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Special
(Edition 3 of ORNL-5198)

Transportation Energy Conservation Data Book

Edition 3

OAK RIDGE NATIONAL LABORATORY operated by UNION CARBIDE CORPORATION for the DEPARTMENT OF ENERGY

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TRANSPORTATION ENERGY CONSERVATION DATA BOOK: EDITION 3

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Regional and Urban Studies Section

Energy Division

Prepared for
Data Analysis Branch
Nonhighway Transport Systems and Special Projects
Transportation Energy Conservation Division
Office of Conservation and Solar Applications
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EDITION 3

Contents

Contents (Cont'd)

Contents (Cont'd)

List of Tables

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Tables (Cont'd)

List of Figures

List of Figures (Cont'd)

List of Figures (Cont'd)

List of Figures (Cont'd)

List of Figures (Cont'd)

List of Figures (Cont'd)

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Abstract

This document is the third edition of the *Transportation Energy Conservation Data Book*, a statistical compendium compiled and published by Oak Ridge National Laboratory (ORNL) under contract with the Transportation Energy Conservation (TEC) Division of the Department of Energy (DOE). Secondary data on transportation characteristics by mode, on transportation energy use, and on other related variables are presented in tabular and/or graphic form.

All major modes of transportation are represented: highway, air, rail, marine, and pipeline. The six main chapters focus on various characteristics of the transportation sector including (1) modal characteristics, (2) current energy use, efficiency and conservation, (3) projections of modal energy use, (4) impact of government activities, (5) supply and cost of energy, and (6) general demographic and economic characteristics.

Included in the more than 400 tables and figures are the following transportation stock and use statistics: number of vehicles, vehicle-miles traveled, passenger-miles and freight ton-miles, fleet characteristics, household automobile ownership, size mix of automobiles, vehicle travel characteristics, and commuting patterns. Energy characteristics presented include energy use by fuel source and transportation mode, energy intensity figures by mode, indirect energy use, production as a percent of consumption, imports as a percent of domestic production, energy prices from the wellhead to the retail outlet, and alternative fuels.

Foreword

This third edition of the *Transportation Energy Conservation Data Book* is the first produced for the Transportation Energy Conservation Division since the formation of the Department of Energy. Therefore, the data book takes on an expanded focus because it must serve the needs of transportation energy conservation policymakers (functions of the Federal Energy Administration) as well as the needs of decision-makers concerned with transportation energy conservation via technological improvements (functions of the Energy Research and Development Administration).

This third edition is also the third that has benefited from the careful attention to detail and dedication of Debby Shonka. More than any single person, Debby has provided the input of time and skill required of a comprehensive data book. Debby now leaves the project as a full-time member to devote similar attention to the raising of a family. We hope to continue to receive her assistance on a part-time basis. If dedications were made for publications such as this, then this volume would certainly be dedicated to Debby Shonka.

The continued improvement of this data book is dependent upon helpful feedback from its users. Most of all, we need to be informed of any errors contained in this volume and/or of any relevant information that is missing. Please contact us with your comments and suggestions (addresses are at the end of the Introduction.)

Philip D. Patterson
Chief, Data Analysis Branch
Division of Transportation
Energy Conservation

Statistical Highlights, 1977

(Numbers in italics are percentages)

Motor Vehicles

Total motor vehicles, thousands	148,759
Vehicles per household	1.96
Households owning one or more[a]	*83.8%*
Automobiles registered, thousands	113,667
Automobiles in use,[b] thousands	99,880
Automobile retail sales	*100%*
Full-size	*25.5%*
Intermediate	*26.6%*
Small	*28.5%*
Imports	*18.1%*
Passenger vans	*1.3%*
Fleets	*13.4%*
Trucks registered, thousands	29,584
Personal use	*41.2%*
Trucks in use,[b] thousands	28,201
Truck retail sales	*100%*
Light-duty	*89.0%*
Medium-size	*6.1%*
Heavy-duty	*4.9%*
Buses registered,[c] thousands	493
Intercity	*4.2%*
Local transit	*11.1%*
School	*79.7%*
Other	*5.0%*
Motorcycles in use, thousands	7,926

Transportation Movement

Passenger	
VMT, all motor vehicles,[d] billions	1,477
Passenger cars[d]	*75.8%*
Personal trucks[d,e]	*7.3%*
Average annual-miles per motor vehicle	11,800
Intercity passenger-miles	*100%*
Highway (passenger car and bus)	*87.0%*
Nonhighway	*13.0%*
Air	*12.0%*
Rail	*0.7%*
Water	*0.3%*
Freight	
Intercity ton-miles[e]	*100%*
Highway (truck)	*23.9%*
Nonhighway	*76.2%*
Air	*0.2%*
Rail	*35.7%*
Water	*16.1%*
Pipeline (oil)	*24.2%*

Energy Use *

Total world[f] (10^{12} Btu)	305,515
Total U.S. (10^{12} Btu)	75,836
Percentage of world use	*24.8%*
Total petroleum (10^{12} Btu)	36,956
Percentage of total U.S. energy	*48.7%*
Percentage consumed by transportation sector	*52.1%*
Total energy, transportation sector (10^{12} Btu)	19,251
Percentage of total U.S.	*25.4%*
Highway	*78.6%*
Passenger car and motorcycle	*52.1%*
Bus	*0.7%*
Truck	*25.5%*
Nonhighway	*21.4%*
Rail	*3.1%*
Air	*8.3%*
Marine (U.S. purchased)	*5.6%*
Pipeline	*2.9%*
Other	*1.2%*
Total petroleum consumed by transportation sector[f] (10^{12} Btu)	18,666
Total energy used by transportation sector	*97.0%*

*Figures for total U.S. energy use, including the transportation sector, are lower than official Energy Information Administration (EIA) estimates for several reasons:
1. EIA includes military;
2. EIA includes indirect energy uses such as road and street lighting;
3. EIA energy use is calculated using a different methodology.

[a]Based on 1974 breakdown.
[b]R. L. Polk estimate as of July 1, 1977.
[c]Based on 1976 breakdown.
[d]Federal Highway Administration estimate as of Nov. 14, 1978.
[e]Census of Transportation, Truck Inventory and Use Survey.
[f]Estimate.

Figures on energy use from Statistical Highlights, 1976, are not comparable with figures from Statistical Highlights, 1977. Different data sources were used to compile the 1977 Statistical Highlights; see Table 2.7 for further reference.

Introduction

The role of energy conservation in solving our present dilemma of increasing energy demand and dwindling energy supplies has long been recognized. In fact, the cornerstone of the President's proposed National Energy Plan is conservation. The National Energy Plan recognizes that the reduction of our near-total dependence on oil and natural gas is crucial to solving the energy crisis. The transportation sector uses some 25% of total energy and some 53% of total petroleum used in the nation. Consequently, it is both a logical and necessary target for national and regional conservation measures.

Developing a comprehensive and effective strategy to reduce energy use in the transportation sector, however, requires a basic understanding of the determinants of energy use in the sector such as fleet sizes, energy intensities, travel characteristics, institutional characteristics, and vehicle operating expenses. This baseline data can be used to identify potential areas for energy resource conservation as well as to project future levels of energy use and the potential impact of conservation policies. At the federal level, the importance of an energy data base has been recognized in the organization of the Department of Energy (DOE) through the establishment of the Energy Information Administration.

Prior to the formation of DOE, the Transportation Energy Conservation (TEC) Division of ERDA recognized the need to coordinate its data collection activities and to develop a single comprehensive data base. In January of 1976, TEC contracted with Oak Ridge National Laboratory (ORNL) to begin work developing a data base that could be used by TEC staff in their evaluation of current and proposed transportation-related technologies. The first edition of the *TEC Data Book** was published in October 1976; Edition 2 came out in October 1977. It is intended that this *TEC Data Book Edition 3* update and supercede those previous documents.

Statistical information on each of the major transportation modes (i.e., highway, air, rail, marine, and pipeline) is provided in the *Data Book*. The data are arranged into six chapters based on subject categories. The chapters focus on various characteristics of the transportation sector including (1) modal characteristics, (2) current energy use, efficiency, and conservation, (3) projections of modal energy use, (4) impact of government regulation, (5) supply and cost of energy, and (6) general demographic and economic characteristics of the United States.

Statistical highlights of 1977 from the *Data Book* are summarized for the user and presented on a one-page tear-out sheet. A synopsis of chapter contents precedes each chapter.

Edition 3 of the *TEC Data Book* includes over 400 pages of tables and figures. To facilitate use of this information we have incorporated five aids in format and presentation techniques. A cross-modal matrix is presented at the end of the book. This first matrix provides a detailed index by mode to the data included in Edition 3. A second matrix provides a nonmodal, fuel-specific index to the data. Third, a logo on the upper right-hand corner of a page indicates the transportation modes represented on that page. Fourth, a permuted title index is also included. By referencing key terms in the table and figure titles, the

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*A. S. Loebl, D. J. Bjornstad, D. F. Burch et al., *Transportation Energy Conservation Data Book, Edition 1,* ORNL-5198, October 1976.

†D. B. Shonks, A. S. Loebl, and P. D. Patterson, *Transportation Energy Conservation Data Book, Edition 2,* ORNL-5320, October 1977.

permuted title index serves to both cluster and more easily identify subject areas addressed on an item-specific basis within the data book. Finally, a three-tiered keyword index to the entire document is provided at the back of the book.

In conjunction with the data collection activity, the Transportation Energy Program at ORNL is developing a comprehensive library of documents relevant to transportation energy conservation. An annotated bibliography of these documents is available under separate cover: *Transportation Energy Conservation Data Book: A Selected Bibliography*. (See form at back of this document.) In addition, a list of other documents available by the Transportation Energy Program at ORNL is provided (see Table of Contents.) These documents include a *Regional Data Book* and a series of research monographs.

The majority of the statistics contained in the *Data Books* are taken from published sources and each table or figure is referenced accordingly. Although the data may be reformatted for presentation by ORNL, the basic data are compiled from a variety of sources. Consequently, neither ORNL nor DOE can endorse the validity or consistency of the statistics presented.

Users of the *TEC Data Book* are encouraged to comment on errors, omissions, emphases, and organization of this report to one of the persons listed on the following page.

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Other Publications Available by the Transportation Energy Program (TEP) at ORNL

VMT Statistics, Lifetime VMT, and Current State Methods of Estimating VMT, TERA, Inc., D. L. Greene, A. S. Loebl, ORNL/TM-6327.

Econometric Analysis of the Demand for Gasoline at the State Level, D. L. Greene, ORNL/TM-6326.

An Investigation of the Variability of Gasoline Consumption Among States, D. L. Greene, ORNL-5391.

Worldwide Transportation/Energy Demand Forecast: 1975-2000, Delta Research Corporation, ORNL/Sub-78/13536/1.

Characteristics of Automotive Fleets in the United States, 1966-1977, D. B. Shonka, ORNL/TM-6449.

Projections of Light Truck Population to Year 2025, Lindsey-Kaufman Company, ORNL/Sub-78/14285.

The Energy Intensity and Related Parameters of Selected Passenger Transportation Modes, A. B. Rose, ORNL-5506.

The Energy Intensity and Related Parameters of Selected Freight Transportation Modes, A. B. Rose, ORNL/TM-6700.

Regional Transportation Energy Conservation Data Book, Edition 1, D. L. Greene, et al., ORNL-5435.

Light Truck Inventory Models: Forecasts to the Year 2000, G. E. Liepins, ORNL/TM-6450.

Transportation Energy Conservation Data Book — A Selected, Annotated Bibliography, Edition 3, B. Y. Barber et al.

Chapter 1

Characteristics of Transportation Modes

Characteristics of Transportation Modes

An awareness of the characteristics of major transportation modes in the United States is essential to an understanding of transportation energy use and conservation. Total energy use in the transportation sector can be viewed as simply the sum total of energy used by the individual modes. Each mode differs in terms of the magnitude of its contribution to energy demand, its energy efficiency, the types of fuels it consumes, and the types of transportation needs it fulfills. The levels of modal demand and the allocation of the nation's varied transportation demands among modes are determined by the complex interaction of individual modal supply characteristics and by the host of social and economic factors which determine the transportation requirements of households, firms, and governments. A knowledge of the basic modal structure of the transportation sector is fundamental in evaluating transportation energy conservation policy issues.

This chapter provides a description of the transportation sector in general, followed by more detailed information for each mode. Particular attention is focused on the highway mode, which accounts for about 77% of the total transportation energy consumption. Modal energy use data and transportation demand determinants, per se, are the topics of Chapters 2 and 6 respectively. The purpose of Chapter 1 is to characterize the total transportation system in terms of vehicles, infrastructure, purchases, costs, fuel consumption, and use patterns.

The chapter is divided into six sections. Section 1.1 presents an overview of all of the transportation modes. Detailed information is presented on number of vehicles and vehicle-miles traveled, by mode. In 1976 passenger automobiles made up 76% and trucks 19% of all transportation vehicles (Table 1.1) and accounted for proportional amounts of vehicle-miles traveled (74% and 21% respectively).

Total transportation activity appears to have resumed a pattern of steady growth after the end of the oil embargo in 1974. Total intercity passenger travel surpassed its preembargo level in 1976 and grew another 5% in 1977. Automobile travel continues to dominate intercity travel (85% of all passenger-miles) although the air mode increased its share to an all-time high of 12%. Bus and rail were far behind with only 1.8% and 0.7% respectively. Intercity freight traffic also expanded, surpassing its pre-embargo high of 2232×10^9 ton-miles in 1973 for the first time. Rail's share continued to decline slightly, though rail still retains the largest share of the traffic (36%). Trucks and pipelines were gainers, each with a 24% modal share in 1977. Pipeline has shown the greatest increase in recent years, increasing its share by almost 40% since 1965.

Section 1.2 gives an expanded treatment of the highway mode. This section, the largest in the data book, gives appropriate representation to the mode that accounted for 99% of all vehicle-miles of travel in 1977. Information is first presented on the size and characteristics of the stock of motor vehicles. Data on cars and trucks in operation illustrate a trend with significant implications for efforts to improve the fuel efficiency of the highway vehicle population. While both have been increasing their numbers, trucks have been doing so more rapidly; thus, expanding their share of the less-efficient vehicles has tended to offset gains from more efficient "downsized" automobiles. Data are also included on motor vehicle registrations, factory shipments, and numbers of vehicles by major use and vehicle configuration. The nature of the truck fleet, in terms of relationships between size, range of operation, fuel type, and use, is explored in a series of tables and graphs. Light trucks are by far the most numerous, and most of these are used predominantly for personal transportation. A strong pattern of increasing importance of diesel trucks with increasing truck size and longer range of operation emerges, reflecting the dominance of diesel trucks in intercity freight operations.

Flows of capital stock are presented next with data on factory shipments, motor vehicle sales, and vehicle scrappage. In 1977 the first factory shipments of diesel trucks under 6,000 lb were made, signaling an emerging trend toward increased diesel penetration of smaller vehicles. The steadily increasing importance of light trucks in the motor vehicle fleet is clearly evident in the sales statistics. Light truck (<10,000 lb) sales in 1977 accounted for over 20% of total retail sales of passenger cars and trucks. All trucks accounted for one in four vehicle sales. Of these, 56% were pickup trucks, 89% were light trucks, and one in four light trucks was a four-wheel-drive vehicle. Historical statistics indicate that a large majority of light trucks are purchased predominantly for use in personal transportation; for this purpose they are energy inefficient. This trend is disturbing in that it is countervailing to trends in automobile fuel efficiency induced by the EPCA standards. Data presented in this section show that automobiles with efficiencies of less than 14 mpg comprised less than 5% of new car sales in 1977. The corresponding figures for 1976 and 1975 were roughly 15% and 30% respectively.

Data from ORNL and BNL studies* of vehicles in fleets show that 13.5% of new car sales go to the fleets of ten or more cars. Since cars remain in a fleet for a relatively short period of time, fleeted cars comprise only 6.5% of cars in operation. Yet, the impacts of fleet owners' decisions about what types of cars to buy last the lifetime of the vehicle and thus have a much larger impact of the total vehicle population. Recently, fleet buyers have

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*D.B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966-1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, Tenn., 1978; Joseph R. Wagner and Randall S. Davis, *Fleet Operator Study*, Interim Briefing Paper presented by Brookhaven National Laboratory and DOE's Contractor's Coordinating Meeting, Sept. 14, 1978.

reduced their purchases of standard sized cars from 97% of all purchases in 1970 to 45% in 1977. The number of vehicles in publicly owned fleets has doubled since 1960, tripled since 1950, and now stands at 2.25 million. These fleeted and publicly owned vehicles may offer special opportunities for energy conservation.

Detailed statistics on motor vehicle use are presented next in the section on Travel Characteristics (Sect. 1.2.3). Annual vehicle-miles of travel (VMT) is one of the most basic items of data on highway travel, and statistics are presented by type of vehicle and area of operation. The uncertainty which exists about this very important piece of data is revealed in a table comparing VMT data from various sources (Table 1.59). While estimates of household VMT are in relatively close agreement (16,400-16,828), estimates of VMT per automobile differ widely (9,494-15,300). Automobile VMT data presented indicate that VMT per car varies with size of car, number of cars owned by a household, and age of car. VMT per truck is strongly related to truck size — with trucks over 26,000 lb being used far more intensively than light trucks and automobiles (more than 50,000 miles the first two years, as opposed to 50,000-20,000 for light trucks and cars).

Journey-to-work statistics from the 1976 Annual Housing Survey confirm that people in the United States overwhelmingly prefer the energy intensive choice of driving alone to work to all other alternatives (73%). Carpooling is next most favored (16%) and is more prevalent outside than within urban areas (Table 1.73). Mass transit is a significant mode only within central cities, where it captures over 13% of all work trips. Overall, those who walk to work only are almost as numerous (4%) as those taking mass transit (5.1%).

Motor vehicle ownership statistics are presented next, highlighting urban and rural ownership patterns but including crosstabulations by income and expenditures by number of cars owned. The most significant difference between levels of urban and rural vehicle ownership is that almost twice the fraction of households in central cities owned no car in 1976 (27%) as did households outside SMSAs (14%). Survey data are used to examine differences among types of vehicles owned in urban and rural areas. Striking differences are apparent only for small cars and light trucks. Small cars (compacts and subcompacts) comprise 30% of all vehicles in metropolitan areas but only 22% in rural environments. Pickup trucks, which make up only 7% and 10% of vehicles owned by central city and suburban residents, respectively, are almost 20% of the vehicles owned by nonmetropolitan residents. This preference for smaller, more efficient cars in urban areas may, in part, be a response to congested, less efficient driving conditions in urban areas.

Section 1.3 is concerned with air transportation and begins with data on aircraft operations in the United States. Separate statistics are presented on certificated, supplemental (charter) and commuter airlines, and general aviation. Domestic air services have been increasing rapidly in recent years although the activities of supplemental carriers and international flights, in general, have not recovered to their preembargo values. The use of air transportation for nonbusiness purposes has been on the increase, raising the share of nonbusiness passenger trips from 45% in 1972 to 55% in 1976.

The energy efficiency of air travel has been improved through (1) more efficient aircraft, (2) higher load factors, (3) improved maintenance, and (4) operational changes such as reduced taxiing and reduced cruising speeds, to the point that Btu per passenger-mile for the mode in 1976 stood at about 80% of their 1971 levels. As a result, fuel consumption increased only 8% over the period, while services provided grew 38% (from 149×10^9 to 206×10^9 passenger-miles). The section also includes statistics on the stock of aircraft use by type. Tone-miles of freight flown are included as well; approximatly half of this as belly freight in passenger aircraft.

Finally, information on airport facilities is included.

Section 1.4 describes the U.S. intercity rail network and contains data on the stocks of freight and passenger cars as well as on usage. Despite declines in the number of freight cars and locomotives and decreases in the length of the rail network, ton-miles carried by rail have increased. This is attributable to increases in the average length of haul (from 490 miles in 1970 to 568 miles in 1977) and the average tons per car (from 54.7 tons per carload in 1975 to 56.8 tone in 1977).

Section 1.5 deals with marine transportation on waterways of the United States. Annual data (1970-1976) on the stock of domestic barges and towing vessels are presented first. While the number of towing vessels increased only 3% from 1970-1976, their total horsepower grew 56% to accommodate a growth in capacity of barges of 58%. Statistics on oceangoing vessels are also provided which document trends toward more and larger tankers and bulk carriers in the world's oceangoing fleet. A ranking of major commodities shipped on U.S. inland waterways is lead by such bulky commodities as iron ore, coal, limestone, and petroleum and petroleum products. The section concludes with a treatment of recreational boating in the United States. From 1973 to 1976 the number of recreational craft expanded from 8 to 11 million units. Usage per boat was also seen to increase slightly, as did gallons of fuel used per boat hour.

Oil and natural gas pipelines are the subject of the final section, Sect. 1.6. Data detailing the inventory of crude oil, product, and natural gas pipelines reveals little expansion of the existing capacity in recent years. Pipelines have always dominated crude oil movements: data on flows show pipelines with 87% of crude ton-miles in 1975. Recently, petroleum products pipelines have taken traffic away from all competing modes, increasing their share of ton-miles from 23% to 35%.

Section 1.1

Overview

[a]Vehicles owned by U.S. military services are not included.

[b]U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., annual, Table MV-1.

[c]American Public Transit Association, *Transit Fact Book*, '77-'78 edition, Washington, D.C., May 1978, p. 35.

[d]U.S. Department of Transportation, Table MV-10.

[e]U.S. Department of Transportation, Table MV-7.

[f]U.S. Department of Transportation, Table MV-9.

[g]Association of American Railroads, *Yearbook of Railroad Facts*, 1978 edition, Washington, D.C., p. 52.

[h]Association of American Railroads, p. 49.

[i]Association of American Railroads, p. 48.

[j]B. V. Cayce, U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, Calendar Year 1976, Washington, D. C., March 1977, p. 112.

[k]B. V. Cayce, p. 46.

[l]B. V. Cayce, pp. 63–65.

[m]The American Waterways Operators, Inc., *1975 Inland Waterborne Commerce Statistics*, Arlington, Va., April 1977, pp. 2–3.

[n]Estimate is the residual after passenger trucks and government trucks are accounted for.

[o]Does not include recreational marine vessels. In 1976, there were approximately 11,323,000 recreational vessels.

[p]Interstate Commerce Commission, *Transport Statistics*, Washington, D.C., Part 1, Table 7, annual.

[q]American Bus Association, *America's Number 1 Passenger Transportation Service*, Washington, D.C., 1977, Table 1, p. 26.

Table 1.1
Number of Vehicles, 1960 through 1977

	1960	1970	1975	1976	1977
Highway[a,b]	74,475,551	111,222,036	137,917,254	143,538,495	148,759,142
Passenger car and taxi	61,683,865	89,279,864	106,712,551	110,351,327	113,667,069
Motorcycle	574,080	2,814,730	4,966,844	4,989,232	5,015,298
Truck	11,945,477	18,748,421	25,775,715	27,719,597	29,583,932
Bus[c]	272,129	379,021	462,144	478,339	492,843
Rail	2,172,081	1,969,680	1,450,552	1,421,107	1,378,184
Operating railroads[d,e]	2,160,215	1,959,080	1,439,883	1,410,430	1,367,553[f]
Passenger cars	28,677	11,442	6,471	5,478	5,512[f]
Locomotives	31,303	29,167	28,210	27,609	27,680[f]
Freight cars[g]	2,032,713	1,868,596	1,359,459	1,331,705	1,287,315
Company service equipment cars	67,522	49,875	45,743	45,638[f]	47,046[f,h]
Heavy rail transit	9,010	9,338	9,608	9,714	9,639[f,h]
Light rail transit	2,856	1,262	1,061	963	992[f,h]
Air[i,j]	78,684	134,422	170,970	180,796	NA
Air carrier[i,j]	2,135	2,679	2,495	2,492	2,473
Certificated	NA	2,437	2,267	2,271	2,234
Supplemental	NA	119	74	77	78
Commercial	NA	123	154	144	161
General aviation	76,549	131,743	168,475	178,304	NA
Water[k]	20,920	25,433	31,884	33,928	NA
Inland water vessels	20,557	23,854	31,027	33,086	NA
Self propelled	4,052	4,230	4,240	4,379	NA
Nonself propelled	16,505	19,624	26,787	28,707	NA
Oceangoing steam and motor vessels[l]	363	1,579	857	842	NA

[a]Vehicles owned by the military services are not included.

[b]These numbers are taken from the Federal Highway Administration's published reports. FHWA revises their numbers but does not publish the revision. The latest revisions can be obtained directly from FHWA and are usually reported by the Motor Vehicle Manufacturer's Association.

[c]Includes intercity, local, and school buses.

[d]After 1974 the data includes only Class I information.

[e]Includes electric railways (except 1976 and 1977) and pullman cars, as reported to ICC.

[f]Preliminary.

[g]Includes cabooses, and freight cars operated by private lines as reported to ICC.

[h]Does not include 39 cable cars, and 4 inclined plane cars.

[i]The aircraft population is not an inventory of the aircraft owned by the air carriers, but represents the aircraft actually used by the air carrier fleet during the last quarter of the calendar year.

[j]Does not include aircraft operated by air taxi operators who hold authority to operate aircraft over 12,500 lb, turbojet aircraft under blanket authority, or aircraft operated by air travel clubs. For 1976, these operations included 235 aircraft.

[k]Does not include recreational water vessels. In 1976, there were 11,323,000 recreational vessels in use.

[l]Only 1,000 gross tons and over, excludes ships operating exclusively on the Great Lakes and Inland waterways and special types such as channel ships, icebreakers, cable ships, etc., and merchant ships owned by any military forces.

Sources: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., Table MV-1, annual; American Public Transit Association, *Transit Fact Book*, '77–'78 edition, Washington, D.C., May 1978, p. 35; Interstate Commerce Commission, *Transport Statistics*, Washington, D.C., Part 1, Table 7, annual; B. V. Cayce, U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, Calendar Year 1976, Washington, D.C., Dec. 1976, pp. 46, 63, 64, and 116; The American Waterways Operators, Inc., *1975 Inland Waterborne Commerce*, Arlington, Va., Apr. 1977, p. 2 and 3; U.S. Department of Commerce, Maritime Administration, *A Statistical Analysis of the World's Merchant Fleets*, annual; Association of American Railroads, *Yearbook of Railroad Facts*, 1978 ed., Washington, D.C., pp. 48, 49, and 52; correspondence from Department of Army, Waterborne Commerce Statistics Center, New Orleans, La.

[a] U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., 1976, Table VM-1.

[b] The international Taxicab Association reported 12,200 million taxicab miles in *Fact Sheet on Taxicab Operations in the United States, Year 1975*, Rockville, MD, Mar. 1977, for the year 1975. This figure was scaled to 1976 using VMT for personal passenger cars from Table VM-1.

[c] Same as source noted in *a* above except derived from appropriate deductions from Table VM-1 data to allow for government VMT statistics as prepared from *Federal Motor Vehicle Fleet Report*, General Services Administration, Federal Supply Serivce (for fiscal year ending June 30, 1976), Washington, D.C., June 1977, Table 10, p 15.

[d] Percentage of 32.5 for personal passenger trucks was obtained from U.S. Bureau of the Census, *Census of Transportation, 1972, U.S. Summary*, TC72-T52, U.S. Government Printing Office, Washington, D.C., 1973, Table 2.

[e] American Bus Association, *America's Number 1 Passenger Transportation Service*, Washington, D.C., 1977; supplemented by private communications with the American Bus Association.

[f] American Public Transit Association, *Transit Fact Book*, 1976—1977 edition, Washington, D.C., June 1977, Table 11, by adding trolley coaches and conventional transit buses.

[g] Using total bus VMT from Table VM-1, figures for intercity, intracity, and federal government buses were subtracted out leaving school and state and local government buses totaling 2979. Table VM-1 reports 2862 school buses; so, 117 of the 2979 were allocated to state and local government buses. National Association State Directors of Pupil Transportation Services, *1975—76 Statistics on Pupil Transportation* reports that school buses are 34% privately owned and 66% publicly owned. Hence state and local government buses were calculated by adding 117 + .66(2862) and school buses as .34(2862).

[h] General Services Administration, *Federal Motor Vehicle Fleet Report*, Federal Supply Service (for fiscal year ending June 30, 1976), Washington, D.C., June 1977, Table 10, p. 15; auto includes sedan, station wagons, ambulances.

[i] State and local government auto and motorcycle and federal government truck and motorcycle were derived using percentages based on U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., 1976, Table MV-7 and using VMT from Table VM-1.

[j] Commercial truck is the residual after non-government trucks, federal government trucks and state local government trucks are subtracted from total truck VMT from Table VM-1.

[k] Ratios of single-unit trucks and combination truck, and rural and urban trucks were derived from Table VM-1 in order to obtain these figures.

[l] American Public Transit Association, *Transit Fact Book*, 1976—77 edition, Washington, D.C., p. 30.

[m] Association of American Railroads, Economics and Finance Department, *Operating and Traffic Statistics*, O.S. Series No. 218, 1976, p. 1.

[n] Association of American Railroads, Economics and Finance Department, *Yearbook of Railroad Facts*, 1978 edition, p. 38.

[o] U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, Calendar Year 1976, Washington, D.C., Table 8-5.

[p] Certificated Air Carriers — Civil Aeronautics Board, *Air Carrier Traffic Statistics*, Washington, D.C., December 1976, Vol. XX11-12, p. 4; supplemental air carriers — same source, p. 91.

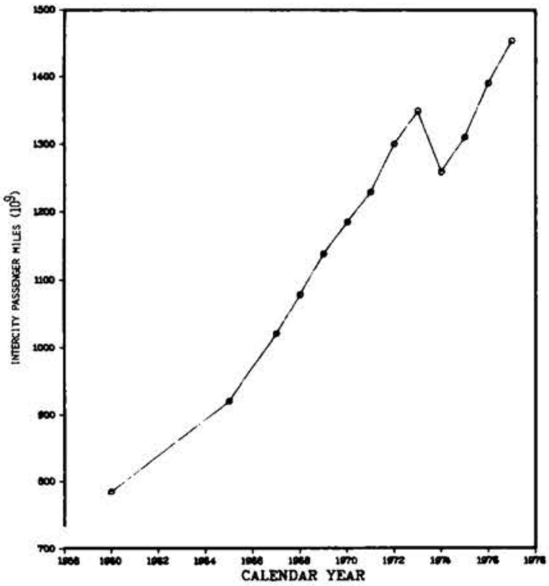

Fig. 1.3
Total Intercity Passenger-Miles, 1960-1977.
(10^9)

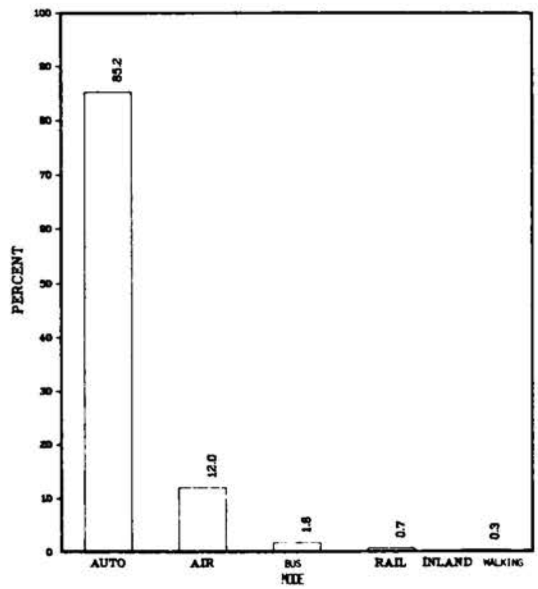

Fig. 1.4
Mode of Intercity Passenger Trips 1977.

Table 1.3
Intercity Passenger-Miles by Mode of Travel, 1960-1977
(percent)

	Automobiles[a]	Buses[a]	Total motor vehicles[a]	Railways, revenue passenger	Inland waterways	Airways, domestic revenue service	Total (%)	Total passenger-miles (10^9)
1960	90.03	2.54	92.57	2.75	0.34	4.34	100.0	784.3
1970	86.59	2.13	88.73	0.91	0.33	10.01	100.0	1184.8
1971	87.12	2.07	89.19	0.72	0.33	9.75	100.0	1229.4
1972	86.82	1.97	88.79	0.67	0.31	10.23	100.0	1300.3
1973	86.40	2.00	88.40	0.70	0.30	10.60	100.0	1348.8
1974	85.00	2.20	87.20	0.80	0.30	11.70	100.0	1259.4
1975	85.80	1.90	87.70	0.80	0.30	11.20	100.0	1310.5
1976	85.40	1.80	87.20	0.70	0.30	11.80	100.0	1390.2
1977	85.20	1.80	87.00	0.70	0.30	12.00	100.0	1453.4
Average annual rate of change (1970–1977)	−0.2	−2.4	−0.3	−3.7	−1.4	2.6		3.0

[a] Includes intra-city portions of intercity trips. Omits rural-to-rural trips, strictly intra-city trips with both origin and destination confined to same city, local bus or transit movement, nonrevenue school, and government bus operations.

Source: *Motor Vehicle Facts & Figures '78*, Motor Vehicle Manufacturer's Association, Detroit, p. 54. (Original source — Interstate Commerce Commission and Transportation Association of America.)

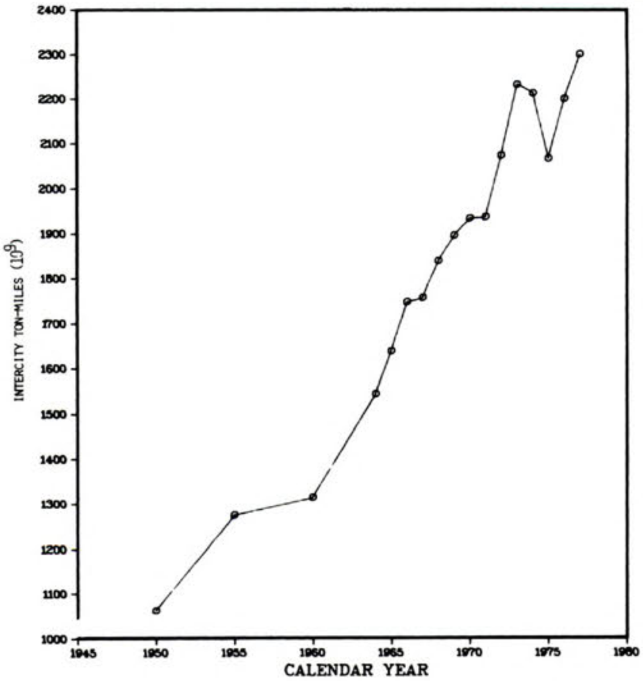

Fig. 1.5
Intercity Ton-Miles, 1950-1977.
(10^9)

Table 1.4
Intercity Freight Movement by Mode
(percent)

	Trucks[a]	Railways[b]	Inland waterways[c]	Pipelines	Domestic airways	Total (%)	Total ton-miles 10^9
1950	16.27	56.17	15.37	12.16	0.03	100.0	1062.6
1960[d]	21.72	44.06	16.76	17.40	0.06	100.0	1314.3
1970	21.30	39.72	16.49	22.29	0.17	100.0	1933.4
1971	22.21	38.42	16.27	22.92	0.18	100.0	1936.5
1972	22.70	37.70	16.40	23.00	0.18	100.0	2073.0
1973	22.60	38.50	16.00	22.70	0.18	100.0	2232.0
1974	22.40	38.50	16.00	22.90	0.18	100.0	2212.0
1975	22.00	36.70	16.60	24.50	0.18	100.0	2066.0
1976	23.20	35.90	17.00	23.80	0.18	100.0	2200.0
1977	23.90	35.70	16.10	24.20	0.17	100.0	2300.0
Average annual rate of change (1970–1977)	1.7	–1.5	–0.3	1.18	0.0		2.51

[a]Ton-miles between cities and between rural and urban areas included, whether private or for hire. Rural-to-rural movements and city deliveries are omitted.

[b]Revenue ton-miles.

[c]Does not include coastwide and intercoastal ton-miles.

[d]1960 and later years include Alaska and Hawaii.

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '78*, Detroit, p. 55. (Taken from Interstate Commerce Commission, American Trucking Association, and Transportation Association of America.)

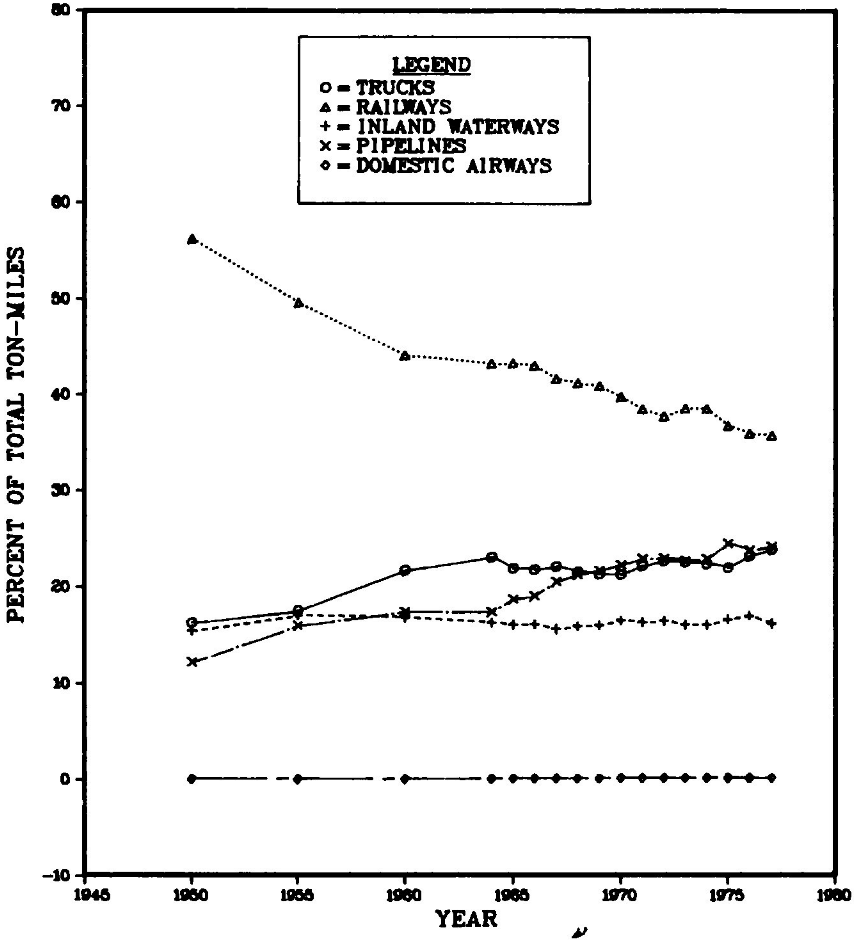

Fig. 1.6
Distribution of Intercity Freight Movement
by Type of Transport, 1950-1977.

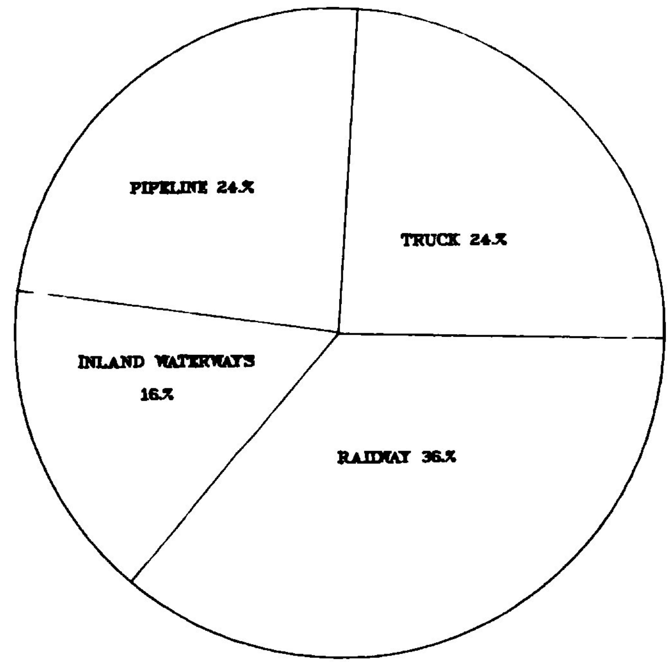

Fig. 1.7
Intercity Ton-Miles by Type of Transport,
1977.

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '78*, Detroit, p. 55. (Original source - Interstate Commerce Commission, American Trucking Association, and Transportation Association of America.)

Table 1.5
Load Factor and Average Length of Haul of Class I Intercity Carriers of Passengers

	Load Factor[a]			Average length of haul (miles)		
	Air	Bus	Rail[b]	Air	Bus	Rail[b]
1950	61.2	50.7	24.6	461	52	65
1960	58.6	45.3	29.8	583	79	65
1970	48.9	46.0	36.7	679	106	38
1975	54.6	44.9	42.4	698	113	37
1977	55.8	41.7	40.6	705	127	37

[a]Load Factor is the percent of capacity utilized; it is determined by dividing either the average number of passengers per unit by the average number of seats per unit or by dividing the total passenger-miles by the total seat-miles.

[b]Rail commutation figures included.

Source: Transportation Association of America, *Transportation Facts and Trends*, 14th edition, Washington, D.C., August 1978, p. 15.

Table 1.6
Average Length of Freight Haul in Domestic Commerce (in statute miles[a])

	Air carriers[b] scheduled	Oil pipeline[c]		Railroad[d] U.S. as a system	Truck, Class[e] I common carrier	Water[f]		
		crude	product			Rivers and canals	Great Lakes	Domestic deep sea
1950	720	292	296	416	235	NA	NA	NA
1960	953	316	271	442	272	282	522	1496
1970	1014	300	357	490	263	330	506	1509
1975	1082	288	366	518	287 (e)	358	530	1362
1976	1075	276	343	540	NA	376	535	1367

[a]These figures do not include any allowance for the additional mileage due to the circuity of the mode.

[b]All certificated airlines.

[c]All oil pipelines subject to ICC regulation.

[d]All operating line-haul railroads.

[e]Class I intercity common carriers.

[f]Includes both for-hire and private carriers.

(e) estimated.

NA — not available

Source: Transportation Association of America, *Transportation Facts and Trends*, 14th edition, Washington, D.C., August 1978, p. 14.

Table 1.7
Intercity Transportation Mileage Within the Continental United States, 1950 through 1976
(statute miles)

	1950	1960	1965	1970	1975	1976
Railroads[a]	223,779	217,552	211,925	206,265	199,411	198,414
Oil pipelines[b]	158,472	190,944	213,764	218,671	225,811	277,066
Natural-gas pipelines and utility main[c]	145,900	239,500	273,000	319,200	331,000	328,526
Inland waterways[d]	24,960	35,253	25,380	25,543	25,543	25,543
Highways[e]	409,133	557,729	617,114	665,903	685,052	689,648
Airways[f]	80,861	293,003	268,275	291,231	313,178	332,662

[a]Data represent aggregate length of roadway of all line-haul railroads, excluding mileage of yard tracks or sidings. Jointly used track is counted only once.

[b]Includes gathering lines.

[c]Includes field and gathering and transmission lines only. Data not adjusted to common diameter equivalent mileage shown as of end of each year.

[d]Includes total length of all commercially navigable inland channels.

[e]Includes paved primary and secondary roads under state control.

[f]1960-1961 airway figures include low/medium frequency routes and very high frequency routes. Only very high frequency routes have been in use since 1962. Jet ranks are included from 1960. Nautical mileage has been converted to statute miles for comparability with the other modes.

Source: Transportation Association of America, *Transportation Facts and Trends*, Fourteenth Edition, Washington, D.C., August 1978, p. 31; American Gas Association, Department of Statistics, 1977, *Gas Facts: A Statistical Record of the Gas Utility Industry*, annual, Arlington, Va., Table 43.

Section 1.2

Highway

Section 1.2.1

Stocks

Both the Federal Highway Administration (FHWA) and R. L. Polk and Co. report figures on the in-use passenger car and truck population. However, their respective estimates are seen to differ for passenger cars by up to 12%. The differences can be attributed to several factors:

1. FHWA count includes all vehicles which have been registered at some time during the calendar year including vehicles retired during the year. The R. L. Polk count includes the vehicles which are registered at an instantaneous point in time, i.e. July 1.
2. Polk figures are restricted to passenger cars, while FHWA figures may include light-duty trucks for some states.
3. Polk factors scrappage rates into their calculations, while the FHWA count includes vehicles that were retired during the year.

From the above discussion, one can see that the Polk estimate is a better indicator of the average auto stock during a calendar year than is the FHWA estimate.

The two truck estimates are much closer, probably because the turnover rate of trucks is lower than that of cars. That is, a truck is less likely to be re-registered within a given year, therefore eliminating double-counting in the FHWA figures.

Table 1.8 Comparison of Estimates of Passenger Cars and Trucks in Use 1950 through 1977 (10^3)

	Passenger cars in use			Trucks in use		
	FHWA/DOT	R. L. Polk	Percent difference from FHWA	FHWA/DOT	R. L. Polk	Percent difference from FHWA
1950	40,339	35,922	11.0	8,599	7,577	11.9
1960	61,682	57,163	7.3	11,914	10,803	9.3
1970	89,280	80,448	9.9	18,748	17,688	5.6
1975	106,712	95,241	10.7	25,776	24,813	3.7
1976	110,351	97,818	11.4	27,720	26,560	4.2
1977	113,667	99,904	12.1	29,584	28,222	4.6

Source: R. L. Polk and Co. and U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., Table VM-1, annual.

THE NUMBER OF CARS IN OPERATION IN THE UNITED STATES HAS INCREASED AT A CONSISTENT RATE SINCE 1950. THE NUMBER OF TRUCKS IN OPERATION HAS INCREASED MOST RAPIDLY SINCE 1965. THIS GROWTH CAN BE ATTRIBUTED TO INCREASED USE OF TRUCKS FOR FREIGHT MOVEMENT AND PERSONAL USE.

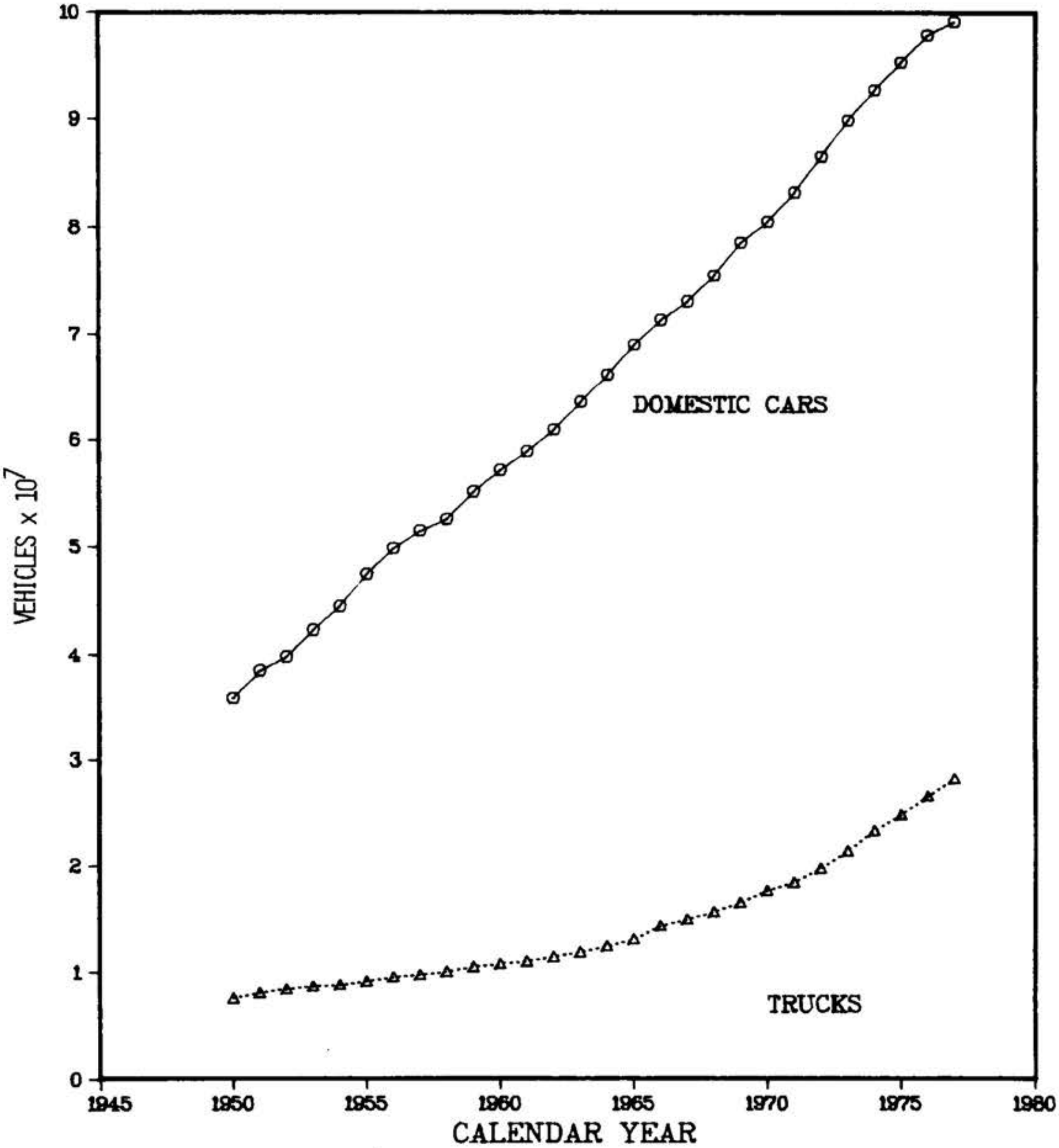

Fig. 1.8
Cars and Trucks in Operation, 1950–1977.
(10^7)

Source: R. L. Polk & Co.

Table 1.9 Passenger Cars in Use as of July 1 of Each Year by Age of Car, 1965 through 1977

Age in years[a]	1965			1970[b]			1975[b]			1976[b]			1977[b]		
	Number (000)	Percent		Number (000)	Percent		Number (000)	Percent		Number (000)	Percent		Number (000)	Percent	
		Simple	Cum.		Simple	Cum.		Simple	Cum.		Simple	Cum.		Simple	Cum.
Under 1	6,408	9.3%	100.0%	6,288	7.8%	100.0%	4,684	4.9%	100.0%	6,472	6.6%	100.0%	7,177	7.2%	100.0%
1-2	7,855	11.4	90.7	9,299	11.6	92.2	9,763	10.3	95.1	7,683	7.9	93.4	9,557	9.6	92.8
2-3	7,315	10.6	79.3	8,816	11.0	80.6	11,332	11.9	84.8	9,746	10.0	85.5	7,477	7.5	83.2
3-4	6,626	9.6	68.7	7,878	9.8	69.6	10,098	10.6	72.9	11,130	11.4	75.5	9,594	9.6	75.8
4-5	5,384	7.8	59.1	8,538	10.6	59.8	8,549	9.0	62.3	9,872	10.1	64.1	10,854	10.9	66.2
5-6	6,002	8.7	51.3	8,506	10.6	49.2	8,341	8.8	53.3	8,249	8.4	54.0	9,563	9.5	55.3
6-7	5,404	7.8	42.6	7,116	8.8	38.6	8,339	8.8	44.5	7,966	8.1	45.6	7,866	7.9	45.7
7-8	3,640	5.3	34.8	6,268	7.8	29.8	7,556	7.9	35.7	7,774	8.0	37.5	7,449	7.5	37.8
8-9	4,527	6.6	29.5	5,058	6.3	22.0	6,113	6.4	27.8	6,856	7.0	29.5	6,963	7.0	30.4
9-10	3,979	5.8	22.9	3,267	4.1	15.7	5,796	6.1	21.4	5,361	5.5	22.5	5,859	5.9	23.4
10-11	3,853	5.6	17.1	2,776	3.5	11.6	4,825	5.1	15.3	4,888	5.0	17.0	4,416	4.4	17.5
11-12	2,030	2.9	11.5	1,692	2.1	8.1	3,234	3.4	10.2	3,923	4.0	12.0	3,887	3.9	13.1
12-13	1,823	2.6	8.6	799	1.0	6.0	2,229	1.5	6.8	2,578	2.6	8.0	3,023	3.0	9.2
13-14	856	1.2	6.0	996	1.2	5.0	1,407	1.5	4.5	1,740	1.8	5.4	1,969	2.0	6.2
14-15	932	1.4	4.8	794	1.0	3.8	689	.7	3.0	1,083	1.1	3.6	1,315	1.3	4.2
15-16	931	1.4	3.4	753	.9	2.8	523	.5	2.3	526	0.5	2.5	818	0.8	2.9
16 & Older	1,368	2.0	2.0	1,583	1.9	1.9	1,742	1.8	1.8	1,943	2.0	2.0	2,093	2.1	2.1
Subtotal	68,936	100.0%		80,427	100.0%		95,220	100.0%		97,790	100.0%		99,880	100.0%	
Year not given	4			22			21			28			24		
Total	68,940			80,449			95,241			97,818			99,904		
Average age	5.90 years			5.55 years			5.99 years			6.16 years			6.23 years		

[a]Each class interval includes lower but not higher age.

[b]Beginning in 1966 certain vehicles previously counted as passenger cars have been counted as trucks. The 1966 change involved an estimated 700,000 vehicles.

Source: R. L. Polk & Co. FURTHER REPRODUCTION PROHIBITED.

TABLE 1.8 POINTS OUT DIFFERENCES IN ESTIMATES OF CARS IN OPERATION IN THE UNITED STATES. SCRAPPAGE RATES ALSO VARY WITH THE BASE DATA SET USED, I.E., R. L. POLK & CO., VS FHWA. NATIONAL AUTOMOBILE DEALERS ASSOCIATION CALCULATES SCRAPPAGE RATES DURING THE CALENDAR YEAR USING FHWA REGISTRATION DATA. R. L. POLK & CO. CALCULATES SCRAPPAGE RATES FROM JULY TO JUNE USING THEIR CARS-IN-OPERATION DATA.

Table 1.10 Estimates of U.S. Auto Scrappage Since 1950

	R. L. Polk & Co.[a]		NADA[b]	
	Scrappage percent of new cars registered during period July 1 through June 30	Scrappage percent of cars in use on July 1	Scrappage percent of new cars registered during period January 1 through December 31	Scrappage percent of cars in use on January 1
1950	58.9	10.3		NA
1960	71.0	7.5	62.6	7.5
1968	66.9	8.4	67.6	8.6
1969	79.2	9.5	63.7	7.8
1970	69.1	7.5	75.7	8.0
1971	69.3	8.5	65.8	7.9
1972	70.4	9.2	62.0	7.6
1973	72.0	8.0	49.3	6.3
1974	68.3	6.1	74.3	6.8
1975	72.6	7.2	74.5	6.3
1976	79.8	8.4	69.5	6.8
1977	NA	NA	64.1	6.8

NA — not available

[a]Cars in use as of July 1 in base year minus cars in use as of June 30 in base year and one plus new car registrations between July 1 in base year and June 30 in base year and one equals scrappage in base year.

[b]Total registrations during base calendar year minus total registrations during base calendar year and one plus total new car registrations in base calendar year and one equals scrappage in base calendar year.

Sources: R. M. Lienert (ed.), *Automotive News — 1978 Market Data Book Issue,* Crain Automotive Group, Inc., Detroit, 1978, p. 28; National Automobile Dealers Association, Research and Dealership Operations Division, *Franchised New Car and Truck Dealer Facts,* McClean, Va., 1978, p. 12; H. A. Stark (ed.), *Ward's Automotive Yearbook,* 40th ed., Ward's Communications, Inc., Detroit, 1978, p. 173.

Table 1.11 Trucks in Use as of July 1 of Each Year by Age of Truck, 1965 through 1977

Age in years[a]	1965			1970[b]			1975[b]			1976[b]			1977[b]		
	Number (000)	Percent		Number (000)	Percent		Number (000)	Percent		Number (000)	Percent		Number (000)	Percent	
		Simple	Cum.		Simple	Cum.		Simple	Cum.		Simple	Cum.		Simple	Cum.
Under 1	946	7.2%	100.0%	1,262	7.1%	100.0%	1,326	5.3%	100.0%	1,893	7.1%	100.0%	2,177	7.7%	100.0%
1–2	1,219	9.3	92.8	1,881	10.6	92.9	2,739	11.0	94.7	2,148	8.1	92.9	2,746	9.7	92.3
2–3	1,057	8.1	83.5	1,536	8.7	82.3	2,848	11.5	83.7	2,732	10.3	84.8	2,109	7.5	82.5
3–4	926	7.1	75.4	1,428	8.1	73.6	2,384	9.6	72.2	2,799	10.5	74.5	2,689	9.5	75.1
4–5	732	5.6	68.3	1,483	8.4	65.5	1,730	7.0	62.6	2,346	8.8	63.9	2,752	9.8	65.5
5–6	817	6.2	62.7	1,339	7.6	57.1	1,668	6.7	55.6	1,697	6.4	55.1	2,291	8.1	55.8
6–7	777	5.9	56.5	1,154	6.5	49.5	1,779	7.2	48.9	1,635	6.2	48.7	1,639	5.8	47.6
7–8	550	4.2	50.6	975	5.5	43.0	1,395	5.6	41.7	1,731	6.5	42.5	1,573	5.6	41.8
8–9	623	4.8	46.4	826	4.7	37.5	1,273	5.1	36.1	1,345	5.1	36.0	1,645	5.8	36.3
9–10	662	5.0	41.6	621	3.5	32.8	1,256	5.1	31.0	1,220	4.6	30.9	1,267	4.5	30.4
10–11	696	5.3	36.6	658	3.7	29.3	1,085	4.4	25.9	1,191	4.5	26.4	1,129	4.0	25.9
11–12	486	3.7	31.3	583	3.3	25.6	884	3.6	21.5	1,024	3.9	21.9	1,096	3.9	21.9
12–13	559	4.3	27.6	383	2.2	22.3	697	2.8	17.9	828	3.1	18.0	922	3.3	18.0
13–14	482	3.7	23.3	417	2.4	20.1	554	2.2	15.1	642	2.4	14.9	736	2.6	14.8
14–15	563	4.3	19.6	414	2.3	17.7	388	1.6	12.9	503	1.9	12.5	566	2.0	12.2
15–16	570	4.3	15.3	432	2.4	15.4	391	1.6	11.3	351	1.3	10.6	442	1.6	10.2
16 & Older	1,441	11.0	11.0	2,278	13.0	13.0	2,393	9.7	9.7	2,455	9.3	9.3	2,422	8.6	8.6
Subtotal	13,106	100.0%		17,671	100.0%		24,790	100.0%		26,540	100.0%		28,201	100.0%	
Year not given	21			15			23			20			21		
Total	13,127			17,686			24,813			26,560			28,222		
Average age	7.98 years			7.33 years			6.94 years			6.97 years			6.93 years		

[a]Each class interval includes lower but not higher age.

[b]Beginning in 1966 certain vehicles previously counted as passenger cars have been counted as trucks. The 1966 change involved an estimated 700,000 vehicles.

Source: R. L. Polk & Co. FURTHER REPRODUCTION PROHIBITED.

Table 1.12 Estimates of U.S. Truck Scrappage Since 1950

	R. L. Polk & Co.[a]		NADA[b]	
	Scrappage percent of new trucks registered during period July 1 through June 30	Scrappage percent of trucks in use on July 1	Scrappage percent of new trucks registered during period January 1 through December 31	Scrappage percent of trucks in use on January 1
1950	57.5	8.7	NA	NA
1960	73.0	6.0	59.7	5.0
1968	51.7	6.2	58.0	6.6
1969	43.2	5.0	48.9	5.7
1970	57.4	5.9	52.7	5.6
1971	44.4	5.7	55.1	6.2
1972	42.4	6.1	42.2	5.7
1973	35.5	4.9	42.9	6.5
1974	37.7	3.9	46.3	5.6
1975	38.6	4.4	47.6	4.9
1976	50.1	6.3	52.2	6.5
1977	NA	NA	46.9	6.2

[a]Trucks in use as of July 1 in base year minus trucks in use as of June 30 in base year and one plus new truck registrations between July 1 in base year and June 30 in base year and one equals scrappage in base year.

[b]Total registrations during base calendar year minus total registrations during base calendar year and one plus total new truck registrations in base calendar year and one equals scrappage in base calendar year.

Sources: R. M. Lienert (ed.), *Automotive News — 1978 Market Data Book Issue*, Crain Automotive Group, Inc., Detroit, 1978, p. 45; National Automobile Dealers Association, Research and Dealership Operations Division, *Franchised New Car and Truck Dealer Facts*, McClean, Va., 1978, p. 34; H. A. Stark (ed.), *Ward's Automotive Yearbook*, 40th ed., Ward's Communications, Inc., Detroit, 1978, p. 173.

THE AVERAGE AGE OF PASSENGER CARS HAS RISEN SLIGHTLY SINCE THE EARLY SEVENTIES. IN 1977, FOUR TO FIVE YEAR OLD AUTOMOBILES ACCOUNTED FOR NEARLY 11% OF THE TOTAL. THE AVERAGE AGE OF PASSENGER CARS IN USE IN THE UNITED STATES IN 1977 WAS 6.2 YEARS. THE AVERAGE AGE OF U.S. CARS AT FIRST TRADE-IN WAS APPROXIMATELY 3.6 YEARS, AND THE AVERAGE AGE OF U.S. CARS AT ANY TRADE-IN WAS 4.3-4.5 YEARS OLD.

THE LIFETIME OF TRUCKS DECLINED BETWEEN THE EARLY SIXTIES AND EARLY SEVENTIES. HOWEVER, SINCE 1973, THE AVERAGE AGE OF TRUCKS HAS REMAINED JUST UNDER SEVEN YEARS.

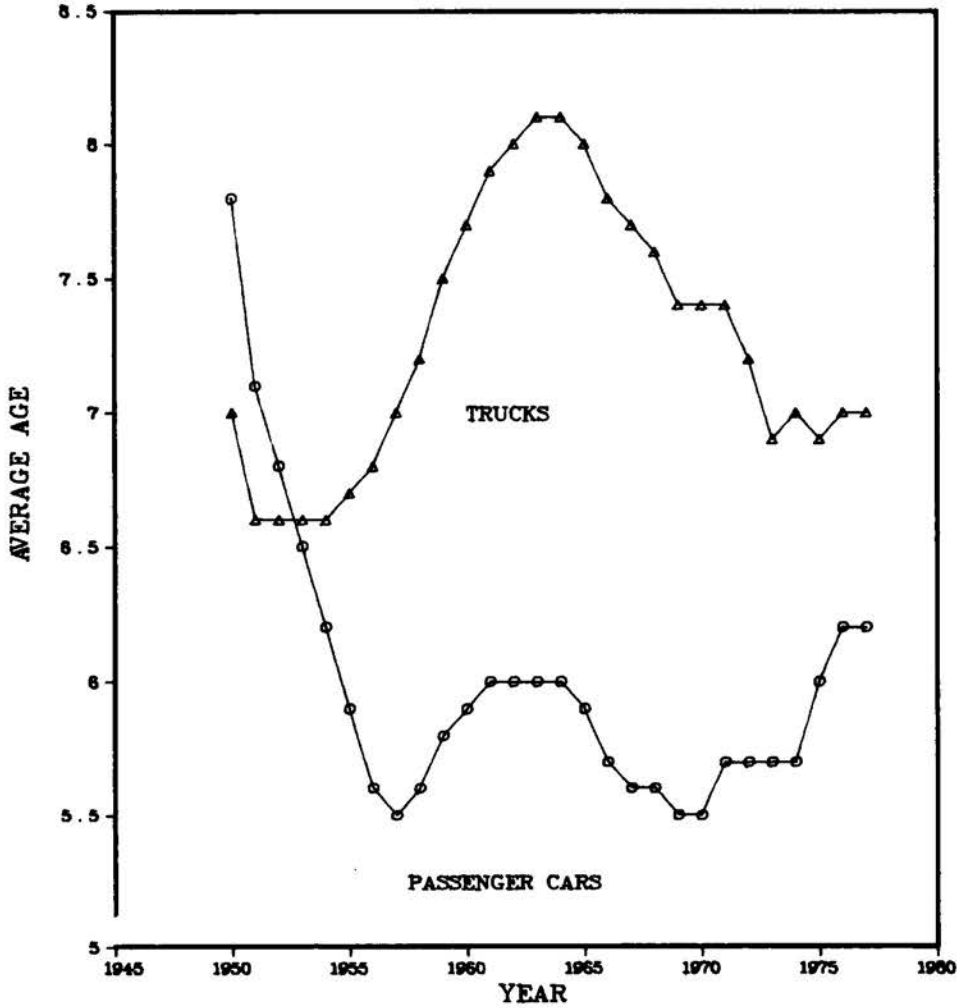

Fig. 1.9

Average Age of Passenger Cars and Trucks in Use in the U.S., 1950-1977.

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '78*, Detroit, 1978, pp. 32 and 33.

Table 1.13 Number of Highway Motor Vehicles Registered in the United States by Type, 1950 through 1977 (10^3)

	Passenger vehicles						Cargo vehicles				All motor vehicles[b]
		Buses									
	Passenger cars	Commercial	School	All buses	% diesel buses[a]	All passenger vehicles[b]	Single-unit trucks	Combinations	All trucks	% diesel trucks	
1950	40,339			224		40,563			8,599		49,162
1960	61,671			272		61,943			11,914		73,858
1970	89,280	90	289	379		89,659	17,788	960	18,748		108,407
1971	92,799	90	307	398		93,197	18,828	974	19,802		112,999
1972	96,860	89	318	407		97,267	20,249	990	21,239		118,506
1973	101,762	90	336	426		102,188	22,205	1,028	23,233		125,421
1974	104,856	90	357	447		105,304	23,545	1,085	24,630		134,900
1975	106,712	94	368	462	16.9	107,175	24,645	1,131	25,776	4.5	132,950
1976	110,351	97	381	478	17.2	110,830	26,499	1,221	27,720	4.7	138,549
1977	113,667			493		114,160	96.6		29,584		143,744

[a]Includes butane and other special fuels. Percentage is based on number of buses in operation rather than registration counts of the states.

[b]Motorcycles are not included. See Table 1.43 for motor motorcycles in use in 1977.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., Table VM-1, MV-9, and MV-10, annual.

TRUCK SALES AS A PERCENT OF TOTAL PASSENGER CARS AND TRUCK RETAIL SALES HAVE STEADILY INCREASED FROM 12% IN 1955 TO 17.7% IN 1970 TO 24.7% IN 1977.

Table 1.14
U.S. Retail Sales of Passenger Cars and Trucks, 1955 through 1977
(in thousands)

	Passenger cars				Trucks					Trucks as a % of total retail sales
	Domestic	Import	Total	% import	Domestic	Import	Total	% import	% diesel[a]	
1955	7,408	58	7,466	0.8	1,012	3	1,015	0.3	NA	12.0
1960	6,142	499	6,641	7.5	926	37	963	3.8	NA	12.7
1970	7,119	1,285	8,405	15.3	1,746	65	1,811	3.6	5.8	17.7
1975	7,053	1,587	8,640	18.4	2,248	231	2,479	9.3	4.1	22.3
1976	8,611	1,500	10,111	14.8	2,944	237	3,181	7.4	4.0	23.9
1977	9,109	2,076	11,185	18.6	3,352	323	3,675	8.8	5.0	24.7

NA — not available

[a]Derived from data on factory sales of diesel trucks.

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '78*, Detroit, 1977, pp. 11 and 18.

A GRADUAL SHIFT FROM LARGER, HEAVIER CARS HAS TAKEN PLACE IN THE PAST FEW YEARS. DOWN-SIZING OF AUTOMOBILES DUE TO FUEL ECONOMY STANDARDS AND CONSUMER CONSERVATION AWARENESS MAY BE ATTRIBUTABLE TO THIS MOVEMENT. IN 1975 THE 4500 LB WEIGHT CLASS HAD THE HIGHEST PERCENT OF CAR SALES. BY 1978, 3500 LB BECAME THE DOMINANT WEIGHT CLASS IN CAR SALES. THE MOST SIGNIFICANT DECREASES HAVE OCCURED IN THE 5000 LB AND 5500 LB WEIGHT CLASSES.

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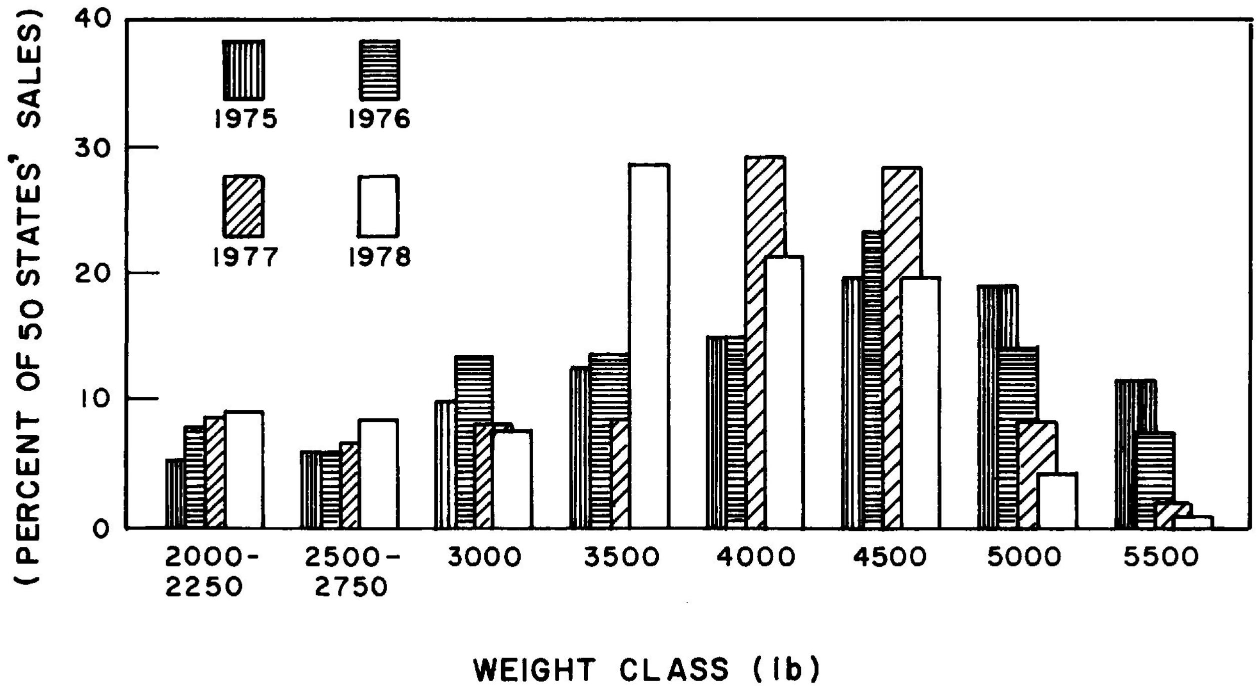


Fig. 1.10 Passenger Car Weight Distributions, 1975 through 1978.

Source: Environmental Protection Agency, Assistant Administrator for Air and Waste Management, Deputy Administrator for Mobile Source Air Pollution Control, Washington, D.C., September 1978.

CAPTIVE IMPORTS ARE MOTOR VEHICLES PRODUCED OVERSEAS FOR DOMESTIC MANUFACTURERS. CAPTIVE IMPORT SALES ARE INCLUDED WITH THE TOTAL IMPORT (NOT DOMESTIC) SALES FIGURES. HOWEVER, THE NATIONAL HIGHWAY AND TRAFFIC SAFETY ADMINISTRATION (NHTSA) HAS BEEN COUNTING CAPTIVE SALES IN THE DOMESTIC CORPORATE AVERAGE FUEL ECONOMY (CAFE).

Table 1.15
U.S. Captive Import Sales, 1975-1977

	1975	% total	1976	% total	1977	% total
Plymouth Arrow			30,430	25.5	47,345	22.2
Dodge Colt	60,356	39.6	48,542	40.7	70,679	33.1
Lincoln-Mercury Capri[a]	55,075	36.0	29,904	25.0	22,458	10.5
Ford Fiesta					40,549	19.0
Buick Opel	36,893	24.3	10,483	8.8	29,067	13.6
Total cars	152,324	100.0	119,359	100.0	213,336	100.0
Percent of total import cars	10.0		8.0		10.3	
Ford Courier	56,073	54.6	54,589	54.4	65,755	49.3
Chevrolet LUV	46,678	45.4	45,670	45.6	67,539	50.6
Total trucks	102,751	100.0	100,259	100.0	133,294	100.0
Percent of total import trucks	44.9		42.2		41.2	

[a]Includes 490 Pantera's in 1975.

Source: H. A. Stark (ed.), Ward's Communications Inc., *Ward's Automotive Yearbook 1978*, 40th ed., Detroit, p. 33.

PRODUCTION OF CARS WITH V-8 ENGINES PEAKED IN 1969. THE TREND IN RECENT YEARS HAS BEEN TOWARD INSTALLATION OF THE "6" IN CARS WHICH USED TO OFFER V-8S EXCLUSIVELY.

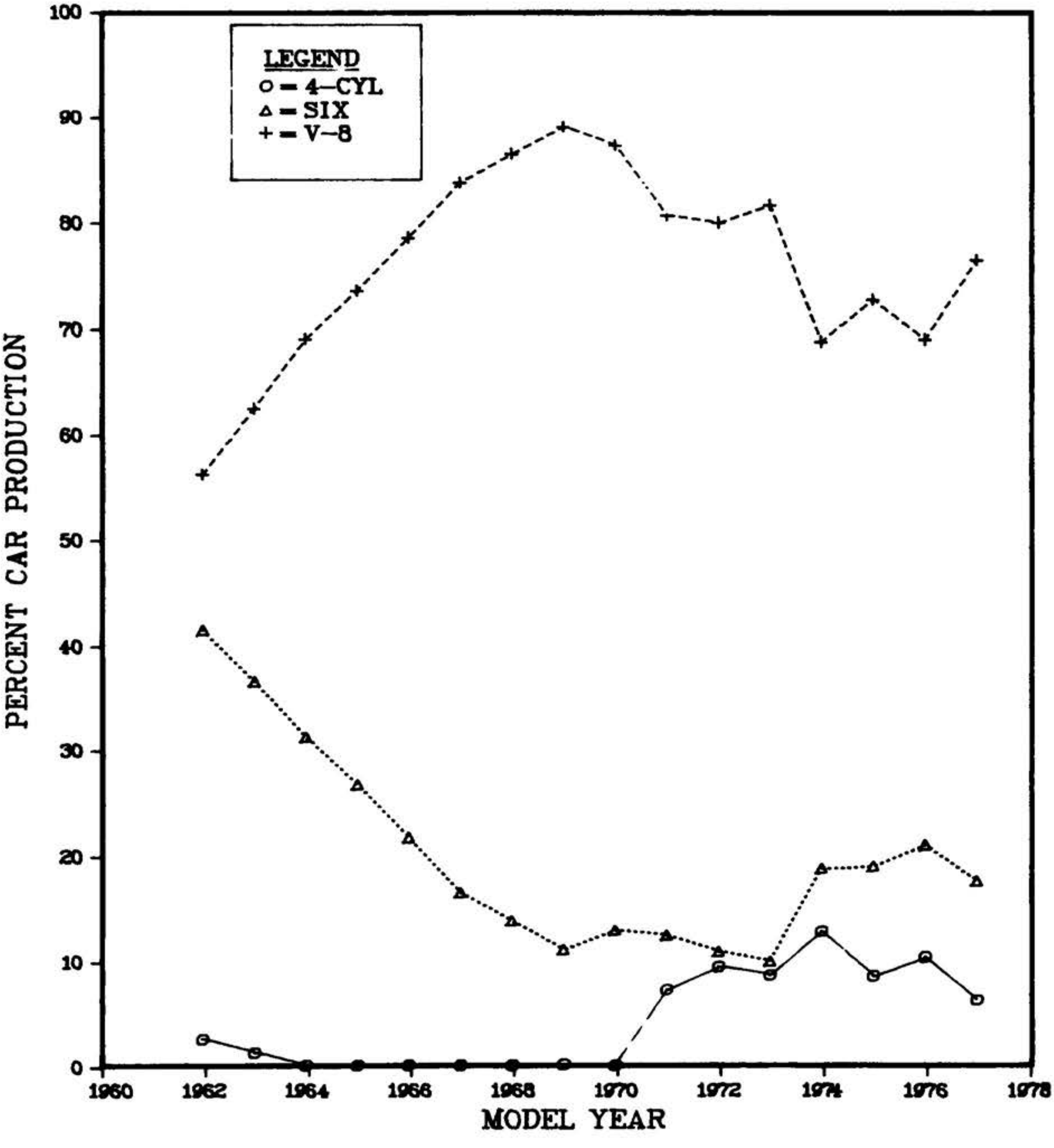


Fig. 1.11 U.S. Car Production by Cylinder Type, 1962-1977.

Source: H. A. Stark (ed.), Ward's Communications Inc., *Ward's Automotive Yearbook,* 1978 ed., Detroit, p. 112.

THE AVERAGE WEIGHT OF A CAR IN THE UNITED STATES HAS DECREASED BY ABOUT 230 LB SINCE 1975. THIS WEIGHT REDUCTION HAS RESULTED MAINLY FROM THE SUBSTITUTION OF PLASTICS, ALUMINUM, AND HIGH-STRENGTH STEEL FOR CAST IRON, CONVENTIONAL STEEL, AND CONVENTIONAL FINE DIE CASTINGS, AND FROM THE SWITCH TO SMALLER COMPONENTS.

Table 1.16 Estimated Materials Consumption in a Typical U.S.-Built Car (lb)

Material	1975	1976	1977	1978
High-strength steel	100	120	127.5	133
Aluminum	81	85.5	98.5	112.5
Plastics	155	162.5	170.5	180
Glass	86	87.5	86	86.5
Copper	33	32	30.5	29
Zinc die castings	50	44	38	31
Rubber	149	153	150	146.5
Lead	25	25	25	25
Stainless steel	28	28	27	26
Iron	580	562	540	512
Plain carbon and coated steel	2125	2075	1995	1915
Fluids, lubricants	180	190	200	198
Other alloy steel, cloth, cardboard, etc.	207	196	185	175
Totals	3799	3760.5	3673	3569.5

Source: H. A. Stark (ed.), Ward's Communications Inc., *Ward's Automotive Yearbook*, 1978 ed., Detroit, p. 65.

SALES OF DIESEL CARS IN THE UNITED STATES HAVE INCREASED APPROXIMATELY SEVEN-FOLD SINCE 1973, WHEN MERCEDES-BENZ, WHICH OFFERED THE ONLY DIESEL CAR IN THE COUNTRY, SOLD 6,252 DIESELS. ACCORDING TO THE REFERENCE CITED BELOW, SRI INTERNATIONAL, THE INCREASE IN DIESEL SALES CAN BE ATTRIBUTED TO SEVERAL FACTORS SUCH AS OPERATIONAL ECONOMY, THE HIGH-MILEAGE USER WHO STANDS TO REDUCE OVERALL COSTS, CONCERN FOR THE ENVIRONMENT AND CONSERVATION, TECHNICAL INTEREST, AND A DESIRE TO BE DIFFERENT (A MATTER OF IMAGE).

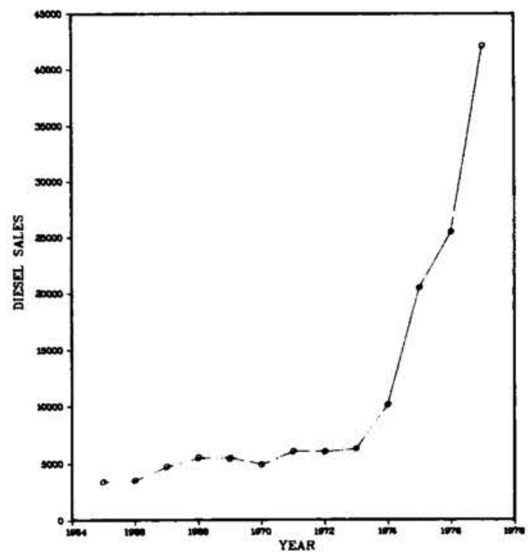


Fig. 1.12 U.S. Sales of Diesel Automobiles, 1965 through 1977.

Table 1.17 U.S. Sales of Diesel Automobiles by Make, 1965 through 1977

	Mercedes-Benz	Peugeot	Scout	Volkswagen	Total
1965	3,419				3,419
1966	3,549				3,549
1967	4,749				4,749
1968	5,494				5,494
1969	5,446				5,446
1970	4,915				4,915
1971	6,016				6,016
1972	5,988				5,988
1973	6,252				6,252
1974	10,108	NA			10,108
1975	18,578	1,944			20,522
1976	20,051	4,203	1,200		25,454
1977	22,434	4,823	2,000	12,861	42,118

Source: Richard L. Goen and Mary E. Ivory, *Diesel Cars in the United States*, SRI International, Menlo Park, Calif., June 1978 (draft report), p. 3.

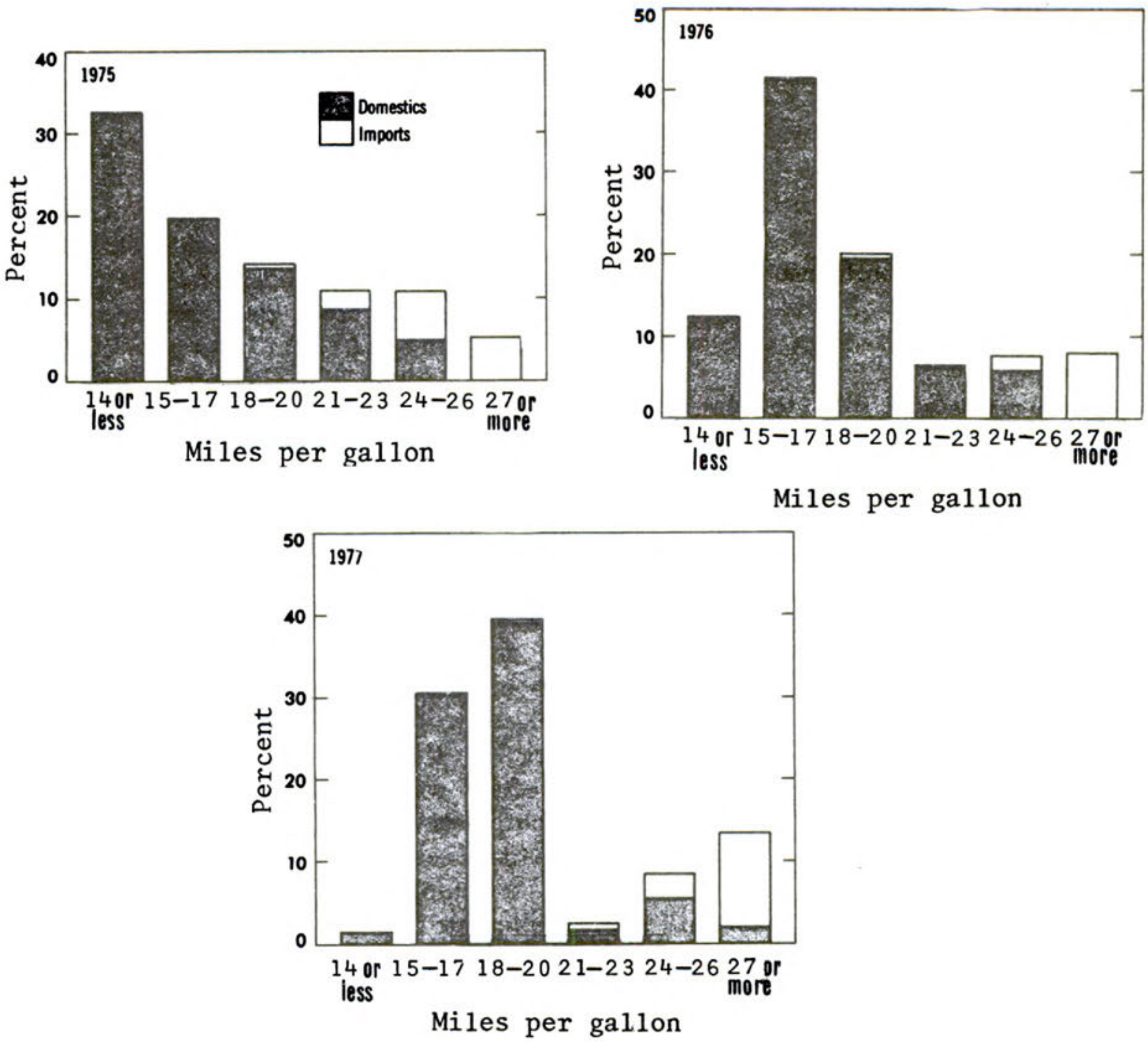


Fig. 1.13 Market Shares of New Car Sales by Gasoline Mileage Rating.

Note: Market share is the percentage that cars in each category are of total new car sales from January through August of each year. For imports, only those from Germany and Japan (including imports by U.S. manufacturers), which account for approximately 80% of all imported cars sold in the U.S., are shown; accordingly percentage totals are less than 100. Gasoline mileage data are from the EPA. For 1976 and 1977, the combined city and highway miles per gallon rating is used; for 1975, a weighted average of city and highway rating is used. Small alterations in the test conditions from year-to-year do not significantly affect results. For models for which a range of engine options is offered, the fuel economy rating of the engine with the most commonly selected number of cylinders and the smallest cubic inch displacement is used. Generally, this is a four-cylinder engine for subcompacts, six-cylinder for compacts, and eight-cylinder for intermediates and full-sized models with an automatic transmission. Imports are largely four-cylinder and manual transmission.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *Survey of Current Business*, Washington, D.C., September 1977, p. 4.

Table 1.18
U.S. New Car Registrations by Market Segment, 1971 through 1977
(percent)

	Subcompact	Compact	Intermediate	Full-size	Passenger vans and miscellaneous	Total domestic	Import	Total registrations
1971	7.6	15.8	20.3	40.5	0.7	84.9	15.1	9,825,708
1972	8.3	15.4	21.7	39.5	0.7	85.6	14.4	10,683,864
1973	9.4	17.7	23.0	33.9	0.8	84.8	15.2	11,350,995
1974	12.4	20.0	24.2	26.6	1.1	84.3	15.7	8,701,094
1975	12.6	21.4	23.9	22.7	1.3	81.9	18.1	8,261,840
1976	10.1	23.1	26.8	24.0	1.3	85.3	14.8	9,751,485
1977	8.5	20.0	26.6	25.5	1.3	81.9	18.1	10,751,924

Note: Cars within size classifications may vary by years.

Sources: H. A. Stark (ed.), Ward's Communications Inc., *Ward's 1976 Automotive Yearbook*, 38th ed., Detroit, p. 137; *Ward's 1978 Automotive Yearbook*, 40th ed., Detroit, p. 159.

AS THE GRAPH BELOW INDICATES, THE TREND IN THE EARLY 1970S WAS TOWARD INCREASED SALES OF SMALL AUTOMOBILES AT THE EXPENSE OF FULL-SIZE AUTOMOBILES. IN 1976, THIS TREND REVERSED ITSELF AND THE MARKET SEGMENT PERCENTAGE FOR FULL-SIZE AUTOMOBILES INCREASED.

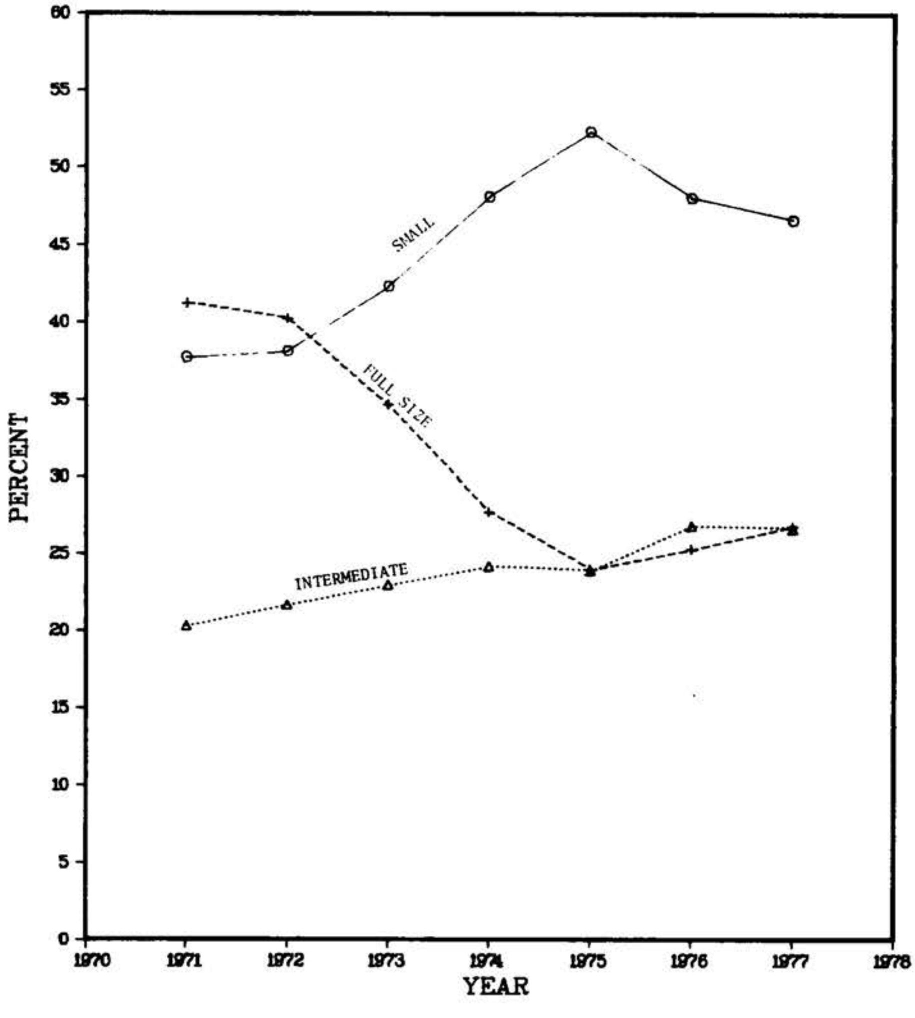


Fig. 1.14 Percent New Car Registration by Ward's Market Segment.[a]

[a]The market segment breakdowns were determined by Ward's classification scheme which is based on car size and merchandising intent. Ward's classification of individual car-lines differs slightly from that of the Environmental Protection Agency (EPA), which classifies cars according to their interior size only.

Note: Small includes subcompacts, compacts, and imports. Full-size include full-size, passenger vans and miscellaneous.

Source: H. A. Stark (ed.), Ward's Communications Inc., *Ward's 1976 Automotive Yearbook*, 39th ed., Detroit, Michigan, 1978, p. 159.

Table 1.19 New Domestic Truck Retail Sales in the United States by GVW, 1971 through 1977

	6,000 & less	6,001-10,000	10,001-14,000	14,001-16,000	16,001-19,500	19,501-26,000	26,001-33,000	Over 33,000	Total	Percent light truck[a]
1971	1,184,741	487,633	6,173	14,643	46,094	139,587	33,749	98,664	2,011,284	83.1
1972	1,497,630	598,813	54,695	10,819	28,608	181,771	35,357	126,225	2,533,918[b]	82.7
1973	1,754,254	758,236	49,771	3,118	15,709	235,569	37,030	154,571	3,008,258[b]	83.5
1974	1,469,093	693,741	21,038	2,693	14,455	207,001	31,036	144,533	2,586,590[b]	83.6
1975	1,101,242	951,710	23,054	1,253	9,073	158,584	22,993	83,148	2,351,057[b]	87.3
1976	1,318,492	1,400,947	43,399	178	8,780	152,759	22,282	97,286	3,044,123[b]	89.3
1977	1,305,788	1,802,692	36,478	3,237	4,847	163,370	28,491	140,643	3,485,546	89.0

[a]10,000 lb or less.

[b]Includes imports by U.S. manufacturers — approximately 102,000 in 1975 and 100,000 in 1976 — but excludes other imports.

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '78*, Detroit, 1977, p. 19.

THE RECENT INCREASE IN NEW DOMESTIC TRUCK RETAIL SALES IS DUE TO AN INCREASE IN SALES OF LIGHT TRUCKS - DEFINED AS 10,000 GVW OR LESS. THE LIGHT TRUCK CATEGORY ITSELF HAS EXPERIENCED A SHIFT FROM LIGHTER (<6,000 LB) TO HEAVIER TRUCKS (6,000-10,000 LB). PART OF THIS TREND RESULTS FROM THE EPA FUEL ECONOMY AND EMISSIONS CONTROL STANDARDS WHICH PREVIOUSLY COULD BE AVOIDED FOR VEHICLES OVER 6,000 LB. THE LIGHTWEIGHT CATEGORY HAS NOW BEEN INCREASED TO 8,500 LB.

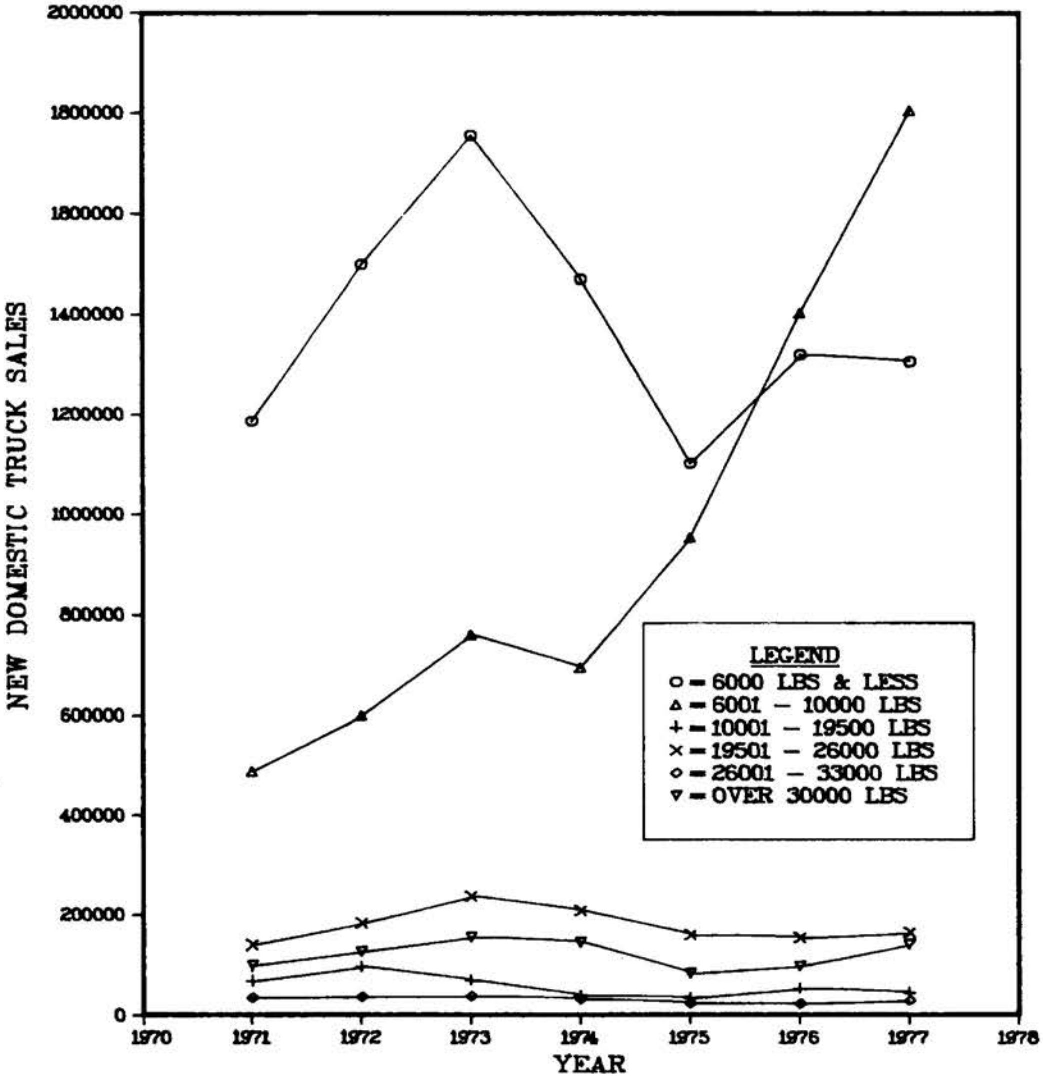


Fig. 1.15 New Domestic Truck Retail Sales in the United States by GVW, 1971 through 1977. (lb)

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '78*, Detroit, 1977, p. 19.

OVER HALF OF THE NEW TRUCKS IN THE UNITED STATES ARE THE CONVENTIONAL PICKUP BODY TYPE (56%). THE FIGURES ON PICKUP COVER PRODUCTION (SEE TABLE 1.21) SUGGEST THAT IN 1977 ABOUT 13% OF THESE TRUCKS WERE REFITTED WITH CAMPER TOPS FOR USE AS RECREATIONAL VEHICLES.

Table 1.20
U.S. New Truck Retail Deliveries by Body Type, 1976 and 1977

	1976	Distribution (%)	1977	Distribution (%)
Less than 10,000 lb	2,719,439	89.3	3,108,480	89.2
Utility	213,334	7.0	252,019	7.2
Car-type pickup	66,667	2.2	76,997	2.2
Compact import pickup	100,251	3.3	133,291	3.8
Van and cutaway chassis	522,815	17.2	575,973	16.5
Conventional pickup	1,703,851	56.0	1,941,206	55.7
Station wagon (truck chassis)	73,270	2.4	87,787	2.5
Passenger carrier	5,274	0.2	6,061	0.2
Multi-stop	33,522	1.1	35,142	1.0
Other	455		4	
10,001-14,000 lb	43,399	1.4	36,478	1.0
14,001-16,000 lb	178		3,237	0.1
16,001-19,500 lb	8,780	0.3	4,847	0.1
19,501-26,000 lb	152,759	5.0	163,370	4.7
26,001-33,000 lb	22,282	0.7	28,491	0.8
33,001 lb and over	97,286	3.2	140,643	4.0
Grand total	3,044,123	100.0	3,485,546	100.0

Source: H. A. Stark (ed.), *Ward's Automotive Yearbook*, 40th ed., Ward's Communications, Inc., Detroit, 1978, p. 147.

PICKUP COVER PRODUCTION FIGURES PROVIDE AN INDICATION OF THE VOLUME OF PICKUP TRUCKS CONVERTED TO RECREATIONAL VEHICLES.

Table 1.21 Pickup Cover Production, 1970 through 1977

1970	91,700
1971	98,400
1972	164,600
1973	223,700
1974	233,400
1975	212,500
1976	215,200
1977	212,000

Source: Recreational Vehicle Industry Association, *Facts and Trends*, Chantilly, Va., 1977-1978, p. 20.

THE DIESEL TRUCK MARKET CONTINUED TO EXPAND IN 1977 WITH THE INCLUSION OF THE FIRST FACTORY-SHIPPED CLASS ONE DIESEL TRUCKS. GIVEN THE ENERGY IMPLICATIONS OF USING DIESEL FUEL AND THE RECENT EXPANSION IN LIGHT TRUCK SALES, THIS TREND IS NOTEWORTHY.

Table 1.22 U.S. Diesel Truck Factory Shipments, 1975 through 1977

Units, lb	1975		1976		1977	
	Units	% Total	Units	% Total	Units	% Total
6,000-less					2,392	1.3
6,001-10,000	1		1,596	1.3	1,128	0.6
10,001-14,000						
14,001-16,000						
16,001-19,500	159	0.2				
19,501-26,000	5,651	5.5	7,708	5.9	14,575	7.9
26,001-33,000	11,819	11.5	11,509	8.9	17,363	9.4
33,001-over	84,878	82.8	108,263	83.9	149,839	80.8
Total	102,508	100.0	129,076	100.0	185,297	100.0

Source: H. A. Stark (ed.), Ward's Communications Inc., *Ward's 1978 Automotive Yearbook*, 40th ed., Detroit, p. 127.

Table 1.23
Factory Installation of Energy-Related Equipment on Domestic and Imported Passenger Cars and Light Trucks by Model Year, 1973 through 1978
(percent of total units)

	1973	1974	1975	1976	1977	1978
Domestic						
Automobiles						
Automatic transmission	93.4	89.8	91.6	91.4	95.2	94.3
V-8 engine	83.5	67.8	71.4	68.7	76.0	69.3
6-cylinder engine	8.6	18.9	19.6	21.1	17.7	22.9
Power steering	87.7	83.3	88.9	89.9	92.0	94.0
Power brakes	75.5	67.2	76.4	80.9	86.9	86.5
Power windows	25.7	18.8	24.5	23.1	27.0	30.3
Power door locks	13.8	11.8	16.9	19.1	24.7	27.7
Air conditioning	72.6	67.9	72.6	74.0	81.7	82.6
Power seats	14.3	10.9	31.3	16.5	21.0	13.4
Speed regulating device	10.6	11.6	19.7	26.4	32.6	38.8
Steel belted radial ply tires	13.3	33.2	81.8	76.9	80.2	77.5
Trucks — 10,000 lb GVW or less						
Automatic transmission	62.9	66.0	66.4	67.8	73.1	70.8
V-8 engine	84.2	84.5	83.9	81.6	84.4	81.4
Air conditioning	28.6	29.3	30.6	33.3	38.2	40.5
Power steering	61.4	68.7	76.7	78.9	87.0	89.3
Power brakes	63.5	67.5	80.2	81.4	86.9	88.0
Four-wheel drive	NA	NA	23.4	23.8	24.6	30.0
Steel belted radial ply tires	NA	NA	6.0	9.1	9.1	7.7
Imports						
Automobiles						
Automatic transmission				26.6	27.6	
4-speed transmission				55.6	44.6	
4-cylinder engine				90.0	88.4	
6-cylinder engine				7.3	7.5	
Power steering				7.3	10.0	
Power brakes				86.9	75.8	
Air conditioning				21.3	27.0	
Steel belted radial ply tires				71.4	80.0	
Trucks — 10,000 lb GVW or less						
4-speed transmission					58.6	
5-speed transmission					32.2	
4-cylinder engine					95.8	
Power brakes					100.0	
Power steering						
Air conditioning					10.5	
Steel belted radial ply tires					26.4	

NA — not available.

Sources: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '77*, Detroit, 1976, p. 13; H. A. Stark (ed.), *Ward's Automotive Yearbook*, 39th ed., Ward's Communications, Inc., 1977, p. 53; *Ward's Automotive Reports*, Vol. 52, No. 14, April 4, 1977; No. 17, April 25, 1977; Vol. 53, No. 12, March 20, 1978; No. 16, April 17, 1978; No. 19, May 8, 1978.

IN GENERAL, THE TYPICAL AMERICAN CAR IS LOADED DOWN WITH OPTIONS - OFTEN TIMES OPTIONS WHICH DECREASE THEIR FUEL ECONOMY SUCH AS AIR CONDITIONING.

THIRTY PERCENT OF 1978 MODEL LIGHT TRUCKS WERE FOUR-WHEEL DRIVE VEHICLES.

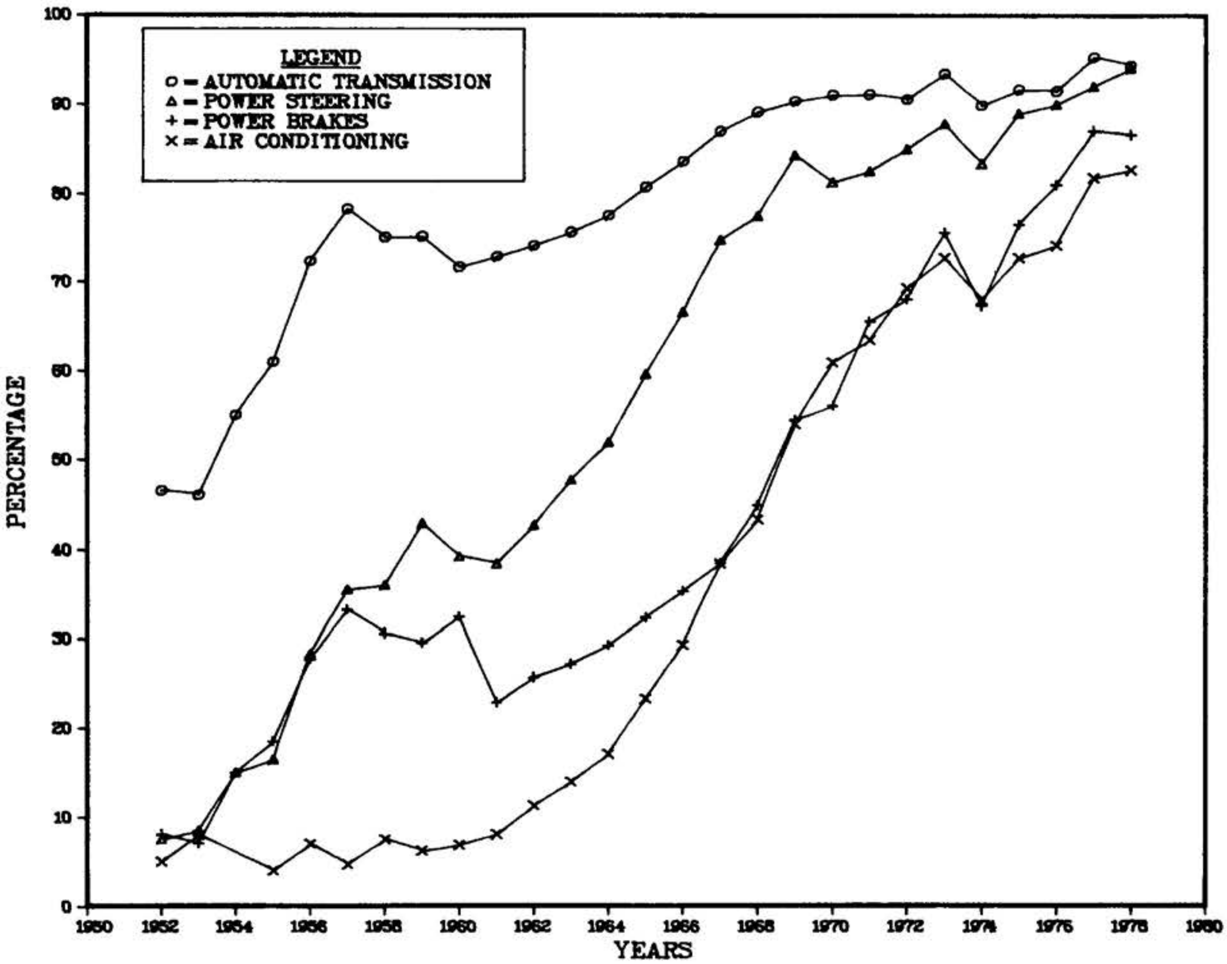


Fig. 1.16 Factory Installation of Energy Related Equipment on Domestic Motor Vehicles. (% of total units)

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures*, Detroit, annual data.

THE DATA BELOW ON USED CAR SALES WERE ESTIMATED BY THE NATIONAL AUTOMOBILE DEALER'S ASSOCIATION (NADA). THEY REFLECT RETAIL AND WHOLESALE USED CAR SALES ONLY, NOT SALES BETWEEN PRIVATE INDIVIDUALS. THERE IS NO SINGLE ACCOUNTING SYSTEM FOR USED CAR SALES. HOWEVER, IT IS ESTIMATED THAT FOR EVERY NEW CAR SOLD, TWO USED CARS CHANGE HANDS.

Table 1.24
Used Vehicle Sales, 1968 through 1977[a]
(10^3)

Year	By franchised new car dealers		By used car dealers
	Retail	Retail and wholesale	
1968	9,720	11,900	3,470
1969	9,710	11,800	2,920
1970	9,250	11,300	2,950
1971	9,960	12,200	3,440
1972	10,300	12,600	3,730
1973	9,940	12,300	3,890
1974	8,630	10,600	3,230
1975	9,140	11,300	3,360
1976	10,040	12,500	3,980
1977	9,980	12,610	4,290

[a] *Ward's Automotive Yearbook 1978* (p. 143) reports franchised dealers used car sales, not including imports, as 9 million in 1976. *Automotive News 1978 Market Data Book Issue* (p. 101) reports franchised dealers used car sales, both wholesale and retail, as 8 million in 1976. The NADA figures are presented here because they collect their data directly from their member dealer associations and then extrapolate for the market as a whole.

Source: *Franchised New Car and Truck Dealer FACTS*, 1978 Edition, National Automobile Dealer's Association, Washington, D.C., p. 7.

Section 1.2.1.1

Trucks

Table 1.25

Selected Characteristics of Truck Stock: 1963, 1967, and 1972
(percentage)

Item	1963	1967	1972
Body type			
Pickup, panel, multistop, or walk-in	65.6	70.3	73.3
Platform and cattlerack	15.9	14.2	12.7
Vans	6.8	5.5	5.9
Beverage truck	[a]	0.5	0.5
Utility truck	[a]	1.1	1.9
Garbage and refuse collector	[a]	0.2	0.4
Winch or crane	[b]	0.3	0.5
Wrecker	[b]	0.4	0.6
Pole or logging	[b]	0.3	0.3
Auto transport	[b]	0.1	0.2
Dump truck	3.7	2.6	2.4
Tank truck (liquid and dry)	2.3	2.0	1.7
Concrete mixer	[b]	0.3	0.4
All other	5.7	2.2	0.2
Size class			
Light	69.5	73.6	74.0
Medium	8.9	13.6	14.3
Light-heavy	10.4	5.2	4.2
Heavy-heavy	6.1	7.6	7.6
Miscellaneous sizes	5.1		
Annual-miles[c]			
Less than 5,000 miles	22.7	56.0[d] (both rows)	23.4
5,000 to 9,999 miles	24.6		28.1
10,000 to 19,999 miles	23.9	30.7	33.5
20,000 to 29,999 miles	6.4	6.9	8.4
30,000 miles and over	6.4	6.4	7.0
Not reported	16.0	[b]	[b]

Item	1963	1967	1972
Truck fleet size			
1 truck	70.3	53.3	61.9
2 to 5 trucks	12.9	19.2	22.0
6 to 19 trucks	8.7	8.7	8.8
20 trucks	8.1	7.5	7.6
Not reported	[b]	11.3	[b]
Vehicle type[e]			
Single-unit trucks	[a]	83.4	95.4
2-axle	[a]	72.1	92.7
3-axle	[a]	11.3	2.8
Combinations	[a]	16.6	4.7
3-axle	[a]	3.3	0.7
4-axles or more	[a]	13.3	4.1
Range of operations[e]			
Local	72.6	79.0	81.3
Short-range	7.7	13.2	8.7
Long-range	1.7	4.9	2.4
Not reported	18.0	2.9	7.6
Type of fuel[e]			
Gasoline	97.1	86.2	87.9
Diesel and LPG	2.1	10.9	4.4
Not reported	0.8	2.9	7.9

Note: Percents may not add to total due to rounding.

[a]Indicates no data was obtained.

[b]Indicates that there were not a significant number of trucks with this characteristic to display.

[c]For the 1967 and 1972 surveys, annual-miles were imputed if not reported.

[d]For the 1967 survey, data were presented for "Less than 6,000 miles" (36.2%) and "6,000 to 9,999 miles" (19.8%).

[e]Data for 1967 do not include pickups and panels.

Source: U.S. Department of Commerce, Bureau of the Census, *1972 Census of Transportation*, "Truck Inventory and Use Survey — United States Summary," Series TC72-T52, Washington, D.C., 1973, p. 1.

FOR-HIRE TRUCKS COMPRISE ONLY 4% OF THE TOTAL TRUCK POPULATION IN THE UNITED STATES. HOWEVER, INTENSITY OF USE, AS IMPLIED BY ANNUAL-MILES PER VEHICLE, IS GREATEST FOR FOR-HIRE TRUCKS.

Table 1.26
Distribution of Trucks by Type of Vehicle and Use, 1975

Trucks and combinations	Private[a]		For-hire		Total	
	Number	Percent of total	Number	Percent of total	Number	Percent of total[b]
Single-unit trucks						
2-axle	22,432,496	94.9	378,845	39.4	22,811,341	92.7
3-axle	596,524	2.5	43,276	4.6	639,800	2.6
All single-unit trucks	23,029,020	97.4	422,121	44.0	23,451,141	95.3
Combinations						
3-axle	102,078	0.4	70,181	7.3	172,259	0.7
4-axle	198,609	0.8	145,899	15.2	344,508	1.4
5 or more axles	318,301	1.4	321,499	33.5	639,800	2.6
All combinations	618,988	2.6	537,579	56.0	1,156,567	4.7
TOTAL	23,648,008[a]	100.0	959,700	100.0	24,607,708	100.0

[a]Of the 23,648,008 private trucks, about 3,000,000 are farm trucks.

[b]This distribution is very similar to the distribution based on FHWA yearly figure. (See Table 1.13.)

Source: *American Trucking Trends 1976 Statistical Supplement*, American Trucking Association, Washington, D.C., p. 20 (Based on vehicle distribution, Truck Inventory and Use Survey, 1972 Census of Transportation, U.S. Department of Commerce, Bureau of Census, with adjustments by The American Trucking Association, Inc. to include pick-up and panel trucks).

THE DISTRIBUTION OF TRUCKS AND TRUCK MILEAGE DIFFERS SIGNIFICANTLY ACROSS USAGE CATEGORIES. LIGHT TRUCKS PREDOMINATE IN PERSONAL TRANSPORTATION, AGRICULTURE, UTILITIES, AND SERVICE INDUSTRIES, WHILE HEAVY-HEAVY TRUCKS ARE THE MOST COMMON IN THE FOR-HIRE CATEGORY. THE MAJORITY OF THESE HEAVY-HEAVY TRUCKS ARE USED IN INTERCITY OPERATIONS AS EVIDENCED BY THEIR SHARE OF TRUCK-MILES.

Table 1.27
Percentage Breakdown of Major Uses by Truck Size Class[a], 1972

	Agriculture	Forestry and lumbering	Mining	Construction	Manufacturing	Wholesale and retail	For-hire	Personal transportation	Utilities	Services	Total
Number of trucks											
Light truck	68.8	39.7	37.1	59.4	42.6	46.9	11.0	95.9	71.4	74.6	74.0
Medium truck	21.3	20.7	21.0	17.0	20.6	28.5	21.8	3.9	16.9	19.8	14.3
Light-heavy truck	6.5	12.2	6.7	6.9	8.1	10.2	7.7	0.3	6.2	3.3	4.2
Heavy-heavy truck	3.6	28.6	35.5	16.9	28.8	14.6	59.6	0.2	5.6	2.5	7.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Truck-miles											
Light truck	73.4	32.4	29.6	60.0	26.8	39.3	4.3	95.4	73.0	74.3	63.2
Medium truck	14.5	12.0	17.7	13.0	12.3	23.6	8.8	4.3	14.8	19.7	12.0
Light-heavy truck	4.1	7.5	4.0	4.7	6.1	9.2	3.6	0.2	5.3	3.0	3.6
Heavy-heavy truck	8.2	48.3	48.9	22.5	55.0	28.1	83.5	0.3	7.1	3.2	21.3
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a]Light – gross vehicle weight of 10,000 lb or less.
Medium – gross vehicle weight of 10,001 to 20,000 lb.
Light-heavy – gross vehicle weight of 20,001 to 26,000 lb.
Heavy-heavy – gross vehicle weight of 26,001 lb or more.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972 Truck Inventory and Use Survey: U.S. Summary*, TC72-T52, U.S. Government Printing Office, Washington, D.C., 1973, p. 6 and 16.

ALMOST 75% OF THE LIGHT TRUCKS WERE USED PREDOMINANTLY FOR EITHER PERSONAL TRANSPORTATION (53.4%) OR AGRICULTURE (20.1%) IN 1972. ALMOST ONE-THIRD OF THE HEAVY-HEAVY TRUCKS WERE LISTED AS "FOR-HIRE," AND THESE ACCOUNTED FOR ALMOST ONE-HALF OF ALL HEAVY-HEAVY TRUCK MILES. THE INTENSITY OF USE OF HEAVY-HEAVY TRUCKS IS ILLUSTRATED BY THE FACT THAT THEIR PROPORTION OF TOTAL MILEAGE IS THREE TIMES THEIR SHARE OF NUMBERS OF TRUCKS.

