

APPENDIX A

SOURCES & METHODOLOGIES

SOURCES & METHODOLOGIES

This appendix 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 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. Since abbreviations are used throughout the appendix, a list of abbreviations is also included.

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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
GSA	General Services Administration
gvw	gross vehicle weight
lpg	liquefied petroleum gas
mpg	miles per gallon
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NPTS	Nationwide Personal Transportation Survey
NVPP	National Vehicle Population Profile
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
VIUS	Vehicle Inventory and Use Survey
vmt	vehicle-miles traveled

Energy Use Sources

Highway energy use

Automobiles

Fuel use in gallons from: DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996; DOT, FHWA, *Highway Statistics Summary to 1995*. Fuel use was distributed among fuel types using the percentages shown in Table A.1.

Table A.1
Automobile Fuel Use and Fuel Type Shares for Calculation of Energy Use

Year	Fuel use (million gallons)	Source for gasohol shares	Source for gasoline/diesel shares	Shares by fuel type		
				Gasoline	Gasohol	Diesel
1970	67,820		1984 NVPP	99.8%	0.0%	0.2%
1975	74,140		interpolated	97.0%	0.0%	3.0%
1976	78,297		interpolated	96.4%	0.0%	3.6%
1977	79,060		interpolated	95.8%	0.0%	4.2%
1978	80,652		interpolated	95.3%	0.0%	4.7%
1979	76,588		1979 RTECS	94.7%	0.0%	5.3%
1980	69,981	FHWA, MF-33e	interpolated	93.9%	0.5%	5.6%
1981	69,112	FHWA, MF-33e	1981 RTECS	93.4%	0.7%	5.9%
1982	69,116	FHWA, MF-33e	interpolated	93.5%	2.3%	4.2%
1983	70,322	FHWA, MF-33e	1983 RTECS	93.2%	4.3%	2.5%
1984	70,663	FHWA, MF-33e	interpolated	92.7%	5.3%	2.0%
1985	71,518	FHWA, MF-33e	1985 RTECS	90.8%	7.7%	1.5%
1986	73,174	FHWA, MF-33e	interpolated	91.0%	7.6%	1.4%
1987	73,308	FHWA, MF-33e	interpolated	92.4%	6.3%	1.3%
1988	73,345	FHWA, MF-33e	1988 RTECS	91.4%	7.4%	1.2%
1989	73,913	FHWA, MF-33e	interpolated	92.6%	6.2%	1.2%
1990	69,568	FHWA, MF-33e	interpolated	92.0%	6.8%	1.2%
1991	64,318	FHWA, MF-33e	1991 RTECS	90.8%	8.0%	1.2%
1992	65,436	FHWA, MF-33e	interpolated	90.8%	7.9%	1.2%
1993	67,047	FHWA, MF-33e	interpolated	89.7%	9.1%	1.3%
1994	67,874	FHWA, MF-33e	1994 RTECS	89.1%	9.6%	1.3%
1995	68,072	FHWA, MF-33e	interpolated	87.6%	11.2%	1.2%
1996	69,221	FHWA, MF-33e	interpolated	88.8%	10.1%	1.0%
1997	69,892	FHWA, MF-33e	interpolated	86.9%	12.2%	0.9%
1998	71,695	FHWA, MF-33e	interpolated	88.0%	11.2%	0.8%
1999	73,283	FHWA, MF-33e	interpolated	88.3%	11.0%	0.6%
2000	73,065	FHWA, MF-33e	2000 NVPP	86.9%	12.6%	0.5%
2001	73,559	FHWA, MF-33e	2001 NVPP	86.5%	13.0%	0.5%
2002	75,471	FHWA, MF-33e	2001 NVPP	83.9%	15.6%	0.5%
2003	74,590	FHWA, MF-33e	2001 NVPP	75.3%	24.2%	0.5%
2004	75,402	FHWA, MF-33e	2001 NVPP	67.2%	32.3%	0.5%
2005	74,418	FHWA, MF-33e	2001 NVPP	66.9%	32.6%	0.5%
2006	74,983	FHWA, MF-33e	2001 NVPP	66.9%	32.6%	0.5%
Heat content used for conversion to btu:				125,000	120,900	138,700
				btu/gallon	btu/gallon	btu/gallon

MotorcyclesDOT, FHWA, *Highway Statistics 2006*, Table VM-1, and annual editions.**Table A.2**
Motorcycle Fuel Use

Year	Fuel use (thousand gallons)	Year	Fuel use (thousand gallons)
1970	59,580	1989	207,420
1971	72,140	1990	191,140
1972	86,620	1991	183,560
1973	103,880	1992	191,140
1974	108,900	1993	198,120
1975	112,580	1994	204,800
1976	120,060	1995	198,262
1977	126,980	1996	195,940
1978	143,160	1997	201,620
1979	172,740	1998	205,660
1980	204,280	1999	211,680
1981	213,800	2000	209,380
1982	198,200	2001	192,780
1983	175,200	2002	191,040
1984	175,680	2003	190,780
1985	181,720	2004	202,447
1986	187,940	2005	189,495
1987	190,120	2006	220,954
1988	200,480		
Heat content used for conversion to btu:		125,000 btu/gallon	

Buses**Transit:**APTA, *Public Transportation Fact Book*, 2007, Washington, DC. Includes motorbus and trolley bus data.**Table A.3**
Transit Bus Fuel Use

