0.688	0.751	0.824	0.873	0.906	0.944	0.974	1.000	1.026	1.062	1.103	1.148	1.200	1.242	1.267
1987	0.375	0.395	0.411	0.435	0.472	0.517	0.544	0.575	0.618	0.671	0.734	0.802	0.851	0.885	0.923	0.949	0.975	1.000	1.036	1.075	1.119	1.170	1.211	1.235
1988	0.362	0.381	0.397	0.420	0.456	0.499	0.525	0.556	0.596	0.648	0.708	0.774	0.822	0.854	0.891	0.916	0.941	0.966	1.000	1.038	1.081	1.130	1.170	1.193
1989	0.349	0.367	0.382	0.404	0.439	0.480	0.506	0.535	0.575	0.624	0.683	0.746	0.792	0.823	0.859	0.883	0.907	0.930	0.963	1.000	1.041	1.088	1.126	1.149
1990	0.335	0.353	0.367	0.388	0.422	0.461	0.486	0.514	0.552	0.600	0.656	0.717	0.760	0.790	0.825	0.848	0.871	0.894	0.925	0.960	1.000	1.046	1.083	1.104
1991	0.320	0.337	0.351	0.371	0.404	0.441	0.465	0.492	0.528	0.574	0.627	0.685	0.727	0.756	0.789	0.811	0.833	0.855	0.885	0.919	0.956	1.000	1.035	1.056
1992	0.310	0.326	0.339	0.359	0.390	0.427	0.449	0.475	0.510	0.554	0.606	0.662	0.703	0.731	0.762	0.783	0.805	0.826	0.855	0.888	0.924	0.966	1.000	1.020
1993	0.304	0.319	0.333	0.352	0.382	0.418	0.440	0.466	0.500	0.543	0.594	0.649	0.689	0.717	0.748	0.768	0.789	0.810	0.838	0.871	0.906	0.947	0.980	1.000

Source:
U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, Washington, DC, monthly.

APPENDIX C

International Data from Lawrence Berkeley Laboratory

Data Sources by Country

In general the LBL analyses proceed bottom-up using each country's main data sources on vehicle activity, as well as travel (passenger-kilometers) and freight (tonne-kilometers). Aggregate data on traffic, travel and freight by mode (including data for car travel derived usually from travel surveys) are split where possible by fuel, ie., into activity for gasoline, diesel, and liquified petroleum gas. Fuel data are developed by each country source, typically by first parsing reported data (rail, bus, some trucking, domestic shipping, domestic air travel) and then splitting the remaining road fuels into modes. Usually the sources are followed, but important exceptions are Sweden, Denmark, and Italy, where LBL has tried to resolve often conflicting information from a number of experts and published sources. For rail energy use, it is assumed (unless data show otherwise) that electricity is used only for passenger travel (as well as for local rail transit) and the diesel fuel is split according to a formula where two passenger-kilometers traveled are equal to one tonne-kilometer of freight hauled. (Air freight is parsed according to weight, approximately seven passengers (with baggage) equals one tonne.) The other modes such as motorcycles, mopeds, and waterborne travel are not usually analyzed and pipelines are omitted for most countries because of a lack of data on volume (tonne-kilometers) or energy consumed or both. LBL omits international shipping and tries to eliminate fuel use for international passenger and freight air transport because there are virtually no data on activity by country of traveler. Also, each country's travel surveys are used to check modal distributions with the aggregate sources.

To insure comparabilty with the U.S., LBL has taken these precautions with "cars." First, U.S. personal light trucks (approximately 2/3 of all light trucks and light truck travel) are counted with automobiles, since these are clearly used as household vehicles and now make up more than 20% of the household vehicle stock. Light trucks and vans in Denmark and Britain are also counted with automobiles, making up about 3-5% of the stock. Light trucks and vans in the other Nordic countries, however, cannot easily be separated from other trucks, so are not counted as "cars." This represents approximately 2% of the personal vehicle stock in Sweden, Norway, and Finland. Mini-cars in Japan are counted as cars. Light trucks are not used extensively as household vehicles in Italy, Germany, and France.

JAPAN

Two sources publish data on transportation energy consumption in Japan: (1) the Ministry of Transport (MOT) and (2) the Ministry of International Trade and Industry (MITI) in cooperation with the Energy and Data Modelling Center (EDMC) of the Institute of Energy Economics (IEE). However, only the MOT collects data through direct surveys, whereas MITI and IEE derive figures for energy consumption through indirect calculation. MITI assumes average fuel-intensity levels and derives energy consumption in a top-down fashion, a practice criticized as unreliable in an earlier study done at Lawrence Berkeley Laboratory (LBL). In addition, of these agencies only the EDMC performs detailed energy analyses of the country's transportation sector, but few of these studies are published outside of Japan.

We use MOT data as the most accurate, bearing in mind the following changes in the data series: before 1981, road vehicle fuel consumption figures are based only on fuel sales data; since 1981, the MOT has conducted surveys, with more modes included in a consistent manner; since 1987, mini-car and mini-truck transport has been counted. We have extrapolated data on the use of mini-cars from after 1987 to prior years using a constant yearly driving distance and the known number of these small vehicles. We assume a load factor of 1.5. The Japanese sources show a significant increase in all automobile load factor after 1987, which boosts passenger travel in this mode by over 10% in one year. We can find no explanation for this rapid change. Although some uncertainties still remain, the characteristics of energy use in Japanese transportation are so striking, and the changes observed so large, compared with the uncertainties, that we feel any conclusions drawn from our data are robust.

Lawrence Berkeley Laboratory has been very careful with Japanese translations, since "car" connotes automobile, truck, bus, and even motorcycle. For this work, car/automobile includes ordinary automobiles and mini-cars, which have a displacement of under 600 CC. Truck includes mini-trucks. Rail activity includes that of both national (JNR) and private companies, and rail energy use includes electricity generated by the JNR itself. In all, the Japanese data are considered most reliable from 1982 and thereafter, but the analysis of 1970-1982 gives a useful picture of actual developments.

Source material - Japan

The Institute of Energy Economics. (1992). Energy Data and Demand of Transportation Sector in Japan, Tokyo: The Energy Data and Modelling Center, The Institute of Energy Economics.

The Institute of Energy Economics, yearly. Enerugii Keizai Toukei Youran (Energy Economics Statistical Survey). Tokyo: Energy Data and Modeling Center, IEE.

Institute of Energy Economics Energy Data Modeling Center. Annual Energy Statistics

Ministry of Transport, 1993. Jidosha Unso Tokei Nenjo ("Automobile Transportation Statistical Yearbook"),

Japan Automobile Association, Rikuun Tokei Yoran (Land Transport Statistical Handbook), various years.

Ministry of Transport, Statistics of Automobile Transportation, Energy Handbook on Transportation, various years.

Ministry of Transport, Unyu Kankei Enerugi Yoran ("Transportation Energy Statistics Handbook"), various years.