Table 1.28
Percentage Breakdown of Truck Size Classes[a] by Major Use, 1972

	Number of trucks					Truck-miles				
	Light	Medium	Light-heavy	Heavy-heavy	Total	Light	Medium	Light-heavy	Heavy-heavy	Total
Agriculture	20.1	32.1	33.2	10.3	21.6	17.7	18.4	17.2	5.9	15.2
Forestry and lumbering	0.5	1.4	2.8	3.6	1.0	0.8	1.4	2.9	3.2	1.4
Mining	0.2	0.6	0.7	1.9	0.4	0.3	0.9	0.7	1.4	0.6
Construction	6.9	10.2	14.0	19.1	8.6	9.1	10.3	12.5	10.1	9.6
Manufacturing	1.3	3.3	4.4	8.5	2.3	1.8	4.3	7.0	10.7	4.2
Wholesale and retail	6.1	18.9	23.0	18.3	9.5	8.2	25.8	33.5	17.3	13.2
For hire	0.6	6.0	7.2	30.6	3.9	0.9	8.9	12.0	47.6	12.2
Personal transportation	53.4	11.0	2.1	1.0	41.2	49.1	11.5	1.5	0.4	32.6
Utilities	2.5	3.1	3.8	1.9	2.6	2.7	2.9	3.4	0.8	2.4
Services	7.7	10.5	6.0	2.5	7.6	8.8	12.2	6.2	1.2	7.5
All other	1.2	3.5	3.4	2.8	1.7	1.3	4.0	3.7	2.1	1.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% of grand total	74.0	14.3	4.2	7.6	100.0	63.2	12.0	3.6	21.3	100.0

[a]Light – gross vehicle weight of 10,000 lb or less.
Medium – gross vehicle weight of 10,001 to 20,000 lb.
Light-heavy – gross vehicle weight of 20,001 to 26,000 lb.
Heavy-heavy – gross vehicle weight of 26,001 lb or more.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972, Truck Inventory and Use Survey: U.S. Summary*, TC72-T52, U.S. Government Printing Office, Washington, D.C., 1973, p. 7-8 and 17-8.

THIS TABLE AND GRAPH SERVE TO REITERATE THE RELATIONSHIP BETWEEN TRUCK SIZE AND INTENSITY OF USE AND INCREASING RELIANCE ON DIESEL TRUCKS.

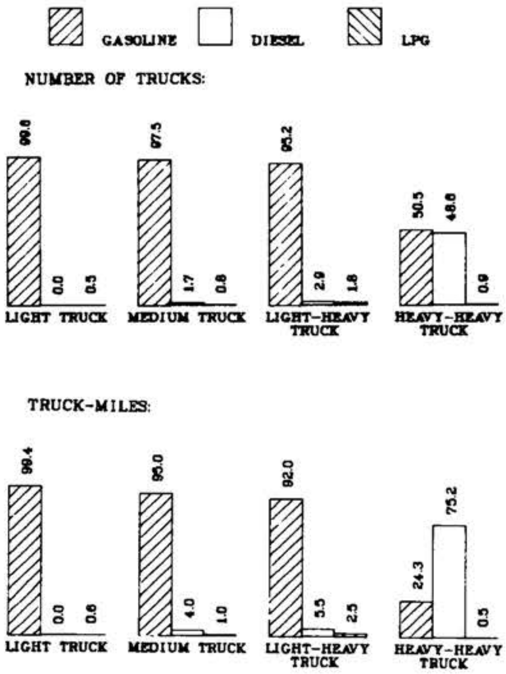


Fig. 1.17. Percentage Breakdown of Truck Size Classes by Fuel Type, 1972.

Table 1.29 Percentage Breakdown of Truck Size Classes[a] by Fuel Type, 1972 (sample size = 114,000)

	Number of trucks					Truck-miles				
	Light	Medium	Light-heavy	Heavy-heavy	Total	Light	Medium	Light-heavy	Heavy-heavy	Total
Gasoline	99.6	97.5	95.2	50.5	95.3	99.4	95.0	92.0	24.3	82.1
Diesel		1.7	2.9	48.6	4.2		4.0	5.5	75.2	17.1
LPG	0.3	0.8	1.8	0.9	0.5	0.6	1.0	2.5	0.5	0.7
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% of grand total	74.0	14.3	4.2	7.6	100.0	63.2	12.0	3.6	21.3	100.0

[a]Light – gross vehicle weight of 10,000 lb or less.
Medium – gross vehicle weight of 10,001 to 20,000 lb.
Light-heavy – gross vehicle weight of 20,001 to 26,000 lb.
Heavy-heavy – gross vehicle weight of 26,001 lb or more.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972, Truck Inventory and Use Survey.*

Table 1.30
Percentage Breakdown of Truck Size Classes[a] by Range of Operation[b], 1972
(sample size = 114,000)

	Number of trucks				
	Light	Medium	Light-heavy	Heavy-heavy	Total
Local	91.4	88.4	87.9	56.4	88.0
Short-range	7.5	9.0	10.9	26.8	9.4
Long-range	1.1	2.5	1.2	16.7	2.6
Total	100.0	100.0	100.0	100.0	100.0
% of grand total	74.0	14.3	4.2	7.6	100.0

[a]Light — gross vehicle weight of 10,000 lb or less.
Medium — gross vehicle weight of 10,001 to 20,000 lb.
Light-heavy — gross vehicle weight of 20,001 to 26,000 lb.
Heavy-heavy — gross vehicle weight of 26,001 lb or more.

[b]Local — mostly in the local area.
Short-range — mostly over-the-road, but usually not more than 200 miles one way to the most distant stop from the place vehicle is stationed.
Long-range — mostly over-the-road trips that usually are more than 200 miles one way to the most distant stop from the place vehicle is stationed.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972, Truck Inventory and Use Survey.*

A CURIOSITY IN THIS TABLE IS THE LARGE PERCENTAGE OF LONG-RANGE TRUCKS LISTED FOR PERSONAL TRANSPORTATION (29.3%). THESE TRUCKS ACCOUNT FOR ONLY 6.5% OF LONG-RANGE TRUCK-MILES. HERE, FOR-HIRE TRUCKS DOMINATE AGAIN WITH OVER 60% OF TRUCK-MILES.

Table 1.31
Percentage Breakdown of Ranges of Operation[a] by Major Uses, 1972

	Number of trucks				Truck-miles			
	Local	Short-range	Long-range	Total	Local	Short-range	Long-range	Total
Agriculture	23.3	9.1	5.2	21.6	18.5	7.1	4.7	15.2
Forestry and lumbering	0.9	2.4	0.7	1.0	1.1	3.2	1.0	1.4
Mining	0.4	0.7	0.1	0.4	0.7	1.0	0.1	0.6
Construction	8.8	11.6	2.8	8.6	10.9	10.1	2.0	9.6
Manufacturing	1.9	4.9	7.6	2.3	2.5	6.7	12.2	4.2
Wholesale and retail	9.2	15.7	7.9	9.5	12.1	20.1	10.1	13.2
For-hire	2.5	9.6	41.8	3.9	3.7	19.7	60.2	12.2
Personal transportation	41.2	33.3	29.3	41.2	37.7	21.4	6.5	32.6
Utilities	2.8	2.9	0.8	2.6	2.8	2.3	0.4	2.4
Services	8.0	6.9	0.9	7.6	9.1	6.2	0.5	7.5
All other	1.5	3.3	3.4	1.7	1.5	2.8	2.7	1.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% of grand total	88.0	9.4	2.6	100.0	71.3	18.0	10.7	100.0

[a]Local — mostly in the local area.
Short-range — mostly over-the-road, but usually not more than 200 miles one way to the most distant stop from the place vehicle is stationed.
Long-range — mostly over-the-road trips that usually are more than 200 miles one way to the most distant stop from the place vehicle is stationed.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972, Truck Inventory and Use Survey: U.S. Summary*, TC72-T52, U.S. Government Printing Office, Washington, D.C., 1973, p. 9 and 19.

THERE IS A STRIKING SPECIALIZATION OF TRUCK FUEL TYPE BY RANGE OF OPERATION. GASOLINE-POWERED TRUCKS ACCOUNT FOR OVER 95% OF LOCAL TRUCK-MILES AND OVER 97% OF ALL TRUCKS IN LOCAL OPERATIONS. WHILE MORE THAN ONE-HALF OF ALL TRUCKS IN LONG-RANGE OPERATIONS ARE GASOLINE POWERED, THEY ARE USED MUCH LESS INTENSIVELY THAN THE DIESELS AND ACCOUNT FOR LESS THAN 18% OF LONG-RANGE TRUCK-MILES.

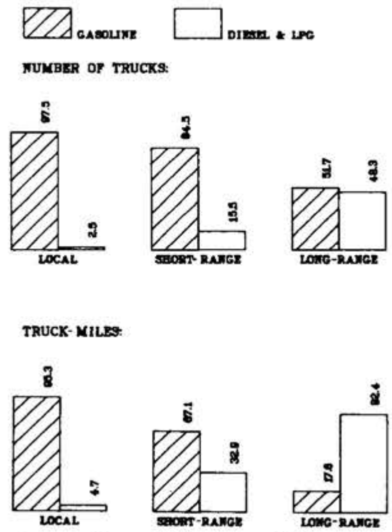


Fig. 1.18. Percentage Breakdown of Ranges of Operation by Fuel Type, 1972.

Table 1.32 Percentage Breakdown of Ranges of Operation[a] by Fuel Type, 1972

	Number of trucks				Truck-miles			
	Local	Short-range	Long-range	Total	Local	Short-range	Long-range	Total
Gasoline	97.5	84.5	51.7	95.2	95.3	67.1	17.6	82.1
Diesel and LPG	2.5	15.5	48.3	4.8	4.7	32.9	82.4	17.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% of grand total	88.0	9.4	2.6	100.0	71.3	18.0	10.7	100.0

[a]Local — mostly in the local area.
Short-range — mostly over-the-road, but usually not more than 200 miles one way to the most distant stop from the place vehicle is stationed.
Long-range — mostly over-the-road trips that usually are more than 200 miles one way to the most distant stop from the place vehicle is stationed.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972, Truck Inventory and Use Survey: U.S. Summary*, TC72-T52, U.S. Government Printing Office, Washington, D.C., 1973, p. 9 and 19.

AN INTERESTING PATTERN OF USAGE EMERGES FOR HEAVY-HEAVY TRUCKS. LOCAL TRUCKING IS DOMINATED BY THE NUMBER OF GASOLINE-POWERED TRUCKS, BUT THE LOCAL TRUCK-MILES ARE ALMOST EQUALLY DIVIDED BETWEEN GASOLINE-POWERED AND DIESEL TRUCKS. DIESEL TRUCKS ASSUME DOMINANCE AS THE RANGE OF OPERATIONS INCREASES; THEY COMPRISE ALMOST 90% OF THE LONG-RANGE HEAVY-HEAVY TRUCKS AND 95% OF LONG-RANGE TRUCK-MILES.

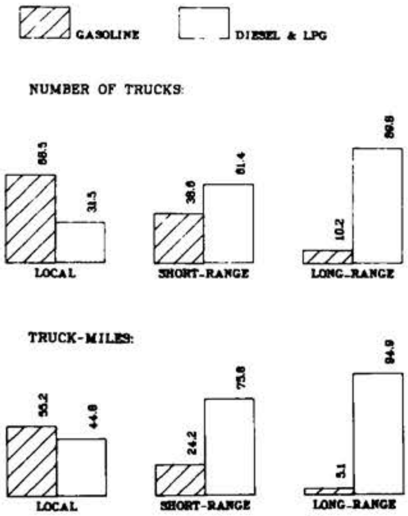


Fig. 1.19 Percentage Breakdown of Ranges of Operation by Fuel Type for Heavy-Heavy Trucks, 1972.

Table 1.33 Percentage Breakdown of Ranges of Operation[a] by Fuel Type for Heavy-Heavy Trucks, 1972 (sample size = 114,000)

	Number of trucks				Truck-miles			
	Local	Short-range	Long-range	Total	Local	Short-range	Long-range	Total
Gasoline	68.5	38.6	10.2	50.7	55.2	24.2	5.1	24.3
Diesel	30.2	60.9	89.8	48.4	43.4	75.4	94.8	75.2
LPG	1.3	0.5	0.1	0.9	1.4	0.4		0.5
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% of grand total	56.5	26.7	16.8	100.0	25.8	33.1	41.2	100.0

[a]Local — mostly in the local area.
Short-range — mostly over-the-road, but usually not more than 200 miles one way to the most distant stop from the place vehicle is stationed.
Long-range — mostly over-the-road trips that usually are more than 200 miles one way to the most distant stop from the place vehicle is stationed.

Source: U.S. Bureau of the Census, *Census of Transportation, 1972, Truck Inventory and Use Survey*; tape processed by ORNL.

Section 1.2.1.2

Fleets

Fleet car retail sales as a percent of total car retail sales were 8.9% in 1966 and stood at 13.4% in 1977. Fleet car sales themselves have increased at an annual rate of 3.6% despite a slump in total car sales, which registered a minimal increase of 0.1% per year between 1966 and 1977. However, there have been considerable year-to-year fluctuations in fleet car sales. Total new car sales peaked in 1973 with a record high of 11.4 million cars sold. At this point, new car sales were on the increase at 3.0% per year. However, the oil embargo halted this growth. Although fleet sales decreased too, their relative share of the total market increased.

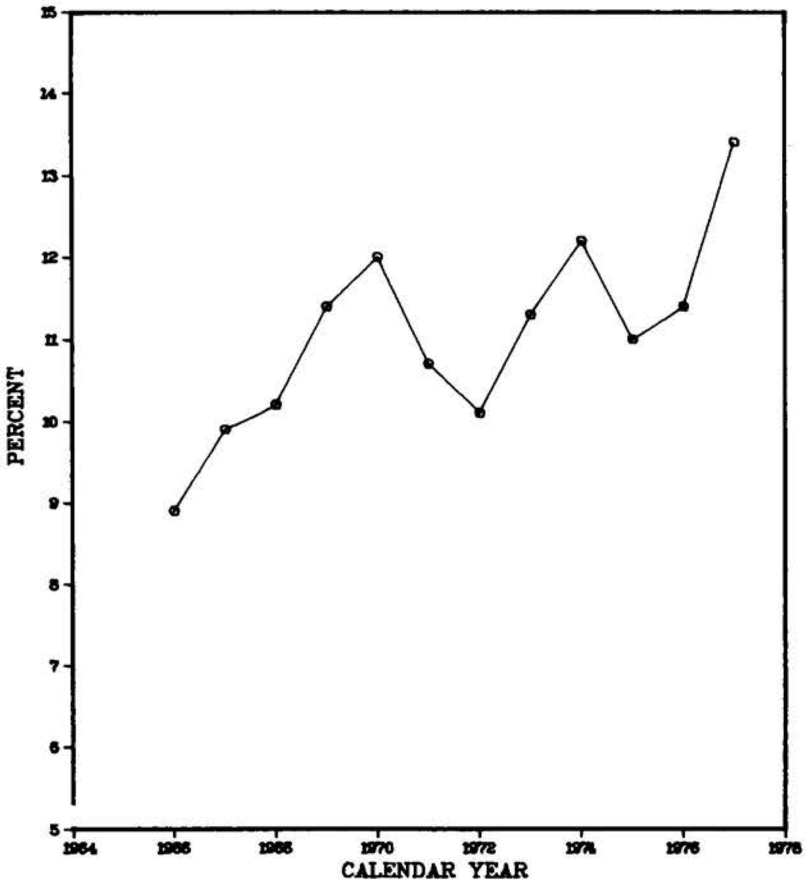


Fig. 1.20 Fleet Car Retail Sales as a Percent of Total Car Retail Sales, 1965 through 1977.

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966–1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN., 1978.

When fleets are defined as cars operating in groups of four or more rather than ten or more, fleets as a percent of total cars in operation doubles. However, the percentage in fleets of four or more has been decreasing over time. This would imply that the smaller fleet operations (i.e., four to nine vehicles) are decreasing relative to the larger fleet operations (i.e., ten or more). Cars operating in fleets of ten or more as a percent of total cars in operation have shown a gradual increase since 1966, from 5.8% to 6.5% in 1977. This percentage has not increased as rapidly as fleets as a percent of new car retail sales. The base population, total cars in operation, has increased at the rate of 3.9% annually since 1966, whereas new car sales have only increased 0.1%.

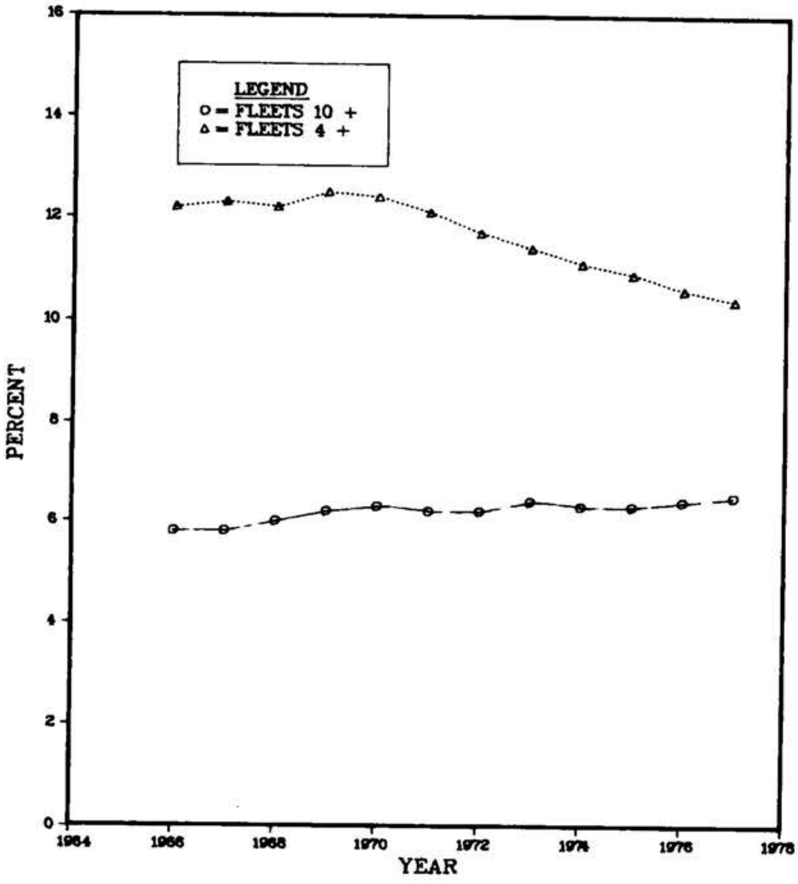


Fig. 1.21 Fleet Cars in Operation as a Percent of Total Cars in Operation, 1965 through 1977.

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966–1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN., 1978.

Table 1.34
New Fleet Car Retail Sales, 1966-1977
(10^3)

	Total[a]	Fleets 10+[b]	Fleets 10+ as % of total
1966	9,028	800	8.9
1967	8,337	825	9.9
1968	9,656	985	10.2
1969	9,583	1,093	11.4
1970	8,405	1,009	12.0
1971	10,250	1,098	10.7
1972	10,950	1,105	10.1
1973	11,439	1,291	11.3
1974	8,867	1,083	12.2
1975	8,640	955	11.0
1976	10,111	1,154	11.4
1977	9,124	1,219	13.4
Average annual rate of growth	0.1	3.6	

[a]Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures, '77*, Detroit, p. 21 (includes imports and domestic).

[b]*Automotive Fleet*, Bobit Publishing Co., Redondo Beach, Calif., April issue annually.

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966-1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN., 1978.

Table 1.35
Fleet Cars in Operation, 1966-1977
(10^3)

	Total[a]	Fleets 10+[b]	Fleets 10+ as % of total	Fleets 4+[b]	Fleets 4+ as % of total	Fleets 4+ including Federal government as % of total[c]
1966	71,264	4,106	5.8	8,710	12.2	12.3
1967	72,968	4,254	5.8	8,940	12.3	12.3
1968	75,358	4,548	6.0	9,166	12.2	12.3
1969	78,495	4,889	6.2	9,780	12.5	12.5
1970	80,449	5,041	6.3	9,992	12.4	12.5
1971	83,138	5,150	6.2	10,070	12.1	12.2
1972	86,439	5,373	6.2	10,094	11.7	11.8
1973	89,805	5,744	6.4	10,214	11.4	11.5
1974	92,608	5,836	6.3	10,324	11.1	11.2
1975	95,241	5,956	6.3	10,398	10.9	11.0
1976	97,818	6,287	6.4	10,403	10.6	10.7
1977	99,904	6,517	6.5	10,414	10.4	NA
Average annual ratio of growth	2.9	3.9		1.5		

[a]Cars in operation as estimated by R. L. Polk & Co. taken from Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '77*, Detroit, p. 34.

[b]*Automotive Fleet*, Bobit Publishing Co., Redondo Beach, Calif., April issue annually.

[c]General Services Administration, *Federal Motor Vehicle Fleet Report*, for each fiscal year.

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966–1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN., 1978.

Business fleets dominate the fleet stock (see Fig. 1.22). In 1967, 46% of fleets in the United States were owned by business corporations. If one considers that a large portion of the cars individually leased are used for business purposes, this figure approaches two-thirds of the total fleet. The fastest growing categories of fleet use are individually leased automobiles and daily rentals. Individually leased automobiles grew at an average annual rate of 12.1% between 1966 and 1977; daily rentals grew 7.2% per year. It appears that companies with larger fleets (25 or more cars) are more likely to lease rather than buy their automobiles, mainly because of the capital investment involved in large fleet inventories.

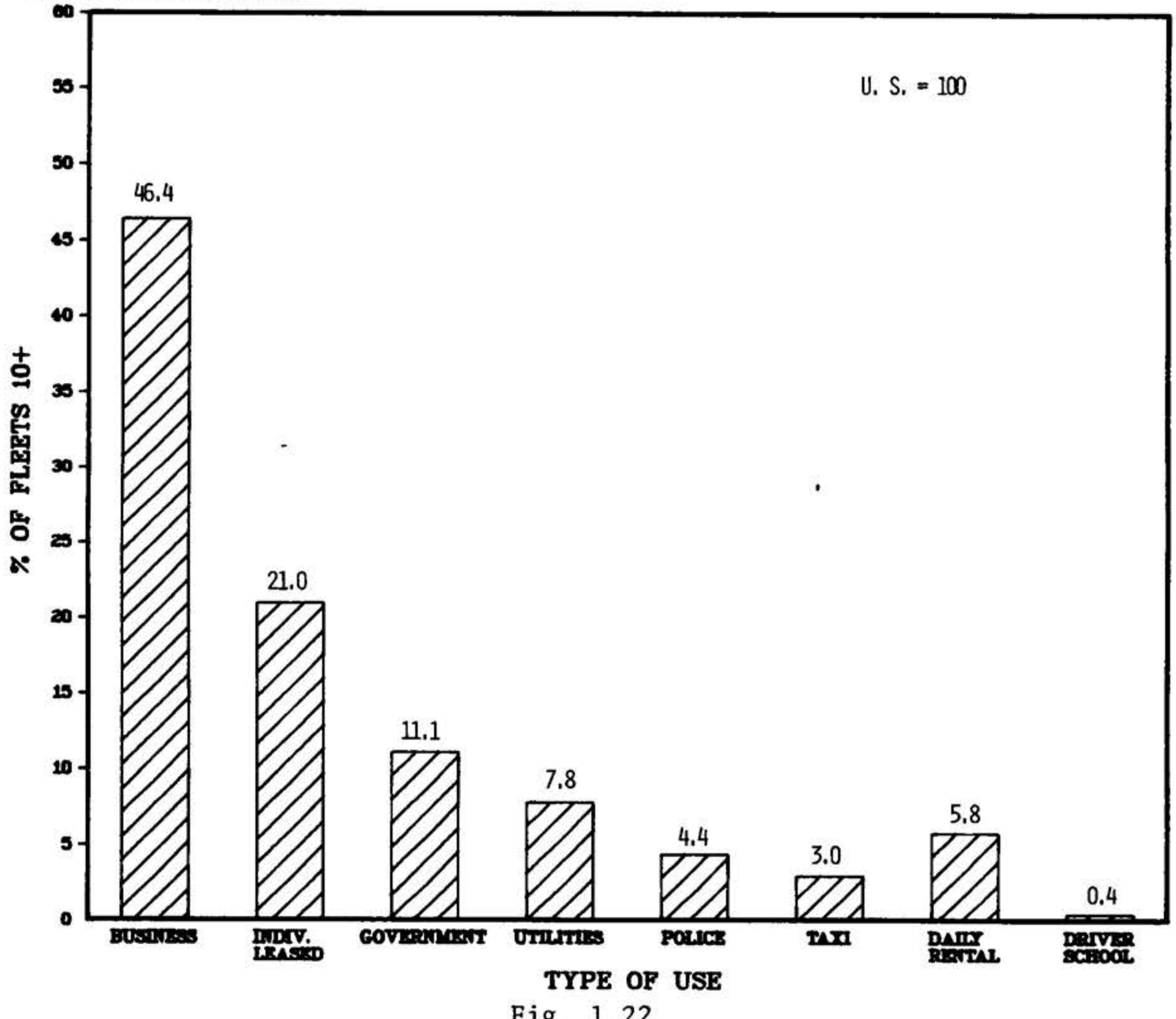


Fig. 1.22
U.S. Cars in Fleets of Ten or More by Type of Use, 1977.
(%)

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966–1967*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN., 1978.

Table 1.36 U.S. Cars in Fleets by Type of Use, 1966 through 1977
(in thousands)

Use	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	Percent distribution 1977	Average annual rate of growth
Business fleets	2,159	2,238	2,381	2,510	2,504	2,546	2,635	2,863	2,902	2,909	3,040	3,067	46.4	3.2
Owned	1,258	1,274	1,299	1,322	1,200	1,210	1,152	1,119	1,088	1,069	1,051	1,036	15.7	-1.8
Leased	901	964	1,082	1,188	1,304	1,336	1,483	1,744	1,814	1,840	1,989	2,031	30.7	7.7
10-24 cars	569	615	664	726	652	668	665	674	674	675	707	716	10.8	2.1
25 or more cars	1,509	1,623	1,717	1,784	1,852	1,878	1,970	2,189	2,228	2,234	2,333	2,351	35.6	4.1
Individually leased	395	487	573	697	803	834	925	994	1,008	1,072	1,217	1,385	21.0	12.1
Government	728	659	662	665	674	695	670	686	701	715	727	735	11.1	-0.3
Utilities	374	386	394	404	416	421	438	467	482	497	508	518	7.8	3.0
Police	165	174	185	191	207	218	236	249	261	278	286	292	4.4	5.3
Taxi	142	146	153	169	171	174	177	182	185	193	202	202	3.0	3.3
Daily rental	180	204	241	297	314	319	341	364	361	354	373	385	5.8	7.2
Driver school	31	31	29	27	25	27	29	27	26	25	26	26	0.4	-1.6
Total 10+	4,106	4,254	4,548	4,889	5,041	5,150	5,373	5,744	5,836	5,956	6,287	6,609	100.0	4.3
Total 4+	8,710	8,940	9,166	9,780	9,992	10,070	10,094	10,214	10,324	10,398	10,403	10,414		1.6

Sources: E. J. Bobit (ed.), *Automotive Fleet*, Vol. 16, No. 6, Bobit Publishing Company, Redondo Beach, Calif., April 1977, p. 22. General Services Administration, *Federal Motor Vehicle Fleet Report*, in each fiscal year.

BROOKHAVEN NATIONAL LABORATORY (BNL) CONDUCTED A STUDY OF FLEET OPERATORS IN THE SUMMER OF 1977. THE DATA COLLECTED IN THAT STUDY ALLOW A SECTOR-BY-SECTOR ANALYSIS OF FLEETS.

Table 1.37 Fleet Characteristics by Sector, 1977

	Fleet composition			Annual-miles	Percent of all cars that sit idle for 8 hours or more at a central location[a]	Average age at replacement (years)
	Average size of fleet	Percent large cars	Percent light trucks			
Police	506	88	4	28,000	20	2.1
Government[b]	425	40	26	14,000	49	4.1
Utilities	137	12	61	11,000	51	6.0
Taxi	31	72	11	51,000	25	2.8
Auto rentals	689	44	9	22,000	18	1.6
Business 25+	205	49	26	25,000	20	2.2
Business 4–24		67	23	25,000	13	2.3
All sectors	238	43	30	18,000	29	3.2

[a]Data shown represent only those respondents who supplied vehicle garaging information.

[b]State and local nonpolice.

Source: Joseph R. Wagner and Randall S. Davis, *Fleet Operator Study*, Interim Briefing paper prepared by Brookhaven National Laboratory and DOE's Contractor's Coordinating Meeting, Sept. 14, 1978.

A MAJOR SHIFT IN THE FEDERAL MOTOR FLEET MIX HAS TAKEN PLACE IN THE LAST THREE YEARS. THE SHIFT HAS BEEN AWAY FROM STANDARD AND MIDSIZE AUTOMOBILES AND TOWARDS COMPACT AND SUBCOMPACT CARS. BETWEEN 1975 AND 1977, THE NUMBER OF STANDARD SIZE AUTOMOBILES WAS REDUCED NEARLY ONE-HALF, WHILE THE NUMBER OF SUBCOMPACTS NEARLY TRIPLED.

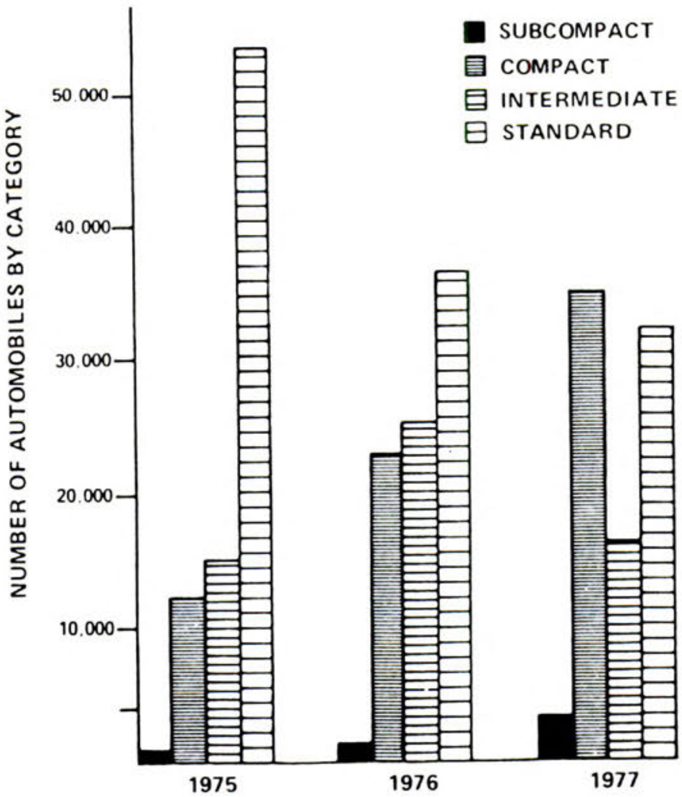


Fig. 1.23 World-Wide Federal Government Automobile Fleet Mix, 1976 through 1977.

Source: Department of Energy, Federal Energy Management Program, *Energy Management in the Federal Government*, August 1978, p. 9.

Table 1.38
Fleet Inventory Summary and Selected Characteristis of Federal Government Motor Vehicles, 1976

	Sedans	Station wagons	Ambulances	Buses	Trucks		Trucks as a percent of total	Total	Percent distribution
					Less than 12,500 lb	12,500 lb and over			
Total civilian	64,402	7,175	423	2,675	73,700	9,795	52.8	158,170	100
Selected agencies.									
Department of Agriculture	3,634	614		151	23,145	1,255	84.7	28,799	18
Department of Interior	1,174	503	8	238	7,201	2,648	83.7	11,772	7
Department of Justice	7,758	208	3	92	1,694	206	19.1	9,961	6
Department of Energy	1,724	185	55	302	6,442	1,005	76.7	9,713	6
General Services Administration	42,648	4,477	279	1,473	27,076	2,547	37.7	78,500	50
United States Postal Service	1,359	*a*	*a*	*a*	115,153	4,908	98.9	121,420	
Domestic	62,947	6,474	422	2,626	80,883		52.7	153,352	
Foreign	1,455	701	1	49	2,612		54.2	4,818	
Total military									
Agencies	22,352	4,548	2,886	7,988	80,895	26,967	74.1	145,636	
Department of Defense — Army	13,565	1,362	1,219	3,901	28,598	10,814	23.0	59,459	
Domestic	17,604	3,703	2,224	5,051	87,449		75.+	116,031	
Foreign	4,748	845	662	2,937	20,413		69.0	29,605	
Total civilian and military plus Post Office	88,113	11,723	3,309	10,663	269,748	41,670	73.2	425,226	
Domestic	81,910	10,177	2,646	7,677	288,393		73.8	390,803	
Foreign	6,203	1,546	663	2,986	23,025		66.9	34,423	

[a]These types not separated in USPS data system.

Source: General Services Administration, *Federal Motor Vehicle Fleet Report*, Washington, D.C., June 1977, Tables 1 and 6.

MORE THAN TWO MILLION VEHICLES ARE OWNED BY FEDERAL, STATE, COUNTY, AND MUNICIPAL GOVERNMENTS. OVER ONE-HALF OF THESE VEHICLES ARE TRUCKS. IN 1976, THERE WERE AN ADDITIONAL 145,636 VEHICLES AVAILABLE FOR MILITARY USE.

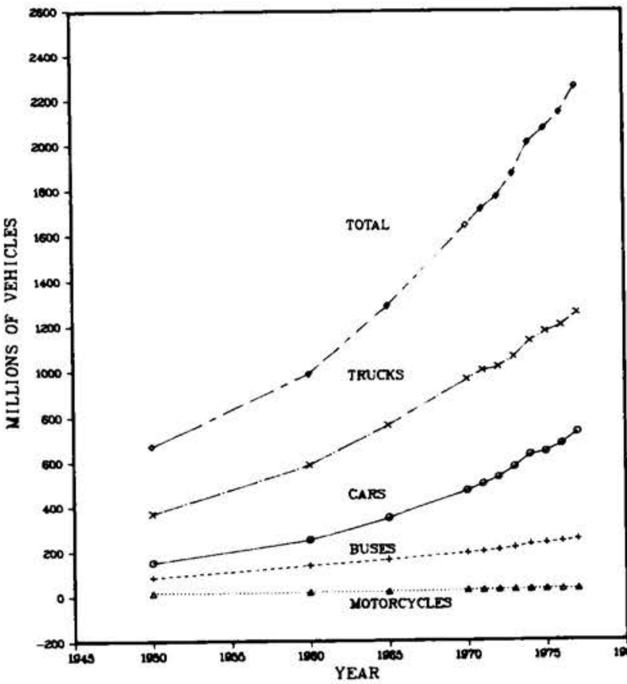


Fig. 1.24 Publicly Owned Registered Vehicles, 1950 through 1977.

Table 1.39 Publicly Owned Registered Vehicles, 1950 through 1977[a]

Year (December 31st)	Passenger cars and taxi	Motorcycles	Buses	Trucks	Total motor vehicles
1950	148,445	9,920	80,446	365,816	55,667,387
1960	251,442	13,887	134,557	584,971	984,857
1970	469,323	21,289	189,085	958,441	1,638,989
1975	641,214	26,256	232,808	1,168,007	2,068,285
1976	675,472	25,584	240,969	1,195,485	2,137,510
1977	728,302	27,434	250,423	1,249,599	2,255,758
% distribution					
1977	32	1	11	55	100

[a]Publicly owned vehicles include federal, state, county, and municipal vehicles. Vehicles owned by the military services are not included.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., Table MV-1, annual.

ONLY RECENTLY HAVE SMALL CARS PENETRATED THE FLEET CAR MARKET. UNTIL 1974, TWO-THIRDS OF THE FLEET VEHICLE STOCK WERE STANDARD SIZE OR LARGER. SINCE 1974 STANDARD-SIZED FLEET CARS HAVE BEEN REPLACED WITH INTERMEDIATE-SIZED CARS, AND ALL FLEET INDUSTRY SOURCES INDICATE THAT THIS DOWNSIZING TREND FOR FLEET CARS WILL CONTINUE.

Table 1.40 New Fleet Car Size Composition[a], 1966 through 1977
(percent)

	Standard	Intermediate	Compact
1966			
U.S. total	53	31	16
AALA fleet	95		5
1970			
U.S. total	42	28	30
AALA fleet	97		3
1973			
U.S. total[b]	34	23	43
AALA fleet[c]	70	24	6
1974			
U.S. total	27	24	48
AALA fleet	62	33	5
1975			
U.S. total	23	24	53
AALA fleet	53	40	7
1976			
U.S. total	24	28	48
AALA fleet	46	48	6
1977			
U.S. total	27	29	45
AALA fleet	45	47	8

[a]Car size classifications may not be consistent between the two sources or with the classifications used in the *TEC Data Book*.

[b]Ward's Communications, Inc., *Ward's Automotive Yearbook*, Detroit, table "U.S. New Car Registrations by Market Share," annual editions.

[c]Information supplied by American Automotive Leasing Association (AALA), which collects data annually in their AALA Fleet Cost Survey. Summary data appear in each April issue of Bobit's *Automotive Fleet*. This car size breakdown applies to the total fleet.

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966-1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN, 1978.

SINCE 1975 AIR CONDITIONERS IN FLEET CARS HAVE BEEN MORE OR LESS STANDARD EQUIPMENT. IN 1977, 95% OF NEW CAR FLEET SALES AND 77% OF TOTAL NEW CAR SALES HAD AIR CONDITIONERS. THE WIDESPREAD USE OF AIR CONDITIONING HAS IMPLICATIONS FOR THE NECESSARY SPECIFICATIONS THAT NEW VEHICLE TECHNOLOGIES MUST MEET IN ORDER TO BE VIABLE FOR FLEET OPERATIONS.

Table 1.41 Percentage of New Fleet Cars with Air Conditioning, Model Years 1967-1978

Model year	Total car sales[a]	AALA fleet[b]
1967	38	46
1968	45	56
1969	54	67
1970	59	78
1971	63	79
1972	70	83
1973	74	83
1974	68	86
1975	72	94
1976	75	95
1977	77[c]	95
1978	83[c]	

[a]Marketing Services, Inc., *Automotive News Almanac*, Detroit, annual issues, 1966-1976.

[b]Information supplied by American Automotive Leasing Association (AALA), which collects data annually in their AALA Fleet Cost Survey. Summary data appear in each April issue of Bobit's *Automotive Fleet*.

[c]As of Dec. 31, 1977.

Source: D. B. Shonka, *Characteristics of Automotive Fleets in the U.S.: 1966–1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN, 1978.

Section 1.2.1.3

Recreational Vehicles

THE RECREATIONAL VEHICLE INDUSTRY ASSOCIATION (RIVA) CITES SEVERAL FACTORS INFLUENCING THE INCREASE IN USE OF RECREATIONAL VEHICLES (RVs):

- EMERGENCE OF CAMPING AS FAVORITE FOR FAMILY OUTINGS,
- INCREASING COSTS OF RESTAURANT MEALS AND ACCOMMODATIONS FOR FAMILIES,
- INCREASE IN TRAVEL BY RETIREES.

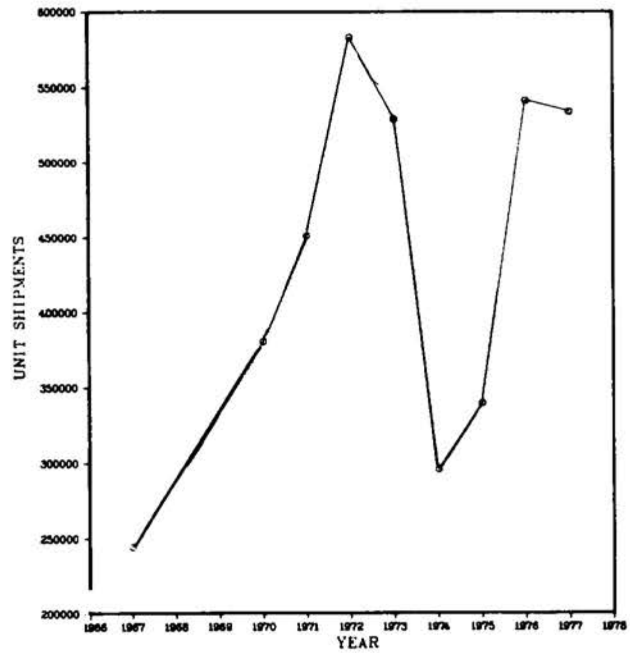


Fig. 1.25
Recreational Vehicle Unit Shipment Trends, 1967 through 1977.

Table 1.42
Recreation Vehicle Unit Shipment Trends by Category, 1967 through 1977

	Travel trailers	Truck campers	Fold-down camping trailers	Motor homes[a]	Total
1967	94,500	61,600	79,280	9,050	244,430
1970	138,000	95,900	116,100	30,300	380,300
1971	190,800	107,200	95,800	57,200	451,000
1972	250,800	105,100	110,200	116,800	582,900
1973	212,300	89,800	97,700	129,000	528,800
1974	126,300	45,400	55,200	68,900	295,800
1975	150,600	44,300	48,100	96,600	339,500
1976	189,700	42,000	53,300	256,100	541,100
1977	167,900	31,900	53,900	280,200	533,900
Average 1977 retail price,	$7,032	$3,089	$2,285	$15,448	

[a]Imports of Volkswagen Campmobile Motor Homes included in 1972–1974 only.

Source: *Facts and Trends 1977*, Recreation Vehicle Industry Association, Chantilly, Va., 1977–1978, pp. 8, 10, 11, and 19.

THE MOTORCYCLE INDUSTRY COUNCIL, INC. ESTIMATES THAT THERE WERE 7.9 MILLION MOTORCYCLES IN USE IN 1977. OF THESE, 4.9 MILLION, OR 62%, WERE REGISTERED WITH FHWA FOR USE ON PUBLIC ROADS (IN COMPLIANCE WITH FEDERAL MOTOR VEHICLE SAFETY STANDARDS). IT IS ESTIMATED THAT MOTORCYCLES IN USE TRAVELED 12.7 BILLION MILES IN 1977 AND REPRESENTED 0.9% OF ALL MOTOR VEHICLE TRAVEL IN 1977.

Table 1.43 Motorcycles Used On and Off Roads in 1977

		Model type		
	U.S. total	On-road	Off-road	Combination
Total motorcycles in use	7,925,600	3,518,400	1,754,000	2,653,200
Motorcycles registered for use on public roads	4,916,000	3,377,700	0	1,538,300
Motorcycles used off road at some time[a]	5,111,100	1,020,300	1,754,000	2,336,800
Total vehicle-miles traveled, 10^9	12.7	8.1	2.0	2.6

[a]Includes some motorcycles registered with FHWA for on-road use which were also used off public roads some of the time.

Source: *1978 Motorcycle Statistical Annual*, Motorcycle Industry Council, Inc., Newport Beach, Calif., pp. 30 & 32.

MOTORCYCLE REGISTRATIONS HAVE INCREASED DRAMATICALLY IN THE LAST 20 YEARS. THIS GROWTH DOES NOT INCLUDE THE GROWTH IN OFF-ROAD AND MOPED VEHICLES.

Table 1.44 Motorcycle Registrations, 1950-1977

1950	454,000
1960	575,000
1970	2,815,000
1975	4,967,000
1976	5,110,000[a]
1977	4,916,000[a]

[a]Estimated.

Source: *1978 Motorcycle Statistical Annual*, Motorcycle Industry Council, Inc., Newport Beach, Calif.

MOTORCYCLE IMPORTS REPRESENT THE MAJORITY OF U.S. MOTORCYCLE SALES. OF THE 1,050,000 MOTORCYCLES IMPORTED INTO THE UNITED STATES IN 1977, 75% WERE IMPORTED FROM JAPAN, 12% FROM EUROPEAN COUNTRIES, AND 1% FROM OTHER COUNTRIES.

Table 1.45 Summary of Annual New Motorcycle Sales, 1969-1977 (10^3)

	Imports[a]				
	Motorcycles	Mopeds[b]	Domestic production[c]	Total U.S. production and imports	% import
1969	640		40	680	94
1970	1,090		35	1,125	97
1971	1,540		25	1,565	98
1972	1,690		35	1,725	98
1973	1,210		45	1,255	96
1974	1,540	13	40	1,593	97
1975	950	32	40	1,022	96
1976	660	78	80	818	90
1977	860	190	110	1,160	91

[a] *U.S. Motorcycle Imports*, Werner C. Single, Foreign Trade Services, W. New York, New Jersey.

[b] Motorized bicycles.

[c] MIC estimate derived by adjusting new-motorcycle registrations for U.S. brands (R. L. Polk & Co., Detroit, Mich.) and information offered by Kawasaki Motors Corporation, Lincoln, Nebr.

Source: Motorcycle Industry Council, Inc., *1978 Motorcycle Statistical Annual*, Newport Beach, Calif.

THE RECENT GROWTH IN THE OUTPUT OF FOUR-WHEEL-DRIVE VEHICLES COUPLED WITH THE RISE IN POPULARITY OF LIGHT TRUCKS HAS COUNTER IMPLICATIONS FOR FUEL ECONOMY STANDARDS FOR MOTOR VEHICLES.

Table 1.46 U.S. Four-Wheel-Drive Model Year Output by Makes and Class, 1974 through 1977

	1974	1975	1976	1977
Sports utility				
Blazer	53,731	46,878	67,092	76,212
CJ-5	43,137	32,486	31,116	32,996
Scout	25,177	18,995	16,327	27,074
CJ-7			21,016	25,414
Jimmy	10,933	10,003	16,660	16,679
Ramcharger	10,037	7,382	12,283	13,777
Bronco	22,653	11,590	13,704	13,593
Trail Duster	4,696	3,172	3,649	6,158
CJ-6	2,826	2,935	2,431	2,754
Traveler			5,894	
Class total	191,467	133,441	184,278	214,657
Station wagons				
Jeep Cherokee		12,925	18,859	31,308
Jeep Wagoneer	15,350	9,296	16,520	19,990
Chevy Surburban	8,823	6,849	10,563	12,601
IH Traveller			5,894	9,620
GMC Surburban	2,297	1,950	3,553	4,427
Travelall	1,603	1,066		
Class total	28,073	32,086	55,389	77,946
Pickups				
Chevy	82,110	104,765	149,459	171,499
Ford	57,590	75,939	128,036	162,723
Dodge	43,324	31,293	44,303	72,101
GMC	15,197	18,977	36,264	45,208
Jeep	17,173	10,138	12,508	15,534
IH	13,874	7,705	3,556	2,688
Class total	229,268	248,817	374,126	469,753
Grand total	448,808	414,344	613,793	762,356
Percent of total light truck sales	21	20	23	25

Source: H. A. Stark (ed.), *Ward's 1978 Automotive Yearbook*, 40th ed., Ward's Communications, Inc., Detroit, 1978, p. 59; *Ward's 1977 Automotive Yearbook*, p. 59; *Ward's 1976 Automotive Yearbook*, p. 51.

SNOWMOBILE SALES REACHED A PEAK DURING THE 1971-72 SELLING SEASON AND THEN DECLINED. HOWEVER, SALES OF NEW SNOWMOBILES WERE ESTIMATED TO BE 220,000 FOR THE 1977-78 WINTER SEASON, AN INCREASE FROM 1976-77 OF NEARLY 12.8%. THIS INCREASE IS DUE IN PART TO THE DEVELOPMENT OF 75,000 MILES OF PUBLIC SNOWMOBILE TRAILS IN THE UNITED STATES.

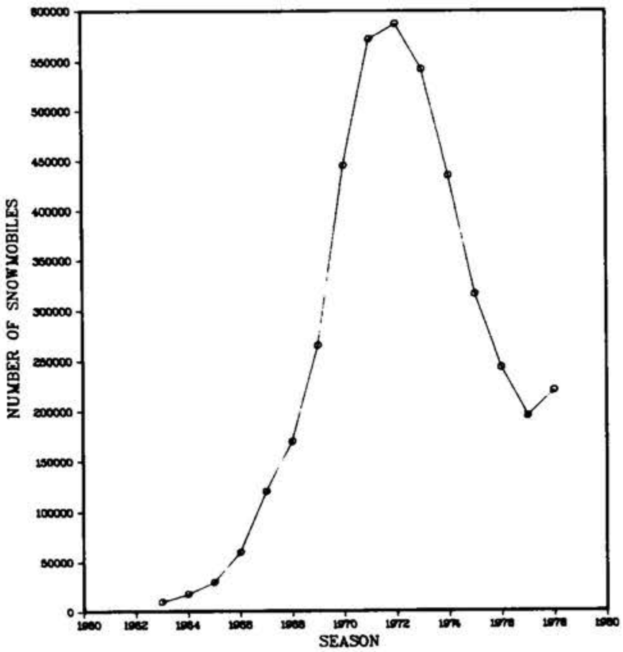


Fig. 1.26
Snowmobile Sales by Selling Season, 1963 through 1978.

Table 1.47
Snowmobile Sales, 1962 through 1978
(by selling season)
(10^3)

Season	Units
1962-63	10
1963-64	18
1964-65	30
1965-66	60
1966-67	120
1967-68	170
1968-69	265
1969-70	445
1970-71	572
1971-72	587
1972-73	542
1973-74	435
1974-75	316
1975-76	243
1976-77	195
1977-78	220

Source: H. A. Stark (ed.), *Ward's 1978 Automotive Yearbook,* 40th ed., Ward's Communications, Inc., Detroit, 1978, p. 60. (Original source: International Snowmobile Industry Association.)

Section 1.2.2

Motor Vehicle Ownership by Household Characteristics

Table 1.48

Household Purchases of New and Used Passenger Cars, 1968 through 1974

Year purchased	New cars				Used cars				Used cars as a percent of total cars
	Number purchased (thousands)	Number purchased per 100 households	Average price paid[a]	Total expenditures (billions)	Number purchased (thousands)	Number purchased per 100 households	Average price paid[a]	Total expenditures (billions)	
1968	7,960	13.1	$2,936	$23.4	13,407	22.1	$ 919	$12.3	63
1969	8,069	13.0	3,021	24.4	12,808	20.6	952	12.2	61
1970	7,051	11.1	3,025	21.3	12,504	19.7	960	12.0	64
1971	8,148	12.5	3,294	26.8	14,564	22.4	1,017	14.8	64
1972	8,539	12.8	3,372	28.8	15,021	22.5	1,054	15.8	64
1973[b]	8,700	12.5	3,490	30.2	12,600	18.2	1,287	16.2	59
1974[b]	8,400	11.9	3,805	32.1	13,500	19.1	1,284	17.4	62

[a]Net price, after allowance for trade-in.
[b]Not strictly comparable to previous years, data collected from Fall 1972 to Fall 1973.

Source: Motor Vehicle Manufacturers Association, *Motor Vehicle Facts & Figures '76*, Detroit, p. 43.

Table 1.49

Household Ownership of Motor Vehicles by Selected Characteristics, 1974

(percent owning in each household group)

	Number of households (in millions)	Motor vehicles			One or more cars	One or more pick-ups	One or more vans or recreational vehicles
		One or more	Two or more	Three or more			
All households	70.8	83.8	45.1	10.2	81.5	17.1	3.2
Annual income							
Under $3,000	8.0	46.2	11.0	1.8	43.2	7.8	1.2
$3,000 to $4,999	7.4	64.2	16.1	2.2	60.7	11.0	1.3
$5,000 to $7,499	8.9	79.4	26.2	4.0	76.0	14.3	2.2
$7,500 to $9,999	8.3	88.3	36.2	4.9	85.0	16.8	2.8
$10,000 to $14,999	15.9	93.9	53.5	9.8	91.7	22.2	3.2
$15,000 to $19,999	9.7	96.7	67.9	14.5	95.5	22.7	4.6
$20,000 to $24,999	5.2	97.4	73.1	21.0	96.9	19.2	5.3
$25,000 and over	7.1	97.2	77.6	29.4	96.7	17.2	5.2
Age of head							
Under 25 years	6.1	85.6	34.0	3.4	81.9	10.0	4.3
25 to 29 years	7.5	89.3	45.4	4.4	86.8	17.2	3.7
30 to 34 years	6.9	90.3	49.7	5.3	87.8	18.1	3.5
35 to 44 years	12.3	90.3	59.7	14.6	88.6	22.8	4.2
45 to 54 years	12.6	89.4	61.2	22.3	87.5	21.9	3.9
55 to 64 years	11.6	85.7	46.9	11.8	83.2	18.1	2.6
65 years and over	13.7	64.2	18.2	2.6	61.9	9.4	1.0
Residence							
Central cities	22.3	72.4	32.1	6.6	71.3	7.4	2.3
Suburban rings	26.2	90.1	52.5	12.7	88.3	15.5	3.8
Outside metropolitan areas	22.3	87.8	49.4	10.9	83.8	28.7	3.3
Region							
Northeast	16.6	75.6	36.5	8.1	74.8	7.5	2.5
North central	18.9	86.2	47.5	10.8	84.4	16.4	3.4
South	22.5	85.5	46.9	10.2	82.6	21.1	2.2
West	12.8	87.9	49.6	12.2	84.1	23.6	5.4

Source: U.S. Department of Commerce, Bureau of the Census, *Selected Data from the 1973 and 1974 Surveys of Purchases and Ownership*, Washington, D.C., July 1976. (Revised)

TRIP LENGTH DOES NOT VARY SIGNIFICANTLY BY THE SEASON OF THE YEAR EXCEPT FOR THE SUMMER MONTHS, WHEN TRIPS OF 100 MILES AND LONGER PEAK.

Table 1.50
Percentage of Automobile Trips by Season and Trip Length

Season of the year	Length of trip (miles)														
	Less than one-half mile	1	2	3	4	5	6-10	11-20	21-30	31-40	41-50	51-99	100 and over	Total	Daily number of trips (000)
Spring (April)	8.2	16.4	13.0	9.5	6.4	8.8	16.1	13.4	4.1	1.7	0.8	0.9	0.7	100.0	254,445
Summer (July-August)	8.4	14.2	13.1	9.7	6.3	8.8	17.4	12.9	4.1	1.7	0.9	1.3	1.2	100.0	236,971
Fall (October)	8.7	15.2	14.9	10.0	6.6	7.8	17.9	11.1	3.6	1.5	0.9	1.1	0.7	100.0	237,936
Winter (January)	8.8	17.6	13.0	10.6	6.1	7.5	16.4	12.1	4.0	1.3	0.8	0.9	0.7	100.0	222,596

Source: H. E. Strate, U.S. Department of Transportation, Federal Highway Administration, *Nationwide Personal Transportation Study — Seasonal Variations of Automobile Trips and Travel*, Report No. 3, Washington, D.C., April 1972, p. 15.

IN 1976, ALMOST 20% OF ALL HOUSEHOLDS IN THE UNITED STATES OWNED ONE OR MORE TRUCKS. THIS FIGURE INCREASES TO 31% LIVING OUTSIDE SMSAs.

Table 1.51
Households with Automobiles and Trucks Available, 1976
(percent)

	Total		Inside SMSAs[a]				Outside SMSAs[a]	
			Total		In central city			
	1970	1976	1970	1976	1970	1976	1970	1976
Automobiles								
1	47.7	48.0	45.8	45.5	45.4	45.4	52.1	53.3
2	29.3	28.5	30.0	29.6	22.1	22.5	27.8	26.0
3 or more	5.5	7.3	5.7	7.8	4.1	5.4	5.1	6.4
None	17.5	16.2	18.5	17.1	28.4	26.7	15.0	14.3
Total percent	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Trucks								
1	NA	19.7	NA	14.5	NA	10.2	NA	31.0
2 or more	NA	2.1	NA	1.3	NA	0.8	NA	3.8
None	NA	78.2	NA	84.2	NA	88.9	NA	65.2
Total percent		100.0		100.0		100.0		100.0
Households, 10^3	67,699	79,316	46,083	53,606	22,584	24,547	21,616	25,710

[a]Standard Metropolitan Statistical Areas.

NA — Not available.

Source: U.S. Department of Commerce, Bureau of the Census, and U.S. Department of Housing and Urban Development, *Annual Housing Survey: 1976*, United States and Regions, Part A: General Housing Characteristics, Washington, D.C., 1978, p. 8.

THE MAJOR DIFFERENCES IN THE TYPES OF VEHICLES OWNED BY URBAN AND RURAL RESIDENTS OCCUR IN THE SMALL CAR AND PICK-UP TRUCK CATEGORIES. SMALL CARS (COMPACTS AND SUBCOMPACTS) COMPRISE MORE THAN 30% OF THE VEHICLES OWNED BY RESIDENTS OF METROPOLITAN AREAS WHILE THEIR RURAL COUNTERPARTS OWN ONLY 22% SMALL CARS. THE PROPORTIONS OF INTERMEDIATE, STANDARD, AND LUXURY CARS DIFFER ONLY SLIGHTLY ACROSS AREAS. VIRTUALLY ALL OF THE DIFFERENCE IS ACCOUNTED FOR BY THE LARGE NUMBERS OF PICK-UPS OWNED BY RURAL HOUSEHOLDS.

Table 1.52
Percentage Breakdown of Personal Motor Vehicle Classes by Location[a] of Residence, 1975

	Metropolitan areas		Nonmetropolitan areas	Percent of total personal motor vehicles
	Central cities	Suburban rings		
Total	100.0	100.0	100.0	
Subcompact	11.0	11.8	7.2	10.2
Compact	19.2	19.2	14.9	17.9
Intermediate	20.8	18.3	19.0	19.1
Standard	33.6	30.7	32.0	31.8
Luxury	5.5	5.8	4.0	5.2
Pickup truck	6.8	9.9	19.0	12.0
Passenger van	1.8	2.8	1.0	2.0
Motor home	0.2	0.2	0.3	0.2
Other[b]	1.0	1.2	2.3	1.5
Percent of total automobiles	24.0	45.0	31.0	100.0

[a]Locational definitions follow those of the U.S. Bureau of the Census for SMSAs.

[b]Not a passenger car, pickup truck, passenger van or motor home.

Source: Washington Center for Metropolitan Studies, *Lifestyles and Household Energy Use: 1975 National Survey.* (3,149 households were surveyed.)

TABLE 1.53 SHOWS THAT WHILE 69% OF ALL PERSONAL MOTOR VEHICLES ARE OWNED BY HOUSEHOLDS IN METROPOLITAN AREAS, THESE HOUSEHOLDS OWN 78% OF ALL SUBCOMPACTS, AND 74% OF COMPACTS. THESE DIFFERENCES MAY WELL REFLECT A POSITIVE INFLUENCE OF THE URBAN TRAVEL ENVIRONMENT ON CONSUMER PREFERENCES FOR SMALLER, MORE EFFICIENT PERSONAL MOTOR VEHICLES.

Table 1.53
Percentage Breakdown of Personal Motor Vehicles by Automobile Classes and Residential Location[a], 1975
(summary)

	Subcompact	Compact	Intermediate	Standard	Luxury	Pickup truck	Passenger van	Motor home	Other[b]	Percent of total automobile
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Metropolitan areas	78.0	74.1	69.3	68.8	75.9	51.5	84.9	58.1	53.4	69.0
Central cities	25.8	25.8	26.1	25.4	25.7	13.3	21.3	19.2	16.0	24.0
Suburban rings	52.2	48.3	43.2	43.4	50.2	38.2	63.6	38.9	37.4	45.0
Nonmetropolitan areas	22.0	25.8	30.7	31.2	24.1	48.5	15.0	41.9	46.6	31.0
Percent of total automobiles	10.2	17.9	19.1	31.8	5.2	12.0	2.0	0.2	1.5	100.0

[a]Locational definitions follow those of the U.S. Bureau of the Census for SMSAs.

[b]Not a passenger car, pickup truck, passenger van, or motor home.

Source: Washington Center for Metropolitan Studies, *Lifestyles and Household Energy Use: 1975 National Survey.*

Table 1.54
Percentage of Motorcycle-Owning-Households
Owning Other Vehicles

Own:	Owning Households
Domestic car(s)	83%
Import car(s)	25
Mini-pickup(s)	5
Full-size pickup(s)	39
Van(s)/Bus(es)	12
4 × 4 vehicle(s)	10
Mini-motorhome(s)	2
Full-size motorhome(s)	2
Sample size	3163

Source: 1977 Motorcycle Market Study conducted by J. D. Power and Associates, Los Angeles, Calif., 1977.

Section 1.2.3

Travel Characteristics

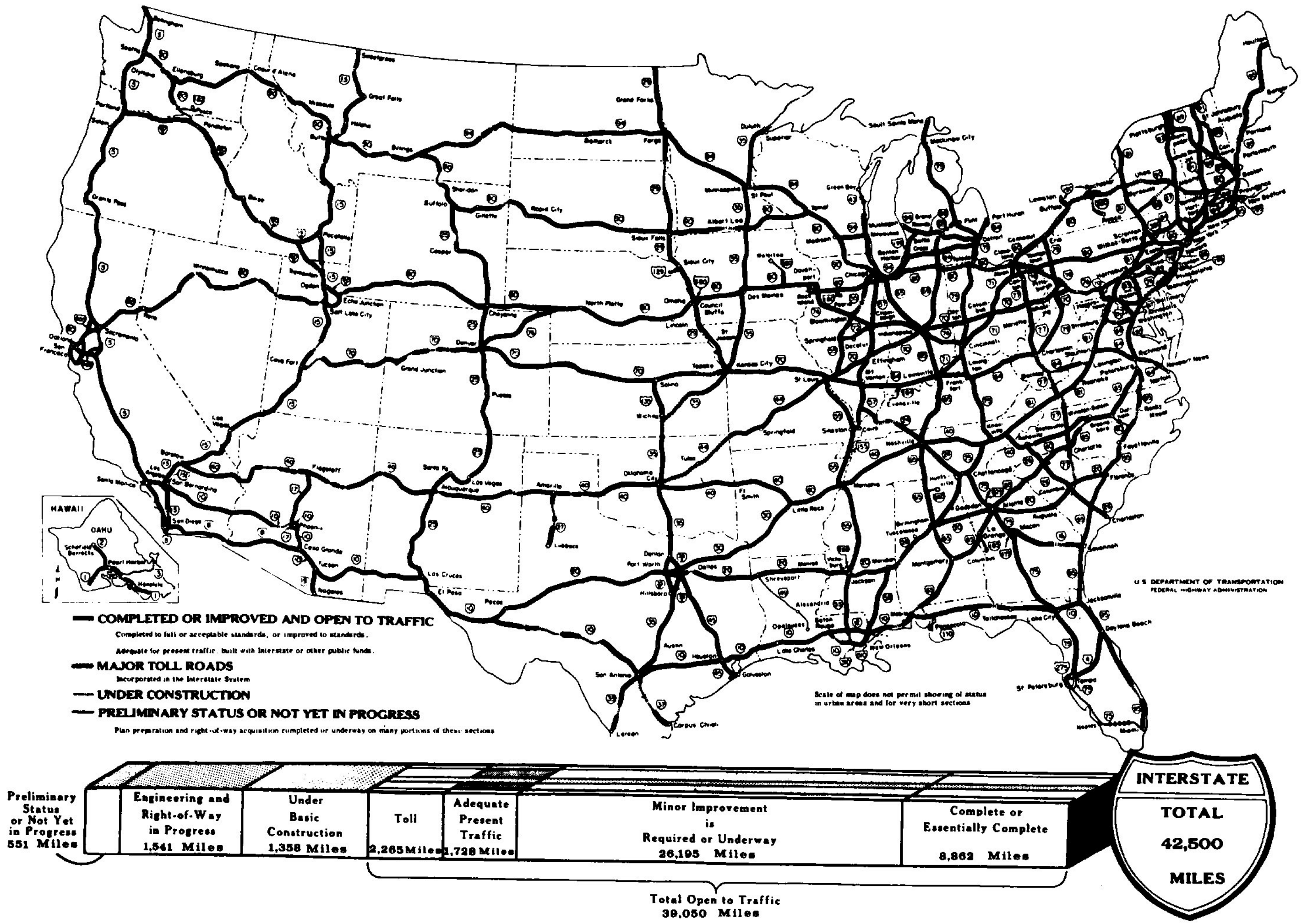


Fig. 1.27
The National System of Interstate and Defense Highways.
(June 13, 1978)

Source: U.S. Department of Transportation, Federal Highway Administration, *Department of Transportation News*, FHWA 11-78 (June 13, 1978), Washington, D.C.

Table 1.55
Highway Motor Vehicle Travel in the United States, 1950 through 1976[a]
(10^6 vehicle-miles)

Year	Passenger vehicles							Cargo vehicles			All motor vehicles
	Passenger cars	Motorcycles[b]	All personal passenger vehicles	Buses			All passenger vehicles	Single-unit trucks	Combinations	All trucks	
				Commercial	School	All buses					
1950	363,613	NA		3,271	810	4,081	367,694	42,452	14,327	90,552	458,246
1960	588,083	NA		2,872	1,481	4,353	592,436	97,930	28,479	126,409	718,845
1970	890,844	10,148	900,992	2,943	2,100	5,043	906,035	174,443	40,227	214,670	1,120,705
1971	939,102	15,053	954,155	2,885	2,212	5,097	959,252	184,396	42,641	227,037	1,186,289
1972	986,407	17,091	1,003,498	2,750	2,359	5,109	1,008,607	213,122	46,613	259,735	1,268,342
1973	1,016,861	19,594	1,036,455	2,548	2,412	4,960	1,041,415	219,128	48,019	267,147	1,308,562
1974	990,721	22,347	1,013,068	2,610	2,450	5,060	1,018,128	211,460	56,059	267,519	1,285,647
1975	1,028,121	22,351	1,050,472	2,648	2,500	5,148	1,055,620	218,894	55,560	274,454	1,330,074
1976	1,074,000	22,452	1,096,452	2,899	2,862	5,761	1,102,213	247,895	59,055	306,950	1,409,163

[a]For a detailed discussion of VMT see TERA, Inc., and D. L. Greene, *VMT Statistics, Lifetime VMT and Current State Methods of Estimating VMT*, ORNL/TM-6327, Oak Ridge National Laboratory, Oak Ridge, Tenn.

[b]Estimated VMT for registered motorcycles only. See Table 1.72 for discussion of motorcycle data.

NA — Not available.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics Summary to 1965*, Washington, D.C., March 1967, Table VM-201A, pp. 40–42; *Department of Transportation News*, Washington, D.C., Table VM-1, annual.

THE SPLIT BETWEEN URBAN AND RURAL TRAVEL VARIES BY TYPE OF MOTOR VEHICLE. OVER 80% OF VMTs TRAVELED BY COMBINATION TRUCKS IS ON RURAL ROADS.

Table 1.56
Motor Vehicle Travel on Urban and Rural Roads, 1976[a]
(percent)

	Personal passenger vehicles[b]	Buses			All passenger vehicles	Trucks			All motor vehicles
		Commercial	School and other nonrevenue	All buses		Single-unit trucks	Combinations	All trucks	
Total travel, 10^6 vehicle-miles	1,096,452	2,899	2,862	5,761	1,102,213	247,895	59,055	306,950	1,409,163
Total travel	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
All rural roads	42.4	41.3	69.5	55.3	42.5	46.5	80.9	53.1	44.8
Main rural roads	35.2	38.1	47.1	42.6	35.3	42.5	79.2	49.5	38.4
Local rural roads	7.2	3.2	22.4	12.7	7.2	4.0	1.7	3.6	6.4
Urban streets	57.6	58.7	30.5	44.7	57.6	53.5	19.1	46.9	55.2

[a]Highway categories for 1976 are based on functional classification and differ from earlier years. Compared to the earlier reporting procedure, main rural travel is 8% higher, local rural travel is 36% lower, and urban travel is 1% higher.

[b]Includes travel by automobiles and motorcycles.

Source: U.S. Department of Transportation, Federal Highway Administration, *Department of Transportation News*, Washington, D.C., March 29, 1978, Table VM-1.

FUEL CONSUMPTION IS RELATED TO TYPE OF TRAVEL CONDITIONS SUCH AS URBAN VS RURAL ROADS. IN 1976, 58% OF TOTAL TRAVEL IN THE UNITED STATES WAS ON URBAN STREETS AND 42% WAS ON RURAL ROADS.

Table 1.57 Automobile Travel: Urban vs Rural Roads, 1950 through 1976[a]

Year	Total (10^9 VMT)	Urban[b]		Rural		VMT per mile of road
		(10^9 VMT)	%	(10^9 VMT)	%	
1950	363.6	182.5	50.2	181.1	48.8	109,749
1955	492.6	233.6	45.4	259.0	54.6	144,119
1960	588.1	284.8	48.4	303.3	51.6	165,849
1965	706.4	375.8	53.2	330.6	48.8	191,436
1970	890.8	489.0	54.99	401.8	45.1	238,820
1971	939.1	516.5	55.0	422.6	45.0	249,827
1972	986.4	558.3	56.6	428.1	43.4	260,470
1973	1,016.9	580.7	57.1	436.2	42.9	267,113
1974	990.7	585.8	57.8	427.3	42.2	259,617
1975	1,028.1	609.6	58.0	440.9	42.0	267,874
1976	1,074.0	631.9	57.6	464.6	42.4	278,455

[a]Travel for 1957–64 includes motorcycles. For 1965–75, total travel excludes motorcycles while urban/rural distribution is based on percentages calculated from vehicle-miles which includes motorcycles.

[b]"Urban" consists of travel on all roads and streets in urban places of 5,000 or greater population.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., Table VM-1 and M-1, annual.

Table 1.58
Average Miles Traveled by Type of Highway Motor Vehicle, 1950 through 1976[a]

Year	Passenger vehicles							Cargo vehicles			All motor vehicles
	Personal passenger vehicles			Buses			All passenger vehicles				
	Passenger cars[b]	Motorcycles[c]	All personal passenger vehicles	Commercial	School	All buses		Single-unit trucks	Combinations	All trucks	
1950	9,020	NA	9,020	36,500	7,775	20,910	9,078	NA	NA	10,776	9,369
1960	9,446	NA	9,446	37,789	7,556	16,004	9,474	NA	NA	10,583	9,652
1970	9,978	3,605	9,783	32,591	7,274	13,306	9,798	9,807	41,903	11,450	10,076
1971	10,121	4,500[d]	9,926	31,949	7,198	12,819	9,938	9,794	43,779	11,465	10,198
1972	10,184	4,500	9,969	30,968	7,414	12,553	9,980	10,525	47,084	12,229	10,370
1973	9,992	4,498	9,767	28,469	7,178	11,662	9,774	9,868	46,716	11,538	10,083
1974	9,448	4,500	9,225	28,968	6,865	11,320	9,233	8,981	51,667	10,861	9,530
1975	9,634	4,500	9,406	28,230	6,788	11,140	9,413	8,882	49,125	10,648	9,644
1976	9,733	4,500	9,506	29,948	7,502	12,045	9,517	9,355	48,366	11,073	9,817

[a]Also, see TERA, Inc. and D. L. Greene, *VMT Statistics, Lifetime VMT and Current State Method of Estimating VMT*, ORNL/TM-6327, Oak Ridge National Laboratory, Oak Ridge, Tenn.

[b]See Table 1.59 for a comparison of estimate of average annual-miles driven by passenger cars.

[c]Estimated VMT for registered motorcycles only. See Table 1.72 for discussion of motorcycle VMT.

[d]Significant difference in values for 1971 and the corresponding values for 1970 represents a change in the basic assumptions of miles per vehicle and miles per gallon, not a shift in the trend.

NA — Not available.

Source: U.S. Department of Transportation, Federal Highway Administration, *Department of Transportation News*, Washington, D.C., Annual, Table VM-1.

A common rule of thumb is that the average American automobile travels 10,000 miles per year. However, as Table 1.59 indicates, the estimates of annual VMT vary significantly.

Table 1.59

Comparison of Estimated Annual-Miles Driven by Automobile

Per Automobile	Per Household	Survey (S) or Estimate (E)	Date	Source
11,600		S	1969	"Annual Miles of Automobile Travel," Report No. 2, *Nationwide Personal Transportation Study*, U.S. Department of Transportation, Washington, D.C., 1972.
11,800	16,800	S	1974	*1973 and 1974 Surveys of Purchases and Ownership*, Bureau of the Census, U.S. Department of Commerce, 1976.
9,494		E	1974	*Selected Highway Statistics, 1974*, Federal Highway Administration, U.S. Department of Transportation, 1976.
9,889	16,828	E	1974	Comprehensive Human Resources Data System (CHRDS), Mathematic Policy Research, Inc.
15,300 (small car) 13,480 (medium car) 14,180 (large car)		S	1976	*Study of Automobile Dynamics*, Arthur D. Little, Inc. 1976.
9,900	16,400	S	1976	*The Study of America Markets: Automobile Markets*, U.S. News and World Report, 1976.

THE CURVE BELOW ILLUSTRATES THE POTENTIAL RATE OF MARKET PENETRATION FOR NEWLY INTRODUCED VEHICLES.

THIS CURVE WAS GENERATED USING THE FOLLOWING ASSUMPTIONS:

- NEW VEHICLES ACCOUNT FOR
  10% OF SALES IN FIRST YEAR INTRODUCED
  20% OF SALES IN SECOND YEAR INTRODUCED
  ETC. UP TO
  100% OF SALES IN TENTH YEAR INTRODUCED
- ONE-YEAR-OLD VEHICLES DRIVE 17.1% OF VMT
  TWO-YEAR-OLD VEHICLES DRIVE 14.3% OF VMT
  THREE-YEAR-OLD VEHICLES DRIVE 12.6% OF VMT
  FOUR-YEAR-OLD VEHICLES DRIVE 11.1% OF VMT
  FIVE-YEAR-OLD VEHICLES DRIVE 10.0% OF VMT
  SIX-YEAR-OLD VEHICLES DRIVE 8.8% OF VMT
  SEVEN-YEAR-OLD VEHICLES DRIVE 7.4% OF VMT
  EIGHT-YEAR-OLD VEHICLES DRIVE 5.8% OF VMT
  NINE-YEAR-OLD VEHICLES DRIVE 4.4% OF VMT
  TEN-YEAR-OLD VEHICLES DRIVE 3.0% OF VMT
  ELEVEN-YEAR-OLD+ VEHICLES DRIVE 5.5% OF VMT

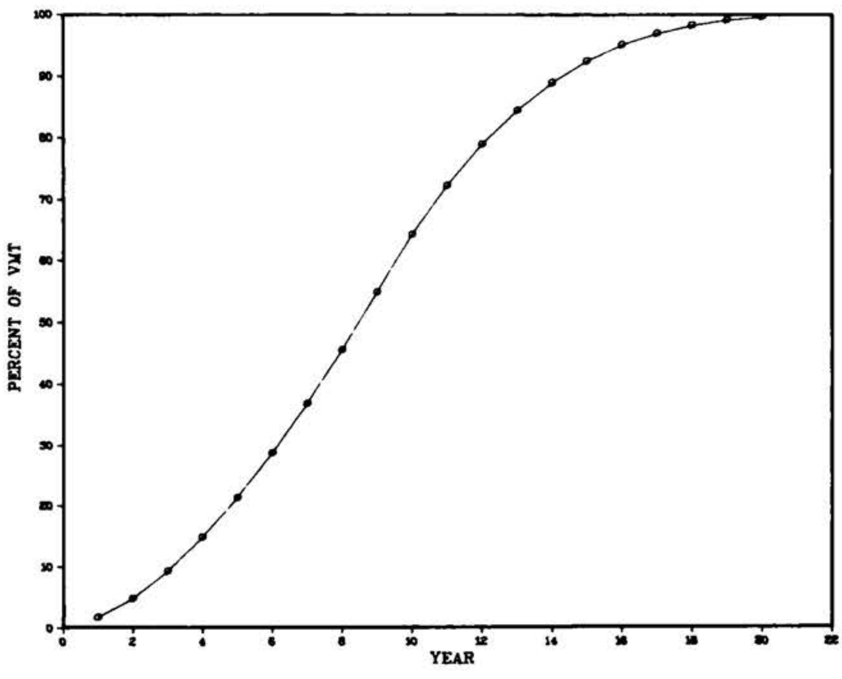


Fig. 1.28 Percent of Vehicle-Miles Traveled by Newly Introduced Vehicles.

THE FIGURES FOR AVERAGE AND MEDIAN ANNUAL-MILES DRIVEN BY ALL CARS INCLUDES MILEAGE FOR AUTOS THAT HAVE NOT BEEN DRIVEN A FULL YEAR. THESE FIGURES REPRESENT THE MILEAGE FOR THE LAST 12 MONTHS AND THEREFORE ARE NOT AN ACCURATE ESTIMATE OF ANNUAL-MILES.

Table 1.60
Distribution of Annual-Miles Driven per Automobile, 1976

Mileage per automobile	All cars	One-car households	Two-car households		Three-car households		
			1st car	2nd car	1st car	2nd car	3rd car
50,000 or more	0.6	0.7	0.4	0.5	1.7	1.1	0.2
25,000 - 49,999	3.5	4.1	4.8	2.0	4.0	3.4	2.2
20,000 - 24,999	5.0	5.5	6.0	3.1	7.2	5.3	3.8
15,000 - 19,999	10.1	10.0	13.2	7.0	13.2	9.7	7.1
12,500 - 14,999	3.4	3.2	3.9	3.2	3.9	2.6	2.8
10,000 - 12,499	26.0	24.7	30.0	22.0	31.7	28.2	20.9
7,500 - 9,999	11.8	13.3	11.5	11.7	10.3	11.5	10.4
5,000 - 7,499	17.4	16.2	14.6	20.6	16.4	21.3	17.9
3,000 - 4,999	9.5	9.5	6.6	13.4	5.8	8.2	12.6
Less than 3,000	12.5	12.8	9.0	16.5	5.8	8.7	22.1
Total cars	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Average annual-miles per car	9,900	10,100	10,900	8,300	12,000	10,400	7,900
Median annual-miles per car	9,700	9,700	10,700	7,400	10,900	10,000	7,100

Note: The sample for this mail study was selected on a national cross-sectional basis from lists maintained by The Reuben H. Donnelley Corporation, with heavy oversampling in the higher income households which control most of the buying activity in selective consumer markets. The findings are based on returns from 11,707 household heads and are projectable to the approximately 65 million households on the Donnelley lists.

Source: *The Study of American Markets: Automotive Market,* U.S. News and World Report, 1977, p. 68.

As in Table 1.60, the figures for the average and median annual-miles driven by car-owning households includes mileage for autos that have not been driven a full year. These figures represent the mileage for the last 12 months and therefore are not an accurate estimate of annual-miles.

Table 1.61 Annual-Miles Driven by Car-owning Households (HH), 1976
(miles per household)

	Median	Average
All car-owning HH	14,300	16,400
One car	9,700	10,100
Two cars	17,800	18,500
Two or more cars	19,300	21,000
Three or more cars	26,000	28,400
New car in 1976	15,900	18,200
New domestic car in 1976	16,000	18,400
New imported car in 1976	15,800	16,900

Note: The sample for this mail study was selected on a national cross-sectional basis from lists maintained by The Reuben H. Donnelley Corporation, with heavy oversampling in the higher income households which control most of the buying activity in selective consumer markets. The findings are based on returns from 11,707 household heads and are projectable to the approximately 65 million households on the Donnelley lists.

Source: *The Study of American Markets: Automotive Market*, U.S. News and World Report, 1977, p. 67.

Table 1.62 Yearly Travel of Passenger Automobiles as a function of Passenger Car Age

Passenger car age	Yearly travel (thousand miles)		Survival probability (percent)	Weighted yearly travel (thousand miles)	% of total weighted yearly travel	
	Simple	Cumulative			Simple	Cumulative
1	18.0	18.0	99.8	18.0	17.1	17.1
2	15.1	33.1	99.3	15.0	14.3	31.4
3	13.4	46.5	98.2	13.2	12.6	44.0
4	12.2	58.7	96.2	11.7	11.1	55.1
5	11.3	70.0	92.9	10.5	10.0	65.1
6	10.5	80.5	87.3	9.2	8.8	73.9
7	9.9	90.4	78.4	7.8	7.4	81.3
8	9.3	99.7	66.1	6.1	5.8	87.1
9	8.8	108.5	51.9	4.6	4.4	91.5
10	8.4	116.9	38.4	3.2	3.0	94.5
11	8.0	124.9	27.3	2.2	2.1	96.6
12	7.6	132.5	19.1	1.5	1.4	98.0
13	7.3	139.8	13.4	1.0	1.0	99.0
14	7.0	146.8	9.5	0.7	0.7	99.7
15	6.7	153.5	6.7	0.4	0.3	100.0
16			0.0	0.0		

Source: U.S. Department of Transportation, National Traffic Safety Administration, *Data and Analysis for 1981–1984 Passenger Automobile Fuel Economy Standards*, Summary Report, Washington, D.C., February 28, 1977, p. A-21.

Table 1.63
Average Annual-Miles for Trucks and Autos, 1972
(10^3 VMT)

Age	Total trucks	Heavy-heavy trucks	Light trucks	Autos
0–2	18.8	52.4	15.3	16.6
2–4	16.9	47.9	13.6	12.8
4–6	13.5	36.0	11.1	10.9
6–8	11.1	28.4	9.5	9.6
8–10	10.0	21.4	9.1	8.6
10–12	8.4	17.9	8.1	7.8
12+	5.6	11.2	5.5	7.2

Source: *1972 Truck Inventory and Use Survey Magnetic Tape, and Nationwide Personal Transportation Survey*, processed by ORNL.

Table 1.64
Percentage of Lifetime VMT Driven at Different Ages, Trucks and Autos, 1972

Age	Total trucks	Heavy-heavy trucks	Light trucks	Autos
0–2	22.3	24.3	21.2	22.6
2–4	20.0	22.3	18.8	17.4
4–6	16.0	16.7	15.4	14.8
6–8	13.2	13.2	13.2	13.1
8–10	11.9	9.9	12.6	11.7
10–12	10.0	8.3	11.2	10.6
12+	6.6	5.2	7.6	9.8

Source: *1972 Truck Inventory and Use Survey Magnetic Tape, and Nationwide Personal Transportation Survey*, processed by ORNL.

THE GRAPH BELOW SHOWS THE DIFFERENCES IN VEHICLE USAGE BY AGE AND SIZE CLASS. HEAVY-HEAVY TRUCKS (>26,000 LB, GVW) ARE USED EXTENSIVELY DURING THE FIRST FEW YEARS BUT THEIR ANNUAL VMTS DECLINE RAPIDLY WITH AGE OF THE TRUCK. AVERAGE ANNUAL VMTS VARY WITH AGE FOR AUTOMOBILES AND LIGHT TRUCKS (<10,000 LB, GVW) BUT NOT AS DRAMATICALLY AS THEY DO FOR THE HEAVY-HEAVY TRUCKS.

THE USE PATTERN IS VERY SIMILAR FOR AUTOS AND LIGHT TRUCKS WHICH REFLECTS THE FACT THAT A LARGE PORTION OF LIGHT TRUCKS IS USED FOR PERSONAL TRANSPORTATION.

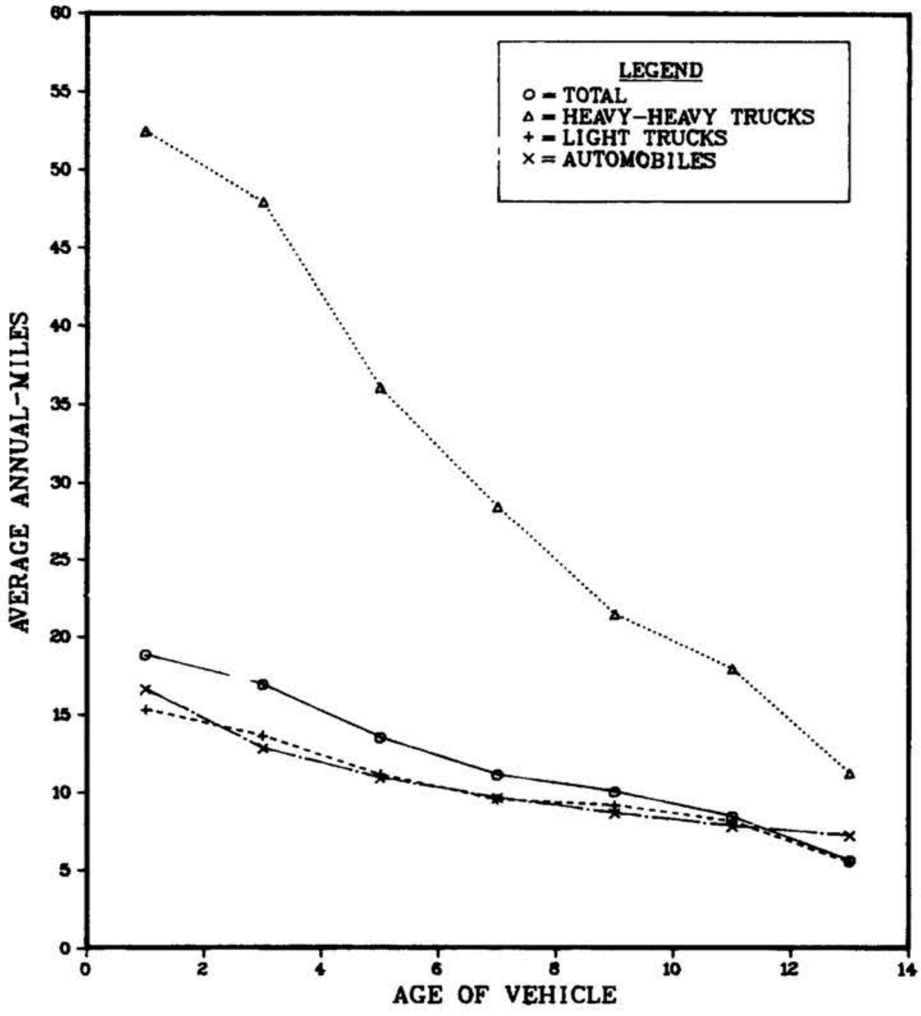


Fig. 1.29
Vehicle Useage by Age and Size Classes.

Source: U.S. Department of Commerce, Bureau of the Census, *Census of Transportation: 1972 Truck Inventory and Use Survey*, Washington, D.C.

THE MAJORITY OF ALL TRUCK TRAVEL IS ACCOMPLISHED BY SMALL PICK-UP AND PANEL TRUCKS – OF THE TYPES ASSOCIATED WITH RECREATIONAL VEHICLES. THESE BASICALLY NONFREIGHT-CARRYING TRUCKS ACCOUNTED FOR 55.2% OF ALL TRUCK-MILES OPERATED IN 1976. THE SECOND MOST INTENSIVE TRUCK USER OF THE HIGHWAYS WAS FOUND TO BE TRACTOR SEMITRAILER COMBINATIONS WITH FIVE OR MORE AXLES – AT 18.0% OF THE TOTAL – FOLLOWED BY 2-AXLE, DUAL-TIRE TRUCKS WITH 13.0%. OVERALL, SINGLE-UNIT TRUCKS REPRESENTED 74.8% OF ALL TRUCK-MILES, WHILE COMBINATIONS ACCOUNTED FOR 25.2%.

Table 1.65
Travel by Truck Type, 1976

	Percent of 1976 miles
Straight trucks	
Pick-up & panel	55.2
Other 4-tire	3.6
2-axle, dual tire	13.0
3-or-more-axle	3.0
Total straight trucks	74.8
Combinations	
Tractor semitrailers	
3-axle	2.3
4-axle	4.0
5-or-more axle	18.0
Other combinations	0.9
Total combinations	25.2
All trucks	100.0

Source: "A Profile of 1976 Truck Traffic," *Research Review*, American Trucking Association, Inc., Number 200, July 14, 1978, p. 3. (Computed by ATA from unpublished preliminary tables provided by Federal Highway Administration.)

ANNUAL-MILES DRIVEN INCREASES WITH TRUCK SIZE. LESS THAN 12% OF LIGHT TRUCKS TRAVELLED MORE THAN 20,000 MILES PER YEAR, WHILE OVER 50% OF TRUCKS HEAVIER THAN 26,000 LB DID. HEAVY-HEAVY TRUCKS TRAVELLING GREATER THAN 20,000 MILES ANNUALLY ACCOUNTED FOR 88% OF ALL HEAVY-HEAVY TRUCK-MILES.

Table 1.66 Percentage Breakdown of Truck Size Classes[a] by Annual-Miles, 1972

	Number of trucks					Truck-miles				
	Light	Medium	Light-heavy	Heavy-heavy	Total	Light	Medium	Light-heavy	Heavy-heavy	Total
Less than 5,000 miles	22.0	33.2	35.8	12.7	23.5	4.8	7.1	7.7	0.9	4.4
5,000 to 9,999 miles	30.2	25.6	25.2	13.8	28.1	19.3	16.5	15.8	2.7	15.3
10,000 to 19,999 miles	36.2	27.8	24.0	22.4	33.5	42.7	34.2	29.5	8.6	34.0
20,000 to 29,999 miles	8.1	8.1	8.3	11.5	8.4	16.9	17.5	17.9	7.7	15.1
30,000 to 49,999 miles	2.9	4.1	4.9	13.4	4.0	9.3	14.0	16.3	14.4	11.2
50,000 to 74,999 miles	0.5	0.9	1.5	11.5	1.4	2.2	4.6	7.8	19.6	6.4
75,000 miles or more	0.4	0.6	0.6	15.1	1.6	5.0	6.4	5.4	46.3	14.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
% of grand total	74.0	14.3	4.2	7.6	100.0	63.2	12.0	3.6	21.3	100.0

[a]Light – gross vehicle weight of 10,000 lb or less.
Medium – gross vehicle weight of 10,001 to 20,000 lb.
Light-heavy – gross vehicle weight of 20,001 to 26,000 lb.
Heavy-heavy – gross vehicle weight of 26,001 lb or more.

Source: U.S. Department of Commerce, Bureau of the Census, *Census of Transportation: 1972 Truck Inventory and Use Survey*, TC72-T52, Washington, D.C., 1973, p. 7-8 and 7-18.

Fleet vehicles are operated differently than cars for personal use. Table 1.67 gives average annual mileage for the U.S. automobile population and estimates for two fleet subsamples. A direct comparison between these sets of numbers indicates that fleet automobiles register two to three times the annual mileage of cars in general. However, such a comparison is somewhat misleading for two reasons. First, according to several surveys, the Federal Highway Administration underestimates average annual mileage by 2000 to 3000 miles per year. Second, there is considerable controversy over how much of the mileage reported for fleet vehicles by businesses is actually for business purposes. However, even when these two qualifiers are added, fleet cars are driven more than the average car.

Table 1.67
Average Annual Mileage for Fleets, 1966–1977

	Total all U.S. cars[a]	AALA fleet cars[b]	*Automotive Fleet* cars[c]
1966	9,506	21,932	22,761
1967	9,531	21,430	
1968	9,627	23,800	21,698
1969	9,782	24,200	
1970	9,978	24,600	22,170
1971	10,121	24,787	
1972	10,184	24,322	22,244
1973	9,992	24,350	
1974	9,448	26,384	20,904
1975	9,634	31,185	
1976	9,733	26,000	21,563
1977		28,568	

[a]U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Table VM-1 annual. These averages tend to underestimate average mileages. See Table 1.59 for comparison of estimates.

[b]Information supplied by American Automotive Leasing Association (AALA) which collects data annual in their AALA Fleet Cost Survey. Summary data appear in each April issue of Bobit's *Automotive Fleet*.

[c]Data estimated by *Automotive Fleet* Research Department.

Source: D. B. Shonka, *Characteristics of Automobile Fleet Operations in the U.S.: 1966–1977*, ORNL/TM-6449, Oak Ridge National Laboratory, Oak Ridge, TN, 1978.

Table 1.68 Average Annual-Miles per Vehicle by Federal Government Vehicles, 1970 through 1976

	1970	1971	1972	1973	1974	1975	1976		
							Total	Sedans	Trucks
Agencies	9,996	9,944	9,220	8,740	8,160	8,139	10,813	13,112	8,941
Department of Agriculture						8,603	9,256	12,015	8,763
Department of Defense – Army	8,967	8,820	8,950	8,202	7,785	7,833	8,056	9,985	7,602
Department of the Interior						7,841	7,614	17,643	5,838
Department of Justice	12,836	12,851	13,172	12,934		15,405	13,917	13,957	13,094
Department of Energy	8,873	7,731	7,998	8,275	7,457	7,987	8,721	10,633	7,793
General Services Administration	11,742	11,701	11,544	11,970	11,178	11,422	11,665	13,007	9,813
United States Postal Service	9,749	9,218	6,725	5,988	5,784	5,373	5,701	23,881	5,502
Domestic	9,942	9,807	9,096	8,625	8,046	7,985	8,490	12,748	7,295
Foreign	10,451	10,711	10,528	9,959	9,278				

Source: General Services Administration, *Federal Motor Vehicle Fleet Report*, Washington, D.C., annual, Tables 46, 10, and 11.

Table 1.69
Taxicab Passenger Operations Ratios, by Fleet Size, 1973 and 1975

Number of taxicabs in the fleet	Percent of taxicabs	Annual passengers per taxicab (10^3)		Vehicle-miles per passenger		Passenger per vehicle-mile		Passenger per trip		Vehicle-mile per trip		Percent paid-miles of vehicle-miles
		1973	1975	1973	1975	1973	1975	1973	1975	1973	1975	1975
Less than 10	2.2	14.1	15.4	2.67	2.74	0.37	0.36	1.62	1.31	4.33	3.59	59.0
10–24	10.6	15.7	15.4	3.49	2.89	0.29	0.35	1.58	1.56	5.52	4.51	56.0
25–49	9.1	11.4	12.9	3.85	3.22	0.26	0.31	1.60	1.61	6.16	5.26	49.0
50–74	10.0	11.1	12.6	6.28	3.51	0.16	0.28	1.21	1.47	7.58	5.15	56.0
75–99	7.7	12.4	19.5	5.33	2.73	0.19	0.37	1.58	1.81	8.41	4.95	59.0
100–200	8.7	10.2	8.5	3.78	4.75	0.26	0.21	1.71	1.29	6.45	6.12	46.0
200 and over	51.7	11.0	9.2	3.75	4.02	0.27	0.25	1.58	1.43	5.91	5.76	53.0
Mean, all operators		11.9	10.9	3.65	3.53	0.27	0.28	1.60	1.46	6.05	5.36	52.0
% change 1973–1975		-8.4		-3.3		3.6		-8.8		-11.4		

Source: Control Data Corp., Well Research Company, U.S. Dept. of Transportation, Office of Transportation Systems Analysis and Information, *Taxicab Operating Characteristics*, Government Printing Office, Washington, D.C., March 1977, p. 3-3.

THE NUMBER OF MILES TRAVELED BY THE AVERAGE RECREATIONAL VEHICLE IN 1974 VARIED FROM A HIGH OF 11,500 MILES FOR A VAN CONVERSION (THIS VALUE IS VERY CLOSE TO THE MILES DRIVEN BY THE AVERAGE AUTOMOBILE) TO A LOW OF ONLY 2,150 MILES FOR A CAMPING TRAILER.

Table 1.70
Average Annual Miles Traveled for Selected Recreational Vehicle Types, 1974

Van conversion	11,500
Mini-Motorhome	7,600
Motorhome	6,900
Truck Camper	4,650
5th Wheel	3,150
Travel Trailer	2,400
Camping Trailer	2,150

Source: Power-Robertson & Company, *Analysis of the U.S. Market for Recreational Vehicles*, Los Angeles, Calif., Table VIII.

A LARGE PORTION OF RECREATIONAL VEHICLE (RV) USE IS CONFINED TO SHORT TRIPS. IN 1976, 35% OF THE TOTAL VACATION TRAVEL WAS UNDER 1,000 MILES PER RV. NEARLY ONE-FIFTH (17.3%) OF THE RVS WERE USED LESS THAN 100 MILES THAT YEAR; 35.3%, MORE THAN 3,000 MILES; 17.7%, MORE THAN 5,500 MILES.

Table 1.71
Percent Distribution by Trip Length of Vacation-Miles Traveled in Recreational Vehicles
1974 through 1976

Miles traveled	1974	1975	1976
1 to 100	15.98	12.21	17.34
101 to 200	1.59	3.18	1.76
201 to 300	3.01	2.65	1.41
301 to 400	1.77	1.95	0.88
401 to 500	3.37	3.36	4.07
501 to 600	2.84	2.65	0.70
601 to 700	0.71	0.88	0.35
701 to 800	2.30	1.76	1.41
801 to 900	1.59	1.59	0.17
901 to 1,000	4.26	5.48	6.90
1,001 to 1,500	7.63	7.96	6.37
1,501 to 2,000	8.34	9.02	10.61
2,001 to 2,500	4.26	5.66	3.89
2,501 to 3,000	8.17	5.66	8.67
3,001 to 3,500	3.90	3.71	1.76
3,501 to 4,000	6.03	7.43	7.78
4,001 to 4,500	2.13	2.65	1.59
4,501 to 5,000	5.50	3.89	5.48
5,001 to 5,500	1.24	1.76	1.06
More than 5,500	15.27	16.46	17.69
			100.00

Source: William D. Glauz et al., *Recreational Travel Impacts: Review of Recreational Travel and Recreational Vehicle Data*, Report No. FHWA-PL-77-018, April 1977.

THE MOTORCYCLE INDUSTRY COUNCIL PRESENTS TWO CONCEPTS OF AVERAGE ANNUAL MILEAGE. THE FIRST CONCEPT IS DEFINED AS THE "ACCUMULATED MILES PER YEAR" BECAUSE IT IS THE ANNUAL AVERAGE OF ALL MILEAGE ACCUMULATED ON THE VEHICLE. THE "MOMENTARY MILES PER YEAR" IS DEPENDENT ON THE MILEAGE ACCUMULATED IN A PARTICULAR YEAR ACCORDING TO THE VEHICLE AGE AND THE CONCEPT THAT ANNUAL MILEAGE DECREASES AS THE MOTORCYCLE AGES.

GENERALLY, THE VALUE OF MOMENTARY MILES PER YEAR IS ABOUT 30-40% LESS THAN THAT OF ACCUMULATED MILES PER YEAR. THIS DIFFERENCE EXISTS BECAUSE THE MAJORITY OF MILEAGE ACCUMULATED ON A MOTORCYCLE OVER THE VEHICLE LIFE IS ACCUMULATED DURING THE FIRST AND SECOND YEARS OF USE, AND THE MAJORITY OF MOTORCYCLES IN USE IN A GIVEN YEAR ARE OLDER THAN TWO OR THREE YEARS OLD. THUS, THE MAJORITY OF MOTORCYCLES IN USE IN A GIVEN YEAR ARE ACTUALLY TRAVELING LESS THAN THE AVERAGE OF MILES ACCUMULATED OVER THE CURRENT VEHICLE LIFE, AND THEREFORE, MOMENTARY MILES PER YEAR IS LESS THAN ACCUMULATED MILES PER YEAR.*

Table 1.72

1977 Average Annual Mileage for Motorcycles

Average annual mileage	Total motorcycles	On-road motorcycles	Off-road motorcycles	Combination motorcycles
1977 momentary miles per year	1,607	2,294	1,161	989
1977 accumulated miles per year	2,332	3,176[a]	1,685	1,641

[a]The Federal Highway Administration estimates average annual miles per motorcycle to be 4,500.

Source: *1978 Motorcycle Statistical Annual*, Motorcycle Industry Council, Inc., Newport Beach, Calif., pp. 34 and 35.

**1977 Motorcycle Statistical Annual*, Motorcycle Industry Council, Inc., Newport Beach, Calif., pp. 34 and 35.

THE GRAPHS GENERATED FROM THE 1972 NATIONAL TRAVEL SURVEY DATA INDICATE THE NATURE OF THE SUBSTITUTION BETWEEN AIR AND HIGHWAY TRAVEL. THEY SHOW THAT AIR TRAVEL VARIES DIRECTLY WITH LENGTH OF TRIP AND HOUSEHOLD INCOME. THAT IS, AS THE TRIP LENGTH OR THE HOUSEHOLD INCOME INCREASES, HOUSEHOLDS BEGIN TO SUBSTITUTE THE AIR MODE FOR THE MOTOR VEHICLE.

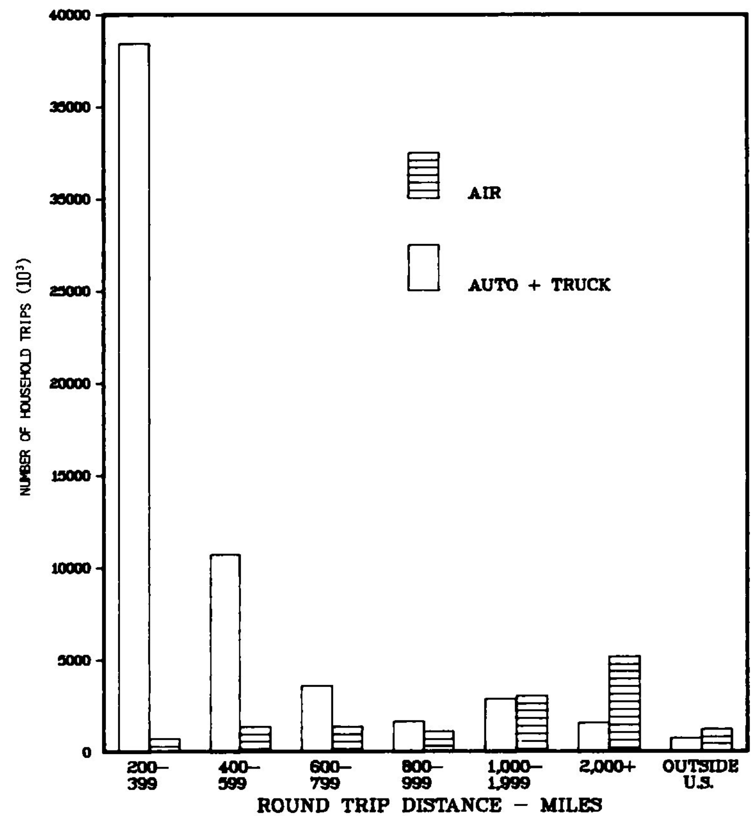


Fig. 1.30

1972 NTS Household Trips by Trip Length.

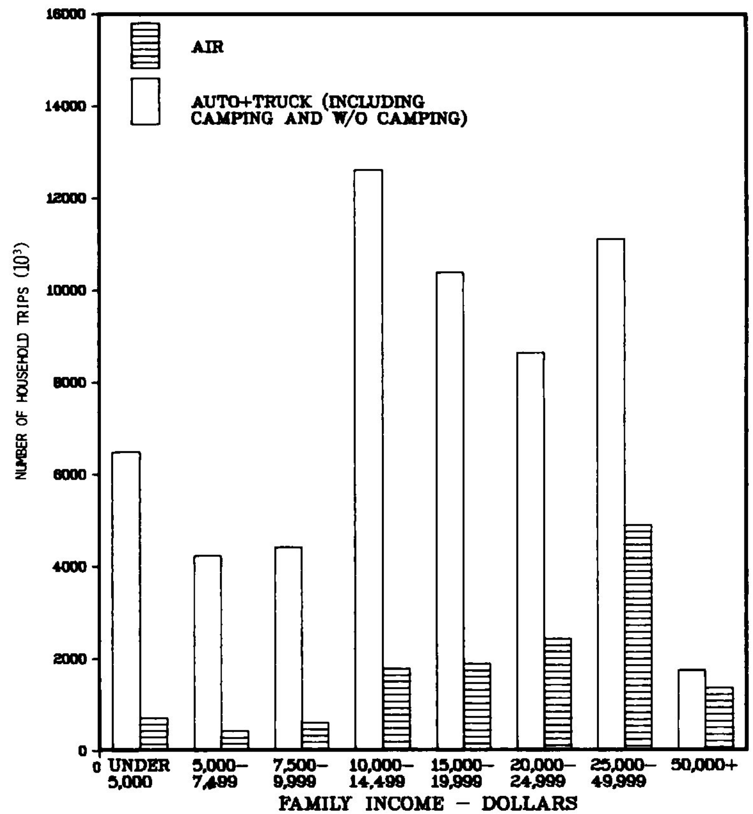


Fig. 1.31

1972 NTS Household Trips by Income Class.

Source: U.S. Department of Commerce, Bureau of the Census, *1972 Census of Transportation, Vol. 1, National Travel Survey*, Washington, D.C., February 1974, p. 6, Table 2.

THE ANNUAL HOUSING SURVEY, CONDUCTED EACH YEAR SINCE 1972 BY THE BUREAU OF THE CENSUS, ASKS GENERAL QUESTIONS ON MEANS OF TRANSPORTATION TO WORK. TABLE 1.73 AND TABLE 1.74 GIVE U.S. TOTALS DERIVED FROM THE 1976 SURVEY. FROM THIS DATA WE SEE THAT MASS TRANSIT IS USED MOST OFTEN IN CENTRAL CITIES (13% OF WORKERS) WHEREAS CARPOOLING IS MOST FREQUENTLY A MEANS OF TRANSPORTATION TO WORK IN AREAS OUTSIDE OF SMSAs (20% OF WORKERS). IN CENTRAL CITIES THE "WALKS ONLY" CATEGORY INCLUDED PEOPLE WHO LIVE WITHIN WALKING DISTANCE OF THEIR PLACE OF EMPLOYMENT; OUTSIDE SMSAs IT INCLUDES PRIMARILY FARMERS OR SUCH SELF-EMPLOYED PERSONS.

Table 1.73
Principal Means of Transportation to Work, by Places of Residence, 1976[a]

	Total	Inside SMSAs			Outside SMSAs
		Total	In central cities	Not in central cities	
Total car	88.9	87.3	79.6	92.9	92.7
Drives self	72.9	73.0	66.9	77.3	72.8
Carpools	16.0	14.3	12.7	15.6	19.9
Mass transportation[b]	5.6	7.8	13.4	3.7	0.5
Bicycle or motorcycle	0.8	0.8	1.0	0.7	0.7
Taxicab	0.2	0.2	0.4		0.2
Walks only	4.0	3.5	5.1	2.3	5.1
Other means	0.6	0.5	0.6	0.4	0.8

[a]The statistics are restricted to household heads who had a job the week prior to enumeration.

[b]Includes railroad, subway, elevated transportation system, bus, and streetcar.

Source: U.S. Department of Commerce, Bureau of the Census, and U.S. Department of Housing and Urban Development, *Annual Housing Survey: 1976*, United States and Regions, Part A: General Housing Characteristics, Washington, D.C., 1978, p. 6.

Table 1.74
Characteristics of Home-to-Work Trips Taken by Household Heads[a], 1976
(percentage of occupied housing units)

	Total	Inside SMSAs			Outside SMSAs
		Total	In central cities	Not in central cities	
Total occupied housing units[b], 10^3	50,347	35,022	14,632	20,391	15,325
Distance from home to work					
Owner and renter occupied	100.0	100.0	100.0	100.0	100.0
Less than 1 mile	8.2	6.1	7.5	5.1	13.1
1 to 4 miles	26.4	25.7	32.9	20.5	27.9
5 to 9 miles	17.4	19.6	21.8	18.0	12.3
10 to 29 miles	27.1	30.4	23.4	35.4	19.7
30 to 49 miles	4.2	3.6	1.7	5.0	5.4
50 miles or more	1.3	0.9	0.6	1.1	2.4
Other[c]	15.4	13.7	12.1	14.9	19.2
Travel time from home to work					
Owner and renter occupied	100.0	100.0	100.0	100.0	100.0
Less than 15 min	31.3	27.2	29.4	25.6	40.6
15 to 29 min	30.7	34.2	36.4	32.7	22.6
30 to 44 min	13.7	15.5	13.8	16.7	9.7
45 to 50 min	4.8	5.2	4.7	5.7	3.8
1 hour to 1 hour and 29 min	3.4	3.6	3.5	3.7	3.0
1 hour and 30 min or more	1.0	1.0	1.0	0.9	1.2
Other[c]	15.1	13.3	11.2	14.7	19.1

[a]Limited to heads who reported having a job the week prior to enumeration.

[b]Limited to units with working household heads.

[c]Includes work at home, no fixed place of work, or not reported categories.

Source: U.S. Department of Commerce and U.S. Department of Housing and Urban Development, *Annual Housing Survey: 1976*, U.S. and Regions, Part A — General Housing Characteristics, Washington, D.C., February 1978, pp. 6 and 7.

Beginning in 1975, a group of questions on travel to work were added as a supplement to the Census Bureau's Annual Housing Survey (AHS). The Travel to Work Supplement is included for the metropolitan area sample which comprises about 60 metropolitan areas to be surveyed over a three-year period. The data presented below represent results obtained from the first cycle, which surveyed 21 of the 60 metropolitan areas.

Eighty-six percent of job commuters in the 21 metropolitan areas use private cars or trucks, 12% use public transportation, and 2% use motorcycles, bicycles, or other means. More job commuters in these areas (18%) are carpooling by private vehicle today than are riding in all forms of public transportation combined (12%). However, 68% of all of these work commuters drive alone by private vehicle.

Table 1.75
Major Mode of Transportation to Work for 21 Standard Metropolitan Statistical Areas[a] (SMSAs), 1975

Mode	All workers		Median distance from home to work (miles)
	Number	Percent	
All workers	12,931		
Not working at home	12,255		7.5
Workers using vehicles	11,650	100	8.0
Auto or truck[b]	10,040	86	8.0
Auto	9,153	79	7.9
Truck	887	8	8.7
Drives alone	7,877	68	7.7
Carpool	2,100	18	9.1
Sharing driving	731	6	12.5
Driving others	541	5	9.1
Riding with someone	829	7	6.6
Public transportation[c]	1,432	12	8.9
Bus or streetcar	1,018	9	7.0
Subway or elevated	177	2	10.1
Railroad	224	2	24.4
% change in use, 1970-1975		22	
Other means[d]	179	2	3.1
Bicycle	86	1	
Walking only	605	5[e]	0.6
Working at home	219	2[e]	
Mode not reported	457	4[e]	6.7

[a]This table is based on preliminary data from the first four months (April-July) of the DOT Travel to Work Supplement to the Annual Housing Survey (AHS) Year II SMSA sample. The user is cautioned that the figures here are for only one-third of the final sample, may contain seasonal biases, and have had only simplified weighting procedures applied. The following SMSAs were surveyed: Atlanta, Ga., Chicago, Ill., Cincinnati, Ohio-Ky.-Ind., Colorado Springs, Colo., Columbus, Ohio, Hartford, Conn., Kansas City, Mo.-Kans., Madison, Wis., Miami, Fla., Milwaukee, Wis., New Orleans, La., Newport News-Hampton, Va., Paterson-Clifton-Passaic, N.J., Philadelphia, Pa.-N.J., Portland, Oreg.-Wash., Rochester, N.Y., San Antonio, Tex., San Bernardino-Riverside-Ontario, Calif., San Diego, Calif., San Francisco-Oakland, Calif., Springfield-Chicopee-Holyoke, Mass.-Conn.

[b]Includes a small number of workers using auto or truck but not specifying type of riding arrangement.

[c]Includes workers using taxicabs.

[d]Includes workers using motorcycles and all other means besides those listed.

[e]Percent of all workers.

Source: U. S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-23, No. 68, "Selected Characteristics of Travel to Work in 21 Metropolitan Areas: 1975," Washington, D.C., February 1978, Tables 1, 2, and 4.

OF ALL MOTORCYCLES USED ON THE STREET, 58% ARE USED AT SOME TIME TO COMMUTE TO WORK OR SCHOOL.

Table 1.76

Types of Motorcycle Street Usage, 1977[a]

	(%)
Total motorcycles registered for street use	100
Motorcycles used for commuting	58
To work, at some time	52
To school, at some time	16

[a] *Survey of Motorcycle Ownership, Usage and Maintenance,* conducted for the Motorcycle Industry Council by the Gallup Organization, Princeton, N.J., January 1975.

Source: *1978 Motorcycle Statistical Annual,* Motorcycle Industry Council, Inc., Newport Beach, Calif., p. 31.

Estimates of cost-per-mile of automobile operation during the first year reported by the Federal Highway Administration (FHWA) and the American Automobile Association (AAA) tend to be lower than estimates based on data obtained from the Hertz Corporation. The following description of dissimilarities in raw data, in assumptions made, and in calculation of the estimates help to explain the discrepancies. (See Table 1.77.)

1. FHWA's estimates are based on independent cost studies done in the Baltimore area. Hertz's figures are based on data obtained from their nationwide operation. AAA figures represent national average cost as computed by Runzheimer and Company.

2. Figures from FHWA and Hertz are calculated for a standard model car operated for personal use. The 1976 AAA figure is calculated for an intermediate model car operated for business use; 1977-1978 figures, for intermediate model cars operated for personal use.

3. Hertz's new-car purchase price is high because the wholesale value of the trade-in is subtracted from the dealer's trade-in allowance.

4. FHWA's per mile depreciation cost, based on 14,500 miles driven the first year, is far below the Hertz figure, which is based on only 10,000 miles for the first year. When Hertz adjusts its own cost data to FHWA mileage, first-year cost is 26.01¢ per mile. When AAA, which also bases its estimate on 10,000 miles per year, adjusts its cost to FHWA mileage, their first-year cost is 15.72¢ per mile.

5. FHWA and AAA cost estimates do not include a finance cost, while the Hertz study suggests adding an interest rate of 7% in addition to finance costs.

6. FHWA and AAA estimates of first-year maintenance and repair costs are considerably lower than comparable Hertz estimates.

Table 1.77 Cost Per Mile for Operating An Automobile
(cents per mile)

	1976	1977	1978
FHWA			
First year	18.73	NA	NA
Average over 10 years and 100,000 miles	17.88	NA	NA
Hertz			
First year	33.68	33.92	NA
Average over 10 years and 100,000 miles	19.32	NA	NA
AAA[b]			
First year	20.21	20.95	19.64[a]

[a]Figure for 2nd quarter of 1978; first quarter figure for 1978 was 19.60.

[b]AAA's figures as computed by Runzheimer and Company are for an intermediate size car; they do not report an average over 10 years and 100,000 miles.

NA — Not available.

Sources: American Automobile Association, "AAA Survey Shows Driving Costs Rising 3.7% in Past 3 Months," *News Release*, Falls Church, Va., August 29, 1977; "AAA Reports Auto Operating Expenses 19.64 Cents a Mile in Second Quarter," *News Release*, Falls Church, Va., August 10, 1978; Donald Moffitt, "How to Figure True Cost of Car Ownership; Why Some Published Figures Differ so Much," *The Wall Street Journal*, November 15, 1976, p. 44; Francis Gawronski, "Cost of Car Tops 30 Cents a Mile," *Automotive News*, December 5, 1977, p. 18.

THE INTERSTATE RURAL HIGHWAY CATEGORY HAS THE HIGHEST AVERAGE SPEED OF THE FIVE HIGHWAY CATEGORIES. THE PERCENTAGES OF VEHICLES EXCEEDING 55, 60, AND 65 MPH ARE ALSO HIGHEST FOR THE INTERSTATE RURAL CATEGORY. THE LOWEST AVERAGE SPEED IS FOUND IN THE MULTILANE UNDIVIDED HIGHWAY CATEGORY AS ARE THE LOWEST PERCENTAGES OF VEHICLES EXCEEDING 55, 60, AND 65 MPH. AVERAGE SPEED RANGES FROM 53.7 MPH TO 58.2 MPH. IT IS NOTEABLE THAT THIS RANGE INCLUDES THE 55-MPH SPEED LIMIT.

Table 1.78
Annual Average Quarterly Speed Monitoring
Data for Fiscal 1976

	Average speed (mph)	Percent in excess of		
		55 mph	60 mph	65 mph
Interstate				
Urban	56.1	57	20	5
Rural	58.2	69	32	10
Multilane				
Divided	55.8	55	21	6
Undivided	53.7	41	13	4
Two-lane rural	54.5	46	18	6

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 1976*, Washington, D.C., p. 32.

THIS FIGURE SHOWS A STEADY INCREASE IN THE AVERAGE SPEED OF FREE-MOVING VEHICLES ON RURAL INTERSTATE HIGHWAYS AND IN THE PERCENTAGE OF FREE-MOVING VEHICLES EXCEEDING 55, 60, AND 65 MPH UNTIL THE MIDDLE OF 1973. THE SUDDEN DECLINE IN 1973 CAN BE ATTRIBUTED TO THE FUEL EMBARGO WHICH BEGAN IN SEPTEMBER OF THAT YEAR AND THE ENSUING IMPOSITION OF A NATIONWIDE 55-MPH SPEED LIMIT. THERE IS A SLOW INCREASE IN THE TREND AFTER 1975.