Year	Methanol (thousand gallons)	LNG (thousand gallons)	LPG (thousand gallons)	CNG (thousand gallons)	Gasoline (thousand gallons)	Diesel fuel (thousand gallons)	Electricity (thousand kilowatt hours)
1994	12,470	1,138	249	3,109	2,103	565,064	102,945
1995	11,967	1,737	269	10,011	2,297	563,767	100,659
1996	11,600	2,278	591	11,527	1,844	577,680	69,130
1997	8,705	3,276	1,033	20,050	2,722	597,636	78,561
1998	4,976	3,075	879	32,260	1,959	606,631	74,352
1999	2,711	5,251	659	39,861	1,402	618,024	75,920
2000	821	10,464	723	50,449	1,315	635,160	78,062
2001	763	11,670	1,171	60,917	1,472	587,184	75,108
2002	8,982	16,762	1,830	77,787	1,264	558,990	75,901
2003	1,867	14,231	1,843	94,881	1,119	535,963	71,126
2004	4,675	16,452	1,727	106,702	1,799	550,466	70,079
2005*	4,675	16,452	1,727	106,702	1,799	550,466	70,079
2006	Data not available; assumed 2006=2005						
Heat content used for conversion to btu:	64,600 btu/gallon	90,800 btu/gallon	91,300 btu/gallon	129,400 btu/gallon	125,000 btu/gallon	138,700 btu/gallon	10,339 btu/kWhr

* Preliminary

Intercity and School:

Eno Transportation Foundation, *Transportation in America*, 2001, Nineteenth Edition, 2003, Washington, DC, pp. 20–23. School bus fuel was assumed to be 90% diesel fuel and 10% gasoline based on estimates from the National Association of State Directors of Pupil Transportation Services. Intercity bus fuel was assumed to be 100% diesel.

Table A.4
Intercity and School Bus Fuel Use

Year	Intercity (million gallons)	School (million gallons)
1970	305.34	299.88
1971	296.73	309.75
1972	288.12	319.62
1973	252.42	327.04
1974	216.72	334.46
1975	181.02	341.88
1976	182.28	389.76
1977	181.86	401.52
1978	180.18	406.98
1979	205.38	404.88
1980	213.78	379.68
1981	205.38	386.82
1982	227.22	398.58
1983	237.30	400.68
1984	169.26	375.06
1985	165.48	425.04
1986	148.68	462.42
1987	155.82	487.20
1988	160.44	511.14
1989	166.74	498.12
1990	159.60	472.08
1991	160.44	533.40
1992	157.08	546.00
1993	171.36	533.40
1994	195.30	546.00
1995	195.30	545.16
1996	199.92	545.16
1997	212.52	544.74
1998	220.08	550.20
1999	241.08	555.66
2000	233.10	577.08
2001	217.35*	538.08*
2002	210.22*	520.44*
2003	208.32*	515.72*
2004	208.87*	517.09*
2005	214.37*	530.70*
2006	214.80*	531.77*
Fuel type shares	100% diesel	90% diesel 10% gasoline
Heat content used for conversion to btu:	138,700 btu/gallon	138,700 btu/gallon 125,000 btu/gallon

* Estimated using the rate of change of bus vehicle-miles traveled from FHWA *Highway Statistics* Table VM-1.

Trucks**Light Trucks:**

DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996;
 DOT, FHWA, *Highway Statistics Summary to 1995*.

Table A.5
Light Truck Fuel Use and Fuel Type Shares for Calculation of Energy Use

Year	Fuel use (million gallons)	Source for gasohol shares	Source for gasoline/diesel /lpg shares	Shares by fuel type			
				Gasoline	Gasohol	Diesel	Lpg
1970	12,313		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1971	13,484		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1972	15,150		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1973	16,828		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1974	16,657		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1975	19,081		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1976	20,828		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1977	22,383		1977 TIUS	97.6%	0.0%	1.6%	0.8%
1978	24,162		Interpolated	97.1%	0.0%	2.0%	0.9%
1979	24,445		Interpolated	96.7%	0.0%	2.4%	1.0%
1980	23,796	FHWA, MF-33e	Interpolated	95.7%	0.5%	2.7%	1.0%
1981	23,697	FHWA, MF-33e	Interpolated	95.1%	0.7%	3.1%	1.1%
1982	22,702	FHWA, MF-33e	1982 TIUS	93.0%	2.3%	3.5%	1.2%
1983	23,945	FHWA, MF-33e	Interpolated	91.0%	4.3%	3.5%	1.2%
1984	25,604	FHWA, MF-33e	Interpolated	90.0%	5.3%	3.5%	1.2%
1985	27,363	FHWA, MF-33e	Interpolated	87.6%	7.7%	3.5%	1.2%
1986	29,074	FHWA, MF-33e	Interpolated	87.7%	7.6%	3.5%	1.2%
1987	30,598	FHWA, MF-33e	1987 TIUS	89.0%	6.3%	3.5%	1.2%
1988	32,653	FHWA, MF-33e	Interpolated	88.2%	7.4%	3.5%	1.0%
1989	33,271	FHWA, MF-33e	Interpolated	89.5%	6.2%	3.4%	0.8%
1990	35,611	FHWA, MF-33e	Interpolated	89.2%	6.8%	3.4%	0.7%
1991	38,217	FHWA, MF-33e	Interpolated	88.1%	8.0%	3.3%	0.5%
1992	40,929	FHWA, MF-33e	1992 TIUS	88.5%	7.9%	3.3%	0.3%
1993	42,851	FHWA, MF-33e	Interpolated	87.3%	9.1%	3.3%	0.3%
1994	44,112	FHWA, MF-33e	Interpolated	86.8%	9.6%	3.3%	0.3%
1995	45,605	FHWA, MF-33e	Interpolated	85.1%	11.2%	3.4%	0.3%
1996	47,354	FHWA, MF-33e	Interpolated	86.2%	10.1%	3.4%	0.3%
1997	49,388	FHWA, MF-33e	1997 VIUS	84.2%	12.2%	3.4%	0.2%
1998	50,462	FHWA, MF-33e	Interpolated	85.0%	11.2%	3.5%	0.3%
1999	52,859	FHWA, MF-33e	Interpolated	84.9%	11.0%	3.6%	0.4%
2000	52,939	FHWA, MF-33e	Interpolated	83.1%	12.6%	3.8%	0.6%
2001	53,522	FHWA, MF-33e	Interpolated	82.4%	13.0%	3.9%	0.7%
2002	55,220	FHWA, MF-33e	2002 VIUS	79.6%	15.6%	4.0%	0.8%
2003	60,758	FHWA, MF-33e	2002 VIUS	71.0%	24.2%	4.0%	0.8%
2004	63,417	FHWA, MF-33e	2002 VIUS	62.9%	32.3%	4.0%	0.8%
2005	58,869	FHWA, MF-33e	2002 VIUS	62.6%	32.6%	4.0%	0.8%
2006	60,662	FHWA, MF-33e	2002 VIUS	62.6%	32.6%	4.0%	0.8%
Heat content used for conversion to btu:				125,000 btu/gallon	120,900 btu/gallon	138,700 btu/gallon	90,800 btu/gallon