FRANCE

Energy use data are both derived from the following sources: **Tableaux des Consommations d'Energie en France** (Observatoire de l'Energie), **Les Comptes des Transports**, (INSEE, the National Statistical Office, in their series **Resultats**) and Didier Bosseboeuf of ADEME, l'Agence d''Environment et de lat Maitrise de l'Energie.

Activity data are mainly from INSEE, complemented by a few other sources. Air passenger (passenger-kilometers) and seat activity (seat-kilometers) data refer to Air Inter, which handles approximately 95% of all domestic flights. Rail activity data for both intercity (passenger-kilometers) travel and freight (tonne-kilometers) refers to SNCF. Bus activity (passenger-kilometers) assumes a load factor (LF) of 23 for years 1970-1980 (which is about the 1983-87 average). It is estimated by multiplying this LF with known vehicle-kilometers numbers.

Vehicle use data are based on the following assumptions: (a) automobile use (kilometers/car/year) for years 1970, 1971, and 1973 is estimated assuming a load-factor (LF) of 1.85 and using activity (passenger-kilometers) and stock data; and (b) gasoline-powered automobile use was estimated, assuming that diesel cars in 1970 went 2.4 times as far as the average car, which narrowed to 2.0 times by 1988 (refer to Observatoire de l'Energie).

Automobile energy use includes liquid petroleum gas (LPG). The 1970-1972 data for both gasoline and diesel powered automobiles are estimated by multiplying toe/vehicle and stock of vehicles. Air energy use is fuel used for domestic flights by Air Inter. After 1985, a new means of accounting for diesel energy use for buses was adopted. Rail electricity use data of SNCF and RATP are converted from primary to delivered energy.

Assumptions for energy use include: (a) 1970-1972 data for gasoline-powered automobiles are based on the 1974 ratio of tons of oil equivalent (toe) and vehicle-kilometers; (b) for these same years, it is assumed that fuel economies were about constant for both diesel and gasoline cars in years 1970 and 1973. This assumption was made to approximate average fuel economy estimates supplied by Didier Bosseboeuf; (c) 95% of air energy use is for passenger use (which is derived from Air Inter's energy intensity figures (megajoules/passenger-kilometers) for domestic flights; and (d) passenger share of rail transport assumes one passenger-kilometer uses as much energy as 1.25 ton-kilometers, which coincides with 1988 data. After 1988 there is a slight series break in the accounting for automotive diesel.

Source material - France

INSEE and OEST (Institut National de la Statistique et des Etudes Economiques and Observatoire Economique et Statistique des Transport). 1987-1994. Les Comptes des Transports (Transport accounts) Paris, France: INSEE. (Published Yearly)

Ministry of Industry, 1975-1994. Tableaux des Consummation d'Energie en France (Tables of Energy Consumption in France). Paris: Ministry of Industry

ITALY

Italian sources present many conflicting figures for both activity and energy use.

Automobile vehicle use data include average kilometers traveled by both gasoline and diesel cars. Truck vehicle use data include 3-wheeled trucks. Intercity activity data refer to freeways and trunk roads. Pipeline activity data include pipelines greater than 50 kilometers.

Intracity passenger and freight movement data exist only for rail. All other intracity movement (bus, car, truck) are estimates from AGIP Petroli.

Energy use from coal in rail transport applies the conversion factor of 7500 kcal/kg (except for 1970 and 1972, which applies 7410 and 6500 kcal/kg, respectively. Assumptions in energy use include: (a) diesel passenger share used in calculating total energy use in rail transport assumes transporting 1.25 persons is equivalent to 1 ton; (b) passenger share of jet fuel use is estimated at 97% which is similarly used for other countries; and (c) jet fuel domestic share energy use is estimated at 18% for 1973 and grows at 1% per year. This assumption allows consistency with AGIP Petroli's modal intensity figures.

There are some inconsistencies in the energy use data: (a) the public sector diesel consumption drops significantly from 1978 and 1979, suggesting that the 1970-1978 time series may include diesel fuel consumption for heating purposes; (b) truck energy use data, which come from Ministry of Transport, are missing for a number of years (1970-1971, 1973-1977, 1979-1986, and 1988) and therefore have been interpolated. If one tries to calculate energy use, weighted by activity (vehicle-kilometers), different numbers result. The question concerns how the Ministry of Transport arrived at their calculations; (c) data on energy consumption of jet fuel in air transport for years 1976-1978 were adjusted to correct for inconsistency; and (d) end-use energy data from the Ministry of Industry appear to be high. It is uncertain if the data include other uses, like heating or cooking.

Source material - Italy

Major sources of data include: ANFIA, *L'automobile in cifre*, 1988; AGIP Petroli; Ministero dei Trasporti, *Conto Nationale Trasporti (Anno 1988 e prime anticiazioni per il 1989* and subsequent years); Ministero dei Trasporti, Piano Generale Trasporti; ISTAT: *Sommario di Statistiche Storiche*; and International Road Federation (IRF), World Road Statistics.

Energy use data come from the following sources: AGIP Petroli; Unione Petrolifera; Ministero dei Trasporti, *Piano Generale Trasporti*; Ministero dell'Industria, Commerciol ed Artigianato, *Bilancio Energetico Nazionale*.

Ministero Dei Trasporti, Direzione Generale Programmazione, Organizzazione e Coordinamento, 1993. Conto nationale dei Trasporti (National Traffic Statistics). Rome: Istituto Poligrafico e Zecca dello Stato. (1989, 1991 and 1992 editions)

Unpublished calculations of AGIP, the State Oil Company (private communication).

SWEDEN

The data on energy use come from two sources: the National Energy Administration (STEV, now NUTEK); and the Transportation Council (TPR, now taken over by the Highway Institute in Linkoeping). In 1977 SIND (the predecessor to STEV) prepared a forecast of energy use in Sweden that was based in part upon detailed breakdowns of energy use in the transportation sector provided by the predecessor of TPR. These were "updated" in subsequent energy studies published by STEV. TPR has continually published data on passenger- and tonne-kilometers. Currently, data on travel and freight are published by the Highway Institute. The Central Bureau of Statistics publishes data on the characteristics of the vehicle stock. The Swedish Automobile Association and AB Bilstatistik publish a yearbook with other details of the vehicle stock, such as the number of cars by weight.