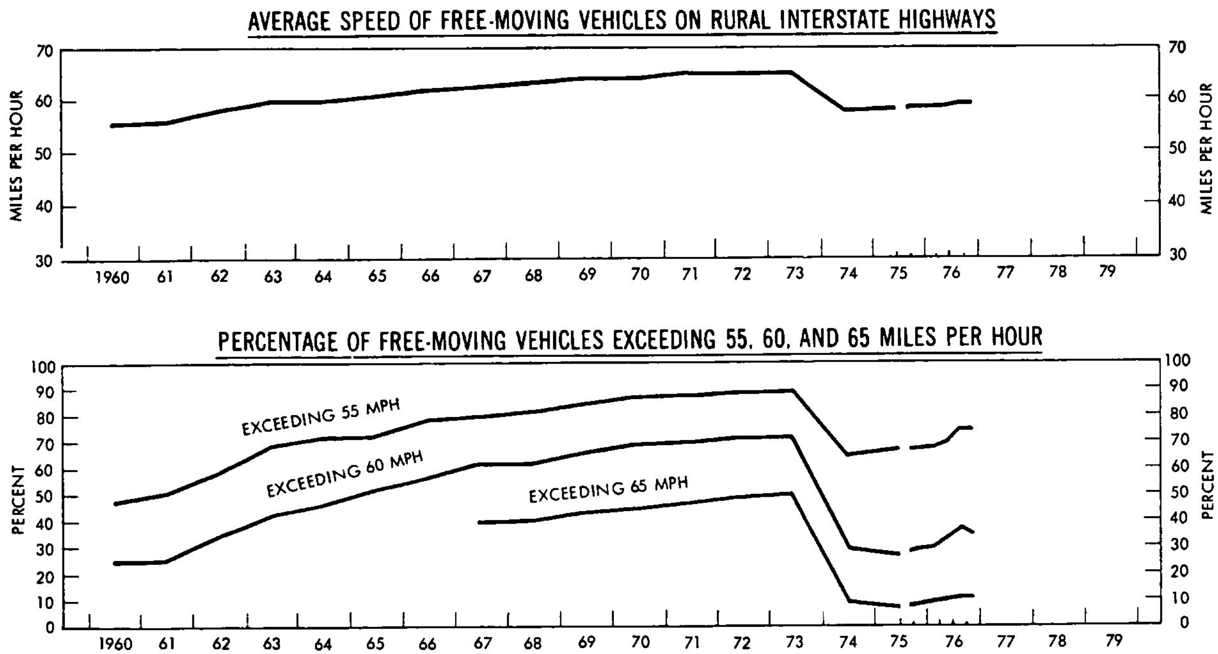


Fig. 1.32 Speed Trends on Rural Interstate Highways[a]

[a]All data represent free-moving traffic on level, straight, noncongested sections of rural interstate highways. Data shown between 1960 and 1975 represent speed trend information collected by several state highway agencies (normally during the summer months) and submitted in annual speed trend reports. Since October 1975 all states have monitored speeds on several highway systems, including the interstate system, as part of the 55 mph speed limit monitoring program. The data are reported to FHWA on a quarterly basis.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics 1976*, Washington, D.C., p. 33.

Section 1.3

Air

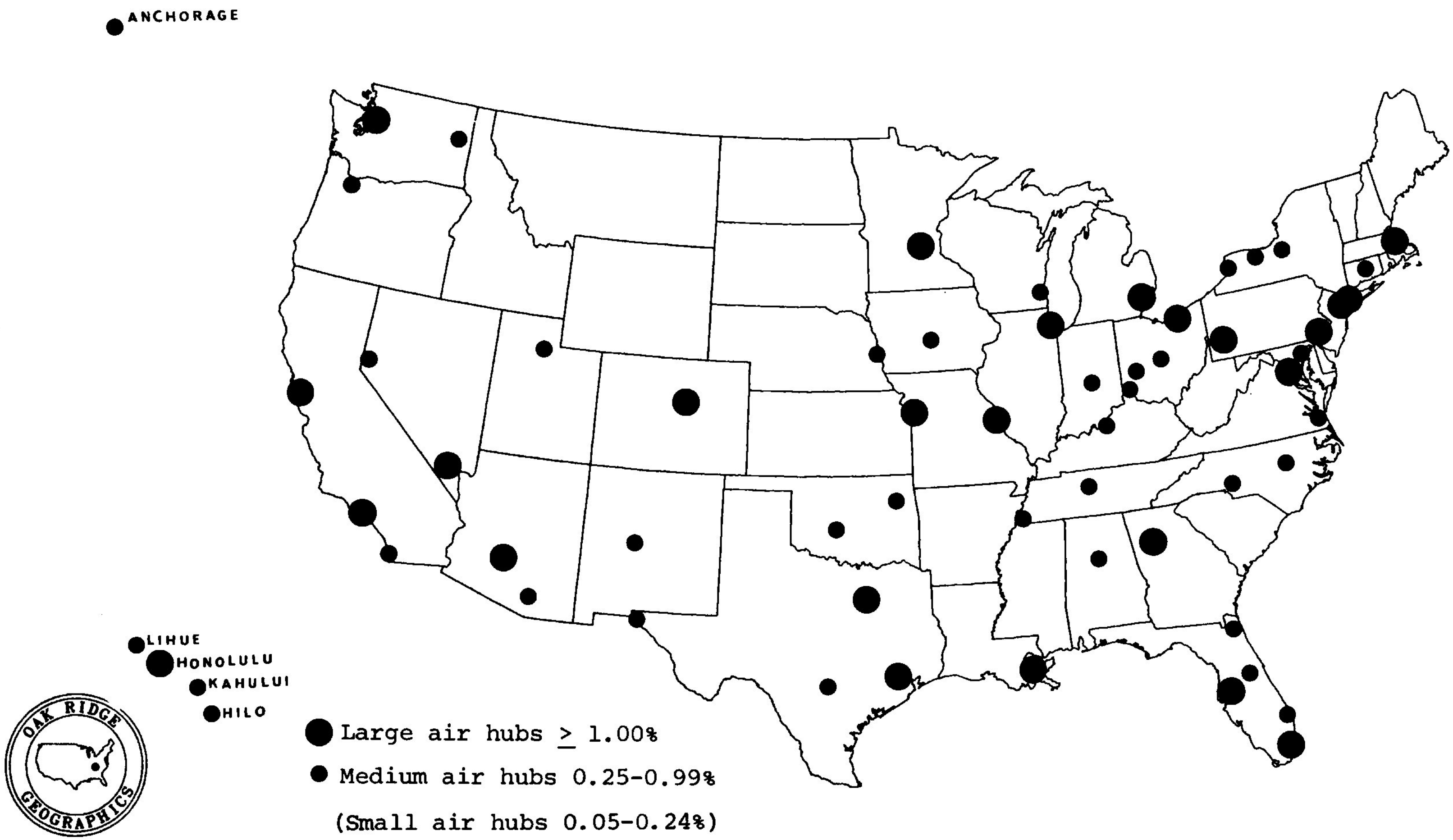


Fig. 1.33 Large and Medium Air Traffic Hubs[a] in the United States, 1976.

[a]Air traffic hubs are defined in terms of the percentage of total U.S. passenger enplanements at the hub.

Source: Civil Aeronautics Board and U.S. Department of Transportation, Federal Aviation Administration, *Airport Activity Statistics of Certificated Route Air Carriers*, Washington, D.C., December 31, 1976.

Table 1.79

Aircraft Departures, Enplanements at Large Air Traffic Hubs, 1976

Large air traffic hubs	Aircraft departures	Enplaned passengers	Percent of U.S. enplanements
Large hubs			
Atlanta, GA	209,839	13,607,032	6.31
Boston, MA	96,033	5,355,214	2.48
Chicago, IL	286,836	18,142,985	8.42
Cleveland, OH	58,462	2,972,586	1.37
Dallas-Ft. Worth, TX	143,862	7,929,000	3.68
Denver, CO	108,778	6,451,520	2.99
Detroit, MI	79,136	4,003,664	1.85
Honolulu, HI	44,607	4,852,861	2.25
Houston, TX	62,447	3,282,614	1.52
Kansas City, MO	55,252	2,331,212	1.08
Las Vegas, NV	51,319	3,260,437	1.51
Los Angeles, CA	150,455	10,391,492	4.81
Miami, FL	118,628	6,876,067	3.19
Minneapolis, MN	65,342	3,604,637	1.67
Newark, NJ	63,639	3,336,376	1.54
New Orleans, LA	45,453	2,307,981	1.10
New York, NY	262,127	14,350,895	6.64
Philadelphia, PA	66,440	3,687,012	1.68
Phoenix, AZ	45,379	2,284,402	1.06
Pittsburgh, PA	88,155	3,922,312	1.82
St. Louis, MO	86,322	3,799,713	1.76
San Francisco, CA	124,910	6,937,356	3.20
Seattle, WA	53,905	3,385,548	1.57
Tampa, FL	53,105	2,522,871	1.17
Washington, D.C.	128,902	6,994,521	3.23
Total 25 large hubs	2,529,333	146,590,308	67.90
Total 39 medium hubs	943,583	39,641,614	18.17
Total 93 small hubs	666,496	21,871,179	9.75
Total U.S.	4,699,090	215,355,045	100.0

Source: Civil Aeronautics Board and the Federal Aviation Administration, *Airport Activity Statistics of Certificated Route Air Carriers*, Washington, D.C. Dec. 31, 1976.

Table 1.80
Air Traffic Activity at FAA Facilities by Aviation Category - Fiscal Years 1972-1976

Workload measure	Year	Total: Total	Total: Annual change	Air carrier: Total	Air carrier: Annual change	Air taxi: Total	Air taxi: Annual change	General Aviation: Total	General Aviation: Annual change	Military: Total	Military: Annual change
Total aircraft operations	1972	53,620,706	-1	9,709,842	-4	1,979,576	NA	38,431,014	-1	3,500,274	*a*
	1973	53,922,674	+1	9,808,402	+1	2,115,273	+7	38,777,459	+1	3,221,540	-8
	1974	56,845,120	+5	9,476,535	-3	2,351,900	+11	42,202,326	+9	2,814,359	-13
	1975	58,934,700	+4	9,374,363	-1	2,708,901	+15	44,159,682	+5	2,691,754	-4
	1976	62,491,505	+6	9,339,479	*a*	2,867,621	+6	47,594,278	+8	2,690,127	*a*
Itinerant operations	1972	33,563,478	*a*	9,709,842	-4	1,979,576	NA	20,379,315	+2	1,494,745	-2
	1973	34,028,828	+	9,808,402	+1	2,115,273	+7	20,633,639	+1	1,471,514	-2
	1974	36,067,118	+6	9,476,535	-3	2,351,900	+11	22,922,885	+11	1,315,798	-11
	1975	37,552,859	+4	9,374,363	-1	2,708,901	+15	24,183,342	+5	1,286,253	-2
	1976	39,660,709	+6	9,339,479	*a*	2,867,621	+6	26,180,772	+8	1,272,837	-1
Local operations	1972	20,619,960	-3					18,632,625	-4	1,987,335	+7
	1973	19,893,846	-1					18,143,820	+1	1,750,026	-13
	1974	20,778,002	+4					19,279,441	+6	1,498,561	-14
	1975	21,381,841	+3					19,976,340	+4	1,405,501	-6
	1976	22,830,796	+7					21,413,506	+7	1,417,290	+1

[a] Less than 0.5 percent.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Current Aviation Statistics Air Traffic Activity Fiscal Year 1976*, Washington, D.C., November 1976, p. 2.

Table 1.81
Number of Aircraft in Operation of Certificated Route Air Carriers by Aircraft Type, 1970-1976

Year	Wide-body jets		Narrow-body jets			Propeller aircraft		Helicopters	Total
	4-engine	3-engine	4-engine	3-engine	2-engine	Turbo prop	Piston		
1970	79	0	812	631	519	316	64	16	2,437
1971	104	13	743	638	530	287	60	14	2,389
1972	106	76	662	662	522	256	63	14	2,361
1973	109	134	603	710	500	238	54	13	2,361
1974	103	169	491	724	501	201	45	10	2,244
1975	97	197	464	765	500	193	45	7	2,268
1976	104	199	429	793	518	180	43	5	2,271
% distribution	4.6	8.8	18.9	34.9	22.8	7.9	1.9	0.2	100.0
% change 1970–1976	31.6		–47.2	25.7	–0.2	–43.0	–32.8	–68.8	–6.8

Source: U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation, Calendar Year 1976*, pp. 50–51.

Table 1.82
Domestic Air Travel Data, 1976[a]

By Round-Trip Distance

Round-trip length (miles)	Person-trips		Persons per trip	Person-miles		Mean round-trip length (miles)
	10^3	%		10^6	%	
200-299	1,833	2.7	1.10	478	0.3	261
300-399	1,719	2.5	1.30	600	0.4	349
400-599	6,879	10.0	1.14	3,444	2.3	501
600-999	14,356	20.9	1.17	11,014	7.4	767
1,000-1,999	15,709	22.9	1.24	22,741	15.2	1,448
Over 2,000	28,083	41.0	1.39	110,928	74.4	3,950
Total	68,579	100.0	1.27	149,205	100.0	2,176

By Trip Purpose

Purpose of trip	Person-trips		Persons per trip	Person-miles		Mean round-trip length (miles)
	10^3	%		10^6	%	
Visit friends and relatives	18,833	27.5	1.52	45,441	30.5	2,413
Other pleasure	13,562	19.8	1.53	42,632	28.6	3,143
Business	29,719	43.3	1.09	51,418	34.4	1,730
Other	6,465	9.4	1.19	9,714	6.5	1,503
Total	68,579	100.0	1.27	149,205	100.0	2,176

[a] A circuity ratio of 1.15 over the great-circle distance is included in all distance-related data.

Source: U.S. Travel Data Center, *1976 National Travel Survey, Full Year Report*, Washington, D.C., 1977.

Table 1.83
Domestic Air Travel Data by Family Income, 1976[a]
(including trips outside the United States)

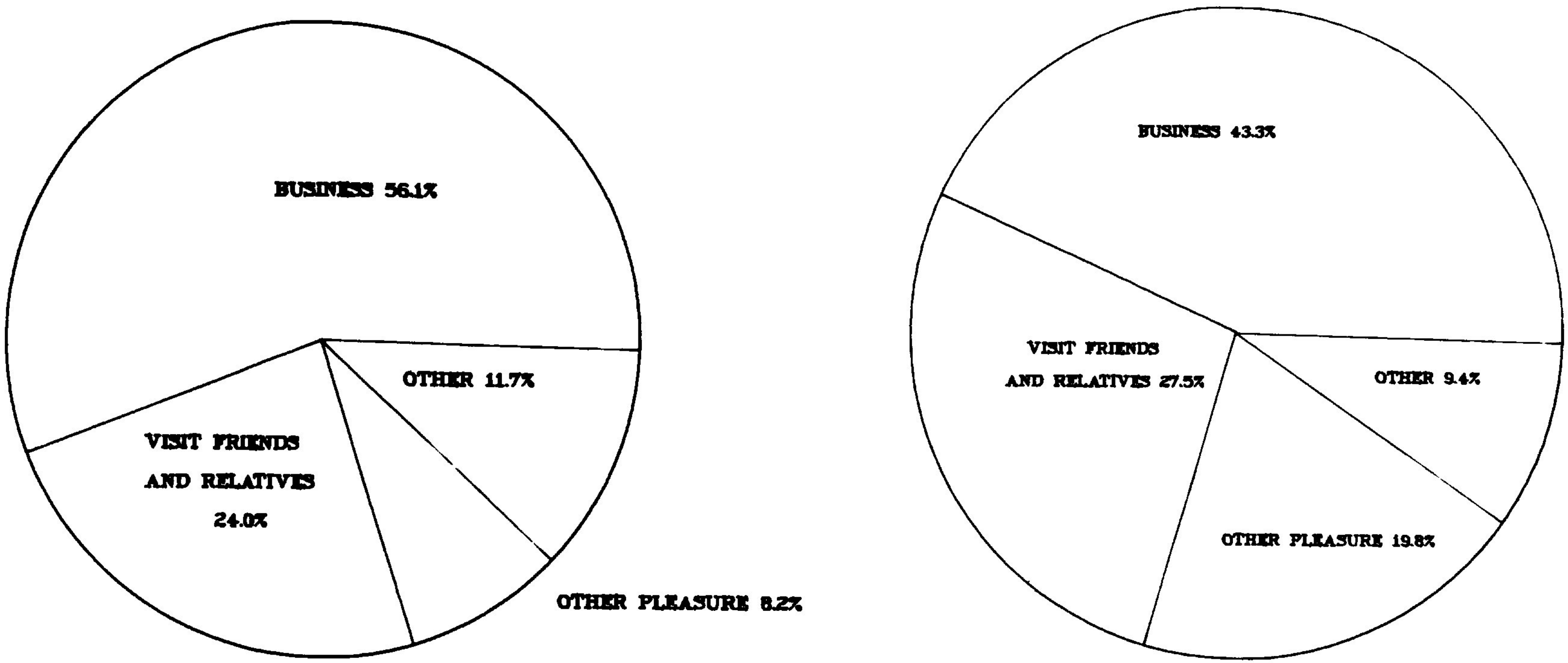
Family income ($)	Person-trips[b] %	Persons per trip	Person-miles[b] 10^6	Person-miles[b] %
Under 5,000	7.1	1.27	12,019	8.1
5,000-9,999	9.1	1.18	14,615	9.8
10,000-14,999	14.8	1.26	21,073	14.1
15,000-24,999	26.7	1.36	41,264	27.6
25,000 and over	28.8	1.30	39,030	26.2
Not answered	13.5	1.34	21,204	14.2
Total	100.0	1.30	149,205	100.0

[a] A circuity ratio of 1.15 over the great-circle distance is included in all distance-related data.

[b] Number of person-trips and mean trip length cannot be calculated due to the inclusion of international data in these categories.

Source: U.S. Travel Data Center, *1976 National Travel Survey, Full Year Report*, Washington, D.C., 1977, p. 42.

MORE PEOPLE ARE TRAVELING BY AIR ON PERSONAL TRIPS THAN EVER BEFORE. SINCE 1972, THE ANNUAL NUMBER OF NONBUSINESS TRIPS BY AIR HAS NEARLY DOUBLED, AND IN 1976 ACCOUNTED FOR 56.7% OF ALL AIR TRIPS.



1972 = 45.58 million person-trips

1976 = 68.58 million person-trips

Fig. 1.34 Comparison of Air Travel Data by Trip Purpose, 1972 and 1976.

Source: U.S. Department of Commerce, Bureau of the Census, *1972 Census of Transportation, Vol. 1, National Travel Survey*, Washington, D.C., February 1974; U.S. Travel Data Center, *1976 National Travel Survey, Full Year Report*, Washington, D.C., 1977.

DEMAND FOR DOMESTIC CERTIFICATED AIR CARRIER PASSENGER SERVICE HAS INCREASED DRAMATICALLY IN RECENT YEARS WHILE THE INTERNATIONAL SECTOR HAS NOT YET RECOVERED TO PRE-EMBARGO VALUES.

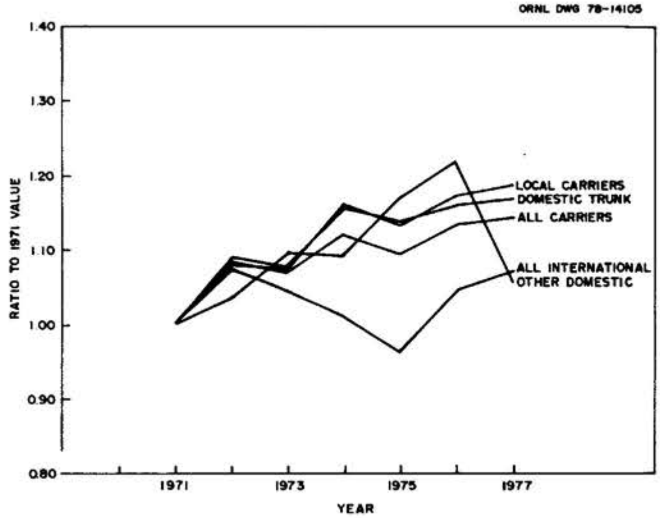


Fig. 1.35
Certificated Route Air Carrier Passenger Load Factors, 1971 through 1977, Normalized to 1971 Values.

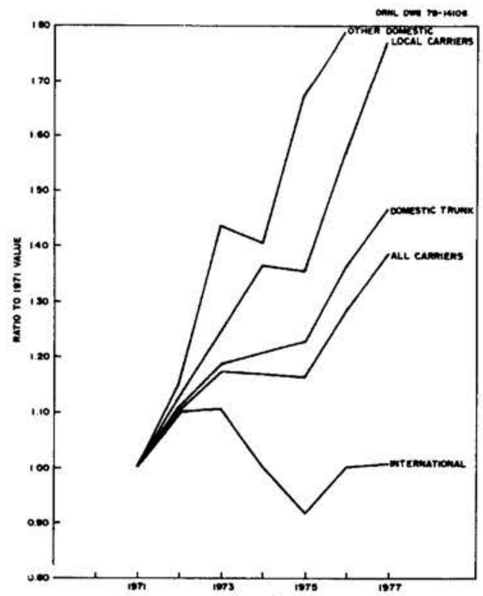


Fig. 1.36
Certificated Route Air Carrier Passenger-Miles, 1971 through 1977, Normalized to 1971 Values.

Source: A. B. Rose, *The Energy Intensity and Related Parameters of Selected Passenger Transportation Modes*, ORNL/TM-6451/V1, Oak Ridge National Laboratory, Oak Ridge, TN, 1978.

Table 1.84 Summary of Certificated Air Carrier Statistics,[a] 1971-1977

	Revenue aircraft-miles (10^6)	Revenue passenger-miles (10^9)	Passenger load factor (%)	Cargo ton-miles (10^6)	
				Passenger flights[b]	Cargo flights
1971	2,489	149.2	50.5	2,301	3,542
1972	2,515	165.3	54.4	2,680	3,828
1973	2,556	174.4	53.6	2,940	3,560
1974	2,351	174.0	56.1	3,054	3,442
1975	2,325	173.3	54.9	3,005	3,181
1976	2,419	191.8	56.7	3,254	3,246
1977	2,525	206.1	57.1	6,976	

[a]In scheduled and nonscheduled service.

[b]Calculated allowing 200 lb per passenger.

Sources: Civil Aeronautics Board, *Air Carrier Traffic Statistics, December 1977*, Washington, D.C., 1978; Civil Aeronautics Board, *Handbook of Airline Statistics. Supplement*, Washington, D.C., 1977; National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41 Schedule T-2*, Washington, D.C., 1970-1977.

Table 1.85
Certificated Air Carrier Passenger Service Operating Statistics by Carrier Type, 1976

	Aircraft-miles (10^6)	Passenger-miles (10^9)	Passenger load factor (%)	Mean stage length (miles)
Domestic carriers	1,994	151.29	56.2	435
Domestic trunks	1,672	136.89	56.4	584
Big four	1,047	85.62	58.5	NA
Others	624	51.27	53.3	NA
Local carriers	284	12.67	53.4	195
Other domestic carriers	34	1.68	61.6	173
International carriers	306	40.46	58.6	1,359
Passenger carriers, total	2,295	191.70	56.7	480

NA — Not available.

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41 Schedule T-2*, Washington, D.C., 1970 to 1977.

Table 1.86
Certificated Air Carrier Passenger Service Operating Statistics by Aircraft Category, 1976

	Percent of all certificated air carriers[a]		Passenger load factor (%)
	Aircraft-miles	Passenger-miles	
Long-haul aircraft	38.7	56.1	56.1
Four-engine narrow-body jet	20.2	22.3	61.4
Turbofan	18.4	20.5	51.3
Turbojet	1.8	1.8	62.0
Wide-body jet	18.5	33.8	53.1
Three-engine	11.5	17.2	51.2
Four-engine	7.0	16.6	55.2
Three-engine narrow-body	37.6	29.9	57.6
Short-haul aircraft	23.1	13.5	57.1
Propellor	3.0	0.9	48.3
Piston	0.2	0.02	47.1
Turboprop	2.8	0.8	51.6
Two-engine narrow-body jet	20.1	12.7	57.6
Helicopters	0.03	0.003	40.2

[a]Values will not sum to 100% exactly because only passenger cabin configurations were considered.

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41 Schedule T-2*, Washington, D.C., 1970–1977.

"SUPPLEMENTAL AIR CARRIERS," CARRIERS PERFORMING PASSENGER AND CARGO CHARTER SERVICES, ARE THE ONLY SEGMENT OF THE AIR MARKET WHICH HAS EXPERIENCED SIGNIFICANT DECLINES IN OPERATIONS IN RECENT YEARS.

Table 1.87
Supplemental Air Carrier Traffic Statistics,
1973 through 1976

	1973	1974	1975	1976
Domestic operations				
Revenue aircraft miles, 10^3	35,026	31,461	25,712	23,818
% military	54.1	57.8	68.2	34.8
Revenue passenger-miles, 10^6	2,005.9	1,802.5	900.0	920.3
% military	1.5	1.9	1.7	1.6
Overall passenger load factor, %	88.1	86.5	89.1	88.8
Cargo ton-miles, 10^6	291.6	281.1	262.8	237.1
% military	86.8	87.4	87.3	87.6
International operations				
Revenue aircraft miles, 10^3	56,769	47,901	39,834	38,822
% military	22.9	24.4	26.6	21.0
Revenue passenger-miles, 10^6	9,783.7	9,060.0	7,845.9	7,278.8
% military	16.3	20.0	23.5	21.1
Overall passenger load factor, %	86.7	87.7	87.7	88.5
Cargo ton-miles, 10^6	111.9	85.8	99.0	147.0
% military	46.8	25.3	17.1	11.6
All operations				
Revenue aircraft miles, 10^3	91,795	79,363	65,546	62,640
% military	34.8	37.7	42.9	39.1
Revenue passenger-miles, 10^6	11,789.6	10,862.4	8,745.8	8,199.1
% military	13.8[a]	17.0	21.3	18.9
Overall passenger load factor, %	86.9	87.5	87.8	88.5
Cargo ton-miles, 10^6	403.5	366.9	361.8	384.1
% military	75.7	72.9	68.1	58.5

[a] A commuter operator is defined as an operator of small aircraft (up to 30 seats and a 7,500 lb payload) performing at least five scheduled round trips per week between two or more points or carrying mail.

Source: Civil Aeronautics Board, *Handbook of Airline Statistics, Supplement*, Washington, D.C., 1975 and 1977 editions.

ALTHOUGH "COMMUTER AIR CARRIERS[a]" STILL REPRESENT ONLY A SMALL PORTION OF THE AIR MARKET IN ABSOLUTE TERMS, THEY HAVE EXPERIENCED RAPID GROWTH OVER THE PAST YEARS.

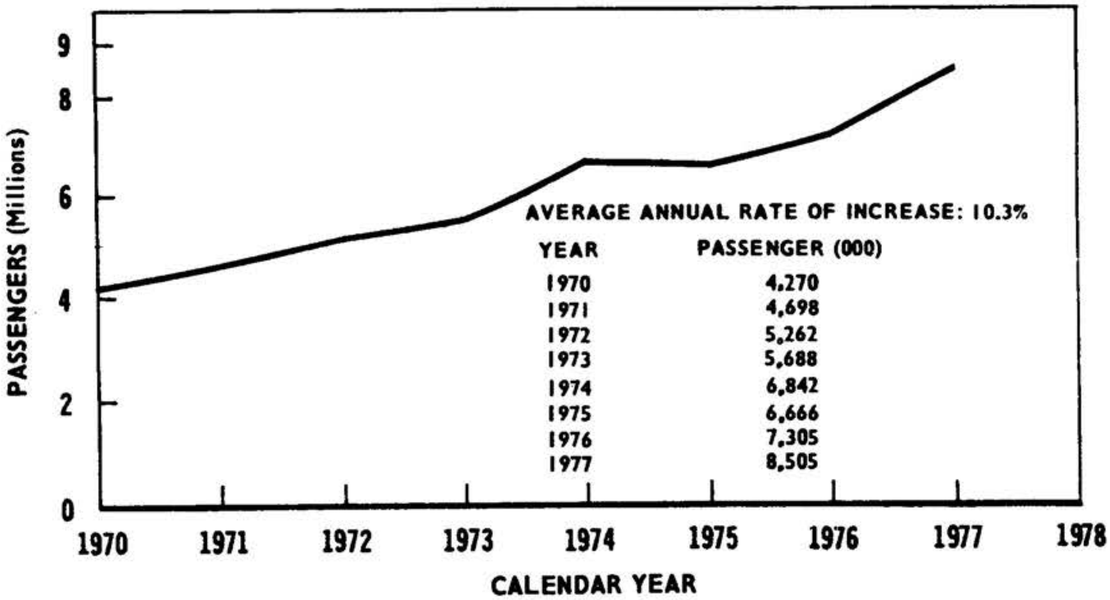


Fig. 1.37 Passengers Carried by Commuter Air Carriers, 1970-1977[a].

[a]A commuter operator is defined as an operator of small aircraft (up to 30 seats and a 7,500 lb payload) performing at least five scheduled round trips per week between two or more points or carrying mail.

Source: Civil Aeronautics Board, *Commuter Air Carrier Traffic Statistics*, Washington, D.C., December 31, 1977.

Table 1.88 Commuter Air Carrier[a] Statistics, 1975-1977

	1975	1976	1977	% change 1976 to 1977
Reporting carriers	235	252	242	-4.0
Airports served		781	764	-2.2
Passengers carried, 10^3	6,666	7,305	8,505	16.4
Passenger-miles, 10^3	698,473	770,784	946,179	22.8
Cargo carried, lbs × 10^3	169,203	216,811	271,242	25.1
Mail carried, lbs × 10^3	164,682	108,597	71,395	-34.3
Average trip distance, miles	105	106	111	4.7

[a]A commuter operator is defined as an operator of small aircraft (up to 30 seats and a 7,500 lb payload) performing at least five scheduled round trips per week between two or more points or carrying mail.

Source: Civil Aeronautics Board, *Commuter Air Carrier Traffic Statistics*, Washington, D.C., 1976 and 1977 editions.

Table 1.89 Active[a] Registered United States Civil Aircraft as of December 31, 1965 through 1976

Year	Active registered civil aircraft		General aviation aircraft					
				Fixed-wing aircraft				
					Single-engine			
	Total	Total air carrier[b]	Total	Multi-engine	4-seat & over	3-seat & less	Rotorcraft[c]	Other[d]
1965	97,741	2,299	95,442	11,977	49,789	31,364	1,503	809
1970	134,539	2,796	131,743	18,291	64,759	44,884	2,555	1,554
1975	171,156	2,681	168,475	24,559	82,621	54,390	4,073	2,832
1976	180,854	2,550	178,304	25,684	88,211	56,730	4,505	3,174

[a]Prior to 1970 this categroy was defined as Eligible Aircraft. These numbers represent a count of the total registered U.S. civil fleet.

[b]Includes helicopters.

[c]Includes autogiros; excludes air carrier helicopters.

[d]Includes gliders, blimps, balloons, and dirigibles.

Table 1.90 Estimated Hours Flown in Active General Aviation by Type of Flying, Calendar Years 1965 through 1976 Actual Use (10^3 hr)

Year	Total estimated hours	Business		Commercial		Instructional		Personal		Other	
		Hours	%	Hours	%	Hours	%	Hours	%	Hours	%
1965	16,733	5,857	35	3,348	20	3,346	20	4,016	24	166	1
1970	26,030	7,204	28	4,582	18	6,791	26	6,896	26	557	2
1975	34,165	9,545	28	6,480	19	8,174	24	9,244	27	722	2
1976	36,128	10,095	28	7,029	19	8,591	24	9,768	27	645	2

Note: "Business" includes business and executive; "commercial" includes air taxi, aerial application, and industrial/special; and "instructional" includes training and rental.

Sources: B. V. Cayce, U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, Washington, D.C., December 1975, pp. 102 and 104; 1976 data: C. Moles and V. Wimbush, *FAA Statistical Handbook of Aviation*, Washington, D.C., December 1976, pp. 114 and 116.

Table 1.91

Estimated Miles Flown in Active General Aviation by Type of Flying, 1965 through 1976
(thousands of miles)

	Estimated total miles flown	Business		Commercial		Instructional		Personal		Other	
		Miles	%	Miles	%	Miles	%	Miles	%	Miles	%
1965	2,562,380	1,204,321	47	461,228	18	358,733	14	512,476	20	25,662	1
1970	3,207,127	1,134,279	35	554,683	17	686,152	22	753,434	24	78,579	2
1973	3,728,534	1,343,723	36	688,402	18	777,868	21	825,099	22	93,492	3
1974	4,042,700	1,433,276	35	789,695	20	815,543	20	919,587	23	84,599	2
1975	4,238,400	1,486,876	35	818,065	19	829,362	20	1,008,276	24	95,821	2
1976	4,476,014	1,562,939	35	885,021	20	873,025	20	1,068,114	24	86,915	2

Note: "Business" includes business and executive; "commercial" includes air taxi, aerial application, and industrial/special; and "instructional" includes training and rental.

Sources: U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, Washington, D.C., December 1974, p. 104; C. Moles and V. Wimbush, *FAA Statistical Handbook of Aviation*, Washington, D.C., December 1976, p. 116.

Table 1.92
Distribution of General Aviation Aircraft and Average Hours Flown by Type of Aircraft and Primary Use of Owner, 1976
(parentheses indicate percentages)

	Estimated total, active	Executive	Business	Personal	Aerial	Instructional	Air taxi	Industrial	Rental	Other	Av hr/ aircraft (weighted)
Fixed-wing, total	170,625 (95.7)	9,482	37,182	84,697	7,183	12,769	5,815	1,874	8,579	3,044	200
Piston aircraft, total	166,201 (93.2)	6,182	36,925	84,650	7,178	12,745	5,291	1,854	8,548	2,828	191
Single-engine	144,881	1,612	28,484	81,462	6,824	12,177	2,327	1,585	8,078	2,332	180
Multiengine	21,320	4,570	8,441	3,188	354	568	2,964	269	470	496	263
Turboprop, total	2,486 (1.4)	1,781	194	34	3	7	347	15	20	85	534
Single-engine	30	3	2	3		2	5		1	14	167
Multiengine	2,456	1,778	192	31	3	5	342	15	19	71	538
Turbojet, total	1,938 (1.1)	1,519	63	13	2	17	177	5	11	131	516
Single-engine	30		5	2				4		19	33
Multiengine	1,908	1,519	58	11	2	17	177	1	11	112	524
Rotary wing, total	4,505 (2.5)	580	388	472	643	296	974	809	41	302	391
Piston, total	2,753	129	295	460	579	281	182	606	28	193	312
Turbine, total	1,752	451	93	12	64	15	792	203	13	199	557
Miscellaneous, total	3,174 (1.8)	18	186	2,160	24	301	2	12	217	254	89
Glider	2,345	9	40	1,681	17	237		2	213	146	
Ballon	824	8	146	479	7	64	2	6	4	108	
Blimp/dirigible	5	1						4			
Total, all aircraft	178,304 (100)	10,080 (5.6)	37,756 (21.2)	87,329 (49.0)	7,850 (4.4)	13,366 (7.5)	6,791 (3.8)	2,695 (1.5)	8,837 (5.0)	3,600 (2.0)	203

Source: C. Moles and V. Wimbush, U.S. Department of Transportation, Federal Aviation Administration, *FAA Statistical Handbook of Aviation*, Calendar Year 1976, Washington, D.C., December 1976, pp. 112 and 115.

Section 1.4

Rail

Fig. 1.38 U.S. Railroad Right of Way.

Source: Stanford Research Institute, *Energy Study of Railroad Freight Transportation, Vol. 2: Industry Description*, Energy Research and Development Administration, Menlo Park, Calif., August 1977, p. 25.

Fig. 1.39 Passenger Railroads in the United States.

Source: Rand McNally, *Handy Railroad Atlas of the United States*, Chicago, Ill., 1978, p. 3.

ALTHOUGH THE NUMBER OF FREIGHT CARS AND LOCOMOTIVES IN OPERATION HAS DECLINED OVER THE YEARS, THE TOTAL TON-MILES TRAVELLED BY FREIGHT TRAINS HAS INCREASED. THIS IS PRIMARILY A RESULT OF AN INCREASE IN THE DISTANCE OF THE AVERAGE HAUL PER TON AND AN INCREASE IN THE AVERAGE TONS PER CAR LOAD CARRIED BY FREIGHT TRAINS.

Table 1.93

Summary Statistics for Freight Trains, 1950 through 1977

	1950	1960	1970	1975	1976	1977
Stocks						
Freight cars	2,008,761	1,965,486	1,784,181	1,723,605	1,699,027	1,666,533
Class 1, %	85.7	84.4	79.8	78.9	78.4	77.2
Locomotives	40,494	29,080	27,086	28,210	27,609	27,680
Diesel electric units, %	34.7	98.9	98.9	98.7	98.9	99.1
Cars per average train	59.0	69.6	70.0	68.6	67.1	67.2
Operations						
Total ton-miles, 10^6	621,305	585,648	777,091	767,479[a]	811,066[a]	NA
Revenue, %	94.7	97.7	98.4	98.3	97.9	NA
Average haul per ton, miles	416	442	490	518	540	568
Freight train-miles, 10^3	514,971	404,464	427,065	402,557	424,571	428,039
Freight car-miles, 10^6	29,784	28,170	29,890	27,565	28,530	28,757
% loaded	68.9	61.4	57.8	54.7	55.4	56.8[b]
Average carload, tons	41.0	44.4	54.9	60.8	61.0	61.1[b]
Average revenue per ton-mile, cents	1.3	1.4	1.4	2.0	2.2	2.3

[a]Preliminary figures.

[b]Estimate

NA — not available.

Sources: Association of American Railroads, *Statistics of Class I Railroads in U.S.*, Washington, D.C., December 1977; Association of American Railroads, *Yearbook of Railroad Facts*, 1977 edition, Washington, D.C., 1977.

THERE HAS BEEN A TREMENDOUS DECREASE IN THE NUMBER OF PASSENGER CARS IN OPERATION SINCE 1950; APPROXIMATELY 9.8% OF THE NUMBER OF PASSENGER CARS IN OPERATION IN 1950 WERE IN OPERATION IN 1977. THERE HAS ALSO BEEN A SUBSTANTIAL DECREASE IN THE NUMBER OF PASSENGER-MILES AND SEAT-MILES TRAVELLED BY PASSENGER TRAINS.

HOWEVER, THERE HAS BEEN A SHIFT IN THE PERCENTAGE OF PASSENGER-MILES TRAVELLED BY COMMUTATION AND INTERCITY PASSENGERS. IN 1950, 84.3% OF ALL PASSENGER-MILES WERE INTERCITY TRAVEL, WHILE 15.7% WERE COMMUTATION TRAVEL. BY 1977 THE PERCENTAGES HAD CHANGED TO 55.4% INTERCITY AND 44.6% COMMUTATION. AT THE SAME TIME THE AVERAGE REVENUE PER PASSENGER-MILE HAS INCREASED BY 120% SINCE 1950.

Table 1.94 Summary Statistics for Passenger Trains, 1950 through 1977

	1950	1960	1970	1975	1976	1977
Stocks						
Passenger cars	37,146	25,655	11,177	6,471	5,478	3,406
Amtrak, %				29.6	37.6	59.2
Load factor[a]	24.6	29.8	36.7	43.0	33.0	NA
Operations						
Revenue passenger-miles, 10^6	31,760	21,258	10,740	9,935	10,304	10,298
Commutation, %	15.7	19.7	42.7	45.4	44.3	44.6
Intercity, %	84.3	80.3	57.3	54.6	55.7	55.4
Total seat-miles, 10^6	129,030	71,409	29,253	23,141	31,161	NA
Average journey per passenger, miles	65.32	65.23	37.83	36.88	37.93	NA
Commutation, %	17.99	20.67	22.28	23.15	23.09	NA
Intercity, %	128.08	139.11	79.34	73.51	74.44	NA
Average revenue per passenger-mile, cents	2.6	3.0	3.9	5.4	5.7	5.7

NA — not available

[a]Load Factor is the percent capacity utilized. It is determined by dividing either the average number of passengers per unit by the average number of seats per unit or by dividing total passenger-miles by the total seat-miles.

Sources: Association of American Railroads, *Statistics of Class I Railroads in U.S.*, Washington, D.C., 1977; Transportation Association of America, *Transportation Facts and Trends*, 14th edition, Washington D.C., April 1978.

THERE HAS BEEN A DECREASE IN THE NUMBER OF CARS LOADED FOR CLASS I RAILROADS WITH 22.5% FEWER CARS BEING LOADED IN 1976 THAN IN 1960. THE COAL COMMODITY GROUP ACCOUNTED FOR 20% OF ALL LOADED CARS IN 1976.

Table 1.95
Class I Railroad Cars of Revenue Freight Loaded, 1960 through 1976, and by Commodity Group, 1976
(10^3)

Year	Cars loaded		Commodity group	Number, 1976	Commodity group	Number, 1976
	Total	Piggyback				
1960	30,441	554	Coal	4,699	Stone, clay, and glass products	943
1965	29,248	1,034	Metallic ores	1,673	Waste and scrap materials	693
1968	28,253	1,337	Chemicals and allied products	1,382	Nonmetallic minerals, n.e.c.[a]	689
1969	28,237	1,344	Grain	1,326	Lumber and wood products, n.e.c.[a,b]	670
1970	27,160	1,257	Motor vehicles and equipment	1,229	Farm products, except grain	428
1971	25,266	1,199	Primary forest products	1,134	Forwarder and shipper association traffic	422
1972	26,105	1,331	Pulp, paper, and allied products	1,101		
1973	27,338	1,535	Food and kindred products, n.e.c.[a]	1,058	Petroleum products	371
1974	26,184	1,512	Crushed stone, gravel, and sand	1,035	Coke	364
1975	23,217	1,221	Grain mill products	1,010	Less than carload	20
1976	23,638	1,409	Metals and products	970	All other carloads	2,419

[a]Not elsewhere classified.

[b]Except furniture.

Source: U.S. Bureau of the Census, Statistical Abstract of the United States: 1977 (98th edition) Washington, D.C., 1977, p. 650. (Taken from Association of American Railroads, Washington, D.C., *Cars of Revenue Freight Loaded*, annual.)

Section 1.5

Marine

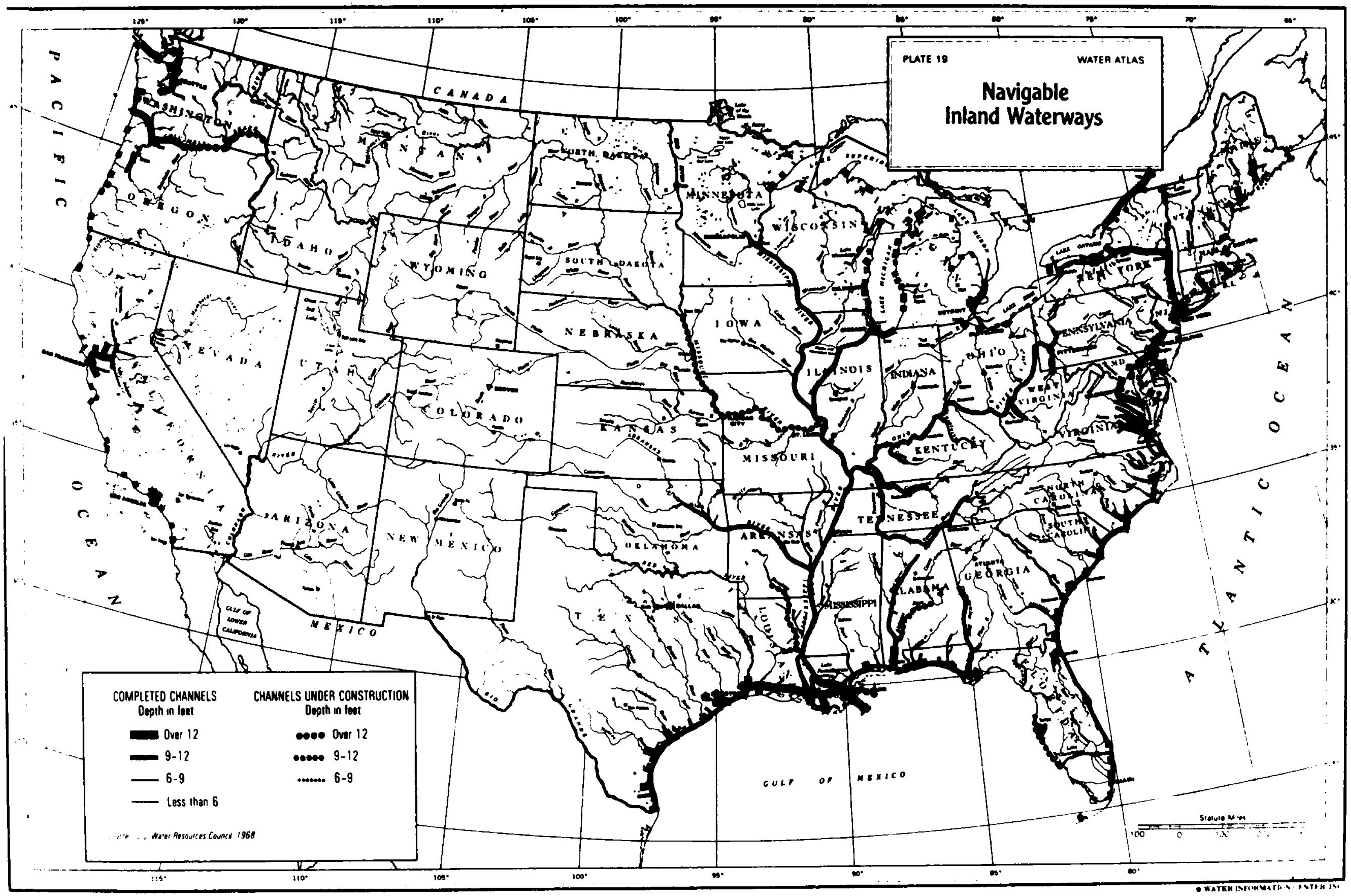


Fig. 1.40
Navigable Inland Waterways

Source: J. J. Geraghty et al., *Water Atlas of the United States*, Water Information Center, Inc., Port Washington, New York, May 1973.

Table 1.96
Number of Vessels Operated for the Transportation of Freight on American Waterways, 1970 through 1976[a]

Types of vessels	1970	1971	1972	1973	1974	1975	1976[b]	% distribution, 1976
Self-propelled								
Towboats and tugs								
Number of vessels	4,230	4,059	4,064	4,035[c]	4,100[c]	4,240[c]	4,379	13.2
Total horsepower	3,955,001	4,217,064	4,447,953	4,621,450	5,088,221	5,585,891	6,161,348	
Non-self-propelled								
Dry cargo barges and scows								
Number of vessels	16,439	17,527	18,804	19,772	21,876	23,164	24,937	
Cargo capacity, net tons	18,272,014	19,710,605	21,342,522	22,647,076	25,525,996	27,135,336	29,454,921	
Tank barges								
Number of vessels	3,185	3,420	3,313	3,375	3,534	3,623	3,770	
Cargo capacity, net tons	6,330,298	7,486,718	7,408,906	7,623,498	8,201,561	8,510,016	9,519,840	
Total non-self-propelled								
Number of vessels	19,624	20,947	22,117	23,147	25,410	26,787	28,707	86.8
Cargo capacity, net tons	24,602,312	27,197,323	28,751,428	30,270,574	33,727,557	35,645,352	38,974,761	
Total vessels	23,854	25,006	26,181	27,182	29,510	31,027	33,086	100.0

[a]From Corps of Engineers, U.S. Army.

[b]Personal correspondence — Department of Army Waterborne Commerce Statistics Center, U.S. Army Engineer Division, Lower Mississippi Valley, New Orleans, La. Figures for 1976 were obtained through personal correspondence.

[c]U.S. Coast Guard reports 6,095 documented vessels of the United States having a service of towing in 1973, 6,111 in 1974, and 6,430 in 1975. The vessels reported by the Corps of Engineers are those used only in the performance of transportation services.

Source: The American Waterways Operators, *1975 Inland Waterborne Commerce Statistics*, Arlington, Va., April 1977, pp. 2 and 3.

THE AVERAGE DEAD WEIGHT TONNAGE (DWT) OF THE WORLD'S OCEANGOING STEAM AND MOTOR SHIPS INCREASED 56.7% FROM 1970 TO 1976. THIS INCREASE WAS CAUSED BY THE INCREASED CARRYING CAPACITY OF TANKERS (72.1% FOR ALL SHIPS AND 51.3% FOR UNITED STATES SHIPS) AND BULK CARRIERS (36.8% FOR ALL SHIPS AND 45.5% FOR UNITED STATES SHIPS). THE NUMBER OF SHIPS IN OPERATION DID NOT RISE AS SHARPLY; HOWEVER THE NEW SHIPS ARE LARGER AND SOMETIMES CARRY AS MUCH AS TWO OR THREE SMALLER OLDER SHIPS WHICH MAY HAVE BEEN RETIRED.

ACTUAL DWT INCREASED 119.2% FOR TANKERS AND 111.6% FOR BULK CARRIERS BECAUSE MORE OIL AND OIL PRODUCTS HAVE BEEN PRODUCED AND EXPORTED BY MANY PRODUCING NATIONS. IN THE CASE OF THE UNITED STATES TANKERS, ACTUAL DWT HAS INCREASED ONLY 38.4% AND BULK CARRIERS DWT HAS DECREASED BY 31.0%. THIS IS IN AGREEMENT WITH THE UNITED STATES DEPENDENCE ON FOREIGN OIL DURING THIS TIME PERIOD.

Table 1.97
Oceangoing Steam and Motor Ships of 1,000 Gross Tons and Over, 1970 through 1976[a,b]

Year	Country of Registry	Total			Type of Vessel: Combination passenger and cargo (including refrigerated cargo)			Freighters (including refrigerated)			Bulk carriers			Tankers (including whaling tanker)		
		Number	Gross tons	Dead-weight tons	Number	Gross tons	Dead-weight tons	Number	Gross tons	Dead-weight tons	Number	Gross tons	Dead-weight tons	Number	Gross tons	Dead-weight tons
	Total all countries	19,980	211,401	326,999	895	7,486	4,396	11,899	67,820	92,355	2,954	47,199	77,173	4,232	88,896	153,075
1970	United States	1,579	15,529	21,346	171	1,572	1,107	1,076	8,909	11,733	38	464	767	294	4,584	7,739
	Private	793	9,780	14,406	19	275	170	475	4,709	6,112	37	457	756	262	4,339	7,368
	Government	786	5,749	6,940	152	1,297	937	601	4,200	5,621	1	7	11	32	245	371
	Total all countries	21,009	250,543	399,552	860	7,090	4,018	12,029	70,073	94,128	3,539	64,822	108,512	4,581	108,558	192,894
1972	United States	1,150	13,111	17,949	153	1,390	957	685	6,548	8,097	32	419	702	280	4,754	8,193
	Private	651	9,300	13,638	12	195	109	361	4,210	5,063	32	419	702	246	4,476	7,764
	Government	499	3,811	4,311	141	1,195	848	324	2,338	3,034	0	0	0	34	278	429
	Total all countries	22,449	306,366	503,348	775	6,366	3,371	12,478	74,288	99,270	4,075	82,303	139,267	5,121	143,399	261,440
1974	United States	922	12,503	17,637	80	765	511	545	6,184	7,294	19	302	534	278	5,252	9,298
	Private	583	9,820	14,446	6	74	50	313	4,467	4,990	19	302	534	245	4,977	8,872
	Government	339	2,683	3,191	74	691	461	232	1,717	2,304	0	0	0	33	275	426
	Total all countries	22,872	333,042	556,572	714	5,833	3,027	12,575	75,284	101,248	4,272	88,194	150,080	5,311	163,731	302,217
1975	United States	857	12,301	17,694	60	595	388	511	5,972	7,051	19	302	544	267	5,432	9,711
	Private	580	10,103	15,028	6	74	50	305	4,445	4,959	19	302	544	250	5,282	9,475
	Government	277	2,198	2,666	54	521	338	206	1,527	2,092	0	0	0	17	150	236
	Total all countries	23,586	358,203	606,499	710	5,697	2,962	12,923	77,939	104,639	4,570	95,451	163,298	5,383	179,116	335,600
1976[c]	United States	842	12,655	18,566	61	610	393	494	5,877	6,930	18	293	529	269	5,875	10,714
	Private	577	10,531	16,020	6	74	50	299	4,420	4,931	18	293	529	254	5,744	10,510
	Government	265	2,124	2,546	55	536	343	195	1,457	1,999	0	0	0	15	131	204

[a] Excludes ships operating exclusively on the Great Lakes and inland waterways and special types such as channel ships, icebreakers, cable ships, etc. and merchant ships owned by any military force.

[b] A more disaggregated table of this information appears in Edition II of the Transportation Energy Conservation Data Book.

[c] Source: U.S. Department of Commerce, Maritime Administration, "Merchant Fleets of the World, Oceangoing Steam and Motor Ships of 1,000 Gross Tons and Over as of December 31, 1976," December 1977, p. 2.

Source: U.S. Department of Commerce, Maritime Administration, "A Statistical Analysis of the World's Merchant Fleets," Washington, D.C., Annual.

Table 1.98
Waterborne Commerce of the United States on U.S. Waterways: Ton-Miles and Tons by Type of Traffic and Average Haul, 1970 through 1976

	Total, foreign and domestic	Foreign[a]			Domestic[d]				
		Total	Great Lakes[b] ports	Coastal[c] ports	Total	Coastwise	Lakewise	Internal	Local
Ton-miles, thousands									
1970	658,951,768	62,756,357	34,345,283	28,411,074	596,195,411	359,784,103	79,416,394	155,815,888	1,179,026
1971	654,763,573	61,599,920	33,962,302	27,637,618	593,163,653	360,204,500	70,381,094	161,339,284	1,238,775
1972	670,019,289	66,476,841	35,087,059	31,389,782	603,542,448	351,508,576	73,131,550	177,538,601	1,363,721
1973	666,497,867	81,806,384	41,400,030	40,406,354	584,691,483	327,649,175	83,765,109	171,890,916	1,396,283
1974	656,164,337	69,819,094	25,799,993	44,019,101	586,345,243	322,802,209	78,880,393	183,202,577	1,460,064
1975	639,450,727	73,466,504	29,944,755	43,521,749	565,984,223	315,845,946	68,516,762	180,399,193	1,222,322
1976	677,180,983	85,327,501	34,347,899	50,979,602	591,853,482	322,932,250	70,684,181	197,072,803	1,164,248
% distribution 1976	100	12.6	40.3	59.7	87.4	54.6	11.9	33.3	0.2
Tons,[e] thousands									
1970	1,530,066	580,969	62,338	518,631	949,097	238,440	157,059	472,123	81,475
1971	1,510,327	565,986	59,450	506,536	944,341	242,916	140,955	479,218	81,253
1972	1,614,909	629,981	60,133	569,848	984,928	242,660	145,013	506,989	90,266
1973	1,757,269	767,394	66,758	700,636	989,875	236,795	156,621	503,237	93,223
1974	1,742,734	764,089	51,462	712,627	978,645	233,358	146,067	511,022	88,198
1975	1,692,182	748,707	56,882	691,825	943,475	231,932	129,331	503,932	78,279
1976	1,832,060	855,964	65,657	790,307	976,096	236,279	132,113	523,973	83,731
% distribution 1976	100	46.7	7.7	92.3	53.3	24.2	13.5	53.7	8.6
Average haul, miles per ton									
1970	430.7	108.0	551.0	54.8	628.2	1,508.9	505.6	330.0	14.5
1971	433.5	108.8	571.3	54.6	628.1	1,482.8	499.3	336.7	15.2
1972	414.9	105.5	583.5	55.1	612.8	1,448.6	504.3	350.2	15.1
1973	379.3	106.6	620.2	57.7	590.7	1,383.7	534.8	341.6	14.9
1974	376.5	91.4	501.3	61.8	599.1	1,383.3	540.0	358.5	16.6
1975	377.9	98.1	526.4	62.9	599.9	1,361.8	529.8	358.0	15.6
1976	369.9	99.7	523.1	64.5	606.3	1,366.7	535.0	376.1	13.9

[a]All movements of U.S. and foreign ships between the United States and foreign countries and between Puerto Rico and Virgin Islands (U.S.A. part) and foreign countries are classified as foreign traffic. Any traffic with the Panama Canal Zone is treated as foreign commerce. Trade between United States territories and possessions, that is, Guam, Wake, American Samoa, etc., and foreign countries is excluded. These statistics are compiled by the Bureau of the Census from U.S. Bureau of Customs reports.

[b]Based on distances transported on Great Lakes and St. Lawrence River to International Boundary at St. Regis, Quebec, Canada.

[c]Ton-miles for coastal ports are based on distances transported on Unites States waterways from entrance channels to ports and waterways only.

[d]Statistics are for U.S. ships on domestic waters.

[e]Excludes intraterritory traffic for which ton-miles were not compiled; 1970, 1,630 thousand tons; 1971, 2,257 thousand tons; 1972, 1,883 thousand tons; 1973, 5,283 thousand tons; 1974, 4,055 thousand tons; 1975, 2,852 thousand tons.

Source: U.S. Department of the Army, Corps of Engineers, *Waterborne Commerce of the United States*, Part 5 — National Summaries, Vicksburg, Miss., Calendar Year 1976, p. 89.

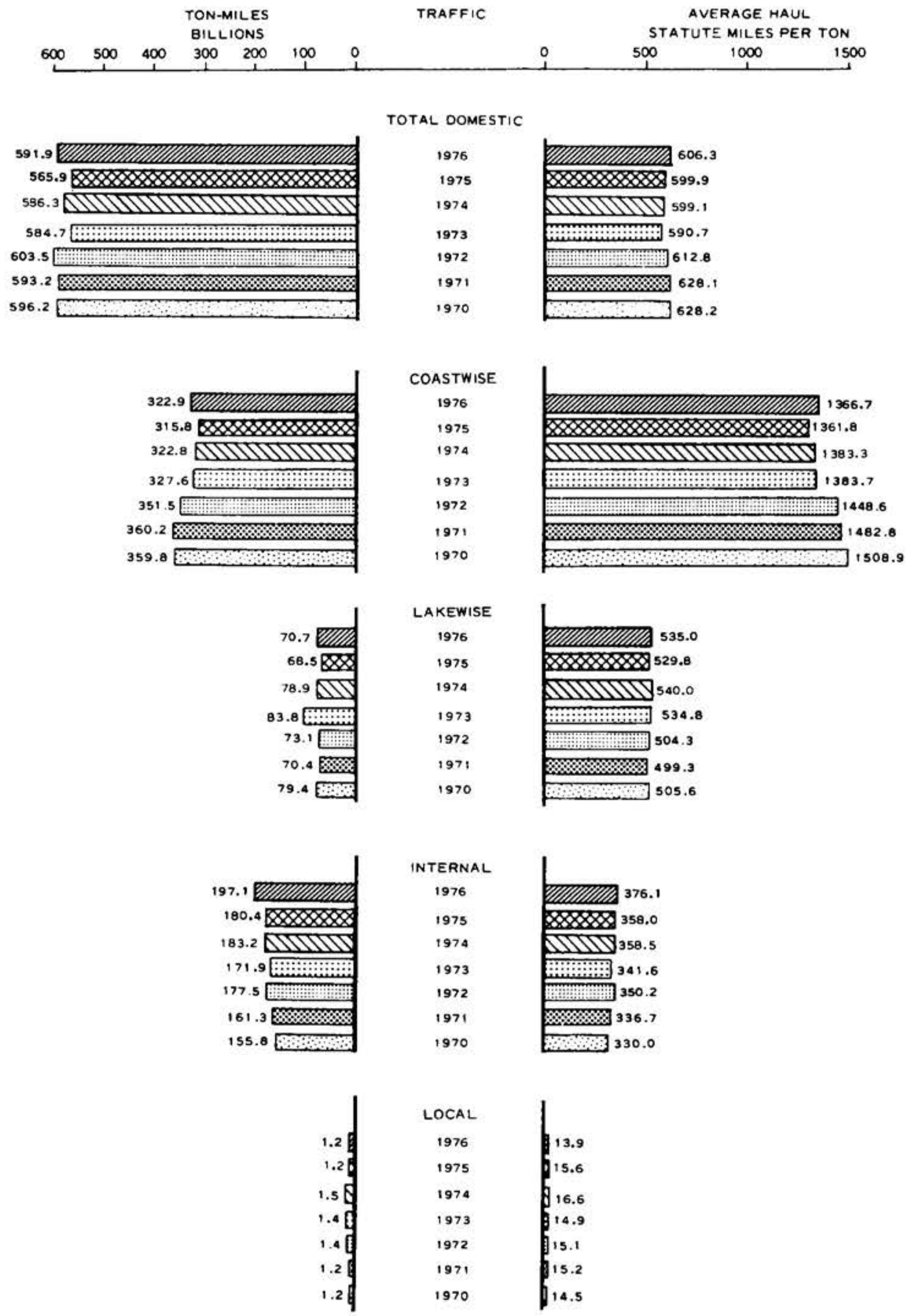


Fig. 1.41
Ton-Miles and Average Haul by Type of Traffic, 1970-1976.

Source: U.S. Department of the Army, Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 1976, Part 5, National Summaries*, 1977, p. 90.

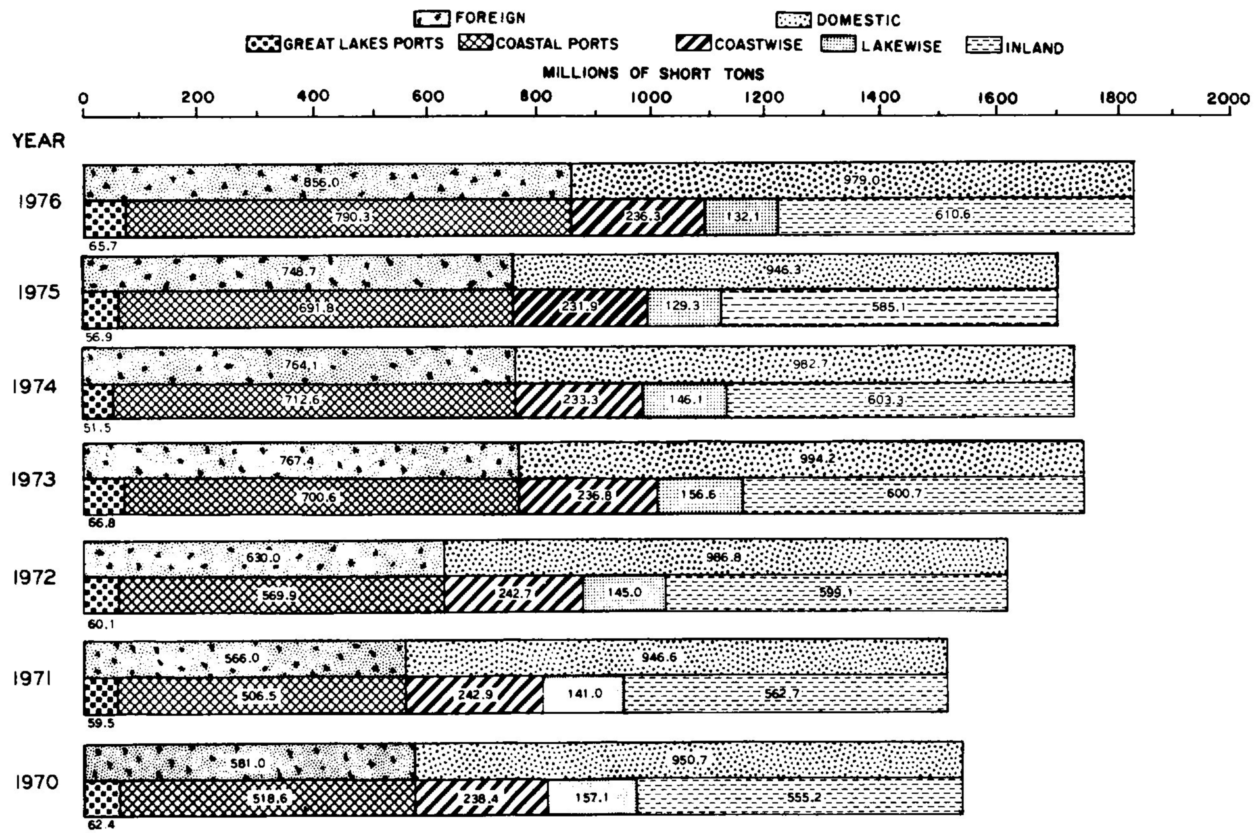


Fig. 1.42
Total Waterborne Commerce of the United States, 1970-1976.

Source: U.S. Department of the Army, Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 1976, Part 5, National Summaries*, 1977, p. 10.

THE COMMODITIES IN TABLES 1.99 AND 1.100 HAVE BEEN THE TOP ITEMS SHIPPED IN THE UNITED STATES INLAND WATERWAYS AND ON THE GREAT LAKES SINCE 1970. DURING THIS TIME THE ENTIRE SHIPPING INDUSTRY HAS BEEN STABLE CONCERNING TONS SHIPPED AND TON-MILES (TABLE 1.98).

Table 1.99

Ranking of the Top 15 Commodities Shipped on the Inland Waterways of the United States in 1976 Exclusive of the Great Lakes (domestic trade)

Commodity	% of domestic tons shipped
1. Bituminous coal and lignite	21.4
2. Residual fuel oil	12.3
3. Sand, gravel, and crushed rock	9.6
4. Crude petroleum	8.7
5. Grain and grain products	7.0
6. Distillate fuel oil	6.8
7. Gasoline	6.3
8. Rafted logs	2.8
9. Waste and scrap, n.e.c.[a]	2.5
10. Basic chemicals and products, n.e.c.[a]	2.0
11. Marine shells, unmanufactured	2.0
12. Soybeans	1.8
13. Fertilizer and fertilizer materials	1.1
14. Iron and steel products	1.0
15. Iron ore and concentrates	1.0

[a]n.e.c. — Not elsewhere classified.

Source: The American Waterways Operators, Inc., *1976 Inland Waterborne Commerce Statistics*, June, 1978, p. 7.

Table 1.100

Ranking of the Top 10 Commodities Shipped on the Great Lakes in 1976 (domestic trade)

Commodity	% of total domestic tons shipped on the Great Lakes
1. Iron ore and concentrates	48.9
2. Limestone	19.6
3. Coal and lignite	15.6
4. Sand, gravel, and crushed rocks	2.8
5. Residual fuel oil	1.8
6. Distillate fuel oil	1.5
7. Wheat	1.1
8. Gasoline	1.1
9. Nometallic minerals, n.e.c.[a]	1.0
10. Gypsum, crude, and plasters	0.7

[a]n.e.c. — Not elsewhere classified.

Source: Department of Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 1976, Part 3: Waterways and Harbors, Great Lakes*, 1977, pp. XII, XIII.

BOAT CLASSIFICATIONS WERE CHANGED IN 1976. WHEN COMPARING DATA FOR 1973 (TABLE 1.101) TO DATA FOR 1976 (TABLE 1.102), CARE MUST BE TAKEN TO COMPARE DATA FROM IDENTICAL CLASSIFICATIONS.

THE 1973 VALUES ARE NOT THE SAME AS FOUND IN EDITION 2 OF THE TEC DATA BOOK BECAUSE THE COAST GUARD RE-ANALYZED THE 1973 DATA USING 1973 BUREAU OF THE CENSUS "POPULATION ESTIMATES (REVISED)." (CENSUS POPULATION DATA FOR 1970 WAS USED FOR THE DATA IN EDITION 2.)

Table 1.101
Number of Boats Used for Recreation and Length of Exposure, 1973

	Number of boats in use			Boat hours			Exposure per boat (hr)	Passenger hours		
	Number of boats in use (10^3)	% of total	% by category	Boat hours (10^3)	% of total boat exposure	% by category		Passenger-hours (10^3)	% of total passenger hours	% by category
Rowboat	934	11.4		86,075	5.6		92	215,864	4.7	
With motor	299	3.7	32.0	26,127	1.7	30.4	87	68,496	1.5	31.7
Jonboat	182	2.2		27,266	1.8		150	64,506	1.4	
With motor	142	1.7	78.0	24,566	1.6	90.1	173	60,931	1.3	94.5
Sailboat	536	6.6		83,828	5.4		155	299,402	4.9	
With motor	72	0.9	13.4	20,403	1.3	24.5	283	76,321	1.6	25.5
Canoe	549	6.7		83,593	5.4		152	183,746	3.9	
With motor	73	0.9	13.3	15,300	1.0	18.3	210	43,095	0.9	23.4
Kayak	35	0.4		1,289	0.1		37	2,799	0.1	
Inflatable	37	0.5		1,217	0.1		33	2,420	0.1	
With motor	15	0.2	40.5	735	<0.1	60.4	49	1,470	<0.1	60.7
Outboard	4,346	53.2		805,237	52.0		185	2,344,043	50.9	
Inboard	568	7.0		217,766	14.0		383	744,672	16.2	
Inboard/Outboard	533	6.5		102,034	6.6		191	379,817	8.3	
Houseboat	45	0.6		12,876	0.8		286	62,456	1.4	
Other powerboat	39	0.5		35,334	2.3		906	84,802	1.9	
Other	381	4.7		93,122	6.0		244	289,709	6.3	
With motor	302	3.7	79.3	88,076	5.7	94.6	292	276,042	6.0	95.3
Total										
With motor	6,435	78.8		1,348,491	87.0		210	4,142,225	90.0	
without motor	1,730	21.2		200,646	13.0		116	466,111	10.0	
Grand total	8,165	100.0		1,549,137	100.0		190	4,604,336	100.0	

Source: U.S. Coast Guard, Washington, D.C., *Recreational Boating in the Continental United States in 1973 and 1976: The Nationwide Boating Survey*, p. 79.

THE NUMBER OF RECREATIONAL BOATS IN USE IN THE UNITED STATES INCREASED FROM 8,165,000 IN 1973 TO 11,322,000 IN 1976. THE PERCENTAGE OF MOTOR AND NONMOTOR BOATS REMAINED ALMOST THE SAME IN THIS TIME PERIOD (78.8% WITH MOTORS IN 1973 AND 77.2% WITH MOTORS IN 1976). ONE SIGNIFICANT CHANGE WAS WITH ROWBOATS IN WHICH 32.0% OPERATED WITH MOTORS IN 1973 AND 62.2% OPERATED WITH MOTORS IN 1976. PASSENGER-HOURS PER BOAT INCREASED FROM 564 TO 674 DURING THIS PERIOD AND BOAT-HOURS PER BOAT INCREASED FROM 189 TO 199 INDICATING MORE PERSONS PER BOATING OUTING IN 1976.

Table 1.102
Number of Boats Used for Recreation and Length of Exposure, 1976[a]

	Number of boats in use			Boat hours			Exposure per boat (hr)	Passenger hours		
	Number of boats in use (10^3)	% of total	% by category	Boat hours (10^3)	% of total boat exposure	% by category		Passenger-hours (10^3)	% of total passenger exposure	% by category
Rowboat	1,482	13.1		172,399	7.6		116	389,886	5.1	
With motor	922	8.1	62.2	125,023	5.5	72.5	136	287,554	3.8	73.8
Jonboat	1,149	10.1		235,931	10.4		205	523,391	6.9	
With motor	994	8.8	86.5	215,300	9.5	91.3	217	488,732	6.4	93.4
Skiff	302	2.7		50,369	2.2		167	127,526	1.7	
With motor	260	2.3	86.1	47,580	2.1	94.5	183	122,756	1.6	96.3
Dinghy	119	1.1		14,477	0.6		122	36,097	0.5	
With motor	77	0.7	64.7	12,197	0.5	84.2	158	31,468	0.4	87.2
Other open lightweight	1,108	9.8		279,575	12.4		252	671,579	8.8	
With motor	1,069	9.4	96.5	277,512	12.3	99.3	260	666,030	8.7	99.2
Sailboat	877	7.7		235,289	10.4		268	749,418	9.8	
With motor	189	1.6	21.6	75,467	3.3	32.1	399	314,701	4.1	42.0
Canoe	905	8.0		110,362	5.0		122	240,345	3.1	
With motor	105	0.9	11.6	9,082	0.4	8.2	87	17,529	0.2	7.3
Kayak	83	0.7		6,581	0.3		79	7,390	0.1	
With motor	5	<0.1	6.0	21	<0.1	0.3	4	43	<0.1	0.6
Inflatable boat	38	0.3		5,541	0.2		146	12,085	0.1	
With motor	5	<0.1	13.2	258	<0.1	4.7	52	515	<0.1	4.3
Inflatable raft	47	0.4		4,823	0.2		103	16,329	0.2	
With motor	1	<0.1	2.1	118	<0.1	2.4	118	470	<0.1	2.9
Noninflatable raft	19	0.2		1,869	0.1		98	5,645	0.1	
With motor	12	0.1	63.2	1,351	0.1	72.3	113	4,608	0.1	81.6
Bowrider runabout	1,689	14.9		329,099	14.6		195	1,213,654	15.9	
Nonbowrider runabout	1,486	13.1		237,424	12.1		184	885,894	11.6	
Cabin cruiser	529	4.7		173,147	7.7		327	1,052,702	13.8	
Houseboat	47	0.4		19,049	0.8		405	125,915	1.7	
Pontoon boat	126	1.1		25,981	1.1		206	143,416	1.9	
Thrill craft	165	1.5		45,584	2.0		276	177,980	2.3	
With motor	157	1.4	95.2	45,451	2.0	99.7	289	177,715	2.3	99.9
Other	1,151	10.2		272,134	12.0		236	1,256,094	16.4	
With motor	1,067	9.4	92.7	262,482	11.6	96.4	246	1,238,915	16.2	98.6
Total										
With motor	8,740	77.2			1,892,532	83.9	216	6,772,618	88.7	
Without motor	2,582	22.8			363,092	16.1	141	862,628	11.3	
Grand total	11,322	100.0			2,255,624	100.0	199	7,635,246	100.0	

[a]1970 census data was used to estimate the number of boats in use when the Coast Guard conducted their Nationwide Boating Survey in 1973. In the 1976 edition of the Nationwide Boating Survey, the 1973 data were reevaluated using 1973 census data. Therefore the data in 1973 is revised from Edition II of the Transportation Energy Conservation Data Book.

Most 1973 and 1976 data cannot be compared because the survey changed the definitions of same types of boats. Comparisons can be made only with identical types (rowboat, jonboat, sailboat, canoe, kayak, and houseboat).

Source: U.S. Coast Guard, Washington, D.C., *Recreational Boating in the Continental United States in 1973 and 1976: The Nationwide Boating Survey*, March, 1978, Page: 80.

Table 1.103
Classification of Pleasure Boats by Type and Horsepower, 1976
(10^3)

Type	Horsepower							Total[a]
	None	1-5	6-10	11-30	31-50	51-100	Over 100	
Rowboat	674	405	458	136	54[b]	22[b]	8[b]	1,757
Skiff	63	46	59	82	63	40	2	355
Dinghy	46	34	40	6	7[b]			133
Jonboat	186	251	333	318	98	26[b]	49[b]	1,261
Other open Lightweight	72	175	269	243	245	136	144[b]	1,284
Sailboat	794	56	90	41	4	6	1	992
Canoe	875	79	24	2	4[b]	1[b]		985
Kayak	84			5[b]				89
Bowrider Runabout	31[b]	50	75	170	447	639	450	1,862
Non-Bowrider Runabout	13[b]	29	61	92	490	507	509	1,701
Cabin cruiser		6[b]	6[b]	4	13	121	414	564
Houseboat					4	8	35	47
Inflatable boat	33	5						38
Inflatable	58	1						59
Non-inflatable Raft	7			11			1	19
Pontoon boat		7	13	53	37	15	6	131
Thrill craft	7	1	1	6	28	40	92	175
Other	105	63	133	124	227	306	340	1,298
Total	3,048	1,208	1,562	1,293	1,721	1,867	2,051	12,750
% of total	23.9	9.5	12.3	10.1	13.5	14.6	16.1	100.0

[a] Includes boats not in use.

[b] The survey doubts the accuracy of these figures because of a misunderstanding of the question or the transfer of incorrect data.

Source: U. S. Coast Guard, *Recreational Boating in the Continental U.S. in 1975 & 1976: The Nationwide Boating Survey*, Washington, D.C., March 1978, pp. 23, 26.

THE CHANGE IN THE PERCENTAGE OF PLEASURE BOATS BY HORSEPOWER CATEGORIES WAS INSIGNIFICANT FROM 1973 TO 1976. (SEE TABLE 1.103.) THERE WAS, HOWEVER, A LARGE SHIFT FROM HEAVIER WOOD AND STEEL BOATS (20.8% IN 1973, 15% IN 1976) TO LIGHTER ALUMINUM AND FIBERGLASS BOATS (75.3% IN 1973, 81.4% IN 1976). THIS SHIFT WAS EVEN MORE DRAMATIC FROM 1970 TO 1977. IN 1970, 31.4% OF ALL PLEASURE BOATS WERE WOOD AND STEEL, 65.5% WERE ALUMINUM AND FIBERGLASS. BY 1977 THESE RESPECTIVE PERCENTAGES WERE 13.6 AND 83.6.*

Table 1.104
Hull Material by Length, 1976
(10^3)

Hull material	Under 16 ft	16-25 ft	26-39 ft	40-65 ft	Over 65 ft	Total[a]
Aluminum	3,266	937	13		2	4,218
Fiberglass	2,259	3,143	153	35	3	5,593
Steel	111	54	13	1		179
Wood	521	516	195	30	3	1,265
Other[b]	310	69	15			394
Combination	530	538	29	4		1,101
Total	6,997	5,257	418	70	8	12,750
% of Total	54.9	41.2	3.3	0.5	<0.1	100

[a]Includes boats not in use.

[b]Includes canvas, ferrocement, rigid plastic, and rubber hulls among others.

Source: Department of Transportation, U.S. Coast Guard, *Boating Statistics 1977*, Washington, D.C., May 1, 1978, p. 29.

*Department of Transportation, U.S. Coast Guard, *Boating Statistics 1974*, May 1, 1975 and *Boating Statistics 1977*, May 1, 1978.

†U.S. Coast Guard, *Recreational Boating in the Continental United States in 1973 and 1976: The National Boating Survey*, Washington, D.C., March 1978.

Section 1.6

Pipeline

Table 1.105 Financial Profile of ICC-Regulated[a] Oil Pipeline Companies, 1974 through 1976

	1974	1975	1976
Number of reporting companies	103	104	111
Total employees, average	15,222	15,108	15,270
Condensed income statement, $\$10^6$			
Operating revenues	1,587.1	1,873.5	2,137.1
Operating expenses	942.6	1,037.8	1,145.7
Net operating income	644.5	835.7	991.4
Federal income taxes on ordinary income	147.7	290.3	317.8
Ordinary income	348.2	455.9	594.1
Net extraordinary items	4.2	1.2	0.7
Net income	352.3	457.1	594.9
Net investment in property plus working capital	5,380.6	7,681.8	10,060.8
Shareholders equity	2,245.7	2,143.8	2,287.2
Return on investment, %	11.98	10.88	9.85

[a]In 1975, ICC-regulated pipeline companies accounted for 84.4% of all oil pipeline ton-miles carried.

Source: Interstate Commerce Commission, *1977 Annual Report*, GPO stock number 026-000-01096-9, Washington, D.C.

Table 1.106 Crude and Product Pipeline Trunk Mileages by Pipe Diameter, 1971 and 1977[a]

Nominal pipeline diameter (in.)	Miles of crude pipelines		Miles of product pipelines	
	1971	1977	1971	1977
2		84		125
3	479	468	702	630
4	3,090	3,260	2,771	2,895
6	9,435	9,518	16,732	17,565
8	19,269	19,303	25,634	27,193
10	11,867	11,358	9,785	11,958
12	10,106	10,156	8,732	9,394
14	571	589	2,441	2,817
16	5,630	5,975	1,603	2,077
18	2,002	2,059	919	1,202
20	5,040	5,251	907	1,238
22	2,664	3,059	9	9
24	1,504	2,256	131	566
26	1,039	1,069	217	287
28			177	597
30	938	2,006	300	520
32			288	288
34	792	785		233
36	2	134	1,058	1,519
40	634	527		183
42	4	4		
48	0	111		
Total	75,066	77,972	72,406	81,296

[a]As of January 1 of given year.

Sources: U.S. Department of the Interior, Bureau of Mines, *Mineral Industry Surveys: Crude Oil and Product Pipelines*, December 1971; Department of Energy, Energy Information Administration, *Crude Oil and Product Pipelines Triennial*, December 1977, p. 2.

A LARGE MAJORITY OF ALL DOMESTIC CRUDE OIL MOVEMENTS ARE BY PIPELINES. IN 1976 OVER 75% OF ALL CRUDE OIL TONS AND OVER 88% OF ALL CRUDE OIL TON-MILES WERE CARRIED BY PIPELINES. THE DIFFERENCE BETWEEN THESE PERCENTAGES INDICATES THAT THE AVERAGE LENGTH OF HAUL BY PIPELINES WAS SUBSTANTIALLY LONGER THAN FOR OTHER MODES.

Table 1.107 Domestic Crude Oil Movements by Pipelines, 1953 through 1976

	Tons carried by pipelines (10^6)	% of all crude oil tons carried	Ton-miles carried by pipelines (10^9)	% of all crude oil ton-miles
1953	283.38	75.2		
1958	307.06	76.4		
1963	351.88	75.2		
1968	425.84	74.1		
1972	487.61	75.8	284.5	78.6
1973	492.38	76.9	302	83.1
1974	464.27	74.8	303	84.4
1975	454.69	74.3	288	86.9
1976	458.51	75.3	308	88.3

Source: Association of Oil Pipe Lines, press release, June 19, 1978.

THE PERCENTAGE SHARE OF ALL PETROLEUM PRODUCTS TONS CARRIED BY PIPELINES HAS BEEN STEADILY INCREASING. FROM 1953 TO 1972 A LARGE PORTION OF THIS INCREASE WAS DUE TO A MODAL SHIFT FROM WATER CARRIERS TO PIPELINES. THE INCREASES SINCE THEN HAVE BEEN PREDOMINANTLY FROM PRODUCTS PREVIOUSLY CARRIED BY MOTOR CARRIERS. ALSO, THE AVERAGE LENGTH OF HAUL BY PIPELINES IS LONGER THAN BY OTHER MODES.

Table 1.108 Domestic Petroleum Products Movements by Pipelines, 1953 through 1976

	Tons carried by pipelines (10^6)	% of all petroleum products tons carried	Ton-miles carried by pipelines (10^6)	% of all petroleum products ton-miles
1953	75.76	15.6		
1958	125.97	20.5		
1963	169.27	23.3		
1968	300.61	30.4		
1972	388.64	32.4	191.3	40.1
1973	419.83	32.7	205	42.7
1974	420.38	33.5	203	41.5
1975	424.76	34.8	219	42.5
1976	475.60	35.6	215	40.8

Source: Association of Oil Pipelines, press release, June 19, 1978.

Table 1.109 Detailed Breakdown of Petroleum Products Carried by Pipelines, 1975 and 1976
(10^6 bbl)

	1975	1976
Turned into lines		
Gasoline, total	1,822.8	2,003.2
Motor	1,819.0	1,998.8
Aviation	3.8	4.4
Jet fuel, total	259.6	323.2
Naphta-type	34.0	43.0
Kerosine-type	225.5	280.2
Kerosine	30.9	30.4
Distillate fuel oil	667.1	745.3
Residual fuel oil		2.7
Natural gas liquids	504.7	567.1
Other		0.3
Delivered from lines		
Gasoline, total	1,821.1	2,010.8
Motor	1,817.2	2,006.5
Aviation	3.9	4.3
Jet fuel, total	256.1	318.4
Naphta-type	34.1	42.6
Kerosine-type	222.0	275.8
Kerosine	29.7	29.4
Distillate fuel oil	668.0	751.0
Residual fuel oil		2.7
Natural gas liquids	497.3	549.5
Other		0.3
Stocks in lines and working tanks at end of year		
Gasoline, total	48.5	47.9
Motor	48.3	47.9
Aviation	0.2	0.1
Jet fuel, total	6.4	7.7
Naphta-type	0.8	1.3
Kerosine-type	5.6	6.4
Kerosine	1.8	1.7
Distillate fuel oil	32.7	29.6
Natural gas liquids	20.9	32.6

Source: Energy Information Administration, *Energy Data Reports, Petroleum Statement, Annual 1976*, Washington, D.C., 1978.

BECAUSE ALL NATURAL GAS IS GATHERED, TRANSPORTED, AND DISTRIBUTED BY PIPELINES, PRODUCTION AND CONSUMPTION STATISTICS ARE SYNONYMOUS WITH TRANSPORTATION STATISTICS.

Table 1.110 Natural Gas Profile, 1974 through 1976
(10^9 ft^3)

	1974	1975	1976
Supply			
Marketed production	21,600	20,109	19,952
Withdrawn from storage	1,701	1,760	1,921
Imports	959	953	964
Total	24,260	22,821	22,837
Disposition			
Delivered to consumers	19,077	17,558	17,764
Residential		4,924	5,051
Commercial		2,268	2,383
Industrial		6,979	6,967
Electric utilities		3,147	3,078
Other		240	285
Extraction loss	887	872	854
Lease and plant fuel	1,477	1,396	1,634
Pipeline fuel	668	583	548
Total consumption	22,111	20,410	20,801
Exports	77	73	65
Stored	1,784	2,104	1,756
Unaccounted for	289	235	216
Total	24,260	22,821	22,837
Total interstate movements	NA	11,317	10,850
Average wellhead value, ¢/10^3 ft^3	30.4	44.5	58.0

Sources: Energy Information Administration, *Energy Data Reports, Natural Gas, Annual, 1976*, Washington, D.C., February 1978, Bureau of Mines, *Mineral Industry Surveys, Natural Gas, Annual*, Washington, D.C., 1974 and 1975.

Table 1.111 Gas Utility Industry Miles of Pipeline and Main by Type, 1950 through 1976[a]
(10^3)

	Total	Field and gathering	Transmission pipeline[b]	Distribution main
1950	387.5	32.8	113.1	241.6
1955	496.7	45.7	145.9	305.1
1960	630.9	55.8	183.7	391.4
1965	767.5	61.7	211.3	494.5
1970	913.3	66.3	252.2	594.8
1971	931.4	66.2	254.8	610.4
1972	948.1	66.9	258.1	623.1
1973	962.9	65.9	263.1	633.8
1974	974.1	66.4	262.2	645.6
1975	980.0	68.5	262.6	648.9
1976	987.7	70.3	258.2	659.1
Steel	876.1	70.1	254.7	551.3
Plastic[c]	47.2	0.1	1.8	45.4
Other	64.3	0.1	1.8	62.4

[a] Includes data for Hawaii subsequent to 1959 and Alaska subsequent to 1960; excludes service pipe. Data not adjusted in common diameter equivalent. Mileage shown as of end of each year.

[b] Includes 3.6 thousand miles of underground storage pipe in 1971, 3.3 thousand miles in 1972, 3.4 thousand miles in 1973, 4.9 thousand miles in 1974, 5.0 thousand miles in 1975, and 5.3 thousand miles in 1976, some of which was formerly included in field and gathering pipe.

[c] Includes fiberglass.

Source: American Gas Association, Department of Statistics, *Gas Facts*, Arlington, Va., 1977, p. 53.

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Chapter 2

Energy Characteristics

Energy Characteristics

Of prime importance to the consideration of energy conservation measures is basic data on energy intensity and energy efficiency. In the transportation sector, a knowledge of how much energy is being used by each mode and what percentage of it is finally converted into useful work is fundamental to the understanding of energy-use patterns and to the formulation of conservation strategies.

Chapter 2 presents statistics on energy use in absolute terms and also in terms of the efficiency of its use. Although the total energy picture is considered, emphasis is centered on the transportation sector which, with its near total reliance on petroleum as an energy source accounted for 54% of total U.S. petroleum consumption in 1977. The importance of the transportation sector is further accentuated when one considers that in 1977 the United States produced only 45% of its petroleum needs.

In Sect. 2.1 statistics are presented on the total gross energy use by consuming sectors and by major sources. The section is organized from the macro the micro level beginning with U.S. energy resource production and consumption and moving to the energy resource consumption breakdown in the individual sectors of the United States transportation system.

In terms of energy use, the transportation sector is dominated by the passenger car, which uses 52% of all transportation energy and 67% of the highway energy. Although these percentages declined in recent years, private automobiles still account for 13% of the total U.S. energy use.

Section 2.2 deals with the energy intensity and efficiency of the transportation modes. Given the available operational data, it is possible to derive values for the productive output per unit of energy used or the energy use per unit productive output for most of the transportation modes. Such values are commonly referred to as energy efficiency and intensity estimates, respectively, and have been the subject of several special studies undertaken through Oak Ridge National Laboratory in the recent past. Presented in Section 2.2 is a summary of the findings of these studies. In reading the material the user should be aware that this section represents a summary of these much larger studies and consequently a substantial number of caveats, explanations, and detailed analyses have been left out. The interested reader is referred to the source studies.

Section 2.1

Energy Resource Consumption

Table 2.1
U.S. Energy Production by Major Source, 1950 through 1977

	1950	1960	1965	1970	1974	1975	1976	1977[a]	1977 (%)	% increase since 1970
Coal[b]										
10^6 short tons	560.4	434.3	527.0	612.7	610.0	654.6	684.9	694.7		13.4
10^{12} Btu[c]	14,647	11,140	13,395	15,248	14,487	15,394	15,868	15,924	26.4	4.4
Natural gas[d]										
10^9 cubic feet	6,262	12,771	16,040	21,921	21,601	20,109	19,952	19,942		-9.0
10^{12} Btu[c]	6,841	14,135	17,652	24,154	23,696	22,019	21,827	21,817	36.2	-9.7
Petroleum[e]										
10^6 bbl	1,974	2,575	2,849	3,517	3,203	3,057	2,976	2,999		-14.7
10^{12} Btu[c]	11,449	14,935	16,524	20,402	18,575	17,730	17,263	17,395	28.9	-14.7
Hydropower										
10^9 kWhr	95.5	145.5	193.9	247.1	301.0	300.0	283.7	220.4		-10.8
10^{12} Btu[c]	1,340	1,566	7,027	2,593	3,143	3,122	2,952	2,293	3.8	-11.6
Nuclear power										
10^9 kWhr		0.5	3.7	21.8	114.0	172.5	191.1	250.9		1,050.9
10^{12} Btu[c]		5	39	232	1,215	1,839	2,037	2,675	4.4	1,053.0
Geothermal										
10^9 kWhr				0.5	2.5	3.2	3.6	3.6		620.0
10^{12} Btu[c]				11	54	69	78	78	0.1	609.1
Total	34,277	41,781	49,637	62,640	61,170	60,173	60,025	60,182	100.0	-3.9

[a]Preliminary.

[b]Includes anthracite coal, bituminous coal, and lignite.

[c]See special table of Btu conversion factors in appendix.

[d]Includes natural gas liquids.

[e]Includes lease condensate.

Source: Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 3.

Table 2.2
U.S. Energy Use By Major Source, 1950 through 1977

	1950	1960	1965	1970	1974	1975	1976	1977[a]	1977 (%)	% increase since 1970
Coal[b]										
10^6 short tons	494	398	472	524	558	562	604	625		19.3
10^{12} Btu[c]	12,913	10,140	11,908	12,698	12,889	12,814	13,748	14,117	18.6	11.2
Natural gas[d]										
10^9 cubic feet	5,942	12,269	15,598	21,367	21,223	19,538	19,946	19,228		-10.0
10^{12} Btu[c]	6,150	12,699	16,098	22,029	21,732	19,948	20,344	19,613	25.9	-11.0
Petroleum[e]										
10^6 bbl	2,375	3,611	4,202	5,365	6,078	5,958	6,391	6,724		25.3
10^{12} Btu[c]	13,489	20,067	23,241	29,537	33,468	32,742	35,086	36,956	48.7	25.1
Hydropower										
10^9 kWhr	97.7	150.0	193.9	249.1	313.7	306.2	292.3	230.3		-7.5
10^{12} Btu[c]	1,371	1,614	2,027	2,614	3,276	3,186	3,042	2,397	3.2	-8.3
Nuclear power										
10^9 kWhr		0.5	3.7	21.8	114.0	172.5	191.1	250.9		1,050.9
10^{12} Btu[c]		5	39	232	1,215	1,839	2,037	2,675	3.5	1,053.0
Geothermal										
10^9 kWhr				0.5	2.5	3.2	3.6	3.6		620.0
10^{12} Btu[c]				11	54	69	78	78	0.1	609.1
Total	33,923	44,525	53,313	67,121	72,634	70,598	74,372	75,836	100.0	13.0

[a]Preliminary.

[b]Includes anthracite, bituminous coal, lignite, and net imports of coke.

[c]See table of Btu conversion factors in this section.

[d]See special table of Btu conversion factors in appendix.

[e]Includes domestically produced crude oil, natural gas liquids, and condensate, plus imported crude oil and products.

Source: Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 5.

Table 2.3
Ratio of U.S. Energy Resource Production to Consumption by Major Sources[a], 1950 through 1977

	1950	1960	1965	1970	1974	1975	1976	1977[b]
Coal[c]	1.13	1.09	1.12	1.17	1.09	1.16	1.13	1.11
Natural gas[d]	1.05	1.04	1.03	1.02	1.02	1.03	1.00	1.04
Petroleum[e]	0.83	0.71	0.68	0.66	0.53	0.51	0.47	0.45
Hydropower	0.98	0.97	1.00	0.99	0.96	0.98	0.97	0.96
Total	1.01	0.94	0.93	0.93	0.84	0.85	0.81	0.79

[a]Production and consumption are equal for nuclear power and geothermal.

[b]Preliminary.

[c]Includes anthracite coal, bituminous, and lignite.

[d]Includes natural gas liquids.

[e]Includes lease condensate.

Source: Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices,* Washington, D.C., May 1978, pp. 3 and 5.

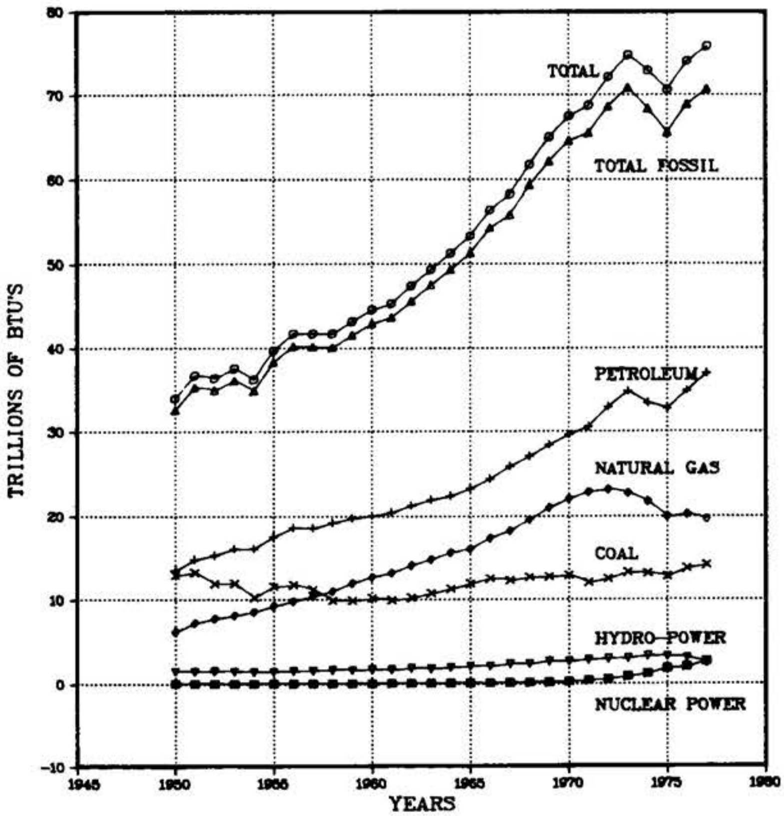

Fig. 2.1. U.S. Energy Resource Consumption.

Source: U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook,* Washington, D.C., annual; *Annual U.S. Energy Use Up in 1976,* Washington,D.C., March 14, 1977, p. 4; Department of Energy, Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices,* Washington, D.C., May 1978.

Table 2.4
Domestic Demand for Refined Petroleum Products by End-Use Sector, 1950 through 1977
(10^3 bbl/day)

	1950	1960	1965	1970	1974	1975	1976	1977[a]	1977 (%)	% increase since 1970
Residential and commercial	1,442	2,331	2,679	3,092	2,898	2,760	2,992	3,180	17.2	2.8
Industrial	1,224	1,759	2,028	2,634	3,126	2,867	3,210	3,443	18.7	30.7
Transportation	3,421	5,284	6,224	7,953	8,953	9,140	9,571	9,912	53.7	24.6
(% of total)	(53.0)	(53.9)	(54.1)	(54.1)	(53.8)	(56.0)	(54.8)	(53.7)		
Electric utility	291	246	325	915	1,534	1,420	1,510	1,708	9.3	86.7
Other	80	177	256	103	142	135	178	199	1.1	93.2
Total	6,458	9,797	11,512	14,697	16,653	16,332	17,461	18,442	100.0	25.5

[a]Preliminary

Source: Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 35.

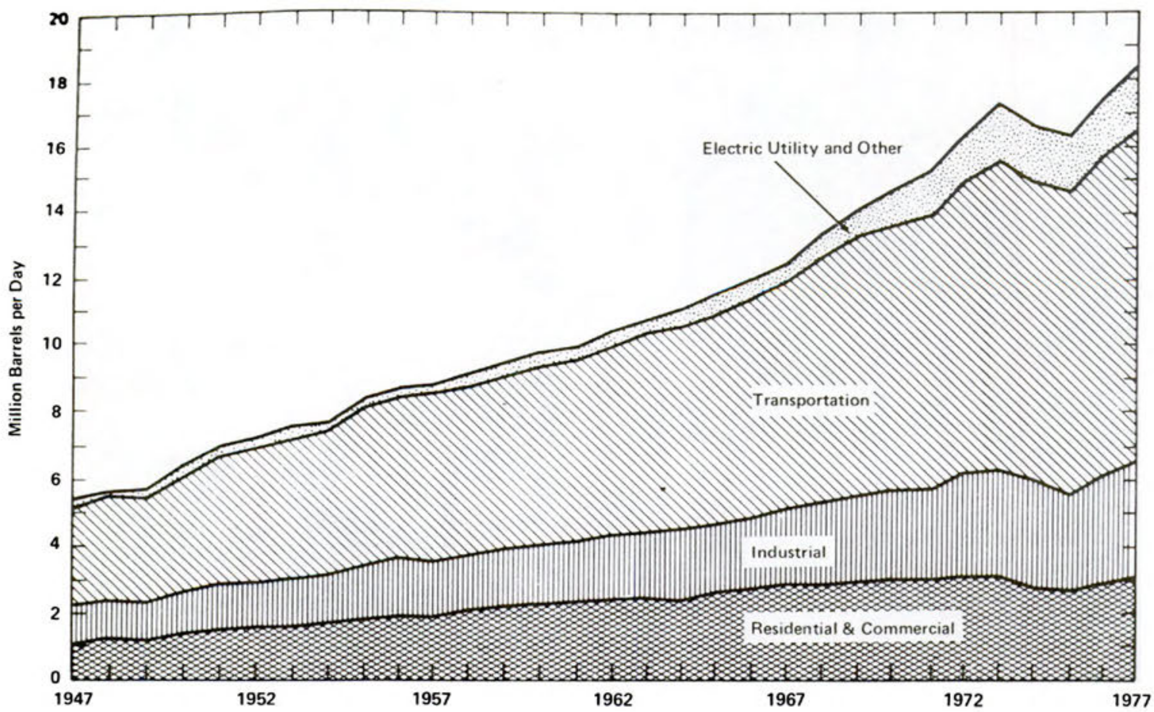

Fig. 2.2. Domestic Demand for Refined Petroleum Products by End-Use Sector, 1947 through 1977.

Source: Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978.

Table 2.5
Petroleum Consumption by Major Product[a] and Major Consuming Sector, 1976

	Household and commercial		Industrial[b]		Transportation		Electricity generation, utilities		Miscellaneous and unaccounted for		Total domestic product demand		% distribution
	10^6 bbl	10^{12} Btu	10^6 bbl	10^{12} Btu	10^6 bbl	10^{12} Btu	10^6 bbl	10^{12} Btu	10^6 bbl	10^{12} Btu	10^6 bbl	10^{12} Btu	
Fuel and power	943.2	5,264.4	665.6	3,883.1	3,453.4	18,569.2	559.0	3,479.3	11.9	72.0	5,633.1	31,268.0	89.5
Liquefied gases	170.0	681.9	70.3	280.8	27.0	108.2					267.0	1,070.9	3.1
Jet fuels					358.0	2,006.7	3.0	17.0			361.0	2,023.7	5.8
Naphtha type					73.2	392.5					73.3	392.5	1.1
Kerosine type					284.7	1,614.2	3.0	17.0			287.7	1,631.2	4.7
Gasoline					2,561.0	13,440.1					2,561.0	13,440.1	38.5
Kerosine	47.4	268.8	13.8	78.2							61.2	347.0	1.0
Distillate fuel	539.8	3,144.3	139.8	814.3	840.4	2,215.8	72.0	419.4	6.2	36.2	1,138.2	6,630.0	19.0
Residual fuel	186.0	1,169.4	196.0	1,232.3	127.0	798.4	484.0	3,042.9	5.7	35.8	998.7	6,278.8	18.0
Still gas			182.0	1,092.0							182.0	1,092.0	3.1
Petroleum coke			64.0	385.5							64.0	385.4	1.1
Raw material[c]	161.0	1,068.4	500.5	2,282.7	27.0	163.8					688.5	3,514.9	10.1
Plant condensate			3.5	19.0							3.5	19.0	
Special naphthas			30.0	157.4							30.0	157.4	0.4
Lubes[d] and waxes			37.0	220.6	27.0	163.8					64.0	384.4	1.1
Petroleum coke[e]			26.0	156.6							26.0	156.6	0.4
Asphalt and road oil	161.0	1,068.4									161.0	1,068.4	3.0
Petrochemical feedstock offtake													
Liquified refinery gas[f]			41.0	159.6							41.0	159.6	0.4
Liquified petroleum gas[f,g]			210.0	719.5							210.0	719.5	2.0
Naphtha (-400 degrees[h])			76.5	401.5							76.5	401.5	1.1
Still gas			16.5	99.0							16.5	99.0	0.3
Miscellaneous (+400 degrees)			60.0	349.5							60.0	349.5	1.0
Miscellaneous and unaccounted for									28.1	154.6	28.1	154.6	0.4
Total	1,104.2	6,332.8	1,166.1	6,165.8	3,480.4	18,733.0	559.0	3,499.3	40.0	226.6	6,349.7	34,937.5	100.0

[a] Includes liquified refinery gas and natural gas liquids.

[b] Includes bunkers, military transportation, and all military use of distillate and residual fuel oils.

[c] Includes some fuel and power used by raw materials industries.

[d] Lubricants are distributed on the basis of data from the Bureau of the Census.

[e] Includes portions of petroleum coke estimated to be consumed in nonfuel uses.

[f] Includes ethane.

[g] Includes LP gas for synthetic rubber.

[h] Type of degrees (i.e., Farenheit or Centigrade) not given by source (ed.).

Source: W. F. Gay, U.S. Department of Transportation, *National Transportation Statistics*, annual report, Cambridge, Mass., September 1978, p. 89.

Table 2.6
Energy Use by Source: Transportation Sector, 1950 through 1976

Year	Coal[a]	Petroleum[b]		Natural gas[c]	Total fossil fuels	Utility electricity purchased	Total energy input	Percent of total gross U.S. energy inputs
	Trillion Btu	Trillion Btu	Percent of transportation sector	Trillion Btu	Trillion Btu	Trillion Btu	Trillion Btu	
1950	1,701	6,785	78.5	130	8,616	24	8,640	25.4
1960	87	10,372	95.7	359	10,818	18	10,836	24.3
1970	8	15,592	95.3	745	16,345	16	16,361	24.3
1971	6	16,286	95.4	766	17,058	17	17,075	24.8
1972	4	17,264	95.5	790	18,058	17	18,075	25.0
1973	3	18,164	96.0	743	18,910	15	18,925	25.3
1974	2	17,720	96.2	685	18,407	19	18,426	25.3
1975	1	17,933	96.7	595	18,529	16	18,545	26.3
1976[d]		18,733	96.9	582	19,315	16	19,331	26.1

[a]Includes anthracite, bituminous, and lignite coals.

[b]Includes bunkers and military transportation.

[c]Consumption of natural gas by pipelines.

[d]Estimated.

Sources: W. F. Gay, U.S. Department of Transportation, *Energy Statistics*, Washington, D.C., August 1976, p. ; U.S. Department of the Interior, Bureau of Mines, News Release, Washington, D.C., March 14, 1977.

Table 2.7
Energy Used by Mode of Transport, 1965 through 1977
(10^{12} Btu)

	1965	1970	1974	1975	1976	1977
Highway[a]	8,942.0	11,629.4	13,417.0	13,750.0	14,620.9	15,122.9
Passenger car and taxi	6,273.4	8,203.0	9,217.7	9,497.6	9,799.8	10,028.2
Motorcycles	8.6	16.9	55.9	55.9	56.1	56.4
Buses	120.0	126.6	114.2	119.2	128.7	132.3
Intercity	37.8	42.3	27.5	25.0	25.3	25.2
School	31.1	37.5	41.6	42.7	48.7	50.2
Local	51.1	46.8	45.1	51.5	54.7	56.9
Trucks	2,540.0	3,282.9	4,029.2	4,077.3	4,636.4	4,906.0
Single unit	1,687.4	2,153.8	2,639.6	2,732.5	3,114.2	3,281.9
Combinations	852.4	1,129.1	1,389.6	1,344.8	1,522.2	1,624.1
Rail	575.3	543.6	629.3	576.6	596.9	609.8
Local rail (heavy and light rail)	27.4	27.6	30.0	30.2	29.3	26.2
Operating railroads[b]	547.9	543.6	599.3	546.4	567.6	583.6
Passenger	87.2	44.8	34.4	32.2	30.3	32.4
Freight	460.7	498.8	564.9	514.2	537.3	551.2
Air[a]	740.0	1,652.1	1,528.8	1,529.8	1,541.2	1,616.9
General aviation	47.4	100.9	115.2	119.7	133.0	153.6
Air carrier[c]	692.6	1,551.2	1,413.6	1,410.1	1,408.2	1,463.2
Water[d]	565.5	753.3	801.3	851.3	998.1	1,102.8
Pipeline[e]	517	744.6	684.8	595.2	559.8	561.6
Gasoline other than highway, water, air reported to FHWA	524.2	474.4	428.0	428.1	472.2	237.0
Total	11,863.9	15,797.4	17,489.4	17,731.0	18,789.1	19,251.0

[a] Civilian only.

[b] Class I only.

[c] Certificated carriers only.

[d] Numbers are for fuel purchased domestically. An ERDA-sponsored study done by Booz, Allen reports an additional 2.14×10^{12} Btu of fuels purchased overseas in 1974 for U.S. Commerce purposes (see Table 2-14).

[e] An Aerospace study reports considerably higher energy consumption for pipelines: 742.1×10^{12} Btu for natural gas pipeline in 1970 (93% of which is natural gas consumption) and 387.4×10^{12} Btu for oil pipeline (78% of which is electricity consumption).

NA — Not available.

Sources: U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook*, Washington, D.C., annual; U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., annual; Tables MF-21 through MF-26 and Table VM-1, American Public Transit Association, *Transit Fact Book*, '75—'76 ed., Washington, D.C., p. 45; Interstate Commerce Commission, *Transport Statistics*, Washington, D.C., annual; Part 1 — Table 31, American Public Transit Association, *Transit Fact Book*, Washington, D.C., annual; p. 45; W. F. Gay, U.S. Department of Transportation, Transportation Systems Center, *Energy Statistics*, Cambridge, Mass., 1976, p. 117; Energy Information Administration, Energy Data Reports, *Petroleum Statement, Annual*, Washington, D.C., Energy Information Administration, *Annual Report to Congress*, Volume III, *Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978.

Table 2.8
Fuel Consumption by Mode of Transportation, 1965 through 1977 (in millions)

	1965	1970	1974	1975	1976	1977
Highway[a]						
Passenger car and taxi						
Gasoline, barrels	1,195.38	1,563.07	1,756.43	1,809.76	1,866.63	1,910.13
Motorcycles						
Gasoline, barrels	1.64	3.21	10.64	10.64	10.67	10.75
Bus						
Intercity						
Distillate fuel oil, barrels	6.49	7.27	4.57	4.31	4.34	4.33
School						
Gasoline, barrels	5.93	7.14	7.93	8.14	9.28	9.56
Local						
Gasoline, barrels	2.18	0.89	0.18	0.12	0.12	0.19[b]
Distillate fuel oil, barrels	5.91	6.44	7.53	8.69	9.27	9.59[b]
Liquefied gases, barrels	0.78	0.74	0.07	0.06	0.02	0.02[b]
Electricity, kWhr	181	143	NA	NA	NA	NA
Trucks						
Single unit						
Gasoline, barrels	321.52	410.40	502.98	520.67	593.20	625.12
Combination						
Gasoline, barrels	68.06	5.33	19.58	16.19		
Distillate fuel oil, barrels	85.06	145.83	220.92	216.28	261.31	278.80
Rail						
Local						
Electricity, kWhr	2,403	2,418	2,630	2,646	2,576	2,303[b]
Operating railroad[c]						
Passenger						
Distillate fuel, barrels	13.20	5.89	3.57	3.31	3.13	3.12
Electricity, kWhr	906	915	1,089	1,132	1,061	1,250
Freight						
Distillate fuel, barrels	75.91	84.79	96.19	87.45	91.55	93.80
Electricity, kWhr	603.18	426.41	401.10	422.01	253.44	417.41
Air[a]						
General aviation						
Gasoline, barrels	6.95	8.62	9.60	9.46	10.30	11.08
Jet fuel, barrels	1.93	9.87	11.50	12.13	14.00	16.92
Air carrier						
Gasoline, barrels	12.36	1.50	1.40	0.84	0.80	0.80
Jet fuel, barrels	110.71	270.83	248.03	247.92	247.62	257.33
Residual fuel oil, barrels	NA	0.03	0.03	0.03	NA	NA
Water[d]						
Residual fuel oil, barrels	73.64	89.86	91.12	96.67	118.50	128.97
Distillate fuel oil, barrels	15.52	19.50	24.26	26.14	29.05	33.51
Gasoline, barrels	2.29	14.24	16.59	17.37	18.19	18.43
Pipeline[e]						
Natural gas, ft^3	500,024	722,166	668,702	582,963	548,323	550,000[b]
Gasoline reported to FHWA other than used for highway, aviation or water, barrels	99.88	90.39	81.55	81.55	89.95	45.14

[a]Civilian only.

[b]Preliminary.

[c]Class I only.

[d]Numbers are for fuel purchased domestically. An ERDA-sponsored study done by Booz, Allen reports an additional 2.14×10^{12} Btu of fuels purchased overseas in 1974 for U.S. Commerce purpose (see Table 2-14).

[e]An Aerospace study reports considerably higher energy consumption for pipelines: 742.1×10^{12} Btu for natural gas pipeline in 1970 (93% of which is natural gas consumption) and 387.4×10^{12} Btu for oil pipeline (78% of which is electricity consumption).

NA – Not available.

Sources: U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook*, Washington, D.C., annual; U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., annual; Tables MF-21 through MF-26 and Table VM-1, American Public Transit Association, *Transit Fact Book*, '75–'76 ed., Washington, D.C., p. 45; Interstate Commerce Commission, *Transport Statistics*, Washington, D.C., annual; Part 1 – Table 31, American Public Transit Association, *Transit Fact Book*, Washington, D.C., annual; p. 45; W. F. Gay, U.S. Department of Transportation, Transportation Systems Center, *Energy Statistics*, Cambridge, Mass., 1976, p. 117; Energy Information Administration, Energy Data Reports, *Petroleum Statement, Annual*, Washington, D.C., Energy Information Administration, *Annual Report to Congress*, Volume III, *Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978.

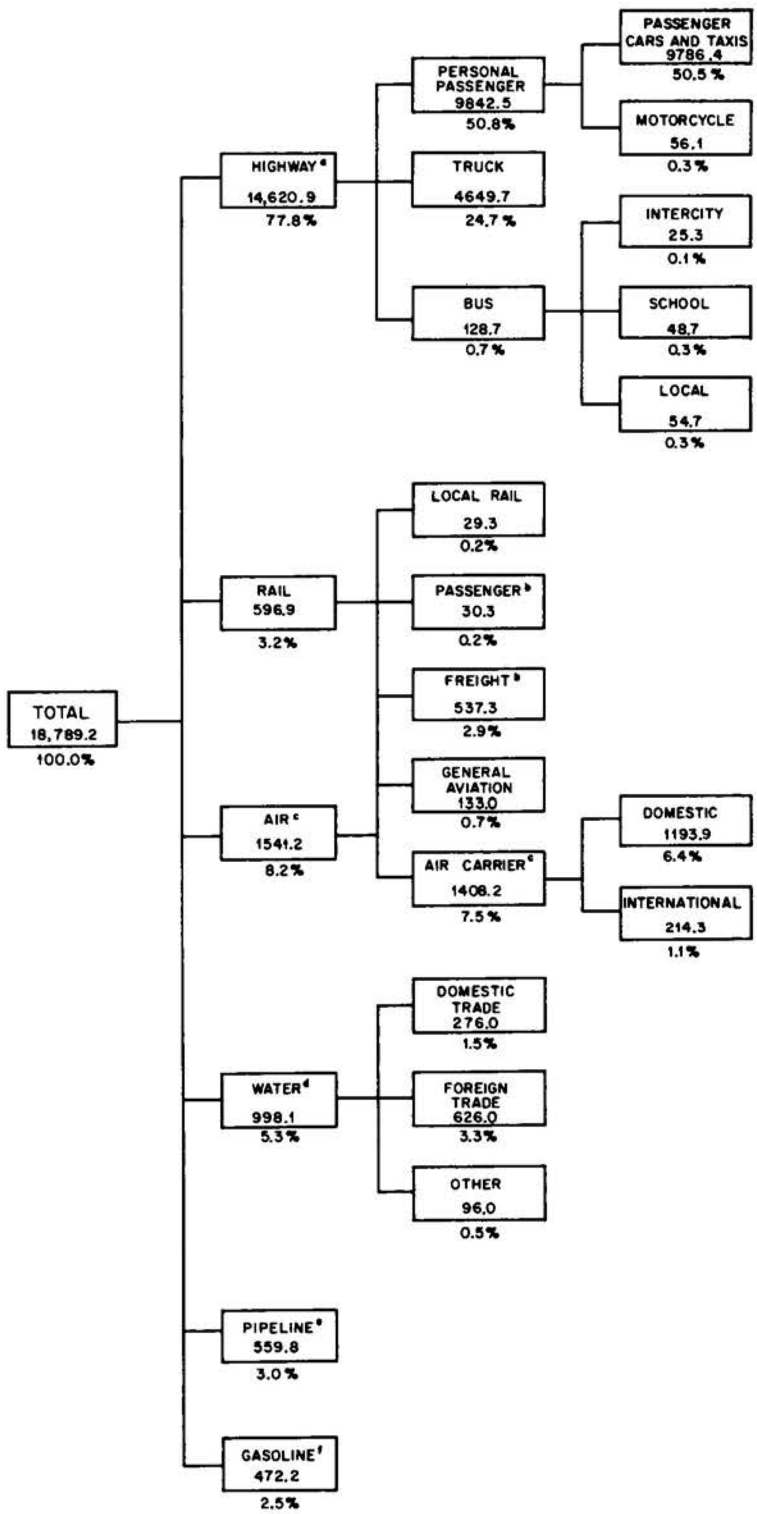

Fig. 2.3
Energy Used by Mode of Transport, 1976.
(10^{12} Btu)

[a]Civilian only.

[b]Class I only.

[c]Certificated carriers only.

[d]Numbers are for fuel purchased domestically. An ERDA-sponsored study done by Booz, Allen reports an additional 2.14×10^{12} Btu of fuels purchased overseas in 1974 for U.S. Commerce purposes.