Medium/Heavy Trucks:

DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996;
 DOT, FHWA, *Highway Statistics Summary to 1995*. Total gallons for other trucks was the difference between total trucks and 2-axle, 4-tire trucks.

Table A.6
Medium/Heavy Truck Fuel Use and Fuel Type Shares
for Calculation of Energy Use

Year	Fuel use (million gallons)	Source for gasoline/diesel /lpg shares	Shares by fuel type		
			Gasoline	Diesel	Lpg
1970	11,316	1977 TIUS	10.4%	89.5%	0.1%
1971	11,812	1977 TIUS	10.4%	89.5%	0.1%
1972	12,964	1977 TIUS	10.4%	89.5%	0.1%
1973	14,320	1977 TIUS	10.4%	89.5%	0.1%
1974	14,341	1977 TIUS	10.4%	89.5%	0.1%
1975	14,598	1977 TIUS	10.4%	89.5%	0.1%
1976	15,408	1977 TIUS	10.4%	89.5%	0.1%
1977	17,082	1977 TIUS	10.4%	89.5%	0.1%
1978	19,121	Interpolated	16.2%	83.5%	0.3%
1979	19,913	Interpolated	22.1%	77.5%	0.5%
1980	19,960	Interpolated	27.9%	71.4%	0.6%
1981	20,376	Interpolated	33.8%	65.4%	0.8%
1982	20,386	1982 TIUS	39.6%	59.4%	1.0%
1983	20,761	Interpolated	35.6%	63.6%	0.8%
1984	21,428	Interpolated	31.5%	67.8%	0.7%
1985	21,405	Interpolated	27.5%	72.0%	0.5%
1986	21,861	Interpolated	23.4%	76.2%	0.4%
1987	22,513	1987 TIUS	19.4%	80.4%	0.2%
1988	22,925	Interpolated	18.8%	81.0%	0.3%
1989	23,512	Interpolated	18.1%	81.6%	0.3%
1990	24,490	Interpolated	17.5%	82.1%	0.4%
1991	24,981	Interpolated	16.8%	82.7%	0.4%
1992	25,453	1992 TIUS	16.2%	83.3%	0.5%
1993	26,236	Interpolated	15.4%	84.1%	0.5%
1994	27,685	Interpolated	14.7%	84.8%	0.5%
1995	28,828	Interpolated	13.9%	85.6%	0.5%
1996	29,601	Interpolated	13.2%	86.3%	0.5%
1997	29,878	1997 VIUS	12.4%	87.1%	0.5%
1998	30,841	Interpolated	12.1%	87.4%	0.5%
1999	33,909	Interpolated	11.8%	87.6%	0.5%
2000	35,229	Interpolated	11.6%	87.9%	0.5%
2001	35,179	Interpolated	11.3%	88.1%	0.5%
2002	36,800	2002 VIUS	11.0%	88.4%	0.5%
2003	35,775	2002 VIUS	11.0%	88.4%	0.5%
2004	33,150	2002 VIUS	11.0%	88.4%	0.5%
2005	27,689	2002 VIUS	11.0%	88.4%	0.5%
2006	28,075	2002 VIUS	11.0%	88.4%	0.5%
Heat content used for conversion to btu:			125,000 btu/gallon	138,700 btu/gallon	90,800 btu/gallon

Off-highway energy use

The off-highway energy use estimates are for the year 2001. The estimates are a combination of data from EPA's NONROAD2002 model and VIUS 1997. First, the NONROAD model was queried on a national basis for energy use by nonroad engines. The resulting database included sector, fuel type, number of gallons used annually, and a description of the off-highway equipment called the source category code (SCC). ORNL sorted the data by SCC and only the SCC's which pertained to off-highway transportation were kept in the database. Examples of exclusions include chainsaws and stationary generators. The EPA model does not include off-highway use of trucks; therefore, the 1997 VIUS was queried to derive the amount of fuel (by sector and fuel type) used by trucks off-road. The rate of change in off-highway transportation-related fuel use from NONROAD2002 between 1997 and 2001 was applied to the 1997 VIUS data to provide an estimate for 2001. The transportation-related fuel use from NONROAD and the VIUS estimates were added together for a total off-highway transportation-related fuel use by sector and fuel type. These totals are found on Table 2.8. Gallons were converted to btu using the gross heat content for each fuel. (Heat content values shown on Table B.4.)

Additional detail on this methodology can be found in the report *Off-Highway Transportation-related Fuel Use*, ORNL/TM-2004/92, April 2004, http://cta.ornl.gov/cta/Publications/pdf/ORNL_TM-2004_92.pdf.

Nonhighway energy use

Air

General Aviation:

DOT, FAA, *General Aviation Activity and Avionics Survey: Annual Summary Report Calendar Year 2006*, Table 5.1, and annual.