In the 1980s J. Wajsmann of TPR began a systematic bottom-up analysis of energy use in the transportation sector. His unpublished analyses have been provided to STEV for their own yearly breakdowns of Swedish energy use. In these he examines the number of vehicles, kilometers driven and consumption of fuel per kilometers for four types of cars (gasoline private cars and taxis, and diesel private cars and taxis), buses, and trucks. He covers domestic air travel and inland shipping, as well as many smaller users of liquid fuels. Data on electricity use for the railways and local transit are published by the Central Bureau of Statistics' El och Fjaerrvaerme Foersoerjning (Electricity Supply Statistics). Wajsmann's analyses cover 1980, and 1983 to 1989. The match with the 1970-76 data is not perfect, but acceptable for our purposes. Using data on the stock of vehicles and modal activity, we have reconstructed 1978 and 1981-82 energy use patterns and interpolated remaining years between 1976 and 1983. We have also estimated automobile vehicle-kilometers and fuel economy for 1970-1976, since the SIND data and their TPR source contain very little information on these two parameters. However, Energiprognosutredning (1974) provides a detailed breakdown of transportation energy use in 1970 and some information for 1973. Assembling these together we believe we have created a reasonable picture of the 1970-76 period that can be compared with the period from 1980 to the present. Finally, a large number of smaller official and unofficial publications reviewed in Appendix 3 of Schipper L.J. and Johnson F., with Howarth R., Andersson B.E., Anderson B.G., and Price LK. 1993. Energy Use in Sweden: An International Perspective. Lawrence Berkeley Laboratory Report LBL-33819. Berkeley, CA: Lawrence Berkeley Laboratory. Published as Schipper and Price 1994 in **Nat. Res. Forum** (May).

Source material - Sweden

Bilindustrifoerening, 1994 (each year). Bilism i Sverige 1993. (Driving in Sweden 1993) Stockholm: AB Bilstatistik.

National Central Bureau of Statistics (Sweden). 1984/5 Resavanorundersoekning. Statistiska meddelanden (1984/5 Survey of travel habits). Stockholm, Sweden: Statistics Sweden

VTI, 1993. VTI Transportstatistik. (Swedish Road Institute Transport Statistics.) Appears Quarterly. Stockholm: DPU (Delegation foer prognos och utvecklingsverksamhet inom transportsektorn, Dept. of Communications).

Vilhelmson, B. 1990. Vaar dagliga roerlighet (Our Daily Mobility). Stockholm, Sweden: Transportforskningsberedning, TFB Rapport 1990:16

FINLAND

Information about the vehicle stock refers to the source: Transport and Communications Statistical Yearbook for Finland 1993. Activity data are partly from a database maintained by the Ministry of Transport (A. Koskinen, private communication), which includes vehicle-kilometers for both travel and freight by vehicle type and fuel. Added to this data was information on buses in Helsinki (Helsingfors Trafikverket). Vehicle-kilometers for cars for the years 1970-74 come from the Ministry database, but for the remaining years LBL used information from the National Road Administration. The published statistics of the Road Administration use 12,000 kilometers as the length of street network in 1975-91 and afterwards switch to 15,000 kilometers. To avoid this discrepancy in the data set a continuous times series was used based on a 15,000 kilometers long street network recently processed by the Road Administration. Passenger-kilometers for cars are from the Road Administration. Passenger-kilometers for buses and motorcycles refer to the source Transport and Communications Statistical Yearbook of Finland 1993. Passenger-kilometers for the buses in Helsinki are from Helsingfors Trafikverket.

Information on energy consumption for road traffic is based on the earlier mentioned database from Ministry of Transport. LBL completed this data with the information on specific consumptions of new cars sold each year estimated by Harri Kallberg of Neste, the State Oil Company (private communication).

LBL made its own estimates for the few years not covered by data provided. These were usually estimated by multiplying published activity levels by the interpolations of energy intensities.

Source material - Finland

Bureau of Statistics (TLK). Annual Abstract of Transportation Statistics. Helsinki: Central Bureau of Statistics.

Central Bureau of Statistics, Transport and Communications Statistical Yearbook for Finland 1993, Helsinki, Finland.

Traffic Authority of Helsinki, Helsingfors Trafikverket, Helsinki, Finland.

NORWAY

Estimates of passenger- and tonne-kilometers activity are published in Samferdsel Statistikk (Transportation Statistics) and in publications from Transport Oekonomisk Institute (TOI) in Oslo. Estimates of automobile use stem from surveys taken in 1967, 1973, 1981, and 1985-88, "Eie og Bruk av Bil". Numbers of vehicles are published in Samferdsel statistikk and in Bil og Vei, the publication of the Norwegian Road Authority (Veg Direktorat). "Cars" (biler) includes virtually all vehicles, but "person biler" represents automobiles for private and business use.

Energy use by mode is poorly documented in public literature. The Bureau of Statistics publishes "Road", "Rail", "Ship", and "Air" energy use by fuel in their yearly Energistatistikk and Energiregnskap. Data from 1976 to 1980 and 1980 to 1986 contain many detailed breakdowns of individual transportation mode's energy use (and activity). Esso (A. Kvamme, private communication) has made their own research into the matter, breaking both the automobile and truck fuel markets into considerable detail. Because the Esso data cover the longest period (1970 to present) and make the most detailed attempt to balance all the various liquid fuels markets, we use the data they kindly provided to match energy use, activity, and energy use per vehicle-kilometers.

Transport Economics Institute has estimated the fuel economy of new cars by examining the most popular models sold and their test fuel consumption.

Source material - Norway

Central Bureau of Statistics (SSB), 1970-1994. Samferdsel Statistikk (Transport statistics) Kongsviner: SSB

OFV, 1994. Bil og Vei: Statistikk 1994 (Car and Road Statistics for 1994.). Oslo: Opplysnings raadet for Veitraffikken.

Rideng, A., 1993. (Transport Oekeonomisk Institutt, various years). Transportytelser i Norge (Transport in Norway) 1946-1992. TOI Rapport 187/1993. Oslo: Transport Economic Institute

Transport Oekeonomisk Institutt. 1993. Norsk reisevaner. Dokumentasjonsrapport for den landsomfattande reisevaneundersoekelsen 1991-2 (National survey of travel habits 1991-2). Report 183. Oslo: Transport Economic Institute

Vibe, N., 1993. Vaare Daglige reiser. Endringer i Nordmenns reisevaner fra 1985 til 1992. (Our Daily Travel. Changes in Norwegians' Daily Travel 1985-1992). TOE rapport 171. Oslo: Transport Economics

DENMARK

Data come from a variety of government and automobile industry sources. Through an earlier contract with the Danish Energy Agency, an LBL team helped authorities revise data for energy and transportation. Data for vehicle use and fuel consumption are provided for each type of vehicle by fuel type: cars, light trucks (under one tonne), buses, various sizes of trucks. Data on passenger travel are provided by the Ministry of Transport publications, with one important exception. Official sources use a constant automobile load factor for the entire 1970-1992 period to convert vehicle-kilometers to passenger-kilometers. After reviewing a number of studies of travel and load factor, it was concluded that this was incorrect. We start with a figure of 1.85 for 1970 and, using surveys for 1975, 1981, 1986, and 1992 and estimating the impact of including children and older people not counted in these surveys, arrive at a load factor close to 1.6 for 1992, using interpolation for years not surveyed. As a result, the data show lower total travel in Denmark than Danish data, and significantly less growth in travel. Light trucks ("vaerebiler") under 1 tonne capacity are counted with automobiles. Foreign (transit) truck traffic is excluded from both tonne-kilometers and energy consumption calculations.