[e]An Aerospace study reports considerably higher energy consumption for pipelines: 742.1×10^{12} Btu for natural gas pipeline in 1970 (93% of which is natural gas consumption) and 387.4×10^{12} Btu for all pipeline (78% of which is electricity consumption).

[f]Gasoline other than that used by highway, marine, or air which is reported to FHWA. This is probably gasoline used by pipelines.

Note: Figure 2.3 reflects unrevised data. Revised data received too late for inclusion in this figure. See Table 2.7 for revised data.

Sources: U.S. Department of the Interior, Bureau of Mines, *Minerals Yearbook*, Washington, D.C., annual; U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Washington, D.C., annual; Tables MF-21 through MF-26 and Table VM-1, American Public Transit Association, *Transit Fact Book, '75—'76 ed.*, Washington, D.C., p. 45; Interstate Commerce Commission, *Transport Statistics*, Washington, D.C., annual; Part 1 — Table 31, American Public Transit Association, *Transit Fact Book*, Washington, D.C., annual; p. 45; W. F. Gay, U.S. Department of Transportation, Transportation Systems Center, *Energy Statistics*, Cambridge, Mass., 1976, p. 117; Energy Information Administration, Energy Data Reports, *Petroleum Statement, Annual*, Washington, D.C., Energy Information Administration, *Annual Report to Congress*, Volume III, *Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978.

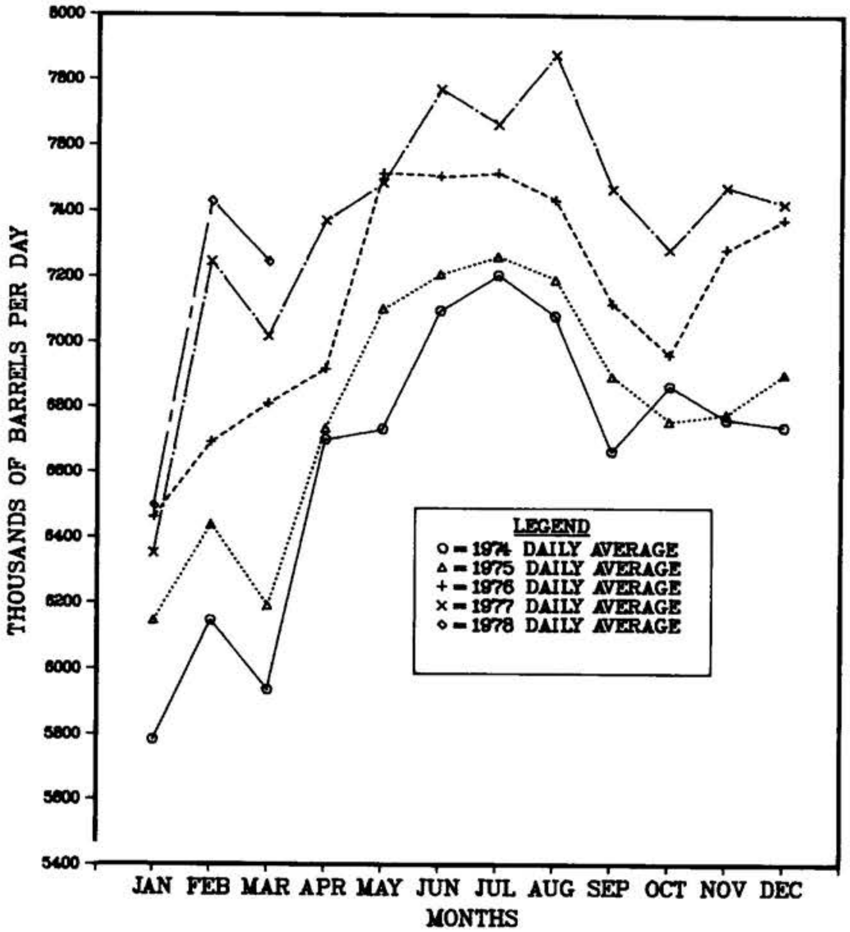

Fig. 2.4. Daily Average Consumption of Motor Gasoline by Month, 1974 through March 1978.

Table 2.9
Daily Average Consumption of Motor Gasoline by Month, 1974 through March 1978
(10^3 bbl/day)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1974	5,784	6,146	5,937	6,700	6,732	7,095	7,204	7,078	6,664	6,864	6,761	6,739
1975	6,146	6,439	6,190	6,733	7,100	7,207	7,261	7,190	6,893	6,756	6,779	6,902
1976	6,462	6,691	6,809	6,917	7,513	7,504	7,514	7,433	7,116	6,962	7,285	7,376
1977	6,351	7,245	7,017	7,370	7,484	7,768	7,663	7,875	7,467	7,283	7,473	7,423
1978	6,496	7,429	7,245									

Source: U.S. Department of Transportation, Federal Highway Administration, *Monthly Motor Gasoline Reported by States*, Washington, D.C., monthly.

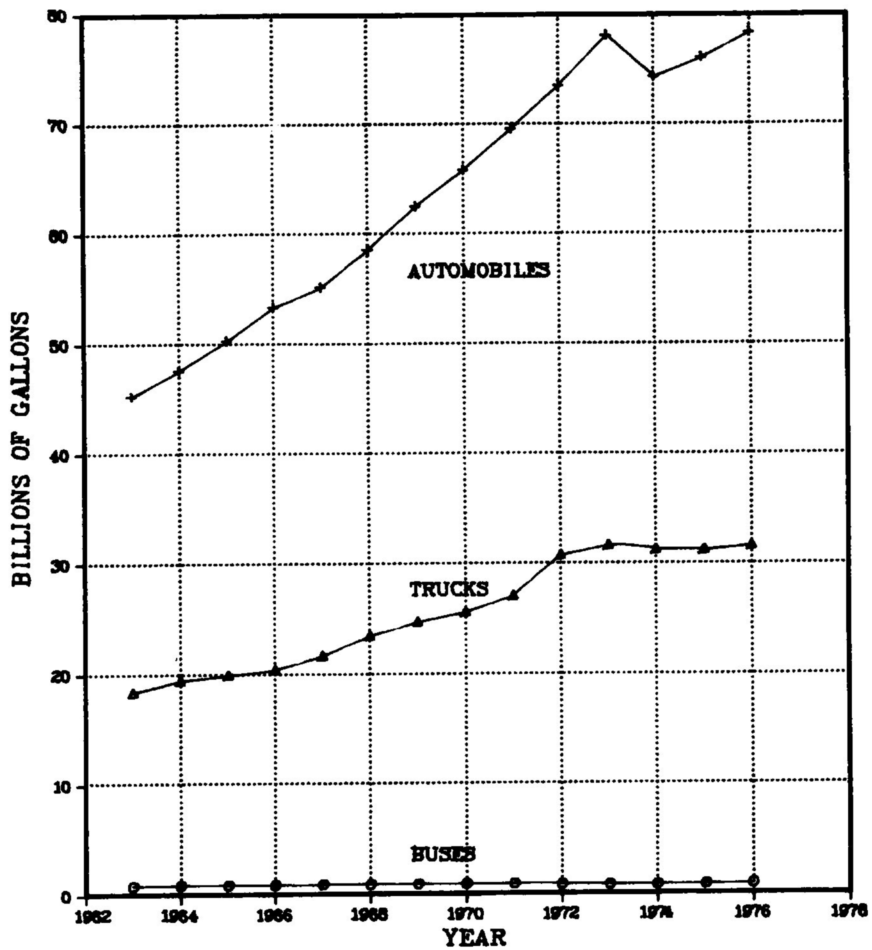

Fig. 2.5. Total Annual Fuel Consumption by Type of Vehicle, 1963 through 1976.

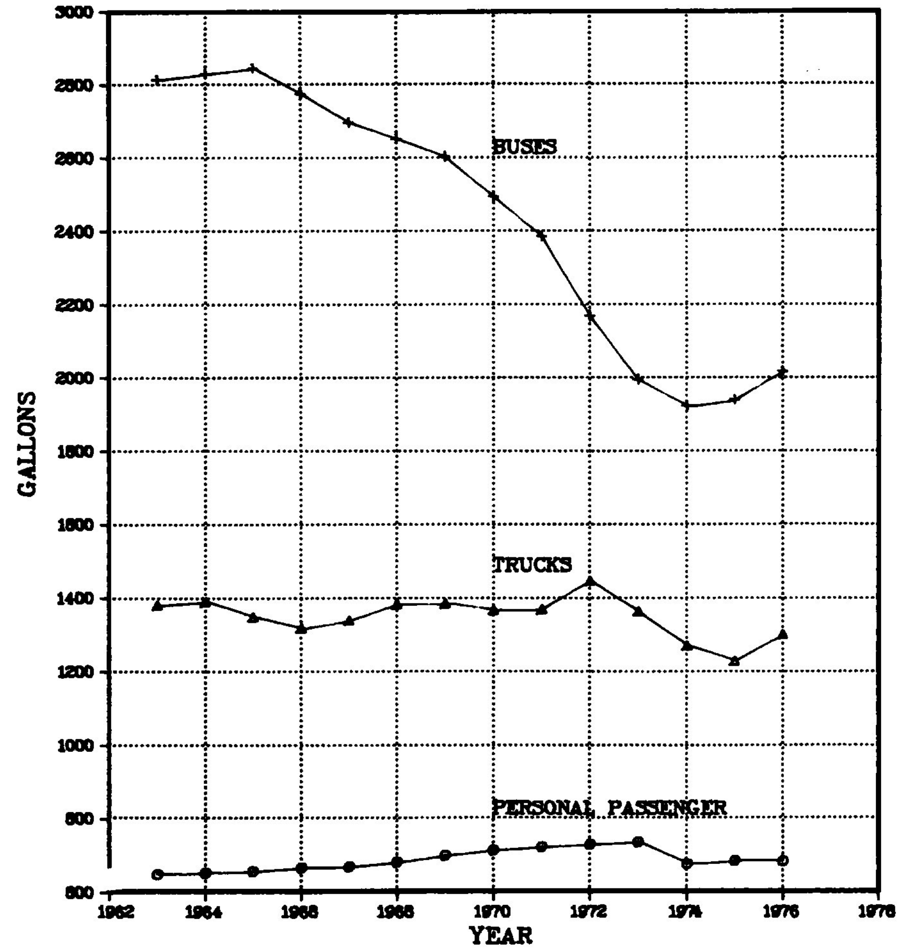

Fig. 2.6. Average Annual Fuel Consumption by Type of Highway Vehicle, 1963 through 1976.

Source: U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, Table VM-1, annual.

ENERGY USE BY MASS TRANSIT VEHICLES EXPERIENCED A STEADY DECLINE FROM 1940 TO 1971. BEGINNING IN 1972 THIS TREND WAS REVERSED THROUGH THE INCREASED USE OF BUS TRANSIT SYSTEMS AS EVIDENCED BY THE INCREASED USES OF NONELECTRICAL ENERGY SOURCES.

Table 2.10
Energy Use by Mass Transit Passenger Vehicles, 1950 through 1977
(10^{12} Btu)

	Electric[a]	Gasoline	Diesel[b]	Propane[b]	Total
1950	59.72	53.75	13.68	[c]	126.72
1955	40.15	30.75	23.94	2.78	97.39
1960	33.07	19.20	28.86	3.51	84.51
1965	29.39	11.44	34.45	3.00	78.22
1970	29.13	4.65	37.53	2.84	74.14
1971	29.07	3.68	35.62	2.43	70.78
1972	27.61	2.46	35.12	2.24	67.44
1973	26.51	1.54	39.20	1.39	68.66
1974	29.91	0.93	43.88	0.29	75.03
1975	30.09	0.63	50.63	0.23	81.61
1976[b]	29.30	0.65	53.98	0.09	84.05
1977[b]	26.19	1.01	55.87	0.10	83.20

[a]Assumes 30% generation and distribution efficiency.

[b]Preliminary.

[c]Propane included with gasoline.

Source: American Public Transit Association, *Transit Fact Book*, '77-'78 ed., Washington, D.C., June 1977, p. 38.

Table 2.11
Civilian Aviation Fuel Consumption, 1973 through 1977
(10^3 bbl)

	1973	1974	1975	1976	1977	Percent change 1976–1977
Air carriers						
AVGAS	1,522	1,363	837	800	795	–0.63
Jet fuel (kerosine)	263,412	239,144	247,610	247,481	256,948	3.83
Jet fuel (naphta)	7,422	8,883	309	142	384	170.42
Total, 10^{12} Btu	1,541.22	1,410.62	1,410.23	1,408.15	1,463.09	3.90
General aviation						
AVGAS	9,762	9,600	9,455	10,302	11,079	7.54
Jet fuel (kerosine)	8,542	11,147	11,373	13,397	16,424	22.59
Jet fuel (naphta)	404	358	760	607	503	–17.13
Total, 10^{12} Btu	101.43	115.12	117.79	132.86	153.52	15.55
Manufacturers						
AVGAS	224	169	150	119	86	–27.73
Jet fuel (kerosine)	2,988	3,004	2,156	2,220	2,113	–4.82
Jet fuel (naphta)	481	302	229	348	438	25.86
Total, 10^{12} Btu	20.69	19.53	14.23	15.07	14.77	–1.99
Total by fuel type						
AVGAS	11,508	11,132	10,442	11,221	11,960	6.59
Jet fuel (kerosine)	274,942	253,295	261,139	263,098	275,485	4.71
Jet fuel (naphta)	8,307	9,543	1,298	1,097	1,325	20.78
Total, 10^{12} Btu	1,663.33	1,545.26	1,541.99	1,556.07	1,631.38	4.84

Sources: Department of Energy, Energy Information Administration, *Energy Data Reports*, "Crude Petroleum, Petroleum Product, and Natural Gas Liquids," Washington, D.C., January 31, 1978, and earlier editions.

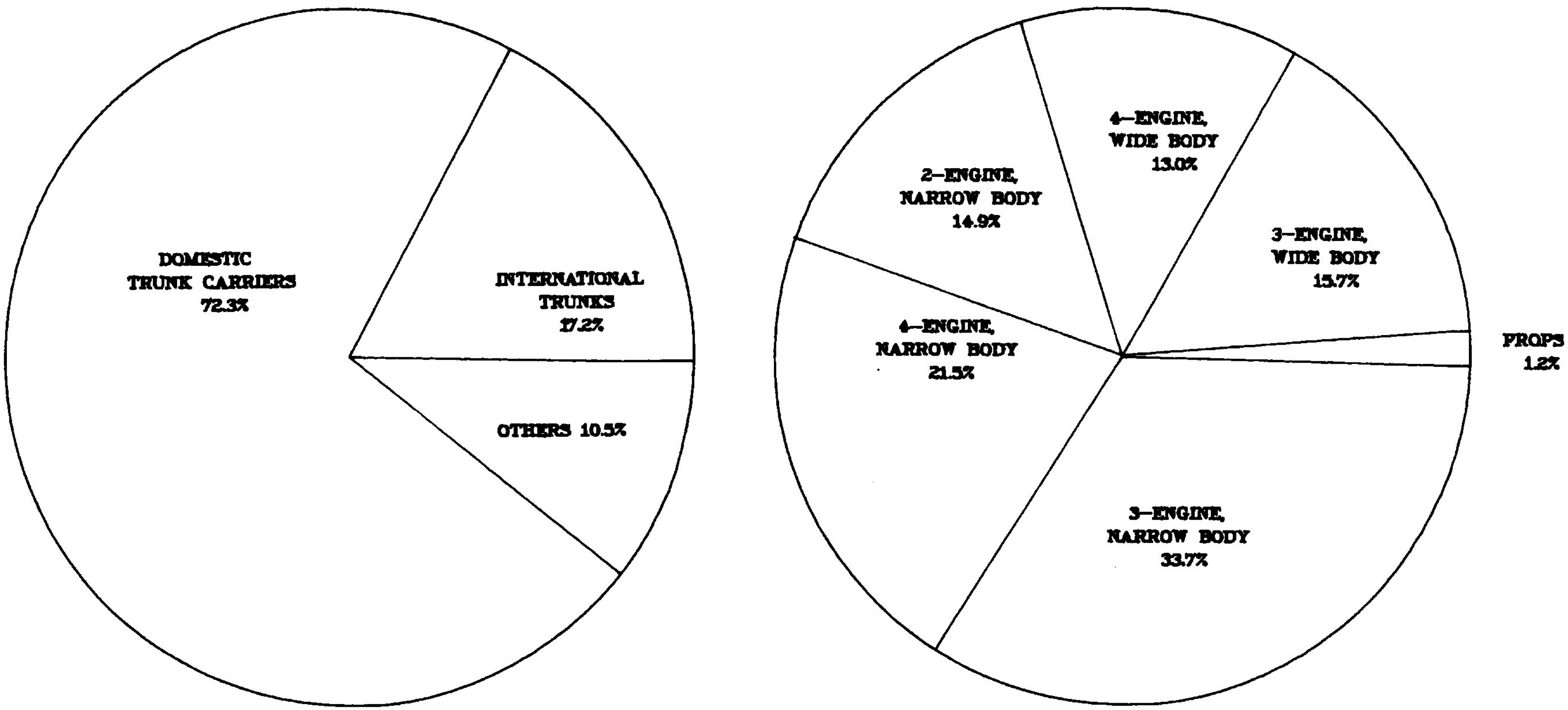

Fig. 2.7. Distribution of Certificated Air Carrier Fuel Use, 1976.
(total consumption = 9230 x 10^6 gal)

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41 Schedule T-2*, Washington, D.C., 1976.

Table 2.12
Domestic Sales of Bunkering Fuels, 1972 through 1976
(10^3 bbl)

	1972	1973	1974	1975	1976
Total					
Distillate fuel oil	22,125	26,786	24,757	26,138	27,050
Residual fuel oil	77,932	92,415	91,052	96,673	118,508
Btu × 10^{12}	619	737	717	608	903
Fuel used in domestic trade					
Distillate fuel oil	15,872	19,473	16,579	18,733	16,831
Residual fuel oil	35,409	35,566	29,687	30,828	28,379
Btu × 10^{12}	315	337	283	303	276
Fuel used in foreign trade					
U.S. flag vessels					
Distillate fuel oil	400	537	499	658	453
Residual fuel oil	9,938	13,501	14,106	12,601	17,845
Btu × 10^{12}	65	88	92	83	115
Foreign flag vessels					
Distillate fuel oil	5,853	6,776	7,679	6,747	9,766
Residual fuel oil	32,584	43,348	47,258	53,243	72,283
Btu × 10^{12}	239	312	342	374	511

Sources: U.S. Department of Commerce, Bureau of the Census, *U.S. Foreign Trade Bunker Fuels*, Washington, D.C., annual; Energy Information Administration, *Energy Data Reports, Fuel Oil Sales, Annual*, Washington, D.C., annual.

The ocean shipping sector (i.e. foreign trade) used 80% of the estimated 2.95 quads of energy used by the marine transportation industry in 1974, according to a recent study conducted under an ERDA contract (see table below).

Table 2.13
Productivity and Energy Use Summary of the Marine Transportation Industry, 1974

Type of marine transportation	No. of vessels	Tons of cargo moved (millions)[a]	Energy consumed (quads)	Percent of total energy consumed
Ocean	4,774	654.9	2.360	80.0
Great Lakes	692	175.3	0.052	1.8
Inland waterways	2,404	535.8	0.089	3.0
Coastal	1,934	213.0	0.112	4.0
Offshore	620		0.064	2.2
Pleasure craft	7,400,000		0.241	8.2
Fishing and misc.	90,300		0.032	0.8
Total	7,500,740	1,579	2.950	100.0

[a]Measured in long tons.

Source: Booz, Allen and Hamilton Inc., *Energy Use in the Marine Transportation Industry — Task I — Industry Summary*, Department of Energy, Transportation Energy Conservation Division, Washington, D.C., January 11, 1977, p. I-5. (Draft).

Currently only about 19% of the energy used for foreign shipping is actually purchased in the United States: 81% is purchased abroad. Over 90% of the total energy is used by vessels registered under foreign flags but engaging in U.S. commerce (see table below). Conventional estimates of energy use by the marine sector of the United States have not taken these facts into account.

Table 2.14
Point of Purchase of Marine Fuel, 1974
(in quads)

Trade	Point of purchase					
	U.S.		Overseas[a]		Total	
	Quads	Percentage	Quads	Percentage	Quads	Percentage
Domestic	0.37	63	0.22	37	0.59	100
Foreign[b]	0.44	19	1.92	81	2.36	100
U.S. flag	0.09	43	0.12	57	0.21	100
Foreign flag	0.35	16	1.80	84	2.15	100
Total	0.81	27	2.14	73	2.95	100

[a]Also includes fuels unaccounted for.

[b]Trade conducted by the ocean shipping sector.

Source: Booz, Allen and Hamilton Inc., *Energy Use in the Marine Transportation Industry — Task — Industry Summary*, Department of Energy, Transportation Energy Conservation Division, Washington, D.C., January 11, 1977, p. I-10. (Draft). (Original source: U.S. Department of Commerce, Bureau of the Census, *Bunker Fuels*.)

A change in the buying pattern indicated above could significantly influence total U.S. energy demand and consumption. For example, all Alaskan oil must be transported on U.S. ships. Therefore, it is expected that domestic energy use will increase. Also, if these U.S. ships "fuel up" (bunker) at U.S. ports, the total energy use in the U.S. will increase.

Section 2.2

Energy Intensity and Efficiency

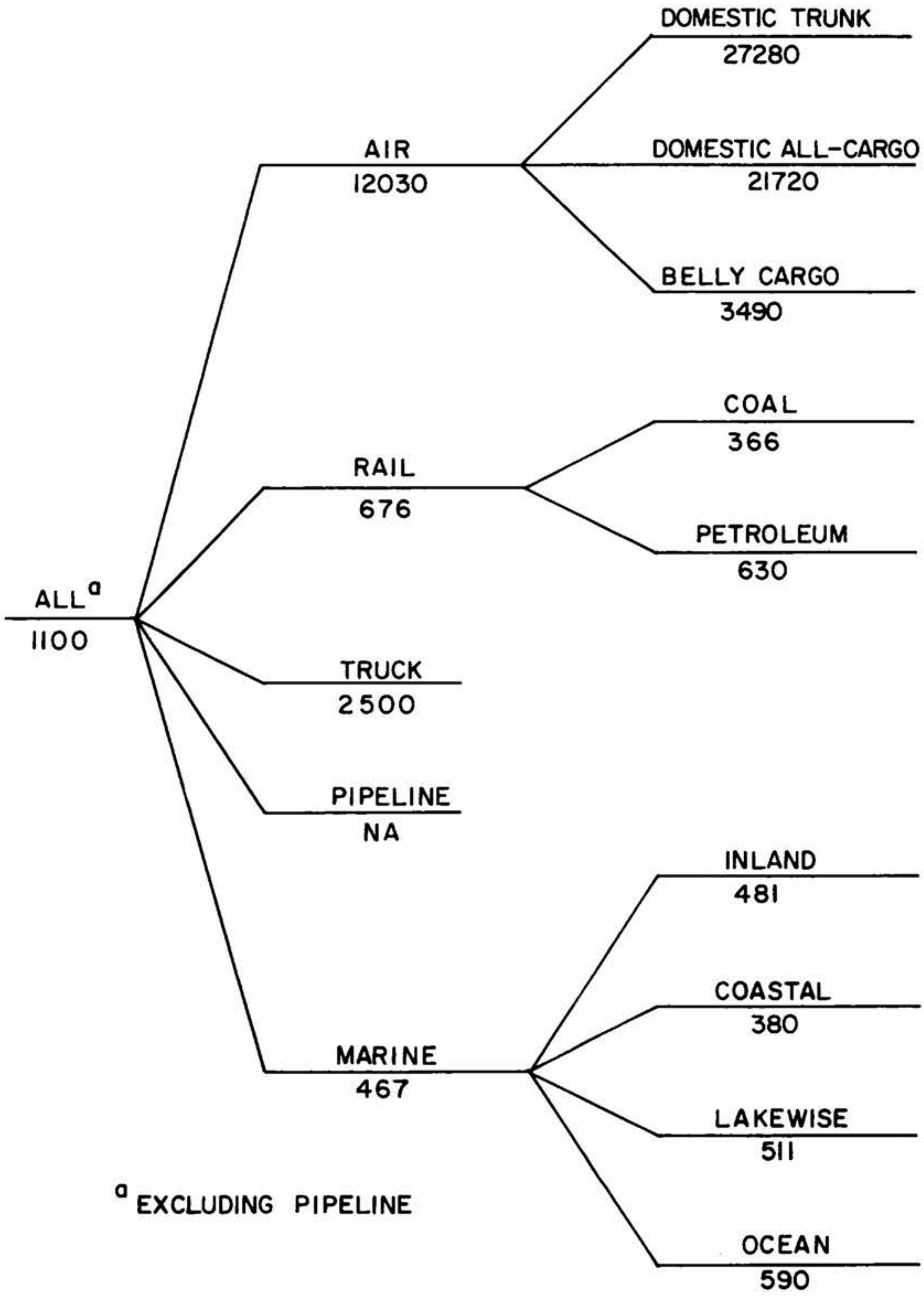

Fig. 2.8. Domestic Freight Energy Intensity, 1976.
(Btu/route-ton-mile)

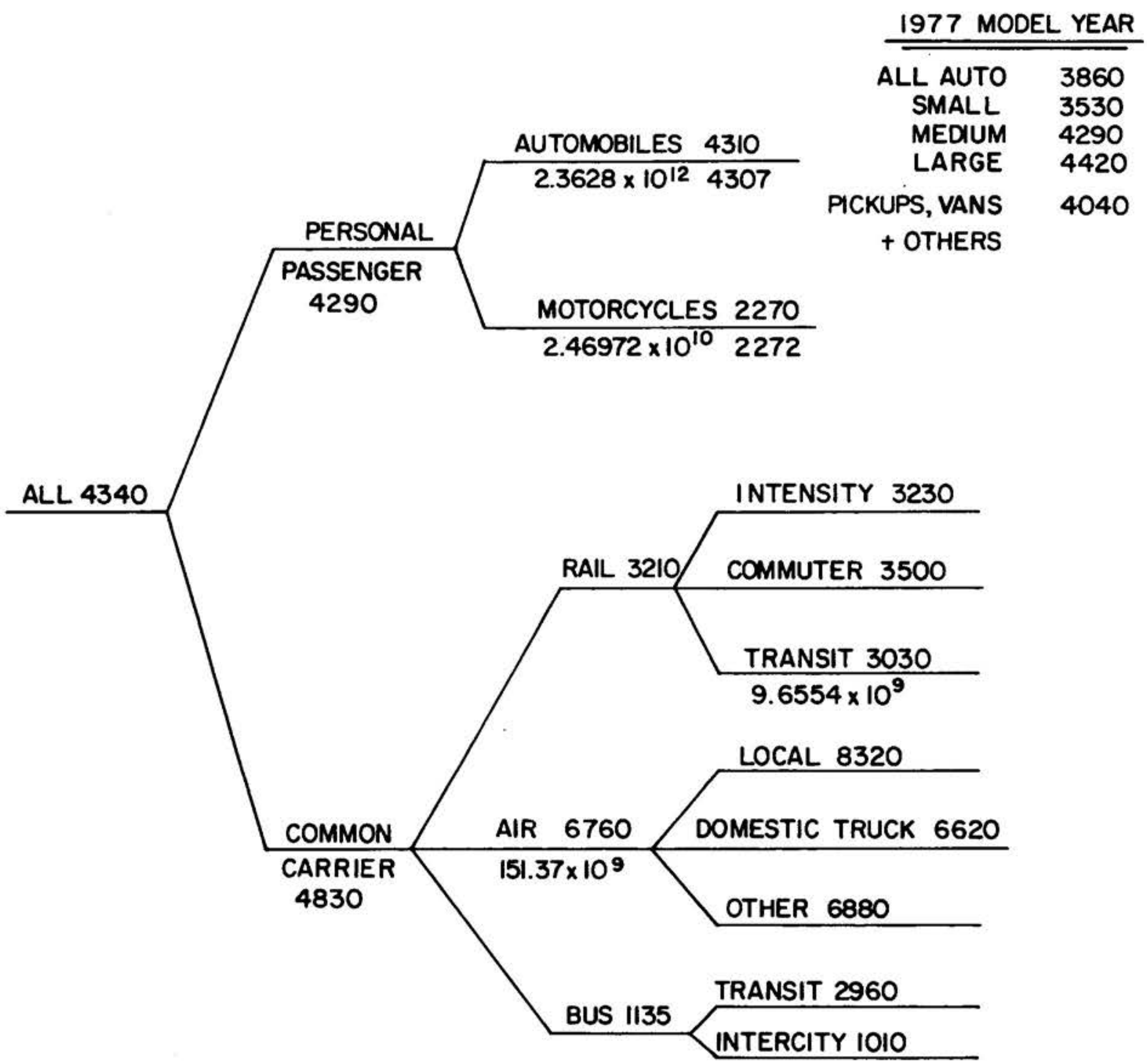

Fig. 2.9
1976 Estimates of Passenger Transportation Energy Intensity.
(Btu/route-passenger-mile)

EACH YEAR NEW MOTOR VEHICLES ACCOUNT FOR ROUGHLY 10% OF ALL REGISTERED AUTOMOBILES. THEREFORE, THERE IS A TIME LAG BEFORE THE NEW CAR FUEL ECONOMY CAN SIGNIFICANTLY AFFECT THE FLEET AVERAGE.

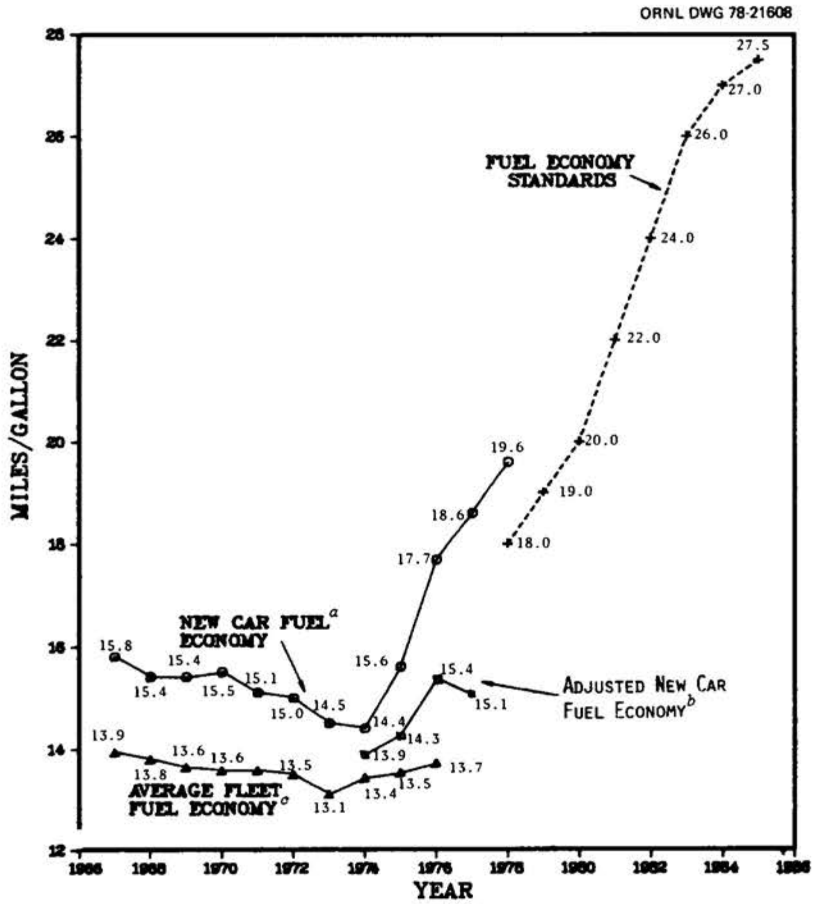

Fig. 2.10. Automobile Fuel Economy and Standards 1967 to 1985.

[a]Based on 1975 Federal Test Procedure (FTP) city/highway-weighted. For the 1975—1978 model years, the new car fuel economy is sales-weighted by manufacturers' sales forecast data. For earlier model years, production data was utilized.

[b]The sales-weighted FTP value adjusted by the values given in Table 2.16 to on-road fuel economy values.

[c]As calculated by the FHWA.

Sources: J. D. Murrel, *Light Duty Automotive Fuel Economy...Trends Through 1978*, SAE Paper 780036, 1978; U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics*, annual; U.S. Department of Transportation, National Highway Traffic Safety Administration, *Automotive Fuel Economy Program, Second Annual Report to Congress*, Washington, D.C., January 1978.

THE FIRST YEAR SINCE 1974 IN WHICH THERE WERE NO SUBSTANTIAL FUEL ECONOMY IMPROVEMENTS IN MOST INERTIA WEIGHT CLASSES WAS 1978. THE IMPROVEMENT IN THE ESTIMATED MODEL YEAR FUEL ECONOMY OVER 1977 IS ALMOST EXCLUSIVELY DUE TO ANTICIPATED SALES SHIFTS TO LIGHTER, MORE EFFICIENT AUTOMOBILES.

THE WEIGHT OF AN AUTOMOBILE IS AN IMPORTANT FACTOR IN DETERMINING ITS FUEL ECONOMY. (AS THE INERTIA WEIGHT INCREASES, THE FUEL ECONOMY DECREASES.) THE FIGURE AND TABLE BELOW SHOW THE EPA-ESTIMATED FUEL ECONOMY (IN MILES PER GALLON) BY INERTIA WEIGHT CLASS FOR MODEL YEARS 1957-1977. THE DIFFERENCE IN FUEL ECONOMY FROM THE LOW-AVERAGE MPG TO THE HIGH-AVERAGE MPG RANGES FROM A 100% TO A 200% INCREASE FOR MOST OF THE MODEL YEARS.

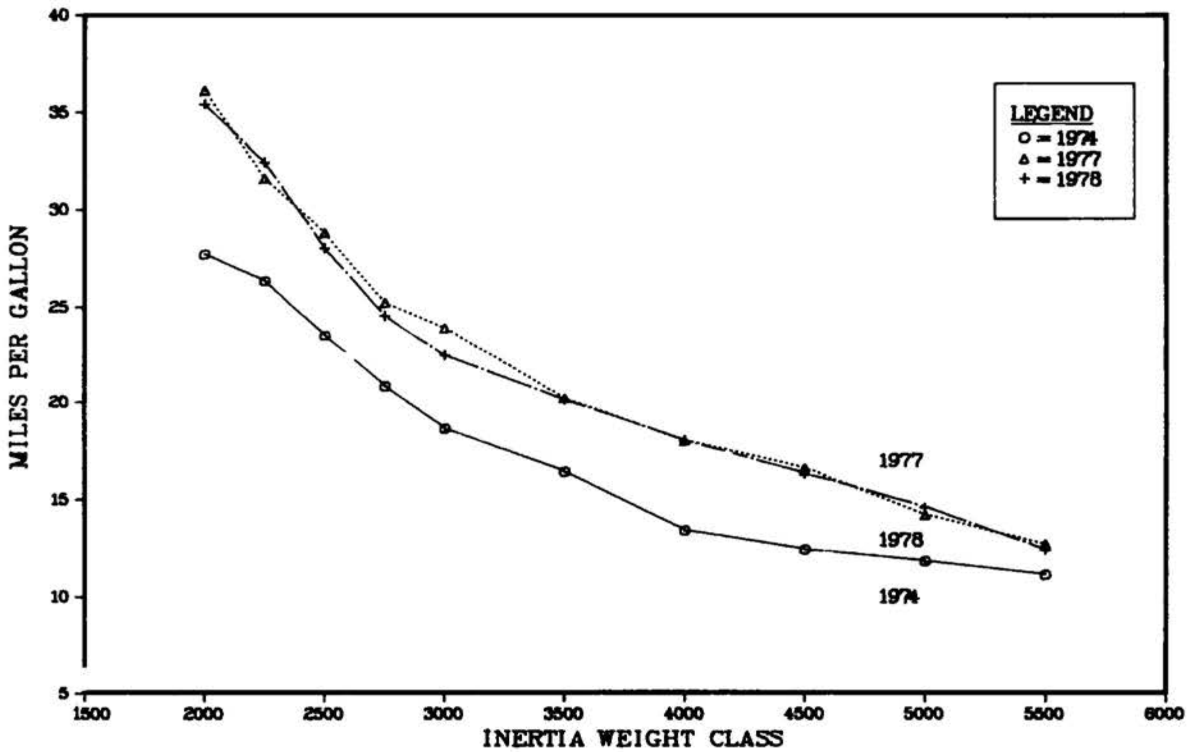

Fig. 2.11. Automobile Fuel Economy for Various Weight Classes by Model Year. (mpg)

Source: J. D. Murrell, *Light Duty Automotive Fuel Economy - Trends Through 1978*, SAE Paper 780036.

Table 2.15
City/Highway Sales-Weighted[a] Passenger Car Fuel Economy by Inertia Weight Class, Model Years 1970 through 1978
(mpg)

Model year	Inertia weight class (lb)										Sales-weighted average
	2000	2250	2500	2750	3000	3500	4000	4500	5000	5500	
1970	27.9	27.1	23.3	22.6	19.5	16.2	14.6	13.6	12.8	10.2	15.5
1971	26.4	26.7	25.5	21.6	19.7	15.5	14.5	13.1	11.6	12.5	15.1
1972	26.6	25.7	23.2	23.8	18.8	15.7	14.3	13.1	12.5	11.3	15.0
1973	26.9	26.6	23.0	21.5	17.5	15.0	13.9	13.2	11.6	10.8	14.5
1974	27.7	26.3	23.5	20.8	18.6	16.4	13.4	12.4	11.8	11.1	14.4
1975	31.4	27.9	24.3	22.2	21.4	17.5	15.6	14.6	13.0	12.0	15.6
1976	32.1	28.7	26.0	24.4	23.4	19.1	17.3	15.5	14.6	13.3	17.7
1977	36.1	31.6	28.8	25.2	23.9	20.2	18.0	16.6	14.2	12.7	18.6
1978	35.4	32.4	28.0	24.5	22.4	20.1	18.0	16.3	14.6	12.4	19.6

[a] 1970–1973 data are from registration summations. 1974 data are based on production figures, and 1975–1978 data are based on manufacturers' sales forecasts.

Source: J. D. Murrell, *Light Duty Automotive Fuel Economy — Trends Through 1978*, SAE Paper 780036.

THERE ARE SUBSTANTIAL DIFFERENCES BETWEEN THE EPA CERTIFICATION AND THE ACTUAL ON-ROAD FUEL ECONOMY OF AUTOMOBILES. FURTHERMORE, THESE DIFFERENCES HAVE BEEN INCREASING OVER THE YEARS. SUBSTANTIAL PORTIONS OF THESE DIFFERENCES MAY BE ATTRIBUTED TO THE OPERATION OF AUXILIARIES (AIR CONDITIONING, ETC.) WHICH ARE SHUT OFF DURING TESTING, THE CARRYING OF PASSENGERS OR BAGGAGE IN ACTUAL USE, THE DIFFERENCES IN THE CONTROLLED LABORATORY AND ACTUAL OPERATING ENVIRONMENTAL CONDITIONS (TEMPERATURE, HUMIDITY), DIFFERENCES IN THE ACTUAL DRIVING PATTERNS TO THE TEST PROCEDURE, AND THE EFFECTS OF ROAD CURVES AND GRADES.

Table 2.16
EPA Certification vs Actual On-Road Fuel Economy, Model Years 1974 through 1977

	1974	1975	1976	1977
Regression equation, On-Road mpg (y) to EPA mpg (x)	$y = 0.65x + 4.38$	$y = 0.81x + 1.63$	$y = 0.74x + 2.32$	$y = 0.65x + 2.98$
Mean certification mpg	14.0	15.5	18.6	19.5
Mean on-road mpg	13.4	14.1	16.0	15.7
Difference (x-y) for car with 20-mpg on-road economy	4.0	2.7	3.9	6.2
Difference for car with EPA sales-weighted mpg	0.5	1.3	2.3	3.5

Source: B. D. McNutt, D. Pirkey, R. Dulla, C. Miller, *A Comparison of Fuel Economy Results from EPA Tests and Actual In-Use Experience, 1974–1977 Model Year Cars*, Department of Energy, Washington, D.C., February 1978.

TO YIELD REALISTIC ESTIMATES, THE EPA CERTIFICATION DATA MUST BE MODIFIED TO TAKE INTO ACCOUNT ACTUAL OPERATING CONDITIONS. THE VALUES IN THE TABLE BELOW WERE DERIVED BY DERATING THE EPA CITY/HIGHWAY MPG BY THE VALUES GIVEN IN TABLE 2.16 AND BY ASSESSING AN ADDITIONAL 4% FUEL PENALTY FOR EACH 10% INCREASE IN VEHICLE WEIGHT.

Table 2.17
U.S. Automobile[a] Energy Intensity, Model Year 1977
(Btu/passenger-mile)[b]

Number of passengers[c]	Passenger automobiles[d]				Station wagons[d]			All cars
	2-seat	Small	Medium	Large	Small	Medium	Large	
1	7,837	7,408	9,061	9,325	6,628	9,293	9,376	8,268
2	3,989	3,770	4,592	4,726	3,384	4,709	4,749	4,199
3		2,560	3,104	3,194	2,304	3,206	3,207	2,508
4		1,956	2,360	2,429	1,766	2,421	2,437	2,170
5			1,915	1,971	1,445	1,963	1,977	1,921
6				1,666		1,659	1,670	1,665
7							1,451	1,451
8							1,288	1,288

[a]Including domestics and imports.

[b]All values are calculated on a route-mile basis. To convert these to a great-circle mile basis they should be multiplied by the intercity automobile circuity ratio of 1.212. No circuity data for urban uses are available.

[c]Including driver.

[d]Size classes were defined based on interior volume: small <110 ft^3; medium 110–120 ft^3; large >120 ft^3; small station wagon <130 ft^3; medium station wagon 130–160 ft^3; large station wagon >160 ft^3.

Source: J. D. Murrell, *Light Duty Automotive Fuel Economy...Trends Through 1978*, SAE Paper 780036, March 1978; B. D. McNutt et al., *A Comparison of Fuel Economy Results From EPA Tests and Actual In-Use Experience, 1974-1977 Model Year Cars*, Washington, D.C., February 1978; C. W. La-Pointe, *Potential for Automotive Fuel Economy Improvement*, presented at the Fourth National Conference On the Effects of Energy Constraints on Transportation Systems, CONF-770878, August 1977; Wards Communications Inc., *Ward's 1978 Automotive Yearbook*, Detroit, Mich., 1978.

A LARGE PROPORTION OF THE AUTOMOBILES MANUFACTURED EACH YEAR HAVE A SERIES OF OPTIONS INSTALLED WHICH SIGNIFICANTLY AFFECT THE FUEL ECONOMY OF THE VEHICLES.

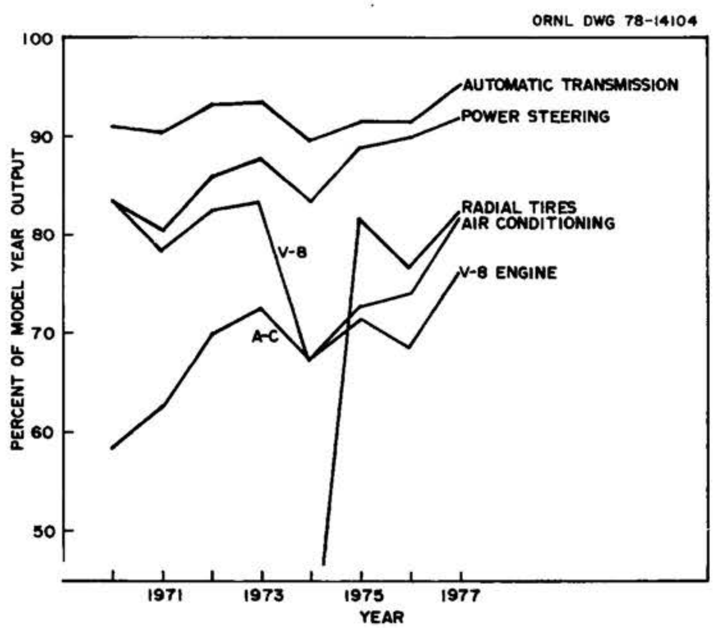

Fig. 2.12. Factory Installations of Popular Options in New Automobiles by Model Year.

Source: Crain Automotive Group, *Automotive News, Market Data Book Issue,* 1971–1978 ed., Detroit, Mich.

Table 2.18
Energy Use Effects of Popular Options

Option	Approximate change in fuel economy
Air conditioning	–13%
Automatic transmission	–14 to 15.5%
Power steering	≥–1%
Radial tires	+2–2.5%
V-8 engine	–18.5%

Source: A. B. Rose, *The Energy Itensity and Related Parameters of Selected Passenger Transportation Modes,* ORNL-5506, Oak Ridge, Tenn., 1979.

THE DEGREE TO WHICH THE ENGINE IS WARMED UP IS AN IMPORTANT DETERMINANT OF AUTOMOBILE FUEL EFFICIENCY. THE COMBINED EFFECTS OF REDUCED LUBRICANT EFFICIENCY AT LOWER TEMPERATURE AND THE HEAT ABSORBED BY THE ENGINE IN RISING TO ITS OPERATING TEMPERATURE CAUSE THE SEVERE DEGRADATION IN FUEL ECONOMY DEPICTED IN FIG. 2.13. AFTER APPROXIMATELY 10 MILES OF DRIVING, THE ENGINE IS FULLY WARMED UP AND THE CUMULATIVE FUEL ECONOMY APPROACHES THE FULLY WARMED UP VALUE ASYMPTOTICALLY AS THE CAR IS DRIVEN FURTHER.

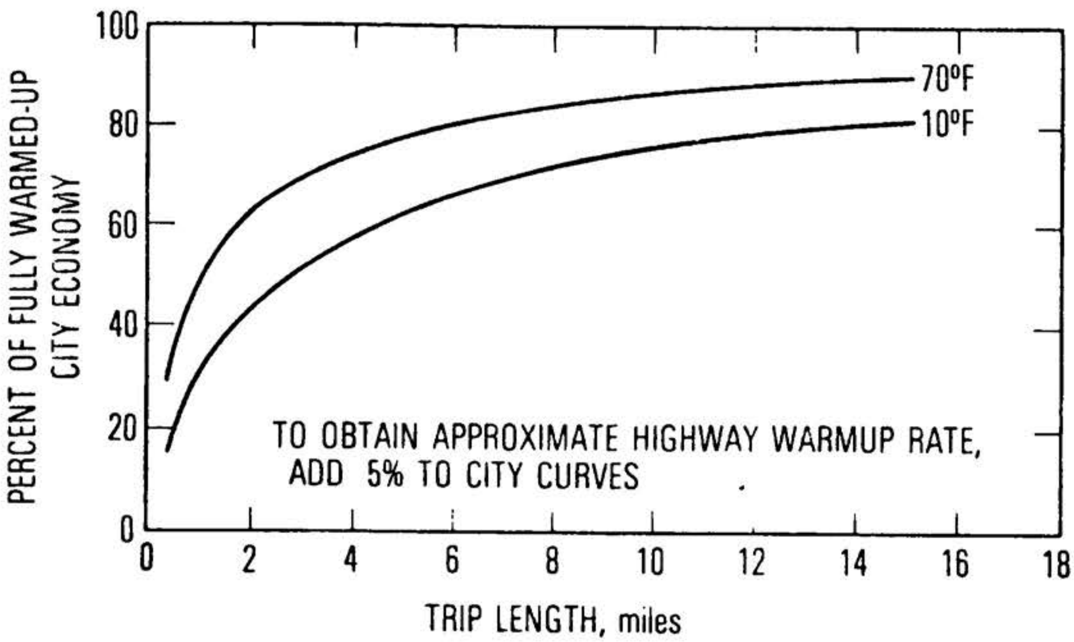

Fig. 2.13. Variation of Automobile Fuel Economy with Trip Length Due to Engine Warm-up.

Source: T. Iura, W. U. Roessler, and H. M. White, *Research Plan for Achieving Reduced Automotive Energy Consumption*, Aerospace Report No. ATR-76 (7467)-1, National Science Foundation, Washington, D.C., 1975, Fig. 2-4.

Table 2.19
Weight Class Distribution for Light-Duty Trucks, Model Years 1975 through 1978

Weight class (lb)	Model Year			
	1975	1976	1977	1978
2750	.1284	.2349	.1554	.1321
3000	.0739	.1319	.1044	.1293
3500	.0274	.0663	.0404	.0599
4000	.2684	.3057	.3247	.3528
4500	.4466	.2332	.3587	.3093
5000	.0552	.0279	.0165	.0166

[a]Data based on manufacturers' sales estimates.

Source: J. D. Murrell, *Light Duty Automotive Fuel Economy — Trends Through 1978*, SAE Paper 780036.

Table 2.20
Sales-Weighted[a] Fuel Economy[b] for Light-Duty Trucks, Model Years 1975 through 1978

Inertia weight (lb)	Fuel economy (mpg)			
	1975	1976	1977	1978
2750	22.3	24.3	25.6	25.9
3000	18.8	20.2	25.5	25.0
3500	20.6	17.7	18.2	18.3
4000	15.6	17.3	19.0	18.3
4500	14.1	14.8	16.7	15.8
5000	11.5	13.1	12.5	18.2
All	15.4	18.0	19.1	18.7

[a]Data based on manufacturers' sales estimates.

[b]EPA urban/highway mpg.

Source: J. D. Murrell, *Light Duty Automotive Fuel Economy — Trends Through 1978*, SAE Paper 780036.

THE USE OF LIGHT TRUCKS AND VANS IS GAINING SUBSTANTIAL POPULARITY. PRESENTED IN THE TABLE BELOW ARE THE ENERGY INTENSITIES TO BE EXPECTED OF THESE VEHICLES WHEN USED FOR PERSONAL TRANSPORTATION.

Table 2.21
U.S. Light Duty Truck Energy Intensity[a],
Model Year 1977
(Btu/passenger-mile)[b]

No. of passengers[c]	Small pickups	Standard pickups	Vans and others
1	6,187	8,669	8,515
2	3,160	4,395	4,324
3	2,154	2,972	2,928
4			2,231
5			1,814
6			1,537
7			1,339
8			1,192
9			1,078
10			987
11			914
12			853

[a]Including domestics and imports.

[b]All values are calculated on a route-mile basis. To convert these to a great-circle-mile basis they should be multiplied by the intercity automobile circuity ratio of 1.212. No circuity data for urban uses are available.

[c]Including driver.

Source: A. B. Rose, *The Energy Intensity of 1977 Model Year Automobiles and Light Duty Trucks*, Oak Ridge National Laboratory, Oak Ridge, Tenn., October 1978, unpublished.

THE LARGE INTERCITY TRUCKS, WITH GROSS VEHICLE WEIGHTS OVER 65,000 LB, SHOULD BE SINGLED OUT BECAUSE THEY ACCOUNT FOR THE OVERWHELMING MAJORITY OF ALL TRUCK CARGO TON-MILES. THEIR ENERGY INTENSITY UNDER ACTUAL OPERATING CONDITIONS IS APPROXIMATELY 2500 BTU/ROUTE-TON-MILE. HOWEVER MANY OF THE NEW TRUCKS ENTERING THE FLEET ARE EQUIPPED WITH A SERIES OF ENERGY-SAVING OPTIONS WHICH WILL DECREASE THIS VALUE SUBSTANTIALLY IN THE NEAR FUTURE. THE SAVINGS POTENTIAL FROM THESE OPTIONS, OUTLINED IN TABLE 2.22, ARE BASED ON THE ACTUAL OPERATING EXPERIENCE FROM THE TRUCKS ALREADY SO EQUIPPED.

Table 2.22
Energy Efficiency Improvements Possible Through Selected Options

Option	% efficiency improvement
Aerodynamic aids (wind deflector, fairings)	5% (mostly around 3%)
Demand actuated fans	6%
Radial tires	10%
Fuel economy engines	20%
Multiple trailers	
Doubles	5%
Triples	28%

Source: Jack Faucett Associates Inc., *Truck Fleet Experience with Fuel Economy Improvement Measures*, Chevy Chase, Md., 1976.

BUSES SERVE A LARGE VARIETY OF TRANSPORTATION NEEDS. THE INTERCITY BUS IS THE MOST ENERGY EFFICIENT OF THE PUBLIC PASSENGER TRANSPORTATION MODES.

Table 2.23
Summary of Bus Energy Intensities, 1970 through 1977

	Trolley coaches (Btu/VMT)	Transit buses (Btu/VMT)[a]	School buses (Btu/VMT)	Intercity buses	
				(Btu/VMT)[a]	(Btu/PM)[b]
1970	49,300	32,500	17,710	NA	NA
1971	52,100	30,420	17,710	NA	NA
1972	50,800	30,540	16,820	22,850	1,050
1973	41,200	30,800	16,820	22,840	1,020
1974	NA	31,520	16,850	22,300	960
1975	44,300	33,750	16,960	22,280	990
1976	NA	34,600	16,890	22,620	1,010
1977	NA	35,100		22,890	980

[a]Large system-to-system variations exist within this category.

[b]These values are calculated on a route-mile basis. For purposes of intermodal comparisons they should be multiplied by a circuity factor of 1.114 to convert them to a great-circle-mile basis.

NA — Not available.

Note: VMT — vehicle-miles traveled.
PM — passenger-mile.

Sources: American Bus Association, *America's Number 1 Passenger Transportation Service*, Washington, D.C., 1977, supplemented with private communications with the American Bus Association; American Public Transit Association, *Transit Fact Book, '76-'77 ed.*, Washington, D.C., June 1977.

SINCE THE NUMBER OF PASSENGER-MILES TRAVELED ON BUS TRANSIT SYSTEMS IS NOT KNOWN, ONE MUST CALCULATE ALL PASSENGER ENERGY INTENSITIES PARAMETRICALLY BY ASSUMING A TRIP LENGTH.*

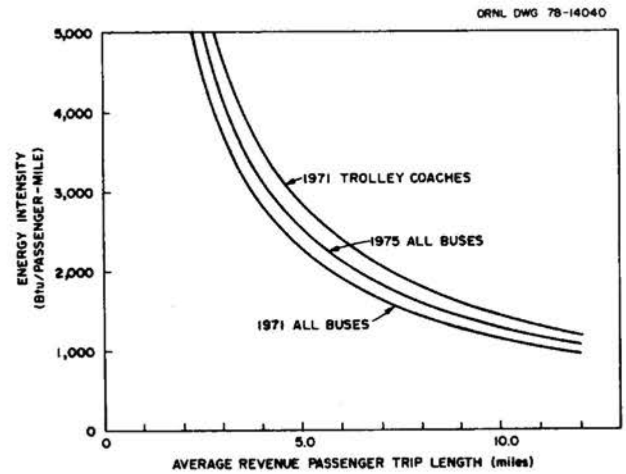

Fig. 2.14. Variation of Transit Bus Energy Intensity with Passenger Trip Length.

*Calculated given that the energy intensity = total energy used (number of passengers x trip length). The mean trip length in 1971 was 4.38 miles. Base data for other years: 1974, 45.11 x 10^{12} Btu, 4057.1 x 10^6 trips; 1975, 51.51 x 10^{12} Btu, 4150.9 x 10^6 trips; 1976, 54.72 x 10^{12} Btu, 4221.9 x 10^6 trips.

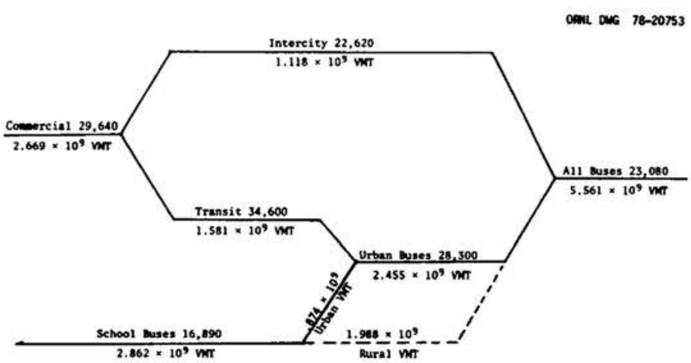

Fig. 2.15. Bus Energy Intensity and VMT Summary 1976. (Btu per route vehicle-mile)

Source: A. B. Rose, *The Energy Intensity and Related Parameters of Selected Passenger Transportation Modes*, ORNL-5506, Oak Ridge, Tenn., 1979.

THE ENERGY INTENSITY OF THE CERTIFICATED ROUTE AIR CARRIER PASSENGER SERVICE HAS SHOWN MARKED IMPROVEMENTS SINCE 1971.

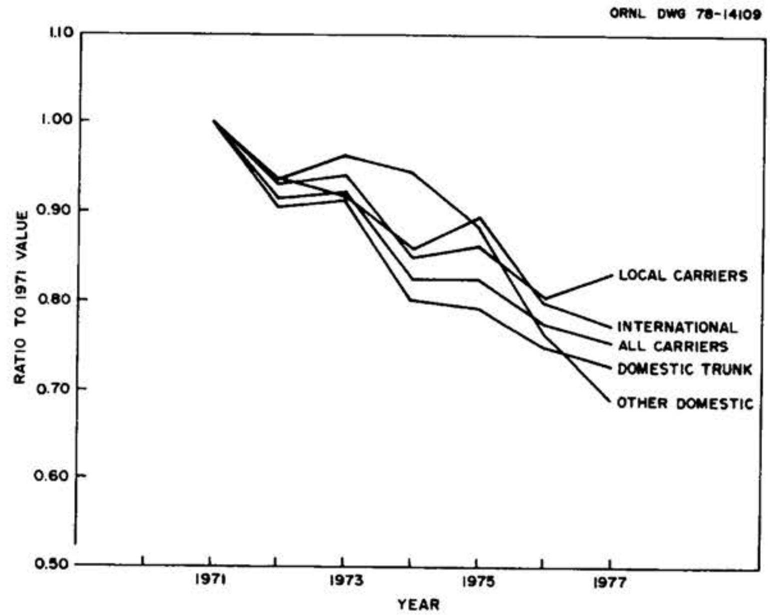

Fig. 2.16. Certificated Route Air Carrier Energy Intensity in Btu Per Passenger-mile, 1971–1977, Normalized to 1971 Values.

Table 2.24
Certificated Air Carrier Passenger Energy Intensity, 1971 through 1977

	Domestic		International		Total	
	Btu/PM	% load factor	Btu/PM	% load factor	Btu/PM	% load factor
1971	8920	48.6	6540	56.6	8290	50.5
1972	8130	52.6	6080	60.3	7590	54.5
1973	8200	52.2	6020	58.4	7650	53.6
1974	7240	55.9	5630	56.8	6870	56.1
1975	7180	55.0	5860	54.4	6870	54.9
1976	6760	56.2	5230	58.6	6440	56.7
1977[a]	6580	56.6	5070	59.9	6260	57.2

[a]Based on data for first three quarters.

Note: PM – passenger-mile.

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41 Schedule T-2*, Washington, D.C., 1970–1977.

THESE LARGE IMPROVEMENTS IN ENERGY INTENSITY ARE DUE TO A COMBINATION OF IMPROVED LOAD FACTORS AND A SERIES OF OPERATIONAL IMPROVEMENTS SUCH AS REDUCED CRUISING SPEEDS, IMPROVED MAINTENANCE, USE OF CRUISE CLIMB, REDUCED HOLDING, AND GROUNDING OF INEFFICIENT AIRCRAFT. IT IS POSSIBLE TO DIFFERENTIATE BETWEEN THESE EFFECTS IN AN ANALYTICAL FASHION AT THE AIRCRAFT CLASS LEVEL.

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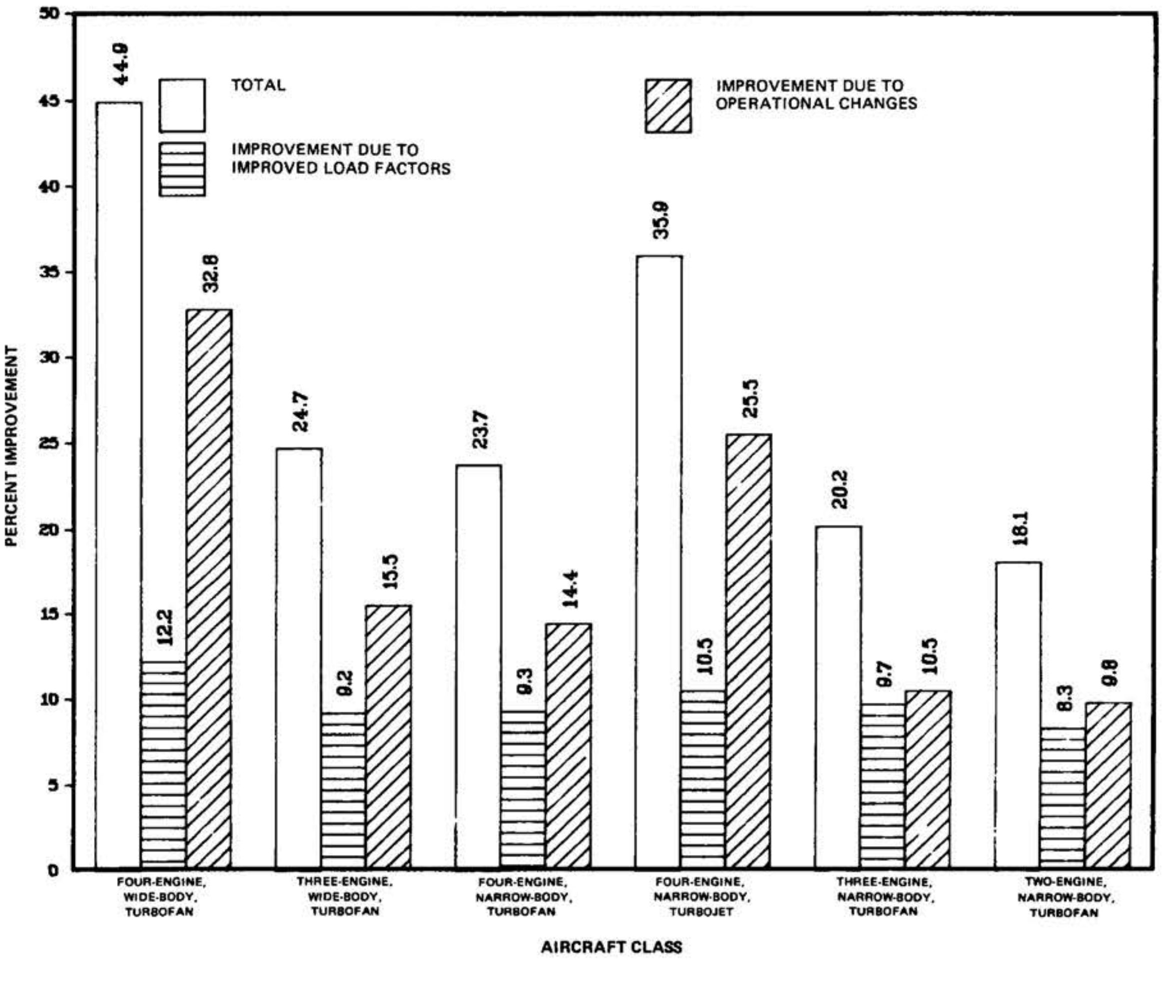


Fig. 2.17. Summary Breakdown of Aircraft Efficiency Improvement, 1971–1976.

Source: A. B. Rose, *The Energy Intensity and Related Parameters of Selected Passenger Transportation Modes*, ORNL-5506, Oak Ridge, Tenn., 1979.

ORNL DWG 78-20747

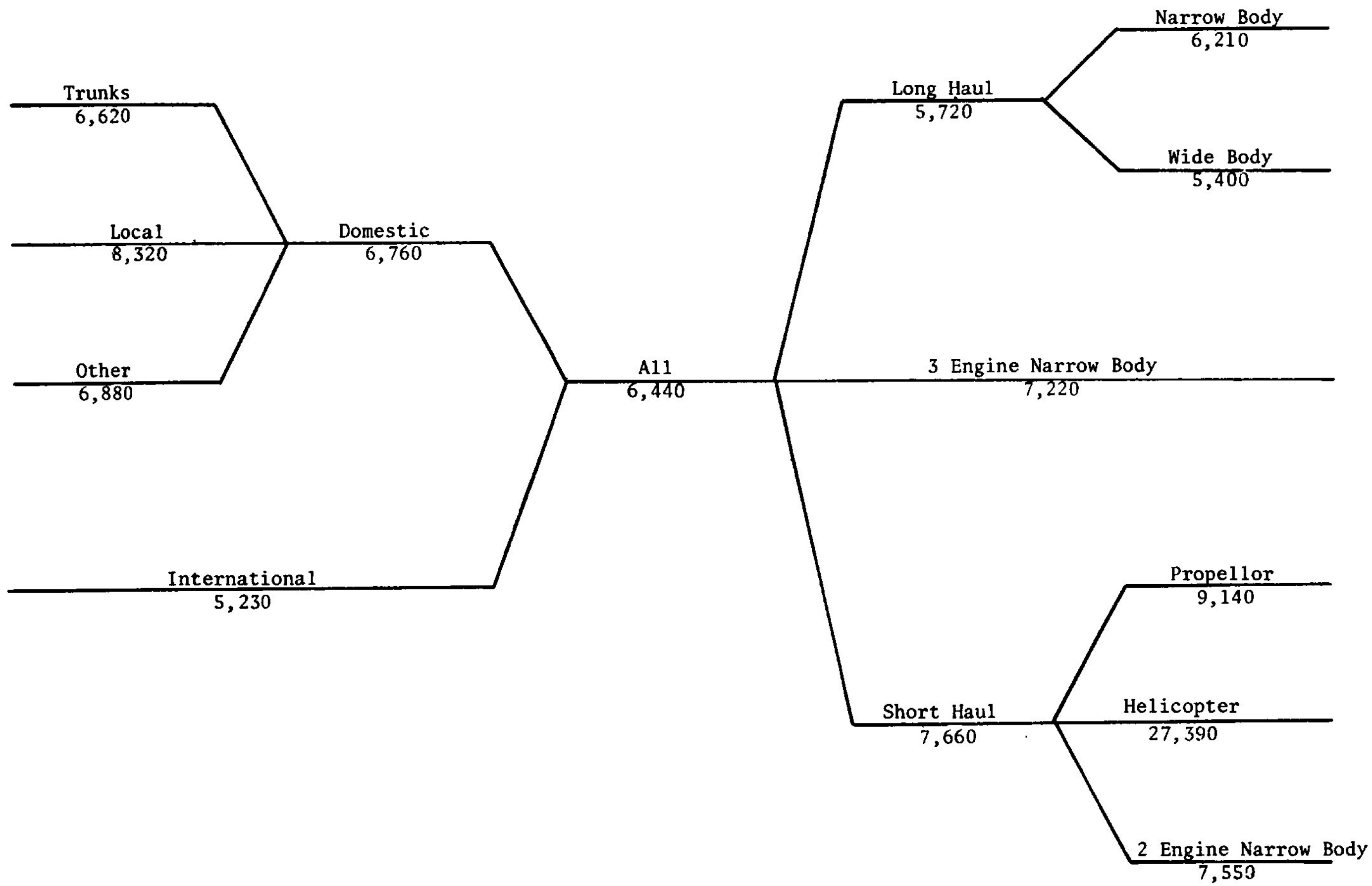
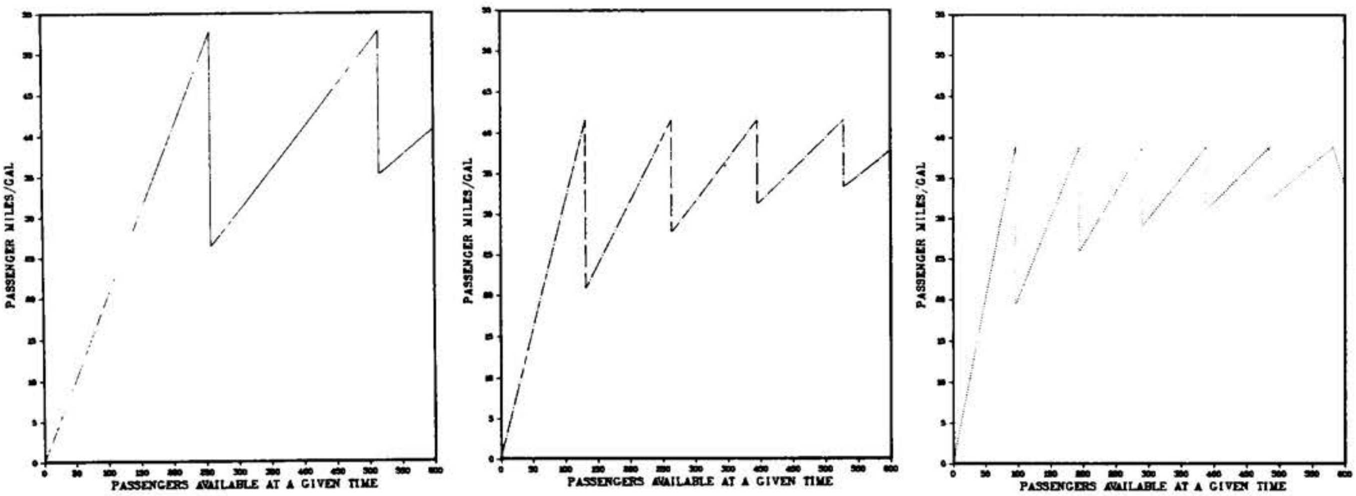


Fig. 2.18. Summary of Certificated Route Air Carrier Energy Intensity, 1976. (Btu/passenger-mile)

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 42 Schedule T-2*, Washington, D.C., 1970–1977.

GIVEN THE BASIC CHARACTERISTICS OF THE AIRCRAFT, ONE CAN CONSTRUCT SIMPLIFIED PLOTS OF ENERGY EFFICIENCY VS PASSENGER DEMAND.



DC-10-10 B727-200 B737-200

Fig. 2.19. Energy Efficiency vs Available Passengers for Three Aircraft Types.

SUPERIMPOSING THE THREE PLOTS CLEARLY SHOWS THAT THE MOST EFFICIENT AIRCRAFT MAY NOT GIVE THE OPTIMUM PERFORMANCE IN A GIVEN APPLICATION IF THE NUMBER OF AVAILABLE PASSENGERS DOES NOT APPROACH ITS CAPACITY. SMALLER, COMPARATIVELY INEFFICIENT AIRCRAFT, OPERATING AT HIGHER LOAD FACTORS, MAY BE THE MOST EFFICIENT SOLUTION.

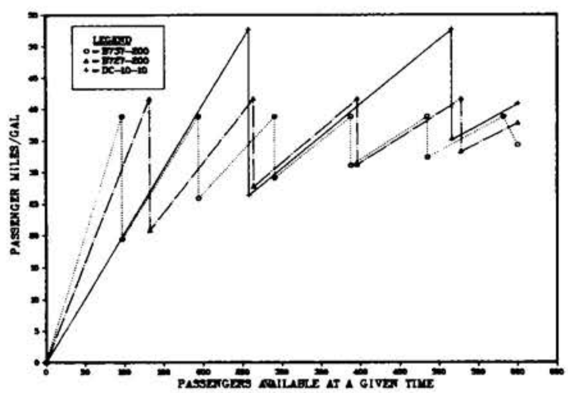


Fig. 2.20. Optimal Aircraft Type vs Available Passengers.

Note: 10 passenger-miles/gal = 13,500 Btu/passenger-miles.

Source: L. J. Williams, NASA Ames Research Center, *Air Transportation Energy Efficiency*, presented at the Fourth National Conference on the "Effects of Energy Constraints on Transportation Systems," Union College, August 1-5, 1977, Fig. 12.

IN 1976, 49.7% OF ALL AIR CARGO WAS CARRIED AS BELLY FREIGHT ON PASSENGER FLIGHTS. IN CALCULATING THE ENERGY INTENSITY OF SUCH CARGO ONE SHOULD CONSIDER ONLY THE INCREMENTAL ENERGY USED TO CARRY THE ADDITIONAL WEIGHT. THIS IS BASED ON THE ASSUMPTION THAT THE AIRCRAFT WOULD FLY EVEN IF NO BELLY FREIGHT WERE CARRIED, WHICH IS JUSTIFIED BECAUSE BELLY FREIGHT ACCOUNTED FOR LESS THAN 10% OF THE REVENUES FROM PASSENGER FLIGHTS.

Table 2.25
Air Cargo Energy Intensity, 1971 through 1977
(Btu/ton-mile)

	All cargo aircraft		Belly freight	Total
	Domestic	International		
1971	33,010	26,890	3,900	19,440
1972	30,540	27,420	3,800	18,430
1973	28,410	26,270	3,700	16,577
1974	28,010	23,850	3,500	14,820
1975	27,090	24,950	3,400	14,980
1976	26,470	23,430	3,400	14,070
1977[a]	26,420	22,200	3,300	13,650

[a]Based on data for first three quarters.

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41, Schedule T-2*, Washington, D.C., 1970–1977; D. J. Maio, M. Mui, U.S. Department of Transportation, Transportation Systems Center, *An Analysis of Air System Fuel Consumption for Combination Passenger/Cargo Service*, working paper, Cambridge, Mass., 1974.

AS WITH PASSENGER SERVICE, SIGNIFICANT DIFFERENCES IN ENERGY INTENSITY EXIST BETWEEN AIRCRAFT AND CARRIER CATEGORIES FOR ALL AIR CARGO SERVICE.

Table 2.26
Energy Intensity and Load Factors for All-Cargo Aircraft, 1976
[Btu/ton-mile, (%)]

	Domestic service			International service			Total
	Trunk air carriers	All-cargo carriers	All domestic	Trunk air carriers	All-cargo carriers	All International	
All aircraft	27,280 (53.8)	21,720 (60.8)	25,360 (56.2)	25,300 (56.3)	21,830 (62.6)	23,310 (59.7)	24,150 (58.2)
Long-haul aircraft	27,080 (53.4)	21,720 (60.8)	25,140 (55.9)	25,250 (56.3)	21,830 (62.6)	23,290 (59.7)	24,030 (58.1)
4-engine narrow-body	28,040 (54.6)	22,880 (60.6)	26,200 (56.6)	28,060 (60.3)	25,550 (60.6)	26,670 (60.5)	26,440 (59.8)
4-engine wide-body	23,070 (48.9)	17,360 (61.8)	20,880 (53.1)	21,080 (51.1)	17,260 (65.2)	18,790 (58.7)	19,280 (57.3)
3-engine narrow-body	32,880 (68.7)	29,730 (74.2)	32,860 (68.7)	50,180 (73.4)		50,180 (73.4)	33,840 (68.9)
Short-haul aircraft			32,570 (61.1)				32,570 (61.1)

Source: National Archives and Records Service, Machine Readable Archives Division, *CAB Form 41, Schedule T-2*, Washington, D.C., 1970-1977.

ALTHOUGH RAIL SYSTEMS ENJOY THE INHERENT ADVANTAGES OF THE LOW ROLLING FRICTION OF STEEL AND A MORE LEVEL RIGHT-OF-WAY OVER OTHER MODES OF TRANSPORTATION, THE AGGREGATE ENERGY INTENSITY VALUES DO NOT FULLY REFLECT THIS. THIS IS PREDOMINANTLY DUE TO THE HIGHLY PEAKED DEMAND PROFILES FOR URBAN RAIL SYSTEMS WHICH RESULT IN AN OVERALL LOW SYSTEMS UTILIZATION, THE LARGE NUMBER OF LOW DENSITY AND SERVICE CAR-MILES IN INTERCITY PASSENGER SYSTEMS, AND THE LARGE PROPORTION OF EMPTY CAR-MILES IN FREIGHT SERVICE.

Table 2.27
Summary of Rail Energy Intensities, 1972 through 1977

Year	Rail transit (Btu/VM)	Rail transit (Btu/PM)[a]	Commuter rail (Btu/PM)[b]	Amtrak (Btu/PM)[c]	Rail freight (Btu/TM)[d]
1972	66,090	2,540	4,680	4,110	706
1973	60,460	2,480	4,710	3,590	667
1974	65,170	2,830	4,400	3,050	662
1975	67,100	2,960	3,900	3,410	681
1976	68,240	2,960	3,500	3,230	676
1977	68,350	2,700	3,790	3,410	667

Note: VM — Vehicle-mile.
PM — Passenger-mile.
TM — Ton-mile.

[a]The values are estimated based on the assumption that the average trip length of 6.82 miles as estimated for 1975 holds for other years.

[b]Includes a small number of intercity operations.

[c]The values are based on route-passenger-miles. For intermodal comparisons they should be multiplied by the lower-bound passenger-mile-weighted circuity ratio of 1.325 to yield great-circle-mile energy intensity values.

[d]As above, except the ton-mile-weighted circuity is 1.321.

Source: American Public Transit Association, *Transit Fact Book, '77–'78 ed.*, Washington, D.C., 1978; Association of American Railroads, *Statistics of Railroads of Class I, Years 1967 to 1977*, Washington, D.C., September 1978; National Railroad Passenger Corporation, *Annual Report to the Interstate Commerce Commission*, Washington, D.C. 1972–1977; Stanford Research Institute, *Energy Study of Rail Passenger Transportation, Volume 2: Description of Operating System*, Menlo Park, Calif., August 1977.

DUE TO VARIATIONS IN THE DENSITIES OF MATERIALS SHIPPED AND TO THE VARIETY OF THE CARS USED FOR SHIPPING, DIFFERENT MATERIALS EXHIBIT DIFFERENT EI VALUES FOR RAIL SHIPMENT. IT IS POSSIBLE TO CALCULATE THE VALUES THEORETICALLY THROUGH THE USE OF RESISTANCE EQUATIONS AND LOCOMOTIVE CHARACTERISTICS.

Table 2.28
Btu Per Route-Ton-Mile Estimates for Railroad Freight
(loaded movements)

Commodity	Car type						
	Boxcar	Covered hopper	Flat car[a]	Gondola	Open-top hopper	Tank car	Misc. cars[b]
Agricultural products	335	235	725	290	380		715
Metallic ores	265	225		195	180		
Coal, coke produced from coal				195	210		
Crude oil, petroleum	440		725			275	415
Nonmetallic minerals	310	225		280	180	195	315
Food, kindred products, and tobacco	420	310	750			266	410
Textiles, apparel, and leather	775		725				
Lumber, wood products, and furniture	475	300	600	340	360		380
Pulp, paper, and allied products	395		700			270	410
Chemicals, allied products	390	240	725			257	380
Rubber, plastic products	875		730				610
Clay, concrete, glass, and stone	350	225	600	295	225		380
Primary metal products	290	175	295	285	185		320
Fabricated metal products	820		725	370			530
Nonelectrical machinery	675		730	425			
Electrical machinery	1,050		750	340			725
Transportation equipment	650	480	846	400		570	
Instruments, photo goods	1,020		770				
Waste, scrap materials	420	300	725	300	190	252	400
Empty movements (distance-weighted)	390	420	796	420	320	399	390–450

[a] Includes TOFC/COFC.

[b] Includes auto rack, refrigerator, and stock cars.

Source: R. H. Leilich, Peat, Marwick, Mitchell and Co., *Modal Energy Consumption and Intensity*, presented at the Third National Conference on "Effects of Energy Constraints on Transportation Systems," Union College, Aug. 2–6, 1976, pp. 25 and 26.

WHEN THE VALUES ON TABLE 2.28 ARE COMBINED BY WEIGHTING FOR CAR TYPES AND EMPTY MILEAGES, THE FOLLOWING EI VALUES RESULT FOR THE COMMODITY GROUPS.

Table 2.29
Rail Energy Intensity by Commodity, 1972

Commodity	Rail Btu consumption (per route-ton-mile)[a]	Rail Btu consumption (per net ton) × 10^3
Agriculture	697	450
Metallic ores	395	74[b]
Coal & coke	366[c]	134
Petroleum	630	397
Nonmet mineral	430	101
Food products	782	699
Textiles	1,523	1,666
Lumber & furn	881	724
Pulp & paper	741	735
Chemicals	562	482
Rubber & plastic	1,621	1,623
Stone & glass	596	315
Primary metal	581	356
Fabric. metal	1,168	877
Nonelec mach.	1,621	1,869
Electric mach.	1,889	2,137
Transport equi.	1,694	1,638
Instruments	1,849	2,980
Scrap	634	176
Average	687	370

[a]To convert these values to great-circle-ton-mile values, a circuity ratio of 1.321 should be applied.

[b]Reflects short length of haul and low energy intensity per net ton-mile (influenced heavily by two-way utilization of equipment in Great Lakes ore movements.

[c]Reflects heavy "drag" movements and longer hauls, which are inherently more energy efficient.

Source: R. H. Leilich, Peat, Marwick, Mitchell and Co., *Modal Energy Consumption and Intensity*, presented at the Third National Conference on "Effects of Energy Constraints on Transportation Systems," Union College, August 2-6, 1976, p. 32.

GIVEN THE LIMITATIONS OF THE AVAILABLE DATA, IT IS POSSIBLE TO CALCULATE ONLY THE OVERALL OPERATIONAL ENERGY INTENSITY OF ALL DOMESTIC WATERBORNE COMMERCE.

Table 2.30
Energy Intensity of U.S. Domestic Waterborne Commerce, 1971 through 1976

Year	Energy intensity (Btu/route-ton-mile[a])	Average length of haul (miles)
1971	504	682
1972	522	613
1973	576	591
1974	483	599
1975	534	600
1976	467	606

[a]To convert these values to great-cirlce ton-miles, a circuity ratio of 1.762 should be utilized.

Sources: U.S. Army Corps of Engineers, *Waterborne Commerce of the United States, Calendar Year 1976*, Vicksburg, Miss., 1977; U.S. Department of the Interior, Bureau of Mines, *Mineral Industry Surveys*, "Fuel Oil Sales, Annual," Washington, D.C., 1971–1976; U.S. Department of Commerce, *U.S. Foreign Trade Bunker Fuels*, Washington, D.C., 1971–1976.

OTHER, MORE DETAILED, ESTIMATES ARE AVAILABLE THROUGH MODELING RESULTS PRESENTED IN A RECENTLY CONDUCTED STUDY.

Table 2.31
Waterborne Commerce Energy Intensity Estimates by Sector and Ship Class (Btu/route-ton-mile)

	Modeled energy intensity
Ocean sector	
Liner	1390
Tramp	1990
Dry bulk	440
Tanker	230
Coastal sector	
Tug/barge	280
Tanker	360
Other	940
Great Lakes sector	
Dry bulk	540
Tanker	650
Tug	300
Inland waterways	
Tug/towboat	480

Source: Booz, Allen & Hamilton, Draft report, *Energy Use in the Marine Transportation Industry, Task I — Industry Summary*, Bethesda, Md., January 1977.

Table 2.32
Recreational Boat Fuel Usage and Energy Intensities, 1976

Boat type	Fuel consumed (10^3 gal)	Fuel used per boat per year (gal)	10^{12} Btu	Btu/passenger-hr	Btu/boat-hr
Rowboat	76,043	82	9.5	33,000	76,000
Jonboat	173,794	175	21.7	44,400	101,000
Skiff	53,881	207	6.7	54,900	141,700
Dinghy	6,709	87	0.8	26,700	68,900
Other open lightweight	294,343	275	36.8	55,300	132,600
Sailboat	15,238	81	1.9	6,000	25,200
Canoe	3,644	35	0.5	28,500	55,100
Kayak	27	5	<0.1	69,800	142,900
Inflatable boat	43	9	<0.1	9,700	19,400
Inflatable raft	20	20	<0.1	4,300	16,900
Noninflatable raft	3,312	276	0.4	86,800	296,100
Bowrider runabout	571,059	338	71.4	58,800	217,000
Nonbowrider runabout	468,840	316	58.6	66,100	246,800
Cabin cruiser	581,076	1,098	72.6	69,100	419,300
Houseboat	34,517	734	4.3	34,100	225,700
Pontoon boat	22,345	177	2.8	19,500	107,800
Thrill craft	78,057	497	9.8	55,100	215,000
Other	688,342	645	86.0	69,400	327,600
Total	3,071,290	351	383.9	56,700	202,800

Source: U.S. Department of Transportation, Coast Guard, Washington, D.C., *Recreational Boating in the Continental United States in 1973 and 1976: The Nationwide Boating Survey*, March 1978, pp. 55 and 80.

BECAUSE OF UNCERTAINTIES INVOLVED IN DETERMINING THE ORIGIN OF THE NATURAL GAS DELIVERED OUT OF THE SYSTEM, NO RELIABLE TON-MILE ESTIMATES FOR THE NATURAL GAS TRANSMITTED ARE AVAILABLE AT PRESENT. HOWEVER, IN THE ABSENCE OF THESE DATA, A MEANINGFUL FUEL ALTERNATIVE MEASURE OF NATURAL GAS PIPELINE ENERGY EFFICIENCY MAY BE CONSTRUCTED. GIVEN IN TABLE 2.33 ARE THE RATIOS OF ENERGY CONSUMED DURING TRANSMISSION OVER THE ENERGY CONTENT OF THE GAS TRANSMITTED. FOR THE PURPOSE OF THIS ANALYSIS, IT WAS ASSUMED THAT NATURAL GAS ACCOUNTED FOR 95% OF ALL FUEL USED FOR TRANSMISSION.

Table 2.33
Energy Efficiency of the Natural Gas
Pipeline System, 1970 through 1976

Year	Natural gas consumed for transmission ($ft^3 \times 10^6$)	Natural gas delivered[a] ($ft^3 \times 10^9$)	Energy intensity ratio (10^{-3})
1970	722,166	19,417	39.1
1971	742,592	19,969	39.1
1972	766,156	20,015	40.3
1973	728,177	20,267	37.8
1974	668,792	19,161	36.7
1975	582,963	17,902	34.3
1976	548,323	17,716	32.6

[a] Natural gas delivered to customers plus net change in underground storage.

Source: American Gas Association, *Gas Facts 1976*, Arlington, Va., 1977.

THE ENGINEERING PRINCIPLES GOVERNING NATURAL PIPELINE FLOWS ARE WELL KNOWN. GIVEN BASIC SYSTEM CHARACTERISTICS, ONE CAN READILY COMPUTE THE ENERGY INTENSITIES FOR POSTULATED FLOWS. MOST RECENT ESTIMATES HAVE PLACED THE SYSTEM'S ENERGY INTENSITY VALUE AROUND 2000 BTU/ROUTE-TON-MILE FOR NATURAL GAS.

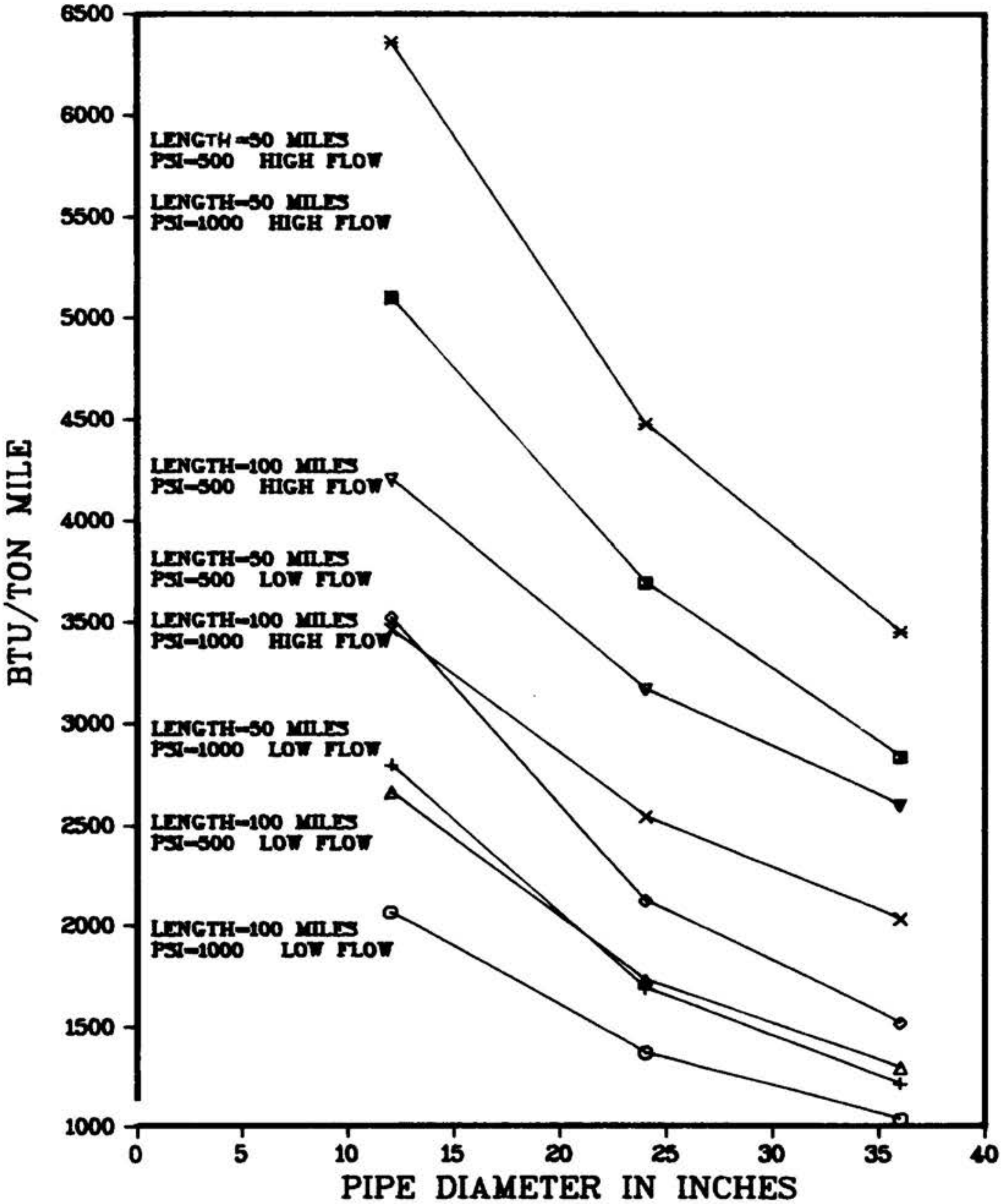


Fig. 2.21. Energy Intensity of Natural Gas Pipelines.

Source: The Aerospace Corporation, *Characterization of the U.S. Transportation System — Pipeline Transportation Systems*, Los Angeles, Calif., March 1977, p. 1-25. (Draft)

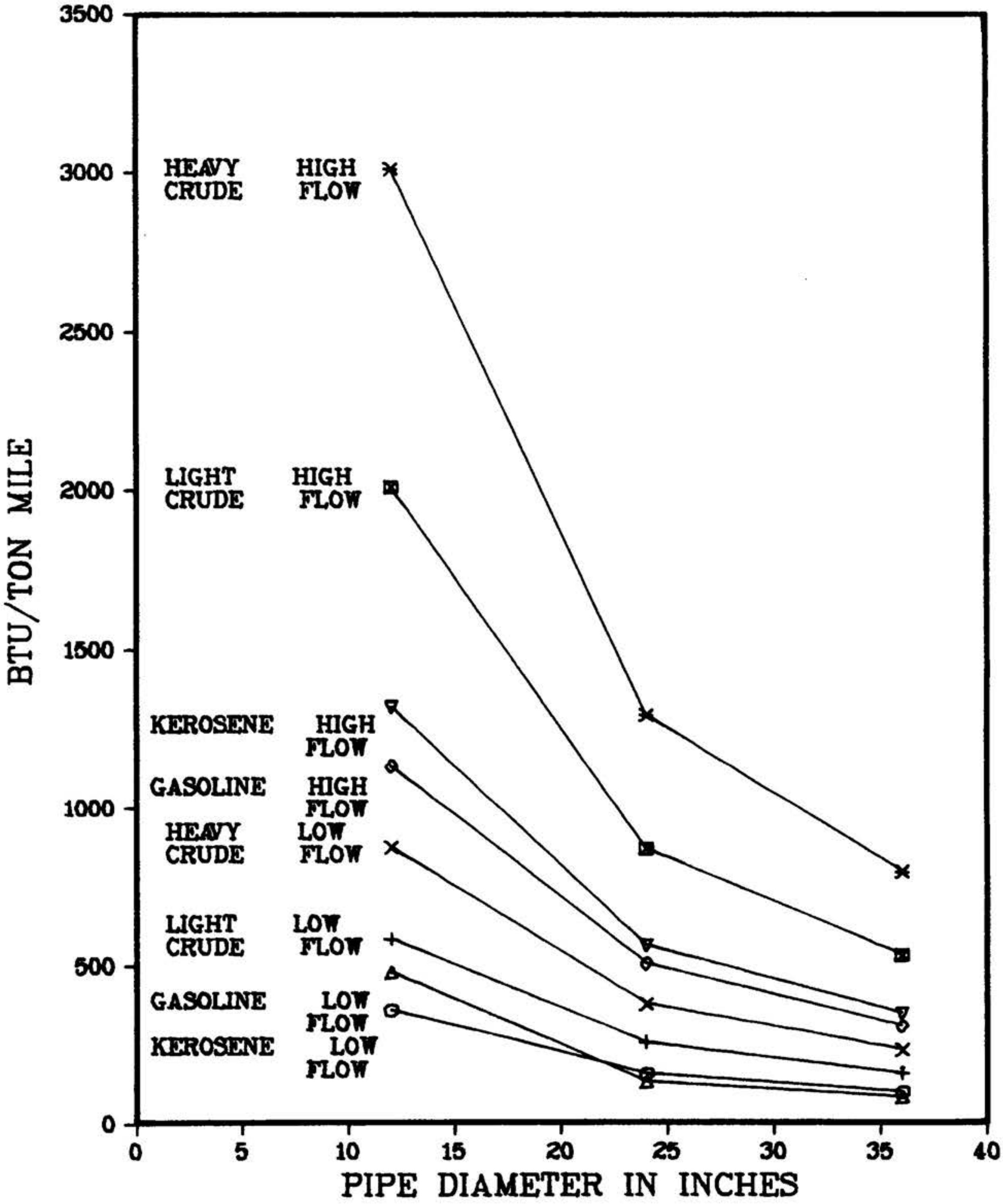


Fig. 2.22. Energy Intensity for Oil Pipelines.

Source: The Aerospace Corporation, *Characterization of the U.S. Transportation System — Pipeline Transportation Systems*, Los Angeles, Calif., March 1977, p. 1-25. (Draft)

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Chapter 3

Transportation Projections

Transportation Projections

This chapter provides the estimates of future transportation and the associated transportation energy demand that TEC is currently using in its baseline projection of the future. These demands and energy projections are required to estimate the impact that DOE policies and technologies might have on future energy use.

An appropriate historical perspective is provided to illustrate how the baseline projection compares with the past. Alternative projections developed within TEC and by others are also presented to show how the baseline TEC projection compares with other estimates for the future. TEC and ORNL welcome any comments that readers might have concerning these projections or any additional projections. TEC does not intend to forecast or predict the future, but rather to develop reasonable baseline projections that can be used for estimating impacts on energy use within a consistent and comprehensive framework.

Table 3.1 shows the sources used extensively in the tables and figures of this chapter. Other sources are located within the chapter when only a few projections from a single source are used. Table 3.2 shows the notations and projections employed in this chapter. It should be emphasized that much of the variations among the projections is due to differences in assumptions employed.

In some of the following sections of this chapter the number of projections listed in the tables exceeds the number of projections plotted on the graphs. The graphs are presented solely to illustrate how the TEC projections compare with the range of alternative projections. No attempt should be made to estimate values from the graphs. The graphs

Table 3.1
Sources Used for Projections

TEC — Historical estimates provided by ORNL and projections provided by the Data Analysis Branch of the Transportation Energy Conservation Division (TEC) of DOE using inputs from models and expert judgment.

TEC Model — *TEC: Transportation Energy Conservation Model*, Jack Faucett Associates, Inc., Chevy Chase, Md., August 1978 (for TEC/DOE).

ANL — Argonne National Laboratory's draft baseline scenario provided under contract for TEC/DOE.

SRI (DOE) — Tom Mandel, William Lee, and Peter Schwartz, *Transportation Energy Demand in Alternative Futures*, SRI International, Menlo Park, Calif., 1978 (for TEC/DOE).

TECNET — Ralph Doggett, Richard Meyer, and Mark Heller, *Ten Scenarios of Transportation Energy Conservation Using TECNET*, International Research and Technology Corporation, McLean, Va., June 1978 (for TEC/DOE).

AYRES — *Worldwide Transportation Energy Demand Forecast: 1975–2000*, Robert U. Ayres, Delta Research Corporation, Arlington, Va., March 1978 (for ORNL and TEC/DOE).

CONSAD — *Estimates of Future Demands for Liquid Fuels — Two Bracketing Scenarios*, Consad Research Corporation, Pittsburgh, Pa., July 1978 (for TRW and Fossil Energy/DOE).

FUTURES — *Strategic Backdrop Analysis for Fossil Fuel Planning: Alternative Socioeconomic Conditions in the United States and their Associated Energy Targets*, The Futures Group, Glastonbury, Conn., 1978 (for Fossil Energy/DOE).

IEA — *Economic and Environmental Implications of a U.S. Nuclear Moritorium, 1985–2010*, Institute for Energy Analysis, Oak Ridge Associated Universities, ORAU/IEA 76-4, September 1976 (for the National Research Council).

WAES — Paul S. Basile, ed. *Energy Supply-Demand Integrations to the Year 2000*, Third Technical Report of the Workshop on Alternative Energy Strategies (WAES), The MIT Press, Cambridge, Mass., 1977.

WHARTON — Runs of the Wharton Auto Model provided by the Transportation Systems Center/DOT, September 1978.

SHELL — *National Energy Outlook, 1980–1900*, Shell Oil Company, July 1978.

NTPSC-M — Is a draft projection from the National Transportation Policy Study Commission. Personal correspondence Ed Bentz to Phil Patterson in accordance with interagency agreement, Oct. 17, 1978, NTPSC/DOE.

Table 3.2
Projection Notations and Descriptions

TEC — Baseline projection with no major conservation apart from the meeting of the 27.5 mpg automobile standard (on the EPA test cycle but not necessarily on the road mpg).

TEC Model — Baseline projection with no major conservation. This projection is documented in the final report but can be easily changed by the user of the interactive TEC Model.

ANL — A draft baseline (before conservation) scenario.

SRI—HG and SRI—CV — High Growth (HG) and Changing Values (CV) scenarios from SRI International. IN HG it is assumed that material and energy resources will be adequate to allow continued high rates of economic growth. In the CV scenario there is a period of resource scarcity, and about one-third of the population adopts a voluntary frugal lifestyle by 2020. In both of these scenarios no energy efficiency improvements in transportation are assumed. (Two other scenarios in the SRI report are not used in this chapter.)

TECNET—B and TECNET—C — The Base (B) and Conservation (C) scenarios are used in this chapter for comparative purposes. (There are eight other scenarios that are not illustrated here.) The B case is business-as-usual with moderate conservation, whereas the C case projects energy use patterns as they might occur with conservation initiatives encouraged by the National Energy Plan.

CONSAD—H and CONSAD—L — The High and Low scenarios are defined by the different assumptions with regard to future population and gross national product.

FUTURES—H and FUTURES—L — Target 1 (called H in this chapter) is a prosperous and expanding economy with a wide choice of lifestyles. Target 2 (not listed in this chapter) is similar to a consensus projection of today that shows a rising standard of living. Target 3 (called L in this chapter) is a limited growth, constrained society with a restricted lifestyle.

IEA—H and IEA—L — The High scenario has higher gross national product and higher population and, therefore, higher total energy use than the Low scenario.

WAES—C1 — Scenario C1 (out of five available WAES scenarios) is used in this chapter. This scenario assumes high income growth, stable oil price, and vigorous energy policy for the 1975—1985 period. It assumes high economic growth, higher oil prices, and vigorous coal use in the 1985—2000 period.

WHARTON — A run of the Wharton Auto Model as of September 1978 that assumes no increase in the real price of gasoline over the 1975—2000 period.

SHELL — This projection assumes gross national product growth of 4.7% for 1975—1980 and 3.1% for 1980—1990, moderate conservation, and adequate supplies of imported oil.

NTPSC-M — National Transportation Policy Study Commission, moderate case.

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have been plotted using data points for a limited number of years and connecting these points with straight lines. Trends should be given more attention than precise values for any given year. In fact, some of the numbers appearing in the tables were estimated by reading values from graphs in the original reports.

The Data Analysis Branch (DAB) of the TEC/DOE has the responsibility for providing baseline (before DOE conservation) transportation energy projections. Table 3.3 shows the projections developed judgmentally by DAB as of September 1978. Some of the transportation demands and associated energy estimates are slightly different from the projections that appeared in Edition 2 of the *TEC Data Book*.

Table 3.3
TEC Baseline Transportation Activity
and Energy Demands
(before DOE conservation)

	1975	1985	2000
Background information			
Population (Series II, millions)	213	233	260
GNP (77 $, trillions)	1.7	2.6	3.9
Price of gallon of gasoline (77 $)	0.65	0.65	1.00
Transportation activity (billions)			
Automobile (VMT)	1050	1393	1933
Truck intercity freight (TMT)	454	630	1050
Air (PMT)	182	300	550
Rail (TMT)	759	900	1500
Marine (TMT)	950	1300	1780
Pipeline (TMT)	763	850	800
Transportation energy (10^{15} Btu)	19.1	21.7	28.3
Automobile	9.5	9.4	10.9
Truck	4.1	5.3	7.6
Bus	0.1	0.1	0.2
Air	1.5	2.5	4.4
Rail	0.6	0.7	1.2
Marine	0.8	1.1	1.5
Pipeline	1.3	1.4	1.3
Miscellaneous (includes military)	1.2	1.2	1.2

Note: VMT — vehicle-miles-traveled.
TMT — ton-miles-traveled.
PMT — passenger-miles-traveled.

ESTIMATES OF THE TOTAL AMOUNT OF ENERGY IN THE TRANSPORTATION SECTOR VARY BY 13% IN THE BASE YEAR 1975. THIS IS DUE TO DIFFERENCES IN THE DEFINITION OF THE TRANSPORTATION SECTOR (FOR EXAMPLE, SEVERAL ESTIMATES OMIT PIPELINE ENERGY USE OR MILITARY TRANSPORTATION ENERGY USE). SEVERAL ESTIMATES OMIT NONPETROLEUM ENERGY USE (CONSAD AND SHELL).

THE FUTURE VALUES OF TRANSPORTATION ENERGY PROJECTED BY THE VARIOUS SOURCES DIFFER FOR THE SAME TWO REASONS AS ABOVE PLUS THE FACT THAT DIFFERENT ASSUMPTIONS ARE MADE WITH RESPECT TO FUTURE:

1. POPULATION LEVELS (ACTUALLY SMALL DIFFERENCES CAN BE ATTRIBUTED TO VARIATIONS IN POPULATION PROJECTIONS AS CAN BE SEEN ON THE FOLLOWING PAGES)
2. GROSS NATIONAL PRODUCT (CAUSES BIG DIFFERENCES IN TRANSPORTATION DEMAND AND THEREFORE TRANSPORTATION ENERGY USE)
3. PASSENGER-MILES AND TON-MILES OF TRAVEL
4. ENERGY INTENSITIES FOR THE SEVERAL MODES
5. TRANSPORTATION ENERGY CONSERVATION MEASURES
6. PRICE OF ENERGY

FOR EXAMPLE, THE TEC BASELINE PROJECTION ASSUMES THE CENSUS POPULATION PROJECTION, LOWER THAN AVERAGE GNP GROWTH, AND LITTLE ENERGY CONSERVATION ASIDE FROM THE ACHIEVEMENT OF THE 27.5 MPG NEW AUTO STANDARD BY 1985.

Table 3.4
Transportation Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			7.4	8.1	9.3	11.4	152.	17.4 (3.5)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	19.1	21.7	28.3			1.6	
TEC Model'	17.9	22.2	28.8	34.5	47.7	1.9	2.0
ANL	16.8	18.3		23.2	26.2		
SRI-HG	18.0	22.5	28.7		53.1	1.9	2.5
CV	18.0	21.6	23.2		33.4	1.0	1.5
TECNET-B	20.0[b]	20.7	27.4	34.4	45.5	1.4	2.1
C	20.0[b]	19.9	20.4	23.6	29.4	0.1	1.5
AYRES	16.5		20.5			0.9	
CONSAD H	17.5	19.8	29.3		60.3	2.1	2.9
L	17.5	15.9	15.0		18.9	−0.6	0.9
FUTURES H	18.6[c]	21.0	24.1		31.3	1.0	1.1
L	18.6[c]	20.7	19.7		22.0	0.2	0.4
IEA-H	18.6	21.4	28.1	33.9		1.7	
L	18.6	19.2	22.2	25.3		0.7	
WAES (C-1)	17.0[d]	18.8	21.3			0.8	
Shell (Oil only)	18.0	21.4				1.8[e]	
NTPSC-M	19.8	21.7	28.6			1.6	
Ratio: High/Low	1.13	1.42	1.95		3.19		

[a]1950-1975 annual growth rate.

[b]1977 data.

[c]1974 data.

[d]1972 data.

[e]Growth rate is for 10-year period only.

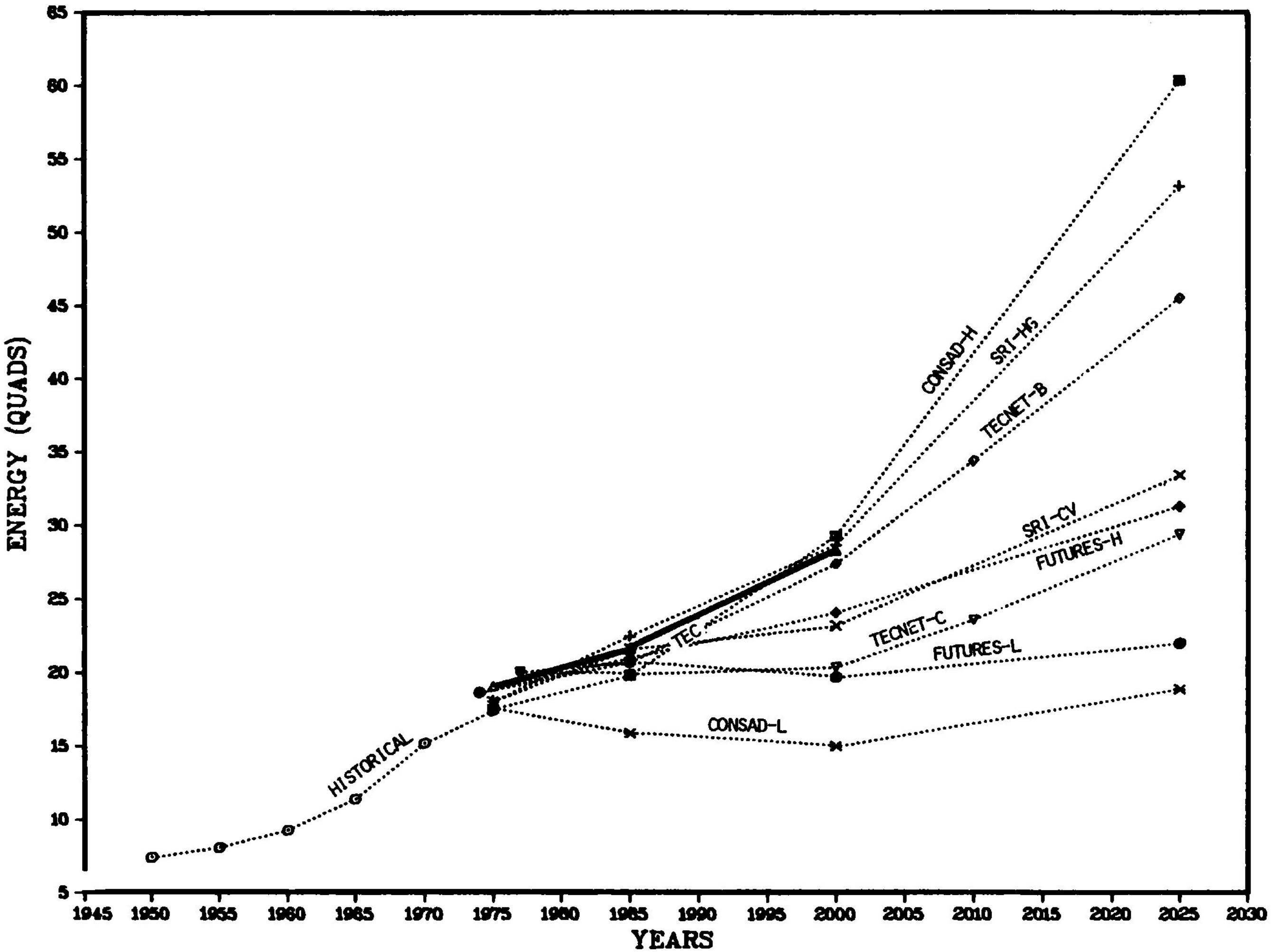

Fig. 3.1
Transportation Energy.
(10^{15} Btu)

THERE ARE VERY SMALL VARIATIONS AMONG THE ALTERNATIVE PROJECTIONS WITH RESPECT TO FUTURE U.S. POPULATION. TEC AND SEVERAL OTHER STUDIES EMPLOY THE SERIES II PROJECTION OF THE BUREAU OF CENSUS (AS OF MAY 1977). THIS PROJECTION ASSUMES A FERTILITY RATE OF 2.1 BIRTHS PER WOMAN, WHICH EVENTUALLY LEADS TO A STABLE POPULATION (ASSUMING NO NET IMMIGRATION).

Table 3.5
Population
(10^6)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	132	133	152	165	180	194	204	213 (1.4)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	213	233	260			0.8	
ANL	213	233	260	275	296	0.8	0.5
SRI-HG	213	233	260		296	0.8	0.5
CV	213	233	260		277	0.8	0.2
TECNET-B	213	234	263	279	300	0.8	0.5
C	213	234	263	279	300	0.8	0.5
AYRES	213	236	266			0.9	
CONSAD H	213	236	264		304	0.9	0.6
L	213	229	246		252	0.6	0.1
FUTURES H	213		259		294	0.8	0.5
L	213		245		250	0.6	0.1
IEA-H	213	231	254	264		0.7	
L	213	228	245	250		0.6	
WAES (C-1)	213	234	263			0.8	
Ratio: High/Low	1.00	1.03	1.09		1.22		

[a]1950–1975 annual growth rate.

THE VARIATIONS IN GNP IN 1975 ARE SMALL BUT GROW SIGNIFICANTLY BY 2000 (A 50% DIFFERENCE BETWEEN THE HIGH AND LOW ESTIMATE). THE TEC ESTIMATE IS IDENTICAL TO THAT OF THE ENERGY INFORMATION ADMINISTRATION/DOE* OUT TO 1990. GNP IS A KEY VARIABLE IN DETERMINING TEC USE FOR SEVERAL REASONS.

HOUSEHOLD INCOME IS A MAJOR DETERMINANT OF PERSONAL TRANSPORTATION, AND IT GENERALLY GROWS IN PROPORTION TO GNP GROWTH. ALSO, FREIGHT DEMAND GROWTH IS GREATLY INFLUENCED BY THE GROWTH AND CHANGING COMPOSITION OF GNP.

Table 3.6
Gross National Product
(1977 \$ 10^{12})

	1940	1945	1950	1955	1950	1965	1970	1975
Historical	0.43	0.70	0.71	0.89	1.02	1.30	1.51	1.70 (3.6)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	1.7	2.6	3.9			3.4	
ANL	1.9[b]	2.6	3.9	5.1	7.2	3.2	2.5
SRI-HG	1.7	2.5	3.9		7.1	3.4	2.4
CV	1.7	2.4	3.3		5.0	2.7	1.7
TECNET-B	1.7	2.4	3.6	4.6	6.2	3.1	2.2
C	1.7	2.4	3.6	4.5	6.1	3.1	2.1
CONSAD H	1.7	2.5	3.9		7.1	3.4	2.4
L	1.7	2.3	3.2		4.8	2.6	1.6
FUTURES H	1.7		4.8		11.0	4.2	3.4
L	1.7		3.3		4.8	2.7	1.5
NTPSC-M	1.7	2.5	4.0			3.5	
Ratio: High/Low	1.00	1.13	1.50		2.29		

[a]1950–1975 annual growth rate.

[b]1977 data.

*DEPARTMENT OF ENERGY, ENERGY INFORMATION ADMINISTRATION, *Annual Report to Congress – Vol. 2*, WASHINGTON, D.C., APRIL 1978.

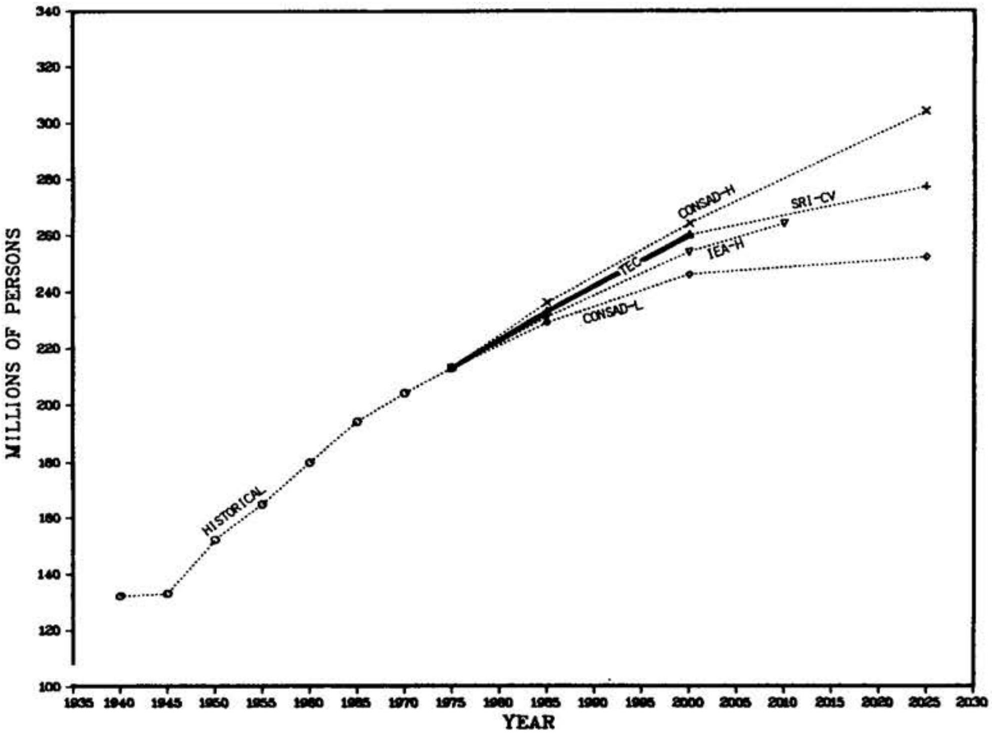

Fig. 3.2
Population.
(10^6)

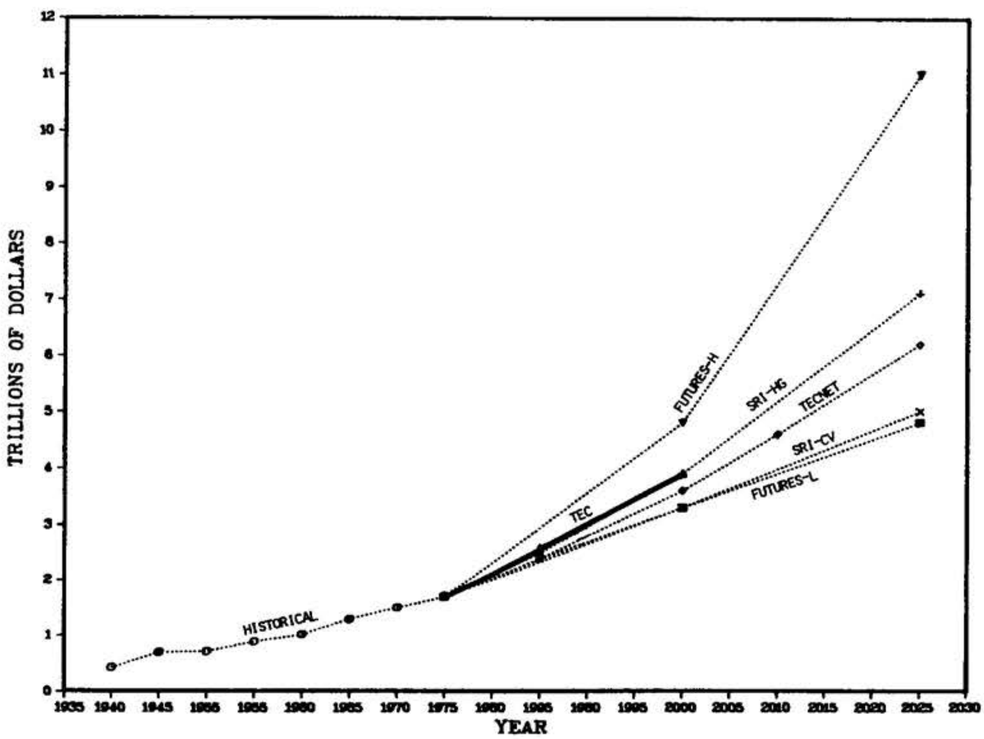

Fig. 3.3
Gross National Product.
(1977 \$ 10^{12})

THERE IS FARILY CLOSE AGREEMENT AMONG THE SOURCES THAT ESTIMATE 1975 PASSENGER-MILES-TRAVELED (PMT). THE DIFFERENCE AMONG SOURCES IN 2000 VALUES IS ONLY 39%, WHICH MAKES THIS ONE OF THE TRANSPORTATION FACTORS HAVING THE SMALLEST VARIATION ACROSS PROJECTIONS.