Table A.7
General Aviation Fuel Use

Year	Jet fuel (million gallons)	Aviation gasoline (million gallons)
1970	208.0	551.0
1971	226.0	508.0
1972	245.0	584.0
1973	304.0	411.0
1974	357.0	443.0
1975	453.0	412.0
1976	495.0	432.0
1977	536.0	456.0
1978	763.0	518.0
1979	736.0	570.0
1980	766.0	520.0
1981	759.0	489.0
1982	887.0	448.0
1983	613.0	428.0
1984	738.9	462.4
1985	691.0	421.0
1986	732.1	408.6
1987	672.7	401.8
1988	746.0	398.0
1989	688.0	342.8
1990	662.0	353.0
1991	579.0	348.0
1992	496.0	306.0
1993	454.1	268.4
1994	470.8	264.1
1995	544.0	276.0
1996	567.5	286.5
1997	639.4	289.7
1998	814.6	311.4
1999	967.2	345.4
2000	998.1	336.3
2001	938.7	319.3
2002	815.5	261.4
2003	820.0	255.5
2004	1,075.2	256.1
2005	1,507.4	323.6
2006	1,636.3	294.7
Heat content used for conversion to btu:	135,000 btu/gallon	120,200 btu/gallon

Domestic and International Air Carrier:

DOT, Bureau of Transportation Statistics, "Fuel Cost and Consumption Tables," www.bts.gov/xml/fuel/report/src/index.xml. The table below shows all international fuel use. Because the data for international include fuel purchased abroad, for the tables in Chapter 2, the international total was divided in half to estimate domestic fuel use for international flights.

Table A.8
Air Carrier Fuel Use

Year	Domestic (thousand gallons)	All international (thousand gallons)	Total (thousand gallons)
1970			10,085,000
1971			10,140,000
1972	Separate estimates for domestic and international are not available from 1970-1976.		10,302,000
1973			10,671,000
1974			10,417,260
1975			10,412,640
1976			10,400,040
1977	8,202,051	1,708,376	9,910,427
1978	8,446,117	1,741,918	10,188,035
1979	8,865,885	1,828,435	10,694,320
1980	8,519,233	1,747,306	10,266,539
1981	8,555,249	2,032,520	10,587,769
1982	8,432,465	1,967,733	10,400,198
1983	8,672,574	1,998,289	10,670,863
1984	9,625,958	2,286,407	11,912,365
1985	10,115,007	2,487,929	12,602,936
1986	11,137,331	2,544,996	13,682,327
1987	11,586,838	2,893,617	14,480,455
1988	11,917,904	3,262,824	15,180,728
1989	11,905,144	3,557,294	15,462,438
1990	12,429,305	3,963,081	16,392,386
1991	11,506,477	3,939,666	15,446,144
1992	11,762,852	4,120,132	15,882,983
1993	11,958,663	4,113,321	16,071,984
1994	12,475,549	4,310,879	16,786,428
1995	12,811,717	4,511,418	17,323,135
1996	13,187,305	4,658,093	17,845,398
1997	13,659,581	4,964,181	18,623,762
1998	13,876,971	5,185,562	19,062,533
1999	14,402,127	5,250,492	19,652,619
2000	14,844,592	5,474,685	20,319,277
2001	14,017,461	5,237,487	19,254,948
2002	12,848,329	4,990,798	17,839,127
2003	12,958,581	4,836,356	17,794,936
2004	13,622,603	4,931,546	18,554,149
2005	13,778,869	5,520,889	19,309,758
2006	13,582,317	6,018,194	19,600,511
Heat content used for conversion to btu:	135,000 btu/gallon	135,000 btu/gallon	135,000 btu/gallon

Water**Freight:**

Total – DOE, EIA, *Fuel Oil and Kerosene Sales 2006*, Table 23. Adjusted sales of distillate and residual fuel oil for vessel bunkering. (This may include some amounts of bunker fuels used for recreational purposes.)

Table A.9
Diesel and Residual Fuel Oil for Vessel Bunkering

Year	Distillate fuel oil (thousand gallons)	Residual fuel oil (thousand gallons)
1970	819,000	3,774,120
1971	880,000	3,307,000
1972	1,013,000	3,273,000
1973	1,125,000	3,859,000
1974	1,018,920	3,827,040
1975	1,097,880	4,060,140
1976	1,220,100	4,977,000
1977	1,407,420	5,416,740
1978	1,578,822	6,614,790
1979	1,630,858	8,002,672
1980	717,376	7,454,242
1981	1,723,143	7,922,512
1982	1,423,216	6,408,818
1983	1,418,890	5,724,115
1984	1,692,141	5,687,375
1985	1,894,016	5,473,614
1986	2,034,215	5,287,347
1987	2,223,258	5,259,272
1988	2,310,367	5,248,981
1989	2,356,444	5,410,263
1990	2,197,004	6,248,095
1991	2,167,640	6,786,055
1992	2,240,170	7,199,078
1993	2,043,745	6,269,882
1994	2,026,899	5,944,383
1995	1,978,105	6,431,238
1996	2,177,608	5,804,977
1997	2,107,561	4,789,861
1998	2,125,568	4,640,153
1999	2,064,590	5,598,630
2000	2,041,433	6,192,294
2001	2,099,011	4,345,284
2002	2,056,465	4,783,956
2003	1,863,150	3,801,425
2004	2,313,448	4,886,978
2005	2,115,381	5,533,552
2006	2,203,876	6,012,838
Heat content used for conversion to btu:	138,700 btu/gallon	149,700 btu/gallon
Domestic share of total fuel use	77.5%	9.3%

Recreational Boating:

Fuel use by recreational boating comes from the EPA's NONROAD2005 model. All the data in Table A.10 were revised according to NONROAD2005. Previous editions used data from NONROAD2004 or other methodologies.