Source material - Denmark

Trafikministeriet (Danish Ministry of Transport). 1990. Transportstatistik 1980-1991 [Transport statistics 1980-1991] Copenhagen, Denmark: Trafikministeriet. Now Published Yearly

Automobil-importoerernes Sammenslutning (VIS), 1994. Vejtransporten i tal og tekst (Road transportation statistics) Hellerup: VIS. Editions from 1975 onward

Tofte, E., and Joergensen, J., 1992. Befolknings Rejsevaner (The Travel Habits of the Population). Copenhagen: Trafikministeriet

Trafik- og Kommunikationsministeriet (Danish Ministry of Transport and Communications). 1988. Persontrafik i 1975, 1981 og 1986 (Personal travel in 1975, 1981, and 1986) Copenhagen, Denmark: Trafik- og Kommunikationsministeriet

Vejdirektoratet, 1994. Tal om Vejtrafik (Data on road traffic). Copenhagen: Veijdirektorat Sektorplanafdelingen

For further information see L. Schipper et al. Energy Use in Denmark in an International Perspective, LBL 32362. Berkeley: Lawrence Berkeley Laboratory.

UNITED KINGDOM

Transportation activity and energy data are taken from the U.K. Digest of Transportation Statistics, published yearly by the Department of Transport. These contain data covering Great Britain (England, Wales, and Scotland), and, for a few tables, the United Kingdom (ie., including N. Ireland) as well. Most data are taken directly from this source. Fuel use for road vehicles from1981 was reanalyzed by B.Oelman, Dept. of Tranpsort (private communication). Light trucks and small vans are counted with automobiles.

Source material - United Kingdom

Department of Transport (DOT). 1970-1994. Transport Statistics: Great Britain. London, UK: Her Majesty's Stationery Office

Transport Department, various years. National Travel Survey. (1972/3, 1982/3, 1985/6, 1990/91) London, UK: Her Majesty's Stationery Office

WEST GERMANY

The primary source of data on transportation and energy use is: Deutsches Institut fuer Wirtschaftsforschung: *Verkehr in Zahlen* (various editions). This handbook contains a nearly complete set of data for traffic, travel and freight activity and energy use from 1950 to 1993. LBL assumed, however, that 1/3 of air fuel was for domestic travel, and formed a split of rail energy into travel and freight components. Additional supporting data for rail and air travel are from: Deutsches Institut fuer Wirtschaftsforschung: *Detaillierung des Energieverbrauchs in der BRD im HuK, Industrie und Verkehr nach Verwendungswecken*; and Deutsches Institut fuer Wirtschaftsforschung, *Der Endenergieverbrauch im Sektor Verkehr nach Subsektoren sowie nach Verwendungsarten und Verkehrsbereichen* (1984).

Source material - West Germany

Deutsches Institut fuer Wirtschaftsforschung (DIW) 1972-1994. Verkehr in Zahlen 1994. (Traffic in Figures). Bonn, Germany: Bundesminister fuer Verkehr

Vergleichende Auswertungen von Haushaltsbefragungewn zum Personennahverkehr (KONTIV 1976, 1982, 1989). Berlin, West Germany: Deutsches Institut fuer Wirtschaftsforschung (DIW). Original is Emnid-Institut GMBH & Co. 1990. KONTIV 1989. (Four Volumes.) Bielefeld, West Germany

Kloas J. and Kuhfeld H. 1987. Verkehrsverhalten im Vergleich (Comparisons of Travel Behavior (KONTIV). DIW (Deutsches Institut fuer Wirtschaftsforschung). Berlin, West Germany: Duncker and Humboldt

UNITED STATES

The transportation data come from three major sources: Oak Ridge National Laboratory (ORNL) and the US Department of Transportation (DOT). Virtually all of the time-series data beginning from 1970 to the present are extracted from ORNL's Transportation Energy Data Book: Editions 11-14, 1991-1994. and subsequent editions, and FHWA Statistical Summary to 1985.

Energy use data are from ORNL's Transportation Energy Data Books.

Assumptions for vehicle use (vehicle-kilometers) and energy use include: (a) light trucks have the same mileage as automobiles, and the share used as personal vehicles is taken from the ORNL data book (for example Table 2.12 of Edition 12.); (b) all light freight vehicle use is assumed to be for intracity transport; (c) domestic air is estimated at 87% of total vehicle-kilometers. Load factor (LF) estimates include the following: (a) automobile LF is estimated at 2.2 persons from 1960 to

1970. It then decreased to 1.87 by 1977, 1.7 by 1983, and 1.59 in 1990. (b) motorcycle LF (not shown) is estimated at 1.1 persons; (c) personal truck LF is estimated at 110% of the automobile LF.

Two areas of concern are: (a) a discrepancy exists between between automobile stock cited in ORNL (Polk) and DOT FHWA. The former survey shows fewer cars than FHWA; and (b) there is a growing population of light trucks used solely for personal travel. TIUS survey data (reported in ORNL and used in the time-series data on stock and activity) show the share of trucks used for personal travel growing from approximately 25% in 1960 to 68% in 1988. This equates to a 77% share of light trucks used for personal travel in 1988.

The Polk data used show declining number of cars in 1992, as noted in Chapter 3. This leads to an apparent increase in distance driven/car. This discrepancy will be resolved in a future issue.

Source material - United States

Davis S.C. 1994. Transportation Energy Data Book: Edition 14. Oak Ridge, TN: Oak Ridge National Laboratory, ORNL-6710 (Edition 14 of ORNL-5198) (and previous editions)

Klinger D. and Kuzmyak R. 1986. Personal Travel in the U.S.: Nationwide Personal Transportation Study (NPTS) Washington, DC: U.S. Department of Transportation, Federal Highway Administration.

U.S. FHWA (Federal Highway Administration). 1993 (and previous years). Highway Statistics 1992. Washington, DC: U.S. Department of Transportation, Federal Highway Administration, FHWA-PL-93-023

U.S. Department of Transportation. 1992. U.S. Nationwide Personal Transportation Survey. Washington, DC: U.S. Dept. of Transportation

Detail of Data Revisions from Edition 14

From time to time the national sources used to compile these tables revise data as better estimates of the components of energy use and transportation activity are made available to Lawrence Berkeley Laboratory (LBL). In this edition the data from Italy, Denmark, Great Britain, Sweden, and Japan have been significantly revised as new historical material appeared. Here are some general notes on changes in the data series.

- For Japan, LBL prepared a separate analysis of trends in transportation activity and energy use in Japan from 1965 to 1991 (Kiang and Schipper, to be published in Transport Policy). This study, and the present data, used unpublished studies from the Japan Institute of Energy Economics as well as published data from the Ministry of Transport. Passenger- and tonne-kilometer data are published by the Institute for Energy Economics' "Energy Data and Modelling Center" every year. The key revisions in the present data are the inclusion of activity of small mini-cars and mini-trucks, including our estimate of the passenger travel in mini-cars back to 1965 (based on load factors from 1987 onward). LBL cannot explain the jump in automobile load factor for "normal" cars that appeared in 1987. This load factor is obtained by comparing time series for vehicle-kilometers and passenger-kilometers for automobiles from the same source.