Table 3.7
Passenger-Miles-Traveled
(10^{12})

	1940	1945	1950	1955	1960	1965	1970
Historical					1.3	1.6	2.0 (4.3)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	2.3	2.9	4.4			2.6	
ANL	2.9[b]	3.2		4.3	5.8		
TECNET-B	2.2[b]	2.9	4.4		7.3	3.1	2.1
C	2.2	2.9	4.3		7.2	3.0	2.1
AYRES	2.3	3.3	5.3			3.4	
CONSAD H	2.2[b]	3.0	4.7		8.5	3.4	2.4
L	2.2[b]	2.7	3.8		5.6	2.4	1.6
Ratio: High/Low	1.05	1.14	1.39		1.52		

[a]1960–1970 annual growth rate.

[b]1977 estimate.

BIG VARIATIONS EXIST ACROSS THE ESTIMATES OF 1975 TON-MILES-TRAVELED (TMT). THIS IS DUE MAINLY TO THE INCLUSION OF ESTIMATES OF INTERNATIONAL MARINE TMT IN THE TECNET CASE (CONSAD FREIGHT DEMANDS ARE DERIVED FROM THE TECNET MODEL AND HAVE A HIGH 1975 TMT ESTIMATE ALSO). AYRES EXCLUDES ANY TMT FOR PIPELINE. SURPRISINGLY, THERE IS LESS VARIATION IN THE YEAR 2025 ESTIMATES THAN THERE IS IN 1975.

Table 3.8
Freight Demand — Ton-Miles-Traveled
(10^{12})

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	0.6	1.0	1.1	1.3	1.3	1.6	1.9	2.07 (2.7)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	2.9[b]	3.7	5.1			2.3	
ANL	2.2[c]	3.0		6.1	8.7		
TECNET-B	3.8[d]	4.6	6.8		13.5	2.0	2.8
C	3.8[d]	4.4	5.9		10.7	1.4	2.4
AYRES	2.1	2.8	3.3			1.8	
CONSAD H	3.8[d]	4.7	7.3		15.5	2.9	3.1
L	3.8[d]	4.3	5.9		9.0	1.9	1.7
NTPSC-M	1.9	3.4	7.1			5.4	
Ratio: High/Low	1.84	1.68	2.21		1.78		

[a]1950–1975 annual growth rate.

[b]Intercity — U.S. Only.

[c]1977 data.

[d]1977 estimate and includes international marine.

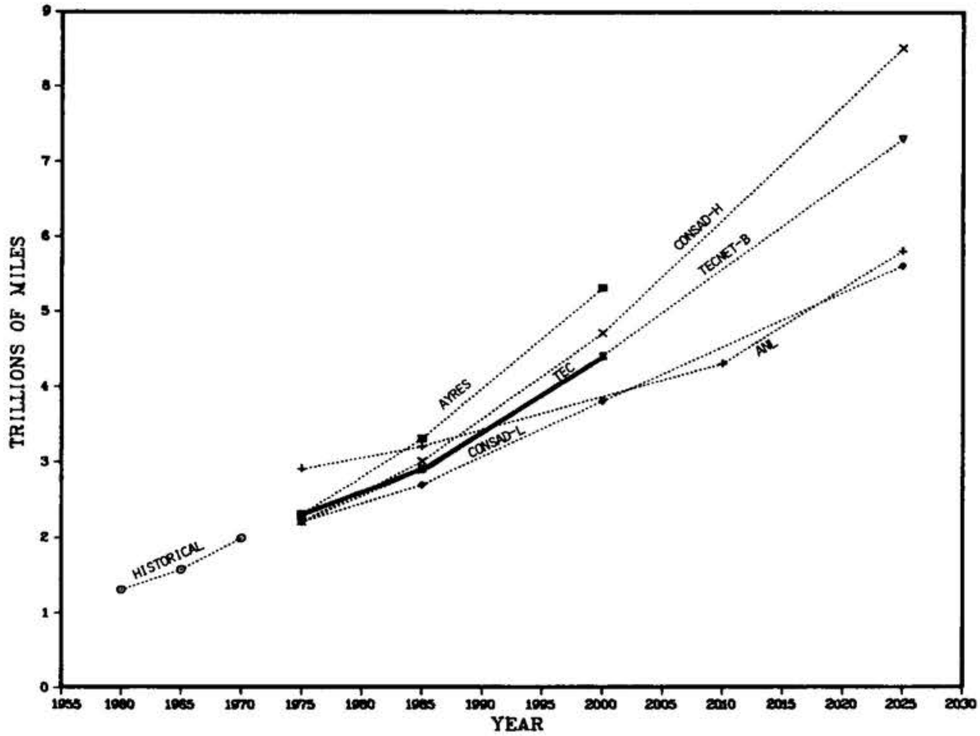

Fig. 3.4
Passenger-Miles-Traveled.
(10^{12})

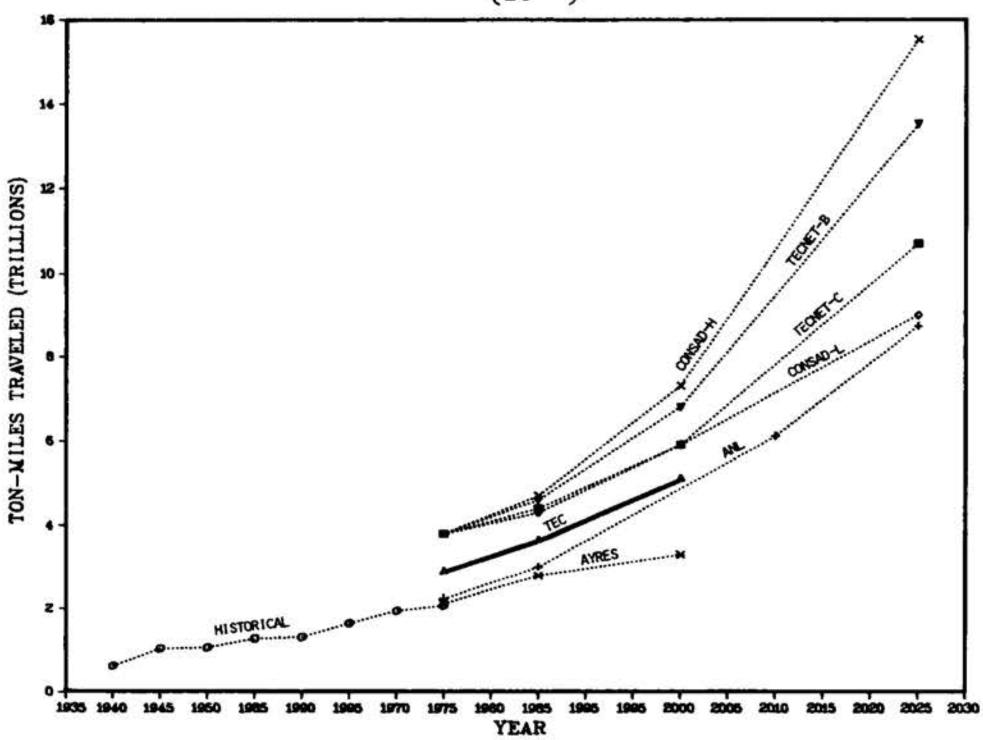

Fig. 3.5
Freight Demand — Ton-Miles-Traveled.
(10^{12})

Many of the projections do not make an explicit assumption with regard to the price of energy. In the SRI scenarios, the higher energy prices in the CV case help to foster the move on the part of some of the population to the "changing values" lifestyle.

Table 3.9
Price of Barrel of Oil
(1977 $)

	1940	1945	1950	1955	1960	1965	1970
Historical[a]	4.42	4.11	6.32	6.27	5.89	5.49	4.96
Projections	1977	1985	2000	2010	2025	Annual Growth Rate 1975–2000	2000–2025
TEC	11.80	11.80	20.00			2.1	
SRI-HG	11.80	14.00	16.00		20.00	1.2	0.9
CV	11.80	17.00	25.00		30.00	3.1	0.7
TECNET-B	11.80	14.00	18.00	20.00	23.00	1.7	1.0
C	11.80	14.00	18.00	20.00	23.00	1.7	1.0
WAES (C-1)	11.50	11.50	17.25			1.6	
Ratio: High/Low	1.03	1.44	1.56		1.50		

[a]Domestic.

The real price of gasoline fell during the 1940–1970 period. The jump in price for imported crude has caused the real price of gasoline to rise in 1977 to about the level that existed in 1955. The results of the Wharton model run presented in this chapter are based on the assumption of a constant real price of gasoline to the year 2000.

Table 3.10
Price of Gasoline
(1977 $)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	0.78	0.68	0.66	0.65	0.63	0.59	0.55	0.64 (–0.1)[a]
Projections	1977	1985	2000	2010	2025	Annual Growth Rate 1975–2000	2000–2025	
TEC	0.7	0.7	1.0			1.7		
TEC Model	0.6	0.7	0.8	0.8	0.9	0.9	0.5	
SRI-HG	0.7	0.7	0.8		0.9	0.6	0.5	
CV	0.7	0.8	1.0		1.11	1.7	0.5	
EIA/DOE "C"[b]		0.7						
WHARTON	0.7	0.7	0.7			0		
Ratio: High/Low	1.06	1.20	1.54		1.29			

[a]1950–1975 annual growth rate.

[b]EIA/DOE "C" is the Medium Demand Medium Supply Case in *Annual Report to Congress, Volume II, Projections of Energy Supply and Demand and Their Impacts*, Energy Information Administration, Department of Energy, DCE/EIA-0036/2, Washington, D.C., April 1978.

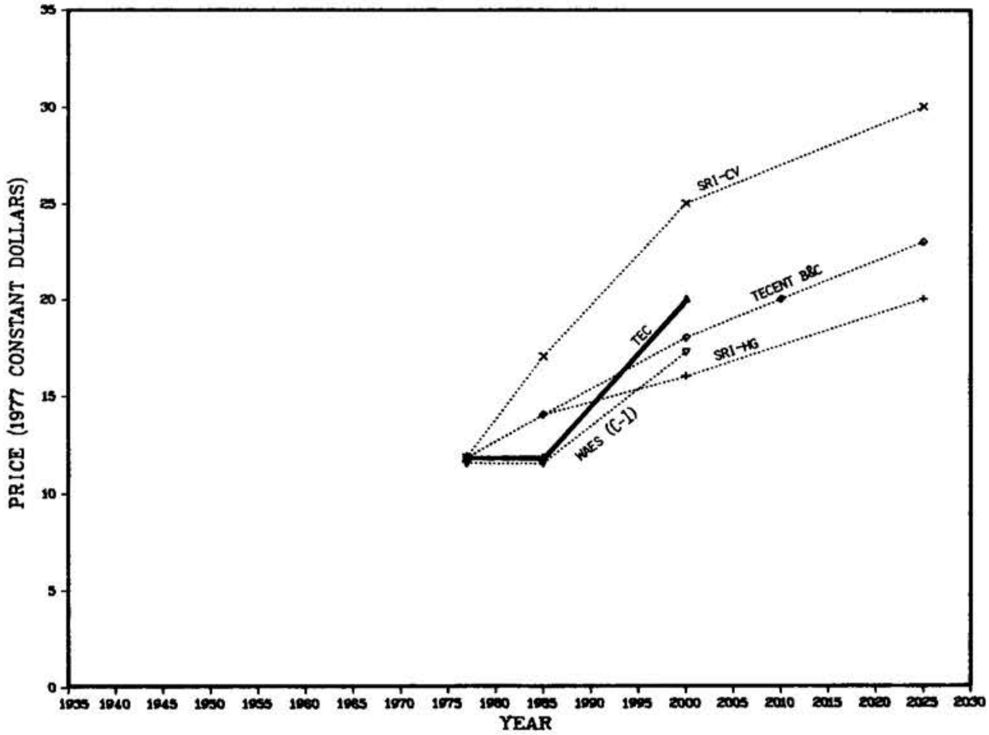

Fig. 3.6
Price of Barrel of Oil.
(1977 constant dollars)

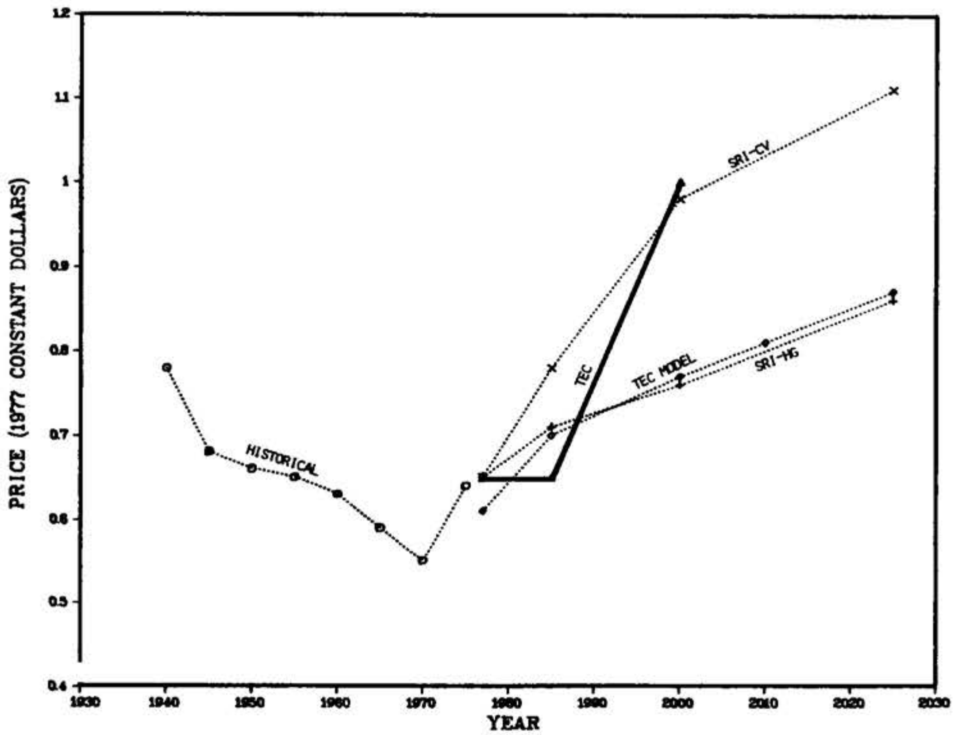

Fig. 3.7
Price of Gasoline.
(1977 constant dollars)

The major reason for the lack of agreement on the 1975 value is a result of using different concepts. TEC and most other estimates use the number of automobiles in use as of July 1 of the year, as counted by R. L. Polk. A higher number is obtained by those (FUTURES and IEA) who use the total number of registered vehicles at the end of the calendar year, as counted by the Federal Highway Administration in DOT. The midyear value is the appropriate one to use when relating year-long miles-traveled and energy use to vehicles. The TECNET model uses R. L. Polk data for 1972 and estimates all future values. Likewise, the TEC model uses an earlier Polk value and estimates the 1975 value.

Table 3.11
Number of Automobiles in Use
(10^6)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	27.7	22.0	35.9	47.4	57.1	68.9	80.4	95.2 (4.0)[a]
Projections	**1975**	**1985**	**2000**	**2010**	**2025**	**Annual Growth Rate 1975–2000**	**Annual Growth Rate 2000–2025**	
TEC	95	117	140			1.6		
TEC Model	98	113	121	128	134	0.9	0.4	
TECNET-B	94	113	162			2.2		
C	94	113	162			2.2		
FUTURES H	105	132	158		180	1.7	0.5	
L	105	127	136		128	1.0	−0.2	
IEA-H[b]	105	126	152	166		1.5		
L	105	115	127	130		0.8		
WAES (C-1)	97[c]	138	166			1.9		
WHARTON		112	139					
Ratio: High/Low	1.12	1.17	1.37		1.41			

[a]1950–1975 annual growth rate.

[b]Registrations.

[c]1972 data.

Auto Vehicle-Miles-Traveled (VMT) are in close agreement in 1975 because most estimates accept the values provided by the Federal Highway Administration. The consensus is that auto VMT will grow by more than 2% annually until 2000 and less than 2% afterward. This is logical because auto saturation levels (in terms of the number owned per capita and the time spent driving them) are expected to be reached sometime around the year 2000.

Table 3.12
Automobile Vehicle-Miles-Traveled
(10^9 VMT)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	250	200	364	493	588	712	901	1050 (4.3)[a]
Projections	**1975**	**1985**	**2000**	**2010**	**2025**	**Annual Growth Rate 1975–2000**	**Annual Growth Rate 2000–2025**	
TEC	1050	1393	1933			2.5		
TEC Model	1081[b]	1365	1743	1945	2243	1.9	1.0	
SRI-HG	1048[c]	1254	1754		2809	2.3	1.9	
CV	1048[c]	1222	1499		2066	1.6	1.3	
TECNET-B	1002	1416	2080	2584		3.0		
C	1002	1413	2071	2561		3.0		
FUTURES-H	1050	1380	1790		2000	2.2	0.4	
L	1050	1250	1280		990	0.8	−1.1	
IEA-H	1050	1390	1820	1990		2.2		
L	1050	1150	1270	1300		0.7		
WAES (C-1)	986[d]	1455	1660			1.9		
WHARTON 78		1480	2231					
2% Annual Growth 300 Day Study	1050	1281	1722	2100	2825	2.0	2.0	
Ratio: High/Low	1.05	1.21	1.76		2.85			

[a]1970–1975 annual growth rate.

[b]1976 data.

[c]1977 data.

[d]1972 data.

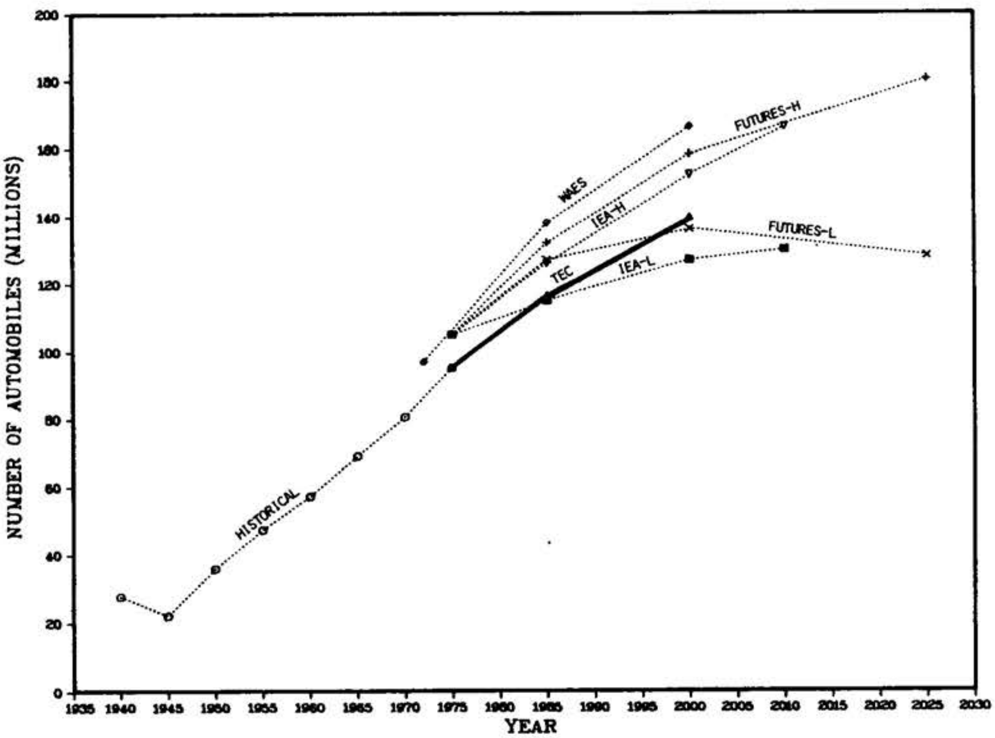

Fig. 3.8
Number of Automobiles in Use.
(10^6)

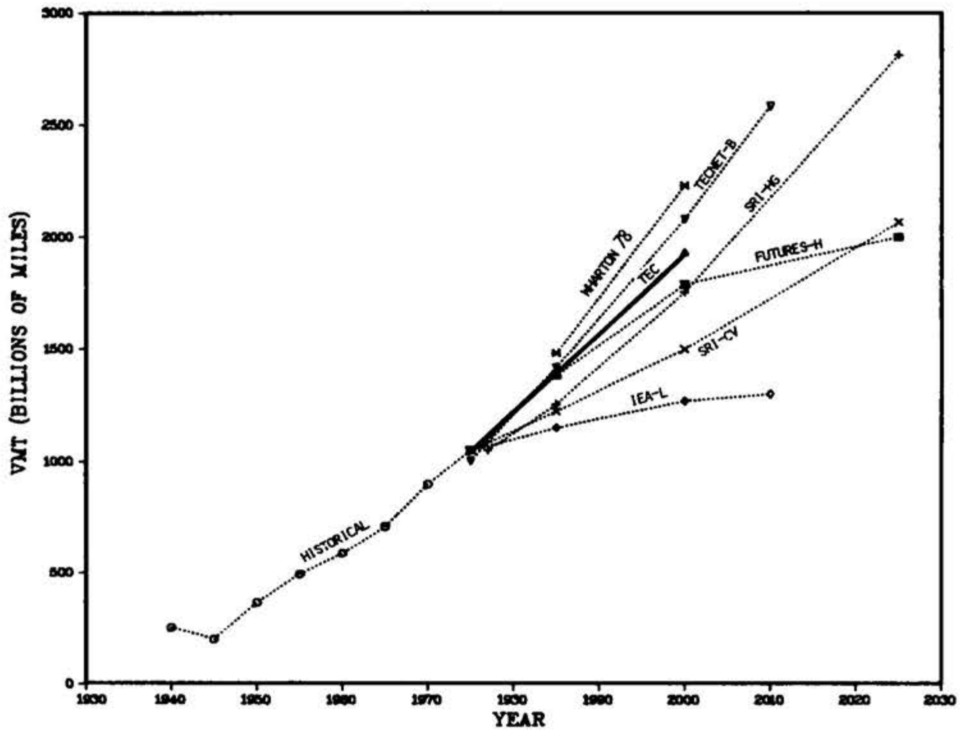

Fig. 3.9
Automobile Vehicle-Miles-Traveled.
(10^9 VMT)

THE GROWTH ASSUMPTIONS FOR ANNUAL-MILES PER AUTOMOBILE VARY GREATLY AMONG THE SOURCES. TEC SHOWS A GROWTH OF 2,700 MILES PER AUTO BY THE YEAR 2000, WHEREAS WHARTON SHOWS A LARGER GAIN AND THE FUTURES-L SHOWS AN ABSOLUTED DECLINE.

Table 3.13
Annual-Miles Per Automobile
(10^3)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical		9.11	10.12	10.40	10.30	10.32	11.20	11.03 (0.3)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	11.0	12.0	13.9			0.9	
TEC Model	11.1	11.9	14.4	15.2	16.8	1.1	0.6
TECNET-B	10.7	12.6	12.9			0.8	
C	10.7	12.6	12.8			0.7	
FUTURES H	10.0	11.0	11.3		11.1	0.5	–0.1
L	10.0	9.9	9.4		7.7	–0.3	–0.8
IEA-H	10.0	11.0	12.0	12.0		0.7	
L	10.0	10.0	10.0	10.0		0	
WAES (C-1)	10.2	10.5	10.0			–0.1	
WHARTON		13.2	16.1				
Ratio: High/Low	1.11	1.32	1.71		2.18		

[a]1950–1975 annual growth rate.

THE TEC VALUE FOR THE YEAR 2000 OF 22.3 MPG IS AN "ON THE ROAD" MPG AND IS CONSISTENT WITH AN EPA-TESTED MPG OF 29.7 WHEN THE DISCOUNT FACTORS DEVELOPED BY BARRY MCNUTT* OF DOE ARE TAKEN INTO ACCOUNT. THE TECNET-C PROJECTION ASSUMES THAT A MIX OF EFFICIENT ELECTRICS, TURBINES, AND STIRLINGS ARE INTRODUCED BEFORE THE YEAR 2000 AND DOMINATE THE AUTO FLEET BY 2025.

FEW CHANGES ARE EXPECTED TO OCCUR BEYOND 2000 IN MOST ALL OF THE PROJECTIONS (EXCEPTING IEA); THE AUTO FLEET WITH CONVENTIONAL ENGINES WILL HAVE REACHED A PEAK MPG BY THAT TIME. THE AUTO FLEET WILL INCREASE ITS MPG MORE RAPIDLY IN IN THE TEN YEARS BETWEEN 1975-1985 THAN IN THE LATER YEARS.

Table 3.14
Auto Fleet-Miles Per Gallon

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	15.29	15.04	14.95	14.53	14.28	14.27	13.57	13.53 (–0.4)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	13.9	18.6	22.3			1.9	
TEC Model	14.4	18.5	21.8	21.8	21.8	1.7	0
SRI-HG	13.1[b]	16.4	23.1		23.1	2.3	0
CV	13.1[b]	16.4	23.1		23.1	2.3	0
TECNET-B	13.3	21.4	25.5			2.6	
C	13.3	21.4	32.0			3.6	
CONSAD H	14.7[d]		22.9			2.0	
L	14.7[d]		43.5			4.8	
FUTURES H	13.9	20.0	28.0		28.0	2.8	0
L	13.9	17.8	28.0		28.0	2.8	0
IEA-H	13.4	19.1	25.9	28.6		2.7	
L	13.4	19.1	25.9	28.6		2.7	
WAES (C-1)	13.5[d]	21.7	29.0			2.8	
WHARTON		17.0	21.8				
Ratio: High/Low	1.08	1.26	2.00	2.00			

[a]1950–1975 annual growth rate.

[b]Assumed 1975.

[c]1977 data.

[d]1972 data.

*MCNUTT ET AL. HAVE SHOWN THAT THERE IS A WIDENING GAP BETWEEN ACTUAL MPG AND EPA-TESTED MPG IN "A COMPARISON OF FUEL ECONOMY RESULTS FROM EPA TESTS AND ACTUAL IN-USE EXPERIENCE, 1974-1977 MODEL YEAR CARS" DOE, FEBRUARY 1978.

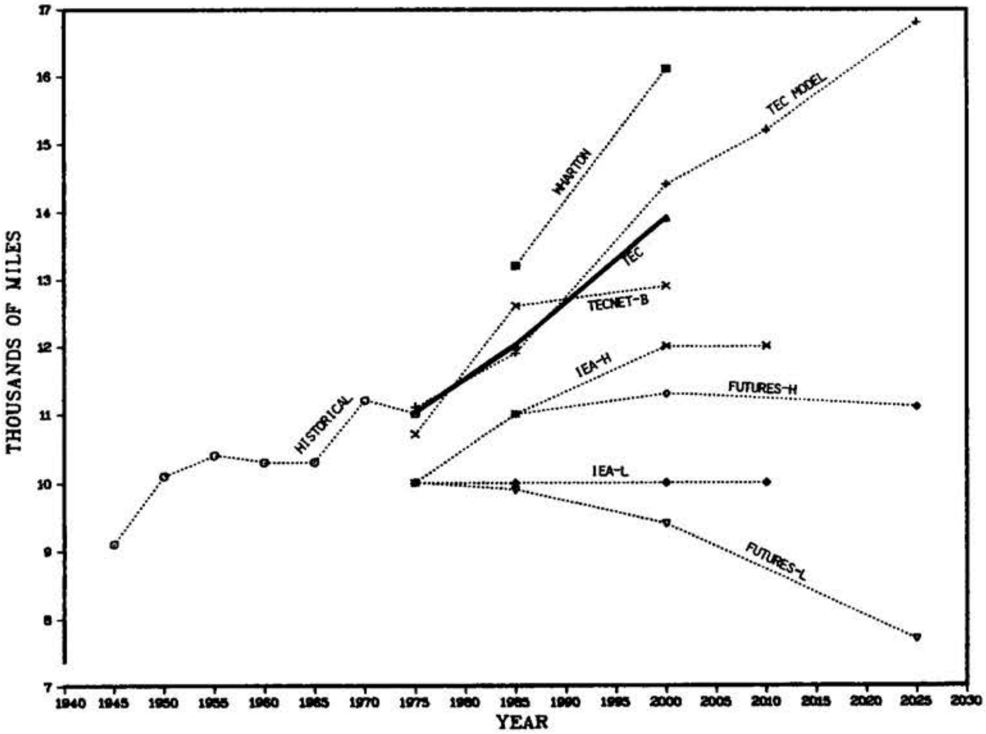

Fig. 3.10
Annual-Miles per Automobile.
(10^3)

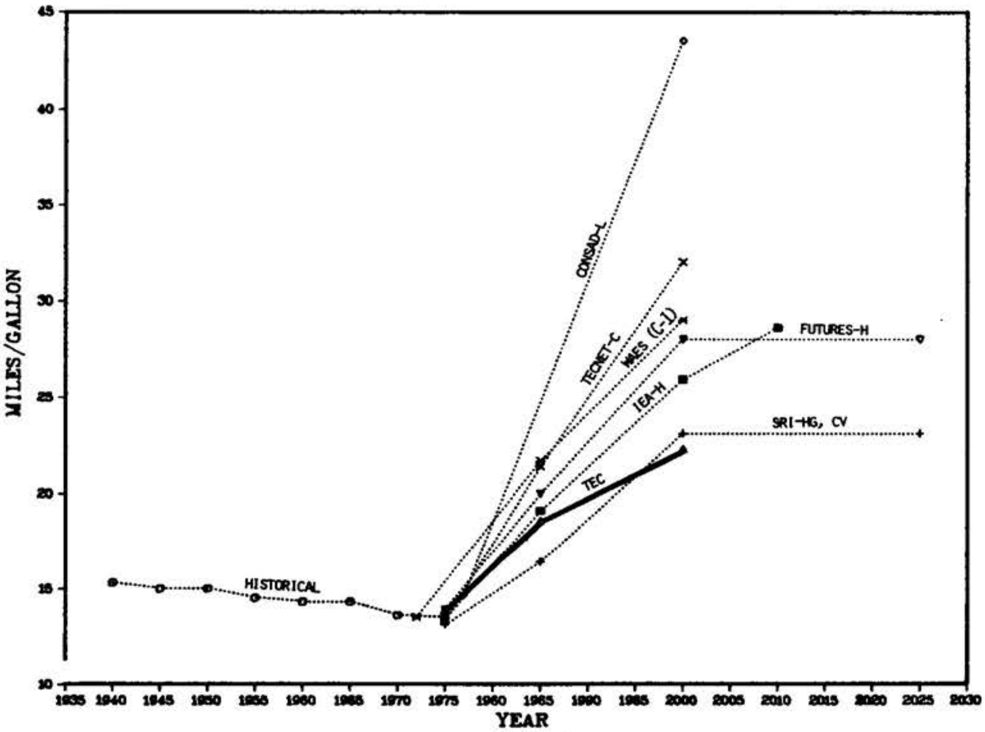

Fig. 3.11
Auto Fleet-Miles per Gallon.

THE AYRES ESTIMATE FOR AUTOMOBILE ENERGY IN 1975 DIFFERS FROM THE OTHERS BECAUSE IT INCLUDES LIGHT TRUCK ENERGY USE. THE WIDE DIFFERENCES THAT EXIST IN FUTURE AUTO ENERGY DEMAND ESTIMATES ACCOUNT FOR A LARGE PART OF THE DIFFERENCES IN TOTAL TRANSPORTATION ENERGY DEMAND SINCE AUTOS MAKE UP SUCH A LARGE PART OF TRANSPORTATION ENERGY DEMAND.

WIDE DIFFERENCES APPEAR AS EARLY AS 1985 IN THESE PROJECTIONS, AND BY THE YEAR 2000 THE HIGHEST PROJECTION IS ALREADY MORE THAN TRIPLE THE LOWEST. BUT NONE OF THE ESTIMATES APPROXIMATE THE HIGH GROWTH THAT HAS OCCURRED DURING THE 1950–1975 PERIOD.

THE LOW VALUES IN 2000 AND 2025 FOR FUTURES-L AND CONSAD-L COULD ONLY BE ACHIEVED THROUGH SOME RADICAL CHANGE IN PERSONAL MOBILITY.

FUTURES-L IS LOW IN 2025 PARTLY BECAUSE AUTO VMT ARE 6% LOWER THAN IN 1975.

Table 3.15
Automobile Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			3.04	4.19	5.25	6.28	8.21	9.44 (4.6)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	9.5	9.4	10.9			0.6	
TEC Model	9.4	9.2	10.0	11.2	12.9	0.3	1.0
SRI-HG	9.5[b]	9.6	9.5		15.2	0	1.9
CV	9.5[b]	9.4	8.0		11.2	–0.7	1.4
TECNET-B	9.5	8.3	10.2		17.2	0.3	2.1
C	9.5	8.3	8.1		11.1	–0.6	1.3
AYRES	11.8	10.1	9.6			–0.8	
CONSAD H	9.5[b]	8.5	10.9		20.0	0.6	2.5
L	9.5[b]	7.1	4.6		5.8	–2.9	0.9
FUTURES H	9.5[b]	8.6	8.0		9.0	–1.1	–0.2
L	9.5[b]	8.8	5.8		4.5	–2.0	–1.0
IEA-H	9.8	9.1	8.8	8.7		–0.4	
L	9.8	7.5	6.1	5.7		–1.9	
WAES (C-1)	9.1[c]	8.3	7.2			–0.8	
SHELL (Oil only)	9.5	9.1					
WHARTON-78	9.5[b]	10.9	12.8			1.2	
Ratio: High/Low	1.26	1.54	2.21		3.45		

[a]1950–1975 annual growth rate.

[b]Assumed 1975 value.

[c]1972 data.

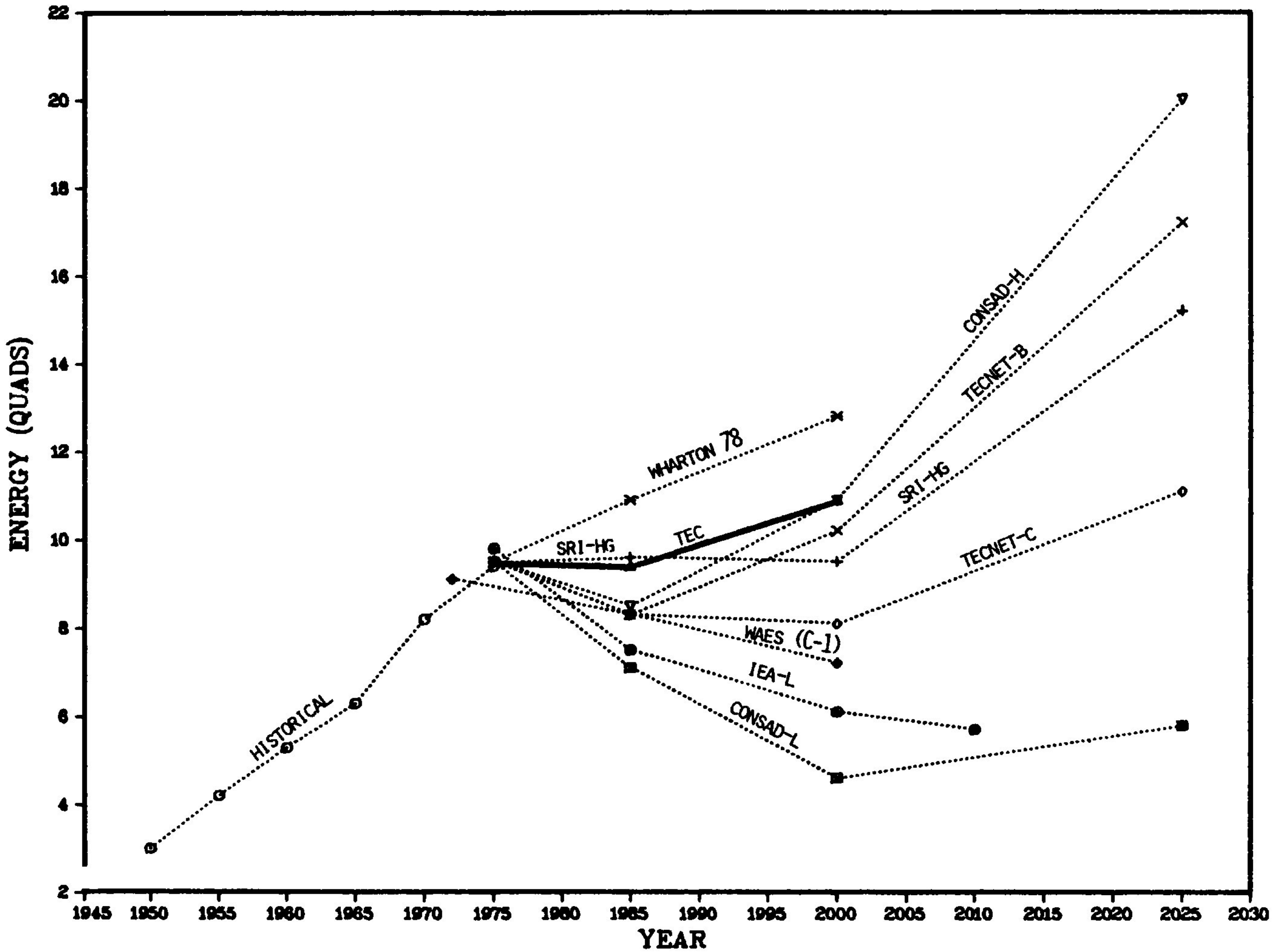

Fig. 3.12
Automobile Energy.
(10^{15} Btu)

ONE OF THE MOST DIFFICULT TRANSPORTATION PHENOMENON TO PROJECT AT THIS TIME IS LIGHT TRUCK [UNDER 10,000 LB GROSS VEHICLE WEIGHT (GVW)] SALES AND TOTAL STOCKS. THE MAJORITY OF LIGHT TRUCKS ARE CURRENTLY BEING PURCHASED FOR PERSONAL USE. HOW LONG THE PENETRATION OF LIGHT TRUCKS INTO THE HOUSEHOLD VEHICLE MIX WILL CONTINUE IS UNCERTAIN. THE ANNUAL RATE OF GROWTH IN LIGHT TRUCK STOCKS OVER THE 1963–1972 PERIOD WAS 5.7. ALL PROJECTIONS FOR THE 1975–2000 PERIOD ARE LESS THAN HALF THIS VALUE. THE TEC PROJECTION IS A JUDGMENTAL ESTIMATE BASED UPON THE THREE SOURCES ON THIS TABLE THAT WERE FUNDED BY TEC.

Table 3.16
Number of Light Trucks (under 10,000 lb GVW) (10^6)

	1940	1945	1950	1963	1967	1972	
Historical				8.8	11.3	14.6 (5.7)[a]	
Projections	**1975**	**1985**	**2000**	**2010**	**2025**	**Annual Growth Rate 1975–2000**	**Annual Growth Rate 2000–2025**
TEC	19.0	32.0	39.0			2.9	
TEC Model	19.3	32.2	37.9	41.0	46.0	2.7	0.8
L-K[b] I	19.3	33.4	49.8		59.1	3.2	1.4
IIA	19.3		37.5		45.0	2.7	0.7
ORNL[c] A	19.0	26.2	36.2			2.6	
B	19.0	26.8	36.7			2.7	
Ratio: High/Low	1.02	1.04	1.20		1.31		

[a]1963–1972 annual growth rate.

[b]L-K stands for *Projection of Light Truck Population to Year 2025*, Lindsey-Kaufman Company, Tenafly, N.J., September 1977 [for ORNL (ORNL/Sub-78/14285/1) and TEC/DOT].

[c]ORNL stands for Oak Ridge National Laboratory draft report: *Light Truck Inventory Models: Forecasts to the Year 2000*, G. E. Liepins, ORNL/TM-6450.

THE TEC ESTIMATE OF FUTURE LIGHT TRUCK SALES IS ON THE LOW SIDE OF THE FEW PROJECTIONS THAT CAN BE FOUND FOR LIGHT TRUCK SALES.

Table 3.17
Light Truck Sales (10^6)

	1940	1945	1950	1955	1960	1965	1970	1973	1974	1975	1976	1977
Historical						1.35	1.35	2.50	2.27	1.94	2.64	3.11

Projections	1975	1977	1980	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	1.94			3.50	4.00			2.9	
TEC Model	2.10			3.54	3.98	4.27	4.76	2.6	0.7
NHTSA[a,b]			3.60						
Hurter[c,d]		3.4		4.7[e]					
DRI[f]		3.32		4.06					
Ratio: High/Low	1.08			1.33					

[a]U.S. Department of Transportation, National Highway Traffic Safety Administration, *Final Impact Assessment of the Light Truck and Van Fuel Economy Standards for Model Years 1980 and 1981*, Washington, D.C., March 15, 1978, p. IV-20.

[b]Domestic only.

[c]Personal communication with Don Hurter, Arthur D. Little, Inc., Cambridge, Mass., August 29, 1978.

[d]Does not include imports.

[e]Includes imports.

[f]Personal communication with Rosemarie Machalek, "DRI Forecast 0678," September 5, 1978.

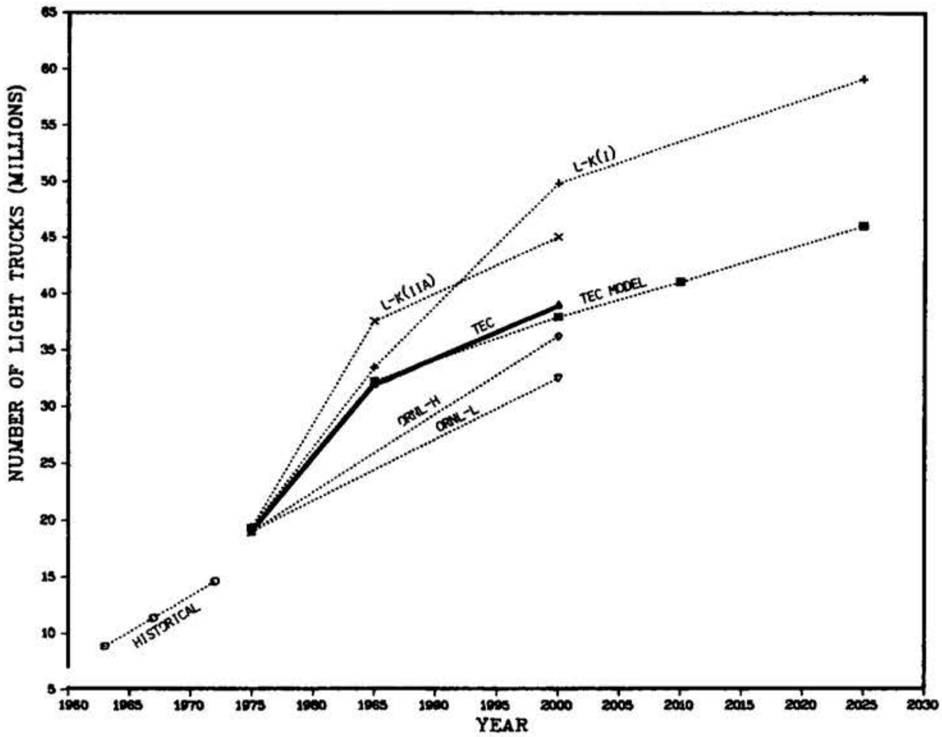

Fig. 3.13
Number of Light Trucks.
(under 10,000 lb GVW)
(10^6)

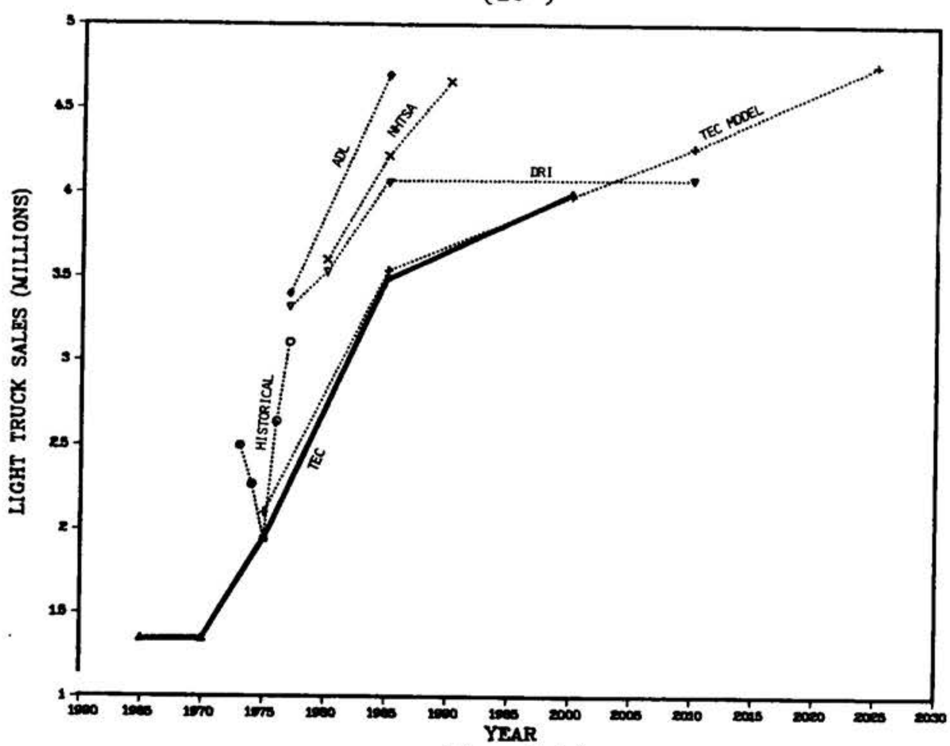

Fig. 3.14
Light Truck Sales.
(10^6)

THE ESTIMATES HERE ARE FOR INTERCITY TRUCKING TON-MILES-TRAVELED ONLY. THUS, TWO MAJOR USES OF TRUCKS (INTRACITY FREIGHT AND PERSONAL USE) AND THE ASSOCIATED ENERGY USE ARE NOT REFLECTED HERE. THE PROJECTIONS DO NOT DIVERGE MUCH UNTIL 2000 WHEN THE HIGHEST PROJECTION IS 42% LARGER THAN THE LOWEST. THE GAP INCREASES TO 200% BY THE YEAR 2025.

Table 3.18
Intercity Truck Ton-Miles-Traveled
(10^9)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	62	67	173	223	285	359	412	454 (3.9)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	454	630	1050			3.4	
TECNET-B	427	630	1067		2643	3.7	3.7
C		624	1025		2417	3.6	3.5
AYRES	447	654	937			3.0	
FUTURES H	454	631	850		1090	2.5	1.0
L	454	614	749		873	2.0	0.6
WAES (C-1)	462[b]	644					
Ratio: High/Low	1.06	1.07	1.42		3.03		

[a]1950–1975 annual growth rate.

[b]1972 data.

THE TRUCK ENERGY SHOWN HERE IS FOR FREIGHT, SERVICE, AND PERSONAL TRUCK USE. THE VARIATIONS GROW DRAMATICALLY OVER TIME.

Table 3.19
Truck Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			1.37	1.72	2.06	2.58	3.32	4.09 (4.5)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	4.1	5.3	7.6			2.5	
TEC Model	4.6	7.4	10.1	11.7	14.8	3.2	1.5
SRI-HG	4.5				24.0		
CV	4.5				18.4		
TECNET-B	4.5[b]	5.5	7.4		13.2	2.0	2.3
C	4.5[b]	5.1	4.7		7.8	0.2	2.1
AYRES						1.0	
CONSAD H		6.4	10.3		25.6		3.7
L		4.7	5.2		6.2		0.7
FUTURES H	4.0[c]	4.5	6.0		7.4	1.6	0.8
	4.0[c]	4.3	5.0		5.3	0.9	0.2
SHELL[d] (Oil only)	4.0	6.4					
Ratio: High/Low	1.1	1.7	2.8		4.8		

[a]1950 1975 annual growth rate.

[b]1977 estimate.

[c]1974 estimate.

[d]Truck and buses.

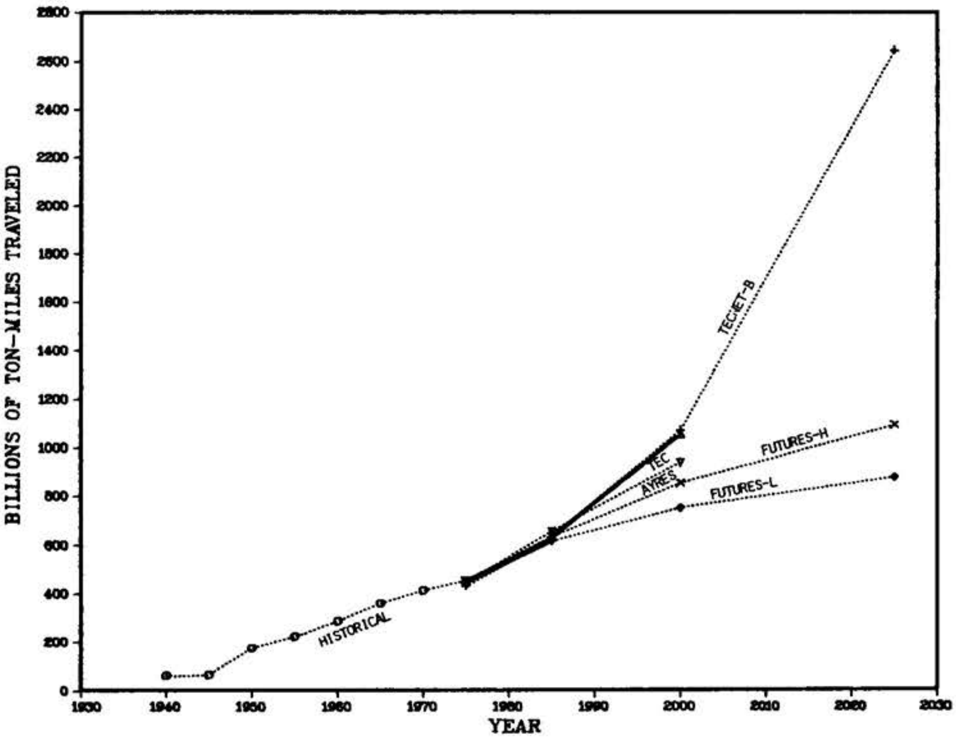

Fig. 3.15
Intercity Truck Ton-Miles-Traveled.
(10^9)

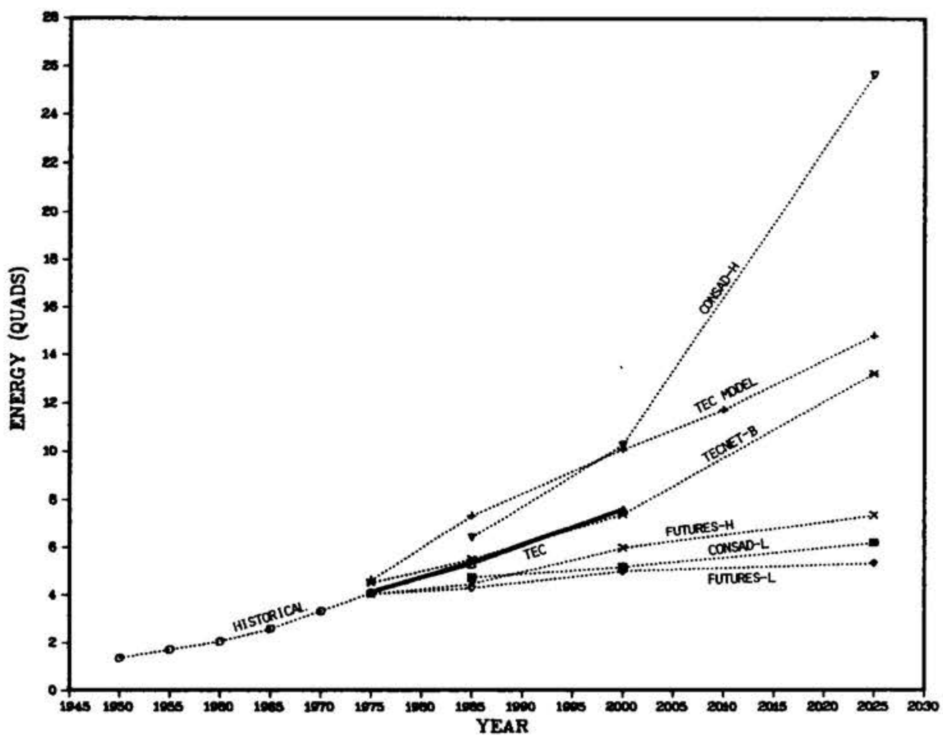

Fig. 3.16
Truck Energy.
(10^{15} Btu)

THE DIFFERENCES IN ESTIMATES OF AIR PASSENGER-MILES-TRAVELED IN 1975 ARE DIFFICULT TO EXPLAIN SINCE EACH ESTIMATE IS SUPPOSED TO REPRESENT DOMESTIC AND INTERNATIONAL TRAVEL BY U.S. CITIZENS ON U.S. AIRCRAFT. THE VARIATIONS ARE VERY LARGE BY THE YEAR 2000.

Table 3.20
Air Passenger-Miles-Traveled
(10^9)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	1.1	3.4	8.0	19.9	30.6	51.9	104.2	131.7 (11.9)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	182	300	550			4.5	
SRI-HG	215	316	542		902	3.8	2.1
CV	215	282	402		564	2.5	1.4
TECNET-B	223[b]	316	542		793	3.9	1.5
C	223[b]	315	541		788	3.9	1.5
AYRES	170	331	815			6.5	
CONSAD H	223[b]	325	579		927	4.2	1.9
L	223[b]	299	467		612	3.3	1.1
FUTURES H	146[c]	280	330		500	3.2	1.7
L	146[c]	275	305		433	2.9	1.4
WAES (C-1)	169[d]	411	654			5.0	
NTPSC-M[e]	148	232	472			4.8	
FAA*	160	313					
Ratio: High/Low	1.40	1.49	2.67		2.13		

[a]1950–1975 annual growth rate.

[b]1977 data.

[c]1974 data.

[d]1972 data.

[e]Domestic travel only.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Aviation Forecast - Fiscal Years 1979-1990*, Washington, D.C., September 1978.

ALTHOUGH GENERAL AVIATION CONSUMES LITTLE MORE THAN 0.1×10^{15} BTU TODAY, IT IS EXPECTED BY ALL PROJECTIONS TO GROW MUCH LARGER IN THE FUTURE.

Table 3.21
General Aviation Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970
Historical							

Projections	1975	1980	1985	1990	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	0.11		0.30		0.52			6.4	
TEC Model	0.12		0.25		0.69	1.27	3.29	7.3	6.5
TECNET-B	0.13[a]		0.23		0.44		0.77	5.0	2.3
C	0.13[a]		0.23		0.44		0.77	5.0	2.3
CONSAD H	0.13[a]		0.24		0.47		0.88	5.8	2.5
L	0.13[a]		0.22		0.38		0.60	4.8	1.8
FUTURES H	0.13[a]		0.20		0.48		2.03	5.8	6.0
L	0.13[a]		0.20		0.48		2.03	5.8	6.0
FAA*	0.11		0.24						
Ratio: High/Low	1.10		1.52		1.81		5.48		

[a]1977 estimate.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Aviation Forecast - Fiscal Years 1979-1990*, Washington, D.C., September 1978.

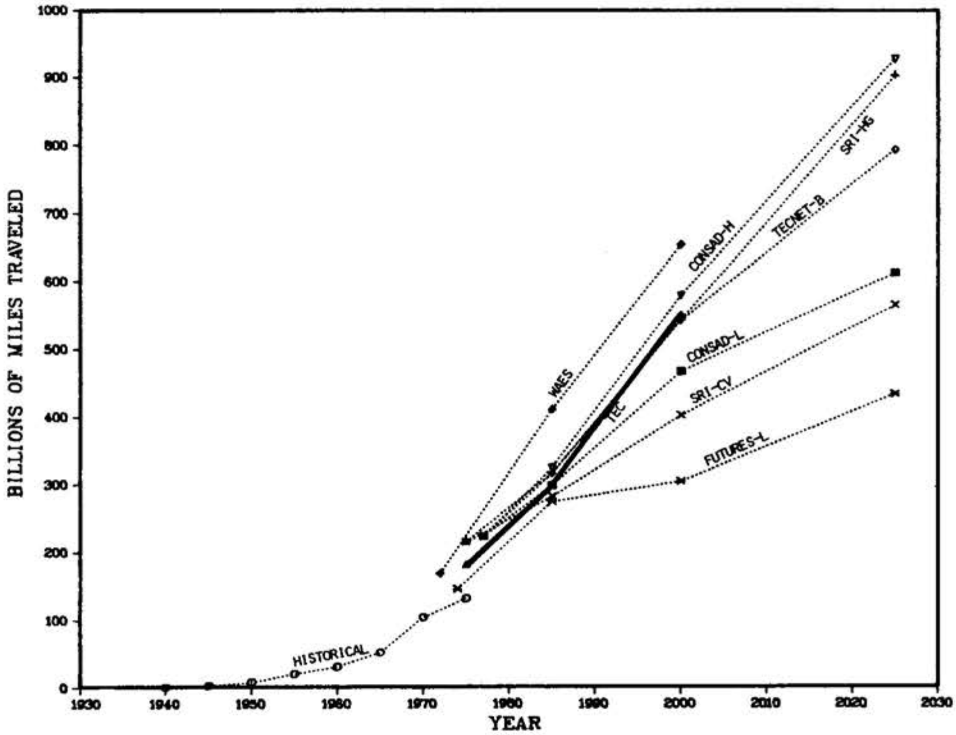

Fig. 3.17
Air Passenger-Miles-Traveled.
(10^9)

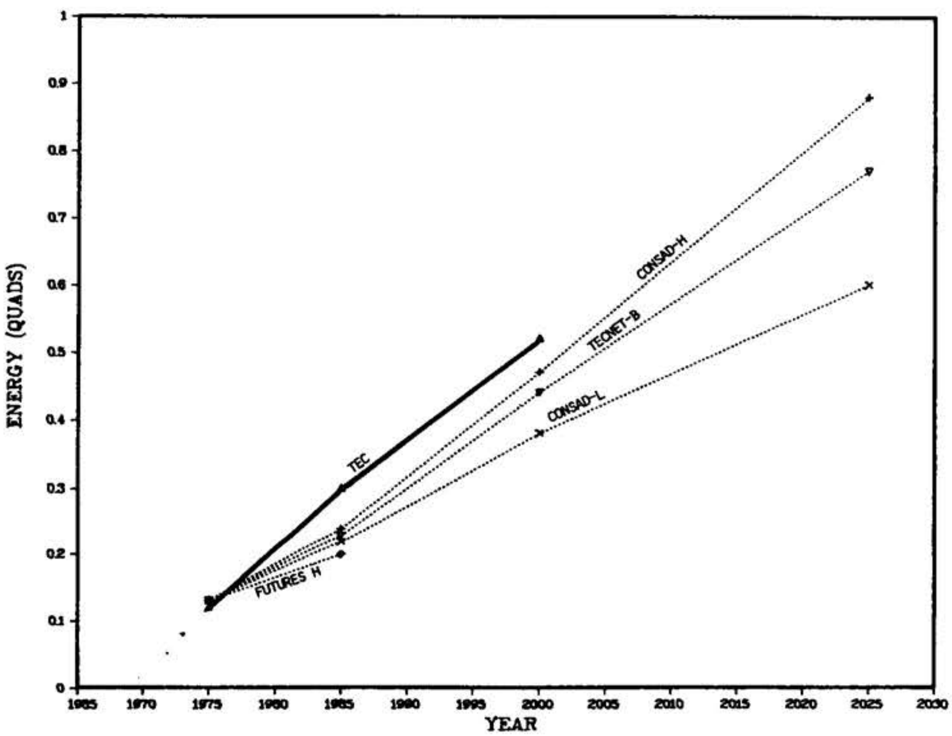

Fig. 3.18
General Aviation Energy.
(10^{15} Btu)

THE PROJECTIONS FOR AIR ENERGY VARY WIDELY ACROSS SOURCES. ANNUAL RATES OF GROWTH DURING THE 1975–2000 PERIOD RANGE FROM 2.1 TO 6.5%, BOTH OF WHICH ARE FAR BELOW THE 13.2% RATE DURING THE 1950–1975 PERIOD.

Table 3.22
Air Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			0.07	0.14	0.28	0.71	1.41	1.53 (13.1)[a]
Projections	1975	1985	2000	2000	2025	Annual Growth Rate 1975–2000	2000–2025)	
TEC	1.5	2.5	4.4			4.4		
TEC Model	1.4	2.6	4.7	6.5	12.0	5.0	3.8	
ANL	2.0[b]	2.4		3.8	4.6			
SRI-HG	1.8	2.9	5.0		8.3	4.2	2.0	
CV	1.8	2.6	3.6		4.9	2.8	1.2	
TECNET-B	1.9	2.5	4.1		6.1	3.1	1.6	
C	1.9		3.2			2.1		
AYRES	1.4	2.7	6.6			6.4		
CONSAD H		2.8	4.9		8.2		2.1	
L		2.5	3.2		3.7		0.6	
FUTURES H	1.4	2.2	3.7		6.5	4.0	2.3	
L	1.4	2.1	3.5		6.2	3.7	2.3	
IEA-H	2.4	3.9	7.7	10.7		4.8		
L	2.4	3.3	4.6	5.7		2.6		
WAES (C-1)	1.3[c]	2.2	3.0			3.0		
SHELL (Oil only)	2.1	2.8						
NPTSC-M[d]	1.0	1.5	2.2			3.2		
FAA*	1.2	1.7	2.0			2.1		
EIA	1.4	1.8						
Ratio: High/Low	1.8	2.2	2.6		3.2			

[a]1950–1975 annual growth rate.

[b]1977 data.

[c]1972 data.

[d]Domestic only.

Source: U.S. Department of Transportation, Federal Aviation Administration, *Aviation Forecast - Fiscal Years 1979-1990*, Washington, D.C., September 1978.

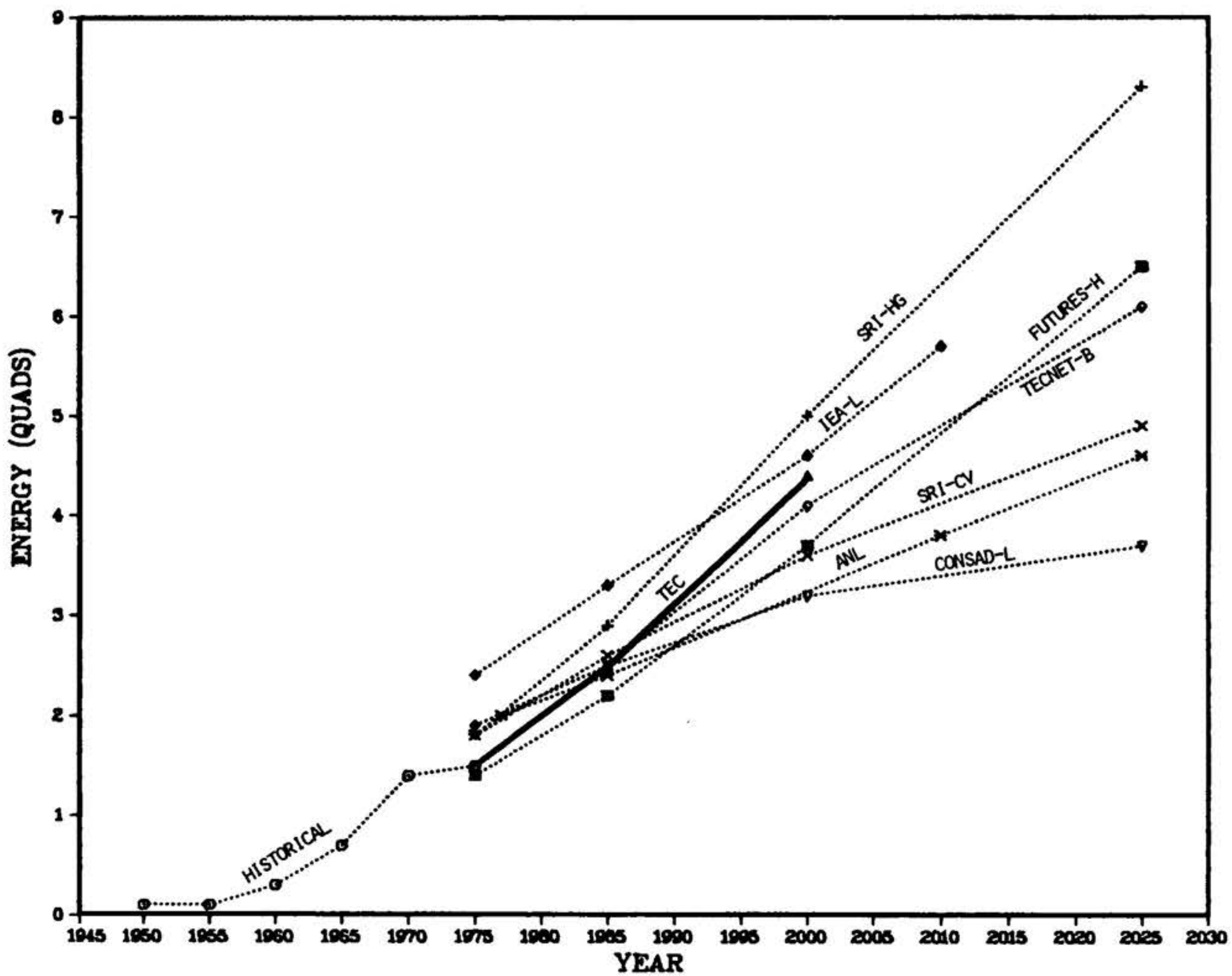

Fig. 3.19
Air Energy.
(10^{15} Btu)

THE ENERGY USED BY BUSES INCLUDES THAT FOR INTERCITY, URBAN TRANSIT, SCHOOL, AND MISCELLANEOUS BUSES. NOTE THAT MOST PROJECTIONS SHOW FUTURE ENERGY GROWTH RATES THAT ARE MUCH LARGER THAN WHAT OCCURRED OVER THE PAST 25 YEARS.

Table 3.23
Bus Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			0.100	0.105	0.112	0.120	0.127	0.119 (0.7)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	0.12	0.13	0.17			1.4	
TEC Model	0.13	0.14	0.19	0.21	0.24	1.5	0.9
SRI-HG		0.17	0.23		0.36		1.8
CV		0.17	0.21		0.28		1.2
TECNET-B		0.19	0.32		0.71		3.2
C		0.19	0.27		0.55		2.9
AYRES	0.12	0.22	0.34			4.3	
CONSAD H		0.18	0.36		0.90		3.7
L		0.17	0.28		0.59		3.0
FUTURES H	0.11[b]	0.13	0.15		0.20	1.2	1.2
L	0.11[b]	0.13	0.12		0.14	0.3	0.6
Ratio: High/Low	1.14	1.69	3.00		4.21		

[a] 1950–1975 annual growth rate.

[b] 1974 data.

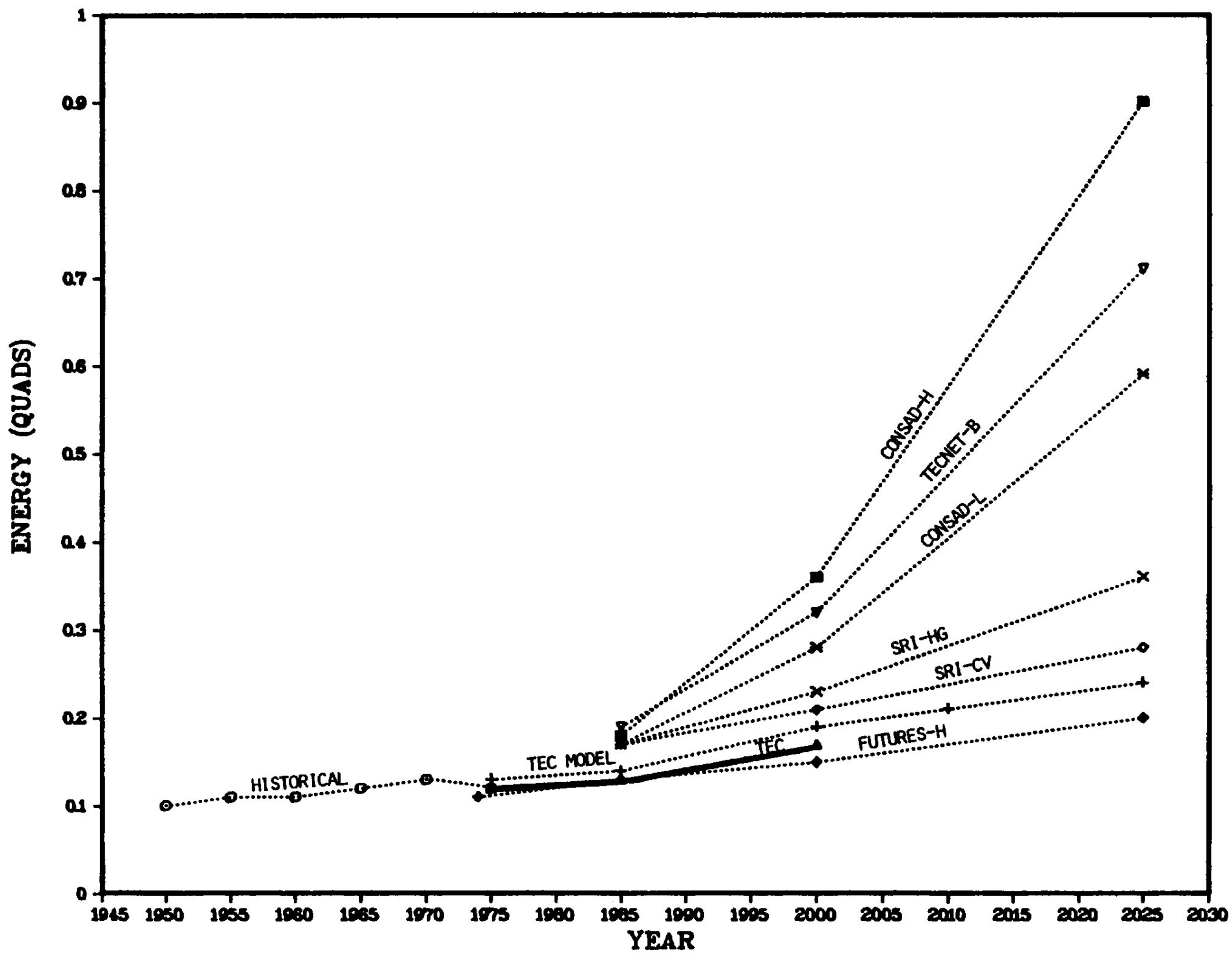

Fig. 3.20
Bus Energy.
(10^{15} Btu)

RAIL FREIGHT ACTIVITY (TMT) IS EXPECTED TO GROW AT A MORE RAPID RATE THAN IN THE LAST 25 YEARS BY MOST OF THE PROJECTIONS. SOME OF THIS GROWTH IS PROBABLY DUE TO INCREASED COAL CARRIED BY RAIL, BUT NONE OF THE PROJECTIONS SHOW COAL MOVEMENTS EXPLICITLY.

Table 3.24
Rail Ton-Miles-Traveled, Historical and Projected Transportation Factors
(10^9)

	1940	1945	1950	1955	1960	1965	1970	1975	
Historical	375	684	592	627	575	706	771	759 (1.0)[a]	

Projected	1975	1980	1985	1990	2000	2025	Annual Growth Rate 1975–2000	2000–2025
TEC	759		900		1500		2.8	
TEC Model	761		1139		1719	2771	3.3	1.9
ANL	945[b]		1305			3759		
TECNET-B	828[c]		1066		1604	3022	2.9	6.7
C	828[c]		1094		1598	2966	2.9	2.5
AYRES	881		1150		1392		1.9	
CONSAD-H			1034		1604	3405		3.1
L			1086		1531	2424		1.9
FUTURES H			988		1203	1441		0.7
L			958		1152	1390		0.8
WAES (C-1)	784[d]		1163		1977		3.4	
Ratio: High/Low	1.25		1.45		1.72	2.70		

[a]1950–1975 annual growth rate.

[b]1977 data.

[c]1977 estimate.

[d]1972 data.

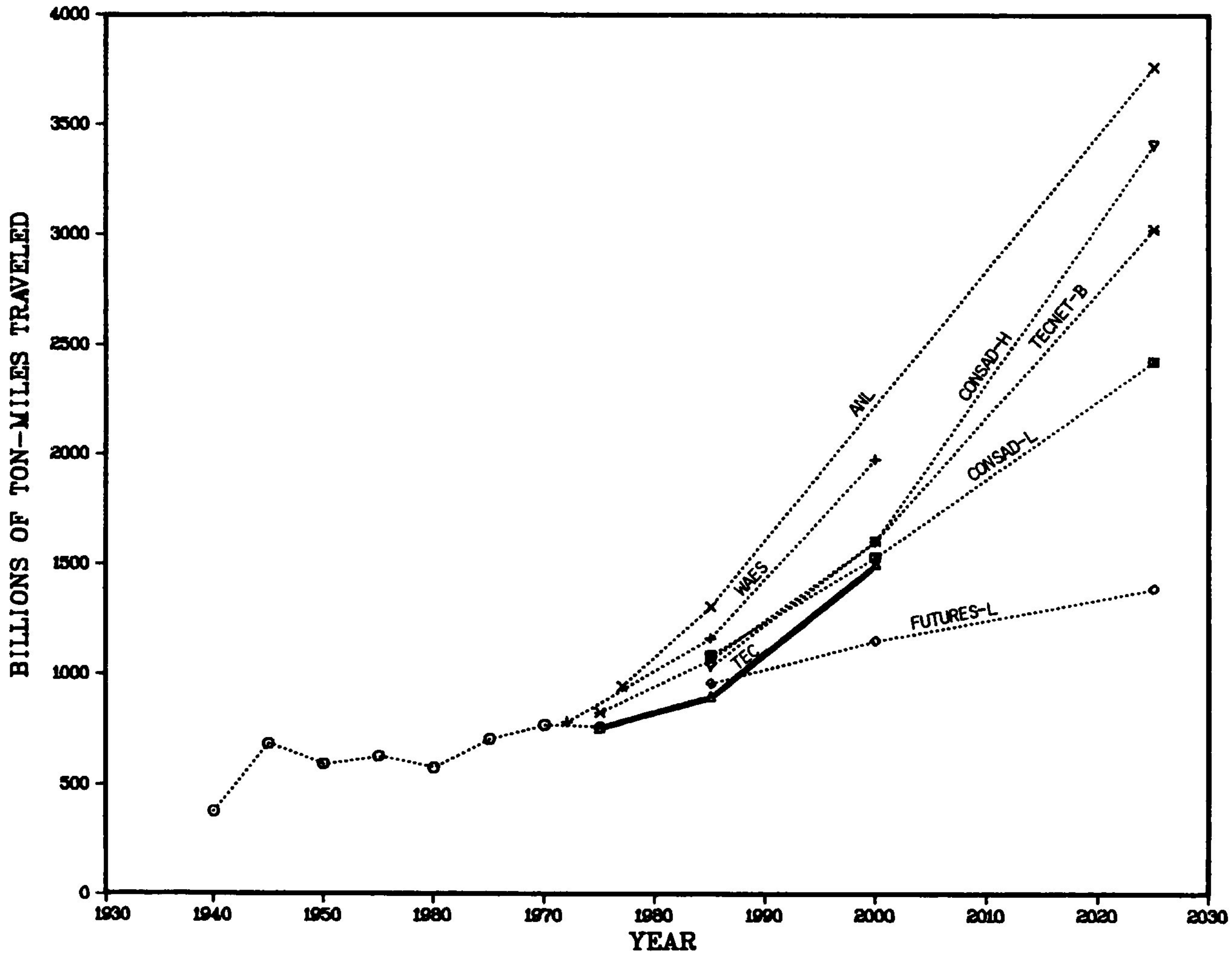

Fig. 3.21
Rail Ton-Miles-Traveled, Historical and Projected Transportation Factors. (10^9)

THE BIG DECLINE IN ENERGY USED BY RAIL OVER THE PAST 25 YEARS OCCURRED MOSTLY FROM THE DECLINE IN PASSENGER RAIL ACTIVITY. EVERY PROJECTION SHOWS A REVERSE IN THE HISTORICAL DOWNWARD TREND IN RAIL ENERGY USE, BUT NONE OF THE PROJECTIONS EXPECT RAIL ENERGY USE IN THE YEAR 2000 TO BE AS LARGE AS IT WAS IN 1950.

Table 3.25
Rail Energy, Historical and
Projected Transportation Factors
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			1.9	0.8	0.5	0.6	0.5	0.5 (−5.0)[a]

Projection	1975	1980	1985	1990	2000	2010	2025	Annual Growth Rate 1975–2000	2000–2025
TEC	0.6		0.7		1.2			3.1	
TEC Model	0.5		0.8		1.10	1.3	1.8	3.0	1.9
ANL	0.5[b]		0.6			1.2	1.6	2.6	
SRI-HG			0.7		0.7		0.8		0.5
CV			0.7		0.9		0.9		0
TECNET-B	0.6[c]		0.8		1.3		2.5	1.3	2.0
C	0.6[c]		0.8		1.1		2.0	1.3	1.3
AYRES	0.7		0.9		1.1			0.7	
CONSAD H			0.7		1.2		2.5		3.1
L			0.6		0.6		0.9		1.8
FUTURES H	0.6[d]		0.7		0.9		1.1	1.4	0.8
L	0.6[d]		0.7		0.8		1.0	1.1	0.8
WAES (C-1)	0.6[d]		0.7		1.1			2.4	
Ratio: High/Low	1.50		1.59		2.24		3.13		

[a]1950–1975 annual growth rate.

[b]1977 data.

[c]1977 estimate.

[d]1972 data.

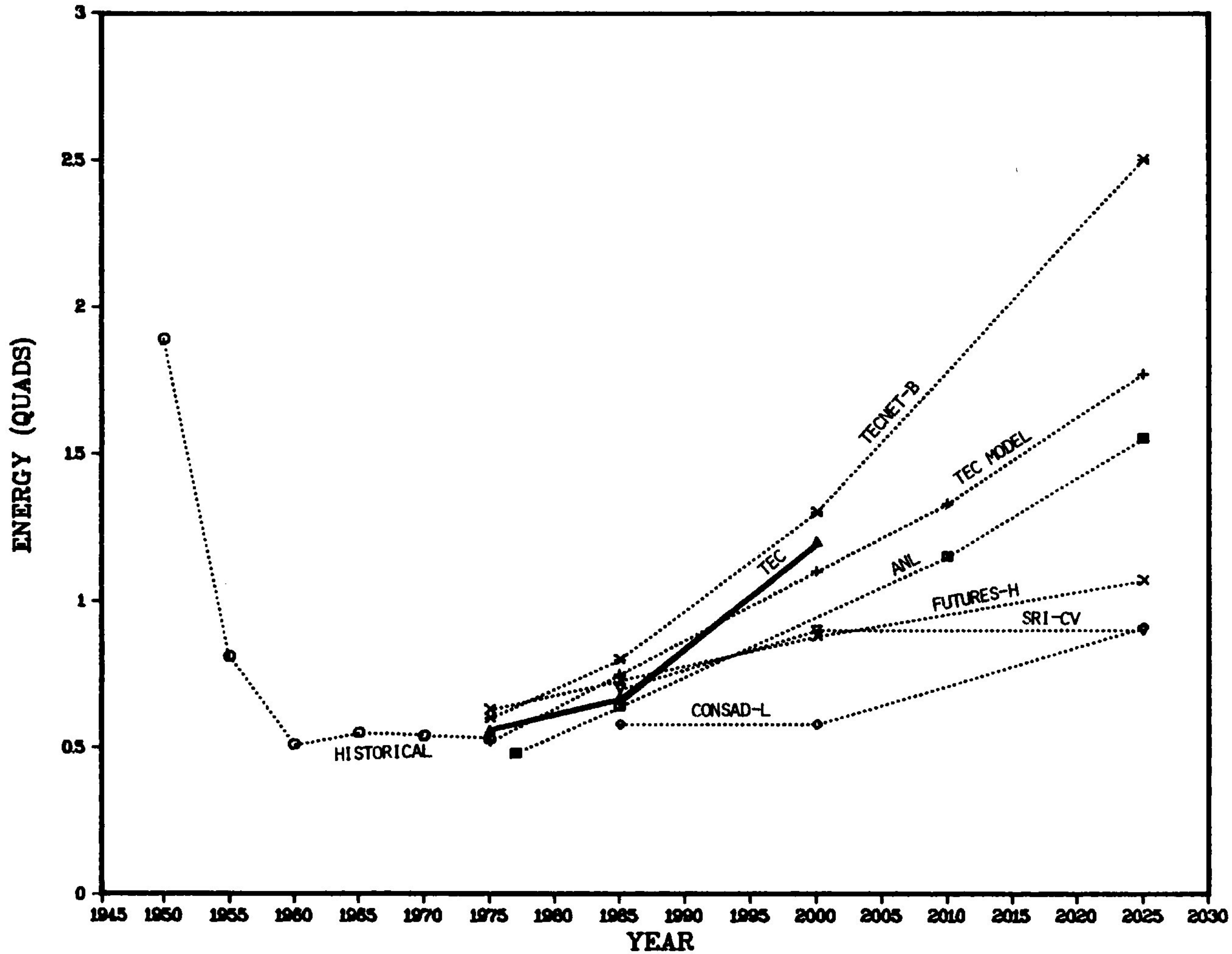

Fig. 3.22
Rail Energy, Historical and Projected Transportation Factors.
(10^{15} Btu)

TECNET estimates of marine Ton-Miles-Traveled (TMT) is higher than others in 1975 because an estimate of international TMT is included. CONSAD is also high since its values are based on the TECNET model. Surprisingly, the projections show as large or larger annual growth rates for the period 2000–2025 as for the 1975–2000 period.

Table 3.26. Marine Ton-Miles-Traveled (10^9)

	1940	1945	1950	1955	1960	1965	1970
Historical	370	271	NA	478	476	489	595 (1.1)[a]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	950	1300	1780			2.5	
ANL	640[b]	847		1719	2465		
TECNET-B	1406[c]	1691	2350		4111	2.3	2.3
C	1406[c]	1664	2222		3812	2.0	2.2
AYRES	820	970	1014			0.8	
CONSAD H	1406[c]	1739	2553		4798	2.6	2.6
L	1406[c]	1607	2179		3321	1.9	1.7
WAES (C-1)	631[d]	737	1589			3.4	
Ratio: High/Low	2.23	2.05	2.52		2.16		

[a]1955–1970 annual growth rate.

[b]1977 data.

[c]1977 estimate.

[d]1972 data.

NA – Not available.

Even though most sources do not estimate international marine TMT, they do estimate the energy use associated with international marine activity. Only ANL and Ayres exclude international energy use from their estimates. One of the most carefully constructed estimates of energy use in the marine sector has been completed by Booz, Allen and Hamilton for TEC/DOE. Their U.S. marine energy totals (10^{15} Btu) are disaggregated in the following way:

	1974	2000	2000 %	% change 1974–2000
Foreign Trade	0.22	0.77	22	250
Great Lakes	0.05	0.10	5	100
Inland Waterways	0.09	0.10	5	11
Coastal	0.11	0.25	14	127
Offshore	0.06	0.20	12	233
Recreation	0.23	0.30	16	30
Fishing and Misc.	0.03	0.10	5	233
Total	0.79	1.82	99	130

Table 3.27. Marine Energy (10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970
Historical			0.66[a]	0.82[a]	0.70[a]	0.55[a]	0.75 (0.5)[b]

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	0.84	1.10	1.50			2.4	
TEC Model	0.72	1.01	1.76	2.66	5.14	3.6	4.4
ANL	0.33[c]	0.52		0.77	1.03		
TECNET-B	0.67[c]	0.80	1.06		1.85	2.0	2.3
C	0.67[c]	0.76	0.74		1.27	0.4	2.2
AYRES	0.45	0.53	0.55				
CONSAD H	0.67[c]	0.83	1.22		2.29		2.6
L	0.67[c]	0.74	0.77		1.18		1.7
FUTURES H	0.80[d]	0.91	1.06		1.39	1.1	1.1
L	0.80[d]	0.90	0.85		0.96	0.2	0.5
BAH[e]	0.79[d]		1.82			3.3	
Ratio: High/Low	1.87	2.62	32.0		5.35		

[a]Excludes gasoline use.

[b]1950–1970 annual growth rate.

[c]1977 estimate.

[d]1974 estimate.

[e]Booz, Allen and Hamilton (BAH), *Energy Use in the Marine Transportation Industry – Industry Future*, TASK IV, Bethesda, Md., December 1977.

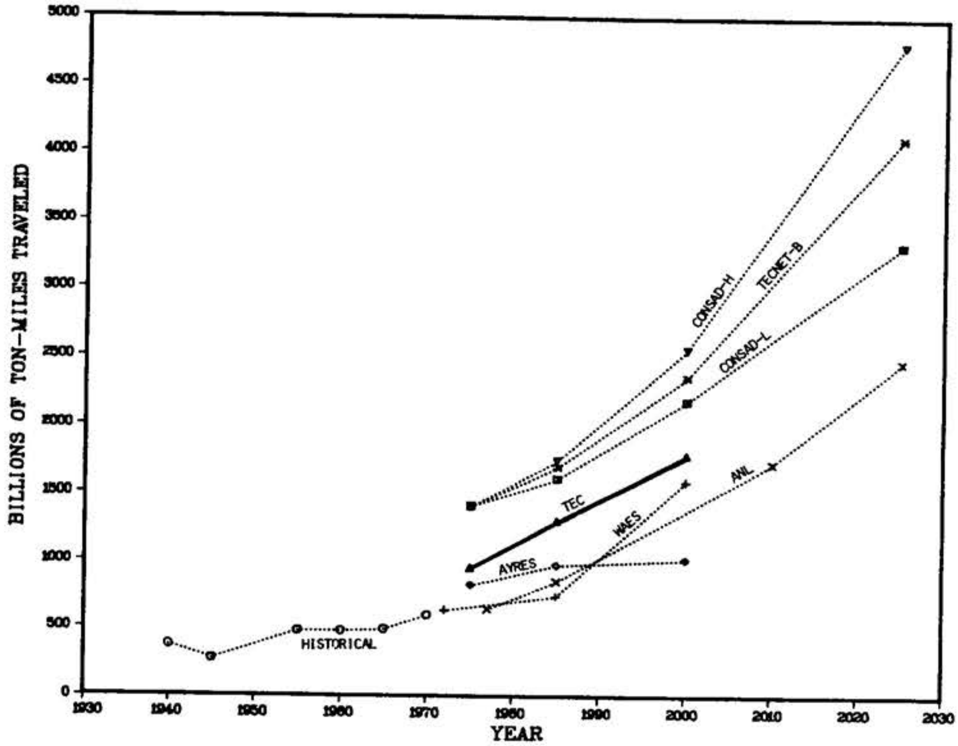

Fig. 3.23
Marine Ton-Miles-Traveled.
(10^9)

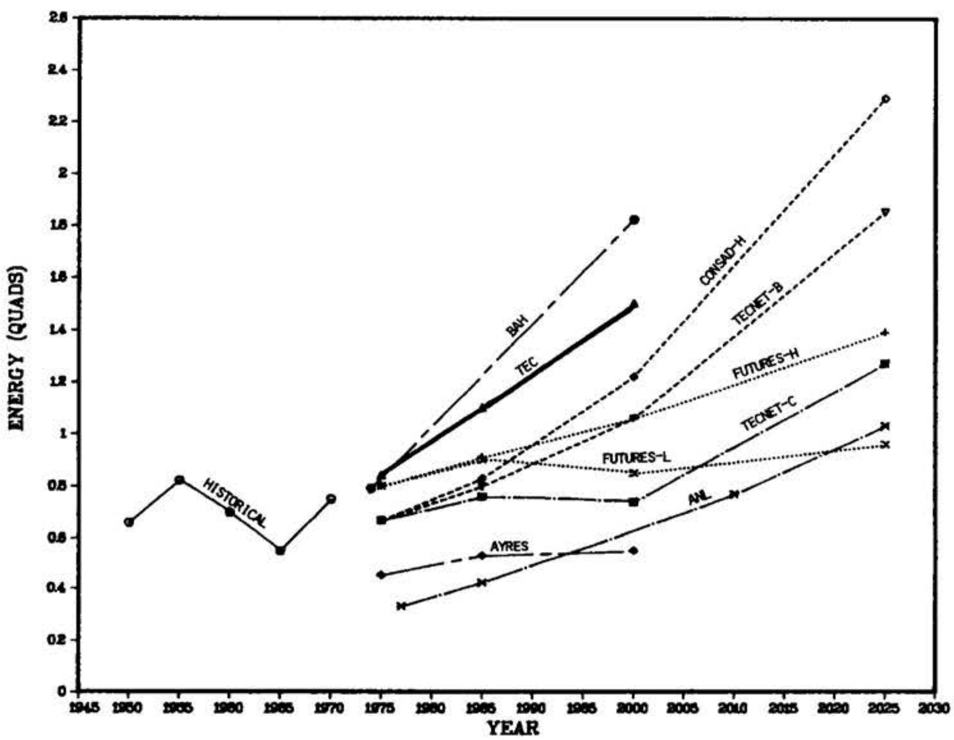

Fig. 3.24
Marine Energy.
(10^{15} Btu)

IN ORDER TO ESTIMATE FUTURE USE OF PIPELINES, ONE MUST HAVE A CLEAR PICTURE OF THE FUTURE USE OF PETROLEUM PRODUCTS AND NATURAL GAS IN THE UNITED STATES. OF THE ESTIMATES ON THIS TABLE, ONLY THE BROOKHAVEN ENERGY TRANSPORTATION SUBMODEL (BETS) VALUES ARE CALCULATED AS PART OF A COMPREHENSIVE NATIONAL ENERGY MODEL.

Table 3.28
Pipeline Ton-Miles-Traveled[a]
(10^9)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical	59	127	129	203	229	306	431	507

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	763	850	800			0.2	
TEC Model	507	719	640	609	564	0.9	−0.5
TECNET-B	788[b]	792	1077		2021	1.4	2.6
CONSAD H	788[b]	799	1167		2322	1.7	2.8
L	788[b]	738	942		1346	0.8	1.4
BETS-SF1	781[b]	907	907			0.7	
SF4	781[b]	827	829			0.3	
Ratio: High/Low	1.55	1.26	1.82		4.12		

[a]Historical and TEC Model values are oil pipelines; the other projections are for oil plus natural gas.

[b]1977 estimate.

SEVERAL OF THE SOURCES SHOW A LEVELING OFF OR DECLINE IN THE ENERGY USED TO POWER PIPELINES. THE FUTURES PROJECTIONS SHOW LARGE GROWTH DESPITE THE FACT THAT THE NATION IS ATTEMPTING TO REDUCE ITS DEPENDENCE ON OIL AND NATURAL GAS.

Table 3.29
Pipeline Energy
(10^{15} Btu)

	1940	1945	1950	1955	1960	1965	1970	1975
Historical			0.13	0.26	0.37	0.53	0.76	0.62 (6.3)

Projections	1975	1985	2000	2010	2025	Annual Growth Rate 1975–2000	Annual Growth Rate 2000–2025
TEC	1.26	1.40	1.32			0.2	
TEC Model	1.04	1.04	0.77	0.67	0.51	−1.2	−1.6
TECNET-B	1.42[b]	1.44	1.60		2.18	0.4	1.2
C	1.42[b]	1.17	0.81		0.69	−2.4	−0.6
FUTURES H	1.13[c]	2.74	3.03		4.46	3.9	1.6
L	1.13[c]	2.56	2.32		2.59	2.8	0.4
BETS[a]-SF1	1.27[b]	1.36	1.05			−0.8	
SF2	1.27[b]	1.36	1.31			0.1	
Ratio: High/Low	1.37	2.63	3.94			8.75	

[a]BETS stands for the *Brookhaven Energy Transportation Submodel*, Joseph R. Wagner, Brookhaven National Laboratory, Upton, N.Y., October 1977.

[b]1977 estimate.

[c]1974 estimate.

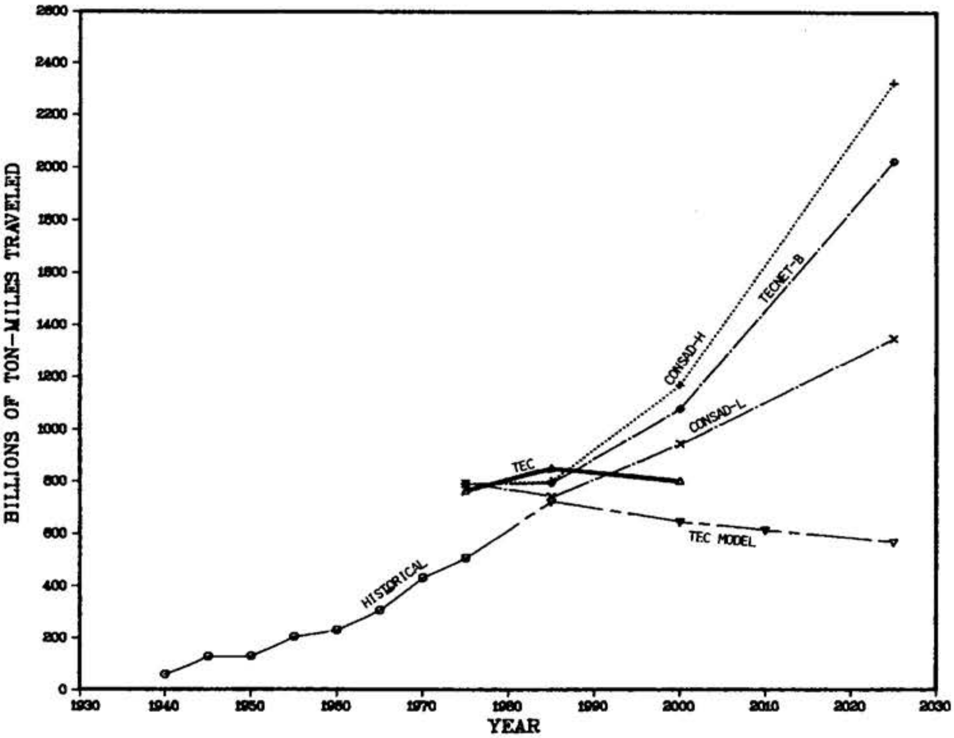

Fig. 3.25
Pipeline Ton-Miles-Traveled.
(10^9)

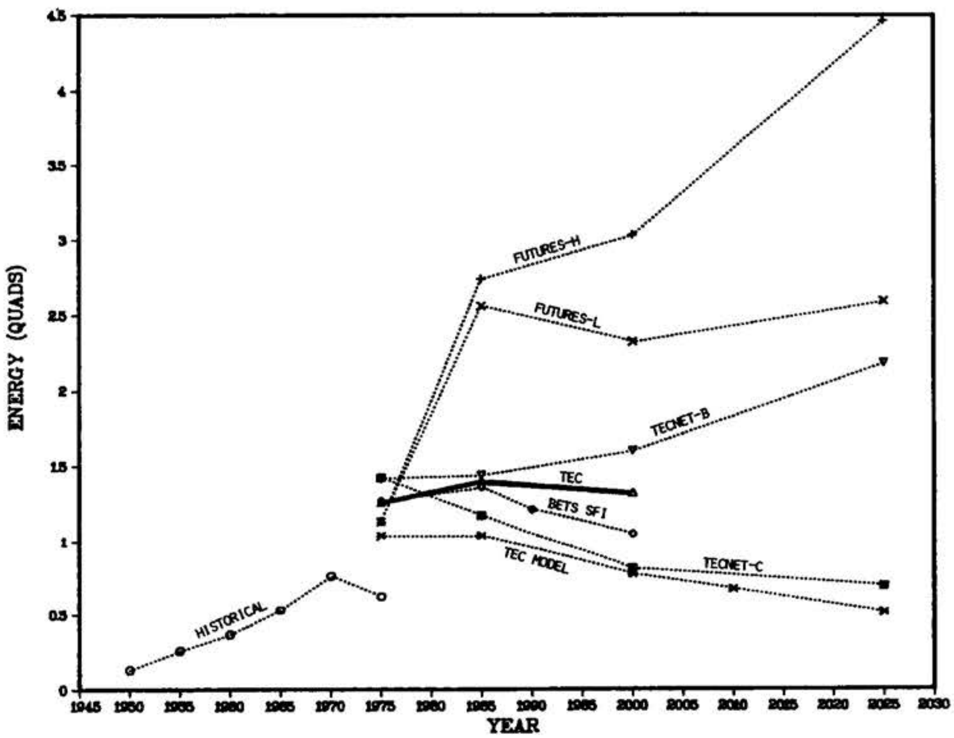

Fig. 3.26
Pipeline Energy.
(10^{15} Btu)

TEC BASELINE GROWTH RATES IN RAIL, MARINE, AND BUS ACTIVITY AND ENERGY ARE THE ONLY ONES THAT SHOW A GREATER PROJECTED RATE OF GROWTH FOR THE NEXT 25 YEARS THAN FOR THE LAST 25 YEARS. THE TEC BASELINE IS A PRE-CONSERVATION PROJECTION AND ITS OVERALL TRANSPORTATION ENERGY GROWTH RATE IS ONLY 1.6 PERCENT COMPARED WITH AN HISTORICAL 3.5 PERCENT RATE OF GROWTH.

Table 3.30
Summary of Projection Comparisons

	Annual Growth Rate 1950–1975	Annual Growth Rate 1975-2000		
		High	Low	TEC Baseline
Transportation Energy Use	3.5	2.1	-0.6	1.6
Population	1.4	0.9	0.6	0.8
Gross National Product	3.6	4.2	2.6	3.4
Passenger-Miles-Traveled	4.3	3.4	2.4	2.6
Ton-Miles-Traveled	2.7	2.9	1.4	2.3
Automobile — Stock	4.0	2.2	0.8	1.6
Vehicle-Miles-Traveled	4.3	3.0	0.8	2.5
Energy Used	4.6	1.2	-2.9	0.6
Trucks — Light Truck Stocks	4.7	3.2	2.2	2.9
Ton-Miles	3.9	3.7	2.0	3.4
Energy Used	4.5	3.2	0.2	2.5
Air — Passenger-Miles-Traveled	11.9	6.5	2.5	4.5
Energy Used	13.1	6.4	2.1	4.4
Rail — Ton-Miles	1.0	3.4	1.9	2.8
Energy Used	-5.0	3.1	0.7	3.1
Marine — Ton-Miles	1.1	3.4	0.8	2.5
Energy Used	0.5	3.6	0.2	2.4
Pipeline — Energy Used	6.3	3.9	-2.4	0.2
Bus Energy	0.7	4.3	0.3	1.4

THE RATIOS IN THIS TABLE SHOW THAT THE VARIATION IN MOST FACTORS INCREASES OVER TIME. FOR EXAMPLE, ALL PROJECTIONS START WITH AN IDENTICAL GNP IN 1975, BUT THE HIGH GNP PROJECTION IN THE YEAR 2000 IS 9 PERCENT HIGHER THAN THE LOW GNP PROJECTION. LIKEWISE, THE VARIATIONS IN TOTAL TRANSPORTATION ENERGY ESTIMATES FOR 1975 VARY BY 13 PERCENT (DUE TO DIFFERENT DEFINITIONS OF THE TRANSPORTATION SECTOR OR THE ENERGY COUNTED), BUT THEY VARY BY 95 PERCENT BY THE YEAR 2000 (DUE TO DIFFERENT ASSUMPTIONS CONCERNING TRANSPORTATION DEMANDS AND CONSERVATION MEASURES).

Table 3.31
Ratio of High to Low Values for
Transportation Factors

	1975	1985	2000	2025
Transportation Energy	1.13	1.42	1.95	3.19
Population	1.00	1.03	1.09	1.22
GNP	1.00	1.13	1.50	2.29
PMT	1.05	1.14	1.39	1.52
TMT	1.84	1.68	2.21	1.78
Automobiles	1.12	1.17	1.37	1.41
Auto VMT	1.05	1.21	1.76	2.85
Annual Miles/Auto	1.11	1.32	1.71	2.18
Auto MPG Fleet	1.08	1.26	2.00	
Auto Energy	1.26	1.54	2.21	3.45
Light Trucks	1.02	1.04	1.20	1.31
Light Truck Sales	1.08	1.33		
Truck TMT	1.06	1.07	1.42	3.03
Truck Energy	1.14	1.71	2.81	4.80
Air PMT	1.40	1.20	2.67	2.13
General Aviation Energy	1.10	1.52	1.81	5.48
Air Energy	1.75	2.17	2.57	3.24
Bus Energy	1.14	1.69	3.00	4.21
Rail TMT	1.25	1.45	1.72	2.70
Rail Energy	1.50	1.59	2.24	3.13
Marine TMT	2.23	2.05	2.52	2.16
Marine Energy	1.87	2.62	3.20	5.35
Pipeline TMT	1.55	1.26	1.82	4.12
Pipeline Energy	1.37	2.63	3.94	8.75

Note: GNP — gross national product.
PMT — passenger-miles-traveled.
TMT — ton-miles-traveled.
VMT — vehicle-miles-traveled.

PROJECTIONS OF AIR EMISSIONS FOR THE BASE CASE (CONTINUAL USE OF THE INTERNAL COMBINATION ENGINE IN THE AUTOMOBILE) SHOW THAT THE THREE MAJOR POLLUTANTS (CO, NOx AND HC) DECLINE IN 1985 RELATIVE TO 1977 VALUES. BY THE YEAR 2000, NOx AND HC EMISSIONS RISE SLIGHTLY ABOVE THE 1985 LEVELS WHEREAS CO EMISSIONS ARE STILL DECLINING.

NOTE THE DECLINE IN IMPORTANCE OF AUTO EMISSIONS TO TOTAL TRANSPORTATION EMISSIONS FOR ALL THREE POLLUTANTS. ON THE OTHER HAND, TRUCKS ACCOUNT FOR A GROWING SHARE OF TRANSPORTATION EMISSIONS OVER TIME.

Table 3.32
Transportation Emissions — Base Case
(10^6 tons)

	1977	1985	2000	2025
Total Transportation				
CO	92.6	57.0	40.8	82.5
NOx	7.6	6.4	6.7	13.2
HC	8.3	4.9	5.0	9.8
CO Emissions				
Auto	59.1	26.3	19.6	33.6
%	64	46	48	41
Truck	32.7	29.7	19.7	46.3
%	35	52	48	56
NOx Emissions				
Auto	3.8	2.1	2.5	4.2
%	50	33	37	32
Truck	2.8	3.0	2.2	5.3
%	37	47	33	40
HC Emissions				
Auto	4.8	2.2	2.2	3.7
%	58	45	44	38
Truck	3.1	2.2	2.0	4.7
%	37	45	40	48

Source: TECNET Run 9/78.

THIS TABLE SHOWS PROJECTIONS OF THE DIRECT AND INDIRECT ENERGY USED IN THE TRANSPORTATION SECTOR. SINCE TECNET IS THE SOURCE FOR THESE PROJECTIONS, THE BASE CASE AND CONSERVATION CASE ON THIS TABLE CORRESPOND TO THE TECNET-B AND TECNET-C PROJECTIONS IN TABLE 3.4 AND ESLEWHERE IN THIS CHAPTER.

NOTE THAT IN BOTH THE BASE CASE AND THE CONSERVATION CASE, INDIRECT ENERGY IS EXPECTED TO GROW RELATIVE TO DIRECT ENERGY.

Table 3.33
Projections of Indirect Energy
(10^{15} Btu)

Base Case	Year		
	1977	2000	2025
Total Direct and Indirect Trans.	28.4	43.9	75.2
Direct Transportation	20.0	27.4	45.5
Indirect Transportation	8.4	16.5	29.7
Equipment Manufacture	4.1	8.8	16.3
Services	3.2	6.2	11.2
Infrastructure	1.1	1.6	2.2
Indirect as Percent of Direct	42%	60%	65%
Conservation Case (Percent Change Compared to Base Case)			
Total Direct and Indirect Trans.	28.4	32.9 (-25)	49.8 (-34)
Direct Transportation	20.0	20.4 (-25)	29.5 (-35)
Indirect Transportation	8.4	12.5 (-25)	20.4 (-32)
Equipment Manufacture	4.1	7.5 (-15)	13.4 (-18)
Services	3.2	3.6 (-42)	5.1 (-55)
Infrastructure	1.1	1.4 (-12)	1.8 (-17)
Indirect as Percent of Direct	42%	61%	69%

Source: TECNET Run 9/78.

PROJECTIONS OF INDIRECT ENERGY USE BY MODE SHOW THAT AUTO, TRUCK, AND AIR ARE THE BIGGER USERS OF INDIRECT ENERGY JUST AS THEY ARE THE BIGGEST USERS OF DIRECT ENERGY. BUT THE RATIOS OF INDIRECT TO DIRECT ENERGY DO VARY BY MODE AS FOLLOWS FOR 1977:

Auto	0.38	Rail	1.06
Truck	0.33	Water	0.88
Bus	0.73	Pipeline	0.31
Air	0.63	Other	0.50

Table 3.34
Projections of Indirect Energy Use
by Transportation Mode
(10^{15} Btu)
(percent change in parentheses)[a]

	Base Case			Conservation Case	
	1977	2000	2025	2000	2025
TOTAL	8.4	16.5	29.7	12.5 (-25)	20.4 (-32)
Highway	5.2	9.8	17.2	7.6 (-22)	12.6 (-27)
Auto	3.6	6.7	11.5	5.4 (-19)	8.7 (-24)
Truck	1.5	2.9	5.2	2.1 (-28)	3.6 (-32)
Bus	0.1	0.2	0.5	0.1 (-36)	
Nonhighway	3.2	6.7	12.5	4.9 (-27)	7.8 (-38)
Air	1.2	2.9	5.5	2.4 (-17)	4.3 (-22)
Rail	0.7	1.3	2.6	0.6 (-53)	0.7 (-74)
Water	0.6	1.1	1.9	0.7 (-39)	1.0 (-40)
Pipeline	0.1	0.2	0.3	0.1 (-42)	0.1 (-72)
Other	0.5	1.2	2.3	1.0 (-15)	1.8 (-19)

[a] Percent changes were calculated using energy values with more significant digits than shown in this table.

Source: TECNET Run 9/78.

Chapter 4

Government Impacts

Government Impacts

The government impacts chapter has been expanded in Edition 3 to analyze the increasing influence exerted by governments (federal and state) on transportation activities and on corresponding energy consumption. The federal government's mandate for researching, developing, and demonstrating new technologies in vehicle types, propulsion systems, and energy storage capabilities highlights the increased impact which government and regulatory agencies are achieving throughout the transportation sector. Consideration of the transportation sector in total energy conservation efforts is important: transportation accounts for 26% of the total energy used and 56% of the total petroleum consumed in the United States.

There are five sections within Chapter 4, and each section illustrates a unique manner in which government policies impact transportation and energy conservation activities. These sections deal with government regulatory activities, government-mandated research, development and demonstration programs, programs directly involved in energy conservation, and taxes and expenditures. The purpose of this chapter is to provide data which identify and, where possible, quantify these governmental activities and their impacts on energy consumption.

Section 4.1, Selected Government Programs and Regulatory Activities, is an introductory look at major governmental agencies directly involved in transportation-energy research and development. Insight into the interrelationships between the Transportation Energy Conservation Division (TEC) and other Department of Energy (DOE) organizations is a major focal point of the section. The technology aspect of TEC is also illustrated in this seciton. Highway Systems, Nonhighway Transport Systems and Special Projects, and Electric Hybrid Systems are detailed.

Also included in this section is an organizational chart of the Department of Transportation (DOT) which outlines the types of data received from the various administrations within DOT. This view of data support from DOT illustrates the retrieval and dissemination activities of both TEC and ORNL.

Section 4.1 focuses upon governmental actions and policies undertaken by the federal government to initiate energy conservation and energy conservation consciousness. In addition, results of governmental conservation efforts are provided to illustrate comparisons between these efforts and the country's energy consumption as a whole.

Also examined in this section are the various federal regulations and standards which directly deal with energy conservation efforts. Passenger car and light truck fuel economy and emission standards are shown. Motor vehicle safety standards are examined in light of their impacts on energy use, and light truck technological improvements are examined as to this potential energy savings. The Environmental Protection Agency's (EPA) proposed regulations impacting various modes and interests are reviewed. Highlights of the proposed gasoline rationing plan are itemized to point out potential impacts on various sectors of the country.

The last portion of this section illustrates some trends directly related to governmental actions. The tables reflect the impact of such imposed measures as the 55-mph speed limit and the fuel economy standards set for automobile manufacturers. These tables show the abrupt change which can occur when governmental regulations or standards are imposed directly upon society.

Section 4.2, Electric and Hybrid Vehicles Program, focuses upon the current state-of-the-art research in this technology. This section commences with an introduction into Public Law (P.L.) 94-413 and its amendment by P.L. 95-238 in 1978. A look at state-of-the-art electric vehicle technology and electric vehicle phase-two goals follows and illustrates current development in the program.

Tables assessing the demand for materials for electric-vehicle propulsion and incentives to stimulate demand for electric vehicles follow. These tables show a few key factors which ultimately will aid in determining to what extent electric vehicles may penetrate the transportation market.

The final portion of this section analyzes the effects of weight and speed on fuel consumption for the electric vehicle, and an examination of the potential market for electric vehicles is shown. A comparison of the electric vehicle driving cycle with the EPA urban, EPA highway, and the heat engine driving cycle provides a look at how the new technologies effect energy consumption.

The Heat Engine Program, Sect. 4.3, is another key TEC program currently developing future technologies in engine systems and use of alternate fuels. The Heat Engine Program has many subprograms which are currently working independently, but ultimately R&D efforts will be combined. Because much of the program is in the developing and research stages, the scarcity of data is evident. This section outlines some of the key subprograms and discusses several test results.

The Heat Engine Program's foundation is Public Law 95-238. As a result of this law, gas turbine and Stirling engine technology efforts were initiated. Section 4.4 describes P.L. 95-238, the Gas Turbine Program, the Stirling Engine Program, and the Alternate Fuels Program in relation to its goals and objectives. Fuel economy and emission results from Stirling engine testing are also included in this section.

Other TEC Programs, Sect. 4.4, gives selected data from other programs within TEC which have not been acknowledged in prior sections of the chapter. One program and two branches are highlighted to round-out the overall look at TEC. The functions of the Technology Assessment and Implementation and Nonhighway Transport branches are outlined and accompanied by tables showing direct results of their efforts. The Ridesharing Program of TEC is also spotlighted by showing the growth of vanpooling in the United States over the last several years. The prime function of each branch and program is to develop means for energy savings. The tables within this section provide a glimpse of the type of research presently on-going within TEC.

The final section, Government Taxes and Expenditures, (4.6) has been greatly reduced from that in Edition 2. Data on the federal and state taxes derived from transportation were updated for 1976. Percentage changes for 1950—1970 and 1970—1976 were developed to add insight into the ratio of the transportation sector's taxes to the total amount of taxes collected. The federal and state expenditures for transportation facilities were updated for 1976, and a percentage change over the years was calculated.

Section 4.1

Selected Government Programs and

Regulatory Activities

ORNL DWG 78-17750

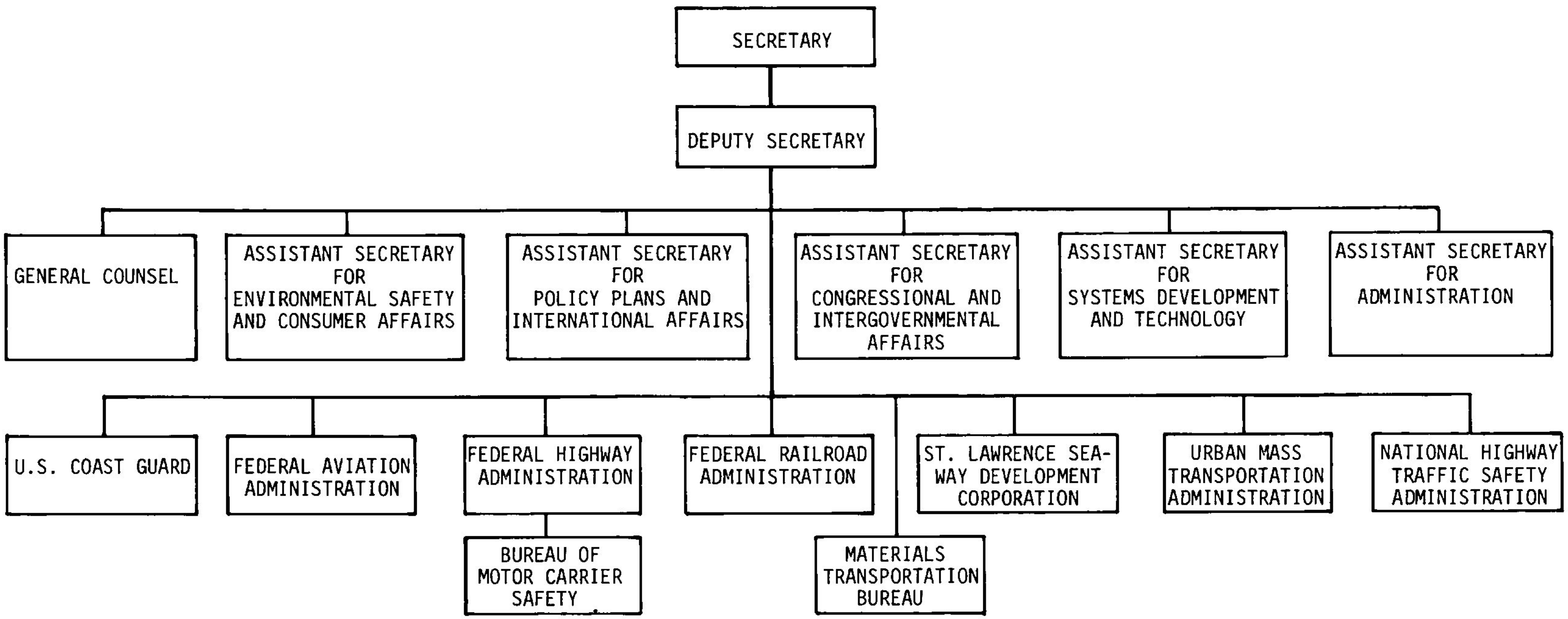

Fig. 4.1. Department of Transportation — organization and responsibilities.