Table A.10
Recreational Boating Fuel Use

Year	Diesel use (gallons)	Gasoline use (gallons)
1970	39,589,953	1,244,804,236
1971	47,130,906	1,252,226,262
1972	54,671,856	1,259,648,217
1973	62,212,803	1,267,070,191
1974	69,753,735	1,274,492,200
1975	77,294,680	1,281,914,303
1976	84,835,632	1,289,336,252
1977	92,376,573	1,296,758,199
1978	99,917,523	1,304,180,198
1979	107,458,470	1,311,602,248
1980	114,999,421	1,319,024,363
1981	122,540,357	1,326,446,317
1982	130,081,302	1,333,686,303
1983	137,622,248	1,341,290,185
1984	145,163,202	1,348,712,302
1985	152,704,140	1,356,134,278
1986	160,245,074	1,363,556,343
1987	167,786,030	1,370,978,262
1988	175,326,970	1,390,334,510
1989	182,867,916	1,409,690,693
1990	190,408,869	1,429,046,923
1991	197,949,808	1,454,007,592
1992	205,490,749	1,478,968,217
1993	213,031,707	1,503,928,793
1994	220,572,649	1,558,368,924
1995	228,113,596	1,612,684,936
1996	235,654,521	1,666,705,087
1997	243,195,481	1,670,031,772
1998	250,736,414	1,671,290,139
1999	258,159,525	1,669,234,443
2000	265,582,657	1,664,722,577
2001	273,547,835	1,666,868,187
2002	281,512,965	1,665,099,320
2003	289,478,093	1,659,719,994
2004	297,443,197	1,651,597,210
2005	305,408,463	1,641,941,981
2006	315,919,616	1,644,859,074
Heat content used for conversion to btu:	138,700 btu/gallon	125,000 btu/gallon

Pipeline

The sum of natural gas, crude petroleum and petroleum product, and coal slurry and water.

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 2006*, Table 1. Cubic feet were converted to Btu using 1,031 Btu/ft³. 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 29.305×10^{-5} kWhr/Btu. Electricity generation and distribution efficiency was 29%. When generation and distribution efficiency are taken into account, 1 kWhr equals 10,339 Btu.

Crude petroleum and petroleum product:

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

Coal slurry and water:

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

Table A.11
Pipeline Fuel Use

Year	Natural gas (million cubic feet)	Estimated natural gas pipeline electricity use (million kWhr)	Electricity constant (trillion btu)
1970	722,166	3,272.9	212.1
1971	742,592	3,365.4	212.1
1972	766,156	3,472.2	212.1
1973	728,177	3,300.1	212.1
1974	668,792	3,031.0	212.1
1975	582,963	2,642.0	212.1
1976	548,323	2,485.0	212.1
1977	532,669	2,414.1	212.1
1978	530,451	2,404.0	212.1
1979	600,964	2,723.6	212.1
1980	634,622	2,876.1	212.1
1981	642,325	2,911.0	212.1
1982	596,411	2,703.0	212.1
1983	490,042	2,220.9	212.1
1984	528,754	2,396.3	212.1
1985	503,766	2,283.1	212.1
1986	485,041	2,198.2	212.1
1987	519,170	2,352.9	212.1
1988	613,912	2,782.3	212.1
1989	629,308	2,852.0	212.1
1990	659,816	2,990.3	212.1
1991	601,305	2,725.1	212.1
1992	587,710	2,663.5	212.1
1993	624,308	2,829.4	212.1
1994	685,362	3,106.1	212.1
1995	700,335	3,173.9	212.1
1996	711,446	3,224.3	212.1
1997	751,470	3,405.7	212.1
1998	635,477	2,880.0	212.1
1999	645,319	2,924.6	212.1
2000	642,210	2,910.5	212.1
2001	624,964	2,832.3	212.1
2002	666,920	3,022.5	212.1
2003	591,492	2,680.7	212.1
2004	566,187	2,566.0	212.1
2005	584,026	2,646.8	212.1
2006	584,497	2,649.0	212.1
Heat content used for conversion to btu:	1,031 btu/cubic foot	10,339 Btu/kWhr	

Note: Formula for estimating electricity use for natural gas pipelines is:
 Natural gas use (in million cubic ft) \times 1,031 btu/cubic ft \times 0.015 \times 29.305 $\times 10^{-5}$ kWhr/btu

Rail

Freight:

AAR, *Railroad Facts*, 2007 Edition, Washington, DC, 2007.

Table A.12
Class I Freight Railroad
Fuel Use

Year	Diesel fuel (thousand gallons)
1970	3,807,663
1971	3,822,907
1972	3,996,985
1973	4,160,730
1974	4,175,375
1975	3,736,484
1976	3,895,542
1977	3,985,069
1978	3,968,007
1979	4,072,187
1980	3,955,996
1981	3,756,439
1982	3,178,116
1983	3,137,295
1984	3,388,173
1985	3,144,190
1986	3,039,069
1987	3,102,227
1988	3,182,267
1989	3,190,815
1990	3,134,446
1991	2,925,970
1992	3,022,108
1993	3,111,981
1994	3,355,802
1995	3,503,096
1996	3,600,649
1997	3,602,793
1998	3,619,341
1999	3,749,428
2000	3,720,107
2001	3,729,985
2002	3,751,413
2003	3,849,229
2004	4,082,236
2005	4,119,879
2006	4,214,459
Heat content used for conversion to btu:	138,700 Btu/gallon

Passenger:Commuter - APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007.