- For Italy, LBL received new estimates of fuel use from AGIP (the Italian State Oil Company) as well as the latest National Accounts for Transportation. AGIP estimates the contribution of local traffic (intra city use of cars and trucks) to totals. LBL estimated energy use by mode for 1975-1978 using interpolation.

- For France, the long-standing yearly Tableaux des Consummations d'Energie, one of the two main data sources for France, did not appear in 1994. Instead, the new data relies on the Les Comptes des Transports as published by INSEE, and these appear to be consistent with both earlier years and with the data published by the earlier source. This source will replace all others in the future.

- For Sweden, The Transportation Council, which used to publish quarterly activity data, ceased to exist in 1991; recently, the Swedish Road Institute in Linkoeping began to publish quarterly data on passenger-kilometers and tonne-kilometers of activity (VTI Transportstatistik.), mostly obtained from the Bureau of Statistics. These data entail slight revisions in freight activity. For automobile activity, there are no widely-accepted figures for either vehicle-kilometers or passenger-kilometers. LBL used estimates developed by the Road Institute (H. Joensson, private communication) as the basis for the activity estimates, and a load factor of 1.5 to get passenger-kilometers. The estimte of fuel use per kilometer for automobiles is higher than theirs and is documented in an appendix to Schipper, et. al., 1993.

- For Norway, LBL dropped figures on fuel use for domestic aviation, as these fail to distinguish domestic from international traffic. Fuel use figures for domestic shipping reflect some revisions as the Bureau of Statistics provides more detailed data in their yearly Energy Balances. Fuel-use figures for road traffic are still provided by Esso, who has made small revisions from time to time.

- The Danish Road Authority published its first own comprehensive road statistics in 1994, which covered data (much revised) through 1992. This book still assumes a constant load factor for automobile use throughout the entire 1970's and 1980's but acknowledges that the national travel surveys give different results. LBL used those surveys to derive their own estimates of passenger kilometers traveled in cars and personal light trucks; the authority, along with the Danish Energy Agency and Ministry of Transport, also revised their estimates of fuel use, particularly that of road diesel. These revisions reflect both best estimates of diesel used by foreign vehicles and use of diesel for space heating. Significant numbers of diesel users obtain their fuel almost tax free and it is believed some of this is used as heating oil, which is heavily taxed.

- The U.K. Ministry of Transport carefully reviewed all trends in road vehicle activity and fuel use from 1982. The results, unpublished, were communicated to LBL by Bruce Oelman, and used to revise the figures from that year forward.

- Data for Western Germany come from the same source each year and show no revisions. In future work we will try to incorporate figures for Eastern Germany, where car ownership has almost reached the level of Western Germany.

- LBL did not receive any data from the Netherlands for 1991 or 1992. The time series will be revised and extended in 1995.

GLOSSARY

Acceleration power - Measured in kilowatts. Pulse power obtainable from a battery used to accelerate a vehicle. This is based on a constant current pulse for 30 seconds at no less than 2/3 of the maximum open-circuit-voltage, at 80% depth-of-discharge relative to the battery's rated capacity and at 20° C ambient temperature.

Air Carrier - The commercial system of air transportation consisting of certificated air carriers, air taxis (including commuters), supplemental air carriers, commercial operators of large aircraft, and air travel clubs.

Certificated route air carrier: An air carrier holding a Certificate of Public Convenience and Necessity issued by the Department of Transportation to conduct scheduled interstate services. Nonscheduled or charter operations may also be conducted by these carriers. These carriers operate large aircraft (30 seats or more, or a maximum payload capacity of 7,500 pounds or more) in accordance with Federal Aviation Regulation part 121.

Domestic air operator: Commercial air transportation within and between the 50 States and the District of Columbia. Includes operations of certificated route air carriers, Pan American, local service, helicopter, intra-Alaska, intra-Hawaii, all-cargo carriers and other carriers. Also included are transborder operations conducted on the domestic route segments of U.S. air carriers. Domestic operators are classified based on their operating revenue as follows:

Majors - over $1 billion
Nationals - $100-1,000 million
Large Regionals - $10-99.9 million
Medium Regionals - $0-9.99 million

International air operator: Commercial air transportation outside the territory of the United States, including operations between the U.S. and foreign countries and between the U.S. and its territories and possessions.

Supplemental air carrier: A class of air carriers which hold certificates authorizing them to perform passenger and cargo charter services supplementing the scheduled service of the certificated route air carriers. Supplemental air carriers are often referred to as nonscheduled air carriers or "nonskeds".

Amtrak - See *Rail.*

Automobile size classifications - Size classifications of automobiles are established by the Environmental Protection Agency (EPA) as follows:

Minicompact - less than 85 cubic feet of passenger and luggage volume.
Subcompact - between 85 to 100 cubic feet of passenger and luggage volume.
Compact - between 100 to 110 cubic feet of passenger and luggage volume.
Midsize - between 110 to 120 cubic feet of passenger and luggage volume.
Large - more than 120 cubic feet of passenger and luggage volume.
Two seater - automobiles designed primarily to seat only two adults.

Station wagons are included with the size class for the sedan of the same name.

Aviation - See *General aviation.*

Aviation gasoline - All special grades of gasoline for use in aviation reciprocating engines, as given in the American Society for Testing and Materials (ASTM) Specification D 910. Includes all refinery products within the gasoline range that are to be marketed straight or in blends as aviation gasoline without further processing (any refinery operation except mechanical blending). Also included are finished components in the gasoline range which will be used for blending or compounding into aviation gasoline.

Barges - Shallow, nonself-propelled vessels used to carry bulk commodities on the rivers and the Great Lakes.

Battery efficiency - Measured in percentage. Net DC energy delivered on discharge, as a percentage of the total DC energy required to restore the initial state-of-charge. The efficiency value must include energy losses resulting from self-discharge, cell equalization, thermal loss compensation, and all battery-specific auxiliary equipment.

Btu - The amount of energy required to raise the temperature of 1 pound of water 1 degree Fahrenheit at or near 39.2 degrees Fahrenheit. An average Btu content of fuel is the heat value per quantity of fuel as determined from tests of fuel samples.

Bunker - A storage tank.

Bunkering fuels - Fuels stored in ship bunkers.

Bus -

Intercity bus: A standard size bus equipped with front doors only, high backed seats, luggage compartments separate from the passenger compartment and usually with restroom facilities, for high-speed long distance service.

Motor bus: Rubber-tired, self-propelled, manually-steered bus with fuel supply on board the vehicle. Motor bus types include intercity, school, and transit.
School and other nonrevenue bus: Bus services for which passengers are not directly charged for transportation, either on a per passenger or per vehicle basis.

Transit bus: A bus designed for frequent stop service with front and center doors, normally with a rear-mounted diesel engine, low-back seating, and without luggage storage compartments or restroom facilities. Includes motor bus and trolley coach.