ORNL–DWG 78-19027

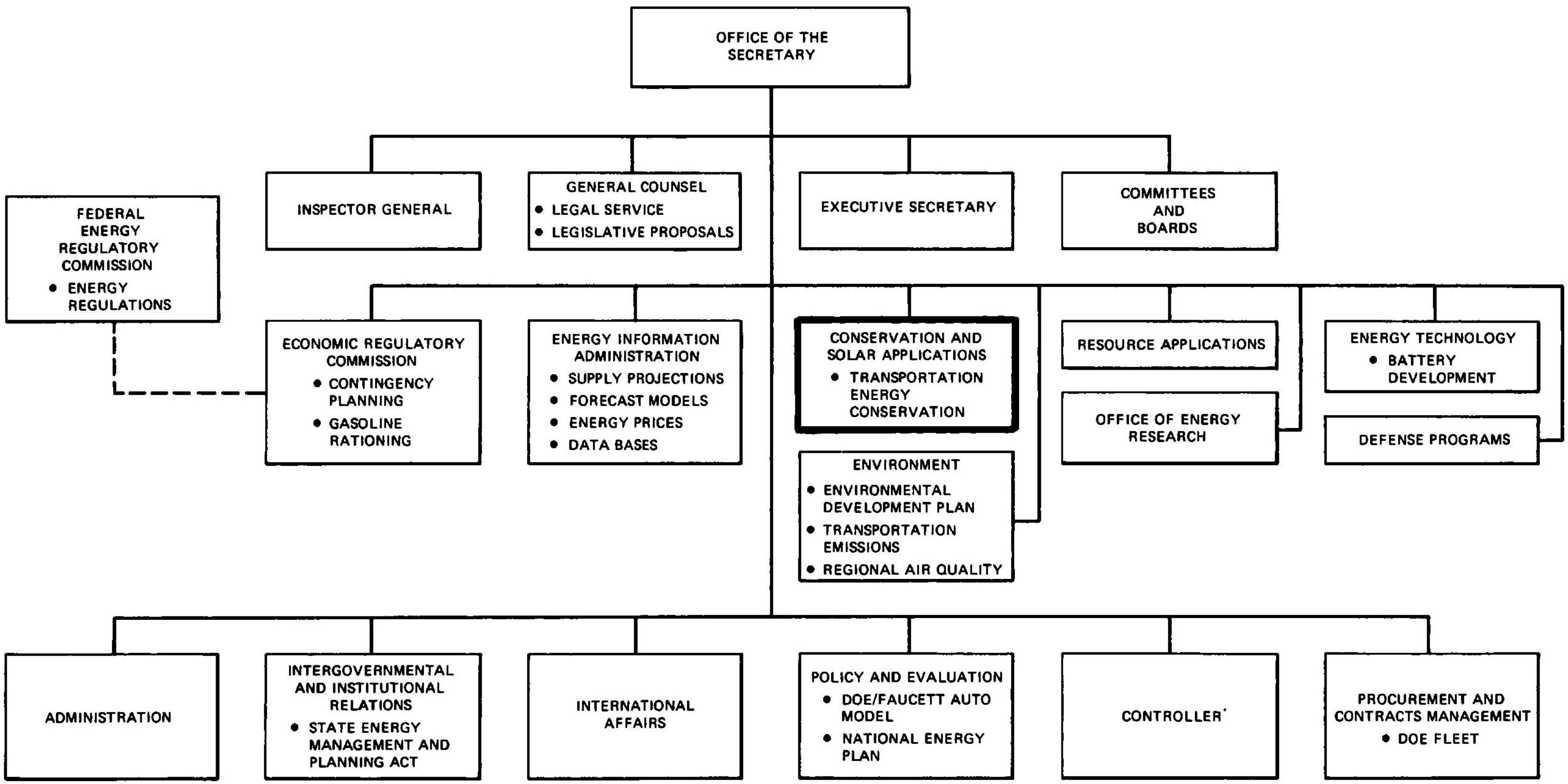

Fig. 4.2. Department of Energy organization and its functional relationship to the Transportation Energy Conservation Division.

Listed below are the passenger car and light truck fuel economy standards set by the DOT National Highway and Traffic Safety Administration (NHTSA). The DOT/NHTSA, starting in 1979 and ending in 1980, will initiate a two-step change in its laboratory test procedures for determining individual fuel economy. The first step updates the road-load factor and manual-shift driving procedure. The second step involves inertia-weight classes. Presently, automobiles up to 3000 lb are divided into test groups of 250-lb increments. In 1980, the automobiles up to 4000 lb will be divided into test groups of 125-lb increments, thus facilitating a closer relationship between test-weights and road-weight of automobiles.

Table 4.1
Passenger Car and Light Truck Fuel
Economy Standards
(mpg)

Year	Passenger cars	Light trucks (2WD)	Light (4WD)	I.H.[a]
1978	18.0			
1979	19.0	17.2[b]	15.8[b]	
1980	20.0	16.0[c]	14.0[c]	14.0
1981	22.0	18.0	15.5[d]	15.0
1982	24.0			
1983	26.0			
1984	27.0			
1985	27.5[e]			

[a]Based on medium-duty truck engines (International Harvester).

[b]Less than or equal to 6,000 lb.

[c]Less than or equal to 8,500 lb.

[d]Can be decreased by 0.5 mpg if by January 1979 EPA has not approved slick oils.

[e]Secretary of the Department of Transportation may amend the fuel economy standard for model year 1985, or for any subsequent model year, to a level which he determines is the maximum feasible average fuel economy level for such model year, except that any amendment which has the effect of increasing an average fuel economy standard to a level in excess of 27.5 mpg, or of decreasing any such standard to a level below 26.0 mpg, should be submitted to the Congress in accordance with Section 551 of the Energy Policy and Conservation Act and shall not take effect if either House of the Congress disapproves such amendment in accordance with the procedures specified in such section.

Sources: Personal communication, Environmental Protection Agency, Assistant Administrator for Mobile Source Air Pollution Control; Joan Claybrook, U.S. Department of Transportation, National Highway Traffic Safety Administration, *Final Environmental Impact Statement Pursuant to Section 102(2)(c), P.L. 91-190 83 STAT. 853 42 U.S.C. 4332(2)(c), for Average Fuel Economy Standards for Light Trucks Model Years 1980 and 1981*, Washington, D.C., March 1978.

A KEY PROVISION OF THE NATIONAL ENERGY ACT PASSED BY THE U.S. CONGRESS AND SIGNED BY THE PRESIDENT IN NOVEMBER 1978 IS THE "GAS GUZZLER TAX." THE PROVISION PLACES AN INCREASING TAX ON VEHICLES WHICH ARE FUEL INEFFICIENT THROUGH 1986. FOR EXAMPLE, A VEHICLE WHICH ACHIEVES THE CORPORATE AVERAGE FUEL ECONOMY (CAFE) STANDARD IN 1980 (20.0) WOULD BE TAXED $500 IF PURCHASED NEW IN 1985; PENALTIES OF OVER $300 CAN BE LEVIED AGAINST NEW CAR PURCHASES BY 1986.

Table 4.2. The Gas Guzzler Tax on New Cars
($)

Vehicle fuel economy		Corporate Average Fuel Economy Standard						
		1980 20.0	1981 22.0	1982 24.0	1983 26.0	1984 27.0	1985 27.5	1986 27.5
≥22.5 mpg				0		0		0
21.5–22.5				0		0		500
	≥21.0 mpg	0	0		0		0	
20.5–21.5				0		0		650
	20.0–21.0	0	0		0		500	
19.5–20.5				0		0		850
	19.0–20.0	0	0		0		600	
18.5–19.5				0		450		1050
	18.0–19.0	0	0		350		800	
17.5–18.5				200		600		1300
	17.0–18.0	0	0		500		1000	
16.5–17.5				350		750		1500
	16.0–17.0	0	200		650		1200	
15.5–16.5				450		950		1850
	15.0–16.0	0	350		800		1500	
14.5–15.5				600		1150		2250
	14.0–15.0	200	450		1000		1800	
13.5–14.5				750		1450		2700
	13.0–14.0	300	550		1250		2200	
12.5–13.5				950		1750		3200
	<13.0	550	650		1550		2650	
<12.5				1200		2150		3850

Source: Department of Energy, Office of Public Affairs, "*Department of Energy Information*," Washington, D.C., October 20, 1978.

SUBSEQUENT TO THE ISSUANCE OF FEDERAL PROPERTY MANAGEMENT REGULATIONS (FPMR), TEMPORARY REGULATION G-28, EXECUTIVE ORDER 12003, DATED JULY 20, 1977, WAS ISSUED WHICH PROVIDED ADDITIONAL REQUIREMENTS TO THOSE ALREADY ESTABLISHED.

IT IS NOW MANDATORY THAT ALL PASSENGER AUTOMOBILES ACQUIRED BY FEDERAL AGENCIES FOR FISCAL YEAR 1978 (BEGINNING OCTOBER 1, 1977) ACHIEVE A FLEET AVERAGE FUEL ECONOMY OF NOT LESS THAN 20 MPG AND EXCEED THE AVERAGE FUEL ECONOMY STANDARD OF 18 MPG.

THE APPLICABLE FLEET AVERAGE FUEL ECONOMY OBJECTIVES BY FISCAL YEAR AND AVERAGE FUEL ECONOMY STANDARDS ARE AS FOLLOWS.

Table 4.3.
Mandatory Federal Government Fleet Fuel Economy Standards

Fiscal Year	Miles per gallon: Manufacturer average fuel economy standard[a]	Miles per gallon: Federal fleet average fuel economy[b] — Passenger Cars
1978	18.0	20.0
1979	19.0	22.0
1980	20.0	24.0
1981	22.0	26.0
1982	24.0	28.0
1983	26.0	30.0
1984	27.0	31.0
1985	27.5	31.5

Note: The Federal Fleet of Light Trucks' and Vans' fuel economy standards are the same as those required for all light trucks and vans in each corresponding year.

[a]Established by Section 502 of the Motor Vehicle Information and Cost Savings Act (89 Stat. 900, 15 U.S.C. 2002) and the Secretary of Transportation.

[b]Established by Executive Order 12003.

Source: General Services Administration, "Federal Property Management Regulations Temporary Regulation G-32," October 1977.

EMISSIONS - BACKGROUND

In 1969 the auto industry and the Executive Branch began to propose exhaust emission standards for the years 1971, 1975, and 1980. In 1970 the U.S. House of Representatives voted to write the standards into federal law, to be effective in 1975. These standards still have not been reached on a mass production scale.

Engineering gains, made with enormous developmental and tooling costs, have been implemented and then been superseded by still more sophisticated material. Given the need to control emissions, the difficult to achieve 20 mpg fuel economy standard in 1980 and a 22 mpg average in 1981 represent formidable obstacles to the industry.

The problem of pollutants and their control is important relative to energy conservation in the U.S. automobile fleet. The pollutant, carbon monoxide (CO), an odorless and poisonous gas, results from the incomplete combustion of gasoline and is caused by insufficient air or inefficient combustion conditions within the engine.

Gasoline is composed of hydrocarbons; and another pollutant, unburned hydrocargon (HC), is fuel molecules that have escaped the combustion process. Because there is always a thin layer of fuel along the cylinder walls that is too cool to burn, even a perfectly tuned engine will emit some of this pollutant; but its quantity is reduced as near-perfect combustion is approached. Hydrocarbons mixed with nitrous oxides (in the presence of sunlight) from photochemical smog, which irritates the eyes and nose.

The pollutant, nitrous oxides (NOx), is a mix of gases formed when the nitrogen present in the injected air is burned with the fuel during combustion. Because nitrogen makes up a large percentage of air, there is no way to eliminate it from the combustion process. Lowering the combustion temperature inside the cylinders of an internal combustion engine helps control the amount of nitrogen that gets converted into oxides of nitrogen. However, lower combustion efficiency goes with lower temperatures, which means that performance and fuel economy both suffer. Means of reducing all three pollutants include (1) air pumps that feed air into exhaust passages to burn up excess carbon monoxide and hydrocarbons, (2) exhaust gas recirculation (EGR) systems to control nitrous oxides by recirculating exhaust gases back into the cylinders to cool and retard combustion, and (3) idle-control and spark-retardant devices.

THE AUTO INDUSTRY HAS UNTIL 1980 BEFORE 0.41 GPM HYDROCARBONS (HC), 7.0 GPM CARBON MONOXIDE (CO), AND 2.0 GPM NITROUS OXIDES (NOx) LIMITING LEVELS WILL TAKE EFFECT. THIS WILL BE FOLLOWED IN 1981 AND BEYOND BY 0.41, 3.4, AND 1.0 LIMITS. BEGINNING IN 1981, HOWEVER, THE ENVIRONMENTAL PROTECTION AGENCY (EPA) COULD APPROVE MANUFACTURERS' PETITIONS FOR A WAIVER OF UP TO 7.0 CO PLUS A 1.5 NOx WAIVER FOR INNOVATIVE ENGINES AND DIESELS.

Table 4.4
Passenger Car and Light Truck Emission Standards as Specified by the Clean Air Amendment of 1977, 1976–1985
(g/mile)

Year	Passenger cars						Light trucks					
	Federal			California[a]			Federal			California		
	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
1976	1.5	15.0	3.1	0.9	9.0	2.0	2.0	20.0	3.1	0.9	17.0	2.0
1977	1.5	15.0	2.0	0.41	9.0	1.5	2.0	20.0	3.1	0.9	17.0	2.0
1978	1.5	15.0	2.0	0.41	9.0	1.5	2.0	20.0	3.1	0.9	17.0	2.0
1979	1.5	15.0	2.0	0.41	9.0	1.5	1.7	18.0	2.3	0.41	9.0	1.5[b]
										0.50	9.0	2.0[c]
1980	0.41	7.0	2.0	0.41	7.0	1.0[d]	1.7	18.0	2.3	0.41	9.0	1.5[b]
										0.50	9.0	2.0[c]
1981	0.41	3.4[e]	1.0[f]	0.41	3.4	1.0[d]	1.7	18.0	2.3	0.41	9.0	1.0[b]
										0.50	9.0	1.5[c]
1982	0.41	3.4[e]	1.0[f]	0.41	3.4	0.4[g]		[h]				
1983	0.41	3.4	1.0[f]	0.41	3.4	0.4[g]						
1984	0.41	3.4	1.0[f]	0.41	3.4	0.4[g]						
1985	0.41	3.4	1.0	0.41	3.4	0.4[g]						

[a]Federal standards applicable to diesel engines.

[b]Less than or equal to 4,000 lb inertia-weight.

[c]Greater than or equal to 4,000 lb inertia-weight.

[d]1.5 g/mile alternatively at 100,000 miles instead of 50,000.

[e]Waiver up to 7 g/mile possible.

[f]Waiver up to 1.5 g/mile possible.

[g]1.0 g/mile alternatively at 100,000 miles instead of 50,000.

[h]Light truck emission standards have not been promulgated beyond 1981.

Source: Material developed from briefings with the Environmental Protection Agency, Assistant Administrator for Air and Waste Management, Deputy Administrator for Mobile Source Air Pollution Control, Sept. 1978.

In December 1975, Congress passed and the President signed the Energy Policy and Conservation Act (EPCA) which provided for, among other things, the development of a gasoline and diesel fuel rationing contingency plan. The nation's increasing dependence on foreign petroleum prompted energy officials to reexamine in 1977 the adequacy of the previous rationing plan. As of September 1978 the Economic Regulatory Administration (ERA) has had regional public hearings on the proposed plan.

Table 4.5. Proposed Gas Rationing Plan Highlights

1. Basic eligibility for ration allotments will be based on motor vehicle registration records maintained by state departments of motor vehicles.
2. Any individual or firm named in the most recent vehicle registration record will be eligible for an allotment.
3. Provisions will be made to transfer eligibility for ration allotments when vehicle ownership is transferred.
4. A new car purchased after the implementation of rationing will be entitled to allotments for subsequent ration periods.
5. Individuals will be allowed to buy and sell ration allotments on a "white market." The white market allows individuals to obtain additional supplies of gasoline by purchasing ration allotments from owners of other registered vehicles or ration exchange centers.
6. Vehicle allotments will be computed for each type of vehicle according to an allotment index based on average annual fuel consumption for the vehicle type. All passenger cars and trucks under 10,000 lb GVW will be assigned the same vehicle index; trucks over 10,000 lb will be assigned higher indexes and motorcycles a lower index.
7. A supplemental allotment will be allowed for designated firms with significant gasoline requirements for off-highway vehicles (e.g., farmers, construction equipment operators, and fishermen). DOE will consult with the Secretary of Agriculture prior to the establishment of allotments to farmers.
8. Each state will be given a state ration reserve to be used for issuing hardship allotments.
9. DOE will establish and maintain a national ration reserve to be used to provide the Department of Defense (DOD) with the allotments required for the maintenance of national security and for such other purposes as DOE finds necessary.
10. In advance of each ration period, DOE will print and mail ration checks with the appropriate allotment amount printed on each check.

Source: DOE, Economic Regulator Administration, Office of Regulations and Emergency Planning, *Proposed Standby Gasoline Rationing Plan*, June 1978.

VEHICLE SAFETY STANDARDS POSE VARYING EFFECTS ON FUEL ECONOMY. THE IMPACT ON FUEL ECONOMY IS GENERALLY DETERMINED BY THE ADDITION OR SUBTRACTION TO THE VEHICLE'S BODY WEIGHT. THE ADAPTION OF PASSIVE RESTRAINTS (AIR BAGS) WILL HAVE THE MOST SIGNIFICANT EFFECT ON FUEL ECONOMY WITHIN THE NEXT FEW YEARS.

Table 4.6.
Proposed Federal Motor Vehicle Safety Standards (FMVSS),
Date of Implementation, and Effects on Fuel Economy

FMVSS Number	Date	Effects on fuel economy
FMVSS 208 — passive restraints, passenger car interior, three phases	1982 1983 1984	1% fuel economy loss
Part 581 — exterior bumpers, two phases	1979 1980	Variable increase in fuel economy, dependent on bumper material
FMVSS 105 — hydraulic brakes, light-duty trucks	1984	Very slight negative effect on fuel economy
FMVSS 101 — controls and displays	1982	No effect on fuel economy
FMVSS 116 - color coding brake fluids	1979	No effect on fuel economy
FMVSS 204[a] — steering column, rear ward displacement	1983	No effect on fuel economy
FMVSS 203[a] — collapsible steering column, light trucks and vans	1983	Very slight negative effect on fuel economy
FMVSS 201[a] — occupant protection and interior impact	1981	Very slight negative effect on fuel economy
FMVSS 127 — speedometers and odometers, accuracy at speeds	1980	No effect on fuel economy

[a]Extension to light trucks and vans contemplated.

Source: Private conversation, National Highway Traffic Safety Administration, Plans and Programs. Office, Washington, D.C., August 8, 1978.

THE LEVEL OF AUTHORITY EXERCISED BY THE INTERSTATE COMMERCE COMMISSION (ICC) VARIES BY MODE OF CARRIER TRANSPORT. FOR EXAMPLE, ICC REGULATIONS AFFECT 100% OF THE RAIL INDUSTRY BUT LESS THAN 50% OF THE TR :K INDUSTRY AND ONLY 77.3% OF THE WATER TRANSPORT INDUSTRY. CONSEQUENTLY, ENERGY CONSERVATION MEASURES THAT RELY ON THE ICC AND ITS PRESENT JURISDICTION FOR ENFORCEMENT WOULD MEET WITH VARYING DEGREES OF SUCCESS, DEPENDING UPON THE MODE OF TRANSPORT CONSIDERED.

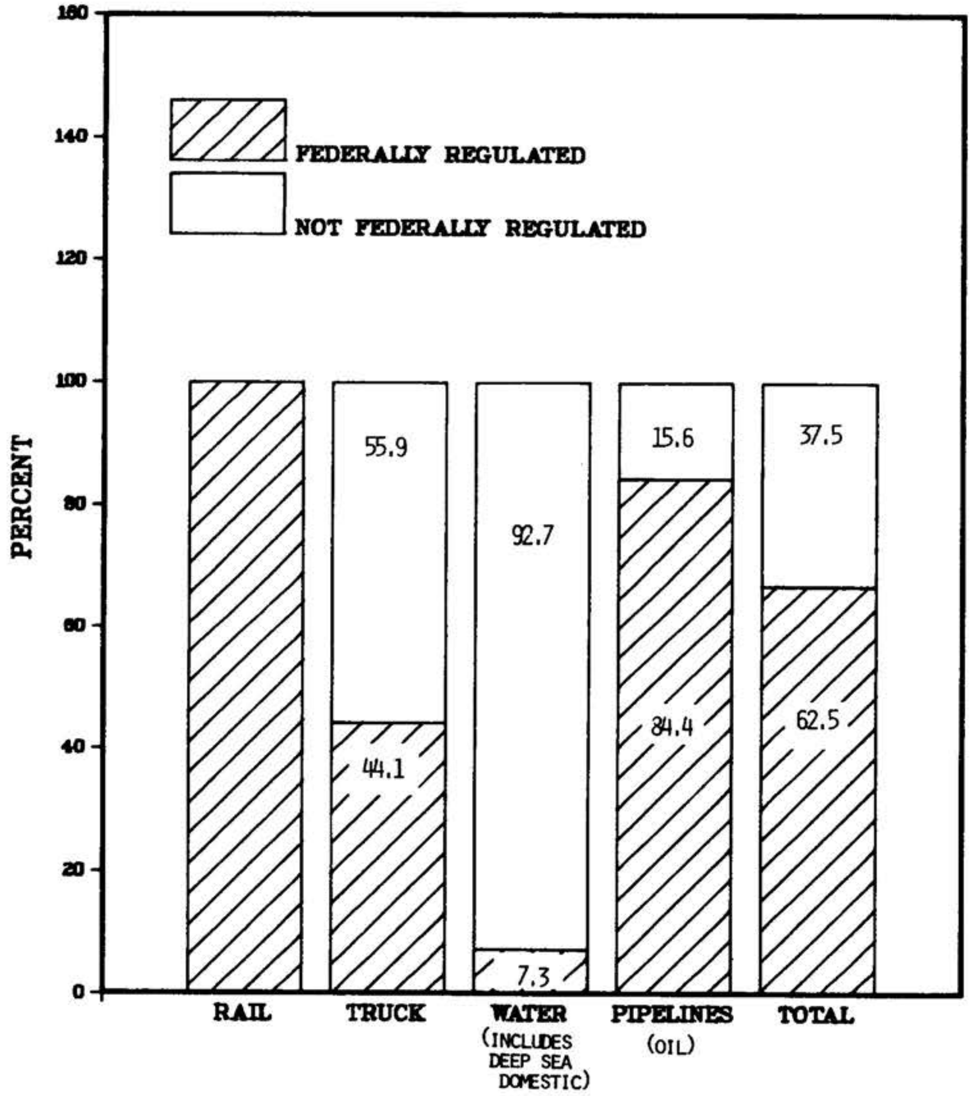

Fig. 4.3.
Intercity Ton-Miles of Federally Regulated and Nonfederally Regulated Carriers, 1975.

Source: Interstate Commerce Commission, *91st Annual Report of the Interstate Commerce Commission, Fiscal Year Ending June 30, 1977*, Washington, D.C., 1977, p. 139.

Section 4.2

Electric and Hybrid Vehicles Program

THE GOAL OF THE ELECTRIC AND HYBRID VEHICLE (EHV) PROGRAM IS TO ASSURE THE AVAILABILITY AND BROAD MARKET ACCEPTANCE OF VEHICLES THAT DO NOT DEPEND UPON PETROLEUM AS THEIR PRINCIPAL ENERGY SOURCE.

1. Implement all the requirements of Public Law 94-413 as amended by P.L. 95-238;
2. Identify market segments that match the capabilities of existing vehicles; demonstrate the commercial viability of electric and hybrid vehicles, starting in 1979; expand the demonstration annually to identify and test new market segments with differing missions, operational characteristics and other variables;
3. Foster the establishment of a self-sustaining hybrid vehicle industry capable of producing, marketing, and maintaining general purpose vehicles in 1985;
4. Foster the establishment of a self-sustaining electric vehicle industry capable of producing, marketing, and maintaining improved specific-mission vehicles by 1984;
5. Foster the capability of the established electric vehicle industry to produce, market, and maintain general-purpose vehicles by 1995-2000.*

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*Lawrence Livermore Laboratory, Transportation Systems Group, *Electric and Hybrid Vehicle Program Plan Review Draft*, May 1978, p. I-V.

Public Law 94-413 as amended by P.L. 95-238 in 1978

The major impact of the Act on the ongoing EHV programs was to compress the time of the original federal program and to require earlier exposure of electric and hybrid vehicles to market forces. Earlier market penetration than original planned can be achieved under the Act because of increased emphasis on the three key factors of supply, demand, and market. Although an alternative element of risk is introduced by this attempt to shorten the time of consumer acceptance of these vehicles, the opportunities to be achieved on a national scale are enhanced by providing a balance between "market pull" (Demonstration and R&D) and "technology push" (R&D Incentives).

Public Law 94-413 as amended by P.L. 95-238 in 1978, contains the following provisions:

- Authorizes and requires DOE to conduct a federal program of research, development, and demonstration designed to bring about the commercialization of electric and hybrid vehicle technology by demonstrating the technical and commercial feasibility of electric and hybrid vehicles.
- Requires that an organization responsible for electric and hybrid vehicle research, development, and demonstration be established as an entity in DOE.
- Requires that research and development be conducted on electric and hybrid vehicles.
- Requires that optimum overall electric and hybrid vehicle designs be determined.
- Requires that a demonstration project be conducted and that performance standards be established for demonstration vehicles.
- Stipulates that specific studies be conducted.
- Stipulates that a program of financial incentives involving planning grants and loans be implemented and provides for small business participation.

The Near-Term Electric Vehicle program will result in the development and delivery to the Department of Energy two Integrated Test Vehicles (ITVs) incorporating technology improvements for energy-efficient operation. The ITVs will meet the Near-Term Objectives and will be amenable to mass production in the early 1980s. These objectives define a four-passenger car similar in concept to today's subcompact vehicle, which is widely used for urban transportation and commuting service. The driving mission for this car is specified by means of the Society of Automotive Engineer J277a (Schedule D) driving cycle, which is representative of urban stop-and-go driving. The two contractors producing the ITVs are: General Electric Company and Garrett/AiResearch Manufacturing Company.

Source: General Electric Company, *Near-Term Electric Vehicle Phase II — Mid-Term Summary Report*, July 1, 1978, p. 1-1.

The DOE Electric Vehicle Demonstration Project has been specifically prescribed by P.L. 94-413 as amended by P.L. 95-238 and established to determine the economic and technological practicability of electric and hybrid vehicles for personal, commercial, and government use in urban and agricultural areas. The project will continue through FY 1986. P.L. 95-238 requires at least the following numbers of vehicles to be added to the project in the fiscal years specified:

200 in FY 1978
600 in FY 1979
1700 in FY 1980
7500 in the period 1981 through 1984.

The five site operators selected for FY 1978 are:
American Telephone and Telegraph Co.
Consolidated Edison of New York, Inc.
E/HV Inc. (Penn. Jersey Subaru, Inc.)
Long Island Lighting Co.
Walt Disney World Co.

Source: Lawrence Livermore Laboratory, *Electric and Hybrid Vehicle Program Plan Review Draft*, May 30, 1978, p. 20.

CURRENT STATE-OF-THE-ART PERFORMANCE VARIABLES ARE WELL WITHIN DOE DEMONSTRATION PERFORMANCE STANDARDS. DOE DEMONSTRATION STANDARDS VARY FOR COMMERCIAL AND PERSONAL TYPE VEHICLES.

Table 4.7
Comparison of Electric Vehicle State-of-the-Art Performance Variables and DOE Demonstration Performance Standards

Performance items	SOA personal vehicle data range		DOE demonstration performance standards		SOA commercial vehicle data range		DOE demonstration performance standards	
Top speeds at which range was tested km/h	50-82		80 km/h for a minimum of 5 minutes		48-84 km/h		70 km/h for a minimum of 5 minutes	
Ref. constant speed range tests								
40 km/h	42-188 km/h				58-120 km/h			
56 km/h	45-141 km/h				43-100 km/h			
Driving cycle range tests								
J 227 s B cycle	32-128		50 km (EV); 200 km (HV)		33-100		50 km (EV); 200 km (HV)	
J 227 s C cycle	34-123				32-89			
Energy use in kWh/km at								
40 km/h	.15-.42 km/h				.18-.47 km/h			
56 km/h	.18-.36 km/h				.24-.51 km/h			
B cycle	.22-.58				.34-.74			
C cycle	.23-.66				.29-.81			
Battery recharge time in hours from 80% DoD	6-18		10 hours		10-16		10 hours	
Acceleration time in seconds	0% DoD	80% DoD	0% DoD	80% DoD	0% DoD	80% DoD	0% DoD	80% DoD
0-32 km/h	6.5-16 s	7.8-25.4 s			5.8-12.2 s	6.8-13.1 s		
0-40 km/h	9.6-21 s	12-35.8 s			8.5-15.3 s	10.5-17.6 s		
0-50 km/h	14.4-32 s	16.4-60 s	16 seconds	16 seconds	12.3-32.4 s	15.3-39.3 s	15 seconds	15 seconds
Gradeability at speeds	0% DoD	80% DoD	0% DoD	80% DoD	0% DoD	80% DoD	0% DoD	80% DoD
24 km/h	3.7-16% G	1.9-15.2% G	10% G @ 25 km/h	10% G @ 25 km/h	10.8-20% G	6.4-14% G	10% G at 25 km/h	10% G at 25 km/h
32 km/h	2.5-9.4% G	2.8-8.5% G			6.4-12.4% G	5.2-8.0% G		
40 km/h	3.2-10.1% G	1.3-8.3% G			3.6-9.7% G	2.8-5.8% G		
50 km/h	2.4-5.8% G	0.9-6.4% G			0.7-8% G	0.7-5.2% G		

b — Standards that have been set for the first demonstration of 200 vehicles

km/h — Kilometers per hour km — Kilometers

DoD — Battery depth of discharge (EV) — Electric vehicle

% G — Percent grade capability (HV) — Hybrid vehicle

s — Seconds

Source: Walter J. Dippold, "Electric Vehicle State-of-the-Art Assessment Update," presentated at the 5th International EHV Symposium, Philadelphia, Penn., October 1978.

CURRENT ESTIMATES OF ELECTRIC VEHICLE PARAMETERS ARE SHOWN TO BE WITHIN DOE-EHV NEAR-TERM PHASE II GOALS. THESE ELECTRIC VEHICLES WILL BE COMPLETED AND READY FOR TESTING BY MAY 1979. WHEN RECEIVED BY THE FEDERAL GOVERNMENT, THE VEHICLES WILL BE TESTED AND EVALUATED, THEN USED IN PROJECTS TO TAKE ADVANTAGE OF ANY UPGRADED OR IMPROVED COMPONENTS AVAILABLE AT THAT TIME.

Table 4.8
Near-Term Electric Vehicle Parameters

Parameter	Near-term goals	Current Phase II technology estimates
Min. passenger capacity	4 adults	4
Max. curb wt., lb	open	2,856
Min. urban range (J227D). M.	75	79
Max. initial cost, projected, 1975 $	5,000	5,000
Min. life, mi	100,000	100,000
Max. life, cycle cost, projected, 1975 $/mi	0.15	0.15
Max. electric recharge energy in urban driving kW-hr/mi	0.50	0.39
Max. recharge time, hr, 110 volt/30 amp	8	8
Min. passing speed, mph	60	68
Min. cruising speed, mph	55	55
Min. accessories	heater/defroster, on board charger	same
Safety features	all FMVSS[a]	all FMVSS[a]
Min. unserviced park duration, dry	7	7
Max. years till production ready	5	5
Max. critical materials required	few	none
Min. acceleration (0 to 30 mph), sec	9	8
Min. merging time (25 to 55 mph), sec	18	11
Sustained speed on 5% grade, mph	50	50
Max. scheduled maintenance	2¢/mile	1.4¢/mile
Battery type		lead acid
Min. ambient temp. range, °F	-20 to +105	-20 to +105

[a]Federal Motor Vehicle Safety Standards.

Source: Department of Energy, Transportation Energy Conservation Division, Electric and Hybrid Vehicle Contractors Coordination Conference, Garrett Corporation Briefing, June 1978.

A BASELINE PROJECTION WHICH ASSUMED NO FEDERAL INCENTIVE PROGRAMS WAS COMPARED TO A SERIES OF PROJECTIONS BASED ON VARIOUS POSSIBLE INCENTIVES. A $3,000 SUBSIDY TO EV PURCHASERS (TABLE 4.9, ITEM 3) WOULD REPRESENT THE MOST ATTRACTIVE INDIVIDUAL INCENTIVE TO THE CONSUMER, WHILE THE COMBINATION OF A 50¢ GAS TAX IN ANNUAL INCREMENTS OF 5¢ AND AN OPERATING SUBSIDY EQUAL TO ONE-THIRD OF INITIAL AND ALL OPERATING COSTS TO PURCHASERS (TABLE 4.9, ITEM 10) REPRESENTS THE BEST STIMULANT FOR EV DEMAND.

Table 4.9
Analysis of Incentives to Stimulate the Demand for Electric Vehicles

Policy	1990 Vehicle sales		1990 On-the-road stock		1990 Distance driven	
	Number	% increase	Number	% increase	millions of km	% increase
Baseline	23,000	--	167,000	--	2,269	--
1. $300 Subsidy to EV Purchasers	32,000	39	231,000	38	3,458	52
2. $1,000 Subsidy to EV Purchasers	67,000	191	491,000	194	7,340	223
3. $3,000 Subsidy to EV Purchasers	554,000	2,308	4,142,000	2,379	61,663	2,617
4. Off-Peak Electricity Prices of Night Time Battery Recharging	31,000	35	226,000	35	3,393	49
5. 50 cents Gas Tax Imposed in Annual Increments of 5 cents Beginning in 1978	69,000	200	457,000	174	7,037	210
6. 10 cents Gas Tax Imposed Immediately	28,000	22	209,000	25	3,127	38
7. Doubling of Range of Vehicle (at no cost)	70,000	204	543,000	225	8,016	253
8. Operating Subsidy, Equal to One-Third of Initial and (with minor exceptions) All Operating Costs	279,000	1,113	2,300,000	1,099	29,974	1,221
9. Combination of 5. and 7.	210,000	813	1,447,000	766	22,223	879
10. Combination of 5. and 8.	809,000	3,417	5,331,000	3,092	82,085	3,515

Source: Department of Energy, Transportation Energy Conservation Division, *The First Annual Report to Congress on the Implementation of Public Law 94-413 — The Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976*, Washington, D.C., December 1977, p. 40.

AN ASSESSMENT OF ACTUAL AND PROJECTED U.S. AND WORLD DEMAND FOR KEY BATTERY MATERIALS PROVIDES A BASELINE AGAINST WHICH ADDITIONAL MATERIAL FOR ELECTRIC CAR BATTERIES MAY BE COMPARED.

Table 4.10

Demand for Materials in the Absence of Electric Cars

Material	Millions of kilograms					
	1974		1990		2000	
	U.S.	World	U.S.	World	U.S.	World
Lead	845	3,077	1,189	5,410	1,388	6,867
Antimony	18	70	33	107	44	128
Nickel	199	704	274	1,128	349	1,442
Zinc	1,328	5,866	2,204	9,081	2,767	11,203
Cobalt	10.4	31.3	14.6	45.8	19.5	62.1
Lithium	4.5	7.3	8.5	16.6	12.7	26.3
Molybdenum	34.5	90.7	60	181	87.5	266

Source: Department of Energy, Transportation Energy Conservation Division, *The Second Annual Report to Congress on the Implementation of Public Law 94-413 — The Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976*, Washington, D.C., Sept. 1977. (Draft), December 1977.

AT THE PRODUCTION RATE OF ONE MILLION ELECTRIC CARS PER YEAR, ELECTRIC CARS WOULD ACCOUNT FOR LESS THAN 10% OF NEW CARS IN THE UNITED STATES. WITH THIS PRODUCTION RATE, SIGNIFICANT DEMAND INCREASES OCCUR FOR EVERY MATERIAL EXCEPT ZINC. LITHIUM SHOWS THE LARGEST INCREASES BECAUSE PRESENT DEMAND IS LOW.

Table 4.11

Increased Demand for Materials from Manufacturing One Million Electric Cars Per Year

Car range, km	Battery material	Percent increase in demand for materials			
		1990		2000	
		U.S.	World	U.S.	World
75	Lead	44	9.6	37	7.6
	Antimony	36	11.0	27	9.4
100-150	Lead	19-31	4.3-6.8	17-27	3.3-5.4
	Antimony	12-19	3.6-5.8	8.6-14.1	3.0-4.8
150-250	Nickel	31-62	7.6-15.0	25-48	6-12
	Zinc	5-10	1.2-2.5	4.0-8.1	1-2
	Cobalt	10-20	3.3-6.3	7.7-15.0	2.4-4.7
250-450	Cobalt	25-47	8.1-15.0	19-35	6.0-11.1
	Lithium	180-340	90-170	120-230	57-110
	Molybdenum	18-35	6.1-12.0	13-24	4.1-7.9

Source: Department of Energy, Transportation Energy Conservation Division, *The First Annual Report to Congress on the Implementation of Public Law 94-413 — The Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976*, December 1977.

TOTAL ELECTRIC VEHICLE USAGE IS MODEST WHEN COMPARED TO OTHER TRANSPORTATION MODES IN THE UNITED STATES. ANNUAL MILEAGE FOR ELECTRIC VEHICLES IS LOW, TYPICALLY 5000 KILOMETERS (3000 MILES) PER VEHICLE EACH YEAR, COMPARED TO AN AVERAGE 18,000 KILOMETERS (11,000 MILES) PER YEAR FOR THE AMERICAN AUTOMOBILE AND 94,000 KILOMETERS (58,000 MILES) PER YEAR BY INTERSTATE BUSES. THE TOTAL ANNUAL TRAVEL FOR ELECTRIC VEHICLES HAS BEEN INCREASING RAPIDLY AND IS PRESENTLY ESTIMATED TO BE APPROACHING 8 MILLION KILOMETERS.

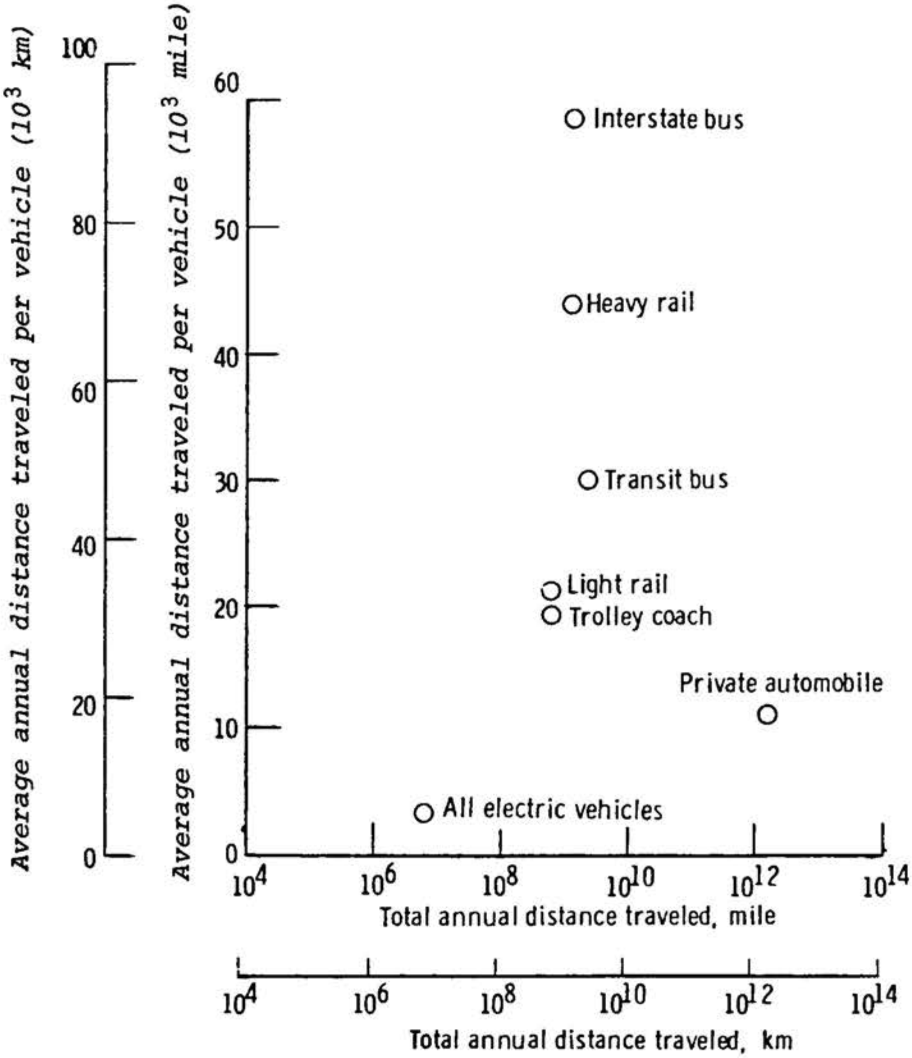

Fig. 4.4. Vehicle Travel in the United States.

Source: Department of Energy, Transportation Energy Conservation Division, *State-of-the-Art Assessment of Electric and Hybrid Vehicles*, Washington, D.C., February 1978, p. 69.

THE ELECTRIC VEHICLE ENERGY CONSUMPTION AT CONSTANT SPEED VARIES CONSIDERABLY AMONG VEHICLES, AND THE SENSITIVITY TO SPEED IS ALSO QUITE DIFFERENT FOR THE DIFFERENT VEHICLES. ENERGY CONSUMPTION IS PROPORTIONAL TO THE WEIGHT OF THE VEHICLE AND THE RATIO OF RESISTIVE ACCELERATION TO THE DRIVELINE EFFICIENCY. ENERGY CONSUMPTION ALSO VARIES WITH SPEED BY THE RELATIVE RATE OF INCREASE OF RESISTIVE ACCELERATION AND DRIVELINE EFFICIENCY AS SPEED IS INCREASED.

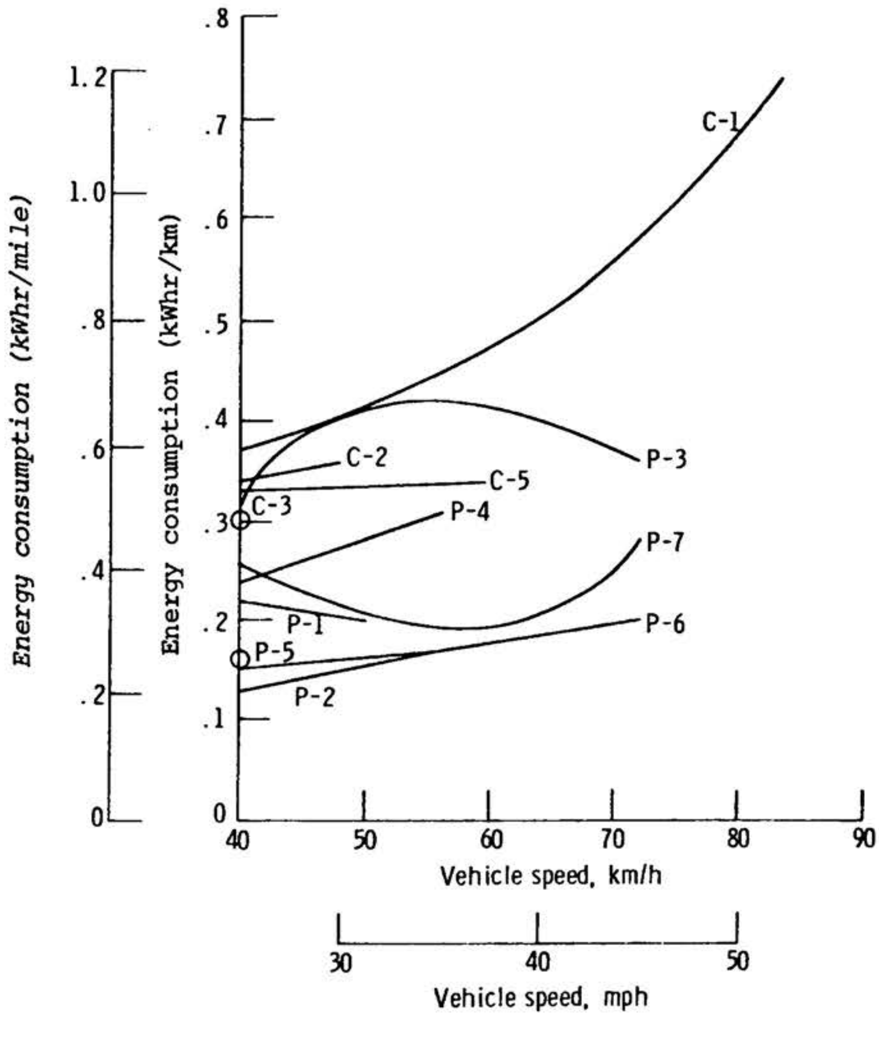

Fig. 4.5. Energy Consumption as a Function of Vehicle Speed for Electric Test Vehicles.

Source: Department of Energy, Transportation Energy Conservation Division, *State-of-the-Art Assesement of Electric and Hybrid Vehicles*, Washington, D.C., February 1978, p. 55.

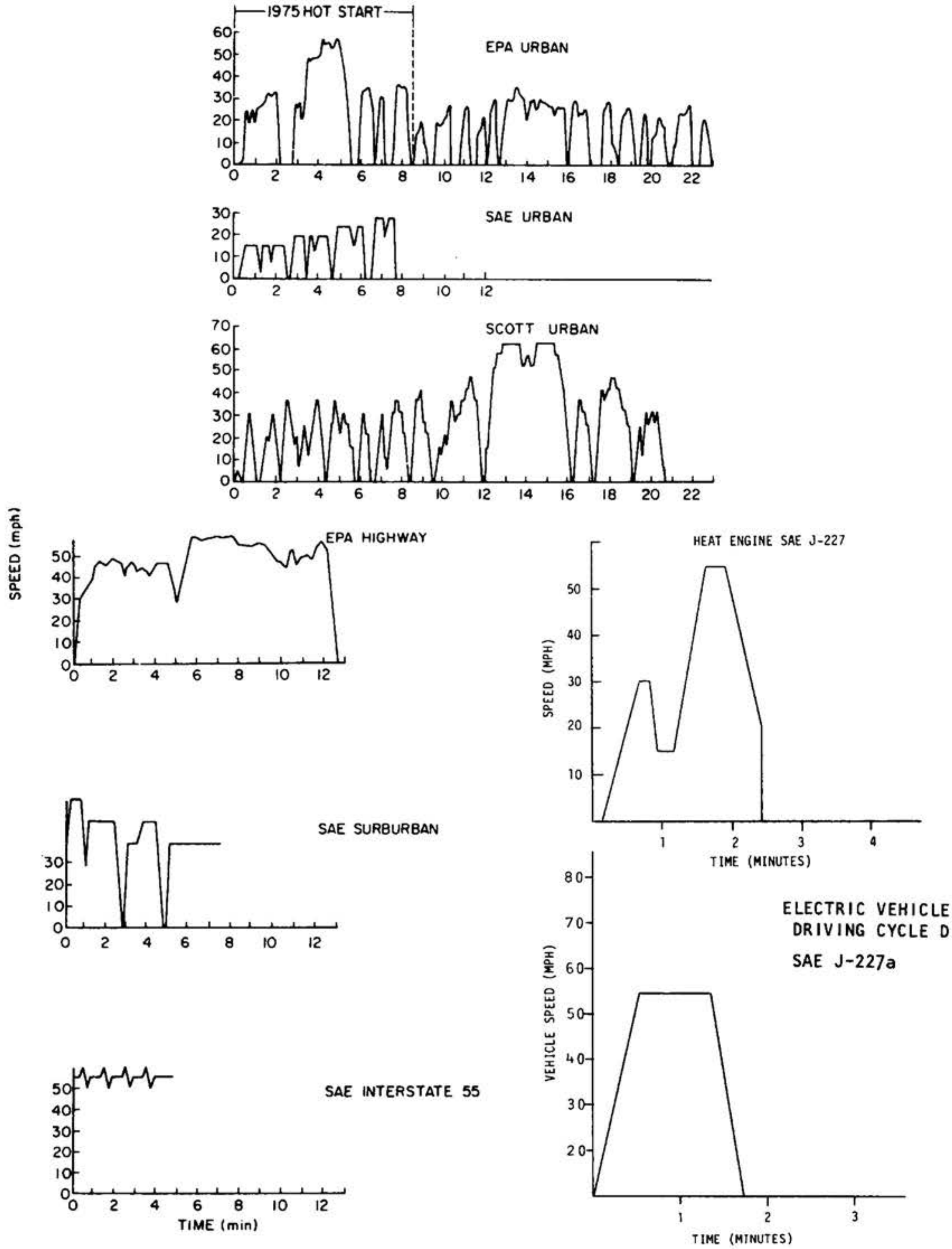

Fig. 4.6. Speed-Time Dependence of Various Driving Cycles.

Sources: M. F. Fels, Princeton University, Center for Environmental Studies, *Driving Cycles for Fuel Economy Testing*, Internal Working Paper, August 1977; Department of Energy, Transportation Energy Conservation Division, *Highway Vehicle Systems Contractors Coordination Meeting*, Washington, D.C., October 1977, p. 296; *State-of-the-Art Assessment*, February 1978, p. 35.

Hybrid Vehicle System

The hybrid vehicle concept has recently reemerged as a means for automobiles to meet stringent exhaust emission limits with a minimum of engine modifications or exhaust gas treatment. The chief market at which hybrid development has been aimed is essentially the same as the market for pure electric vehicles: the small, utilitarian 2- and 4-passenger private car and some light duty commercial applications.

The typical hybrid concept (an internal combustion engine and a battery system) is a competitor with the pure electric vehicle in the small vehicle market. The hybrid offers the possibility of better performance (i.e., improved acceleration, longer range, etc.) at the expense of more complex engine/powertrain design and control and the need to deal with two energy sources (electricity and fuel).

Hybrid vehicle technology is much less developed than pure electric technology both in this country and abroad. Volkswagon and Robert Bosch, Inc. of Germany, and Petro-Electric, Gould, General Motors, and University of Florida of the United States are among the organizations that have experimented with hydrid vehicles. However, most of the work has been at the proof-of-concept stage rather than at the prototype or pre-production level. No hybrid vehicles are being offered for sale to the general public at this time.

The hybrid vehicle system R&D task area is only beginning, with the definition of near-term vehicle performance specifications and development of preliminary designs scheduled for completion by the fourth quarter of FY 1979. Near-term vehicles based on these designs are scheduled for delivery by the first quarter of FY 1982 and several advanced vehicles for about four years later.

Sources: Department of Energy, Transportation Energy Conservation Division, *The First Annual Report to Congress on the Implementation of Public Law 94-413 — The Electric and Hybrid Vehicle Research, Development and Demonstration Act of 1976*, December 1977, p. 2; Department of Energy, Transportation Energy Conservation Division, *Environmental Development Plan*, March 1978, p. 54.

Section 4.3
Heat Engine Program

THE HEAT ENGINE PROGRAM WAS BEGUN IN 1971. THE INITIAL OBJECTIVE WAS THE DEVELOPMENT OF HEAT ENGINES WITH SIGNIFICANTLY REDUCED EXHAUST EMISSIONS. IN 1972, A SECOND OBJECTIVE, HIGH FUEL ECONOMY, WAS ADDED TO THE PROGRAM. ALL KNOWN TYPES OF HEAT ENGINES WERE STUDIED AND EVALUATED WITH REGARD TO POTENTIAL FOR LOW-COST PRODUCTION, VERSATILITY IN ENGINE SIZE, TECHNICAL BARRIERS TO DEVELOPMENT, AND INDUSTRY INTEREST IN THE CANDIDATE ENGINE AS WELL AS FOR FUEL ECONOMY AND EMISSIONS. THE PROGRAM IS MANAGED BY THE OFFICE OF HIGHWAY SYSTEMS IN THE DIVISION OF TRANSPORTATION ENERGY CONSERVATION. PROJECT MANAGEMENT HAS BEEN DELEGATED TO THE NASA-LEWIS RESEARCH CENTER, CLEVELAND, OHIO.

HEAT ENGINE PROGRAM

Objectives

Public Law 95-238, signed into law in February 1978, directed a program plan in which the Heat Engine Highway Vehicle Program encompasses the following objectives:

- To develop by 1983 advanced gas turbine and Stirling automobile propulsion systems that have:
  - at least 50 % improvement in fuel economy compared to an internal combustion engine automobile system for similar performance.
  - emission levels that meet or exceed the most stringent federal research standards (0.4/3.4/0.4 g/mile, HC/CO/NOx).
  - ability to use a broad range of liquid fuel derived from crude oil as well as synthetic fuels from coal, oil shale, and other sources.
  - suitability for production engineering and commercialization.
- To develop technology which will overcome barriers to better fuel economy without sacrificing other characteristics listed.

Sources: Department of Energy, Transportation Energy Conservation Division, *Heat Engine Program Plan*, August 1978, (draft); George M. Thur, *Department of Energy Automotive Heat Engine Program*, Society of Automotive Engineers Technical Paper Series, August 1978, p. 4.

THE GAS TURBINE DEVELOPMENT PROGRAM WAS INITIATED IN 1972 WITH THE CHRYSLER CORPORATION. THE CURRENT UPGRADED ENGINE DESIGN IS APPROACHING DESIGN POWER AND SFC* GOALS AFTER TWO YEARS OF SYSTEM DEVELOPMENT. CONTRACTING TEAMS FOR THIS PHASE WERE CAREFULLY SELECTED TO PROVIDE A BLEND OF AUTO AND AEROSPACE ENGINEERING APPROACHES. THESE TEAMS WERE: (1) ALLISON DIVISION/PONTAIC DIVISION-GENERAL MOTORS; (2) CHRYSLER CORPORATION; (3) AIRESEARCH/FORD MOTOR COMPANY; AND (4) WILLIAMS RESEARCH/ AMERICAN MOTORS GENERAL.

GAS TURBINE HIGHWAY VEHICLE SYSTEMS PROGRAM

Objectives

The major objectives of the Gas Turbine Highway Vehicle Systems Program are as follows.

- To provide within the U.S. automobile industry by 1983 the technology base to permit the industry to make a decision concerning production development of improved gas turbine propulsion systems. An improved gas turbine propulsion system is defined as one which incorporates existing and near-term technology and which exhibits some significant improvement in efficiency, driveability, utilization of alternate fuels, and reduced emissions and/or reduced cost over existing gas turbine propulsion systems thereby improving the marketability of the systems. In this approach, major advances in technology are not required so that relatively early development programs can be undertaken with reasonable risk.
- To allow programmatic decisions to be made by 1984 on continued efforts toward more advanced gas turbine propulsion systems. An advanced gas turbine propulsion system is defined as one which incorporates significant advances in technology and achieves major improvements in several of the system performance indices. Because of its dependence on major advances in technology, the advanced gas turbine propulsion system development requires a strong supporting research and technology program, is no longer range and entails somewhat higher risk.
- To develop enabling technology for production of more advanced gas turbine propulsion systems in the early 1990s.

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*Specific Fuel Consumption: Pound of fuel/horsepower/hour, burned by the engine.

THE GAS TURBINE PROGRAM WILL PROVIDE THE MASS TRANSPORTATION INDUSTRY WITH DEMONSTRATION INFORMATION ON ADVANTAGES OF GAS TURBINES IN URBAN BUSES. THE PROGRAM WILL ALSO PROVIDE THE GOVERNMENT WITH OPERATIONAL DATA ON USE OF GAS TURBINES IN HEAVY-DUTY, STOP-AND-GO APPLICATIONS.

ENGINE SPECIFICATIONS OF THE GAS TURBINE ENGINE FOR DOE/TEC-DOT/UMTA BUS APPLICATION

TYPE: TWO-SHAFT, TWIN REGENERATOR WITH POWER TRANSFER

Weight	Approx. 1800 lb	
Power Rating	300 Hp	@85°F 500 ft altitude
SFC	Pre-Production	0.40 lb/hp-hr
	Production	0.40 lb/hp-hr
	Production Improved	0.38 lb/hp-hr (2200°F Turbine Inlet)

Sources: Department of Energy, Transportation Energy Conservation Division, *Highway Vehicle Systems Contractors Coordination Meeting: Thirteenth Summary Report*, March 1978, p. 56; George M. Thur, *Department of Energy Automotive Heat Engine Program*, Society of Automotive Engineers Technical Paper Series, August 1978, p. 6.

THE STIRLING-CYCLE ENGINE OFFERS HIGHLY DESIRED LEVELS OF FUEL ECONOMY AND EMISSIONS AND OF MULTIFUEL CAPABILITY. THE STIRLING IS AN EXTERNAL, CONTINUOUS COMBUSTION ENGINE. IT USES A CLOSED CYCLE, AND A GAS SUCH AS HYDROGEN OR HELIUM IS SEALED WITHIN THE ENGINE. THE ENGINE NOW UNDER STUDY UTILIZES FOUR DOUBLE-ACTING PISTONS. EACH PISTON SERVES AS THE DISPLACER FOR ONE CYLINDER AND AS THE POWER PISTON FOR THE NEXT CYLINDER; THUS THE SPECIFIC VOLUME (VOLUME/POWER) IS CUT NEARLY IN HALF. THE FOUR CYLINDERS ARE ARRANGED IN A CIRCLE TO ALLOW THE USE OF ONE HEATER FOR ALL THE CYLINDERS.

STIRLING ENGINE PROGRAM

Objectives

The major objectives of the Stirling engine program are as follows.

- To provide the U.S. automobile industry with an option by 1984 to enter into propulsion development of improved Stirling engine propulsion systems.
- To allow programmatic decisions to be made by 1983 on continued efforts toward more advanced Stirling engine propulsion systems.
- To develop enabling technology for possible production of advanced Stirling engine propulsion systems in the early 1990s.

Sources: Department of Energy, Transportation Energy Conservation Division, *Environmental Development Plan*, March 1978, p. 13; George M. Thur, *Department of Energy Automotive Heat Engine Program*, Society of Automotive Engineers Technical Paper Series, August 1978, p. 6; Lawrence Livermore Laboratory, *TAC Program Plan*, September 1978, p. III-5 (due to current reorganization and uncertainty of the program status, this document represents the present scope of the program as of September 1, 1978, in draft form).

FUEL ECONOMY TESTS ARE MEASURED AGAINST A BASELINE MPG STANDARD. USE OF DIESEL FUEL WOULD YIELD AN ADDITIONAL 11% INCREASE IN ECONOMY. THE BEST VEHICLE TEST RESULT IS 12.6 MPG LESS THAN THE BASELINE. SEVERAL CHANGES HAVE BEEN MADE TO THE ENGINE, AND DYNAMETER TESTS HAVE RESULTED IN A SIMULATED 14.4 MPG.

WITH ADDITIONAL IMPROVEMENTS UNDERWAY, IT IS FELT THAT THE PHASE I OBJECTIVES OF 15.7 MPG WILL BE ACHIEVED. PRELIMINARY ANALYSIS SHOWS THAT A HIGH-TEMPERATURE, CERAMIC HEATER-HEAD STIRLING ENGINE MIGHT BE CAPABLE OF ACHIEVING UP TO 23.3 MPG.

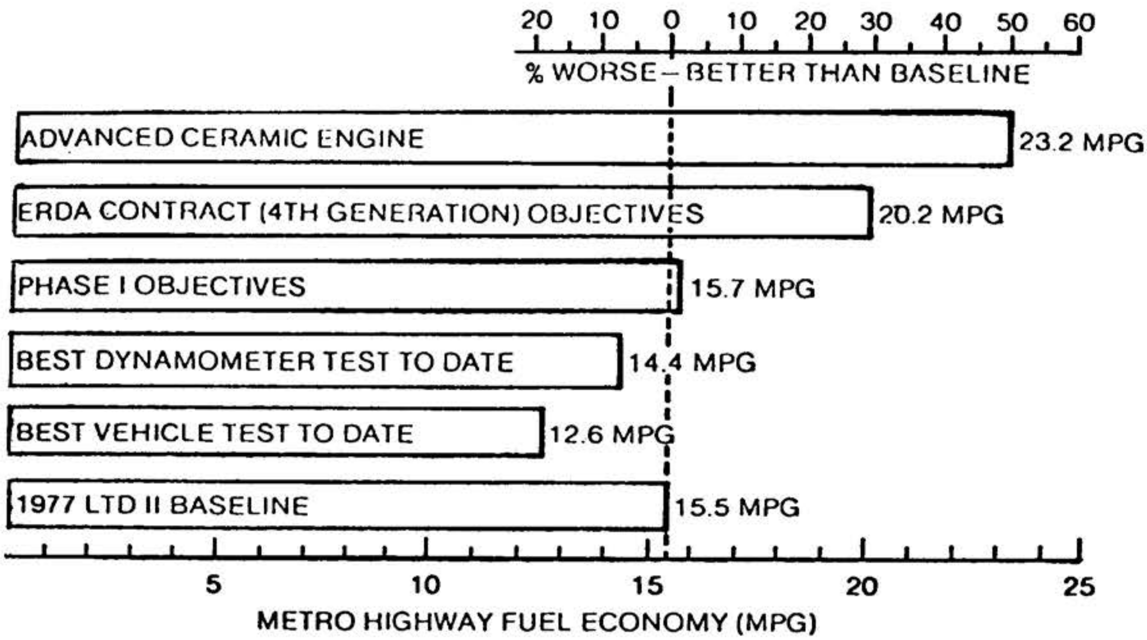

Fig. 4.7. Stirling Engine Fuel Economy.

Source: Department of Energy, Transportation Energy Conservation Division, *Highway Vehicle Systems Contractors Coordinating Meeting, Thirteenth Summary Report*, Washington, D.C., March 1978, p. 247.

INITIAL EMISSION TESTS ON THE STIRLING-POWERED VEHICLE HAVE NOT YET MET EXPECTATIONS. VEHICLE TESTS RESULTED IN HC AND NOx LEVELS BOTH ABOVE THE LOW MILEAGE AND 50,000 MILE OBJECTIVES. WITH IMPROVED FUMER OPERATION, DYNAMOMETER TESTS HAVE RESULTED IN HC AND NOx LEVELS BELOW THE 50,000 MILE OBJECTIVES. HOWEVER, NOx AND CO LEVELS WERE STILL HIGHER THAN THE LOW MILEAGE OBJECTIVES.

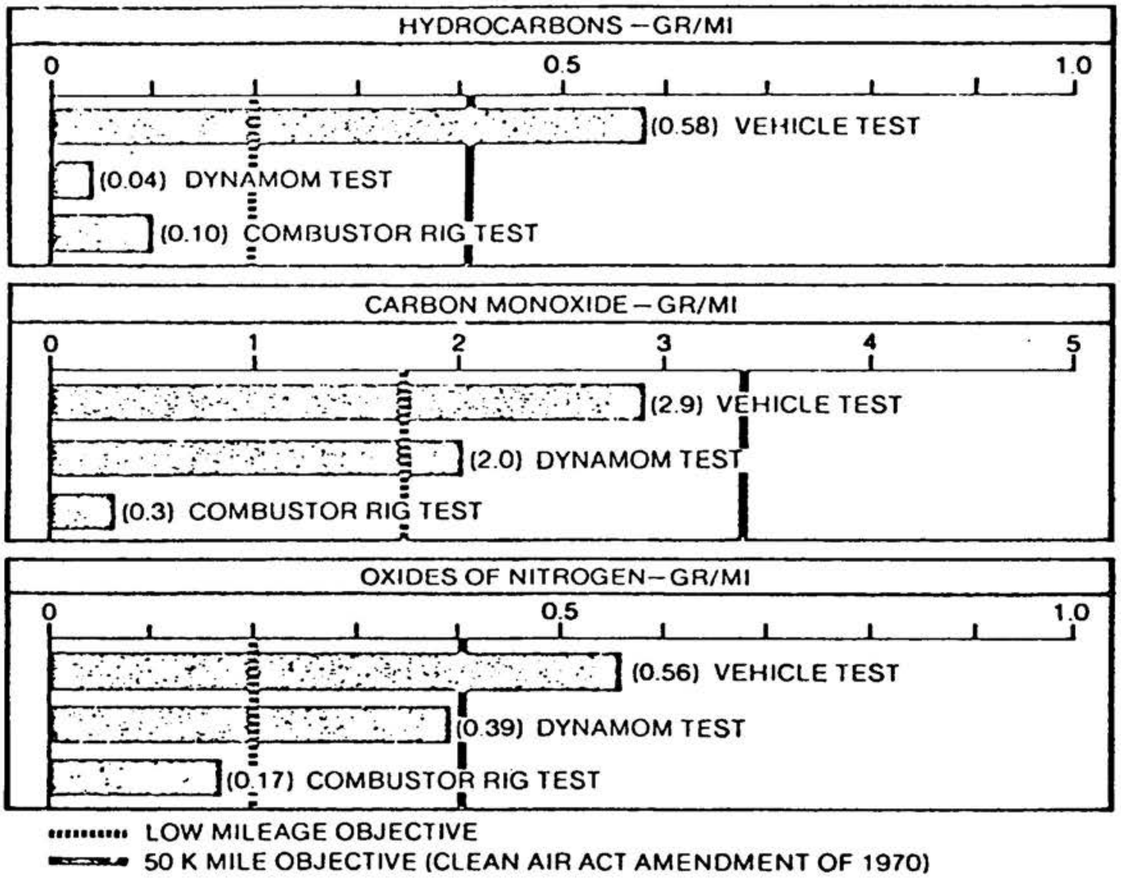

Fig. 4.8. Stirling Engine Emissions.

Source: Department of Energy, Transportation Energy Conservation Division, *Highway Vehicle Systems Contractors Coordinating Meeting, Thirteenth Summary Report*, Washington, D.C., March 1978, p. 249.

THE ALTERNATIVE FUELS UTILIZATION PROGRAM PROVIDES FOR GOVERNMENT PARTICIPATION IN R&D DESIGNED TO FIND THE BEST MEANS OF USING ALTERNATIVE FUELS IN HIGHWAY VEHICLES FROM THE STANDPOINT OF RESOURCE/FUEL/ENGINE SYSTEM OPTIMIZATION. THE GOAL OF THE PROGRAM IS TO LOWER THE UNCERTAINTY COSTS ASSOCIATED WITH DEVELOPMENT OF ALTERNATIVE FUEL TECHNOLOGIES IN THE TRANSPORTATION SECTOR AND TO ENCOURAGE THE USE OF SUCH FUELS.

ALTERNATIVE FUELS UTILIZATION PROGRAM

Objectives

- Identification and evaluation of new hydrocarbon fuels based on an understanding of the fuels production and the design of engines optimized for these fuels.
- Identification and evaluation of alcohol fuels based on an understanding of fuels production and engine design optimized for these fuels.
- A study of the consequences of using synfuels in standard or improved existing engine types.
- An assessment of advanced fuels including hydrogen and carbonaceous fuels.
- An assessment of the use of nonstandard fuel in an emergency.

Source: Lawrence Livermore Laboratory, *TAC Program Plan,* September 1978, p. III-7 (due to current reorganization and uncertainty of the program status, this document represents the present scope of the program as of September 1, 1978, in draft form).

Section 4.4

Other TEC Programs

AN ENERGY STUDY OF MARINE TRANSPORTATION SPONSORED BY THE NONHIGHWAY TRANSPORT SYSTEMS BRANCH IDENTIFIED SPECIFIC REGULATIONS THAT IMPACT OR COULD IMPACT COMMERCIAL MARINE TRANSPORTATION ENERGY CONSUMPTION. THREE OF THE REGULATIONS IDENTIFIED HAVE IMPACTS GREATER THAN 1 % OF TOTAL INDUSTRY CONSUMPTION IN 1974.

Table 4.12
Energy Impacts Due to Regulatory Actions

Case study	Energy impact increase (decrease) in quads	Percent of industry consumption in 1974	
		Low	High
Puget Sound tanker regulations	0.0003 to 0.001	0.01 —	0.35
Foreign sale of Alaskan crude	0.006 to 0.103	2.29 —	3.58
Segregated ballast	0.0 to 0.066	0.00 —	2.29
Inland waterway user charges	0.003 to 0.005	0.10 —	0.17
Cargo pooling or service rationalization	(0.0 to (0.073)	(0.00) —	(2.54)
Minibridge	(0.005)	(0.17)	
Lock and dam 26	0.0 to 0.0007	0.00 —	0.02

Source: Department of Energy, Transportation Energy Conservation Division, Nonhighway Transport Systems, *An Energy Study of the Marine Transportation Industry, Volume I,* June 1978; Booz-Allen and Hamilton, *An Energy Study of the Marine Transportation Industry, Vol. I,* Department of Energy, Transportation Energy Conservation Division, Washington, D.C., December 1977.

AN ENERGY STUDY OF RAILROAD FREIGHT TRANSPORTATION SPONSORED BY THE NONHIGHWAY TRANSPORT SYSTEMS BRANCH HAS ANALYZED SEVERAL CONSTRUCTION OPPORTUNITIES AS TO THEIR POTENTIAL ENERGY IMPACTS.

Potential Rail Freight Transportation Energy Conservation Opportunities

Improved Equipment

1. Use of aluminum cars — 15% energy reduction
2. 15% improvement in wheel-rail adhesion — 5% energy reduction
3. Wheel bearing seals for cars with roller bearings — 6% energy reduction
4. Recovering waste heat from exhaust of a diesel engine — 8% energy reduction

Road Bed Improvement and Braking Energy Recovery

Small energy savings can be obtained by:
1. Rebuilding of lines to reduce curves and grades,
2. Recover braking energy by regeneration and storage

Improved Operations

Many improvements in rail operations have resulted in fuel savings. Standardization of fueling equipment, matching of locomotive consists to loads, coordination of brake application and throttle procedures are a few energy saving devices.

Alternative Fuels

The substitution of alternate fuels for petroleum is a direct energy saver. Alternate fuels being studied to include heavier petroleum fuels, synthetic petroleum, ammonia, and hydrogen.

Intermodal Systems

Combinations of highway and rail transport of freight offer potential energy advantages. In the future, coordination of systems will increase by a new service that provides for wider-load-carrying capacity with highway dimensions.

Encouragement of Shippers to Use Railroads

Shippers can be encouraged to use rail in two ways:
1. Controls applied to trucking
2. Changes to railroad operations would bring selected market segments to rail.

Regulations and Tariffs

1. Change rate structure to encourage shorter hauls,
2. Lower rates on backhauls,
3. Allow nonrailroad car owners to contribute to the freight car fleet,
4. Allow rail carriers to raise or lower the rates charged for the transportation of various commodities along low-density branch lines.

Source: SRI International, *An Energy Study of Railroad Freight Transportation, Volume I*, Department of Energy, Transportation Energy Conservation Division, August 1977.

The average vanpool trip is 25 miles one way, and the average transit commuter trip is 6 miles one way. The commuting market being served by vanpools is essentially the 27% of commuters traveling in excess of 10 miles to work. This market segment consumes 69% of commuter vehicle-miles of travel. While approximately 93% of the vanpools serve suburban or rural employment locations, only 5% serve Central Business Districts (CBD) locations. The remaining 2% of vanpools serve both CBD and suburban work locations.

Table 4.13
The Growth of Employer-Sponsored Vanpools, 1973-1978[a]

	Number of sponsors	Number of sites	Number of vanpools	% Change
April 1973	1		6	
April 1974	15		125	1,198.3
April 1975	25		240	92.0
April 1976	56		643	167.9
April 1977	86		1,100	71.1
February 1978	122	163	1,986	80.6

[a]These figures do not include the estimated 2,000–3,000 driver-owner-operated vanpools believed to be in existence in the United States.

Source: Environmental Protection Agency and Department of Energy, Assistant Secretary for Conservation and Solar Applications, Transportation Programs Office, "Vanpooling, An Update," May 1978.

Section 4.5

Government Taxes and Expenditures

Table 4.14
Federal Taxes Derived from Transportation, 1950–1976
($ 10^6)

	1950	1960	1965	1970	1975	1976	% change 1950-1970	% change 1970-1976
Corporate income and profits taxes								
Transportation companies	862	684	779	788	1,470	1,188	-8.6	50.8
Transport equipment mfgrs., exc. motor	162	322	518	629	565	578	288.3	8.1
Motor vehicle and equipment mfrgrs.	1,799	1,729	2,591	2,927	1,697	1,943	62.7	33.6
Automotive sales and services	342	214	287	451	794	680	31.9	50.8
Total	3,165	2,949	4,175	4,795	4,526	4,389	51.5	8.5
Excise Taxes[a]								
Gasoline	568	2,224	2,627	3,447	3,839	4,086	506.9	18.5
Diesel and special motor fuels		82	151	265	363	413		55.8
Use tax on large motor vehicles		45	103	141	212	126		-10.6
Lubricating oil	45	47	48	57	57	63	26.7	10.5
Motor vehicles, parts, and accessories	781	1,781	2,439	2,439	495	549	212.2	-77.5
Tires, tubes, and tread rubber	184	299	458	614	634	678	233.7	10.4
Transportation of property	340	2		11	47	45	-96.8	309.1
Transportation of people	229	261	122	337	803	846	47.2	151.0
Other excise taxes[b]	831	1,235	2,280	2,546	2,797	2,933	206.4	14.8
Total	2,978	5,976	8,228	9,975	9,247	9,739	234.9	-2.4
Income and employment taxes[b]	2,673	7,856	9,199	18,343	29,450	30,312	586.2	65.3
Total federal transportation taxes	8,816	16,781	21,602	33,013	43,223	44,653	274.5	35.3
Total federal taxes	38,957	91,775	114,435	195,722	293,823	302,520	402.4	54.6
Transportation taxes as a percent of total	22.6	18.3	18.9	16.9	14.7	14.8		

[a]No adjustments have been made for changes in rates or coverage.

[b]Paid by people employed in transportation.

Sources: Transportation Association of America, *Transportation Facts and Trends*, 13th ed., Washington, D.C., 1976, p. 27; *Transportation Facts and Trends*, Quarterly Supplement, Washington, D.C., April 1978, p. 27.

Table 4.15
State Taxes Derived from Transportation, 1950–1976
($ 10^6)

	1950	1960	1965	1970	1975	1976	% change 1950-1970	% change 1970-1976
Corporate income taxes	171	153	308	374	657	681	118.7	
Excise taxes								
Motor fuels	1,544	3,335	4,300	6,283	8,255	8,660	306.9	37.8
Motor vehicle and operator licensing	755	1,468	2,021	2,955	3,941	4,355	291.4	47.4
Other state taxes[a]	549	1,307	1,762	3,239	5,389	6,030	490.0	56.2
Total	2,848	6,110	8,083	12,476	17,585	19,045	338.1	52.7
Individual income taxes[a]	98	309	475	1,194	2,446	2,790	1,118.4	133.7
Total state transportation taxes	3,117	6,572	8,866	14,044	20,688		350.6	
Total state taxes	7,929	18,036	26,126	47,961	80,155	89,252	504.9	86.1
Transportation taxes as a percent of total	39.3	36.9	33.9	29.3	25.8			

[a]Paid by people employed in transportation.

Sources: Transportation Association of America, *Transportation Facts and Trends*, 12th ed., Washington, D.C., 1975, p. 27; *Transportation Facts and Trends*, Quarterly Supplement, Washington, D.C., April 1978, p. 27.

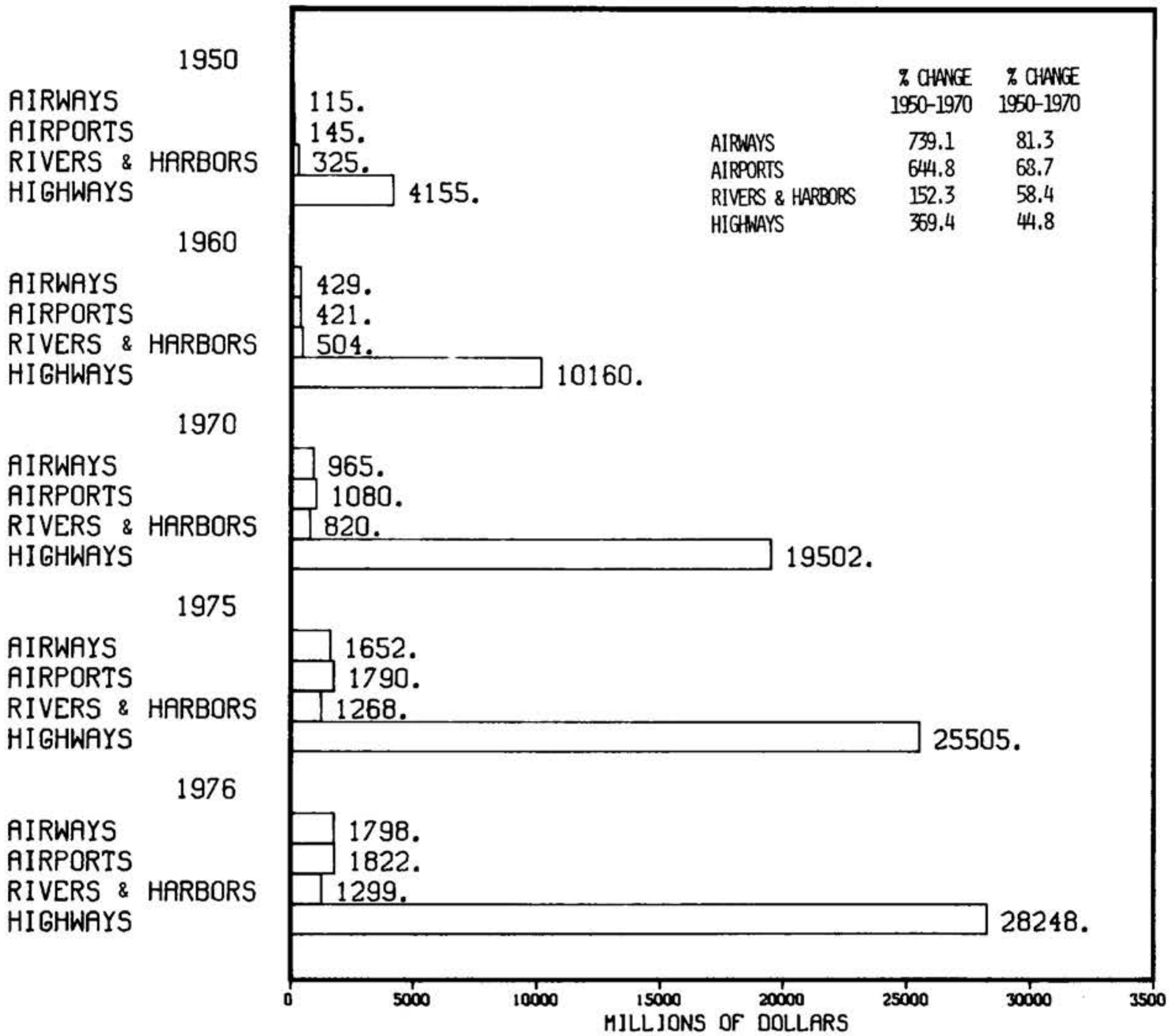

Fig. 4.9
Federal and State Expenditures for Transportation Facilities.

Source: Transportation Association of America, *Transportation Facts and Trends*, 12th ed., Washington, D.C., 1975; *Transportation Facts and Trends*, Quarterly Supplement, Washington, D.C., April 1978.

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Chapter 5

Energy Supply

Energy Supply

The emphasis of Chapter 5 centers around the energy supply for transportation systems in the United States. Currently, energy use by the transportation sector totals over 19 quadrillion Btu annually, of which almost 97% is derived from petroleum-based sources. In 1977, the transportation sector alone accounted for 53.7% of the petroleum products consumed in the United States. While current energy supply (petroleum) is the focus of this chapter, Sect. 5.4 provides information from the Department of Energy's Alternative Fuels Program and other federal programs concerned with research and development of alternatives to petroleum.

Section 5.1 provides data on the production of energy, mainly petroleum, for selected years from 1950 through 1977. Domestic production of petroleum, while declining since 1970, within the last year has stabilized as a result of production from Alaska's North Slope. More important, however, is the fact that domestic production as a percent of total consumption (which includes imports) has decreased from 84.9% in 1950 to 47.1% in 1977. This decrease is directly attributable to an increase in domestic petroleum consumption and the exhaustion of domestic resources.

As a result, petroleum imports have risen substantially. Section 5.2 provides summary data on imports of both crude oil and refined petroleum products. The United States' dependence on foreign sources for crude oil has been increasing rapidly since 1970. In 1977 crude oil imports as a percent of domestic production reached 80%. Of the petroleum imported in 1977, OPEC nations accounted for over 70% of the total, with Arab members supplying 36%. Thus far in 1978, the United States is importing close to 8,000,000 bbl of petroleum per day.

Section 5.3 deals with the price of energy items and focuses in particular on crude oil and various petroleum products. While annual petroleum imports have continued to rise, the current price of petroleum products has risen also. However, the real (deflated) prices of these products reveals a different picture. In the case of gasoline and motor oil, the real price actually fell 0.8% between 1976 and 1977 (Table 5.11).

The final section of Chapter 5 (Sect. 5.4) deals with the potential availablity and feasibility of alternative fuels for transportation use. Currently, the Department of Energy and its subcontractors are involved in an estensive research effort aimed at the development of alternative fuels. A brief summary of DOE's work in this area is presented in this final section.

Section 5.1

Domestic Production

From 1950 to 1970 total U.S. energy production grew at an average rate of 2.4% per year. From 1970 to 1975, production declined 0.3% per year and then stablized in 1976 and 1977. Crude oil, which accounted for 29% of the total production in 1977, peaked in 1970 and from 1970 through 1976 decreased at an average annual rate of 1.7%. In 1977, however, production rose slightly due to the addition of production from Alaska's North Slope. While coal production has increased 4.4% since 1970, natural gas has decreased 9.7%. In 1977 fossil energy accounted for over 90% of total production. However, nuclear power and geothermal registered the greatest increases between 1970 and 1977.

Table 5.1. Energy Production by Primary Energy Type, 1950 through 1977
(10^9 Btu)

	Coal[a]	Natural gas[b]	Crude oil[c]	Hydropower	Nuclear power	Geothermal	Total gross energy production
1950	14,647	6,841	11,449	1,340			34,277
1960	11,140	14,135	14,935	1,566	5		41,781
1970	15,248	24,154	20,402	2,593	232	11	62,640
1975	15,394	22,019	17,730	3,122	1,839	69	60,173
1976[d]	15,868	21,827	17,263	2,952	2,037	78	60,025
1977[d]	15,924	21,817	17,395	2,293	2,675	78	60,182
% Distribution							
1977	26	36	29	4	4		100
Average annual rate of change (1970–1977)	0.6	−1.4	−2.3	−1.7	41.8	32.3	−0.6

[a]Includes anthracite coal, bituminous coal, and lignite.

[b]Includes natural gas liquids.

[c]Includes lease condensate.

[d]Preliminary.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 3.

THE GRAPH BELOW PROVIDES A VISUAL ANALYSIS OF THE INCREASING UNITED STATES DEPENDENCE ON FOREIGN OIL. IT IS INTERESTING THAT THE TOTAL ENERGY CURVE AND PETROLEUM CURVE DECREASED AT A FAIRLY PROPORTIONAL RATE BETWEEN 1950 AND 1970. SINCE THEN THE PETROLEUM CURVE HAS BEEN DECLINING AT AN INCREASING RATE AS A RESULT OF A DECREASE IN PETROLEUM PRODUCTION AND AN INCREASE IN DOMESTIC ENERGY PRODUCTION OF OTHER SOURCES. THE TOTAL ENERGY CURVE IS GREATER THAN 100% WHEN THE UNITED STATES PRODUCED MORE ENERGY THAN IT CONSUMED.

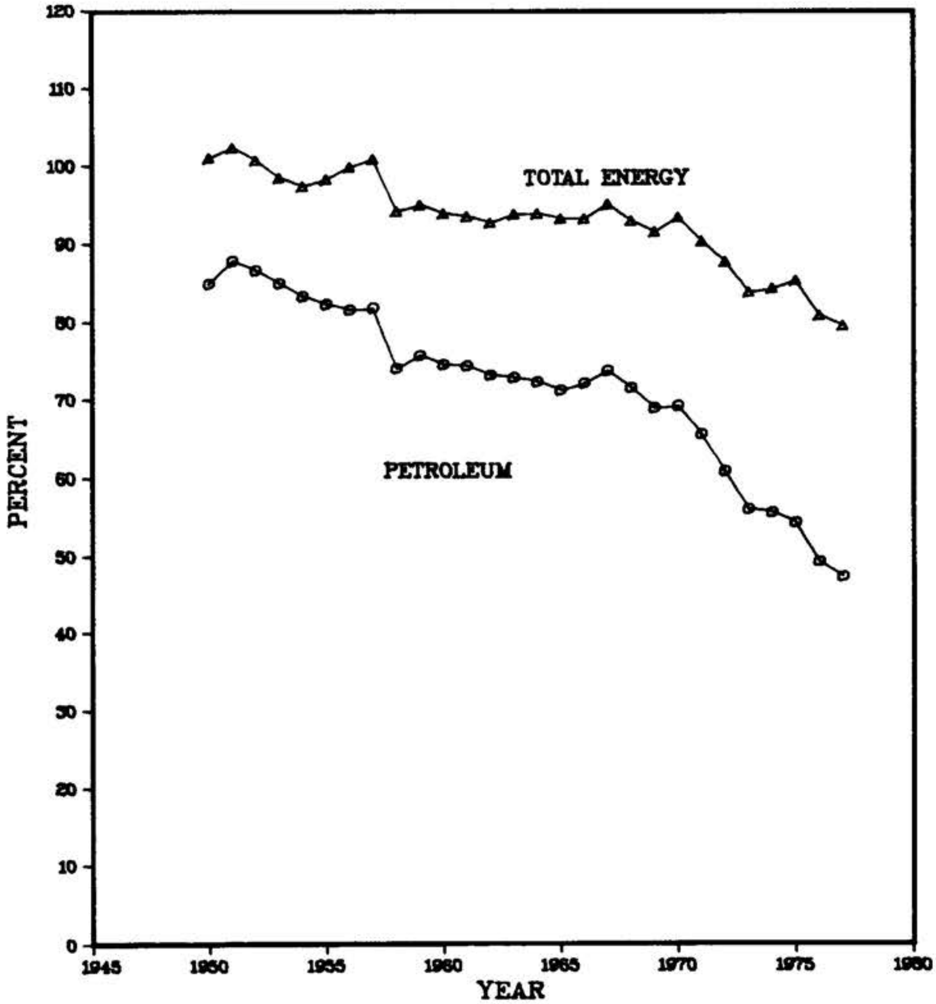

Fig. 5.1
Comparison of the Percent U.S. Petroleum Production of Total Petroleum Consumption and Percent U.S. Total Energy Production of Total Energy Consumption, 1950 through 1977.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress - Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, pp. 3 and 5.

WHILE U.S. ENERGY CONSUMPTION INCREASED 123.6% BETWEEN 1950 AND 1977, DOMESTIC PRODUCTION AS A PERCENT OF CONSUMPTION DECREASED 21.4%. ONE OF THE MAIN REASONS FOR THIS IS INCREASED U.S. DEPENDENCE ON FOREIGN OIL.

Table 5.2. U.S. Domestic Petroleum and Total Domestic Energy Production and Consumption

	Total energy			Petroleum[b]		
	Total consumption[a]	Domestic production	Domestic % production of consumption	Total consumption[a]	Domestic production	Domestic % production of consumption
1950	33,923	34,277	101.0	13,489	11,449	84.9
1960	44,525	41,781	93.8	20,067	14,935	74.4
1970	67,121	62,640	93.3	29,537	20,402	69.1
1975	70,598	60,173	85.2	32,742	17,730	54.2
1976	74,372	60,025	80.7	35,086	17,263	49.2
1977	75,836	60,182	79.4	36,956	17,395	47.1

[a] Includes imports.

[b] See glossary - petroleum.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress - Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, pp. 3 and 5.

SINCE 1950 THE DOMESTIC DEMAND FOR REFINED PETROLEUM PRODUCTS IN THE UNITED STATES HAS ALMOST TRIPLED. THE GREATEST INCREASES HAVE OCCURRED IN THE DEMAND FOR TRANSPORTATION FUELS, WITH THE DEMAND FOR GASOLINE INCREASING 165% AND DISTILLATE FUEL 209.1%. THE GASOLINE/DISTILLATE RATIO HAS REMAINED RELATIVELY STABLE BETWEEN 2.2 AND 2.4%.

Table 5.3. Domestic Demand for Refined Petroleum Products, 1950 through 1977 (10^3 bbl/day)

	Total gasoline	Jet fuel[a]	Distillate fuel oil	Residual fuel oil	Kerosene[a]	Other products[b]	Total products	Gasoline/ distillate ratio
1950	2,724		1,082	1,517	323	812	6,458	2.5
1960	4,130	281	1,872	1,529	362	1,623	9,797	2.2
1970	5,839	967	2,540	2,204	263	2,884	14,697	2.3
1975	6,713	1,001	2,851	2,461	159	2,137	16,322	2.4
1976	7,014	987	3,133	2,801	169	3,357	17,461	2.2
1977[c]	7,214	1,037	3,345	3,048	165	3,613	18,422	2.2
Average annual rate of change (1970–1977)	3.1	1.0	4.0	4.7	–6.4	3.3	3.3	

[a]Prior to 1965 kerosene-type jet fuel was included with kerosene. Prior to 1952 naphtha-type jet fuel was included with gasoline. Prior to 1965 special naphthas were included with gasoline.

[b]Includes ethane, liquefied petroleum gases, petrochemical, feedstocks, special naphthas, lubricants, wax, coke, asphalt, road oil, still gas, plant condensate, and miscellaneous products.

[c]Preliminary.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 33.

GASOLINE HAS TRADITIONALLY ACCOUNTED FOR THE LARGEST PERCENTAGE OF REFINED PETROLEUM PRODUCTS OUTPUT, AND IN 1977 IT WAS 39.2% OF THE TOTAL.

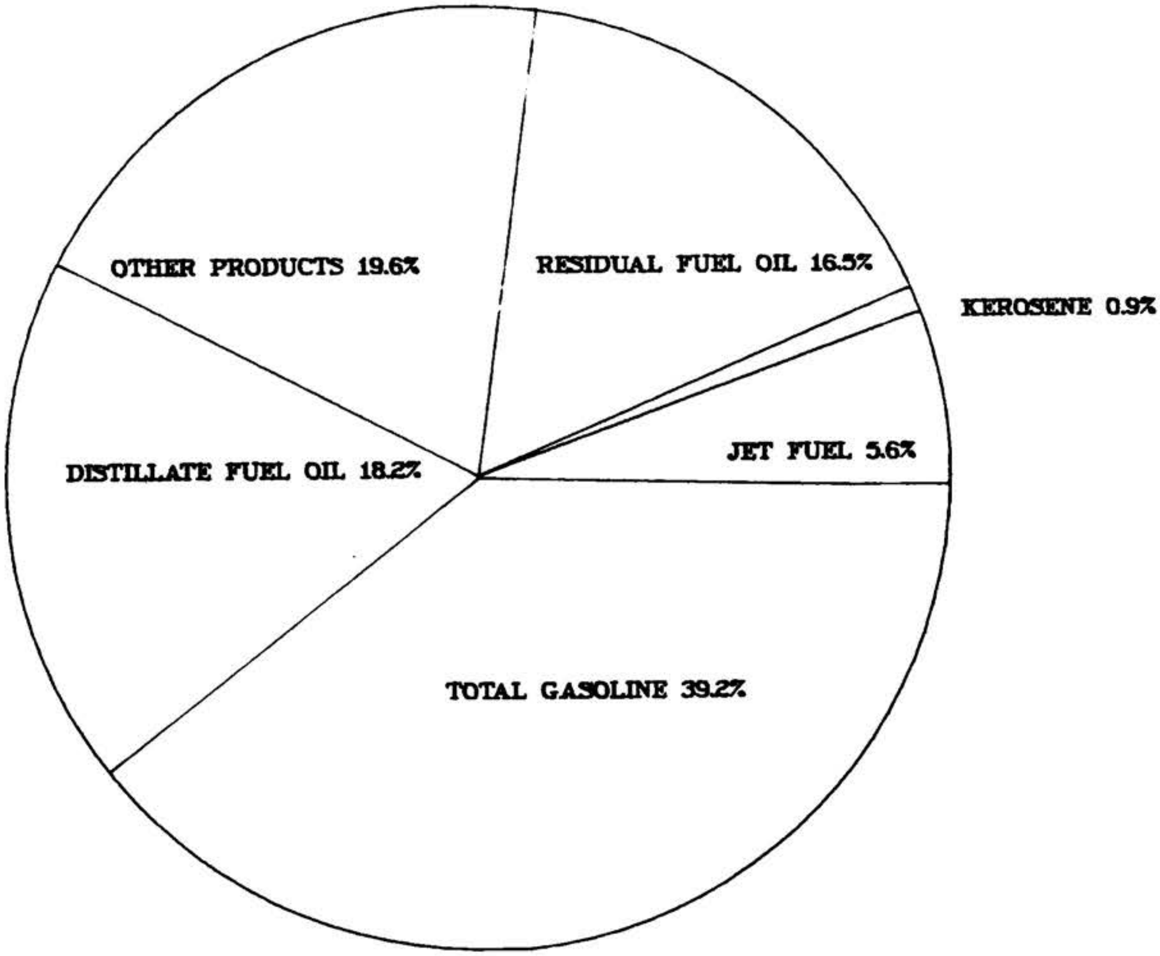

Fig. 5.2. Refined Petroleum Products Output, 1977.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress - Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 33.

ALTHOUGH THE DOMESTIC DEMAND FOR REFINED PETROLEUM PRODUCTS INCREASED AT AN AVERAGE ANNUAL RATE OF 4.6% BETWEEN 1950 AND 1970, THE RATE SLOWED TO 2.2% FROM 1971 TO 1975. HOWEVER, SINCE 1975 THE DEMAND IS INCREASING AT 6.3% PER YEAR.

Table 5.4. Domestic Demand for Refined Petroleum Products by End-Use Sector, 1950 through 1977 (10^3 bbl/day)

	1950	1960	1965	1970	1974	1975	1976	1977[a]	1977 (%)	% increase since 1970
Residential and commercial	1,442	2,331	2,679	3,092	2,898	2,760	2,992	3,180	17.2	2.8
Industrial	1,224	1,759	2,028	2,634	3,126	2,867	3,210	3,443	18.7	30.7
Transportation	3,421	5,284	6,224	7,953	8,953	9,140	9,571	9,912	53.7	24.6
(% of total)	(53.0)	(53.9)	(54.1)	(54.1)	(53.8)	(56.0)	(54.8)	(53.7)		
Electric utility	291	246	325	915	1,534	1,420	1,510	1,708	9.3	86.7
Other	80	177	256	103	142	135	178	199	1.1	93.2
Total	6,458	9,797	11,512	14,697	16,653	16,332	17,461	18,442	100.0	25.5

[a]Preliminary.

Source: Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 35.

SINCE 1950 THE TRANSPORTATION SECTOR HAS ACCOUNTED FOR MORE THAN 50% OF THE PETROLEUM PRODUCTS CONSUMED IN THE UNITED STATES; IN 1977 THIS SECTOR ACCOUNTED FOR 53.7%.

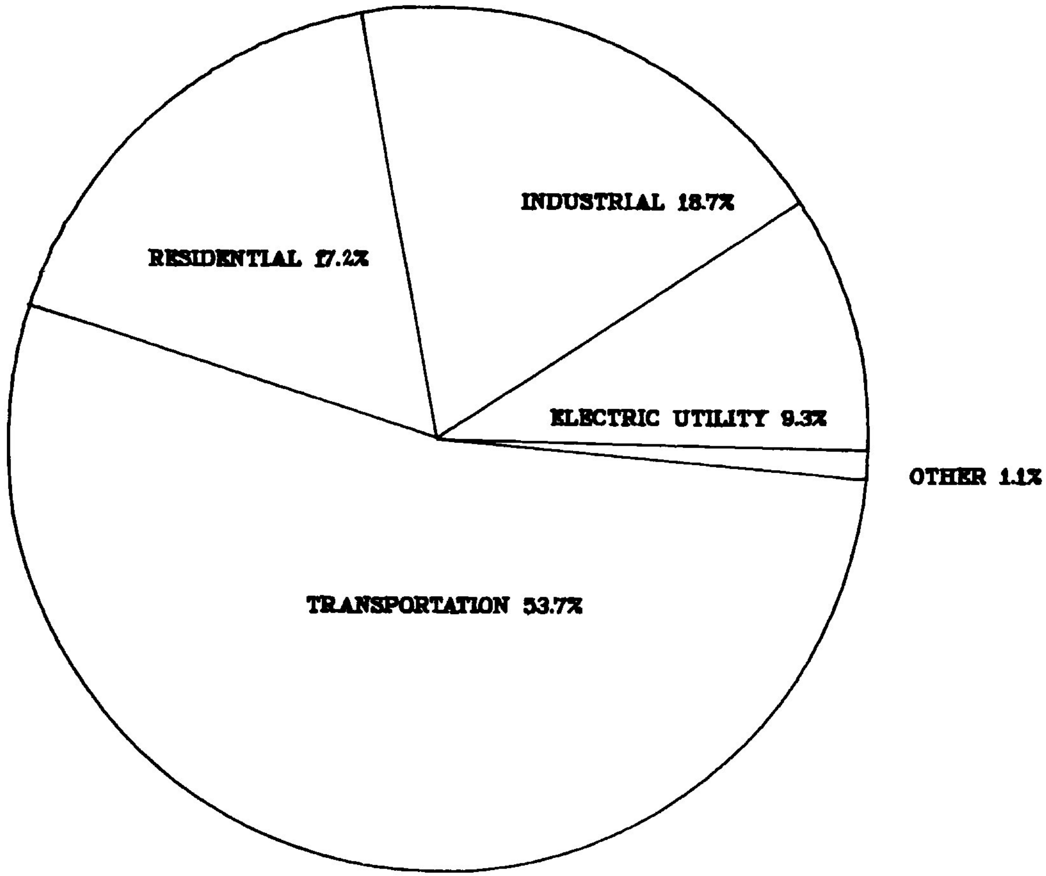

Fig. 5.3. Percent Domestic Demand for Refined Petroleum Products by End-Use Sector, 1977.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress - Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 35.

Table 5.5. Percentage Yields of the Major Refined Products from a Barrel of Crude Oil in the United States, 1950 through 1976

Year	Gasoline	Kerosene	Jet fuel	Distillate and residual fuel oil	Lubricants	Wax	Coke	Asphalt	Other finished products
1950	43.0	5.6		39.2	2.5	0.2	0.8	2.8	5.9
1960	45.2	4.6	3.0	33.6	2.0	0.2	2.0	3.3	6.1
1970	45.5	2.4	7.5	28.8	1.6	0.2	2.7	3.7	7.6
1975	46.5	1.2	7.0	31.2	1.2	0.1	2.8	3.2	6.8
1976	45.5	1.1	6.8	32.0	1.3	0.1	2.6	2.8	7.8
Average annual rate of change (1970–1976)	0.0	–12.2	–1.6	1.8	–3.4	–10.9	–0.6	–4.5	0.4

Source: DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics*, 33rd ed., Dallas, Tex., October 1977, p. 63.

THE TABLE AND FIGURES (TABLE 5.5 AND FIG. 5.4) SHOWING THE PERCENT YIELD FROM A BARREL OF CRUDE OIL IN THE UNITED STATES SHOW THE INCREASE IN RELATIVE IMPORTANCE OF JET FUEL AS A FINAL PRODUCT SINCE 1950, AND THE DECLINE IN THE YIELD OF DISTILLATE AND RESIDUAL FUEL OIL OVER THE SAME PERIOD.

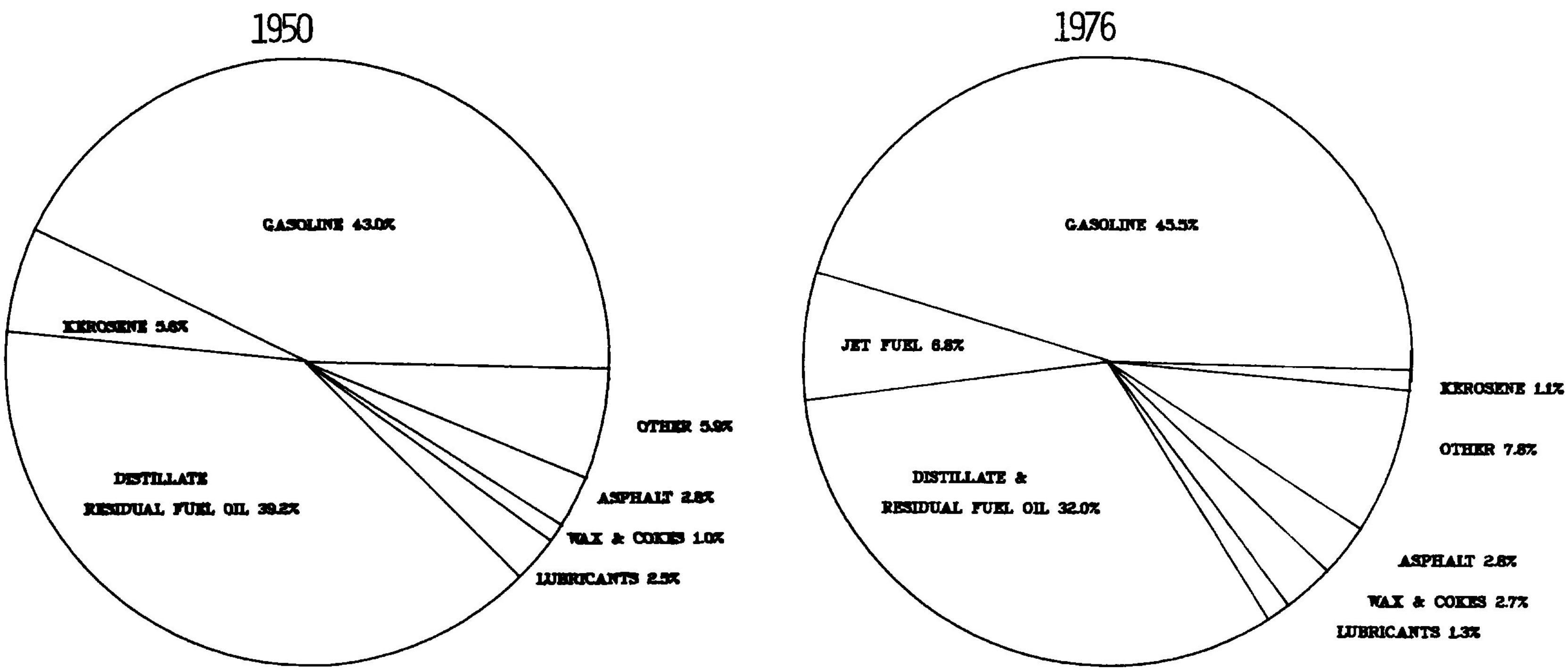

Fig. 5.4. Percentage Yields of the Major Refined Products from a Barrel of Crude Oil in the United States, 1950 through 1976.

Source: DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics*, 33rd ed., Dallas, Tex., October 1977, p. 63.

WHILE FOSSIL FUELS HAVE TRADITIONALLY ACCOUNTED FOR THE MAJORITY OF ELECTRICITY PRODUCED IN THE UNITED STATES, THE TABLE BELOW SHOWS THE INCREASING IMPORTANCE OF NUCLEAR ENERGY IN THE PRODUCTION OF ELECTRICITY. IN 1977, FOSSIL FUELS ACCOUNTED FOR OVER 77% OF THE TOTAL ELECTRICITY PRODUCED. THE PERCENTAGE PRODUCED BY COAL HAS REMAINED FAIRLY STABLE WHILE NATURAL GAS DECLINED AT AN AVERAGE RATE OF 3.2% PER YEAR SINCE 1972. OIL, WHILE DECREASING IN 1974 AND 1975, SHOWED AN OVERALL INCREASE WHICH AVERAGED 9% ANNUALLY SINCE 1972.

Table 5.6. Production of Electricity by Primary Energy Source, 1971 through May 1978

	Total net production (10^6 kWhr)	Percentage produced by source					
		Coal	Oil	Gas	Nuclear	Hydroelectric	Other[a]
1971	1,612,593	44.3	13.6	23.2	2.4	16.5	0.1
1972	1,749,629	44.2	15.6	21.4	3.1	15.6	0.1
1973	1,860,440	45.7	16.8	18.3	4.5	14.6	0.1
1974	1,867,103	44.5	16.0	17.2	6.1	16.1	0.1
1975	1,917,638	44.5	15.1	15.6	9.0	15.6	0.2
1976	2,037,775	46.4	15.7	14.4	9.4	13.9	0.2
1977	2,124,580	46.4	16.8	14.4	11.8	10.4	0.2
1978							
January	197,795	43.0	19.8	11.3	13.1	12.7	0.2
February	173,668	40.7	21.9	11.7	12.6	12.9	0.2
March	173,104	38.6	21.2	12.8	13.0	14.2	0.2
April	159,750	44.1	15.6	13.3	11.0	15.9	0.1
May	175,184	43.7	13.9	14.3	11.7	16.4	0.1
Average annual rate of change (1971–1977)	4.7	0.8	3.6	−7.6	30.4	−7.4	12.3

[a]Includes electricity produced from geothermal power, wood, and waste.

Source: J. Gaynor (ed.), Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, D.C., July 1978, p. 33.

Section 5.2

Imports

THE UNITED STATES DEPENDENCE UPON FOREIGN SOURCES FOR CRUDE OIL HAS BEEN INCREASING RAPIDLY SINCE 1970. IN 1977 CRUDE OIL IMPORTS AS A PERCENT OF DOMESTIC PRODUCTION REACHED 80%, 13% HIGHER THAN THE ESTIMATED VALUE FOR 1978.

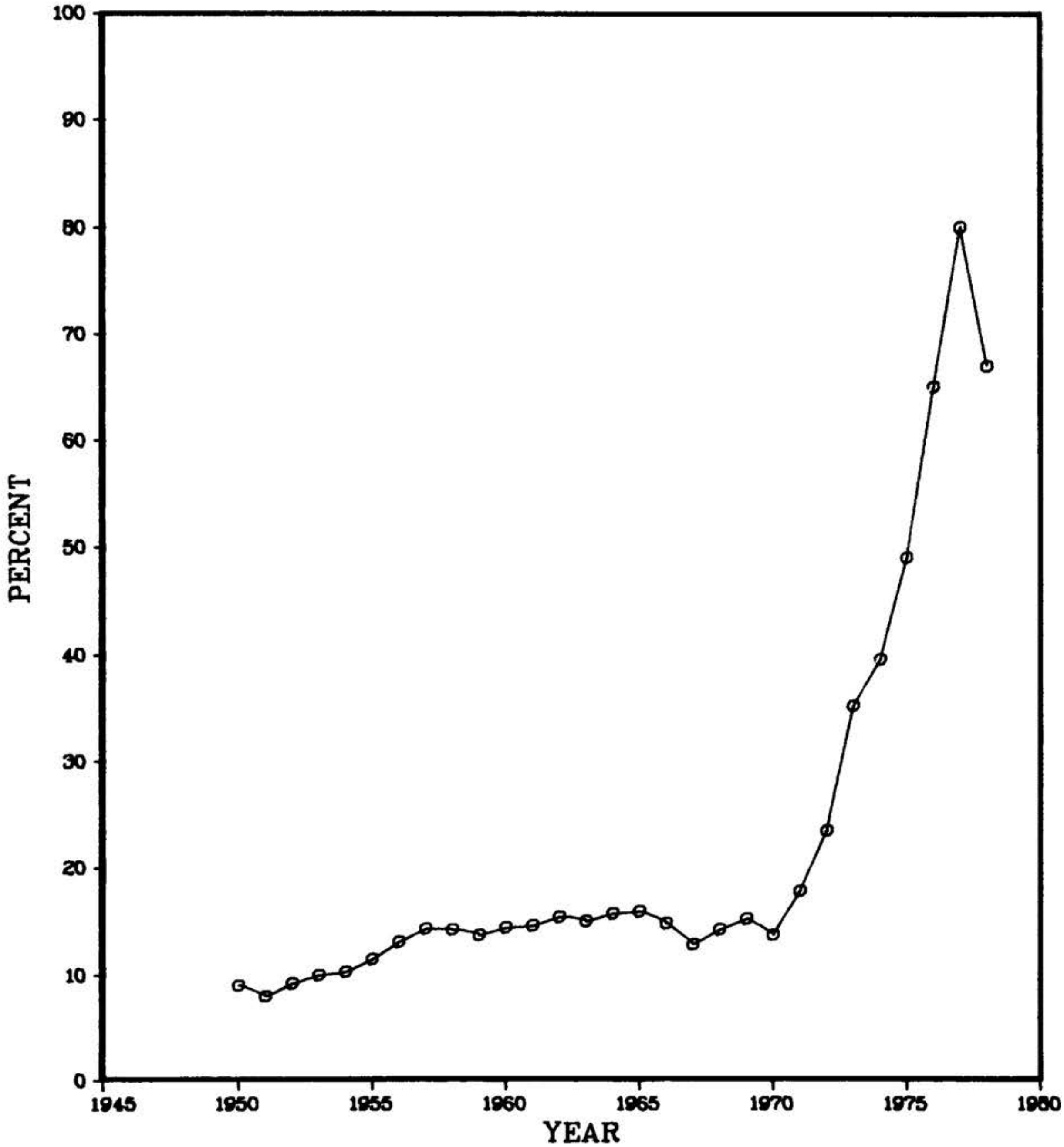

Fig. 5.5. U.S. Crude Oil Imports as Percent of Domestic Production, 1950 through 1978.

Source: J. Gaynor (ed.), Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, D.C., monthly.

THE FIGURE BELOW PROVIDES A VISUAL REPRESENTATION OF THE RELATIONSHIP BETWEEN TOTAL PETROLEUM IMPORTS AND IMPORTS FROM OPEC NATIONS.

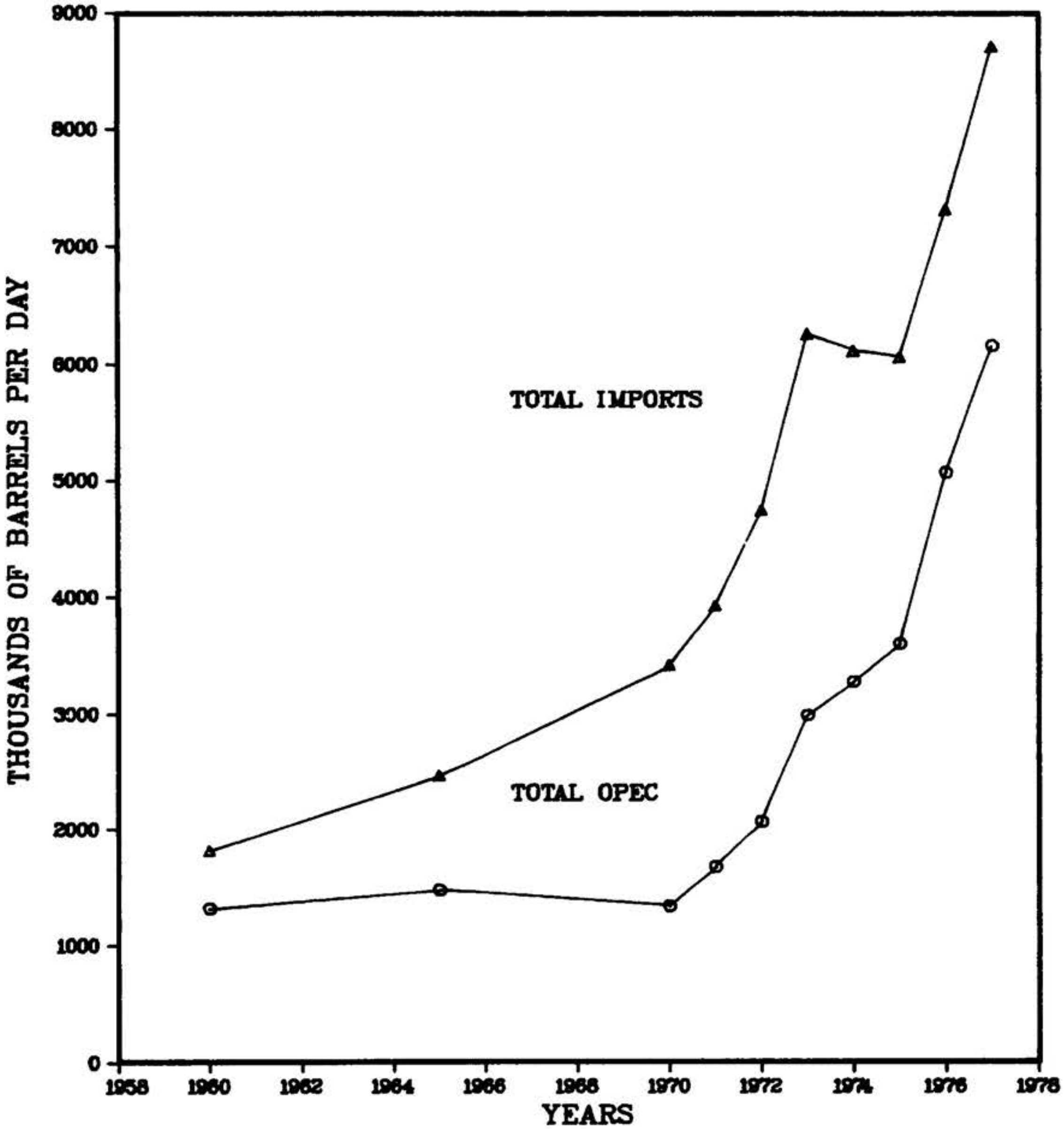

Fig. 5.6. Petroleum Imported Directly from OPEC Countries, 1960 through 1977.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress - Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 27.

ALTHOUGH IMPORTS OF PETROLEUM FROM OPEC NATIONS REMAINED FAIRLY STABLE DURING THE 1960S, A 24% PER YEAR AVERAGE INCREASE HAS BEEN WITNESSED THUS FAR IN THE 1970S. IN 1977 IMPORTS FROM OPEC NATIONS ACCOUNTED FOR OVER 70% OF OUR TOTAL PETROLEUM IMPORTS – A SUBSTANTIAL INCREASE FROM THE 39% FIGURE OF 1970. IN 1977 SAUDI ARABIA AND NIGERIA ACCOUNTED FOR ABOUT 29% OF THE TOTAL OPEC IMPORTS.

Table 5.7. Percent of Total Imports of Petroleum Imported Directly from OPEC[a] Countries, 1960 through 1977

	Saudi Arabia	Iran	Venezuela	Libya	Indonesia	United Arab Emirates	Algeria	Nigeria	Other OPEC[b]	Total OPEC	Arab members of OPEC[c]	Total imports (10^3 bbl/day)
1960	4.6	1.9	50.2		4.2				11.5	72.4	6.1	1,815
1970	0.9	1.1	28.9	1.4	2.0	1.8	0.2	1.5	1.1	39.0	4.3	3,419
1975	11.8	4.6	11.6	3.8	6.4	1.9	4.6	12.6	2.0	59.5	22.6	6,056
1976	16.8	4.1	9.6	6.2	7.4	3.5	5.9	14.0	1.8	69.3	33.1	7,312
1977[d]	15.8	6.2	7.8	8.3	6.1	3.8	6.3	13.1	3.3	70.7	36.4	8,708

[a]Organization of Petroleum Exporting Countries.

[b]Includes Ecuador, Gabon, Iraq, Kuwait, and Qatar.

[c]Includes Saudi Arabia, Iraq, Qatar, Libya, United Arab Emirates, Algeria, and Kuwait.

[d]Preliminary.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 27.

IN 1977, SIGNIFICANT PERCENTAGES OF MINERALS AND METALS CONSUMED IN THE UNITED STATES WERE SUPPLIED BY FOREIGN IMPORTS. OVER 50% OF THE APPARENT DOMESTIC CONSUMPTION IN 23 DIFFERENT METHALS AND MINERALS CAME FROM IMPORTS.