Table A.13
Commuter Rail Fuel Use

Year	Diesel (thousand gallons)	Electricity (million kWhr)
1984	58,320	901
1985	55,372	1,043
1986	54,608	1,170
1987	51,594	1,155
1988	53,054	1,195
1989	52,516	1,293
1990	52,681	1,226
1991	54,315	1,239
1992	54,951	1,124
1993	59,766	1,196
1994	61,900	1,244
1995	63,064	1,253
1996	61,888	1,255
1997	63,195	1,270
1998	69,200	1,299
1999	73,005	1,322
2000	70,818	1,370
2001	72,204	1,354
2002	72,847	1,334
2003	72,264	1,383
2004	71,999	1,449
2005	76,714	1,484
2006	Data not available; assumed 2006 = 2005	
Heat content used for conversion to btu:	138,700 Btu/gallon	10,339 Btu/kWhr

Transit – APTA, Public Transportation Fact Book, 2007, Washington, DC, 2007.
Includes light rail and heavy rail.

Table A.14
Transit Rail Fuel Use

Year	Electricity (million kWhr)		Total
	Light rail	Heavy rail	
1970			2,561
1971			2,556
1972			2,428
1973			2,331
1974			2,630
1975			2,646
1976	Light rail and heavy rail data are		2,576
1977	not available separately from		2,303
1978	1970 to 1985.		2,223
1979			2,473
1980			2,446
1981			2,655
1982			2,722
1983			2,930
1984			3,092
1985			2,928
1986	173	3,066	3,239
1987	191	3,219	3,410
1988	243	3,256	3,499
1989	242	3,286	3,528
1990	239	3,284	3,523
1991	274	3,248	3,522
1992	297	3,193	3,490
1993	281	3,287	3,568
1994	282	3,431	3,713
1995	288	3,401	3,689
1996	321	3,322	3,643
1997	361	3,253	3,614
1998	381	3,280	3,661
1999	416	3,385	3,801
2000	463	3,549	4,012
2001	487	3,646	4,133
2002	510	3,683	4,193
2003	507	3,632	4,138
2004	553	3,684	4,237
2005	571	3,769	4,430
2006	Data are not available; assumed 2006 = 2005		
Heat content used for conversion to btu:	10,339 Btu/kWhr	10,339 Btu/kWhr	10,339 Btu/kWhr

Intercity – Personal communication with Amtrak, Washington, DC, 2007.

Table A.15
Intercity Rail Fuel Use

Year	Diesel fuel (thousand gallons)	Electricity (thousand kWhr)
1994	73,516	308,948
1995	72,371	335,818
1996	71,226	362,689
1997	75,656	389,559
1998	75,999	416,429
1999	79,173	443,300
2000	94,968	470,170
2001	96,846	455,703
2002	84,432	518,306
2003	74,621	536,950
2004	68,605	550,695
2005	65,477	531,377
2006	62,463	548,856
Heat content used for conversion to btu:	138,700 Btu/gallon	10,339 Btu/kWhr

Calculation of Million Barrels per Day Crude Oil Equivalent

One gallon of gasoline, diesel fuel, or lpg is estimated to be the equivalent of one gallon of crude oil. Petroleum used for electricity was calculated using the following formula:

$$\{[(BTU*S)/G]/P \}/365/1000$$

BTU = Btus of electricity from Table 2.4

S = Share of petroleum used in making primary electricity (Calculated from Table 2.6 from the EIA, *Monthly Energy Review*)

G = Electricity generation and distribution (assumed 29%)

P = Btus per barrel of petroleum product (Table A3 from the EIA, *Monthly Energy Review*).

Passenger Travel and Energy Use

Automobiles

Number of vehicles, vehicle-miles – DOT, FHWA, *Highway Statistics, 2006*, Table VM-1. Data series shown in Table 4.1.

Passenger-miles – Vehicle-miles multiplied by an average load factor.

Load factor – 2001 NHTS shows automobile load factor as 1.1 persons per vehicle.

Energy intensities –

Btu per vehicle-mile – Automobile energy use divided by vehicle-miles.

Btu per passenger-mile – Automobile energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-3. Data series shown in Table 2.6.

Light trucks

Number of vehicles, vehicle-miles – DOT, FHWA, *Highway Statistics 2006*, Table VM-1. Data by truck type were multiplied by the shares of trucks/truck travel which are for personal use (Table A.17).

Passenger-miles – Vehicle-miles multiplied by an average load factor.

Load factor – 2001 NHTS shows personal light truck load factor as 1.72 persons per vehicle.

Energy intensities -

Btu per vehicle-mile – Personal light truck energy use divided by personal light truck vehicle-miles.

Btu per passenger-mile – Personal light truck energy use divided by personal light truck passenger-miles.

Energy use – See Energy Use Sources, p. A-6, A-7 (light trucks, medium/heavy trucks). Data by truck type were multiplied by the shares of truck fuel use which are for personal use (Table A.17) which were derived by ORNL from the 2002 VIUS Micro Data File on CD.

Table A.16
Share of Trucks, Truck Travel,
and Fuel Use for Personal Travel

Personal trucks	
85.6%	2-axle, 4-tire trucks
26.9%	Other single-unit and combination trucks
Personal truck travel	
80.9%	2-axle, 4-tire trucks
13.1%	Other single-unit and combination trucks
Personal truck fuel use	
78.0%	2-axle, 4-tire trucks
6.0%	Other single-unit and combination trucks

Note:

Since these shares come from the 2002 VIUS, they may underestimate the amount of personal trucks, truck travel, and energy use for 2006.

Motorcycles

Number of vehicles, vehicle-miles – DOT, FHWA, *Highway Statistics 2006* Table VM-1.

Passenger-miles – Vehicle-miles multiplied by an average load factor.

Load factor - 2001 NHTS shows motorcycle load factor as 1.22 persons per vehicle.

Energy intensities –

Btu per vehicle-mile – Motorcycle energy use divided by vehicle-miles.

Btu per passenger-mile – Motorcycle energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-4. Data series shown in Table 2.6.

Demand Response

Number of vehicles, vehicle-miles, passenger-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007.

Load factor – Passenger-miles divided by vehicle-miles.