Trolley coach: Rubber-tired electric transit vehicle, manually-steered, propelled by a motor drawing current, normally through overhead wires, from a central power source not on board the vehicle.

Calendar year - The period of time between January 1 and December 31 of any given year.

Captive imports - Products produced overseas specifically for domestic manufacturers.

Carbon dioxide (CO_2) - A colorless, odorless, non-poisonous gas that is a normal part of the ambient air. Carbon dioxide is a product of fossil fuel combustion.

Carbon monoxide (CO) - A colorless, odorless, highly toxic gas that is a normal by-product of incomplete fossil fuel combustion. Carbon monoxide, one of the major air pollutants, can be harmful in small amounts if breathed over a certain period of time.

Car-mile (railroad) - A single railroad car moved a distance of one mile.

Cargo ton-mile - See *Ton-mile*.

Certificated route air carriers - See *Air carriers*.

Class I freight railroad - See *Rail.*

Clean Fuel Vehicle - Vehicle meeting the clean fuel vheicle exhaust emissions standards with no restriction on fuel type.

Coal slurry - Finely crushed coal mixed with sufficient water to form a fluid.

Combination trucks - Consist of a power unit (a truck tractor) and one or more trailing units (a semi-trailer or trailer). The most frequently used combination is popularly referred to as a "tractor-semitrailer" or "tractor trailer".

Commercial sector - See *Residential and Commercial sector.*

Commuter railroad - See *Rail.*

Compact car - See *Automobile size classifications.*

Constant dollars - A series of figures is expressed in constant dollars when the effect of change in the purchasing power of the dollar has been removed. Usually the data are expressed in terms of dollars of a selected year or the average of a set of years.

Consumer Price Index (CPI) - An index issued by the U.S. Department of Labor, Bureau of Labor Statistics. The CPI is designed to measure changes in the prices of goods and services bought by wage earners and clerical workers in urban areas. It represents the cost of a typical consumption bundle at current prices as a ratio to its cost at a base year.

Continuous discharge capacity - Measured as percent of rated energy capacity. Energy delivered in a constant power discharge required by an electric vehicle for hill climbing and/or high-speed cruise, specified as the percent of its rated energy capacity delivered in a one hour constant-power discharge.

Corporate Average Fuel Economy (CAFE) standards - CAFE standards were originally established by Congress for new automobiles, and later for light trucks, in Title V of the Motor Vehicle Information and Cost Savings Act (15 U.S.C.1901, et seq.) with subsequent amendments. Under CAFE, automobile manufacturers are required by law to produce vehicle fleets with a composite sales-weighted fuel economy which cannot be lower than the CAFE standards in a given year, or for every vehicle which does not meet the standard, a fine of $5.00 is paid for every one-tenth of a mpg below the standard.

Crude oil - A mixture of hydrocarbons that exists in the liquid phase in natural underground reservoirs and remains liquid at atmospheric pressure after passing through surface separating facilities.

Crude oil imports - The volume of crude oil imported into the 50 States and the District of Columbia, including imports from U.S. territories, but excluding imports of crude oil into the Hawaiian Foreign Trade Zone.

Current dollars - Represents dollars current at the time designated or at the time of the transaction. In most contexts, the same meaning would be conveyed by the use of the term "dollars".

Disposable personal income - See *Income*.

Distillate fuel oil - The lighter fuel oils distilled off during the refining process. Included are products known as ASTM grades numbers 1 and 2 heating oils, diesel fuels, and number 4 fuel oil. The major uses of distillate fuel oils include heating, fuel for on-and off-highway diesel engines, and railroad diesel fuel.

Domestic air operator - See *Air carrier*.

Domestic water transportation - See *Internal water transportation*.

Electric utilities sector - Consists of privately and publicly owned establishments which generate electricity primarily for resale.

Emission standards - Standards for the levels of pollutants emitted from automobiles and trucks. Congress established the first standards in the Clean Air Act of 1963. Currently, standards are set for four vehicle classes - automobiles, light trucks, heavy-duty gasoline trucks, and heavy-duty diesel trucks.

Energy capacity - Measured in kilowatt hours. The energy delivered by the battery, when tested at C/3 discharge rate, up to termination of discharge specified by the battery manufacturer. The required acceleration power must be delivered by the battery at any point up to 80% of the battery's energy capacity rating.

Energy efficiency - In reference to transportation, the inverse of energy intensiveness: the ratio of outputs from a process to the energy inputs; for example, miles traveled per gallon of fuel (mpg).

Energy intensity - In reference to transportation, the ratio of energy inputs to a process to the useful outputs form that process; for example, gallons of fuel per passenger-mile or Btu per ton-mile.

Ethanol (C_2H_5OH) - Otherwise known as ethyl alcohol, alcohol, or grain-spirit. A clear, colorless, flammable oxygenated hydrocarbon with a boiling point of 78.5 degrees Celsius in the anhydrous state. In transportation, ethanol is used as a vehicle fuel by itself (E100), blended with gasoline (E85), or as a gaoline octane enhancer and oxygenate (10% concentration).

Fixed operating cost - See *Operating cost.*

Fleet vehicles -

Private fleet vehicles: Ideally, a vehicle could be classified as a member of a fleet if it is:

a) operated in mass by a corporation or institution,
b) operated under unified control, or
c) used for non-personal activities.

However, the definition of a fleet is not consistent throughout the fleet industry. Some companies make a distinction between cars that were bought in bulk rather than singularly, or whether they are operated in bulk, as well as the minimum number of vehicles that constitute a fleet (i.e. 4 or 10).

Government fleet vehicles: Includes vehicles owned by all federal (GSA), state, county, city, and metro units of government, including toll road operations.

Foreign freight - Movements between the United States and foreign countries and between Puerto Rico, the Virgin Islands, and foreign countries. Trade between U.S. territories and possessions (e.g. Guam, Wake, American Samoa) and foreign countries is excluded. Traffic to or from the Panama Canal Zone is included.

Gas Guzzler Tax - Originates from the 1978 Energy Tax Act (Public Law 95-618). A new car purchaser is required to pay the tax if the car purchased has a combined city/highway fuel economy rating that is below the standard for that year. For model years 1986 and later, the standard is 22.5 mpg.

Gasohol - A mixture of 10% anhydrous ethanol and 90% gasoline by volume. There are other fuels that contain methanol and gasoline, but these fuels are not referred to as gasohol.

Gasoline - See *Motor gasoline*.

General aviation - That portion of civil aviation which encompasses all facets of aviation except air carriers. It includes any air taxis, commuter air carriers, and air travel clubs which do not hold Certificates of Public Convenience and Necessity.

Gross National Product - A measure of monetary value of the goods and services becoming available to the nation from economic activity. Total value at market prices of all goods and services produced by the nation's economy. Calculated quarterly by the Department of Commerce, the Gross National Product is the broadest available measure of the level of economic activity.