IMPORTS SUPPLIED SIGNIFICANT PERCENTAGE OF MINERALS AND METALS CONSUMPTION IN 1977

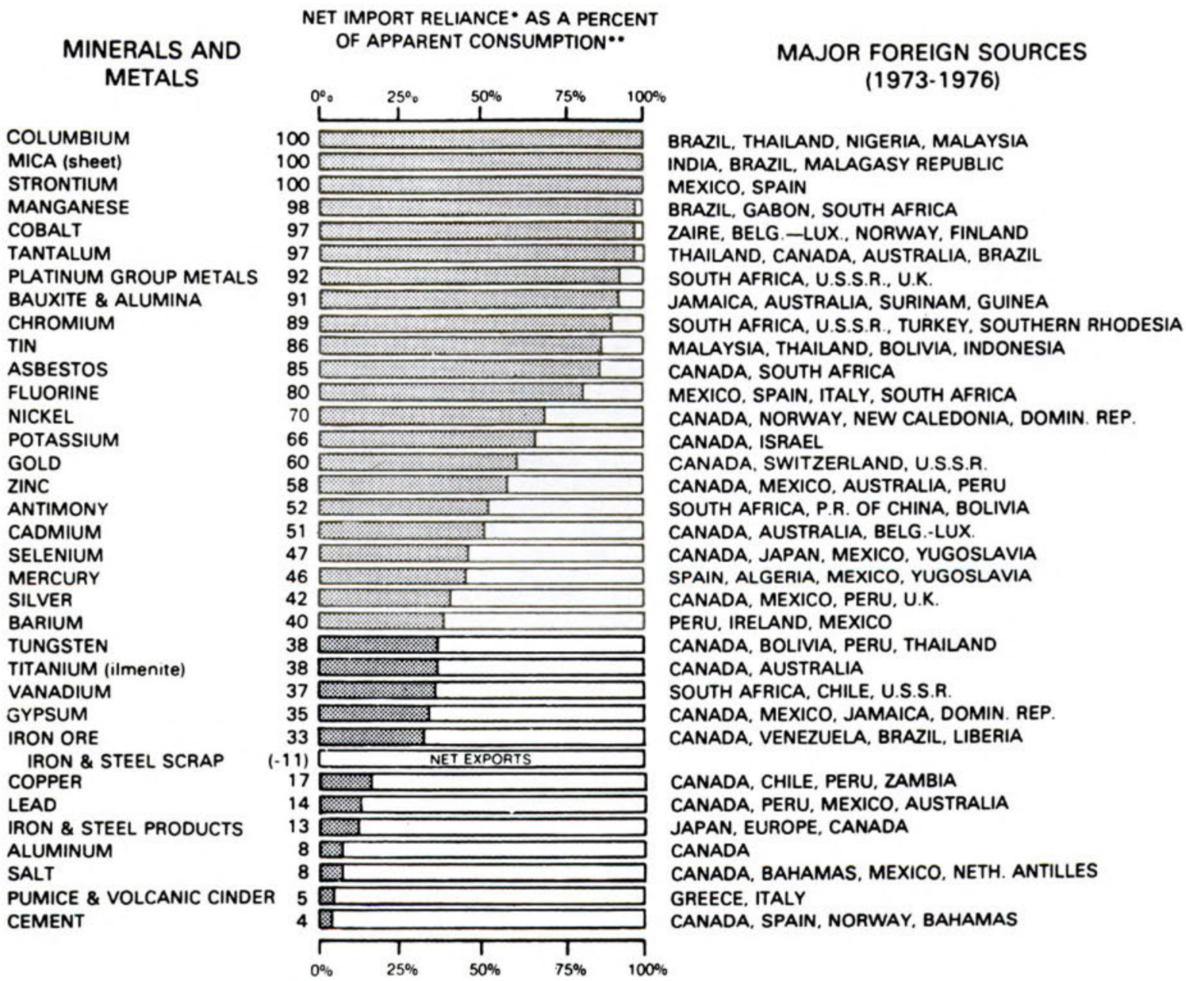

Fig. 5.7. Imports of Strategic Materials by the United States in 1977.

Source: U.S. Department of the Interior, Bureau of Mines, *Minerals and Materials: A Monthly Survey*, Washington, D.C., January 1978, p. 6.

Section 5.3
Energy Prices

THE PETROLEUM PRICE RELATIONSHIP AMONG THE MAJOR PRODUCING COUNTRIES HAS CHANGED SIGNIFICANTLY SINCE 1970. THE UNITED STATES POSTED THE HIGHEST PRICE FOR PETROLEUM IN 1970 BY MORE THAN 60¢ PER BARREL; BY 1973 THE UNITED STATES PRICE WAS ALMOST $1.00 PER BARREL LOWER THAN THE SIX OTHER MAJOR OIL PRODUCING COUNTRIES. BY 1976 THE PRICE PER BARREL IN THE UNITED STATES HAD RISEN TO $8.13, A PRICE STILL FAR BELOW THE AVERAGE OF $11.94 PER BARREL POSTED BY THE SIX OTHER COUNTRIES.

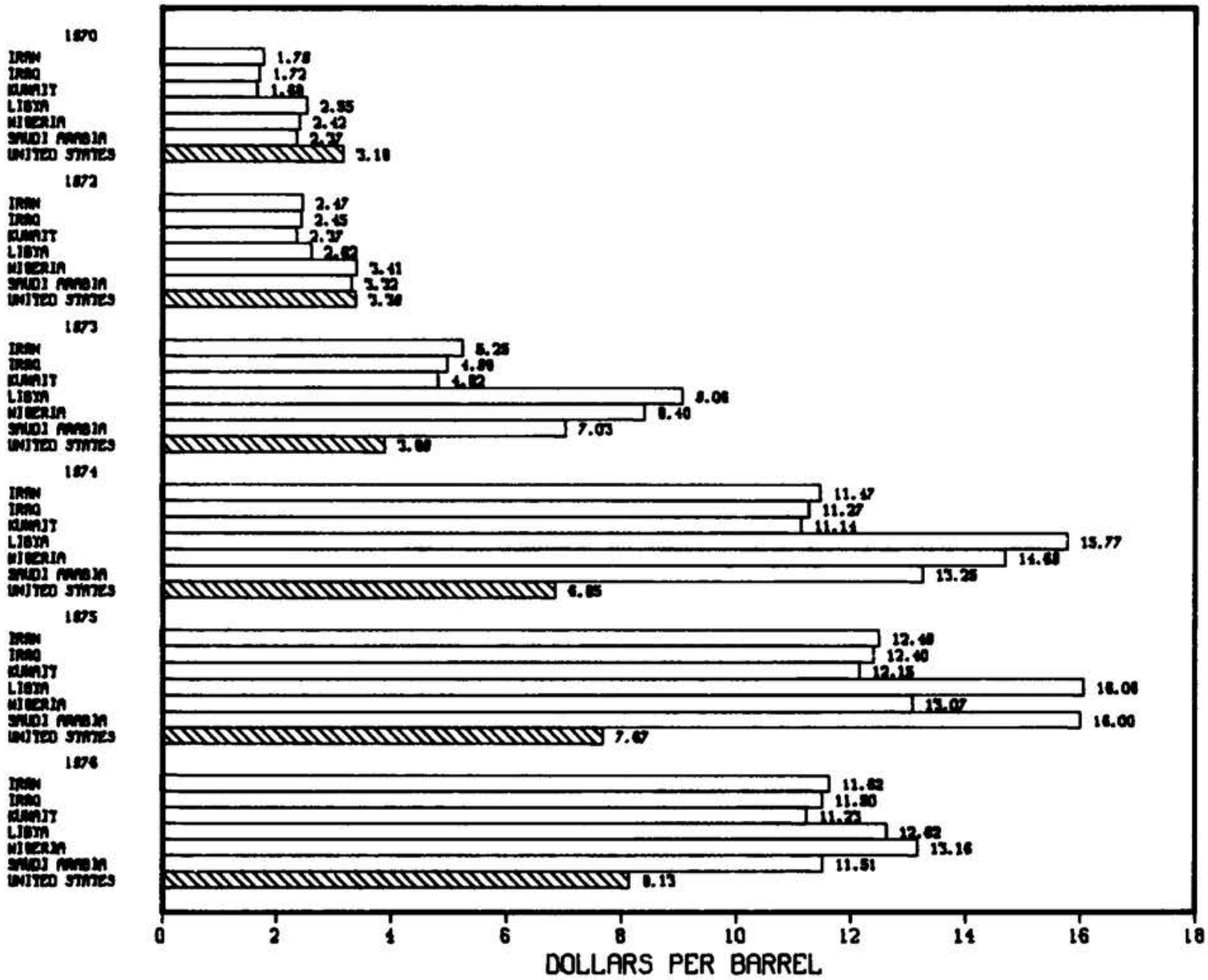

Fig. 5.8. Posted Price of Petroleum by Major Producing Countries, 1970 through 1976.

Source: DeGolyer and MacNaughton, *Twentieth Century Petroleum Statistics*, Dallas, Texas, October 1977, p. 15.

BETWEEN 1950 AND 1970 THE REAL (DEFLATED) COMPOSITE PRICE OF ALL FOSSIL FUELS DECREASED AT AN AVERAGE ANNUAL RATE OF 1.5%. IN THE EARLY 1970S THIS TREND REVERSED, AND FROM 1975 TO 1977 THE REAL PRICE INCREASED BY MORE THAN 13%. THE LARGEST INCREASE IN THE REAL PRICE OF MINERAL FUELS OCCURRED IN 1974; ALTHOUGH THIS TREND HAS SLOWED IN RECENT YEARS, IT IS CONTINUING UPWARD.

Table 5.8. Prices of Domestically Produced Mineral Fuels, 1950 through 1977[a] (cents per 10^6 Btu)

	Crude oil		Natural gas liquids		Natural gas		Bituminous coal		Anthracite coal		Composite[b]		GNP implicit price deflators
	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	Current	Deflated	
1950	43.3	102.6	55.0	130.4	6.0	14.2	18.5	43.8	35.0	83.0	26.3	62.3	42.19
1960	49.7	92.0	56.7	105.0	13.6	25.2	17.9	33.1	30.8	57.0	29.8	55.2	54.01
1970	54.8	76.3	50.0	69.6	16.6	23.1	23.9	33.3	42.6	59.3	30.4	42.3	71.85
1975	130.3	130.3	116.4	116.4	43.6	43.6	81.8	81.8	127.2	127.2	85.4	85.4	100.00
1976	140.3	133.3	139.6	132.7	56.6	53.8	84.1	79.9	136.6	129.8	94.6	89.9	105.20
1977[c]	146.6	131.6	187.3	168.2	76.4	68.6	92.1	82.7	142.0	127.5	108.0	97.0	111.37
Average annual rate of change (1970–1977)	15.1	8.1	20.8	13.4	24.4	16.8	21.3	13.9	18.8	11.6	19.9	12.6	

[a]All fuel prices taken as close as possible to the point of production.

[b]Weighted by relative importance of individual fuels in total mineral fuels production.

[c]Preliminary.

Note: Data are in both current and 1975 prices.

Source: Department of Energy, Energy Information Administration, *Annual Report to Congress — Statistics and Trends of Energy Supply, Demand, and Prices*, Washington, D.C., May 1978, p. 19.

THE TABLE BELOW SHOWS THE GRADUAL INCREASE IN THE COST OF FUEL FOR AIR, TRUCK, RAIL, AND MARINE VESSELS. WHILE THE INCREASE IN THE PRICE OF ALL TYPES OF AVIATION FUEL HAS AVERAGED 3.31¢ PER GALLON OVER THE PAST THREE YEARS, THE PRICES OF NO. 2 DIESEL FUEL AND BUNKER "C" FUEL HAVE INCREASED ONLY 2.64¢ AND 1.55¢ PER GALLON, RESPECTIVELY.

Table 5.9. Cost of Fuel for Air, Truck, Railroad, and Marine Vessels, 1970 through 1977 (¢/gal)

	Aviation fuels			Truck No. 2 diesel fuel		Railroad fuel		Marine
	Aviation gasoline (retail)	Naphtha-type (retail)	Kerosene-type (retail)	Truck stops	Service stations	Diesel oil	Coal ($/net ton)	Bunker "C" (retail)
1970		11.02				10.73	6.00	
1971		11.60				10.88	10.68	
1972		11.59				10.97	10.69	
1973		12.56				13.49	12.40	
1974		21.79				26.59	12.93	
1975	41.13[a]	27.47	29.83[a]	51.05	51.67	30.00	16.90	24.6[a]
1976	43.12	31.54	31.17	52.08	52.93	32.38	23.22	24.8
1977	47.52	35.00	35.75	56.52	56.77	35.14		27.7
Average annual rate of change (1975–1977)	7.5	12.9	9.5	5.2	4.8	8.2		6.1

[a]Cost based on 6-month average.

Sources: J. Gaynor (ed.), Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, D.C., monthly; Association of American Railroads, Economics and Finance Department, *Statistics of Railroads of Class I in the United States: Years 1965 to 1976*, Washington, D.C., annual.

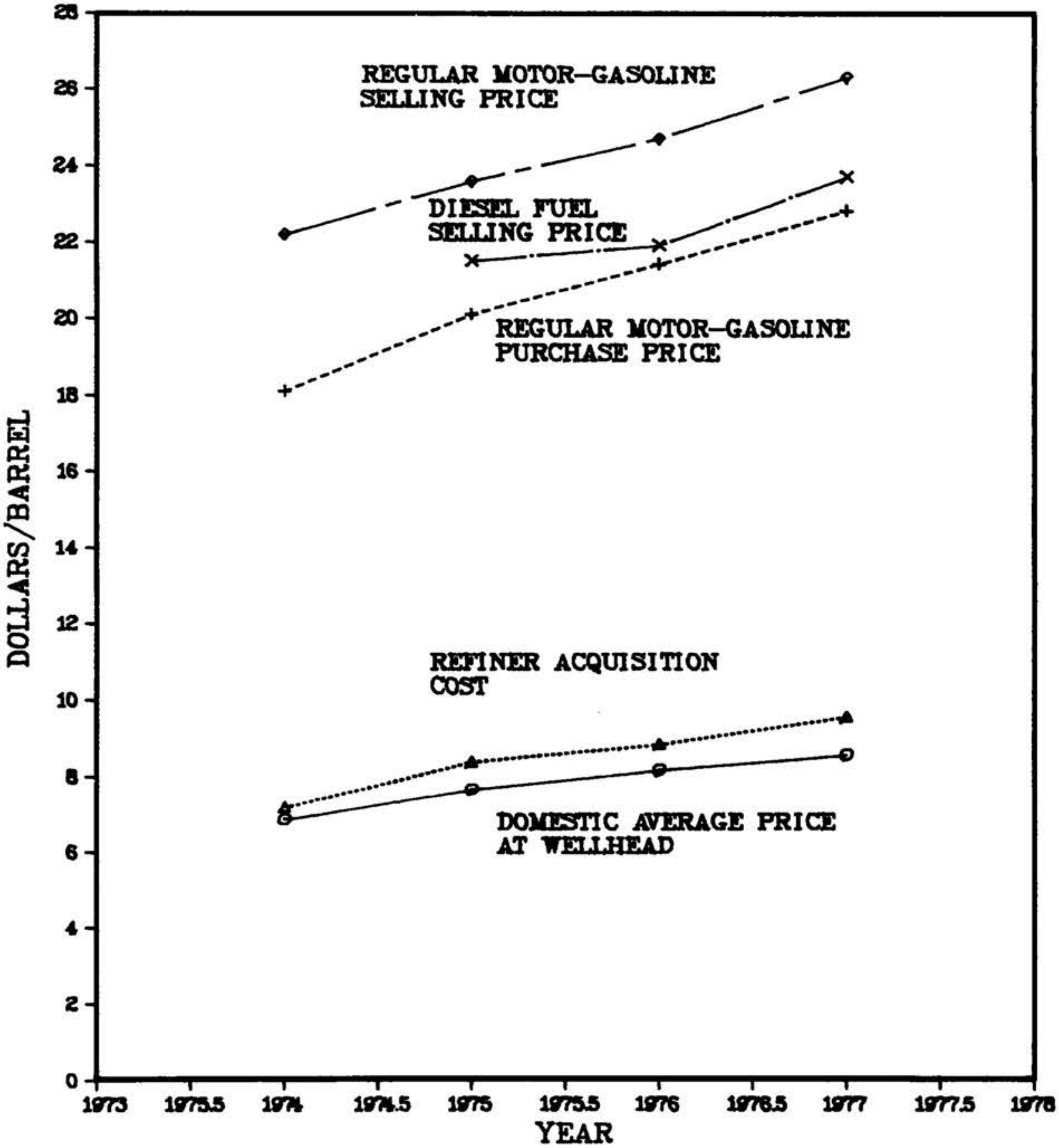

Fig. 5.9. Cost of Crude Oil from Well to Consumer,
1974 through 1977.

Source: J. Gaynor (ed.), Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, D.C., monthly.

DESPITE THE GRADUAL INCREASE IN THE PRICE FOR GASOLINE FROM 1975 THROUGH 1977, THE REAL (DEFLATED) PRICE HAS REMAINED FAIRLY CONSTANT. IN THE CASE OF REGULAR, SELF-SERVICE GASOLINE, THE REAL PRICE HAS ACTUALLY DECLINED 2.7¢ PER GALLON.

Table 5.10. Average Retail Prices for Motor Gasoline, 1973 through April 1978
(¢/gal)

	Regular				Premium				Unleaded				Implicit GNP price deflator
	Full service		Self service		Full service		Self service		Full service		Self service		
	Constant 1975	Current	Constant 1975	Current	Constant 1975	Current	Constant 1975	Current	Constant 1975	Current	Constant 1975	Current	
1973	46.9	39.0											83.21
1974	57.9	52.8											91.25
1975	56.2	56.2	55.1	55.1	60.9	60.9	NA	NA	59.8	59.8	NA	NA	100.00
1976	55.8	58.7	52.7	55.4	60.6	63.8	57.7	60.7	59.4	62.5	NA	NA	105.20
1977	56.2	62.6	52.2	58.2	61.1	68.1	58.1	64.7	59.6	66.4	57.1	63.6	111.37
1978													
January		61.7		57.2		67.7		63.5		65.8		61.6	
February		61.6		57.1		67.7		64.0		65.7		61.8	
March		61.7		57.0		68.0		63.9		65.8		61.8	
April		62.0		57.4		68.3		64.2		66.1		62.0	

NA — Not available.

Source: J. Gaynor (ed.), Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, D.C., April 1976, p. 54, July 1978, pp. 67-69.

FROM 1974 THROUGH 1977, HOME HEATING OIL AND MOTOR GASOLINE PRICES HAVE EXPERIENCED AN APPROXIMATE 0.1¢ PER GALLON INCREASE, WHILE THE PRICE OF DIESEL FUEL AND RESIDUAL FUEL HAS RISEN LESS SHARPLY.

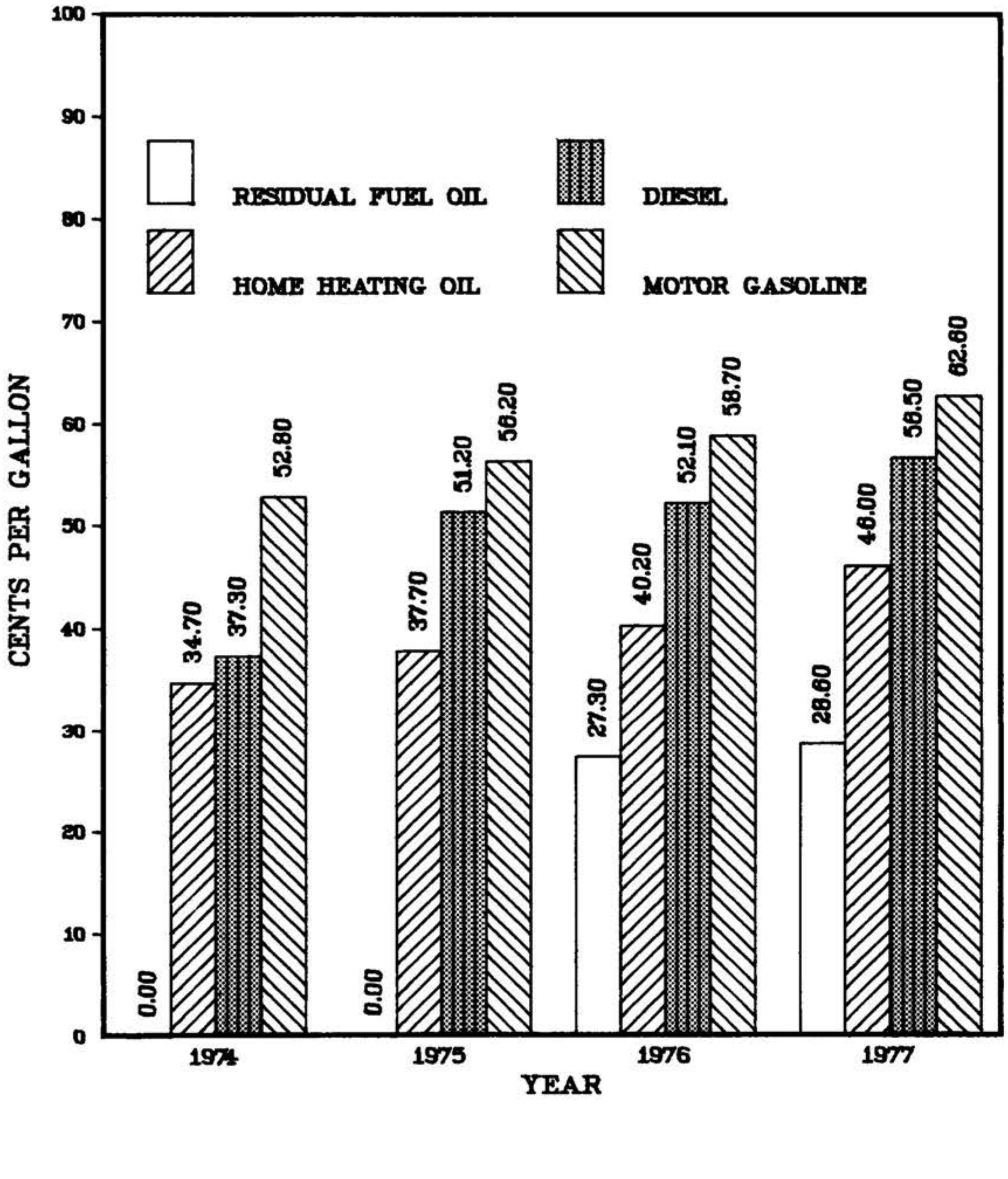

Fig. 5.10. Comparison of Cost of Residual Fuel Oil, Home Heating Oil, Diesel, and Gasoline.

Source: J. Gaynor (ed.), Department of Energy, Energy Information Administration, *Monthly Energy Review*, Washington, D.C., monthly.

While the average annual deflated price for energy items decreased from 1958 to 1973, events during 1973 and 1974 drastically changed energy price trends. From 1973 through 1976, following the rise in oil import prices, real costs of energy items increased sharply (6.2% annually). However, in 1976 and 1977 this trend gradually slowed, with the exception of natural gas. In the case of gasoline and motor oil, real costs actually fell 0.8%.

Table 5.11. Consumer Real Price Changes of Energy Items, 1958 to 1977

Consumer prices	Average annual percent change		
	1958 to 1973	1973 to 1976	1976 to 1977[a]
All energy	-0.8	6.2	2.9
Fuel oil and coal		12.9	6.1
Gasoline and motor oil	-1.0	5.1	-0.8
Natural gas	-0.4	7.1	11.6
Electricity	-1.2	3.5	0.1

[a]Changes for energy consumption and wholesale prices computed from third quarter 1976 to third quarter 1977. Other changes are from year to year.

Source: President of the United States, *Economic Report of the President Transmitted to Congress January 1978, Together with the Annual Report of the Council of Economic Advisers*, Washington, D.C., p. 181.

Section 5.4

Alternate Fuels

Alternate Fuels

At present, transportation in the United States is almost totally dependent on petroleum-based products. As discussed in Sect. 5.1 through Sect. 5.3, our domestic oil resources are diminishing. This fact, along with increased energy demand, has resulted in a continuing increase in the importation of crude oil and petroleum products. In recent years the United States has been importing more than 40% of its crude oil and petroleum products, which compares with about 25% of all energy imports of ten years ago. Not only has the rise in petroleum imports had a direct effect on U.S./world economic stability, it also creates a climate for price escalation by exporting countries.

Based on projections of world oil production (Fig. 5.11), the need to develop alternate fuels and fuel systems to meet future transportation energy needs has been recognized. This section provides a general summary of work funded by DOE in the development of alternate fuels. Cost considerations of alternate fuels and the timing and degree of penetration of alternate fuel products into the transportation sector are also discussed. The DOE has estimated that the time needed to develop, demonstrate, and produce (commercially) new fuels and fuel system designs ranges from ten years and up and that market penetration factors for the automobile/truck fleet may amount to another ten years. Therefore, the predicted peak in world oil production precedes the time anticipated for development and implementation of alternatives to petroleum-based transportation in the United States.*

Two feasibility studies[†] were conducted to determine the most logical alternatives to petroleum-based fuels for transportation. The

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*University of Miami and Escher Technology Associates, for Department of Energy, Transportation Energy Conservation Division, *Alternative Fuels and Intercity Trucking*, Alternative Fuels Utilization Program, Washington, D.C., June 1978, p. 289.

†F. H. Kant et al., *Feasibility Study of Alternative Fuels and Automotive Transportation*, U.S. Environmental Protection Agency Report EPA-460/3-74-009 (3 volumes) June 1974.

J. Pangborn and J. Gillis, *Alternative Fuels for Automotive Transportation — A Feasibility Study*, U.S. Environmental Protection Agency Report EPA-460/3-74-012 (3 volumes) July 1974.

candidate fuels were evaluated in terms of economic, technical, performance, and implementation criteria. These studies produced a list of alternative fuels and their penetration into the transportation sector divided into three time frames:

Near Term (1975–1985)

- Gasoline from oil shale or coal
- Distillates (diesel) oils from oil shale or coal
- Alcohol-gasoline blends

Mid Term (1985–2000)

- Gasoline from coal or oil shale
- Distillates from coal or oil shale
- Alcohol (methanol, ethanol) from coal

Far Term (Beyond 2000)

- Gasoline from coal or oil shale
- Distillate oils from coal or oil shale
- Methanol from coal
- Nuclear-based hydrogen fuel from water

These studies focused on fuels that could provide a major portion of our national fuel needs for which implementation is feasible on the national level. Therefore, fuels that could be derived from forest, agriculture, and municipal solid wastes, or from crops grown specifically for biomass conversion, do not appear in the summary. It has been noted elsewhere, however, that synthetic fuels from these and like sources could contribute significantly to local and regional transportation energy needs.

Based on studies conducted recently under the Alcohol Fuels Program,* DOE has determined that alcohols (primarily methanol) could play a major role in filling future transportation energy needs. In the short term, methanol can be produced from coal; but beyond the year 2000, it would be produced by conversion of energy crops and agricultural and municipal wastes. Ethanol is now being produced through the fermentation of sugar cane or grain. The DOE has estimated that it would be possible

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*Department of Energy, Office of the Under Secretary, Task Force on Fuels, *Alcohol Fuels Program Plan*, Alcohol Fuels Program, Washington, D.C., March 1978, pp. 1–5.

to build ten methanol-from-coal plants with a daily capacity of 6,000 tons by 1990. At this rate of production methanol could provide about 5% of the energy needed to meet projected transportation gasoline demand in the year 1990. Adding one new plant per year with the same capacity at a cost of $450–$500 million per plant, by 2000 methanol could supply about 8%–9% of the projected gasoline demand. On the other hand, ethanol production (based on 10–30 million gallons per year fermentation plants) would be able to supply less than 1% of the total 1985 liquid-fuels demand.

While it is generally acknowledged that alcohol from coal, and petroleum-like liquids from shale rock and coal, can provide a significant percentage of our transportation fuel by 2000, little hard data about the post-petroleum-era energy systems has been accumulated. Some alternatives do seem more feasible than others:*

- Hydrocarbon Synthetic Fuels — Synfuels from coal and oil shale; methanol produced from coal, biomass or biosolar conversion, and organic waste.
- Electricity — Generated from coal and nuclear power, and ultimately from geothermal and/or solar energy.
- Hydrogen — Producible from coal, biomass or biosolar conversion, organic waste, and from any electrical source including nuclear, geothermal, and solar energy systems by electrolysis of water.

The tables and graphics presented in this section represent findings from some of these DOE projects.

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*University of Miami and Escher Technology Associates, for Department of Energy, Transportation Energy Conservation Division, *Alternative Fuels and Intercity Trucking*, Alternative Fuels Utilization Program, Washington, D.C., June 1978.

THE CONCENTRATED EFFORT OF THE FEDERAL GOVERNMENT IN THE DEVELOPMENT OF ALTERNATIVE FUELS HAS BEEN DEMANDED BY THE LIMITED TIME BEFORE THE COMMERCIAL PRODUCTION AND USE OF SYNTHETIC FUELS WILL BE REQUIRED. FIGURE 5.11 ILLUSTRATES PROJECTED NEED FOR DESIGN OF ALTERNATE FUELS IN RELATION TO WORLD OIL PRODUCTION. THE PROJECTED AMOUNT OF TIME NEEDED FOR READY AVAILABILITY OF SYNTHETIC FUELS COINCIDES WITH PROJECTED PEAK OIL PRODUCTION.

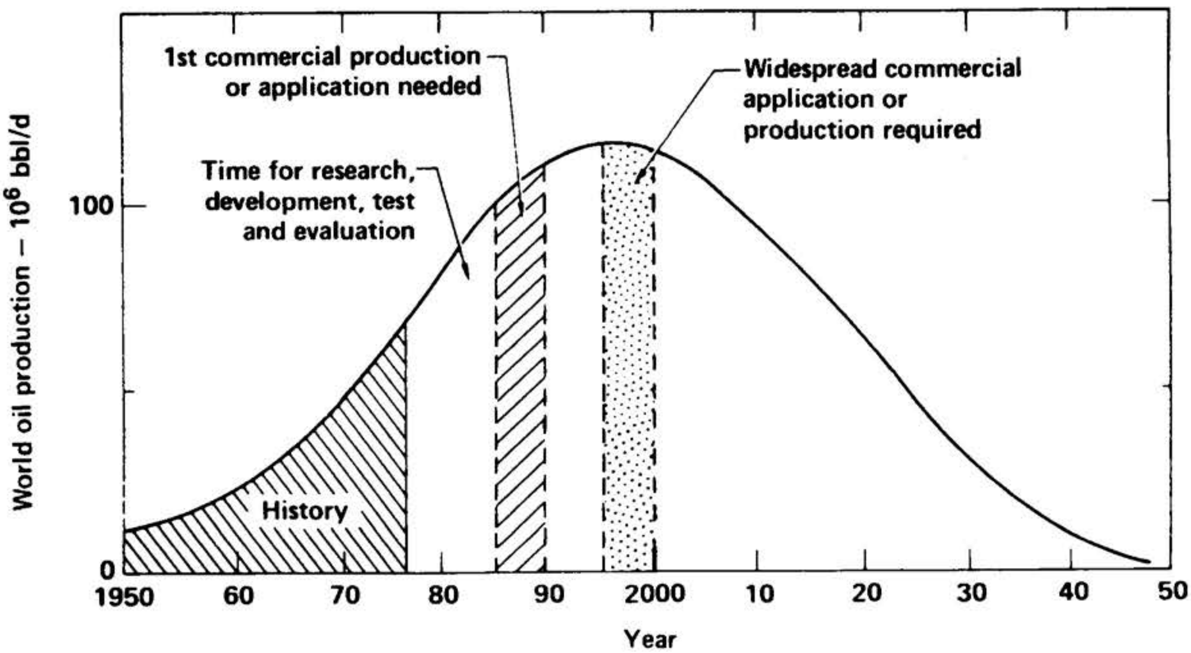


Fig. 5.11
Projected Need for Commercial Production and Use of Synthetic Fuels as a Function of World Oil Production.

Source: Department of Energy, Assistant Secretary for Conservation and Solar Applications, Transportation Energy Conservation Division, *Program Planning Document Highway Vehicle Alternative Fuels Utilization Program (AFUP)*, Alternative Fuels Utilization Program, Washington, D.C., April 1978, pp. 1–8.

ALTHOUGH SYNTHETIC CRUDES WILL REPRESENT AN INSIGNIFICANT PORTION OF THE LIQUID FUEL MARKET IN 1985, THEY COULD REPRESENT MORE THAN 5% OF THE LIQUID FUEL MARKET BY 1990. AT THIS LEVEL, SYNTHETIC CRUDES WOULD BEGIN TO HAVE A NOTICEABLE EFFECT ON THE SUPPLY OF TRANSPORTATION FUELS.

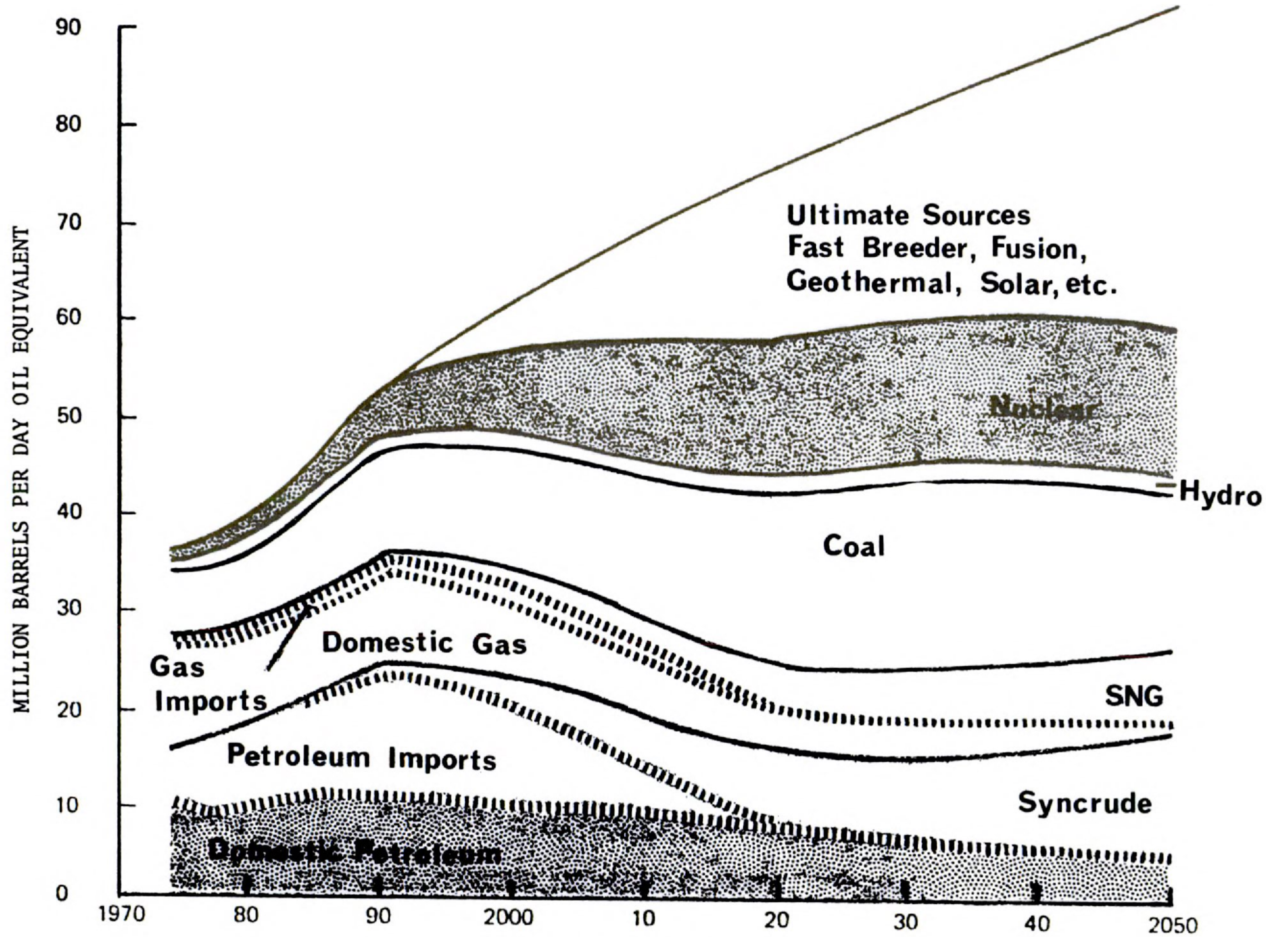
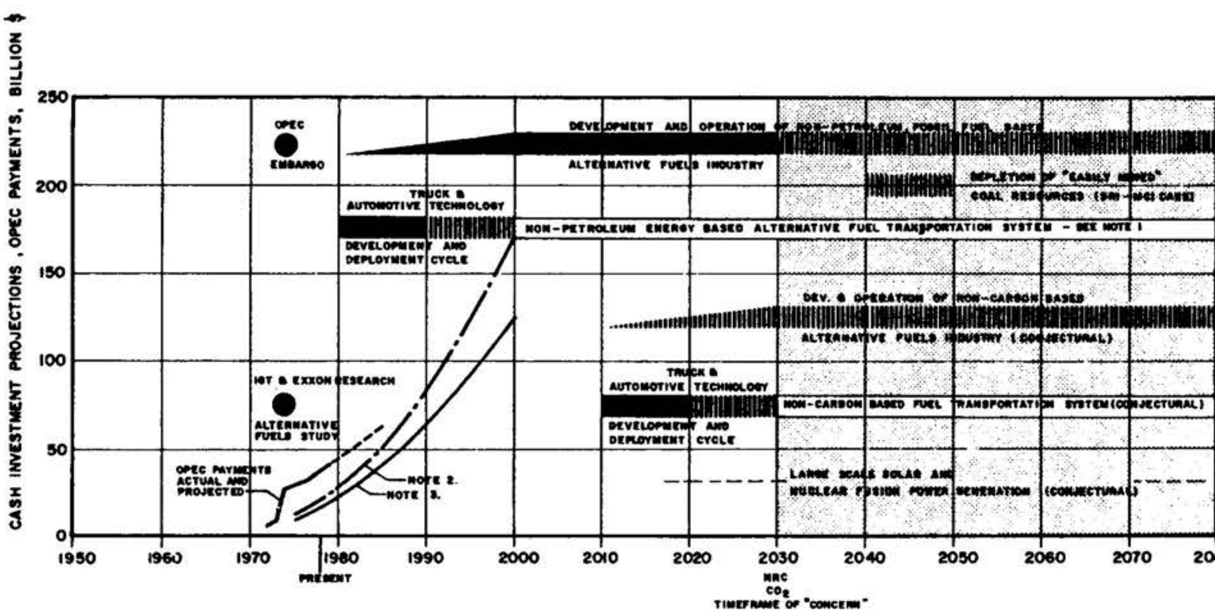


Fig. 5.12
U.S. Energy Supplies.

Source: R. F. Wilson and W. T. Tierney, Texaco Inc., *Future Transportation Fuels — Optimization of the Vehicle-Fuel-Refinery System*, presented at the American Petroleum Institute 41st Midyear Meeting, Refining Division, Los Angeles, Calif., May 10–13, 1975.

5-39

THE FIGURE BELOW, THOUGH PARTLY CONJECTURAL, ILLUSTRATES THE TECHNOLOGICAL-DEVELOPMENT AND FUELS-DEVELOPMENT CYCLES IN RELATIONSHIP TO THE PROJECTED TIME FRAME FOR SIGNIFICANT RELIANCE ON SYNTHETIC, NONPETROLEUM-BASED FUELS. WHILE COAL- AND OIL-SHALE-BASED SYNTHETIC FUELS ARE EXPECTED TO CONTRIBUTE SIGNIFICANTLY TO FUTURE TRANSPORTATION ENERGY SUPPLIES, THE QUESTIONS OF THE TIME AND EXTENT OF THIS CONTRIBUTION IN TERMS OF MEETING AUTOMOTIVE AND TRUCK DEMAND REMAIN UNANSWERED. THE DEVELOPMENT OF ALTERNATE FUELS AND ENGINE- AND FUEL-SYSTEMS ARE THEREFORE CONCERNS OF VERY HIGH PR'ORITY IN ENERGY PLANNING. THE PROPOSED TIME FRAME FOR ACCOMPLISHMENT OF THESE OBJECTIVES IS 1990-2000.



Note 1: If coal and oil shale systems can be brought on line on sufficient scale to provide a more than adequate supply of transportation fuels, and if these fuels are in forms similar to present day gasoline and diesel fuels, no significant technology development or deployment would be required in the trucking/automotive industry. This is the future preferred by the original equipment manufacturers and users. This future scenario is not assured.

Note 2: SRI projected fuels industry investment, at 5% inflation rate, required to sustain the conventional fuels industry and develop the synthetic fuels from coal and oil shale industry.

Note 3: SRI projected fuels industry investment, at 5% inflation rate, required to sustain the conventional fuels industry.

Fig. 5.13
A Concept of the Long-Term Energy Future of Transportation Fuel Demands, Needs, and Technological Development.

Source: University of Miami and Escher Technology Associates, for Department of Energy, Transportation Energy Conservation Division, *Alternative Fuels and Intercity Trucking*, Alternative Fuels Utilization Program, Washington, D.C., June 1978, Fig. 10-1, p. 296.

TABLE 5.12 SUMMARIZES THE CONVERSION EFFICIENCIES, COSTS, AND POTENTIAL AVAILABILITY OF CONVERTED LIQUID FUELS. FEW DIRECT COMPARISONS HAVE BEEN MADE OF THE PROCESSES AND PRODUCTS LISTED BELOW. IT IS APPARENT THAT COAL IS THE ONLY RESOURCE THAT EXISTS IN SUFFICIENT QUANTITIES TO SUPPLY THE TOTAL LIQUID FUELS REQUIREMENT VIA ALCOHOL. BIOMASS AND MUNICIPAL SOLID WASTE, ALTHOUGH LIMITED, COULD PROVIDE FUELS TO SUPPLY LOCAL, OR POSSIBLY REGIONAL, NEEDS. THE LIMITING FACTOR IN TERMS OF BOTH ECONOMICS AND OUTPUT IS THE AVAILABILITY OF CONVERSION PLANTS.

Table 5.12
Liquid Fuel Conversion Efficiencies, Costs[a] and Potential Availability, 1976—2000

Resource	Resource cost (delivered)	Principal conversion process	Fuel product	Overall process conversion efficiency	Estimated fuel cost at plant gate		Percent 1976 liquid fuels demand[b] potentially supplied (31×10^{15} Btu)	Percent 2000 liquid fuels demand[b] potentially supplied ($32\text{-}46 \times 10^{15}$ Btu)[c]
					$/gal	$/$10^6$ Btu		
Coal	$18-22/ton	Via synthesis gas	Methanol	0.50-0.60	0.30-0.50	5.3-8.8	100	100
Biomass								
Farm crops and residues	$65-400/ton	Fermentation	Ethanol	NA	1.00-1.30	13.2-17.1	<1.0-8.0	
Standing forest	$12-17/ton	Via synthesis gas	Methanol	0.48-0.68	0.35-0.50	6.2-8.8	<1.0-1.0	
Forest crops and residues	$2-28/ton	Via synthesis gas	Methanol	0.48-0.68	0.35-0.57	6.2-10.0	<1.0-5.0	
Terrestrial energy farms	$21-33/ton	Via synthesis gas	Methanol	0.48-0.68	0.40-0.71	7.0-12.5	<1.0-19.0	
							Total 2.0-33.0	25-33
Municipal solid waste	Up to $30/ton[d]	Via synthesis gas	Methanol	0.25-0.40	0.60-1.09	10.6-19.2	2.0-3.0	4.0-5.0
Reference bases								
Natural gas	$1-2.5/mSCF	Via synthesis gas	Methanol	0.61-0.91	0.17-0.44[e]	3.0-7.0	<1.0	<1.0
Petroleum	$9-14/bbl	Cracking	Gasoline	0.85-0.96	0.36-0.40[e]	3.1-3.5	44.0 (actual)	NA
Coal syncrude	$23-27/bbl	Liquefaction	Synthetic gasoline	0.55-0.68	0.60-0.78[e]	5.2-6.8	100	100
Shale oil	$17-22/bbl	Retorting	Synthetic distillate	NA	0.40-0.50	3.2-3.9		
Petroleum	$9-14/bbl	Ethylene hydration	Ethanol	0.85-0.96	1.23-1.30[e]	16.3-17.2	<1.0	<1.0
Petroleum	$9-14/bbl	Cracking	Distillate	0.85-0.96	0.30-0.38[e]	2.4-3.0	NA	NA
Methanol from coal	$0.30-0.50/gal	Catalysis	Synthetic gasoline	0.56-0.65	0.74-1.35	6.40-11.7	100	100

[a]Constant 1977 dollars at time technology is ready for commercialization (which varies with feedstock/process).

[b]Based only on known currently available plus potentially available resource quantities (does not consider capabilities for conversion facilities).

[c]Depends on degree of conservation achieved.

[d]In the process of Municipal Solid Waste to reclaim energy (either liquid or gaseous forms) the collection costs can actually be considered as a "negative cost" (i.e., cost benefit) since collection of Municipal Solid Waste must be performed whether or not it is used for energy purposes.

[e]Current market prices. Other prices are estimates based on various studies/analyses.

NA — Not available.

Source: Department of Energy, Office of the Under Secretary, Task Force on Fuels, *Alcohol Fuels Program Plan*, Alcohol Fuels Program, Washington, D.C., March 1978, Table 3-1, A-1, p. 3-3, A-3.

COAL RESOURCES IN THE UNITED STATES ARE EXTENSIVE, HOWEVER DEPOSITS VARY GREATLY WITH RESPECT TO CHEMICAL COMPOSITION AND COSTS OF EXTRACTION AND TRANSPORT. WHILE SYNTHETIC FUELS FROM COAL HAVE BEEN IDENTIFIED AS FEASIBLE ALTERNATIVE TRANSPORTATION FUELS, THE ABOVE FACTORS MAY AFFECT THE TIMING AND DEGREE OF THEIR PENETRATION INTO THE TRANSPORTATION SECTOR.

Table 5.13
Estimated U.S. Coal Resources
(10^6 tons)

	Total identified coal resources January 1, 1972	Total reserve base January 1, 1974	Economically recoverable reserves January 1, 1974
Bituminous	686,033	232,897	61,503
Subbituminous	424,073	165,460	47,606
Lignite	449,519	28,197	7,470
Anthracite	21,362	7,384	1,824
Appalachian		113,283	29,836
Midwest		108,023	28,814
West		212,632	59,753
Total	1,580,987	433,938	118,403

Source: Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, Table 1.2, p. 195.

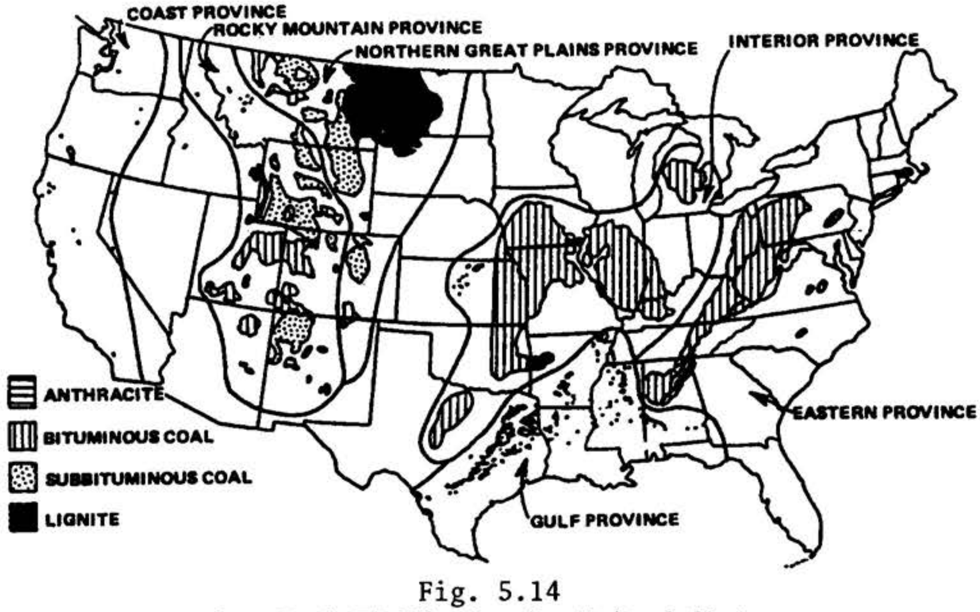


Fig. 5.14
Major Coal Fields in the United States

THE NUMBER OF LIQUEFICATION PROCESSES LISTED IN TABLE 5.14 GIVES AN INDICATION OF THE EXTENT OF THE INTEREST IN THE DEVELOPMENT OF COAL CONVERSION SYSTEMS TO PRODUCE FUEL FORMS SUITABLE FOR USE IN THE TRANSPORTATION SECTOR. THE PRODUCTS OF THESE PROCESSES VARY SIGNIFICANTLY AS TO FORM AND CHEMICAL COMPOSITION. HOWEVER THE TYPICAL PRODUCT IS A PETROLEUM-LIKE LIQUID WHICH CAN BE PROCESSED THROUGH EXISTING REFINERIES TO YIELD HYDROCARBON FUELS. CURRENTLY, THE FISCHER-TROPSCH AND THE LURGI-RUHRGAS PROCESSES ARE THE MOST ADVANCED.

Table 5.14
Current Major Coal Liquefication Processes by Type of System

Technique	Max size demonstrated (tpd)	Status
Pyrolysis		
Coed	36 tpd	Dismantled
Toscoal	25 tpd	Inactive
Garrett	4 tpd	Active
Lurgi-Ruhrgas	850 tpd	Commercial
Cleancoke	1/4 tpd	100 tpd pilot plant designed
Solvent Hydrogenation		
SRC	50 tpd	NA
H-Coal	3 tpd	600 tpd plant under construction
Synthoil	1/2 tpd	10 tpd unit under construction
Exxon Donor	1/2 tpd	200 tpd plant being designed
Consol	20 tpd	Being renovated
Bergius	1000 tpd	NA
Pott-Broche	NA	NA
Hydrocarbonization		
Coal Con	10 tpd	2600 tpd demonstration planned
Cities Service	2 (lb/hr)	Laboratory development
Rocket dyne	1 (ton/hr)	Laboratory development
Cuny	NA	Laboratory development
Indirect Liquification		
Fischer-Tropsch	NA	Commercial

NA — Not available.

Source: Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, pp. 70–73.

METHANOL FROM COAL IS CONSIDERED ONE OF THE LEADING ALTERNATE FUEL CANDIDATES BECAUSE IT CAN BE BLENDED WITH AUTOMOTIVE GASOLINE AND USED TO AUGMENT FUEL SUPPLIES. BY 1990, METHANOL FROM COAL COULD ACCOUNT FOR 5% OF THE ENERGY NEEDED FOR PROJECTED TRANSPORTATION GASOLINE DEMAND.

Table 5.15
Current Major Coal Gasification Processes Capable of Yielding Synthesis Gas Suitable for Methanol Manufacturing

Process	Maximum size demonstrated	Current status
High Btu gas		
Chevron gasification	NA	Development details not available
Medium Btu gas		
Agglomerating	Bench scale	25 ton/day demonstration plant almost complete
Patgas		30-40 min. runs only
Bianchi	NA	Pilot plant in France
Bi-Gas	100 lb/hr	120 ton/day pilot plant under construction
CO_2 acceptor	30 ton/day	Designing commercial plant
Electrofluidic	12 in. diam. reactor pilot plant	
Exxon Gasification	0.5 ton/day	500 ton/day plant planned
Garrett's Coal Gasification	3.6 ton/day	250 ton/day plant planned
G.E. Gas	50 lb/hr	
Koppers-Totzek	16 commercial plants[a]	
Lurgi Pressure Gasification	14 commercial plants[a]	U.S. plants are under construction and in operation
Molten Salt Kellog	NA	Experimental
Sun Gasification	NA	Experimental
Synthane	4 in. diam. reactor pilot plant	75 ton/day pilot plant under construction
Two-Staged Fluidized Gasification	Several models	Pilot plant designed
Texaco	10 ton/day pilot unit	200 ton/day plant being refitted in Germany
Low Btu gas		
Wellman-Galusha	Commercial	2 plants in U.S.A.
Winkler	Commercial	Being considered for installation in U.S.A.

NA — Not available.

[a]Outside continental United States.

Source: Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, Table B.10, p. 152.

Figure 5.15 illustrates that a 50% reduction in coal resource requirements is attainable through increasing coal conversion efficiences from 35% to 55% and increasing relative engine efficiencies of transportation vehicles using liquefied coal or coal products from 100% to 130%. The first goal (increasing coal conversion efficiencies) is being reached by utilization of the H-Coal (solvent hydrogenation) process; the second (increasing relative engine efficiencies) has been adopted as a priority project by the Department of Energy's Transportation Energy Conservation Division. Figure 5.15 is based on a normalized thermal efficiency of 35% of the present SASOL* plant and an Otto engine at relative efficiency of 100.

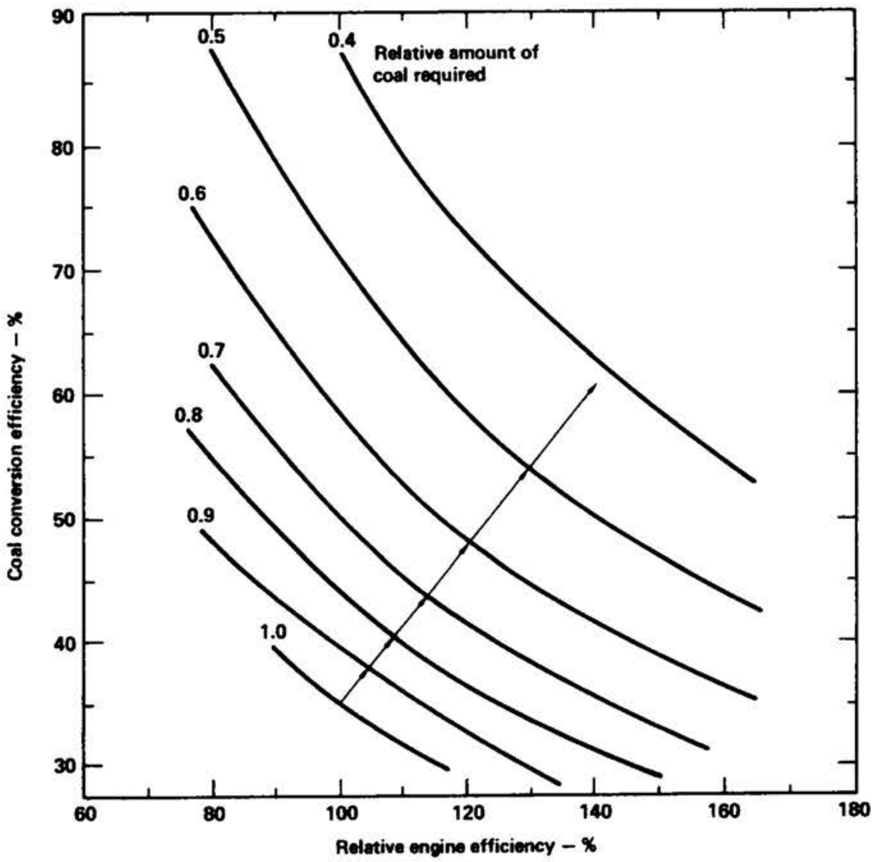


Fig. 5.15
Relative Resource Requirements for Fuel/Engine Systems Based on Coal Liquids.

Source: Department of Energy, Assistant Secretary for Conservation and Solar Applications, Transportation Energy Conservation Division, *Program Planning Document Highway Vehicle Alternative Fuels Utilization Program (AFUP)*, Alternative Fuels Utilization Program, Washington, D.C., April 1978, Fig. 4.2, p. 4-7.

*SASOL – South African Coal, Oil and Gas Corporation.

THE LOCATIONS OF MAJOR U.S. OIL SHALE DEPOSITS ARE SHOWN IN FIG. 5.16. THE VAST MAJORITY OF THE HIGH-GRADE DEPOSITS OF OIL SHALE IN THE UNITED STATES ARE FOUND IN THE GREEN RIVER FORMATION LOCATED IN WYOMING, COLORADO, AND UTAH. GASOLINE AND DISTILLATE OILS PRODUCED FROM OIL SHALE ARE LIKELY TO BECOME AVAILABLE BEFORE 1985, BUT ARE NOT LIKELY TO HAVE A SIGNIFICANT IMPACT ON TRANSPORTATION ENERGY USE UNTIL THE POST-1985 PERIOD.

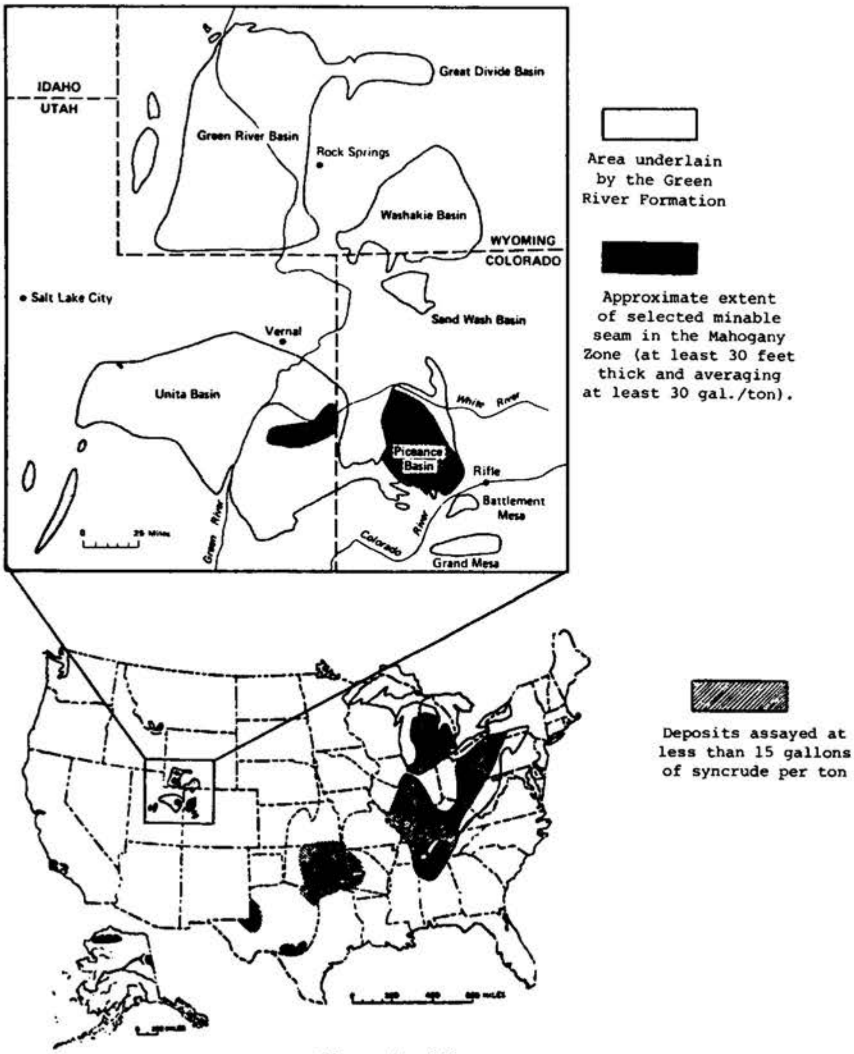


Fig. 5.16
Principle Oil Shale Deposits in the U.S.

Sources: University of Miami and Escher Technology Associates, for Department of Energy, Transportation Energy Conservation Division, *Alternative Fuels and Intercity Trucking*, Alternative Fuels Utilization Program, Washington, D.C., June 1978, Fig. 8-9, p. 184; Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, Fig. 1-4, p. 197.

Known worldwide deposits of oil shale are numerous; however, a great deal of uncertainty exists regarding estimates of in-place reserves. Differences in the composition of various shales and the preliminary nature of exploration efforts account for the questionable reliability of these estimates. Table 5.16 shows that known reserves of oil shale have been estimated at 334×10^{10} bbl with almost 75% of all reserves occurring the United States. The U.S. Bureau of Mines has estimated the total reserve at 2200×10^9 bbl while the National Petroleum Council maintains a slightly lower estimate of 2000×10^9 bbl.

Table 5.16
Major Oil Shale Deposits by Country, 1978

Country	Estimated total oil in place (10^9 bbl)	Thickness (ft)	Estimated U.S. gallons per short ton
Australia	0.27	0-88	13-100
Brazil	800.0	60-328	13-20
Balkans and Central Europe	0.34		
Canada	50.0	200	25
China	28.1	450	15
Congo	100.0	30	25
France	0.425	3-50	10-27
Germany (West)	2.0	16	12
Great Britain			
Israel	0.2	0-140	12
Italy	35.0	16	25
Luxembourg	0.7		
New Zealand	0.56	5	50
Republic of South Africa	0.13	3	48
Spain	0.28	14	30-35
Sweden	2.5	50	15
Thailand and Burma	2.8	20	25-70
United States	2200.0		
Piceance Basin, Colorado		1940	10-65
Uinta Basin, Utah		700	10-65
Green River Basin, Wyoming		15-80	10-65
Brooks Range, Alaska		4	130
Indiana, Kentucky		0-400	10
U.S.S.R.	115		
Total	3,340		

Source: Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, Table 1-4, p. 198.

DESPITE THE NUMBER OF SHALE CONVERSION PROCESSES, NO ONE PROCESS HAS BEEN SHOWN TO BE BEST FOR THE PRODUCTION OF TRANSPORTATION FUELS. IT IS LIKELY THAT A COMBINATION OF RETORTING PROCESSES WOULD BE MOST EFFICIENT IN THE PRODUCTION OF TRANSPORTATION FUEL.

AT PRESENT, LITTLE PROGRESS IS BEING MADE IN THE UNITED STATES IN RETORT AND IN SITU PROCESS DESIGN. ONLY THE PARAHO PLANT IS OPERATING ON A LARGE SCALE, ALTHOUGH THE TOSCO II AND UNION DESIGNS SHOW CONSIDERABLE PROMISE. FOREIGN PROCESSES AVAILABLE ON AN EQUAL OR LARGER SCALE ARE THE LURGI-RUHRGAS, RUSSIAN, AND PETROSIX PROCESSES.

Table 5.17
Current Shale Conversion Processes by Type of System, Demonstrated Size, and Current Status

Technique	Max demonstrated size (tpd)	Current status
Retorting		
N-T-U	150	Active
USBM Gas Combustion	500 ($lb/hr/ft^2$)	Inactive
Texaco Hydrotorting	NA	Laboratory development
Union A	1,200	Inactive
Union B	10,000	10,000 tpd demonstration plant planned
Tosco II	1,000	Active
Lurgi-Rhurgas	12	4,000 tpd demonstration plant planned
Petrosix	2,500	Active
Paraho Direct and Indirect	450	13,000 tpd commercial plant planned
Superior Oil	480	Pilot plant under construction
USSR Kiviter	1,102	1,102 tpd plant under construction[a]
USSR Galotec	3,600	3,306 tpd plant under construction[a]
In-situ		
USBM		Active — field experiments
Sinclair		Inactive — field experiments ended in 1966
Equity		Inactive — field experiments ended in 1971
Shell		Inactive — field experiments ended in 1972
Dow		Active — recently proposed (to DOE) 7 yr $42 × 10^5$ project
Nuclear		Inactive — experimental work ended in 1968
Occidental-modified		Active — commercial operations under development
Geokinetics		Active — field experiments
Lawrence Livermore		Inactive — experimental plans never approved

[a]Several smaller plants are in operation. The largest Galoter in operation has a capacity of 551 tons per day while the largest Kiviter operates at a capacity of 275 tons per day.

Source: Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, pp. 28–56.

FIGURE 5.17 PRESENTS DATA SHOWING THE SAVINGS IN OIL SHALE RESOURCES ASSOCIATED WITH IMPROVED EFFICIENCIES OF BOTH CONVERSION PROCESSES AND ENGINE DESIGN.

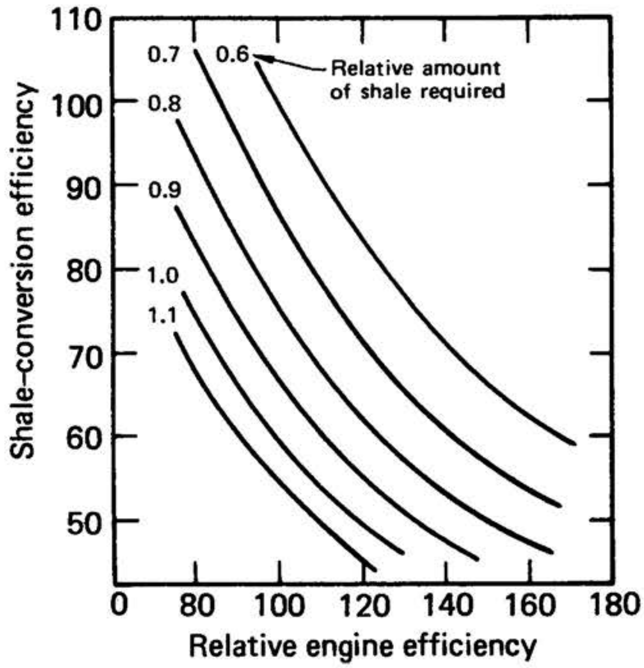


Fig. 5.17
Relative Amounts of Oil Shale Required for Various Fuel/Engine System Efficiencies.[a]

[a]This figure is based data normalized to TOSCO II technology plus the Otto engine.

Source: C. J. Anderson, Lawrence Livermore Laboratory, *Alternative Fuels for Transportation: Implications of the Broadcut Option*, University of California, Livermore, Calif., July 11, 1977, p. 8.

THE ULTIMATE POTENTIAL OF TAR SANDS AS A PETROLEUM SUBSTITUTE IS MUCH LOWER THAN THAT OF COAL OR SHALE. ESTIMATES OF ULTIMATE RESERVES INDICATE THAT THE TAR SAND POTENTIAL IS ONLY APPROXIMATELY 2% THAT OF COAL AND 8% THAT OF OIL SHALE. TAR SANDS HAVE A LOWER POTENTIAL THAN THAT OF PETROLEUM CRUDE. AS SEEN IN THE TABLE BELOW, THE MAJORITY OF TAR SAND DEPOSITS ARE LOCATED IN CANADA (APPROXIMATELY 80%) AND VENEZUELA (APPROXIMATELY 20%).

Table 5.18
Tar Sand Reserves

Location	In-place reserves (10^6 bbl)
Canada	711,000
Venezuela	200,000
Madagascar	1,800
U.S.A.	2,100
Albania	400
Rumania	25
U.S.S.R.	25

Source: W. F. Taylor and H. J. Hall, Exxon Research and Engineering Company, *Future Synthetic Fuels*, U.S. Department of the Army, Washington, D.C., September 1975, p. 56.

THE COMPATIBILITY OF TAR SAND CRUDE WITH PRESENT PETROLEUM TECHNOLOGY IS BETTER THAN THAT OF SHALE-ROCK- OR COAL-DERIVED CRUDES. THE TECHNOLOGY AVAILABLE TO PROCESS HEAVY PETROLEUM CRUDE OIL CAN BE USED TO PROCESS TAR-SAND-DERIVED CRUDE.

COST IS DIRECTLY RELATED TO THE TIMING AND DEGREE OF PENETRATION OF ALTERNATE FUELS INTO THE TRANSPORTATION SECTOR. AS THE PRICE OF PETROLEUM-BASED PRODUCTS INCREASES, ALTERNATE FUELS FROM BIOMASS CONVERSION PROCESSES WILL BECOME INCREASINGLY COMPETITIVE. CURRENTLY, ETHANOL PRODUCTS ARE THE MOST EXPENSIVE, WHILE OIL PRODUCTS FROM SOLID WASTE, COAL, AND OIL SHALE ARE LEAST EXPENSIVE. THE COST OF ETHANOL FROM VARIOUS PROCESSES FALLS BETWEEN THE COSTS FROM OIL PRODUCTS AND ETHANOL.

Table 5.19
Costs of Biosolar Liquid Synfuels for Transportation

Product	Source	Process	$/10^6 Btu	$/bbl, c.o.e.[a]	Source
Methanol	Tree crop	Pyrolysis/ synthesis	5.20	30	American Energy Research Company, 1976
Methanol	Municipal solid waste	Pyrolysis/ synthesis	6.45	38	American Energy Research Company, 1976
Methanol	Municipal solid waste	Pyrolysis/ synthesis	5.91	34	Mitre Corporation, 1975
Methanol	Coal	Various surface	2.91-5.11	17-30	Lawrence Livermore Laboratory, 1976
Methanol	Air/water	D-T fusion	1.65-12.96	10-75	Brookhaven National Laboratory, 1975
Methanol	Steel production	By-product	2.81	16	Mitre Corporation, 1975
Methanol	Coal	In situ gasification	2.68	16	Lawrence Livermore Laboratory, 1975
Ethanol	Corn @ $2/bu	Fermentation	12.50	72	American Energy Research Company, 1976
Ethanol	Corn @ $1/bu	Fermentation	8.99	52	Mitre Corporation, 1975
Ethanol	Municipal solid waste	Acid hydrolysis	9.56-19.67	56-114	Mitre Corporation, 1975
Ethanol	Waste paper	Enzymatic hydrolysis	8.87	51	Mitre Corporation, 1975
Ethanol	Cellulosic waste	Enzymatic hydrolysis	11.00-24.30	66-141	Food Sciences Laboratory, USA Natick R&D, 1975
Ethanol	Free waste sugar	Fermentation	1.80	10	D. L. Miller in *Cellulose as a Chemical and Energy Resource*, 1975
Ethanol	Sugar cane	Fermentation of sucrose	12.60	73	Lawrence Livermore Laboratory, 1976
Oil	Material solid waste	Pyrolysis	3.70	22	C. S. Finney and D. E. Garrett, in *Energy Sources 1* 1975; and H. W. Schulz in *Professional Engineer 45*, 1975
Gasoline	Material solid waste	Pyrolysis	4.72	25	G. D. Smith et al., *Symposium on Alternate Fuel Resources*, 1976
Gasoline	Petroleum	35¢/gal at refinery	2.77	16	Mitre Corporation, 1975
Oil	Shale	Gas combustion retorting	2.03	12	Lawrence Livermore Laboratory, 1976
Oil	Coal	Various surface	2.98	17	Lawrence Livermore Laboratory, 1976

[a]c.o.e. — crude oil equivalent.

Source: Carl J. Anderson, Lawrence Livermore Laboratory, for Department of Energy, *Biosolar Synfuels for Transportation*, University of California, Livermore, Calif., January 17, 1977, Table 1, pp. 5–6.

A WIDE RANGE OF ESTIMATES EXISTS CONCERNING THE POTENTIAL CONTRIBUTION OF BIOSOLAR SYNTHETIC FUELS IN MEETING OUR NATION'S ENERGY NEEDS. A REASONABLE CONCLUSION FROM TABLE 5.21 IS THAT WHILE FUELS FROM THESE SOURCES COULD CONTRIBUTE TO OUR TRANSPORTATION ENERGY NEEDS, THEY ARE INSUFFICIENT SOURCES IN AND OF THEMSELVES. THIS IS TRUE EVEN THOUGH BY THE YEAR 2000 THE PROJECTED ENERGY RECOVERABLE FROM WASTE WILL INCREASE SUBSTANTIALLY, ASSUMING INCREASED WASTE AVAILABILITIES AND CONVERSION EFFICIENCIES.

Table 5.20
Projected Energy Recoverable for Transportation from Waste in Year 2000

	Gross amount (10^6 tons/year)	Fraction potentially recoverable	Conversion factor (tons/ton)	Potential quads producible[a]
Agriculture waste	700-820	0.4	0.3	1.44-2.28
Feedlot residue	133	0.7	0.3	0.48-0.64
Municipal solid waste	200-227	0.7	0.2	0.48-0.73

[a]Based on conversion of lower gross quantity to methanol and higher quantity to ethanol. A quad is 10^{15} Btu.

Source: Carl J. Anderson, Lawrence Livermore Laboratory, for Department of Energy, *Biosolar Synfuels for Transportation*, University of California, Livermore, Calif., January 17, 1977, Table 5, p. 9.

Table 5.21
Magnitude of Biosolar Synthetic Fuels Available for Transportation, 1975

Total U.S.	Conversion process and product	Available amount (10^6 tons/yr)	Fraction potentially recoverable	Conversion factor (ton/ton)	Potential energy produced (10^{15} Btu)	% of U.S. energy demand	Source
Grain crop	Ethanol by fermentation	246	1.0	0.28	1.6	12	American Energy Research Co., 1976
Agriculture waste	Methanol by pyrolysis	640-3000	0.1	0.3	0.32-1.5	3-12	American Energy Research Co., 1976
		360	0.1	0.3	0.18	1.7	A. Poole, in *The Energy Conservation Papers*, R. H. Williams (ed), 1975
Feedlot residue	Methanol by pyrolysis	47	0.7	0.3	0.17	1.7	A. Poole, in *The Energy Conservation Papers*, R. H. Williams (ed), 1975
Municipal solid waste	Methanol by pyrolysis	140	0.7	0.2	0.3	3	American Energy Research Co., 1976
		87	0.7	0.2	0.2	2	A. Poole, in *The Energy Conservation Papers*, R. H. Williams (ed), 1975
Forest waste	Methanol by pyrolysis	130	0.5	0.3	0.3	3	American Energy Research Co., 1976
All organic waste	Oil by pyrolysis	880	0.15	0.28	1	8	D. L. Klass, in *Proceedings, Clean Fuels from Biomass, Sewage, Urban Refuse, and Agricultural Wastes, Jan. 27-30, 1976*

Source: Carl J. Anderson, Lawrence Livermore Laboratory, for Department of Energy, *Biosolar Synfuels for Transportation*, University of California, Livermore, Calif., January 17, 1977, Table 3, p. 8.

METHANOL HAS BEEN IDENTIFIED AS A PROBABLE ALTERNATE FUEL FOR THE TRANSPORTATION SECTOR. TABLE 5.22 INDICATES THAT THE COST OF PRODUCING METHANOL IS VARIABLE AND THAT THE PRODUCTION FROM MUNICIPAL SOLID WASTE IS CURRENTLY THE MORE EXPENSIVE METHOD.

Table 5.22
Comparison of Methanol Production Costs from Various Studies Using Gasification Processes

	AEC[a]	ORNL[b]	AEC[a]	Seattle[c]	Dupont[d]
Energy output, tpd (Btu)	5000 (1×10^{11})	12,500 (2.5×10^{11})	5000 (1×10^{11})	300 (5.6×10^{9})	5000 (1×10^{11})
Gasification process	Koppers-Totzek		Winkler	Purox(pyrolysis)	Texaco
Input Fuel tpd (Btu)	9900 (2.1×10^{11})	14,900 (3.7×10^{11})	13,700 (2.37×10^{11})	1500 (15×10^{9})	8430
	East. bituminous coal 21.3×10^{6} Btu/ton	East. bituminous coal 25×10^{6} Btu/ton	West. Sub-bituminous coal 17.2×10^{6} Btu/ton	Municipal solid waste 5000 Btu/ton	High sulfur East. bituminous coal
Thermal efficiency, %	46	60-67	41	38	51.5
Total cost[e] per 10^{6} Btu output	\$2.57	\$1.57-1.72	\$2.15	\$6.54	\$10.00[f]

[a]Atomic Energy Commission.

[b]Oak Ridge National Laboratory.

[c]City of Seattle, Washington.

[d]Dupont Chemical Corporation.

[e]Total costs include capital investments, operating costs, and input fuel costs.

[f]Study based on a plant scheduled for startup in 1983. With low interest financing guaranteed by the federal government, costs could be reduced to \$7.63/10^{6} Btu.

Source: Southwest Research Institute, for Department of Energy, Transportation Energy Conservation Division, *Identification of Probable Automotive Fuels Composition: 1985–2000*, Alternate Fuels Utilization Program, Washington, D.C., May 1978, Table 4, p. 170.

TABLES 5.23 AND 5.24 PROVIDE SUMMARY DATA ON HEALTH AND SAFETY ASSESSMENTS OF ALCOHOL FUELS. WHILE FEW TESTS HAVE BEEN RUN ON VARIOUS ALCOHOL/GASOLINE BLENDS, TOXICITY RATINGS AND COMBUSTION LEVELS ARE AVAILABLE FOR NEAT ETHANOL AND METHANOL. LIKE GASOLINE, BOTH METHANOL AND ETHANOL POSE POTENTIAL EXPLOSION AND FIRE HAZARDS ASSOCIATED WITH THEIR HANDLING AND STORAGE. WHILE IT IS KNOWN THAT INGESTION, INHALATION, AND ABSORPTION OF METHANOL, ETHANOL AND THEIR COMBUSTION PRODUCTS (ESPECIALLY FORMALDEHYDE) ARE EXTREMELY DANGEROUS, INFORMATION ON HEALTH EFFECTS RELATED TO LOW-LEVEL, CHRONIC EXPOSURE IS ALMOST COMPLETELY LACKING.

Table 5.23
Comparative Combustion and Safety Hazard of Alcohols and Gasoline

	NFPA Hazard[a] Identification Signals[b]			
	Health	Fire	Reactivity	Extinguishing agents
Gasoline	1	3	0	*c,d*
Methanol	1	3	0	*e,d*
Ethanol	0	3	0	*f,e,d*

[a]National Fire Protection Association.

[b]4 indicates a severe hazard, 0 indicates no special hazard.

[c]Foam.

[d]Carbon dioxide or dry chemical.

[e]Alcohol foam.

[f]Water.

Source: Mueller Associates, Inc., for Department of Energy, Transportation Energy Conservation Division, *Status of Alcohol Fuels Utilization Technology for Highway Transportation*, Alternative Fuels Utilization Program, Baltimore, Md., June 1978, Table IV-6, p. 42.

Table 5.24
Comparative Toxicity Ratings[a] of Alcohols and Gasoline

	Eye contact	Inhalation	Skin penetration	Skin irritation	Ingestion
Gasoline[b]	2	3	3	1	2
Methanol	2	2	2	1	1
Ethanol	2	1	1	1	1

[a]1 = mild, 5 = extreme toxicity.

[b]Estimated, depends on volume.

Source: Mueller Associates, Inc., for Department of Energy, Transportation Energy Conservation Division, *Status of Alcohol Fuels Utilization Technology for Highway Transportation*, Alternative Fuels Utilization Program, Baltimore, Md., June 1978, Table IV-5, p. 40.

TABLE 5.25 PRESENTS THE CHARACTERISTICS OF ALTERNATIVE FUELS FOR INTERCITY TRUCKING AND THEIR PROJECTED EFFECT ON THE FUEL STORAGE SYSTEM. WHILE THESE FUELS HAVE BEEN LABORATORY TESTED TO SOME EXTENT, OPTIMUM FUEL ENGINE DESIGN HAS NOT BEEN ACHIEVED. RESEARCH IS NEEDED IN THE FOLLOWING AREAS:

1. FUEL DELIVERY LINES SYSTEM
2. LOW-PRESSURE FUEL DELIVERY PUMP
3. FUEL INJECTION OR INDUCTION SYSTEM
4. ENGINE BLOCK ASSEMBLY, INCLUDING LUBRICATION SYSTEM, INTAKE
5. COMBUSTION AND EXHAUST-RELATED SUBSYSTEMS
6. IGNITION SYSTEM
7. COOLING SYSTEM
3. CONTROL SYSTEM
9. ENGINE AND VEHICLE ACCESSORIES, INCLUDING STARTING SYSTEM
10. INSTRUMENTATION SYSTEM
11. DRIVE TRAIN AND SUSPENSION SYSTEM.

Table 5.25
Some Characteristics of Nonpetroleum-Based Alternative Fuels

Fuel	Form	Lower heating value (Btu/lb)	Fuel weight (lb)	Fuel volume (gal)	Tank weight[a] (lb)	Tank spherical diameter (ft)	Total weight (lb)
Acetylene	Dissolved in acetone	20,780	1,333	1,167	3,236	6.7	4,569
Ammonia	Liquid at 200 psi	8,000	3,100	482	500	4.9	3,600
CO	2000 psig gas	4,350	6,000	7,158	6,664	12.2	12,664
Coal	Powdered	10,000	2,254	225	120	3.7	2,384
#2 diesel	Liquid	18,480	1,344	200	130	3.6	1,474
Ethanol	Liquid	11,930	2,100	320	190	4.3	2,290
#6 fuel oil	Liquid	17,160	1,351	167	143	3.5	1,494
Gasoline	Liquid	19,290	1,300	214	128	3.8	1,428
Hydrazine	Liquid	7,000	6,022	715	785	5.7	6,807
Hydrogen	Cryogenic liquid	51,620	477	805	714	5.9	1,191
	Magnesium hydride	51,620	477		8,232	4.1	8,709
Kerosene	Liquid	19,090	1,300	192	120	3.7	1,420
LPG	Pressurized liquid	19,940	1,355	318	333	4.3	1,688
Methanol	Liquid	9,080	2,744	413	248	4.7	2,992
Methane	Cryogenic liquid	21,250	1,155	326	286	4.4	1,441
Vegetable oil (cottonseed)	Liquid	16,110	1,544	193	133	3.7	1,677

[a]Weight estimates based on extrapolations from 20 gallon gasoline energy equivalent tanks assuming spherical configuration. No allowance made for increased wall thickness. Estimates are thus low for tank weights but are judged adequate for the purposes of this presentation.

Source: University of Miami and Escher Technology Associates, for Department of Energy, Transportation Division, *Alternative Fuels and Intercity Trucking*, Alternative Fuels Utilization Program, Washington, D.C., June 1978, Table 9-3, Fig. 9-6 thru 9-19, pp. 231–254.

FIGURE 5.18 PROVIDES A GRAPHIC REPRESENTATION OF THE EFFECTS OF ALCOHOL FUELS ON EMISSIONS AND ENGINE PERFORMANCE. WHILE NITROGEN OXIDES ARE APPRECIABLY REDUCED AND THERMAL EFFICIENCY INCREASED WITH THE USE OF 100% METHANOL, A 10% METHANOL-90% GASOLINE BLEND (WITH REGULATED EMISSIONS) RESULTS IN A FUEL ECONOMY WHICH IS NOT SIGNIFICANTLY DIFFERENT FROM THAT OF 100% GASOLINE. THESE CHARACTERISTIC CHANGES ARE ROUGHLY PROPORTIONAL TO THE ALCOHOL CONTENT.

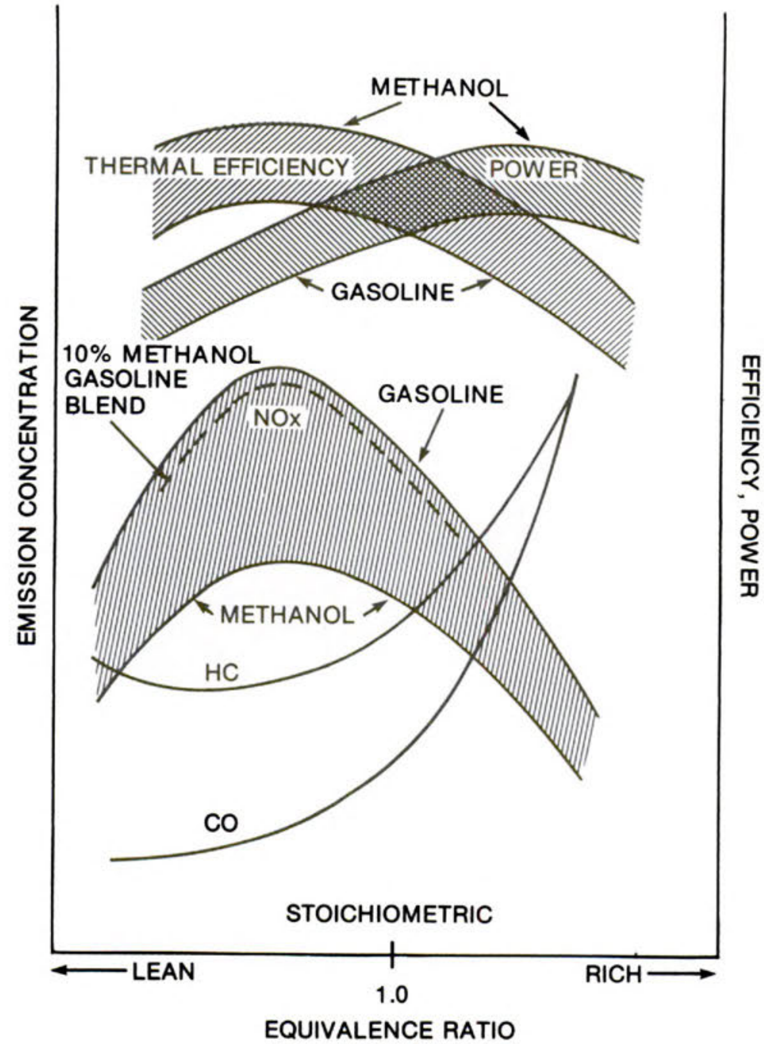
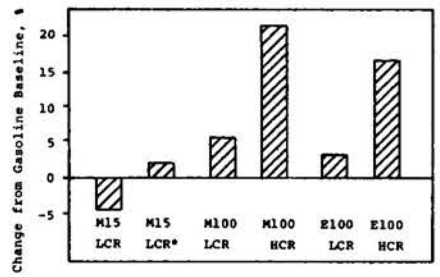


Fig. 5.18
Effects of Alcohol Fuels on Engine
Performance and Emissions.

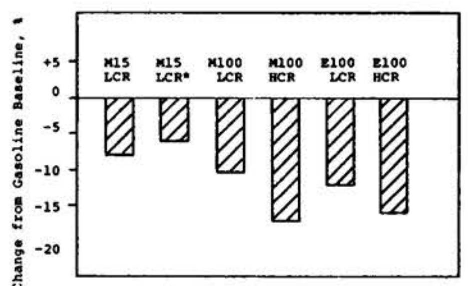
Source: University of Santa Clara, University of Miami, and E. E. Ecklund, for Department of Energy, Transportation Energy Conservation Division, *Comparative Automotive Engine Operation When Fueled with Ethanol and Methanol*, Alcohol Fuels Program, Alternative Fuels Utilization Program, Washington, D.C., May 1978, p. III-10.

FIGURES 5.19 AND 5.20 COMPARE POWER OUTPUT AND ENERGY CONSUMPTION OF ENGINES FUELED WITH VARIOUS ALCOHOLS (AND ALCOHOL BLENDS) TO A PRODUCTION GASOLINE ENGINE. THE DATA ARE ON ENGINES FOR WHICH IGNITION AND CARBURETION CALIBRATIONS WERE ADJUSTED TO ACCOUNT FOR THE FUEL USED. TAKING INTO ACCOUNT THE LOSS OF POWER CAUSED BY A LEANER MIXTURE, ENGINES USING M15 FUEL WILL CONSUME APPROXIMATELY 7% LESS FUEL – WITH NO ENGINE ADJUSTMENTS FUEL ECONOMY IS REALIZED AS A RESULT OF LEANING EFFECTS.



E100: neat ethanol (5% water)
M15: 15 volume % methanol blend
M100: neat methanol
LCR: low compression ratio engine
HCR: high compression ratio engine
*: carburetor adjusted to restore equivalence ratio

Fig. 5.19
Comparative Power Output of Engines Using Several Alcohol Fuels and Gasoline.



E100: neat ethanol (5% water)
M15: 15 volume % methanol blend
M100: neat methanol
LCR: low compression ratio engine
HCR: high compression ratio engine
*: carburetor adjusted to restore equivalence ratio

Fig. 5.20
Comparative Specific Energy Consumption of Engines Using Several Alcohol Fuels and Gasoline.

Source: Mueller Associates, Inc., for Department of Energy, Transportation Energy Conservation Division, *Status of Alcohol Fuels Utilization Technology for Highway Transportation*, Alternative Fuels Utilization Program, Baltimore, Md., June 1978, Figs. VI-8, 9, pp. 92–93.

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Chapter 6

Population, Income, and the National Economy

Population, Income, and the National Economy

Chapter 6 takes an in-depth look at the demographic and economic factors which influence and/or are influenced by transportation demand. The population statistics presented in Sect. 6.1 provide a demographic profile of the United States. The size of the nation's transportation fleet is closely related to its population size (and to its driving-age population in the case of motor vehicles). However, the auto fleet has grown much more rapidly than the population over the last 25 years. Therefore, the chapter also presents variables which reflect changing lifestyles (e.g., increasing per capita income and decreasing average size of household).

Data in Sect. 6.1 indicate that the median age of the U.S. population continued to increase in 1977. The fastest-growing age group was the population from 25 through 34 years of age, which is also the age group with the highest number of licensed drivers per capita. The increase in number of households in the United States is due largely to a rapid increase in one-person (primary individual) households. This increase also results in a reduced average household size. In 1977 there were almost two licensed drivers per household and approximately 1.3 cars available for each household. The driver per vehicle ratio approached one to one.

In 1976 median household income in constant 1975 dollars was $11,990; median family income was $14,218 (see Tables 6.5 and 6.7). Although household income has increased greatly since 1967 in terms of current dollars, real household income measured in terms of constant 1975 dollars actually has increased only slightly. Family income has increased more, which may be due to an increase in two-wage-earner families.

Section 6.2 deals with the impact of transportation on our national economy. Personal consumption expenditure (PCE) on transportation represents 14% of total PCE in the United States. This has increased 41% since 1970. Expenditures on transportation comprise the fourth-largest item on which people in the United States spend their income. However, transportation's contribution to total national income has actually decreased slightly since 1970 and was 3.6% of total national income in 1977.

Table 6.11 and Fig. 6.8 show the U.S. balance of payments. The data show that overall the United States is importing more goods than it is exporting. The recent negative change in our balance of payments is related to the large increase in petroleum prices in 1973.

The wages and salaries paid by the transportation industry and the corresponding employment level reflect the decrease in rail and marine activity over the last few decades. Trucking, air, pipeline, and transportation services have increased but not enough to offset the decline in rail and marine.

Employees involved directly in the transportation industry comprise about 3% of total U.S. employment. However, if one extends the definition to include employees involved in related areas such as transportation equipment manufacturing, automotive sales and services, or government officials involved with transportation, the percent of the total civilian labor force involved with transportation increases to 11%.

Section 6.1

Population and Income

BETWEEN 1970 AND 1977 THE U.S. POPULATION CONTINUED TO AGE, WITH THE MEDIAN AGE OF THE POPULATION BEING 29.4 YEARS IN 1977. BOTH THE PRESCHOOL-AGE AND THE ELEMENTARY-SCHOOL-AGE POPULATION DECLINED, WHILE THE FASTEST GROWING AGE GROUP WAS THE POPULATION FROM 25 THROUGH 34 YEARS OF AGE. THIS IS ALSO THE AGE GROUP WITH THE HIGHEST PERCENT OF LICENSED DRIVERS.

Table 6.1
Age Structure of the Population: July 1, 1970 and 1977
(10^3)

Age	Population		Percent distribution		Population change, 1970–77	
	July 1, 1977	April 1, 1970	July 1, 1977	April 1, 1970	Number	Percent
All ages, total	216,817	204,335	100.0	100.0	+12,482	+6.1
Under 5 years	15,236	17,163	7.0	8.4	–1,927	–11.2
5 to 13 years	32,227	36,675	14.9	17.9	–4,448	–12.1
14 to 17 years	16,783	15,854	7.7	7.8	+929	+5.9
18 to 24 years	28,602	24,455	13.2	12.0	+4,147	+17.0
25 to 34 years	33,149	25,146	15.3	12.3	+8,003	+31.8
35 to 44 years	23,543	23,214	10.9	11.4	+330	+1.4
45 to 54 years	23,389	23,254	10.8	11.4	+135	+0.6
55 to 64 years	20,395	18,603	9.4	9.1	+1,793	+9.6
65 years and over	23,494	19,972	10.8	9.8	+3,521	+17.6

[a]Total population including Armed Forces overseas.

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-25, No. 721, "Estimates of the Population of the United States, by Age, Sex, and Race: 1970 to 1977," Washington, D.C., 1978, p. 2 and 4.

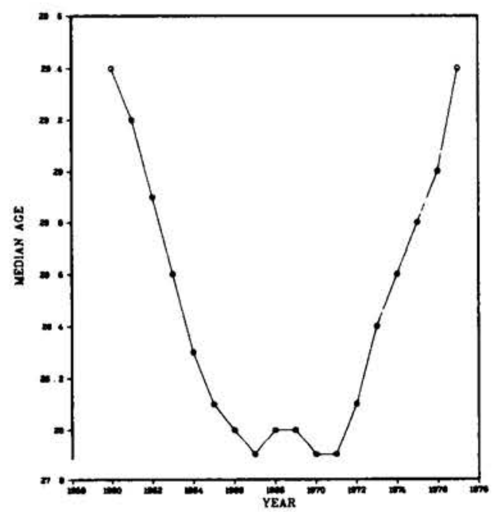

Fig. 6.1. Median Age of the Population, 1960–1977[a].

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-25, No. 721, "Estimates of the Population of the United States, by Age, Sex, and Race: 1970 to 1977," Washington, D.C., 1978, pp. 2 and 4.

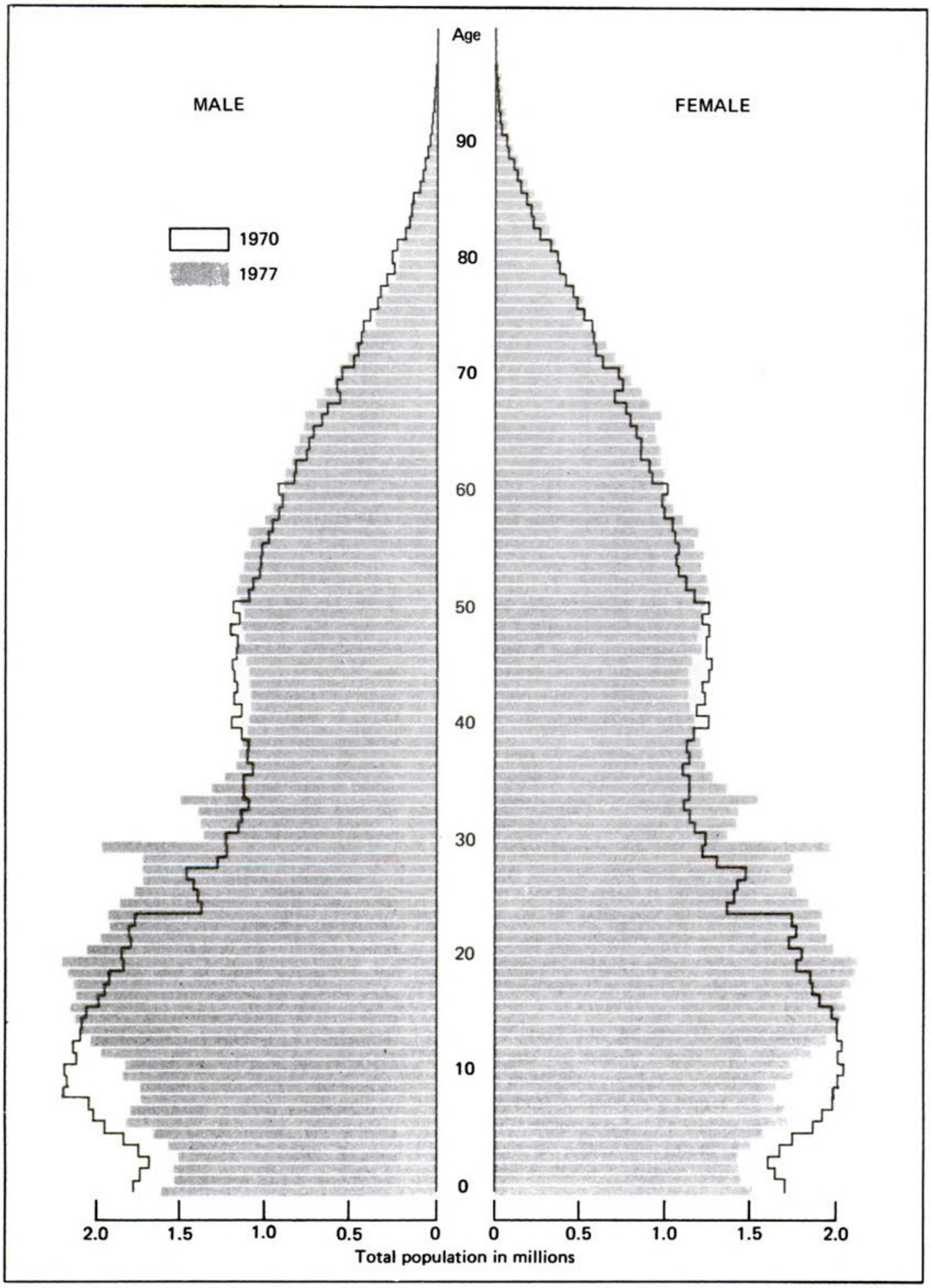

Fig. 6.2. Distribution of the Total Population by Age and Sex: April 1, 1970 and July 1, 1977.

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports: Population Estimates and Projections*, Series P-25, No. 721, Washington, D.C., Figure 2, p. 3.

IN 1977, THE RATIO OF LICENSED DRIVERS TO HOUSEHOLDS WAS 1.86 TO 1.0. THERE WERE 1.3 CARS AVAILABLE PER HOUSEHOLD IN THE UNITED STATES.

Table 6.2
Household and Family Units, 1950 through 1978
(10^3)

	1950	1960	1970	1975	1976	1977	1978
Households[a]							
total	43,554	52,799	63,401	71,120	72,867	74,142	76,030
Primary families[b]	38,838	44,905	51,456	55,563	56,056	56,472	56,958
Primary individuals[c]	4,716	7,895	11,945	15,557	16,811	17,669	19,071
Cars per household[d]	0.82	1.08	1.26	1.33	1.34	1.34	
Licensed drivers per household					1.84	1.86	
Families[b]							
total	39,303	45,111	51,586	55,712	56,245	56,710	57,215

[a]All persons who occupy a housing unit.

[b]A group of two or more persons residing together who are related by blood, marriage, or adoption. A primary family includes among its members the married couple or person maintaining a household. A "secondary family" include no member related to the person or persons maintaining the household, that is, lodgers, guests, or resident employees.

[c]Persons maintaining a household with no relatives in the household.

[d]Passenger cars in operation, as estimated by R. L. Polk & Co.

Sources: U.S. Bureau of the Census, *Current Population Reports*, Series P-20, No. 313, "Households and Families by Type: March 1977 (advance report)," U.S. Government Printing Office, Washington, D.C., 1978, Table 5; U.S. Bureau of the Census, *Current Population Reports*, Series P-20, No. 327, "Households and Families by Type: March 1978 (advance report)," U.S. Government Printing Office, Washington, D.C., 1978, Table 1.

THE RAPID INCREASE IN PRIMARY INDIVIDUAL HOUSEHOLDS HAS CONTRIBUTED TO THE RECENT REDUCTION IN AVERAGE HOUSEHOLD SIZE, WHICH DECLINED FROM AN ESTIMATED 3.14 PERSONS IN 1970 TO 2.86 PERSONS IN 1977. THE HIGHEST RATE OF INCREASE SINCE 1970 IN PERSONS LIVING ALONE HAS BEEN FOR THOSE UNDER AGE 25, ESPECIALLY MALES. THIS TREND COULD HAVE IMPACTS ON THE GROWTH IN NUMBER OF CARS PURCHASED BECAUSE, ON THE AVERAGE, HOUSEHOLDS, REGARDLESS OF SIZE, TEND TO HAVE AT LEAST ONE CAR AVAILABLE.

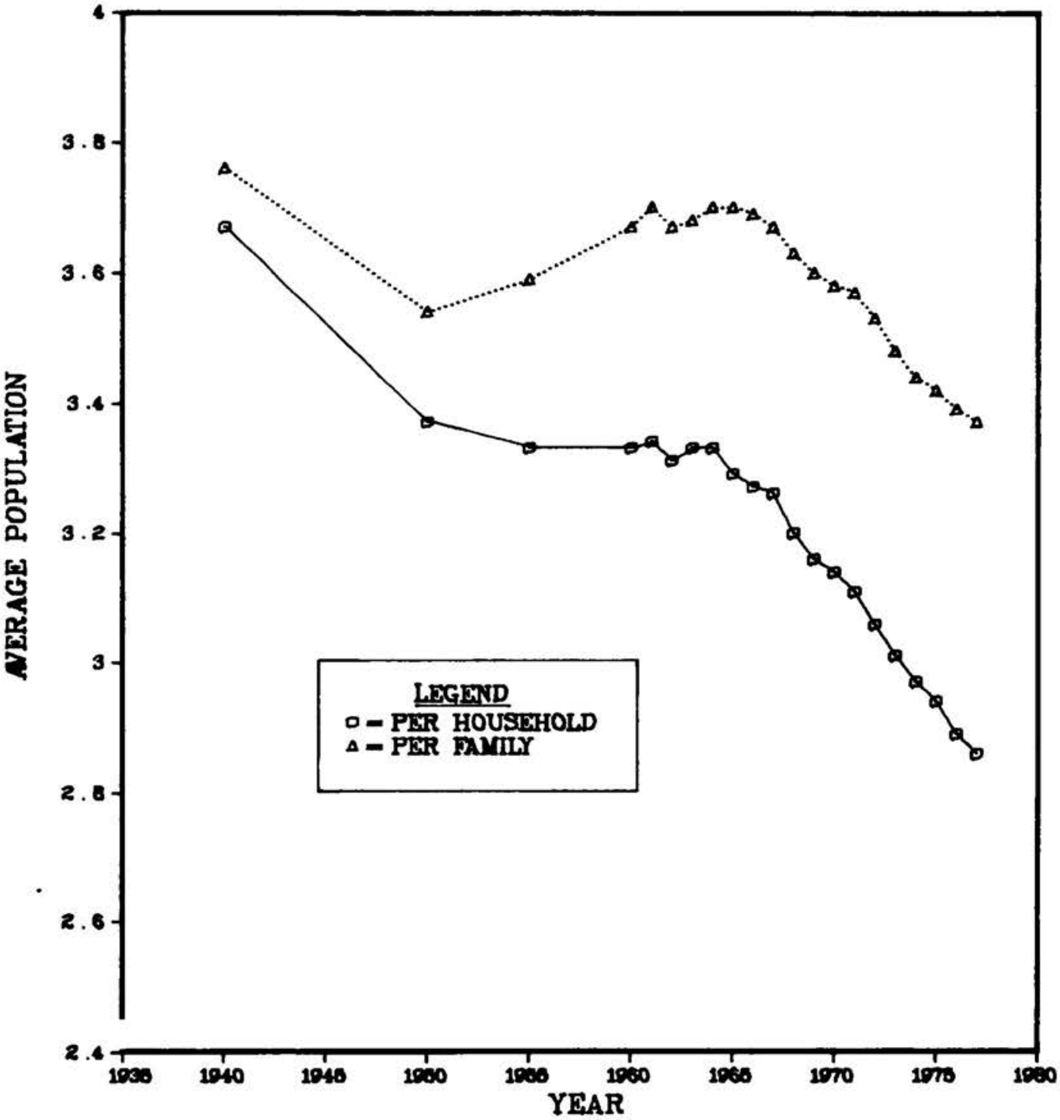

Fig. 6.3. Average Population Per Household and Per Family, 1940-1977.

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-20, No. 313, "Households and Families by Type: March 1977 (Advance Report)," Washington, D.C., 1978, p. 4.

IN 1977, OVER TWO-THIRDS OF THE NATION'S FAMILIES LIVED IN METROPOLITAN AREAS. SIXTY PERCENT OF THE FAMILIES HAD 3 OR LESS MEMBERS.

Table 6.3
Selected Characteristics of Families, 1977
(10^3)

Characteristics	Number	Percent
Total families	56,710	100.0
Type of residence		
Metropolitan areas	37,955	66.9
Nonmetropolitan areas	18,755	33.1
Nonfarm	54,526	96.1
Farm	2,184	3.9
Size of family		
2 persons	21,530	38.0
3 persons	12,472	22.0
4 persons	11,483	20.2
5 persons	6,209	10.9
6 persons	2,800	4.9
7 persons or more	2,216	3.9
Tenure		
Homeowners	40,815	72.0
Renters of private housing	14,844	26.2
Renters of public housing	1,050	1.9
Age of family members		
All members	190,844	100.0
Under 18 years	63,885	33.5
18 to 64 years	111,886	58.6
65 years and over	15,073	7.9

Source: U.S. Bureau of the Census, *Current Population Reports*, Series P-20, No. 313, "Households and Families by Type: March 1977 (advance report)," U.S. Government Printing Office, Washington, D.C., 1978, Table 4.

IN 1977 THE NUMBER OF DRIVERS PER VEHICLE, WHICH INCLUDES TRUCKS AND BUSES, APPROACHED ONE. HOWEVER, THERE ARE ONLY 0.8 CARS PER DRIVER.

Table 6.4
Licensed Drivers by Age, 1977[a]
(%)

Age	Male	Female	Total
Under 16[b]			
16	1.4	1.3	1.4
17	2.2	2.1	2.2
18	2.5	2.5	2.5
19	2.7	2.7	2.7
20-24	13.4	13.8	13.6
25-29	12.8	13.5	13.1
30-34	10.6	11.3	10.9
35-39	8.5	9.1	8.8
40-44	7.5	7.8	7.6
45-49	7.4	7.6	7.5
50-54	7.3	7.5	7.4
55-59	6.8	6.8	6.8
60-64	5.6	5.3	5.5
65-69	4.7	4.0	4.4
70 +	6.3	4.6	5.5
Total	100.0	100.0	100.0
Total, 10^3	74,195	63,706	137,901
Drivers per capita	0.70	0.57	0.64
Drivers per person 18+			0.90
Drivers per vehicle			0.96
Cars per driver			0.83

[a]Estimated for 1977 from calendar year reports of state authorities and other sources.

[b]Insignificant number.

Source: U.S. Department of Transportation, Federal Highway Administration, *Selected Highway Statistics, 1976*, Washington, D.C.

MEDIAN HOUSEHOLD INCOME IN CURRENT DOLLARS INCREASED TO $12,686 IN 1976. HOWEVER, IN TERMS OF CONSTANT DOLLARS THE PATTERN HAS BEEN SOMEWHAT ERRATIC, WITH PERIODS OF DECREASE. (SEE TABLE 6.7 FOR FAMILY INCOME.)

Table 6.5
Median and Mean Household Income in Current and Constant Dollars, 1967-1976

	Current dollars		1975 constant dollars[a]	
	Median	Mean	Median	Mean
1967	7,143	7,989	11,521	12,885
1968	7,743	8,760	11,986	13,560
1969	8,389	9,544	12,319	14,015
1970	8,734	10,001	12,114	13,871
1971	9,028	10,383	12,005	13,807
1972	9,697	11,286	12,480	14,525
1973	10,512	12,157	12,726	14,718
1974	11,197	13,094	12,224	14,295
1975	11,800	13,779	11,800	13,779
1976	12,686	14,922	11,990	14,104

[a]Deflated by the consumer price index.

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-60, No. 109, Washington, D.C., 1978, pp. 9-10.

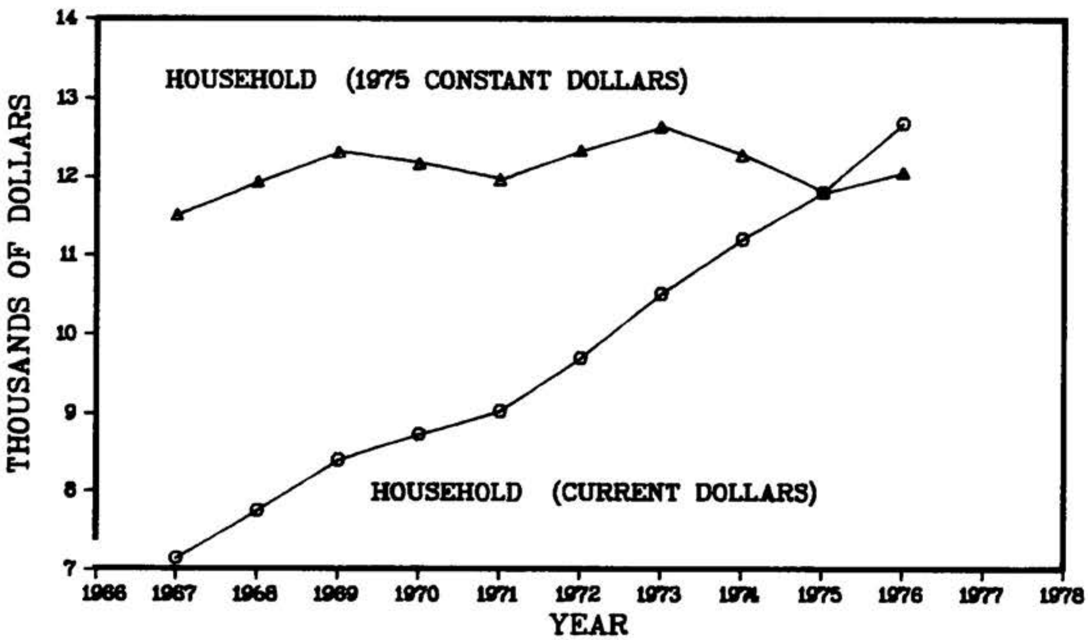

Fig. 6.4. Median Household Income in Current and 1975 Constant Dollars.

INCREASE IN HOUSEHOLD INCOME IS MOST DRAMATIC BETWEEN ONE-PERSON AND TWO-PERSON HOUSEHOLDS. THIS PROBABLY REFLECTS A SUBSTANTIAL AGE EFFECT.

Table 6.6
Median and Mean Income by Size of Household[a], 1976
(in current and constant 1975 dollars)

Household size	Number of households (10^3)	Current dollars		1975 constant dollars[b]	
		Median income	Mean income	Median income	Mean income
Total	72,142	12,686	14,922	11,990	14,104
One-person	15,532	5,365	7,400	5,071	6,994
Two-person	22,775	12,206	14,354	11,537	13,567
Three-person	12,794	15,139	16,945	14,309	16,016
Four-person	11,630	17,133	18,975	16,194	17,935
Five-person	6,285	17,723	19,910	16,751	18,818
Six-person	2,864	17,648	20,336	16,680	19,221
Seven-or-more person	2,263	16,428	19,296	15,527	18,238

[a]Includes members 14 years old and over.

[b]Deflated by the consumer price index.

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-60, No. 109, Washington, D.C., 1978, p. 24.

THE GAP BETWEEN MEDIAN FAMILY INCOME AND MEDIAN HOUSEHOLD INCOME CONTINUES TO WIDEN. PART OF THE DISCREPANCY IS PROBABLY DUE TO THE INCREASE IN SINGLE-PERSON HOUSEHOLDS WITH A SIMULTANEOUS INCREASE IN TWO-EARNER FAMILIES. (SEE TABLE 6.5 FOR HOUSEHOLD INCOME.)

Table 6.7
Median and Mean Family Income in Current and Constant Dollars, 1950-1977

	Current dollars		1975 constant dollars[a]	
	Median	Mean	Median	Mean
1950	3,319	3,815	7,425	8,535
1955	4,418	4,962	8,871	9,964
1960	5,620	6,227	10,218	11,322
1965	6,957	7,704	11,872	13,147
1966	7,532	8,395	12,491	13,922
1967	7,933	8,801	12,795	14,195
1968	8,632	9,670	13,362	14,969
1969	9,433	10,577	13,851	15,532
1970	9,867	11,106	13,685	15,404
1971	10,285	11,583	13,677	15,403
1972	11,116	12,625	14,306	16,248
1973	12,051	13,622	14,590	16,492
1974	12,902	14,711	14,085	16,060
1975	13,719	15,546	13,719	15,546
1976	14,958	16,870	14,138	15,945
1977	16,009	18,264	14,218	16,220

[a]Deflated by the consumer price index.

Source: U.S. Department of Commerce, Bureau of the Census, *Current Population Reports*, Series P-60, No. 114, Washington, D.C., 1978, p. 44 and p. 57; *Current Population Reports*, Series P-60, No. 116, Washington, D.C., 1978, p. 2.

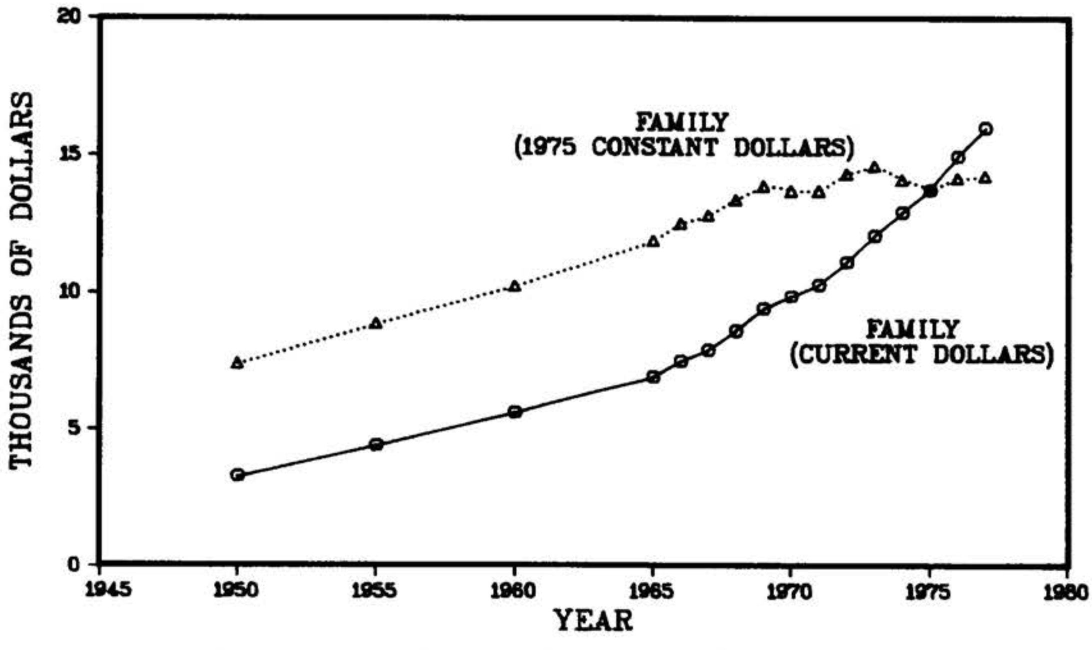

Fig. 6.5. Median Family Income in Current and 1975 Constant Dollars, 1950-1977.

Section 6.2

National Economy

TRANSPORTATION EXPENDITURES HAVE INCREASED 42% SINCE 1970, WHEREAS TOTAL PERSONAL CONSUMPTION EXPENDITURES ONLY INCREASED ABOUT 26% OVER THE SAME PERIOD.

Table 6.8
Gross National Product by Major Component, 1950-1977
(10^6 1975 constant dollars[a])

	1950	1960	1970	1974	1975	1976	1977	% increase since 1970
Gross national product (GNP)	678,293	936,823	1,367,319	1,548,372	1,528,833	1,616,087	1,694,511	23.9
(%)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	(100.0)	
Personal consumption expenditures (PCE)	455,004	601,561	861,233	974,907	979,070	1,036,354	1,083,332	25.8
(% of GNP)	(67.1)	(64.2)	(63.0)	(63.0)	(64.0)	(64.1)	(63.9)	
Transportation	60,239	78,487	108,604	126,126	125,493	142,970	154,534	42.3
(% of PCE)	(13.2)	(13.0)	(12.6)	(12.9)	(12.8)	(13.7)	(14.0)	
Gross private domestic investment	127,554	141,537	195,983	235,166	190,919	230,971	267,431	36.4
(% of GNP)	(18.8)	(15.1)	(14.3)	(15.2)	(12.5)	(14.3)	(15.8)	
Net exports of goods and services	4,499	8,095	5,492	6,619	20,403	7,076	-10,005	-282.2
(% of GNP)	(0.7)	(0.9)	(0.4)	(0.4)	(1.3)	(0.4)	(-0.6)	
Government[b] purchases of goods and services	91,237	185,630	304,611	331,679	338,441	341,686	353,753	16.1
(% of GNP)	(13.4)	(19.8)	(22.3)	(21.4)	(22.1)	(21.1)	(20.9)	

[a]Deflated by the implicit GNP price deflator.

[b]Federal, state, and local.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables*, Washington, D.C., 1976, pp. 2-3; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 18.