Energy intensities –

Btu per vehicle-mile – Energy use divided by vehicle-miles.

Btu per passenger-mile – Energy use divided by passenger-miles.

Energy use – APTA, *2006 Public Transportation Fact Book*, Washington, DC, 2006.

Vanpool

Number of vehicles, vehicle-miles, passenger-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007.

Load factor – Passenger-miles divided by vehicle-miles.

Energy intensities –

Btu per vehicle-mile – Energy use divided by vehicle-miles.

Btu per passenger-mile – Energy use divided by passenger-miles.

Energy use – APTA, *2006 Public Transportation Fact Book*, Washington, DC, 2006.

Buses

Transit

Number of vehicles, vehicle-miles, passenger-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007. Data series shown on Table 5.12.

Load factor – Passenger-miles divided by vehicle-miles.

Energy intensities –

Btu per vehicle-mile – Transit bus energy use divided by transit bus vehicle-miles.

Btu per passenger-mile – Transit bus energy use divided by transit bus passenger-miles.

Energy use - See Energy Use Sources, p. A-4. Data series shown in Table 5.12.

Intercity

Energy use – See Energy Use Sources, p. A-5 . Data series shown in Table 5.13. Because the 2001 and 2002 data are not available, the rate of change in bus VMT from FHWA, *Highway Statistics 2006*, was used to estimate the change in energy use.

School

Number of vehicles – DOT, FHWA, *Highway Statistics 2005*, Table MV-10. Data series shown in Table 5.13.

Energy use – See Energy Use Sources, p. A-5 . Data series shown in Table 5.13. Because the data past 2000 are not available, the rate of change in bus VMT from FHWA, *Highway Statistics 2006*, was used to estimate the change in energy use.

Air

Certificated air carriers

Aircraft-miles, passenger-miles – DOT, BTS, *Air Carrier Traffic Statistics*, www.bts.gov/programs/airline_information/air_carrier_traffic_statistics, Washington, DC.

Load factor – Passenger-miles divided by aircraft-miles.

Energy intensities -

Btu per passenger-mile – Certificated air carrier energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-10. All of domestic fuel use and half of international fuel use was considered to be domestic use.

Note: These data differ from the data in Table 9.1 because that table contains data on ALL domestic AND international air carrier energy use and passenger-miles.

General aviation

Number of vehicles – DOT, FAA, *General Aviation Activity and Avionics Survey: Calendar Year 2006* Data series shown in Table 9.2.

Energy intensities –

Btu per passenger-mile – General aviation energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-9. Data series shown in Table 9.2.

Recreational boating

Number of vehicles and energy use – U.S. EPA, NONROAD2005 model.

Rail

Intercity

Number of vehicles, vehicle-miles, passenger-miles – AAR, *Railroad Facts, 2007 Edition*, Washington, DC, 2007.

Load factor – Passenger-miles divided by vehicle-miles.

Energy Intensities -

Btu per vehicle-mile – Intercity rail energy use divided by vehicle-miles.

Btu per passenger-mile – Intercity rail energy use divided by passenger-miles.

Energy use - See Energy Use Sources, p. A-18. Data series shown in Table 9.11.

Transit

Number of vehicles, vehicle-miles, passenger-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007. Sum of light and heavy rail transit. Data series shown on Table 9.13.

Load factor – Passenger-miles divided by vehicle-miles.

Energy intensities –

Btu per vehicle-mile – Light and heavy transit rail energy use divided by vehicle-miles.

Btu per passenger-mile – Light and heavy transit rail energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-17. Data series shown in Table 9.13.

Commuter

Number of vehicles, vehicle-miles, passenger-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007. Data series shown on Table 9.12.

Load factor – Passenger-miles divided by vehicle-miles.

Energy intensities –

Btu per vehicle-mile – Commuter rail energy use divided by vehicle-miles.

Btu per passenger-mile – Commuter rail energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-16. Data series shown in Table 9.12.

Highway Passenger Mode Energy Intensities

Automobiles

Btu per vehicle-mile – Automobile energy use divided by automobile vehicle miles of travel.

Energy use – See Energy Use Sources, p. A-3. Data series shown in Table 2.6.

Vehicle-miles – DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996; DOT, FHWA, *Highway Statistics Summary to 1995*. Data series shown in Table 4.1.

Btu per passenger-mile – Automobile energy use divided by automobile passenger-miles.

Energy use – See Energy Use Sources, p. A-3. Data series shown in Table 2.6.

Passenger miles – Vehicle miles multiplied by an average load factor.

Vehicle-miles – DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996; DOT, FHWA, *Highway Statistics Summary to 1995*. Data series shown in Table 4.1.

Load factor – NPTS 1969, 1977, 1983/84, 1990, and 1995, and NHTS 2001.

Table A.17
Automobile Load Factor used to calculate Passenger-Miles

Year	Source	Load Factor
1970	1969 NPTS	1.90
1971	Interpolated	1.90
1972	Interpolated	1.90
1973	Interpolated	1.90
1974	Interpolated	1.90
1975	Interpolated	1.90
1976	Interpolated	1.90
1977	1977 NPTS	1.90
1978	Interpolated	1.88
1979	Interpolated	1.87
1980	Interpolated	1.85
1981	Interpolated	1.83
1982	Interpolated	1.82
1983	1983/84 NPTS	1.80
1984	Interpolated	1.77
1985	Interpolated	1.74
1986	Interpolated	1.71
1987	Interpolated	1.69
1988	Interpolated	1.66
1989	Interpolated	1.63
1990	1990 NPTS	1.60
1991	Interpolated	1.60
1992	Interpolated	1.60
1993	Interpolated	1.60
1994	Interpolated	1.60
1995	1995 NPTS	1.60
1996	Interpolated	1.60
1997	Interpolated	1.59
1998	Interpolated	1.59
1999	Interpolated	1.58
2000	Interpolated	1.58
2001	2001 NHTS	1.57
2002	2001 NHTS	1.57
2003	2001 NHTS	1.57
2004	2001 NHTS	1.57
2005	2001 NHTS	1.57
2006	2001 NHTS	1.57

Light trucks

Btu per vehicle-mile – Light truck energy use divided by light truck vehicle miles of travel.