Gross vehicle weight (gvw) - The weight of the empty vehicle plus the maximum anticipated load weight.

Heavy-heavy truck - See *Truck size classifications*.

Household - Consists of all persons who occupy a housing unit, including the related family members and all unrelated persons, if any, who share the housing unit.

Housing unit - A house, apartment, a group of rooms, or a single room occupied or intended for occupancy as separate living quarters. Separate living quarters are those in which the occupants do not live and eat with any other persons in the structure and which have either (1) direct access from the outside of the building or through a common hallway intended to be used by the occupants of another unit or by the general public, or (2) complete kitchen facilities for the exclusive use of the occupants. The occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated persons who share living arrangements.

Hydrocarbon (HC) - A compound that contains only hydrogen and carbon. The simplest and lightest forms of hydrocarbon are gaseous. With greater molecular weights they are liquid, while the heaviest are solids.

Income -

Disposable personal income: Personal income less personal tax and non-tax payments.

National income - The aggregate earnings of labor and property which arise in the current production of goods and services by the nation's economy.

Personal income: The current income received by persons from all sources, net of contributions for social insurance.

Industrial sector - Construction, manufacturing, agricultural and mining establishments.

Intercity bus - See *Bus*.

Internal water transportation - Includes all local (intraport) traffic and traffic between ports or landings wherein the entire movement takes place on inland waterways. Also termed internal are movements involving carriage on both inland waterways and the water of the Great Lakes, and inland movements that cross short stretches of open water that link inland systems.

International air operator - See *Air carrier.*

International freight - See *Foreign freight.*

Jet fuel - Includes both naphtha-type and kerosene-type fuels meeting standards for use in aircraft turbine engines. Although most jet fuel is used in aircraft, some is used for other purposes such as generating electricity in gas turbines.

Kerosene-type jet fuel: A quality kerosene product with an average gravity of 40.7 degrees API and 10% to 90% distillation temperatures of 217 and 261 degrees centigrade. Used primarily as fuel for commercial turbojet and turboprop aircraft engines. It is a relatively low freezing point distillate of the kerosene type.

Naphtha-type jet fuel: A fuel in the heavy naphtha boiling range with an average gravity of 52.8 degrees API and 10% to 90% distillation temperatures of 117 to 233 degrees centigrade used for turbojet and turboprop aircraft engines, primarily by the military. Excludes ramjet and petroleum.

Kerosene - A petroleum distillate in the 300 to 500 degrees Fahrenheit boiling range and generally having a flash point higher than 100 degrees Fahrenheit by the American Society of Testing and Material (ASTM) Method D56, a gravity range from 40 to 46 degrees API, and a burning point in the range of 150 to 175 degrees Fahrenheit. It is a clean-burning product suitable for use as an illuminant when burned in wick lamps. Includes grades of kerosene called range oil having properties similar to Number 1 fuel oil, but with a gravity of about 43 degrees API and an end point of 625 degrees Fahrenheit. Used in space heaters, cooking stoves, and water heaters.

Kerosene-type jet fuel - See *Jet fuel.*

Large car - See *Automobile size classifications.*

Light duty vehicles - Automobiles and light trucks combined.

Light truck - Unless otherwise noted, light trucks are defined in this publication as two-axle, four-tire trucks. The U.S. Bureau of Census classifies all trucks with a gross vehicle weight less than 10,000 pounds as light trucks (See *Truck size classifications*).

Light-heavy truck - See *Truck size classifications.*

Liquified petroleum gas (lpg) - Consists of propane and butane and is usually derived from natural gas. In locations where there is no natural gas and the gasoline consumption is low, naphtha is converted to lpg by catalytic reforming.

Load factor - A term relating the potential capacity of a system relative to its actual performance. Is often calculated as total passenger miles divided by total vehicle miles.

Low-emission vehicle - A clean fuel vehicle meeting the low-emission vehicle standards.

Medium truck - See *Truck size classifications.*

Methanol (CH_3OH) - A colorless poisonous liquid with essentially no odor and very little taste. It is the simplest alcohol and boils at 64.7 degrees Celsius. In transportation, methanol is used as a vehicle fuel by itself (M100), or blended with gasoline (M85).

Midsize car - See *Automobile size classifications.*

Minicompact car - See *Automobile size classifications.*

Model year - In this publication, model year is referring to the "sales" model year, the period from October 1 to the next September 31.

Motor bus - See *Bus.*

Motor Gasoline - A mixture of volatile hydrocarbons suitable for operation of an internal combustion engine whose major components are hydrocarbons with boiling points ranging from 78 to 217 degrees centigrade and whose source is distillation of petroleum and cracking, polymerization, and other chemical reactions by which the naturally occurring petroleum hydrocarbons are converted into those that have superior fuel properties.

Naphtha-type jet fuel - See *Jet fuel.*

National income - See *Income.*

Nationwide Personal Transportation Study (NPTS) - A nationwide home interview survey of households that provides information on the characteristics and personal travel patterns of the U.S. population. Surveys were conducted in 1969, 1977, 1983 and 1990 by the U.S. Bureau of Census for the U.S. Department of Transportation.

Natural gas - A mixture of hydrocarbon compounds and small quantities of various non-hydrocarbons existing in the gaseous phase or in solution with crude oil in natural underground reservoirs at reservoir conditions.

Nitrogen Oxides (NO_x) - A product of combustion of fossil fuels whose production increases with the temperature of the process. It can become an air pollutant if concentrations are excessive.

Operating cost -

Fixed operating cost: In reference to passenger car operating cost, refers to those expenditures that are independent of the amount of use of the car, such as insurance costs, fees for license and registration, depreciation and finance charges.

Variable operating cost: In reference to passenger car operating cost, expenditures which are dependent on the amount of use of the car, such as the cost of gas and oil, tires, and other maintenance.

Organization for Petroleum Exporting Countries (OPEC) - Includes Saudi Arabia, Iran, Venezuela, Libya, Indonesia, United Arab Emirates, Algeria, Nigeria, Ecuador, Gabon, Iraq, Kuwait, and Qatar. Data for Saudi Arabia and Kuwait include their shares from the Partitioned Zone (formerly the Neutral Zone).

Other single-unit truck - See *Single-unit truck.*

Oxygenate - A substance which, when added to gasoline, increases the amount of oxygen in that gasoline blend. Includes fuel ethanol, methanol, and methyl tertiary butyl ether (MTBE).

Particulates - Carbon particles formed by partial oxidation and reduction of the hydrocarbon fuel. Also included are trace quantities of metal oxides and nitrides, originating from engine wear, component degradation, and inorganic fuel additives. In the transportation sector, particulates are emitted mainly from diesel engines.

Passenger-miles traveled (PMT) - One person traveling the distance of one mile. Total passenger-miles traveled, thus, give the total mileage traveled by all persons.