Energy use – See Energy Use Sources, p. A-6. Data series shown in Table 2.6.

Vehicle-miles – DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996; DOT, FHWA, *Highway Statistics Summary to 1995*. Data series shown in Table 4.2.

Buses

Transit

Btu per vehicle-mile – Transit bus energy use divided by transit bus vehicle-miles.

Energy use – See Energy Use Sources, p. A-4. Data series shown in Table 5.12.

Vehicle-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007. Data series shown on Table 5.12.

Btu per passenger-mile – Transit bus energy use divided by transit bus passenger-miles.

Energy use – See Energy Use Sources, p. A-4. Data series shown in Table 5.12.

Passenger-miles – APTA, *Public Transportation Fact Book*, 2007, Washington, DC, 2007. Data series shown on Table 5.12.

Intercity

Btu per passenger-mile – Intercity bus energy use divided by intercity bus passenger-miles.

Energy use – See Energy Use Sources, p. A-5. Data series shown in Table 5.13. Because the data past 2000 are not available, the rate of change in bus VMT from FHWA, *Highway Statistics 2006*, was used to estimate the change in energy use.

Passenger-miles – (Data past 2000 are not available.) Eno Foundation for Transportation, *Transportation in America 2001*, Nineteenth edition, Washington, DC. Data series shown in Table 5.13.

Nonhighway Mode Energy Intensities

Air

Certificated air carriers

Btu per passenger-mile – Certificated air carrier energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-10. All of domestic fuel use and half of international fuel use was considered to be domestic use.

Passenger-miles – DOT, BTS, *Air Carrier Traffic Statistics*, www.bts.gov/programs/airline_information/air_carrier_traffic_statistics, Washington, DC. Pre-1994 data are from various editions of the *FAA Statistical Handbook of Aviation* (no longer published). Scheduled service passenger-miles of domestic air carriers and half of international air carriers were used to coincide with fuel use.

Note: These data differ from the data in Table 9.1 because that table contains data on ALL domestic AND international air carrier energy use and passenger-miles.

General aviation

Btu per passenger-mile – General aviation energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-9. Data series shown in Table 9.2.

Passenger-miles – (Data past 2000 not available.) Eno Foundation for Transportation, *Transportation in America 2001*, Nineteenth edition, Washington, DC. Data series shown in Table 9.2.

Rail

Intercity

Btu per passenger-mile – Intercity rail energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-18. Data series shown in Table 9.11.

Passenger-miles – AAR, *Railroad Facts, 2007 Edition*, and previous annual editions.

Transit

Btu per passenger-mile – Transit rail energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-17. Data series shown in Table 9.13.

Passenger-miles – APTA, *Public Transportation Fact Book, 2007*, Washington, DC, 2007. Data series shown on Table 9.13.

Commuter

Btu per passenger-mile – Commuter rail energy use divided by passenger-miles.

Energy use – See Energy Use Sources, p. A-16. Data series shown in Table 9.12.

Passenger-miles – APTA, *Public Transportation Fact Book, 2007*, Washington, DC, 2007. Data series shown on Table 9.12.

Freight Movement and Energy Use

Rail

Number of locomotives, ton-miles, tons shipped, average length of haul – AAR, *Railroad Facts, 2007 Edition*, Washington, DC, 2007. Data series shown in Table 9.8.

Energy intensity – Class I rail energy use divided by freight car-miles.

Energy use – See Energy Use Sources, p. A-15. Data series shown in Table 9.8.

Water

Number of vehicles – U.S. Department of the Army, Army Corps of Engineers, “Summary of U.S. Flag Passenger and Cargo Vessels, 2006,” New Orleans, LA, 2003.

Ton-miles, tons shipped, average length of haul – U.S. Department of the Army, Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 2006*, Part 5: National Summaries, New Orleans, LA, 2006. Data series shown in Table 9.4.

Btu per ton-mile – Domestic waterborne commerce energy use divided by ton-miles.

Energy use – See Energy Use Sources, p. A-11. Data series shown in Table 9.4.

Freight Mode Energy Intensities

Truck

Btu per vehicle-mile – Heavy single-unit and combination truck energy use divided by vehicle miles

Energy use – See Energy Use Sources (medium/heavy trucks), p. A-7.

Vehicle-miles – DOT, FHWA, *Highway Statistics 2006*, Table VM-1 and annual editions back to 1996; DOT, FHWA, *Highway Statistics Summary to 1995*. Data series is the total of vehicle travel data on Tables 5.1 and 5.2.

Rail

Btu per freight car-mile – Class I rail energy use divided by freight car-miles.

Energy use – See Energy Use Sources, p. A-15. Data series shown in Table 9.8.

Freight car miles – AAR, *Railroad Facts, 2007 Edition*, Washington, DC, 2006. Data series shown in Table 9.8.

Btu per ton-mile – Class I rail energy use divided by ton-miles.

Energy use – See Energy Use Sources, p. A-15. Data series shown in Table 9.8.

Ton-miles – AAR, *Railroad Facts, 2007 Edition*, Washington, DC, 2007. Data series shown in Table 9.8.

Water

Btu per ton-mile – Domestic waterborne commerce energy use divided by ton-miles.

Energy use – See Energy Use Sources, p. A-11. Data series shown in Table 9.4.

Ton-miles – U.S. Department of the Army, Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 2006*, Part 5: National Summaries, New Orleans, LA, 2006. Data series shown in Table 9.4.