Passenger rail - See *Rail, "Amtrak" and "Transit Railroad".*

Personal Consumption Expenditures (PCE) - As used in the national accounts, the market value of purchases of goods and services by individuals and nonprofit institutions and the value of food, clothing, housing, and financial services received by them as income in kind. It includes the rental value of owner-occupied houses but excludes purchases of dwellings, which are classified as capital goods (investment).

Personal income - See *Income.*

Petroleum - A generic term applied to oil and oil products in all forms, such as crude oil, lease condensate, unfinished oil, refined petroleum products, natural gas plant liquids, and non-hydrocarbon compounds blended into finished petroleum products.

Petroleum consumption - A calculated demand for petroleum products obtained by summing domestic production, imports of crude petroleum and natural gas liquids, imports of petroleum products, and the primary stocks at the beginning of the period and then subtracting the exports and the primary stocks at the end of the period.

Petroleum exports - Shipments of petroleum products from the 50 States and the District of Columbia to foreign countries, Puerto Rico, the Virgin Islands, and other U.S. possessions and territories.

Petroleum imports - All imports of crude petroleum, natural gas liquids, and petroleum products from foreign countries and receipts from Guam, Puerto Rico, the Virgin Islands, and the Hawaiian Trade Zone. The commodities included are crude oil, unfinished oils, plant condensate, and refined petroleum products.

Petroleum inventories - The amounts of crude oil, unfinished oil, petroleum products, and natural gas liquids held at refineries, at natural gas processing plants, in pipelines, at bulk terminals operated by refining and pipeline companies, and at independent bulk terminals. Crude oil held in storage on leases is also included; these stocks are know as primary stocks. Secondary stocks - those held by jobbers dealers, service station operators, and consumers -are excluded. Prior to 1975, stock held at independent bulk terminals were classified as secondary stocks.

Petroleum products supplied - For each petroleum product, the amount supplied is calculated by summing production, crude oil burned directly, imports, and net withdrawals from primary stocks and subtracting exports.

Quad - Quadrillion, 10^{15}. In this publication, a Quad refers to Quadrillion Btu.

Rail -

Amtrak (American Railroad Tracks): Operated by the National Railroad Passenger Corporation of Washington, DC. This rail system was created by President Nixon in 1970, and was given the responsibility for the operation of intercity, as distinct from suburban, passenger trains between points designated by the Secretary of Transportation.

Class I freight railroad: Defined by the Interstate Commerce Commission each year based on annual operating revenue. A railroad is dropped from the Class I list if it fails to meet the annual earnings threshold for three consecutive years.

Commuter railroad: Those portions of mainline railroad (not electric railway) transportation operations which encompass urban passenger train service for local travel between a central city and adjacent suburbs. Commuter railroad service - using both locomotive-hauled and self-propelled railroad passenger cars - is characterized by multi-trip tickets, specific station-to-station fares, and usually only one or two stations in the central business district. Also known as suburban railroad.

Transit railroad: Includes "heavy" and "light" transit rail. **Heavy transit rail** is characterized by exclusive rights-of-way, multi-car trains, high speed rapid acceleration, sophisticated signaling, and high platform loading. Also known as subway, elevated railway, or metropolitan railway (metro). **Light transit rail** may be on exclusive or shared rights-of-way, high or low platform loading, multi-car trains or single cars, automated or manually operated. In generic usage, light rail includes streetcars, trolley cars, and tramways.

Residential and Commercial sector - Consists of housing units, non-manufacturing business establishments (e.g., wholesale and retail businesses), health and educational institutions, and government offices.

Residential Transportation Energy Consumption Survey (RTECS) - This survey was designed by the Energy Information Administration of the Department of Energy to provide information on how energy is used by households for personal vehicles. It has been conducted five times since 1979, the most recent being 1991.

Residual fuel oil - The heavier oils that remain after the distillate fuel oils and lighter hydrocarbons are boiled off in refinery operations. Included are products know as ASTM grade numbers 5 and 6 oil, heavy diesel oil, Navy Special Fuel Oil, Bunker C oil, and acid sludge and pitch used as refinery fuels. Residual fuel oil is used for the production of electric power, for heating, and for various industrial purposes.

Rural - Usually refers to areas with population less than 5,000.

Sales-weighted miles per gallon (mpg) - Calculation of a composite vehicle fuel economy based on the distribution of vehicle sales.

Scrappage rate - As applied to motor vehicles, it is usually expressed as the percentage of vehicles of a certain type in a given age class that are retired from use (lacking registration) in a given year.

School and other nonrevenue bus - See *Bus*.

Single unit truck - Includes two-axle, four-tire trucks and other single unit trucks.

Two-axle, four tire truck: A motor vehicle consisting primarily of a single motorized device with two axles and four tires.

Other single-unit truck: A motor vehicle consisting primarily of a single motorized device with more than two axles or more than four tires.

Special fuels - Consist primarily of diesel fuel with small amount of liquified petroleum gas, as defined by the Federal Highway Administration.

Specific acceleration power - Measured in watts per kilogram. Acceleration power divided by the battery system weight. Weight must include the total battery system.

Specific energy - Measured in watt hours per kilogram. The rated energy capacity of the battery divided by the total battery system weight.

Subcompact car - See *Automobile size classifications*.

Supplemental air carrier - See *Air carrier*.

Ton-mile - The movement of one ton of freight the distance of one mile. Ton-miles are computed by multiplying the weight in tons of each shipment transported by the distance hauled.

Transmission types -

A3 - Automatic three speed
A4 - Automatic four speed
A5 - Automatic five speed
L4 - Automatic lockup four speed
M5 - Manual five speed

Transit bus - See *Bus*.

Transit railroad - See *Rail.*

Transportation sector - Consists of both private and public passenger and freight transportation, as well as government transportation, including military operations.

Truck Inventory and Use Survey (TIUS) - Survey designed to collect data on the characteristics and operational use of the nation's truck population. It is conducted every five years by the U.S. Bureau of the Census. Surveys were conducted in 1963, 1967, 1972, 1977, 1982, 1987, and 1992. The 1992 data have not yet been released.

Trolley coach - See *Bus*.

Truck size classifications - U.S. Bureau of the Census has categorized trucks by gross vehicle weight (gvw) as follows:

Light - Less than 10,000 pounds gvw (Also see *Light Truck.*)
Medium - 10,001 to 20,000 pounds gvw
Light-heavy - 20,001 to 26,000 pounds gvw
Heavy-heavy - 26,001 pounds gvw or more.

Two-axle, four-tire truck - See *Single-unit truck.*

Two seater car - See *Automobile size classifications*.

Ultra-low emission vehicle - A clean fuel vehicle meeting the more stringent Ultra-low emission standards.

Urban - Usually refers to areas with population of 5,000 or greater.

Variable operating cost - See *Operating cost*.

Vehicle-miles traveled (vmt) - One vehicle traveling the distance of one mile. Total vehicle miles, thus, is the total mileage traveled by all vehicles.

Zero-emission vehicle - A clean fuel vehicle meeting even more stringent zero-emission vehicle standards.

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Notations:

- * indicates the end of the title
- () indicates the page number

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