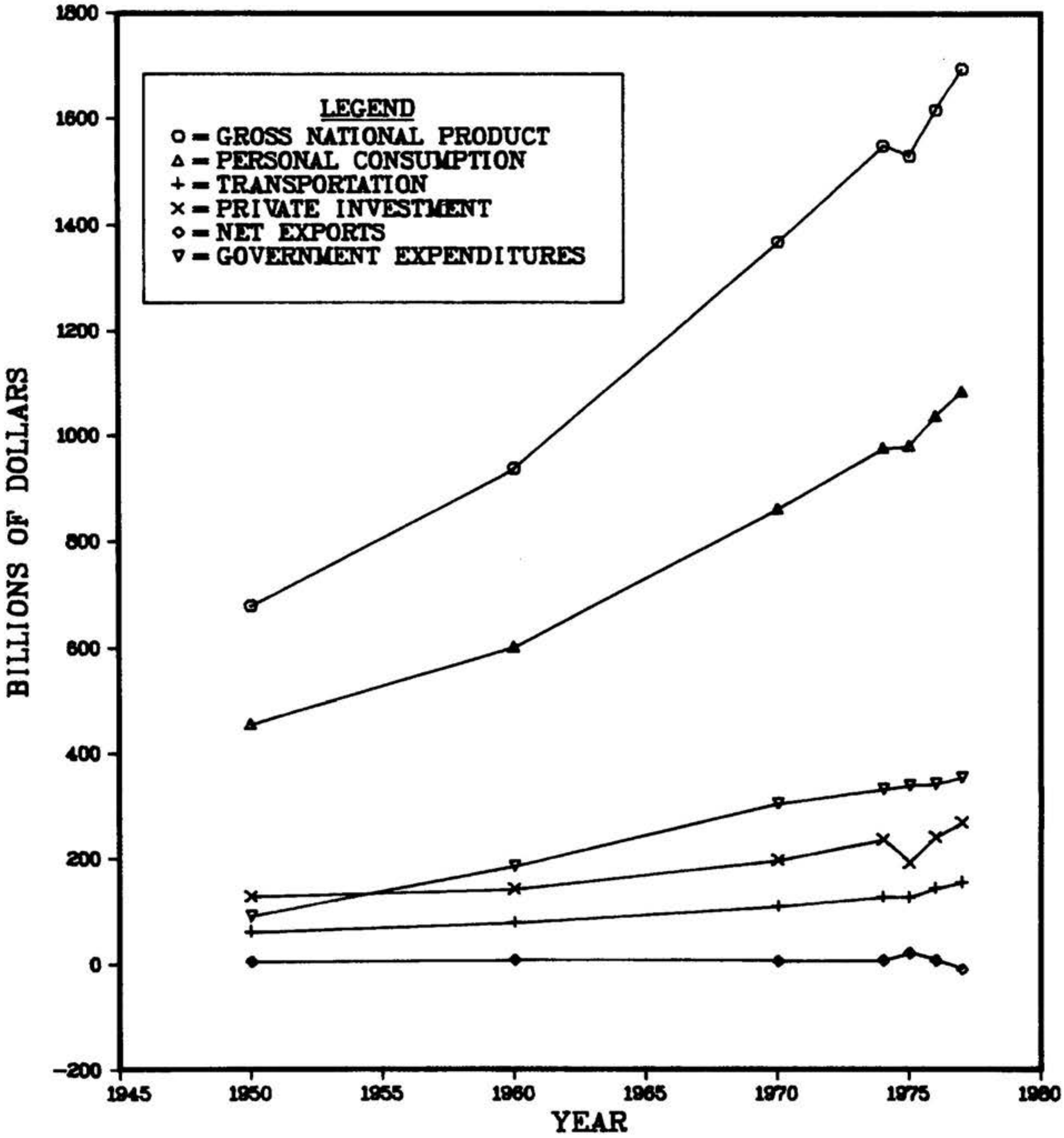

Fig. 6.6. Gross National Product by Major Component
(constant 1975 dollars)

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables*, Washington, D.C., 1976, pp. 2-3; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 26.

Table 6.9
Personal Consumption Expenditures by Type of Product, 1950–1977
(10^6 1975 constant dollars[a])

	1950	1960	1970	1974	1975	1976	1977	1977 %	% increase since 1970
Total	427,161	572,819	845,581	961,941	979,070	1,035,369	1,083,916	100.0	28.2
Food and tobacco	129,328	155,111	201,066	220,221	224,319	229,802	235,166	21.7	17.0
Clothing, accessories and jewelry	52,757	56,804	76,003	82,543	81,971	84,215	85,851	7.9	13.0
Personal care	5,425	9,242	14,922	14,556	14,228	14,401	15,035	1.4	0.8
Housing	48,311	84,832	128,431	147,612	150,151	157,982	165,836	15.3	29.1
Household operation	64,722	81,322	119,968	141,237	142,265	150,686	158,906	14.7	32.4
Medical care expenses	20,258	35,264	68,124	83,151	89,155	99,131	105,990	9.8	55.6
Personal business	14,588	25,093	42,820	49,174	51,558	53,036	54,307	5.0	26.8
Transportation	56,553	74,737	106,630	124,448	125,493	142,834	154,617	14.3	45.0
(% of total)	(13.2)	(13.0)	(12.6)	(12.9)	(12.8)	(13.8)	(14.3)		
Recreation	24,804	31,479	56,025	65,843	66,527	69,361	72,949	6.7	30.2
Private education and research	3,749	6,604	13,493	14,877	15,459	16,198	16,890	1.6	25.2
Religious and welfare activities	5,207	8,590	11,668	12,567	12,979	13,474	13,821	1.3	18.4
Foreign travel and other, net	1,457	3,739	6,429	5,712	4,965	4,250	4,548	0.4	-29.2

[a]Deflated by the implicit price deflator for personal consumption expenditures.

Source: U.S. Department of Commerce, Bureau of Statistical Analysis, *The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables*, Washington, D.C., 1976, pp 88-91; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 37.

TRANSPORTATION EXPENDITURES AS A PERCENT OF TOTAL PERSONAL CONSUMPTION EXPENDITURES REGISTERED AN ALL-TIME HIGH AT 14.3% IN 1977.

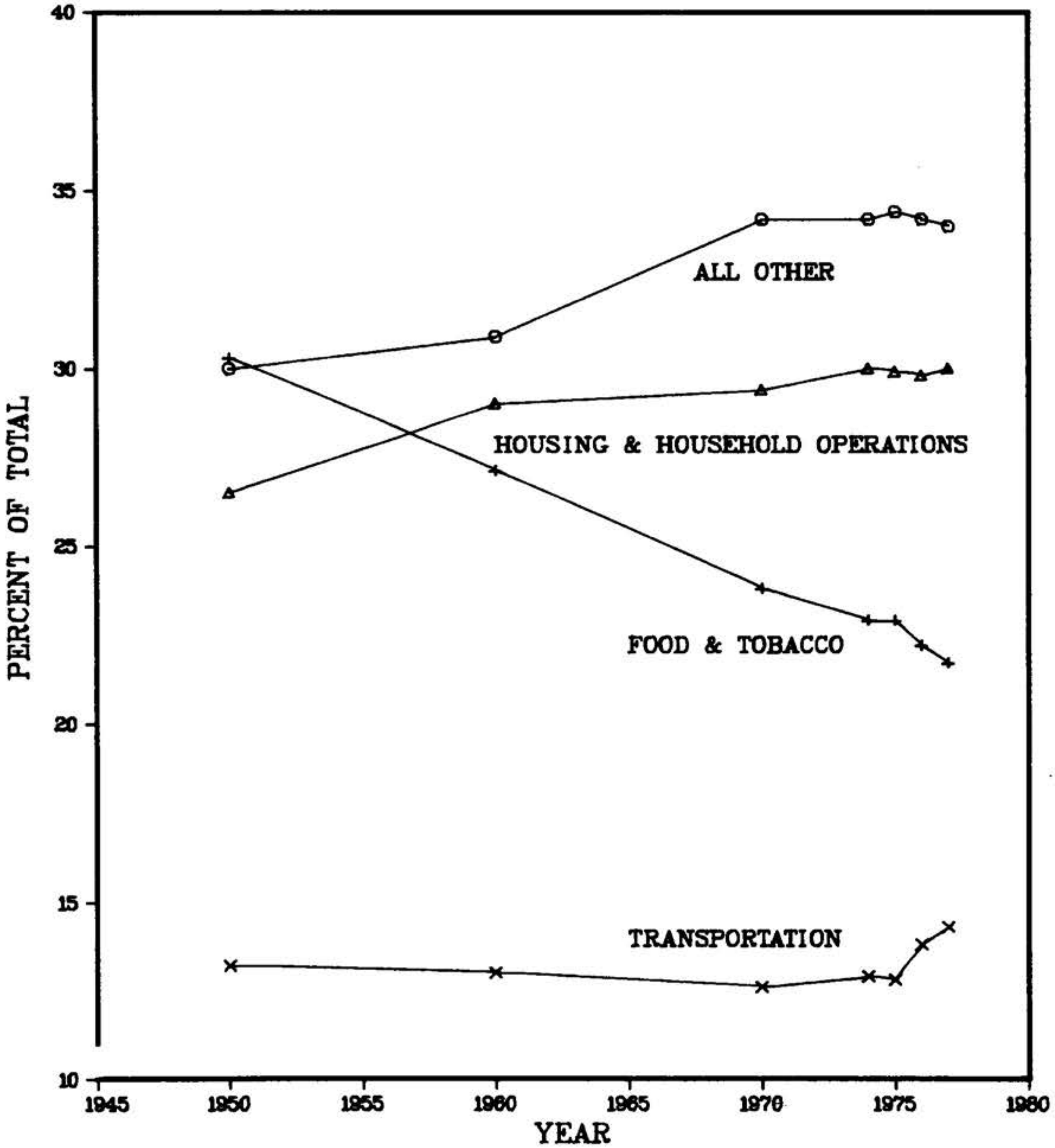

Fig. 6.7. Personal Consumption Expenditures by Type of Product, 1950-1977.

Source: U.S. Department of Commerce, Bureau of Statistical Analysis, *The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables*, Washington, D.C., 1976, pp. 88-91; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 37.

EXPENDITURES FOR USER-OPERATED TRANSPORTATION ACCOUNTED FOR MORE THAN 94% OF TOTAL TRANSPORTATION EXPENDITURES IN 1977. AIRLINES CONTINUED TO GAIN IN POPULARITY WHILE RAILWAY AND INTERCITY BUS CONTINUED TO EXPERIENCE A DECREASE IN THEIR GROSS INCOME.

Table 6.10
Personal Consumption Expenditures within the Transportation Sector, 1950-1977
(10^6 1975 constant dollars[a])

	1950	1960	1970	1974	1975	1976	1977	1977 %	% increase since 1970
Transportation total	56,553	74,737	106,630	124,448	125,493	142,834	154,617	100.0	45.0
User-operated transportation									
Total	50,309	68,861	99,075	116,490	117,860	134,681	146,125	94.5	47.5
New cars and net purchases of used cars	27,087	30,310	41,464	44,415	45,904	58,421	64,681	41.8	56.0
Tires, tubes, accessories, and parts	3,438	4,381	6,268	7,473	7,490	7,797	8,530	5.5	36.1
Maintenance	5,583	8,930	15,370	19,042	20,388	21,960	23,252	15.0	51.3
Gasoline and oil	12,287	21,116	30,059	39,393	39,509	40,670	41,736	27.0	38.8
Tolls	216	546	879	826	798	799	780	0.5	-11.3
Insurance	1,698	3,577	5,036	5,341	3,771	5,035	7,136	4.6	41.7
Purchased local transportation									
Total	4,304	3,572	3,445	3,036	2,999	3,116	3,142	2.0	- 8.8
Street, electric, railway, and local bus	3,044	2,283	2,149	1,874	1,787	1,847	1,860	1.2	-13.4
Taxicab	1,084	1,074	1,060	946	1,006	1,056	1,074	0.7	1.3
Railway (commutation)	176	215	235	216	206	213	207	0.1	-11.9
Purchased intercity transportation									
Total	1,940	2,304	4,110	4,922	4,634	5,037	5,350	3.5	30.2
Railway (noncommutation)	877	539	253	280	254	267	262	0.2	3.6
Intercity bus	688	511	678	667	605	577	575	0.4	-15.2
Airline	314	1,192	2,960	3,767	3,595	3,994	4,294	2.8	45.1
Other	62	62	220	208	180	198	218	0.1	- 0.9

[a]Deflated by the implicit price deflator for personal consumption expenditures.

Source: U.S. Department of Commerce, Bureau of Statistical Analysis, *The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables*, Washington, D.C., 1976, pp. 90-1; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 37.

IN THE TABLE BELOW, A NEGATIVE SIGN DENOTES AN EXCESS OF IMPORTS OVER EXPORTS IN THE U.S. BALANCE OF PAYMENTS. SERVICES RENDERED WAS THE ONLY AREA WHERE THE BALANCE OF PAYMENTS WAS POSITIVE. HOWEVER, THIS WAS NOT ENOUGH TO OFFSET THE HUGE DEBTS FROM PETROLEUM AND OTHER IMPORTS OF MERCHANDISE.

Table 6.11
U.S. Balance of Payments
(10^6 constant 1975 dollars[a])

	1970	1971	1972	1973	1974	1975	1976	1977	% increase since 1970
Goods and services	8,070	3,244	−2,450	13,154	9,402	22,591	9,540	−7,779	−196.4
Merchandise[b,c] (trade balance)	3,622	−2,992	−8,160	1,054	−5,900	8,990	−8,875	−28,031	−873.9
Agriculture products	2,060	2,558	3,680	11,043	12,733	12,396	11,235	9,098	341.6
Food and live animals	−1,418	−1,539	−901	4,706	5,041	9,918	5,173	1,417	100.0
Crude material (excluding fuels)	1,806	1,254	1,488	4,045	5,335	4,218	3,685	4,125	128.4
Mineral fuels	−2,060	−2,937	−4,128	−7,816	−24,120	−22,006	−28,302	−36,234	−1658.9
Petroleum	−3,168	−3,766	−4,903	−8,528	−25,729	−23,906	−29,278	−36,141	−1040.8
Chemicals	3,307	2,945	2,693	3,949	5,261	4,995	4,931	5,255	58.9
Manufactured goods	−4,694	−6,797	−8,287	−7,309	−7,181	−3,783	−6,099	−9,436	−100.9
Machinery	8,476	7,406	6,928	8,611	13,234	16,570	15,311	13,337	57.4
Transport equipment	863	−9	−1,699	−449	2,246	5,453	3,394	620	−28.2
Motor vehicle and ports	−2,113	−3,468	−4,001	−3,872	−2,615	161	−2,044	−3,633	−71.9
Services[c]	4,448	6,236	5,708	12,098	15,302	13,600	18,414	20,252	355.3
Transportation and travel	−2,816	−3,067	−3,849	−3,685	−3,404	−2,563	−2,041	−2,782	1.2
Unrequited transfers	−4,790	−5,106	−5,146	−4,923	−8,138	−4,871	−5,088	−4,675	2.4
Private	−1,526	−1,479	−1,403	−1,498	−1,115	−904	−900	−930	39.0
Government	−3,266	−3,627	−3,743	−3,425	−7,024	−3,966	−4,188	−3,746	−14.7
Long-term capital movement	−8,833	−12,011	−7,161	−8,107	−7,378	−18,951	−14,610	−11,216	−27.0
Short-term capital movement	−9,350	−26,480	664	−7,060	−3,553	−3,351	208	−7,911	15.4
Total	−14,902	−40,353	−14,092	−6,936	−9,668	−4,582	−9,951	−31,582	−111.9

[a]Deflated by the implicit GNP price deflator.

[b]Only selected subcategories are listed.

[c]Subcategories' data are from *Survey of Current Business*.

Source: International Monetary Fund, *Balance of Payment Yearbook*, Vol. 29, May 1978, p. 23; U.S. Department of Commerce, Bureau of the Census, *Survey of Current Business*, annual data.

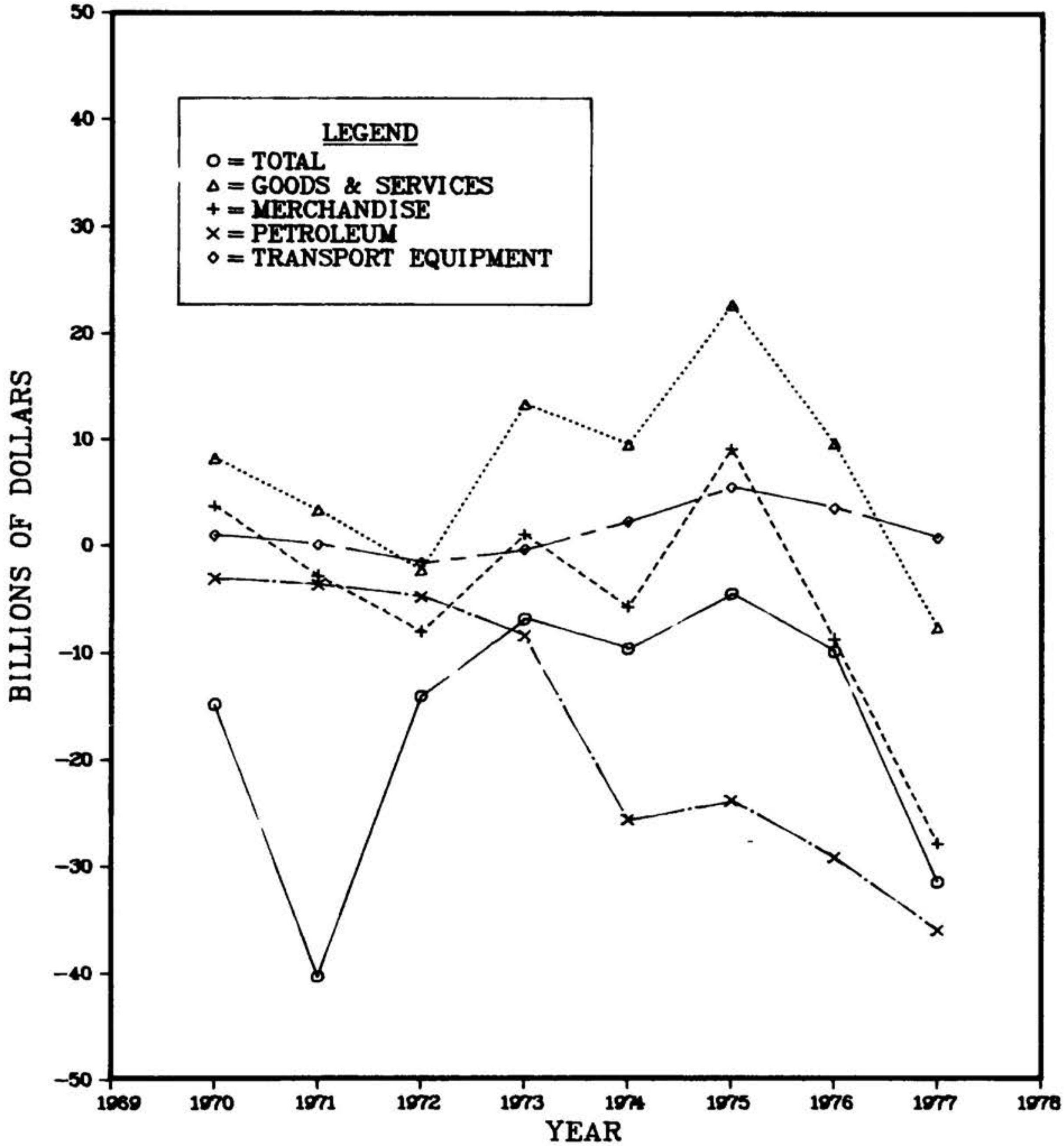

Fig. 6.8. U.S. Balance of Payments.
(constant 1975 dollars)

Source: International Monetary Fund, *Balance of Payment Yearbook*, Vol. 29, May 1978, p. 23; U.S. Department of Commerce, Bureau of the Census, *Survey of Current Business*, annual data.

THE RATIO OF VALUE OF IMPORTED PETROLEUM TO TOTAL BALANCE OF PAYMENTS DEFICIT INCREASED TO THE HIGHEST POINT IN 1975 THEN DECLINED TO APPROXIMATELY 1.3 IN 1977.

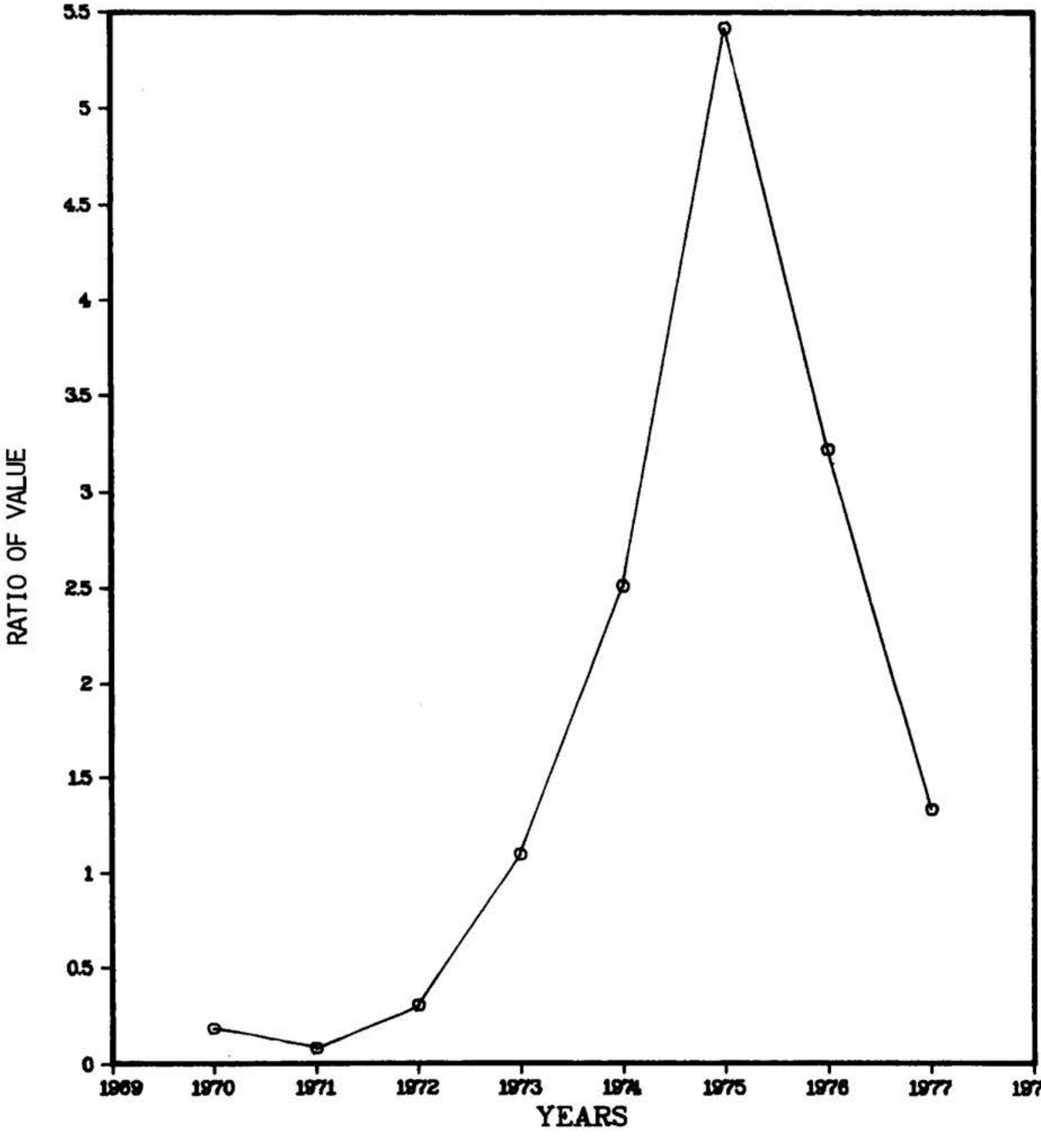

Fig. 6.9. Ratio of Value of Imported Petroleum to Total Balance of Payments Deficit, 1970-1977.

Source: International Moentary Fund, *Balance of Payment Yearbook*, Vol. 29, May 1978, p. 23; U.S. Department of Commerce, Bureau of the Census, *Survey of Current Business*, annual data.

Table 6.12
General Income Indicators
($\$10^6$)

Item	1950	1960	1965	1970	1974	1975	1976	1977	% increase since 1970
Current dollars									
Gross national product	286,172	505,978	688,110	982,419	1,412,889	1,528,833	1,700,124	1,887,177	92.1
Net national product	262,319	458,266	630,627	891,592	1,275,238	1,366,879	1,522,323	1,691,986	89.8
National income	236,203	412,008	565,959	798,374	1,135,959	1,215,002	1,359,183	1,515,301	89.8
Personal income	226,102	399,724	537,031	801,271	1,154,936	1,255,486	1,380,854	1,528,990	90.8
Disposable personal income	205,511	349,370	472,157	685,935	984,627	1,086,658	1,184,365	1,302,995	90.0
1975 constant dollars[a]									
Gross national product	678,293	936,823	1,177,263	1,367,319	1,548,372	1,528,833	1,616,087	1,694,511	23.9
Net national product	621,756	848,484	1,078,917	1,240,907	1,397,521	1,366,879	1,447,075	1,519,248	22.4
National income	559,855	762,836	968,279	1,111,168	1,244,886	1,215,002	1,291,999	1,360,601	22.4
Personal income	535,914	740,092	918,787	1,115,200	1,265,683	1,255,486	1,312,599	1,372,892	23.1
Disposable personal income	487,108	646,862	807,796	954,676	1,079,043	1,086,658	1,125,822	1,169,969	22.6

[a]Deflated by the implicit GNP price deflator.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929-1974, Statistical Tables,* Washington, D.C., 1976, pp. 22-3 and pp. 66-7; *Survey of Current Business,* 58, No. 7, Washington, D.C., July 1978, p. 29 and p. 35.

THE TOTAL NATIONAL INCOME HAS INCREASED 24% SINCE 1970. THE COMMUNICATION, ELECTRIC AND UTILITY, AND SERVICE INDUSTRIES HAD A HIGHER TOTAL GROWTH (AROUND 30%). THE CONSTRUCTION, AGRICULTURE, AND GOVERNMENT SECTORS ALL HAD LESS THAN 20% GROWTH IN THIS PERIOD. THEREFORE, THEIR RELATIVE SHARE OF TOTAL INCOME DECREASED SLIGHTLY.

Table 6.13
National Income by Industry[a], 1950–1977
(10^6 1975 constant dollars[b])

	1950	1960	1970	1974	1975	1976	1977	1977 %	% increase since 1970
Total national income	572,394	769,289	1,113,165	1,248,253	1,234,054	1,311,191	1,380,535	100.0	24.0
Agriculture	43,352	32,342	34,036	46,245	42,827	38,516	40,041	2.9	17.6
Mining	12,465	10,392	10,870	17,029	18,149	19,265	20,813	1.5	91.5
Construction	28,376	38,830	60,990	68,200	61,795	64,354	69,347	5.0	13.7
Manufacturing[c]	180,839	232,268	299,774	326,392	312,467	344,985	367,132	26.6	22.5
Petroleum and coal products	8,161	8,139	9,230	15,317	12,893	16,485	17,405	1.3	88.6
Transportation equipment and ordnance	5,366	15,304	20,153	15,413	15,715	16,004	17,095	1.2	-15.2
Motor vehicle and equipment	15,610	15,551	16,821	19,410	19,045	26,999	31,225	2.3	85.6
Transportation	31,714	33,588	42,182	48,491	44,455	49,018	52,422	3.8	24.3
(percent of national income)	(5.5)	(4.4)	(3.8)	(3.9)	(3.6)	(3.7)	(3.8)		
Railroad	16,765	12,424	10,594	11,111	9,987	11,227	11,277	0.8	6.4
Local and interurban passenger transit	3,333	2,998	3,212	3,028	2,933	3,071	3,116	0.2	-3.0
Trucking and warehousing	6,729	10,898	16,465	20,484	18,395	19,921	21,666	1.6	31.6
Water	2,429	3,027	3,484	3,622	3,323	3,473	3,729	0.3	7.0
Air	1,123	2,536	6,065	7,577	7,062	8,169	9,074	0.6	49.6
Pipeline	614	648	735	702	820	952	1,119	0.1	52.2
Transportation services	720	1,057	1,627	1,966	1,935	2,203	2,442	0.2	50.1
Communication	7,933	15,234	24,495	26,867	27,066	29,877	31,386	2.3	28.1
Electric, gas, and utility	9,272	16,521	20,688	20,210	24,302	25,886	26,524	1.9	28.2
Wholesale and retail	97,061	119,861	170,095	191,751	194,227	204,648	212,784	15.4	25.1
Finance, insurance, and real estate	54,067	89,998	128,914	140,722	140,375	150,060	159,746	11.6	23.9
Services	51,439	82,666	143,777	164,629	168,516	179,533	191,370	13.9	33.1
Government	55,876	97,587	177,343	197,715	199,875	205,048	208,969	15.1	17.8

[a]Without capital consumption adjustment.

[b]Deflated by the implicit GNP price deflator.

[c]Only select subcategories are listed.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929–1974, Statistical Tables*, Washington, D.C., 1976, pp. 188–89; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 53.

THE PERCENT INCREASE IN WAGES AND SALARIES FOR THE TRANSPORTATION INDUSTRY SINCE 1970 HAS ONLY BEEN ABOUT 78% THAT OF ALL INDUSTRIES. WAGES AND SALARIES DERIVED FROM RAIL, URBAN TRANSIT, AND MARINE ACTIVITIES HAVE DECREASED SINCE 1970 WHILE TRUCKING, AIR, PIPELINE, AND TRANSPORTATION SERVICE HAVE INCREASED.

Table 6.14
Wages and Salaries by Industry, 1950–1977
(10^6 1975 constant dollars[a])

	1950	1960	1970	1974	1975	1976	1977	1977 %	% increase since 1970
Wages and salaries	348,485	503,484	760,547	837,319	805,872	846,086	883,220	100.0	16.1
Agriculture	7,483	6,480	7,403	8,466	8,110	8,787	8,898	1.0	20.2
Mining	7,585	7,323	8,071	9,673	10,823	11,597	12,620	1.4	56.4
Contract construction	18,865	29,115	46,153	51,181	44,998	46,072	47,940	5.4	3.9
Manufacturing[b]	119,194	166,027	220,143	231,658	211,045	225,807	239,128	27.1	8.6
Petroleum and coal products	2,278	2,707	2,804	2,986	3,103	3,327	3,483	0.4	24.2
Transportation equipment and ordance	4,307	13,253	17,293	13,590	13,016	13,103	13,557	1.5	-21.6
Motor vehicles and motor equipment	7,634	8,758	11,312	13,723	11,841	14,431	16,721	1.9	47.8
Transportation	23,342	26,991	33,890	36,934	34,085	36,146	38,127	4.3	12.5
(% of total)	(6.7)	(5.4)	(4.4)	(4.4)	(4.2)	(4.3)	(4.3)		
Railroad	12,273	10,181	8,725	8,959	8,035	8,531	8,702	1.0	- 0.3
Local and interurban passenger transit	2,747	2,394	2,516	2,325	2,269	2,320	2,308	0.3	- 8.3
Trucking and warehousing	4,702	8,439	12,576	15,196	13,560	14,551	15,671	1.8	24.6
Water	1,972	2,550	2,934	2,710	2,593	2,699	2,865	0.3	- 2.4
Air	830	2,348	5,608	6,005	5,894	6,174	6,589	0.7	17.5
Pipeline	277	296	255	255	285	305	314		23.1
Transportation services	519	783	1,276	1,483	1,449	1,566	1,677	0.2	31.4
Communication	5,404	8,263	12,984	15,362	15,250	16,112	16,854	1.9	29.8
Electric, gas, and utility	4,594	6,828	9,304	10,284	10,106	10,615	11,034	1.2	18.6
Wholesale and retail	61,100	84,266	124,909	139,443	135,876	142,865	148,692	16.8	19.0
Finance, insurance, and real estate	13,816	23,242	38,139	42,957	42,403	44,218	46,336	5.2	21.5
Services[b]	33,309	54,210	98,040	115,992	117,678	125,512	133,342	15.1	36.0
Auto repair, services, and garage	1,223	1,868	3,230	3,722	3,641	3,945	4,226	0.5	30.8
Government	53,610	91,002	161,408	175,318	175,441	178,354	180,285	20.4	11.7
Rest of the world	185	-263	102	50	57	-1	-36		-135.3

[a] Deflated by the implicit GNP price deflator.

[b] Only select subcategories are listed.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929–1974, Statistical Tables*, Washington, D.C., 1976, pp. 200-1; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 54.

TOTAL EMPLOYMENT IN THE TRANSPORTATION INDUSTRY HAS INCREASED SLIGHTLY (2.6%) SINCE 1970. THE HIGH DECREASES IN RAIL (-15.6%) AND WATER (-10.1%) EMPLOYMENT WERE OFFSET SOMEWHAT BY A 35% INCREASE IN EMPLOYMENT IN TRANSPORTATION SERVICES. EMPLOYEES INVOLVED DIRECTLY IN TRANSPORTATION COMPRISE ABOUT 3% OF TOTAL U.S. EMPLOYMENT.

Table 6.15
Employment by Industry, 1950–1977
(10^3)

	1950	1960	1970	1974	1975	1976	1977	1977 %	% increase since 1970
Full and part-time employees[a]	52,432	62,743	79,306	85,692	84,123	86,502	89,607	100.0	13.0
Agriculture	2,495	2,088	1,492	1,607	1,615	1,786	1,729	1.9	15.9
Mining	925	698	627	696	748	778	829	0.9	32.2
Contract construction	2,388	2,889	3,557	4,048	3,573	3,615	3,866	4.3	8.7
Manufacturing[b]	15,232	16,755	19,410	20,069	18,320	19,029	19,724	22.0	1.6
Petroleum and coal products	217	207	189	190	189	195	199	0.2	5.3
Transportation equipment	487	1,078	1,251	962	914	910	931	1.0	-25.6
Motor vehicles and equipment	801	717	813	910	786	877	951	1.1	17.0
Transportation	2,784	2,562	2,696	2,780	2,623	2,670	2,767	3.1	2.6
(% of total)	(5.3)	(4.1)	(3.4)	(3.2)	(3.1)	(3.1)	(3.1)		
Railroad	1,373	885	626	579	530	528	528	0.6	-15.6
Local and interurban passenger transit	359	282	285	275	268	267	267	0.3	- 6.3
Trucking and warehousing	626	866	1,080	1,202	1,112	1,148	1,213	1.4	12.3
Water	239	233	218	204	194	193	196	0.2	-10.1
Air	87	191	353	369	366	371	387	0.4	9.6
Pipeline	27	23	17	16	17	18	18		5.9
Transportation services	73	82	117	135	136	145	158	0.2	35.0
Communications	727	839	1,123	1,194	1,177	1,168	1,189	1.3	5.9
Electric, gas, and utility	548	614	691	743	732	735	749	0.8	8.4
Wholesale and retail	9,369	11,434	15,266	17,107	17,142	17,853	18,668	20.8	22.3
Finance, insurance, and real estate	1,931	2,705	3,713	4,228	4,249	4,338	4,518	5.0	21.7
Services[b]	7,149	9,747	13,490	15,311	15,702	16,309	17,181	19.2	27.4
Auto repair, services, and garage	206	268	386	442	441	470	504	0.6	30.6
Government	8,884	12,412	17,241	17,909	18,242	18,221	18,387	20.5	6.6

[a]Employment in domestic industries only.

[b]Only select subcategories are listed.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929–1974, Statistical Tables*, Washington, D.C., 1976, pp. 204–5; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 54.

THE EMPLOYMENT FIGURES BELOW WERE COMPILED BY THE TRANSPORTATION ASSOCIATION OF AMERICA (TAA). THEY INCLUDE BOTH EMPLOYEES DIRECTLY INVOLVED IN TRANSPORTATION AND EMPLOYEES INVOLVED IN RELATED AREAS SUCH AS TRANSPORTATION EQUIPMENT MANUFACTURING AND GOVERNMENT BUREAUCRACIES. ACCORDING TO THE TAA FIGURES, U.S. EMPLOYMENT IN TRANSPORTATION AND RELATED INDUSTRIES IS ABOUT 11% OF THE TOTAL CIVILIAN LABOR FORCE.

Table 6.16
U.S. Employment in Transportation and Related Industries[a]
(10^3 number of persons employed)

	1950	1960	1970	1975	1976	1977	% increase since 1970
Transportation service	2,625	2,364	2,436	2,294	2,307	2,347	- 3.6
Air	86	191	351	362	370	380	8.3
Bus, intercity and rural	47	41	43	39	40	39	- 9.3
Local transport	157	101	77	69	69	68	-11.7
Railroads	1,391	885	627	538	528	534	-14.8
Oil pipeline	29	23	18	17	17	17	- 5.6
Taxi	121	121	107	83	77	72	-32.7
Trucking and trucking terminals	557	770	998	996	1,009	1,038	4.0
Water	237	232	215	190	197	199	- 7.4
Transportation equipment manufacturing	1,379	1,692	1,915	1,767	1,830	1,921	0.3
Aircraft and parts	283	646	669	514	484	479	-28.4
Motor vehicles and equipment	926	829	914	892	948	1,013	10.8
Railroad equipment	60	43	51	52	43	46	- 9.8
Ship and boat building and repair	85	141	170	194	214	226	32.9
Other transportation equipment	25	33	111	115	141	157	41.4
Transportation-related industries	3,215	3,989	4,693	4,880	5,016		
Automotive and accessory retail dealers	652	807	996	1,076	1,116	1,152	15.7
Automotive wholesalers	176	215	320	367	380	394	23.1
Automotive services and garages	161	251	384	400	447		
Gasoline service stations	343	453	614	616	627	624	1.6
Highway and street construction	210	294	331	297	299	339	2.4
Petroleum refining	282	311	333	380	397	427	28.2
Other industries							
Truck drivers and deliverymen	1,131	1,418	1,356	1,325	1,319	1,313	- 3.2
Shipping and receiving clerks	260	240	359	419	431	443	23.4
Government transportation employees	491	671	789	788	763		
U.S. Department of Transportation[b]	18	38	66	75	74	75	13.6
Highway employees — state and local	380	532	607	604	582		
Post office	75	83	104	98	94	91	-12.5
Other[c]	18	18	12	13	13	13	8.3
Total transportation employment	7,710	8,716	9,833	9,729	9,916		
Total employed civilian labor force	58,920	65,778	78,627	84,783	87,485	90,546	15.2
Percent transportation of total	13.1	13.3	12.5	11.5	11.3		

[a]These figures were derived by the research staff of the Transportation Association of America. For a discussion of the methodology used see the referenced document.

[b]DOT was established in 1966; prior years' figures are for the Federal Aviation Administration only.

[c]Include ICC, CAB, Maritime Administration, Railroad Retirement Board, and Coast Guards.

Source: Transportation Association of America, *Transportation Facts and Trends*, 12 ed., Washington, D.C., July 1976, p. 23; *Transportation Facts and Trends*, Quarterly Supplement, Washington, D.C., April 1977, p. 23; *Transportation Facts and Trends*, Quarterly supplement, Washington, D.C., April 1978, p. 23.

Table 6.17
Employment and Establishments for Selected Motor-Vehicle-Related Businesses, 1967 and 1972

Kind of business	Establishments[a] (1,000) 1967	Establishments[a] (1,000) 1972	Paid employees[b] (1,000) 1967	Paid employees[b] (1,000) 1972
Retail trade				
Automotive dealers	105.5	131.8	906.8	1,073.0
Motor vehicle dealers — new and used cars			696.3	765.6
Motor vehicle dealers — used cars only	62.0	64.2	38.6	39.4
Tire, battery, and accessory dealers	29.2	37.5	129.6	167.7
Misc. automotive dealers	14.3	30.1	42.2	100.3
Gasoline service stations	213.1	226.5	575.2	747.7
Wholesale trade				
Motor vehicles and auto equipment	31.2	35.6	341.1	391.8
Automobiles and other motor vehicles	4.8	5.6	91.9	102.3
Automotive equipment	23.3	27.0	214.1	246.1
Tires and tubes	3.1	3.0	35.1	43.4
Services				
Auto repairs, services, and garages	139.2	169.0	316.2	392.5
Automobile repair shops	109.9	127.2	187.9	237.9
Automobile parking	10.6	10.5	33.5	37.3
Car and truck rental and leasing other services	18.7	31.3	95.0	117.3
Manufacturing				
Motor vehicles and equipment	2.7	3.4	739.4	806.6
Motor vehicles	0.2	0.2	321.2	339.2
Motor vehicle parts and accessories	1.7	2.1	364.9	399.9
Truck and bus bodies	0.6	0.8	30.4	42.8
Truck trailers	0.2	0.3	22.9	24.7

[a] As of December 31, represents all establishments (except for wholesale trade and manufacturing which represent only establishments employing one or more workers at any time during the year).

[b] Workweek including March 12, except quarterly average for manufacturing.

Source: U.S. Department of Commerce, Bureau of the Census, *Census of Manufacturers: 1972*, Series Mc 72(2), Washington, D.C., 1973.

A SUMMARY OF ANNUAL BUDGETS FOR A FOUR-PERSON FAMILY AT THREE BUDGET LEVELS IN THE URBAN U.S. IN AUTUMN 1977 AND THE PERCENT INCREASE IN THE BUDGETS SINCE 1976 ARE PRESENTED BELOW. DUE TO THE INCOME TAX POLICY CHANGE, PERSONAL INCOME TAXES DECREASED APPROXIMATELY 13% FOR THE LOWER BUDGET AND INCREASED 5% AND 9% FOR THE INTERMEDIATE AND HIGHER BUDGET RESPECTIVELY.

Table 6.18
Autumn 1977 Urban Family Budgets and Percent Change Since 1976[a]
(in current dollars)

	Lower budget	% increase 1976-1977	Intermediate budget	% increase 1976-1977	Higher budget	% increase 1976-1977
Total budget	10,481	4.4	17,106	5.4	25,202	6.1
Total family consumption	8,657	6.1	13,039	5.4	17,948	5.3
Food	3,190	6.2	4,098	6.2	5,159	6.2
Housing	2,083	6.1	4,016	4.5	6,085	4.5
Transportation	804	4.8	1,472	4.9	1,913	4.9
(% of total)	(9.3)		(11.3)		(10.6)	
Clothing	828	3.6	1,182	3.6	1,730	3.6
Personal care	282	6.4	377	6.2	535	6.4
Medical care	980	9.4	985	9.4	1,027	9.4
Other family consumption	489	4.5	909	4.6	1,499	4.5
Other items	472	4.7	763	4.4	1,288	4.4
Taxes and deductions	1,352	- 5.4	3,303	5.4	5,965	8.9
Social security and disability	632	4.6	961	7.0	985	8.1
Personal income taxes	720	-12.7	2,342	4.7	4,980	9.1

[a]The budgets represent the costs of three hypothetical lists of goods and services that were specified in the mid-1960s and updated annually. These budgets are for a precisely defined urban family of four: a 38-year-old husband employed full time, his nonworking wife, a boy of 13, and a girl of 8. After about 15 years of married life, the family is settled in the community and the husband is an experienced worker.

Source: U.S. Department of Labor, Bureau of Labor Statistics, *Autumn 1977 Urban Family Budgets and Comparative Indexes for Selected Urban Areas*, USDL: 78-393, Washington, D.C., April 26, 1978.

THE IMPLICIT PRICE DEFLATOR OF THE GNP REPRESENTS A GIVEN YEAR'S GNP AT CURRENT PRICES AS A RATIO TO THE SAME YEAR'S GNP VALUED AT THE PRICES OF A BASE YEAR (HERE CONSTANT 1975 PRICES). AS SUCH, IT IS AN INDEX OF THE GENERAL PRICE LEVEL IN THE ECONOMY. THE INDEX OF PERSONAL CONSUMPTION EXPENDITURES IS THAT COMPONENT OF THE IMPLICIT PRICE DEFLATOR WHICH MEASURES THE PRICE LEVEL CHANGES OF PERSONAL CONSUMPTION GOODS. IT DIFFERS FROM THE CONSUMER PRICE INDEX IN THAT IT IS AN INDEX OF THE PRICE LEVEL AFFECTING ALL CONSUMERS WHILE THE CPI IS INTENDED TO COVER ONLY URBAN WAGE EARNERS AND CLERICAL WORKERS.

Table 6.19
Implicit Price Deflator (1975 = 100)

	GNP	Personal consumption expenditures
1950	42.19	44.94
1951	45.04	47.86
1952	45.62	48.97
1953	46.31	49.92
1954	46.94	50.32
1955	47.96	50.79
1956	49.47	51.82
1957	51.14	53.48
1958	51.95	54.67
1959	53.10	55.70
1960	54.01	56.72
1961	54.49	57.36
1962	55.49	58.23
1963	56.30	59.10
1964	57.18	59.89
1965	58.45	61.00
1966	60.37	62.74
1967	62.15	64.32
1968	64.94	66.93
1969	68.20	70.02
1970	71.85	73.18
1971	75.52	76.42
1972	78.65	79.11
1973	83.21	83.46
1974	91.25	92.48
1975	100.00	100.00
1976	105.20	105.30
1977	111.37	111.31

Source: U.S. Department of Commerce, Bureau of Economic Analysis, *The National Income and Product Accounts of the United States, 1929-1974*, Statistical Tables, Washington, D.C., 1976, pp. 264-265; *Survey of Current Business*, 57, No. 7, Washington, D.C., July 1977, p. 53; *Survey of Current Business*, 58, No. 7, Washington, D.C., July 1978, p. 61.

THE CONSUMER PRICE INDEX (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 BASE YEAR (HERE CONSTANT 1975) PRICES. THE CPI IS THUS A MEASURE OF THE PURCHASING POWER OF A "TYPICAL" CONSUMER'S DOLLAR. OVER THE PAST TEN YEARS, THE TRANSPORTATION COMPONENT HAS RISEN SLIGHTLY LESS THAN THE CPI AS A WHOLE. HOWEVER, THE TRANSPORTATION COMPONENT HAS INCREASE MORE SINCE 1973.

Table 6.20
Consumer Price Indexes, 1950–1978
(1975 = 100)

	All items	Purchasing power of the dollars	Transportation	New cars	Used cars	Gasoline
1950	44.7	2.23	45.3	65.4		
1951	48.3	2.07	48.1	68.5		
1952	49.3	2.03	51.3	74.4		
1953	49.7	2.01	52.8	75.1	60.9	
1954	49.9	2.00	52.0	73.9	51.8	
1955	49.8	2.01	51.4	71.2	49.0	
1956	50.5	1.98	52.4	73.3	47.2	
1957	52.3	1.91	55.3	77.1	52.9	
1958	53.7	1.86	57.2	79.5	54.8	
1959	54.2	1.84	59.5	83.0	61.1	
1960	55.0	1.81	59.5	81.9	57.1	54.2
1961	55.6	1.80	60.2	81.9	59.4	
1962	56.2	1.78	61.4	81.6	64.8	
1963	56.9	1.76	61.8	81.1	65.6	
1964	57.6	1.73	62.6	80.9	68.4	
1965	58.6	1.70	63.7	79.1	67.9	55.6
1966	60.3	1.66	64.6	77.7	66.3	
1967	62.0	1.61	66.4	78.4	68.3	
1968	64.6	1.55	68.5	80.6	NA	
1969	68.1	1.47	71.2	81.8	70.4	
1970	72.1	1.38	74.8	84.3	71.2	61.3
1971	75.2	1.33	78.8	87.8	75.3	61.8
1972	77.7	1.29	79.6	87.0	75.5	63.0
1973	82.6	1.21	82.2	87.1	80.3	69.1
1974	91.6	1.09	91.4	92.1	83.7	93.6
1975	100.0	1.00	100.0	100.0	100.0	100.0
1976	105.8	0.94	109.9	106.3	114.7	104.2
1977	112.6	0.89	117.7	112.0	124.9	110.2
1978, April	118.8	0.84	120.2	118.5	121.1	111.4

Source: U.S. Bureau of Labor Statistics, monthly data in *Monthly Labor Review*.

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APPENDIX

CONVERSIONS

Conversion of Constant Dollar Values

Many types of information in this Data Book are expressed in dollar values. For example, the price of a barrel of oil, the Gross National Product, the incomes earned by the households, and the price of a gallon of gasoline are all expressed in dollar values. Generally, constant dollars are used. That is, dollars of a fixed value for a specific year such as 1975 dollars.

To convert current dollars to constant dollars, or to convert constant dollars for one year to constant dollars for another year, requires conversion factors such as those in the two tables on this page.

The first table shows conversion factors using the Gross National Product (GNP) inflation factors. These factors allow one to convert the GNP value expressed in 1975 dollars to the 1977 dollars by multiplying times 1.110.

The second table shows conversion factors for the Consumer Price Index (CPI) inflation factors. The base year (constant dollar year) for GNP estimates is 1972, and 1967 is the base year (constant dollar year) for CPI estimates.

Note that the CPI values do not show changes as large as those for the GNP values, but the two indices do move together.

Table A.1. GNP Inflation Index (base year = 1972)

	To				
From	1958	1967	1972	1975	1977
1958	1.000	0.837	0.661	0.520	0.468
1967	1.195	1.000	0.790	0.621	0.559
1972	1.513	1.266	1.000	0.786	0.708
1975	1.912	1.610	1.272	1.000	0.901
1977	2.122	1.787	1.413	1.110	1.000

Table A.2. CPI Inflation Index (base year = 1967)

	To				
From	1958	1967	1972	1975	1977
1958	1.000	0.866	0.691	0.537	0.508
1967	1.155	1.000	0.798	0.620	0.586
1972	1.447	1.253	1.000	0.777	0.735
1975	1.861	1.612	1.287	1.000	0.945
1977	1.969	1.705	1.361	1.058	1.000

Table A.3
Nomenclature and Powers of Ten

	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	d
UNITY	10^{0}		
Ten	10^{1}	deca	da
One hundred	10^{1}	hecto	h
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 A.4
Standard Metric Units and Abbreviations

Parameter	Base unit name	Preferred unit and prefix
Energy	Megajoule	MJ
Specific energy	Megajoule/kilogram	MJ/kg
Specific energy consumption	Megajoule/kilogram•kilometer	MJ/kg•km
Energy consumption	Megajoule/kilometer	MJ/km
Energy economy	Kilometre/kilojoule	km/KJ
Power	Kilowatt	kw
Specific power	Watt/kilogram	W/kg
Power density	Watt/metre^3	W/m^3
Speed	Kilometer/hour	km/h
Acceleration	Meter/second^2	m/s^2
Range (distance)	kilometre	km
Weight	Kilogram	kg
Torque	Newton•metre	N•m
Volume	Metre^3	m^3
Mass; payload	Kilogram	kg
Length; width	Metre	m
Brake specific fuel consumption	Kilogram/megajoule	kg/MJ
Fuel economy (heat engine)	Kilometer/litre	km/l

Table A.5
Energy Use and Production-Related Conversions

Heat Values of Fuels	
Coal	
Anthracite	25.4×10^6 Btu/short ton = 29.7 MJ/kg
Bituminous	26.2×10^6 Btu/short ton = 30.6 MJ/kg
Lignite	12.4×10^6 Btu/short ton = 14.5 MJ/kg
Bituminous and lignite	
Production av	23.5×10^6 Btu/short ton = 27.5 MJ/kg
Consumption av	22.8×10^6 Btu/short ton = 26.7 MJ/kg
Natural gas	
Wet	1,095 Btu/ft^3 = 40.79 MJ/kg
Dry	1,021 Btu/ft^3 = 38.04 MJ/kg
Liquid	95,800 Btu/gal = 3569 MJ/kg
Crude petroleum	138,100 Btu/gal = 5145 MJ/kg
Fuel oils	
Residual	149,700 Btu/gal = 41.73 MJ/liter
Distillate	138,700 Btu/gal = 38.66 MJ/liter
Automotive gasoline	125,000 Btu/gal = 34.84 MJ/liter
AVGAS	124,000 Btu/gal = 34.56 MJ/liter
Jet fuel (naphtha)	127,500 Btu/gal = 35.54 MJ/liter
Jet fuel (kerosene)	135,000 Btu/gal = 37.63 MJ/liter
Lubricants	144,400 Btu/gal = 40.25 MJ/liter
Waxes	131,800 Btu/gal = 36.74 MJ/liter
Asphalt and road oil	158,000 Btu/gal = 44.04 MJ/liter
Petroleum coke	143,400 Btu/gal = 39.97 MJ/liter

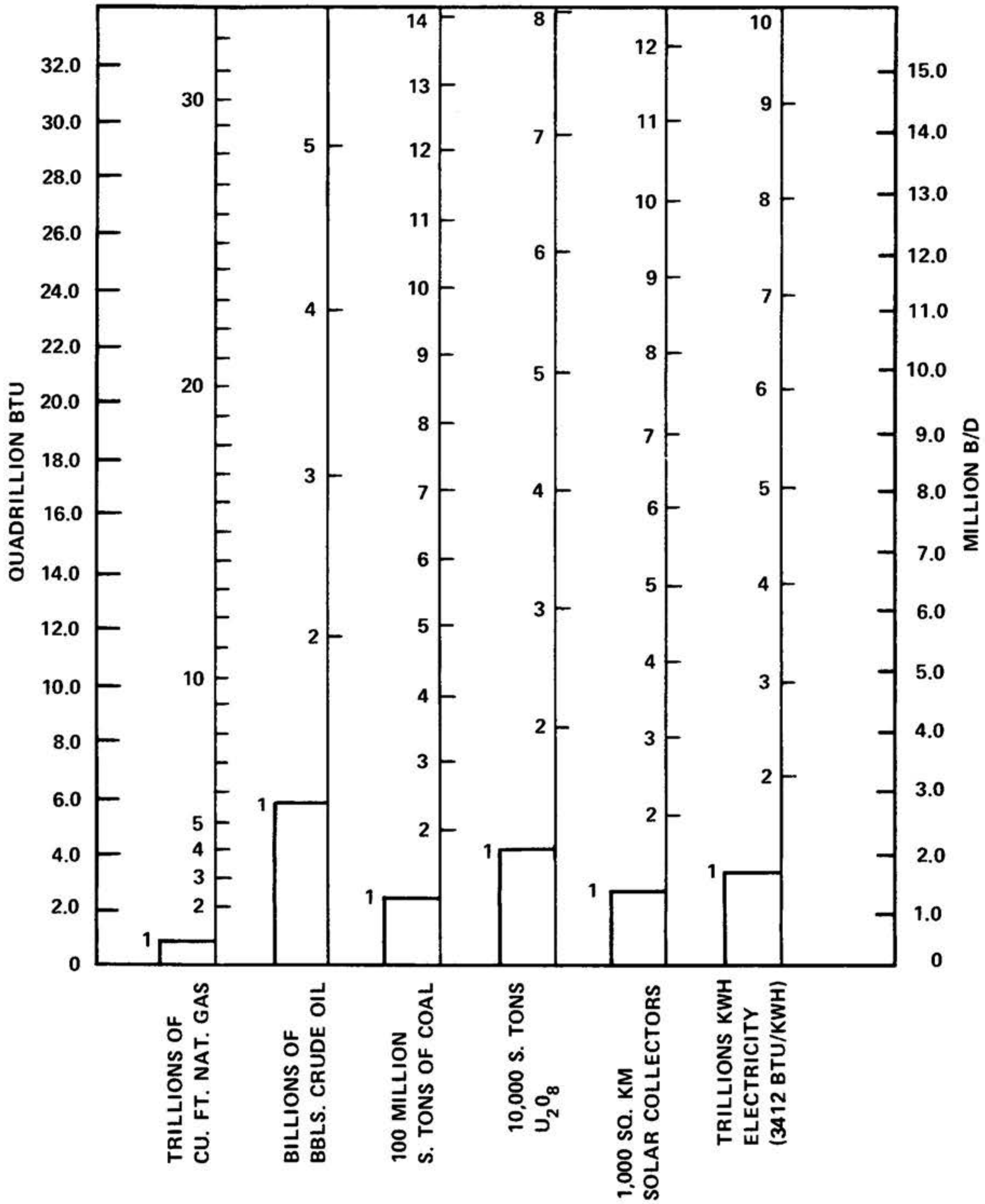

Fig. A.1
Gross Measures of Annual Energy Supply/Demand Commonly Used in the United States.

Table A.6
Alternative 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
	= 246.1 thousand short tons coal/day
	= 90.09 million short tons coal/year
	= 5.681 billion ft^3 natural gas/day
	= 2.074 trillion ft^3 natural gas/year
	= 22.33×10^{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
	= 676.2 thousand short tons coal/day
	= 246.8 million short ton coal/year
	= 15.56 billion ft^3/day natural gas/day
	= 5.68 trillion ft^3/year natural gas/day
	= 61.19×10^{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
	= 42.55 thousand short tons coal/day
	= 15.53 million short tons coal/year
	= 979.4 thousand ft^3 natural gas/day
	= 357.5 billion ft^3 natural gas/year
	= 38.51×10^{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
	= 116.6 thousand short tons coal/day
	= 42.55 million short tons coal/year
	= 2.683 billion ft^3 natural gas/day
	= 979.4 billion ft^3 natural gas/year
	= 10.55×10^{11} MJ/year
1 million short tons coal/day	= 4.052 million bbl/day crude oil
	= 1.479 billion bbl/year crude oil
	= 23.50 trillion Btu/day
	= 8.578 quadrillion Btu/year
	= 365.0 million short tons coal/year
	= 23.02 billion ft^3 natural gas/day
	= 8.401 trillion ft^3 natural gas/year
	= 90.50×10^{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
	= 2.734 million short tons coal/day
	= 63.06 billion ft^3 natural gas/day
	= 23.02 trillion ft^3 natural gas/year
	= 24.79×10^{12} MJ/year
1 billion ft^3 natural gas/day	= 0.1760 million bbl/day crude oil
	= 64.25 million bbl/year crude oil
	= 1.021 trillion Btu/day
	= 0.3727 quadrillion Btu/year
	= 43.45 thousand short tons coal/day
	= 15.86 million short tons coal/year
	= 365.0 billion ft^3 natural gas/year
	= 39.32×10^{10} 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
	= 119.0 thousand short tons coal/day
	= 43.45 million short tons coal/year
	= 2.740 billion ft^3 natural gas/day
	= 10.77×10^{11} MJ/year
1 mega joule/year	= 44.78×10^{-8} bbl/day crude oil
	= 16.34×10^{-5} bbl/year crude oil
	= 2.597 Btu/day
	= 947.9 Btu/year
	= 11.05×10^{-8} short tons coal/day
	= 4.034×10^{-5} short tons coal/year
	= 25.43×10^{-4} ft^3 natural gas/day
	= 0.9285 ft^3 natural gas/year

Table A.7
Energy Unit Conversions

1 Btu = 778.2 ft-lb	1 kWhr = 3412 Btu
= 107.6 kg-m	= 2.655×10^{6} ft-lb
= 1055 J	= 3.671×10^{5} kg-m
= 39.30×10^{-5} hp-hr	= 3.60×10^{6} J
= 39.85×10^{-5} metric hp-hr	= 1.341 hp-hr
= 29.31×10^{-5} kWhr	= 1.360 metric hp-hr
1 kg-m = 92.95×10^{-4} Btu	1 J = 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-hr	= 37.25×10^{-8} hp-hr
= 37.04×10^{-7} metric hp-hr	= 37.77×10^{-8} metric hp-hr
- 27.24×10^{-7} kWhr	= 27.78×10^{-8} kWhr
1 hp-hr = 2544 Btu	1 metric hp-hr = 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-hr	= 0.9863 hp-hr
= 0.7475 kWhr	= 0.7355 kWhr

Table A.8
Distance and Velocity Conversions

1 in. = 83.33×10^{-3} ft	1 ft = 12.0 in.
= 27.78×10^{-3} yd	= 0.333 yd
= 15.78×10^{-6} mile	= 189.4×10^{-3} mile
= 25.40×10^{-3} m	= 0.3048 m
= 0.2540×10^{-6} km	= 0.3048×10^{-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/sec = 0.6818 mph = 1.0972 km/hr

1 m/sec = 3.281 ft/sec = 2.237 mph = 3.600 km/hr

1 km/hr = 0.9114 ft/sec = 0.2778 m/sec = 0.6214 mph

1 mph = 1.467 ft/sec = 0.4469 m/sec = 1.609 km/hr

Table A.9
Force 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	102.0	737.6	0.9478
Metric horsepower	0.9863	0.7355	1	542.5	0.1757	0.6971
Ft-lb per sec	1.82×10^{-3}	1.356×10^{-3}	1.84×10^{-3}	1	0.3238×10^{-3}	1.285×10^{-3}
Kilocalories per sec	5.615	4.187	5.692	3088	1	3.968
Btu per sec	1.415	1.055	1.434	778.2	0.2520	1

Table A.10
Energy Intensity and Efficiency Conversions

1000 Btu/mile = 621.5 Btu/km
= 66.86×10^3 kg-m/km
= 655.6 kJ/km
= 1.53 km/MJ
= 0.2931 kWhr/mile
= 0.1822 kWhr/km
= 125.0 mpg[a]
= 1.882 liter/100 km

1000 Btu/km = 1609 Btu/mile
= 107.6×10^6 kg-m/km
= 1055 kJ/km
= 0.9479 km/MJ
= 0.4716 kWhr/mile
= 0.2931 kWhr/km
= 77.67 mpg[a]
= 3.028 liter/100 km

10 mpg[a] = 12,500 Btu/mile
= 7767 Btu/km
= 835.8×10^3 kg-m/km
= 8195 kJ/km
= 0.1220 km/MJ
= 3.664 kWhr/mile
= 2.277 kWhr/km
= 23.52 liter/100 km[a]

10 liter/100 km[a] = 5315 Btu/mile
= 3302 Btu/km
= 355.4×10^3 kg-m/km
= 3484 kJ/km
= 0.2870 km/MJ
= 1.558 kWhr/mile
= 0.9683 kWhr/km
= 23.52 mpg[a]

1000 kJ/km = 1525 Btu/mile
= 947.8 Btu/km
= 102.0×10^3 kg-m/km
= 1 km/MJ
= 0.4469 kWhr/mile
= 0.2778 kWhr/km
= 81.97 mpg[a]
= 2.869 liter/100 km[a]

1 kWhr/mile = 3412 Btu/mile
= 2120 Btu/km
= 228.1×10^3 kg-m/km
= 2237 kJ/km
= 0.4470 km/MJ
= 0.6214 kWhr/km
= 36.64 mpg[a]
= 6.419 liter/100 km[a]

[a]Assuming automotive gasoline at 125,000 Btu/gal.

Table A.11
Volumetric and Flow Rate Conversions

The conversions for flow rates are identical to those for volumetric measures, provided the time units are identical.

1 U.S. gal	= 231 in.^{3}	1 liter	= 61.02 in.^{3}
	= 0.1337 ft^3		= 3.531×10^{-2} ft^3
	= 3.785 liters		= 0.2624 U.S. gal
	= 0.8321 Imperial gal		= 0.2200 Imperial gal
	= 0.1781 bbl		= 6.29×10^{-3} bbl
	= 7.500 lb foreign crude[a]		= 1.982 lb foreign crude[a]
	= 7.034 lb domestic crude[a]		= 1.858 lb domestic crude[a]
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
	= 0.2139 bbl		= 34.97 Imperial gal
	= 9.007 lb foreign crude[a]		= 315.0 lb foreign crude[a]
	= 8.4472 lb domestic crude[a]		= 295.4 lb domestic crude[a]

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
	= 4.274 bbl/day	= 1560 bbl/year
	= 216.2 lb foreign crude/day[a]	= 78901 lb foreign crude/day[a]
	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
	= 47.57 lb foreign crude/day[a]	= 17362 lb foreign crude/year[a]
	= 44.59 lb domestic crude/day[a]	= 16276 lb domestic crude/year[a]
1 bbl/hr	= 137.8 ft^3/day	= 49187 ft^3/year
	= 1008 U.S. gal/day	= 3.679×10^5 U.S. gal/year
	= 839.3 Imperial gal/day	= 3.063×10^5 Imperial gal/year
	= 3815 liter/day	= 1.393×10^6 liter/day
	foreign crude[a]	
	= 7560 lb/day	= 2.759×10^6 lb/year
	= 3.780 short tons/day	= 1380 short tons/year
	= 3.375 long tons/day	= 1232 long tons/year
	domestic crude[a]	
	= 7090 lb/day	= 2.588×10^6 lb/year
	= 3.545 short tons/day	= 1294 short tons/year
	= 3.165 long tons/day	= 1155 long tons/year

[a]Assuming representative specific gravities of 25.6 for foreign crude oil and 36.0 for domestic crude oil.

AIR CARRIER, DOMESTIC OPERATIONS: Operations within and between the 50 states and the District of Columbia. Includes domestic operations of the certificated trunk carriers and Pan American's intra-national flights, the local service, helicopter, intra-Alaska, intra-Hawaii, domestic all-cargo and other carriers. It also includes transborder operations conducted on the domestic route segments of U.S. air carriers.

AIR CARRIER, INTERNATIONAL OPERATIONS: Operations outside the territory of the United States; includes operations between the United States and foreign countries and between the United States and its territories and possessions. Includes both the combination passenger/cargo and all-cargo carriers engaged in international and territorial operations.

AIRCRAFT OPERATION: An aircraft arrival at, or departure from, an airport with FAA airport traffic control service. There are two types of operations — local and itinerant.

1. Local operations are performed by aircraft which:
   (a) operate in the local traffic pattern or within sight of the tower;
   (b) are known to be departing for, or arriving from, flight in local practice areas located within a 20-mile radius of the control tower;
   (c) execute simulated instrument approaches or low passes at the airport.
2. Itinerant operations:

   All aircraft arrivals and departures other than local operations.

AIRCRAFT TYPE: A term used in grouping aircraft by basic configuration — fixed-wing, rotorcraft, glider, dirigible, and ballon.

AIR TAXI OPERATIONS: Air taxi operations and commuter air carrier operations (takeoffs and landings) carrying passengers, mail, or cargo for revenue in accordance with Federal Air Regulations (FAR) Part 135 or Part 121.

AIR TRAFFIC HUB: A city and/or Standard Metropolitan Statistical Area requiring aviation services; it is <u>not</u> an airport. Communities fall into four classes as determined by <u>each</u> community's percentage of the total enplaned passengers in scheduled service of the fixed-wing operations of the domestic certificated route air carriers in the 50 states, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration.

ALCOHOL FUELS: Alcohols such as methanol and ethanol that are capable of being blended with gasoline for use in automobile engines.

ALL-CARGO CARRIER: One of a class of air carriers holding certificates of public convenience and necessity (issued by the Civil Aeronautics Board) authorizing the performance of scheduled air freight and express and mail transportation over specified routes as well as the conduct of nonscheduled operations, which may include passengers.

ALTERNATE FUELS: Refers to those fuel forms other than petroleum which may be suitable for use by the transportation sector.

AMTRAK (AMERICAN RAILROAD TRACKS): Operated by the National Railroad Passenger Corporation of Washington, D.C. 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.

ANNUAL-MILES PER AUTOMOBILE: According to the Federal Highway Administration: average miles traveled by all passenger automobiles in one year.

API: American Petroleum Institute.

ASPHALT: A petroleum product extracted as a refining residue or by solvent precipitation from residual fractions. Solid or semisolid at normal temperatures, asphalt liquefies when heated. It is a sticky adhesive and a highly waterproof, durable material in which the predominating constituents are bitumens.

AVIATION GASOLINE (AVGAS): All special grades of gasoline for use in aviation reciprocating engines, as given in 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 (i.e., any refinery operation except mechanical blending). Also includes 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.

BIOMASS (BIOSOLAR) CONVERSION: The production of fuel or energy from organic matter, whether it be plant material, animal manure, municipal sewage sludge, or solid waste. Conversion techniques can be grouped into two categories: thermal and biological systems. Thermal systems include direct or mass burning, pyrolysis, and hydrogenation. Biological systems use digestion by anaerobic bacteria to produce methane gas.

BIOSOLAR CONVERSION: See BIOMASS CONVERSION.

BONDED FUELS: Fuels produced outside the customs limits of the United States, held in bond under continuous U.S. customs custody in accordance with Treasury Department Regulations, and destined for use outside of the United States, its territories, or possessions.

BOWRIDER RUNABOUT: Any boat of the runabout type having a cockpit or seating inset in the forward deck, usually forward of the windshield provided for the operator. This type includes some bass boats, console fishing boats, jersey speed skiffs, etc.

BREEDER REACTOR: A reactor which produces fissionable fuel as well as consumes it and usually creates more than it consumes. The new fissionable material is created by capture in fertile materials of neutrons from fission.

BTU — BRITISH THERMAL UNIT: The amount of heat required to raise the temperature of one pound of water one degree Fahrenheit.

BUNKER C/NUMBER 6 FUEL OIL: A high viscosity oil used mostly by ships, industry, and large-scale heating installations. This heavy fuel requires preheating in the storage tank to permit pumping and additional preheating to permit atomizing at the burners.

BUS (INCLUDING SCHOOL BUSES): A motor vehicle with a long body equipped with seats or benches for passengers, usually operating as part of a scheduled service line.

BUSINESS CORPORATE FLEET: Business entities that are engaged in a commercial enterprise but find the need for transportation as an adjunct to their businesses.

CABIN CRUISER: Typically a craft of more than 18 feet in length having an enclosed cabin or accommodation spaces providing for one or more of the following: berths, galley, toilet, salon. Usually powered by one or more outboard engines or inboard/outboard. May have any hull shape including catamarans. May have a steadying sail but not a sail for propulsion. Other names are express cruiser, day cruiser, motor yacht, sedan, and trawler yacht.

CANOE: Small, lightweight craft which is relatively long and narrow, usually propelled by paddles, although may be fitted for sail or a motor. Typically 13 feet to 17 feet long with a maximum beam of less than 3 feet. Some versions are as long as 30 feet with the same proportions. Usually open but may be fitted with a lightweight deck or spray covers. Bottom shape is usually symmetrical fore and aft with rounded sections. Other names are piroque, dugout, skinboat, Canadienne, and duckboat. Construction material is aluminum, plastic, fiberglass, wood, or wood and canvas.

CAPTIVE IMPORTS: Those products produced overseas specifically for domestic manufacturers.

CARBON DIOXIDE (CO_2): A colorless, odorless, nonpoisonous gas that is a normal part of the ambient air; CO_2 is a product of fossil fuel combustion.

CARBON MONOXIDE (CO): A colorless, odorless, highly toxic gas that is a normal byproduct 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 through one mile.

CARGO TON-MILE: The transportation of one ton of freight a distance of one mile.

CARGO VEHICLE: A truck which carries goods or merchandise (freight).

CATALYSIS: A process in which the rate of chemical reaction is hastened or retarded by contact with an unrealted substance called the catalyst, which is a substance capable of changing the rate of a reaction without itself undergoing any net change.

CATALYTIC CONVERTORS: All domestic cars, and most imports, manufactured in recent years are equipped with catalytic convertors. These devices use the catalysts platinum and paladium to enhance the chemical control of hydrocarbon and carbon monoxide emissions and result in better-tuned engines that deliver higher performance and greater fuel economy. Nevertheless, some drawbacks to these systems do exist. Catalytic convertors require the use of more-expensive unleaded gasolines because lead (and antiknock additives) chemically poison the catalysts, which results in the release of dangerous pollutants until the converter is replaced. Such replacement is expensive because of the relative unavailability of platinum and paladium.

CEILING PRICE: The maximum permissible selling price, prior to February 1, 1976, for a particular grade of domestic crude oil in a particular field was the May 15, 1973, posted price plus $1.35 per barrel.

CERTIFICATED AIR CARRIER: One of a class of air carriers holding certificates of public convenience and necessity (issued by the Civil Aeronautics Board) authorizing the performance of scheduled air transportation over specified routes and a limited amount of nonscheduled operations. This general carrier grouping includes the all-purpose carriers (i.e., the so-called passenger/cargo carriers) and the all-cargo carriers and comrises all of the airlines certificated by the Board except the supplemental air carriers. Certificated route air carriers are often referred to as "scheduled airlines," although they also perform nonscheduled service.

CHASSIS: The frame, wheels, and machinery of a motor vehicle on which the body is supported.

CHASSIS WITHOUT CAB: A unit in which a body or other equipment is installed after the chassis is shipped from the assembly plant.

CIRCUITY FACTOR RATIO: The ratio of total distance traveled to the minimum intercity distance.

CIVILIAN POPULATION: See Population, Civilian.

CLASS A CARRIERS BY INLAND AND COASTAL WATERWAYS: A carrier with an average annual operating revenue that exceeds $500,000.

CLASS B CARRIERS BY INLAND AND COASTAL WATERWAYS: A carrier with an average annual operating revenue greater than $100,000 but less than $500,000.

CLASS I RAILROAD: A railroad with an annual operating revenue of greater than $10,000,000. These operating companies represent about 99% of the railroad industry in terms of traffic, operate 96% of rail mileage, and account for 94% of the workers employed by all railroad companies.

CLASS II RAILROAD: A railroad with an annual operating revenue less than $10,000,000.

COAL: A solid, brittle, more or less distinctly stratified combustible carbonaceous rock formed by partial to complete decomposition of vegetation. It varies in color from dark brown to black, is not fusible without decomposition, and is very insoluble. Coals can be ranked or divided into the following classes: (1) lignite, (2) sub-bitumonous, (3) bituminous, (4) semibituminous, (5) semianthracite, and (6) anthracite.

COAL GASIFICATION: The conversion of coal to gas which is suitable for use as a fuel. The gas produced may be categorized as:

HIGH-BTU GAS: Consists essentially of methane (CH_u), has a heating value of approximately 1000 Btu/ft^3, and is compatible with natural gas. It can be mixed with natural gas or substituted for it in pipeline systems that serve the residential sector and most of the industrial sector in the United States.

MEDIUM-BTU GAS: Consists of a mixture of methane, carbon monoxide, hydrogen, and other gases. It has a heating value in the range of 300 to 700 Btu/ft^3. It is not suitable as a pipeline quality gas, but it is suitable as a fuel for most industrial consumers.

LOW-BTU GAS: Consists of a mixture of carbon monoxide, hydrogen, and other gases and has a heating value in the range of 150 to 300 Btu/ft^3. This fuel is being studied for use as an industrial fuel or as a raw material for manufacturing ammonia, methanol, and other compounds.

COAL LIQUIFICATION: The process of converting coal into a liquid fuel. There are several different processes used to obtain liquids from coal. Some processes burn coal, condense the resulting gases, and add hydrogen to form a liquid; other processes chemically dissolve coal with hydrogen to form a liquid.

COAL SLURRY: Finely crushed coal mixed with sufficient water to form a fluid. To use coal slurry pumped through a pipeline as fuel, expensive drying and dewatering pretreatment has been necessary.

COAL TAR: A gummy, black substance produced as a byproduct when bituminous coal is distilled.

COKE: The residue left by petroleum which has been distilled to dryness.

COMBINATION TRUCKS: Consist of a power unit (a truck tractor) and one or two trailing units (a semi-trailer). The most frequently used combination is popularly referred to as a "tractor-semitrailer" or a "tractor trailer."

COMMERCIAL BUS: Any bus used to carry passengers at rates specified in tariffs; charges may be computed per passenger (as in regular route service) or per vehicle (as in charter service).

COMMERCIAL SECTOR: See RESIDENTIAL AND COMMERCIAL SECTOR.

COMMUTATION: In reference to Class I rail, passenger traffic handled between designated points at less than the basic fare per trip. It does not include traffic moving on basic rates of round trip, half rates, clergy, charity, military, special excursions, and other special-rated traffic.

COMPACT-SIZE CAR: An automobile industry designation usually consisting of cars with a wheelbase between 101 and 111 inches. After 1975 these are included in the SMALL category.

CONDENSATE: The liquid resulting when a vapor is subjected to cooling and/or pressure reduction. Also, liquid hydrocarbons condensed from gas and oil wells.

CONSTANT DOLLARS: A series is said to be 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 some selected year or the average of some set of years.

CONSUMER PRICE INDEX (CPI): An index issued by the U.S. Department of Labor, Bureau of Labor Satistics. 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 price.

CONSUMPTION: A calculated demand for petroleum products obtained by adding domestic production and imports of crude petroleum and natural gas liquids and imports of petroleum products to the primary stocks at the beginning of the period and then subtracting the exports and the primary stocks at the end of the period.

CONVERSION EFFICIENCY FACTOR: The ratio of output energy to gross input energy. It is usually expressed in percent.

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.

CRUDE OIL TRUNK LINES (PIPELINE SYSTEMS): One of three types of pipeline network that is used to transport crude oil to the refineries for processing.

CRUDE RUNS: Amount of crude actually processed by the refiner for the production of petroleum products, as distinct from capacity.

CRUDE SHALE OIL: The oil obtained as a distillate by the destructive distillation of oil shale.

CURRENT DOLLARS: Dollars current at the time designated or at the time the transaction listed took place. In most contexts, the same meaning would be conveyed by the simple term "dollars."

CURRENT POPULATION SURVEY (CPS): This is a monthly nationwide survey conducted by the Bureau of the Census. The primary purpose of the CPS is to obtain monthly labor force statistics for the U.S. Department of Labor. However, to obtain current demographic data between the decennial census of population, the Census Bureau adds supplementary questions to the CPS in March each year. This yearly survey is the major source of demographic data issued in the Census' Current Population Reports series.

CYCLE DUTY OR LOAD FACTOR (PIPELINE): The fraction of the time that the pumps are operated at rated horsepower capacity and/or the pipeline throughput is at peak design levels.

DEISEL ENGINE: An internal combustion engine in which the fuel is sprayed directly into the combustion chamber and ignited by the high temperature to which the air in the combustion chamber has been heated during the compression process. There are approximately 400 different variations in size, number of cylinders, and power output of diesel engines. The engines are relatively costly, but they operate with high efficiency combined with a long life span that needs service infrequently.

DINGHY: Typically, a small boat used as a tender or auxiliary to a larger vessel. Most dinghys are 7 to 12 feet in length, beamy, and with a round bilge. They are usually fitted as rowing boats, but may also use a small outboard engine or sails. Materials are usually plywood, aluminum, or fiberglass, but occasionally they are made of plastic or wood and canvas. This boat type includes boats that are occasionally called prams.

DISPOSABLE PERSONAL INCOME: Includes personal income less personal tax and nontax payments.

DISTILLATE FUEL OIL: The lighter fuel oils distilled off during the refining process. Included are products known as ASTM grades Nos. 1 and 2 heating oils, diesel fuels, and No. 4 fuel oil. The major uses of distillate fuel oils include heating, fuel for on- and off-highway diesel engines, and railroad diesel fuel.

DISTILLATE OIL: Fuel which may be used in diesel engines (i.e., water vessels, railroads, trucks, etc.).

DOMESTIC FLEET: Comprised of the following motor vehicles: sedans of all types, station wagons, ambulances, buses, trucks, and truck tractors registered in the United States, its territories, and possessions.

DOMESTIC FREIGHT: All commercial goods movement between points in the United States, Puerto Rico and the Virgin Islands, excluding traffic with the Panama Canal Zone. Cargo moved for the military in commercial vessels is reported as ordinary commercial cargo; military cargo moved in military vessels is omitted.

ELECTRIC UTILITIES SECTOR: The sector made up of privately and publicly owned establishments which generate electricity primarily for resale.

ELECTRIFIED ROADWAY (RAILROAD): Track along which a locomotive or rail motor car can receive electrical power generated at a remote location.

EMISSION STANDARDS: Federally established standards under control of the U.S. Congress. The current national emission standards for new automobiles and light trucks are set at 1.5 g of hydrocarbon (HC) per mile, 1.5 g of carbon monoxide (CO) per mile, and 3.1 g of nitrogen oxide (NO_x) per mile (effective September 1976).

END-USER: Usually refers to any company, other than a wholesale purchaser-consumer, that is an ultimate consumer of refined petroleum products, natural gas, or other energy product.

ENERGY EFFICIENCY: In reference to transportation, the inverse of energy intensiveness: the ratio of outputs from a process to the energy inputs; for example, passenger-miles traveled (PMT) per gallon of fuel.

ENERGY EFFICIENCY, INDUSTRY: See Industry Energy Efficiency.

ENERGY INTENSITY (PIPELINE): The energy intensity of oil transport via pipelines expressed as Btu/ton-mile. The fraction of through-put energy needed to pump a ton of oil a mile.

ENERGY INTENSITY (RAILROADS): Energy consumed per unit of service provided. The operating energy intensity is determined from actual fuel use by the railroads and actual service provided and includes the effect of operating inefficiences. The calculated energy intensity is determined analytically using a model of the railroad system and often does not include system operating inefficiencies.

ENERGY INTENSITY (WATER TRANSPORTATION): Fuel energy required per ton-mile of freight carriage (Btu/ton).

ENERGY INTENSIVENESS: In reference to transportation, the ratio of energy inputs to a process to the useful outputs from that process; for example, gallons of gasoline per passenger-mile or Btu per ton-mile.

ETHANOL: An alcohol produced by solar energy via the process of photosynthesis from plant material (biomass). Since biomass is a renewable energy source suitable for ethanol production by fermentation and distillation, this alcohol has a potential as an automotive fuel. However, the current cost of ethanol fuel is excessive and market prices of ethanol are about two times those of methanol. With crude oil prices continually rising, there is expected to be a possibility of making production cost-competitive by the use of new production technologies.

ETHYLENE: Colorless olefinic gas ($_2H_4$) derived from the cracking of petroleum.

FISCHER-TROPSH PROCESS: A coal gasification process wherein the carbon in coal is gasified with oxygen and/or steam to form a synthesis gas. In the presence of a catalyst, the synthesis gas mixture reacts to form a mixture of hydrocarbons. Depending on the relative concentrations of temperature, pressure, and reactant ratios, either liquid or gaseous products can be produced.

FIXED-WING AIRCRAFT: Aircraft having nonrotating wings fixed to the airplane fuselage and outspread in flight.

FLEET: A group of motor vehicles operating under unified control, as by a commercial or military organization.

FLEET: In accepted industry nomenclature, it identifies an entity whose requirements extend to the purchase and/or lease of ten or more new cars each year.

FLEET (GOVERNMENT): See Government Fleet.

FLEET SIZE (TRUCK): The fleet is an operational unit operated by a truck owner from a single "base of operation" and is necessarily smaller than the total fleet that an owner has if he operates from more than base. (The data shown in the fleet section of the tables are based on the number of trucks found in fleets of specified size and not the number of fleets.)

FOSSIL FUELS: Any naturally occurring fuel of an organic nature such as coal, crude oil, or natural gas.

GASOLINE: A refined petroleum product which, by its composition, is suitable for use as a fuel in internal combustion engines.

GEOTHERMAL ENERGY: Heat from the earth's interior. It has high potential for electric power production, space heating, etc. Geothermal resources fall into three categories: steam, hot water, and hot rocks.

GOVERNMENT FLEET: A group of motor vehicles operating under a unified control. Includes all federal (GSA), state, county, city, and metro area units of government including toll road operations.

GREAT-CIRCLE PATH: The shortest distance between any two terrestrial points.

GREAT LAKES — LAKEWISE (WATER TRANSPORTATION): Traffic between United States ports on the Great Lakes system.

GROSS ENERGY: The total of inputs into the economy of the primary fuels (petroleum, natural gas, and coal, including imports) or their derivatives plus the generation of hydro and nuclear power converted to equivalent energy inputs.

GROSS NATIONAL PRODUCT (GNP): Total value at market prices of all goods and services produced by the nation's economy. As calculated quarterly by the Department of Commerce, 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: In reference to truck size class, a gross vehicle weight of 26,001 pounds or more.

HEAVY RAIL: Subway-type transit vehicle railway constructed on exclusive private right-of-way with high-level platform stations.

HELICOPTER: A heavier-than-air aircraft that derives lift from one or more revolving "wings," or blades which are engine-driven about an approximately vertical axis. A rotorcraft does not have conventional fixed wings; nor in any but some earlier models is it provided with a conventional propeller, forward thrust and lift being furnished by the rotor. The powered rotor blades also enable the machine to hover and to land and to take off vertically.

HIGHWAY TRUST FUND: Established in 1956 by Congress to finance construction of the National System of Interstate and Defense Highways. Eighty-nine percent of the proposed 42,500-mile system is open to traffic, with work underway on an additional 11%. Completion is expected in the early 1980s. The Trust Fund has been expanded to support mass transit development in urban areas. Programs funded by the Trust Fund include: highway safety grants to the states and local governments for highway safety programs, including support of the federal highway safety program standards; highway safety research by the Department of Transportation; highway mass transit facilities such as reserved lanes, special roadways, shelters, loading platforms, and parking areas; research, development, and initial testing of advanced transportation systems and concept for all modes of urban transportation; and pilot programs designated to alleviate urban traffic congestion through improved highways and highway-related systems.

HOUSEBOAT: A boat designed for use in sheltered water and having barge- or pontoon-type displacement or semiplaning hulls. Characterized by a relatively low freeboard main hull in combination with a relatively high, flat-sided deck house. Usually has complete living accomodations on the inside of the deckhouse. May be powered by outboard, inboard/outboards, or inboard engines. Usually over 24 feet in length. The hull construction may be aluminum, steel, fiberglass, or occasionally plywood.

HOUSEHOLD: As defined by the Bureau of Census, a household consists of all persons who occupy a housing unit; it includes the related family members and all unrelated persons, if any, who share the housing unit.

HOUSING UNITS: A house, an 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 hall which is used or 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 lighest forms of hydrocarbon are gaseous. With greater molecular weights they are liquid, while the heaviest are solids.

HYDROGENATION: The addition of hydrogen to an organic molecule to increase the ratio of hydrogen to carbon as is necessary for the production of gaseous or liquid fuels. This process can be used for the production of oil or gas from coal, and has also been successfully tested in laboratory situations to make these fuels from organic waste.

HYDROPOWER (HYDROELECTRIC): A type of generating station or power or energy output in which the prime mover is driven by water power.

ICC-REGULATED CARRIER: A motor common carrier operating in interstate commerce under a grant of authority from the Interstate Commerce Commission and subject to its economic regualtion.

ICC-REGULATED PIPELINE: A pipeline company operating in interstate commerce under a grant of authorization from the Interstate Commerce Commission (ICC) and subject to economic regulation by the Commission. Such a pipeline company is required to report relevant statistics to the ICC. Petroleum companies and pipelines are regulated, while only natural gas companies are regulated.

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.

INBOARD-DIESEL: A boat whose primary propulsion is supplied by a diesel engine located within, and permanently attached to, the hull.

INBOARD-GASOLINE: A boat designed such that the primary propulsion is supplied by a gasoline engined located within, and permanently attached to, the hull.

INBOARD-OUTBOARD: Also referred to as inboard/outdrive. It is regarded as inboard because the power unit is located inside the boat.

INDEPENDENT REFINER: A refiner who, in the third quarter of 1973, obtained directly or indirectly more than 70% of his refinery input of domestic crude oil (or 70% of the refinery input of domestic and imported crude oil) from producers who do not control, are not controlled by, and are not under common control with, such a refiner.

INDUSTRIAL SECTOR: Construction, manufacturing, agricultural, and mining establishments.

INDUSTRY ENERGY EFFICIENCY: The development, design, construction, and operation of industrial processes and equipment to minimize the energy requirements of fabricating, forming, converting, or producing industrial or agricultural products.

INFLATABLE BOAT: A boat which gets its shape and buoyancy from inflation of flexible rubber or plastic tubes. Usually in the shape of an elipse, but occasionally in the shape of a canoe or horseshoe. May be powered by paddles, oars, or outboard. May have a wood transom for mounting outboard motor.

INFLATABLE RAFT: A flat platform supported by inflated tubes or truck tire innertubes. Usually unpowered but may have a small portable outboard motor.

INLAND AND COASTAL WATERWAYS, INLAND AND COASTAL CHANNELS: Includes the Atlantic Coast Waterways, the Atlantic Intracoastal Waterway, the New York State Barge Canal System, the Gulf Coast Waterways, the Gulf Intracoastal Waterway, the Mississippi River System (including the Illinois Waterway), Pacific Coast Waterways, the Great Lakes, and all other channels (waterways) of the United States, exclusive of Alaska, that are usable for commercial navigation.

INLAND-INTERNAL (WATER TRANSPORTATION): 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 waters of the Great Lakes: inland movements that cross short stretches of open water that link inland systems.

IN SITU: Refers to rock, fossil, or soil that is in its natural or original position from when it was formed or deposited.

IN SITU COAL GASIFICATION: Coal gasified underground by pumping hot steam-oxygen mixtures through coal seams.

INTERCITY BUS — CLASS I: An interstate motor carrier of passengers with an average annual gross revenue of at least $1,000,000.

INTERCITY BUS — TOTAL: Includes Class I, II, and III interstate bus carriers, all of which report to the Interstate Commerce Commission, and intrastate carriers.

INTERMEDIATE-SIZE CAR: An automobile industry designation usually consisting of cars with a wheelbase between 112 and 118 inches.

INTERNATIONAL (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 (i.e., Guam, Wake, American Samoa, etc.) and foreign countries is excluded. Traffic to or from the Panama Canal Zone is included.

INTRACOASTAL-COASTWISE (WATER TRANSPORTATION): Domestic traffic receiving a carriage over the ocean or the Gulf of Mexico. Traffic between Great Lakes ports and seacoast ports, when having a carriage over the ocean, is also termed coastwise.

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 known as primary stocks. Secondary stocks in those held by jobbers, dealers, service station operators, and consumers are excluded. Prior to 1975, stocks held at independent bulk terminals were classified as secondary stocks.

JET ENGINE: An engine which converts fuel and air into a fast-moving stream of hot gasses which effect propulsion of the device of which the engine is a part.

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 for generating electricity in gas turbines.

JOHNBOAT: A small rowboat adaptable for use with an outboard motor having square bow and stern. Usually with a flat bottom and hard chines. Usually a lightweight open boat with bench seats, but may have a very short forward deck. Most commonly constructed of aluminum, but may also be built of wood planks or fiberglass. (Sometimes spelled jonboat.)

KAYAK: A very lightweight, double-ended boat with a watertight deck. Usually fitted for flanges in which spray skirts can be attached so that the boat can be rolled completely over without taking water. Propelled by double-bladed paddles.

KEROGEN: A bituminous material occurring in oil shale that yields oil when heated. It is formed from algae and sea organisms or from waxy spores and pollen grain.

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 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 No. 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-BASE 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.

LARGE AIR TRAFFIC HUB: A community enplaning 1% or more of the total enplaned passengers in all services and all operations for all communities within the 50 States, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration. (Also see AIR TRAFFIC HUB).

LESSEE: The company engaging the leasing company for services.

LESSEE DEALER: An independent marketer who leases a gas station and land and has use of tanks, pumps, signs, etc. He typically has a supply agreement with a refiner or a distributor and purchases products at dealer tank wagon prices. As used herein, this marketing category is limited to those lessee dealers who are supplied directly by a refiner or any affiliated or subsidiary company of a refiner.

LIGHT: In reference to truck size class, a gross vehicle weight of 10,000 pounds or less.

LIGHT-HEAVY: In reference to truck size class, a gross vehicle weight of 20,001 to 26,000 pounds.

LINE MILEAGE: The aggregate length of roadway of all line-haul railroads. It does not include the mileage of yard tracks or sidings, nor does it reflect the fact that a mile of railroad may include two or more parallel tracks. Jointly used track is counted only once.

LIQUID 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: The ratio of actual load to full capacity.

LOCAL: In reference to area of operation of trucks, mostly in the local area, in or around the city and suburbs, or within a short distance of the farm, factory, mine, or place vehicle is stationed.

LOCAL: In reference to water traffic, movements of freight within the confines of a port, whether the port has only one or several arms or channels, except by car-ferry and general ferry.

LOCAL RURAL ROADS: Streets, other than principal arteries of travel, that are outside urban boundaries.

LOCOMOTIVES: Self-propelled units of equipment designed solely for moving other equipment.

LONG-RANGE: In reference to area of operation of trucks, mostly over-the-road trips that usually are more than 200 miles one way to the most distant stop from the place vehicle is stationed.

LUBRICANTS: All lubricants containing more than 50% by volume of refined petroleum distillates or specially treated petroleum residium. Includes lubricating greases, lube basestocks, and all grades of lubricating oils, from spindle oil to cylinder oil, and those used in greases.

LURGI PROCESS: A coal gasification process which employs a bed of crushed coal traveling downward through the gasifier and operating at pressures up to 30 atmospheres. Steam and oxygen are admitted through a revolving steam-cooled grate which also removes the ash produced at the bottom of the gasifier. The coal is carbonized and dried by gases passing upward through the coalbed, resulting in the production of a hydrogen rich gas.

MAIN RURAL ROADS: Streets outside urban boundaries that are generally recognized as principal arteries of travel.

MARKET SHARE: Percent of the total market captured by a specific commodity (e.g., compact cars of total car sales).

MASS TRANSPORTATION: Usually includes railroad, subway, elevated transportation systems, bus, and streetcar.

MEDIUM: In reference to truck size class, a gross vehicle weight of 10,001 to 20,000 pounds.

MEDIUM AIR TRAFFIC HUB: A community enplaning from 0.25 to 0.99% of the total enplaned passengers in all services and all operations for all communities within the 50 States, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration. (Also see AIR TRAFFIC HUB).

METHANOL: A colorless mobile alcohol of pungent odor and taste. It is produced from natural gas, heavy residues, and naphtha using a process that first leads to a carbon monoxide-hydrogen mixture (synthesis gas). From this synthesis gas, methanol is synthesized at elevated pressure and temperature using an appropriate catalyst. Because of this two-step process, any energy form that can produce hydrogen and carbon monoxide is potentially suitable for the production of methanol. Thus, methanol may be considered as a universal fuel that could be produced from a wide variety of energy sources and materials.

MIDDLE DISTILLATES: A category of petroleum fuel that includes the diesel fuels burned by surface transportation carriers, as well as home heating oil.

MILE (STATUTE): 5,280 feet.

MILES OF TRACK (RAILROAD): Total miles of railroad track in the United States, including multiple main tracks, yard tracks, and sidings owned by both line-haul and switching and terminal companies.

MOTORCYCLE: Two-wheeled automotive vehicle having one or two saddles and sometimes a sidecar with a third supporting wheel.

MOTORBUS: Rubber-tired, self-propelled transit vehicle with fuel supply carried on board the vehicle.

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 C 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.

MULTI-STOP TRUCK: A vehicle designed such that the driver can stand at the wheel and get in and out easily for door-to-door deliveries.

MUNICIPAL MILEAGE: Roads inside city, municipal district, or urban boundaries; includes extensions of the state primary system, state secondary roads within delimited incorporated and unincorporated places, mileage under local control, local city streets, roads, and public ways not under state control within such places.

NAPHTHA: Any one of a wide variety of volatile hydrocarbon mixtures. They are sometimes obtained from coal tar, but are more often derived from petroleum. Physical properties vary widely; the initial boiling point may be as low as 80 degrees F and end points may reach 260 degrees C (500 degrees F). Naphthas find their use as solvents and diluents.

NAPHTHA-BASE 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 C. Used for turbojet and turboprop aircraft engines, primarily by the military. Excludes ramjet and petroleum.

NATIONAL INCOME: The aggregate earnings of labor and property which arise in the current production of goods and services by the nation's economy.

NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAY (INTERSTATE SYSTEM): Established in 1944, changes were made in the extent of the system and increased funding was established. The system is limited to 42,500 miles and intended to serve as a direct connection between the nations principal metropolitan areas, cities, and industrial centers.

NATURAL GAS: A mixture of hydrocarbon compounds and small quantities of various nonhydrocarbons existing in the gaseous phase or in solution with crude oil in natural underground reservoirs at reservoir conditions.

NATURAL GAS LIQUIDS (NGL): Products obtained from natural gasoline plants, cycling plants, and fractionators after processing the natural gas. Included are ethane, liquified petroleum (LP), gases (propane, butane, and propane-butane mixtures), natural gasoline, plant condensate, and minor quantities of finished products such as gasoline, special naphthas, jet fuel, kerosene, and distillate fuel oil.

NET ENERGY: The total of the sector inputs (i.e., household, commercial, transportation, and industrial); consists of direct fuels and purchased electricity.

NET NATIONAL PRODUCT: Includes gross national product less capital consumption allowances.

NEW CRUDE OIL: Prior to February 1, 1976: the total number of barrels of domestic crude oil produced and sold in a specific month less the base protection control for that month and less the current cumulative deficiency.

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.

NONBOWRIDER RUNABOUT: An open power boat partially decked over with seats, with an automotive type steering wheel, and usually with a windshield for the operator. May have a portable shelter top of canvas or plastic. Powered by inboards, outboards, inboard/outboard, or water jet. Size range is typically between 15 feet and 26 feet, but there are extreme designs ranging from 10 feet to 40 feet. Bottom shape is usually a planing hull having a straight run of buttocks. This can include round bilge, V-bottom tunnel hull, and tri-hull. This type includes some bass boats.

NONHUB: A community enplaning less than 0.05% of the total enplaned passengers in all services and operations for all communities within the 50 States, the District of Columbia, and other U.S. areas designated by the Federal Aviation Administration. (Also see AIR TRAFFIC HUB).

NONSELF-PROPELLED: Vessels not containing within themselves the means for their own propulsion.

NUCLEAR POWER: Power released in exothermic nuclear reactions and useful in ways comparable with electric power.

NO. 2 DISTILLATE FUEL OIL: A petroleum distillate which meets the specifications for No. 2 heating oil and/or the specifications for diesel fuel grade No. 2.

OCTANE RATING: A number that is used to measure the antiknock properties of a liquid motor fuel.

OIL SHALE: A finely grained sedimentary rock composed mostly of clay that contains an organic material called kerogen. When the kerogen is heated to about 482 degrees C (900 degrees F), it is converted to shale oil and gas. The shale oil that is derived from kerogen is low in sulfur; and although it varies in some respects from conventional petroleum, it can be refined into most petroleum products.

OLD CRUDE OIL: Prior to February 1, 1976: the total number of barrels of crude oil produced and sold from a property in a specific month, less the total number of barrels of new crude oil for that property in that month and less the total number of barrels of released crude oil for that property in that month.

OPEC: Organization of Petroleum Exporting Countries including: Saudi Arabia, Iran, Venezuala, Libya, Indonesia, United Arab Emirates, Algeria, Nigeria, Ecuador, Gabon, Iraq, Kuwait, and Qatar.

OPERATING CRUDE OIL REFINING CAPACITY: The amount of crude a refiner is capable of processing in the short run, as distinct from shut-down capacity.

OPERATING LEASE: Also known as Net Lease or Closed End Lease, where lessor takes full risk on sale of used car. Price from beginning to end is therefore guaranteed, except for mileage stopper of varying amount.

OTHER DISTILLATE FUEL OILS: All other refined petroleum products not included in any other category and which, when produced in conventional distillation operations, have a boiling range from 10% point at 167 degrees C to 90% point at 375 degrees C. Included are products known as No. 1 and No. 4 distillate fuel oils and diesel oils.

OTHER THAN COMMUTATION: In reference to Class I rail, passenger traffic other than that handled between designated points at less than the basic fare per trip. It does include traffic moving on basic rates of round trip, half rates, clergy, charity, military, special excursions and other special-rated traffic.

OTTO ENGINE: An internal combustion engine conceived by Beau de Rochas and built by Otto. Large numbers of the engines were built and sold at the end of the 19th century; the principal changes since then include: much higher speed, lighter weight, smaller bulk, and greater efficiency. The engine operates on an OTTO CYCLE, which essentially requires four strokes of the piston for a cycle.

OUTBOARDS: As pertaining to boats, this classification includes "portable engines." Some are so large as to preclude portability in its true sense, but they are considered "outboard" because they are not permanently affixed to the structure of the craft. It also includes all "outboard" motors regardless of the method or location used to mount the engine, that is, motor wells, "kicker pits," motor pockets, etc.

PANEL TRUCK: A small, fully enclosed vehicle such as many stores use for delivery.

PASSENGER/CARGO AIR CARRIER: One of a class of air carriers holding certificates of public convenience and necessity issued by the Civil Aeronautics Board authorizing the performance of scheduled air transportation of passengers and property over specified routes.

PASSENGER ENPLANEMENTS: The count of the total number of passengers boarding aircraft including originating, stopover, and transfer passengers.

PASSENGER-MILE: One passenger traveling one mile.

PASSENGER-MILE (AIRCRAFT): One passenger transported one mile. Passenger-miles are computed by summation of the products of the aircraft-miles flown on each interairport flight state multiplied by the number of passengers carried on that flight stage.

PMT: Passenger-miles traveled. See PASSENGER-MILES.

PASSENGER REVENUE TON-MILE (AIRCRAFT): One ton of revenue passenger weight (including all baggage) transported one mile. Effective January 1, 1970, passenger weight standard for both "Domestic" and "International" operations is 200 pounds.

PASSENGER TRAIN CARS: Cars typically found in passenger trains include coaches, sleeping cars (formerly called Pullman cars), parlor cars, dining cars, lounge cars, baggage cars, crew-dormitory cars, and observation cars.

PERFORMANCE (AUTOMOBILE): Capability of the automobile to accelerate, to perform passing maneuvers, and to climb grades. It is specified as the time required to accelerate from 0 to 60 mph.

PERSONAL CONSUMPTION EXPENDITURES: 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: The current income received by persons from all sources net of contributions for social insurance.

PETROLEUM: A material occurring naturally in the earth and predominantly composed of mixtures of chemical compounds of carbon and hydrogen with or without other nonmetallic elements such as sulfur, oxygen, nitrogen, etc. Petroleum may contain, or be composed of, such compounds in the gaseous, liquid, and/or solid state, depending on the nature of these compounds and the existent conditions of temperature and pressure.

PETROLEUM CONSUMPTION, ELECTRIC UTILITY SECTOR: Domestic demand for all fuel oils at electric utilities.

PETROLEUM CONSUMPTION, INDUSTRIAL SECTOR: Domestic demand for petroleum products for use by establishments engaged in processing unfinished materials into another form or product. Excludes industrial space heating.

PETROLEUM CONSUMPTION, "OTHER" SECTOR: Domestic demand for miscellaneous products and for some agricultural uses.

PETROLEUM CONSUMPTION, RESIDENTIAL AND COMMERCIAL: Domestic demand for petroleum products by private households and nonmanufacturing establishments. Includes industrial space heating and road paving.

PETROLEUM CONSUMPTION, TRANSPORTATION SECTOR: Domestic demand for petroleum products for on-highway use, aircraft and vessel bunkering, and railroad use.

PICK-UP TRUCK: A vehicle with an enclosed cab for the driver and an open-topped metal box over the rear wheels.

PIPELINE: A line of pipe with pumping machinery and apparatus for conveying a liquid or gas.

PISTON: In engines and pumps, a reciprocating device in a cylinder or tube which receives pressure from, or delivers pressure to, a fluid.

PISTON-POWERED AIRCRAFT: An aircraft operated by engines in which pistons moving back and forth work upon a crank shaft or other device to create rotational movement.

PONTOON BOAT: Any of various boat types similar to rafts or houseboats. The hull can consist of a platform supported by two pontoons which usually are made of aluminum or steel and usually are cylindrical in shape. May have a roof structure which is usually canvas or lightweight aluminum. Usually propelled by an outboard motor. Distinguished from a houseboat by the absence of enclosed deckhouse.

POPULATION, CIVILIAN: Represents the resident population minus the Armed Forces stationed in the United States.

POPULATION, RESIDENT: Includes residents of the 50 States and the District of Columbia but excludes residents of the Commonwealth of Puerto Rico, residents of the outlying areas under U.S. sovereignty or jurisdiction (principally American Samoa, Panama Canal Zone, Guam, the Virgin Islands of the United States, and the Trust Territory of the Pacific Islands), and other American Citizens (military and civilian) living overseas.

POPULATION, TOTAL: Includes the total population overseas, the resident population, and the Armed Forces stationed in foreign countries, Puerto Rico, and the outlying areas but not their dependents.

POSTED PRICES: Reference prices on which governments assess the tax and royalty obligations of the concession-holding companies.

PRIMARY FAMILY: A group of two or more persons residing together who are related by blood, marriage, or adoption. A primary family includes among its members the married couple or person maintaining a household. A "secondary family" includes no member related to the person or persons maintaining the household, that is, lodgers, guests, or resident employees.

PRIMARY INDIVIDUAL: Persons maintaining a household with no relatives in the household.

PROCESSING GAIN: Represents the amount by which total refinery output is greater than input for a given period of time. This difference is due to the processing of crude oil into products which, in total, have less weight than the crude oil processed. Therefore, in terms of volume (barrels), the total output of products is greater than input.

PRODUCTIVE CAPACITY: Defined by the Federal Energy Administration as the maximum daily average sustainable production rate for crude oil and natural gas for the 60-day period following December 31, 1974, taking into account the following conditions: (1) No significant reduction in ultimate recovery from the field would result. (2) All economically feasible changes to maximize production would be made to existing wells, well equipment, and surface facilities as well as new drilling and changes in operational practices. (3) No change in constraints on flaring of gas or discharging of brines into water sheds would be made. (4) Productivity would decline at capacity operating conditions. (5) Gas withdrawal from underground storage facilities was not included. (6) Transportation and a market for all production except the North Slope of Alaska would be available. (7) No change in economic conditions, no legal constraints on production, and no changes in ownership equity systems would occur.

The American Petroleum Institute, however, defines crude oil productive capacity as the maximum daily crude production rate, at the point of custody transfer, that could be achieved in 90 days (following December 31 of any given year) with existing wells, well equipment, and surface facilities — plus work and changes that can be reasonably accomplished within the time period using present service capabilities and personnel and with productivity declining as it would under capacity operation.

PROPANE: A gaseous paraffin hydrocarbon, C_3H_8, occurring in crude oil, natural gas, and refinery cracking gas. It is used a fuel, a solvent, and a refrigerant.

PROPELLER: A device for propelling an aircraft that has blades on an engine-driven shaft and that, when rotated, produces by its action on the air a thrust approximately perpendicular to its plane of rotation.

PROVED RESERVES (ECONOMICALLY RECOVERABLE RESERVES): Those resources (coal, oil, natural gas) that have actually been discovered and can be produced under current economic and technological conditions.

PSI: Pounds per square inch.

PYROLYSIS: The chemical decomposition of waste in the absence of oxygen where materials are heated at atmospheric pressure and several products are obtained: low-Btu gas, char (partially burned carbon residue), and a heavy tar-like oil. All three of these products can be used as fuels; however, the oil has a high viscosity and a lower Btu value than ordinary fuel oil.

RAIL MOTOR CARS: Self-propelled passenger rail cars which are driven by electric motors energized from an electrified roadway or by a generator driven by a diesel or gas turbine engine.

RAILROAD LINE: The aggregate length of roadway of all line-haul railroads. A mile of line may include two or more parallel tracks and be used by two or more railroad companies.

RANGE OF OPERATIONS OF VEHICLES: According to the Bureau of Census:
Local — mostly in the local area.
Short-range — mostly over the road, but usually not more than 200 miles one way to the most distant stop from the place the vehicle is stationed.
Long-range — mostly over the road trips that are more than 200 miles one way to the most distant stop from the place the vehicle is stationed.

RANGE OIL: A grade of kerosene similar to No. 1 distillate heating oil with a gravity of about 43 degrees API and having a maximum end-point of 374 degrees C.

REFINED PRODUCT TRUNK LINES (PIPELINE SYSTEMS): One of three types of pipeline network that is used to transport refined petroleum products (i.e., gasoline, kerosene, residual oil, etc.) from the refineries to local distribution centers near large market areas.

REFINER ACQUISITION COST: The cost to the refiner, including transportation and fees, of crude petroleum. The composite cost is the average of domestic and imported crude costs and represents the amount of crude cost which refiners may pass on to their customers.

REFINERIES: Those industrial plants, regardless of capacity, processing crude oil feedstock and manufacturing refined petroleum products, except when such a plant is a petrochemical plant.

REFINERS: Those firms that own, operate, or control the operations of one or more refineries.

REFINERY CAPACITY: The maximum throughput of crude oil for which the plant is designed. A refinery's output of refined products will usually be about 5% smaller than this, allowing for waste and for the products burned to keep the refinery and its auxiliary plant in operation.

REFINERY YIELD: The amount of each product of refinery output expressed as a percentage of total input of crude oil and unfinished oils rerun (net) in a given period. In computing yields, all natural gas liquids and other hydrocarbon inputs are considered as resulting in gasoline output, output before computing the yield of gasoline from the input of crude oil, and unfinished oils rerun (net).

REGULATED WATER CARRIER: A common and contract carrier subject to economic regulation by the Interstate Commerce Commission. For reporting purposes carriers are divided into three classes based on their average annual operating revenues in accordance with the following definitions: Class A companies are those having annual operating revenue exceeding $500,000; Class B companies are those having annual operating revenue between $100,000 and $500,000; Class C companies have annual operating revenues less than $100,000.

RENTAL: Refers to daily rental (less than 6 months) of vehicles primarily associated with the well-known firms.

RESERVES: Identified deposits of minerals known to be recoverable with current technology under present economic conditions. Categories of reserves are: (1) Measured Reserves — identified resources from which an energy commodity can be economically extracted with existing technology and whose location, quality, and quantity are known for geologic evidence supported by engineering evidence; (2) Indicated Reserves — reserves based partly on specific measurements, samples, or production data, and partly on projections for a reasonable distance on geologic evidence; and (3) Inferred Reserves — reserves based on broad geologic knowledge for which quantitative measurements are not available. Such reserves are estimated to be recoverable in the future as a result of extensions, revisions of estimates, and deeper drilling in known fields.

RESIDENT POPULATION: SEE POPULATION, RESIDENT.

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.

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 known as ASTM grades Nos. 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.

RESOURCES: Includes reserves as well as minerals that have been identified but cannot now be extracted because of economic or technological limitations, as well as economic or subeconomic materials that have not yet been discovered. Undiscovered recoverable resources are quantities of a mineral commodity that may be reasonably expected to exist in favorable geologic settings but that have not yet been identified by drilling. Exploration will permit the reclassification of such resources to the reserves category.

RETORT: A vessel in which substances are subjected to heat for the purpose of distillation or decomposition. A retort is distinguished from a till in that it is more often used for the treatment of solid or semisolid substances as in the case of coal.

REVENUE PASSENGER LOAD FACTOR (AIRCRAFT): Revenue passenger-miles as a percentage of available seat-miles in revenue passenger services and representing the proportion of aircraft seating capacity that is actually sold and utilized.

REVENUE PASSENGER-MILE (AIRCRAFT): One revenue passenger transported one mile in revenue service. Revenue passenger-miles are computed by summation of the products of the revenue aircraft miles flown on each interairport hop multiplied by the number of revenue passengers carried on that hop.

REVENUE PASSENGER-MILE (BUS): One revenue passenger carried one mile generates one passenger-mile. The revenue passenger-miles reported thus represent the total distance traveled by all bus passengers.

REVENUE TON-MILE OF FREIGHT (AIRCRAFT): One short ton of freight transported one statute mile. Ton-miles are computed by summation of the products of the aircraft-miles flown on each interairport flight stage multiplied by the number of tons carried on that flight stage.

REVENUE TON-MILES (RAILROAD): The product of weight of the contents of a freight car in tons and the distance transported in miles; that is, n tons moved m miles generate $n \times m$ ton-miles.

REVENUE VEHICLE-MILE (LOCAL TRANSIT): One vehicle (bus, trolley car, subway car, etc.) traveling one mile while revenue passengers are on board. The revenue vehicle-miles reported thus represent the total mileage traveled by vehicles in scheduled or unscheduled revenue-producing services.

ROWBOAT: Small lightweight open boat with a flat, round, or semi V bottom shape. Construction may be wood, metal, plastic, or fiberglass. Propelled by oars although some still consider this type a rowboat even when fitted with an outboard motor. It may also have provisions for rigging a portable mast and sail. The hull may be double-ended or have a transom stern. Specific types are known by the following names: peapod, dory, pulling boat, punt, wherry, whaleboat, duckboat, whitehall, and many others. Although, in the vernacular, it usually refers to a boat less than 16 feet long, it may be 30 feet or longer.

RURAL: Usually refers to places with less than 5,000 people.

RURAL MILEAGE: Roads outside city, municipal district, or urban boundaries.

SAILBOAT: Any boat built primarily to be propelled by sails.

SCHEDULED SERVICE (AIRCRAFT): Transport service operated over an air carrier's certificated routes, based on published flight schedules including extra sections and related nonrevenue flights.

SCOW: A large, flat-bottomed boat with broad square ends used chiefly for transporting sand, gravel, or refuse.

SELF-PROPELLED TOWBOATS AND TUGS: A compact shallow-draft boat with squared bow and towing knees for pushing tows of barges on inland waterways. A tug, also termed as towboat, is a strongly built boat used for towing and pushing. Both of these vessels have within their structure the means for their own propulsion.

SHALE OIL: The liquid oil product recoverable from the thermal decomposition of kerogen, the organic material present in oil shale.

SHORT-RANGE: In reference to area of operation of trucks, mostly over-the-road (beyond the local area) but usually not more than 200 miles one way to the most distant stop from the place vehicle is stationed.

SKIFF: A flat-bottom shallow draft open boat of simple construction with sharp bows and square stern. Some types, notably the St. Lawrence skiff, have been highly developed with rounded sections and construction features which require a high degree of boat-building skill. Orginally designed for propulsion by oars, but may be fitted with an inboard motor, an outboard motor, or sails. Construction is usually wood or aluminum, but may be fiberglass.

SOLVENT REFINED COAL: A coal liquefication process in which the coal is mixed with a liquid solvent then heated and passed to a high pressure reactor where hydrogen and hydrogen sulfide are separated from the mixture. It is then filtered, the solvent is distilled for reuse, and the final product is recovered either as a liquid or solid.

STANDARD-SIZE CAR: An automobile industry designation which usually consists of cars with a wheelbase of greater than or equal to 119 inches.

STATE PRIMARY SYSTEM: Highways that have been so officially designated by states. They encompass the principal intercounty, intercity and interstate roads of all states.

STATE SECONDARY ROADS: Reported mileage in the tables for the states (taken from the Highway Statistics 1970 Bulletin) that have designated both a primary and a secondary system.

STATION WAGON (ON TRUCK CHASSIS): A truck having an enclosed body of paneled design with several rows of folding or removable seats behind the driver, similar to an automobile station wagon.

STILL GAS: Any form or mixture of gas produced in refineries by cracking, reforming, and other processes, the principal constituents of which are methane, ethane, ethylene, butane, butylene, propane, propylene, etc. Used as a petrochemical feedstock or as a fuel at the refinery. Refinery gas.

STIRLING ENGINE: An external-combustion engine that has pistons that move up and down in cylinders. It uses a fixed volume of a working fluid that constantly flows back and forth between a hot top space and a cold bottom space in a cylinder and relies on continuous external combustion of a fuel that supplies heat to the working fluid through the upper wall of a cylinder. The theoretical efficiency of the Stirling engine is substantially higher than that of diesel and other internal-combustion engines. These engines have a lower emission of harmful exhaust gases, lower noise level, and lower fuel consumption than that of gasoline engines and no oil consumption; however, the cost of the engine is the major factor in its use at present.

SUBCOMPACT-SIZE CAR: An automobile industry designation usually consisting of cars with a wheelbase of less than or equal to 100 inches. After 1975 these are included in the SMALL category.

SUPPLEMENTAL AIR CARRIER: One of a class of air carriers now holding certificates, issued by the Civil Aeronautics Board (CAB), 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 "nonskeds," that is, nonscheduled carriers.

SYNCRUDE: Synthetic crude oil suitable for use as a refinery feedstock and for petrochemical production.

SYNTHETIC CRUDE: The total liquid, multicomponent hydrocarbon mixture resulting from a process involving molecular rearrangement of charge stock. Synthetic crude is usually obtained from coal and oil shale.

SYNTHETIC FUEL: A fuel which does not exist in nature but which must be manufactured or synthesized. Generally, synthetic fuels are derived from other forms of fossil fuels that are less convenient for consumer use. Synthetic liquid fuels are produced from coal, shale, and tar sands.

SYNTHETIC OIL: Oil produced artificially, as in the Bergius or the Fischer-Tropsch processes.

SYSTEM OPTIMIZATION (TRANSPORTATION PROPULSION): Improvements in engine displacement/inertia weight combinations and combustion limitations for alternate fuels.

TANK BARGES: Flat barges that travel on inland waterways, have no engines, and must be pulled by a towboat. They usually carry fluid such as oil.

TAR SANDS: Geologic deposits of sand and clay which are heavily impregnated with oil.

TAXI FLEET: Licensed cabs engaged in the transportation of people using cars.

THRILLCRAFT: Usually a lightweight, single-engine boat of unusual design which will accomodate one or two people for joyriding or pulling a skier. Some persons include any high performance boat in this category.

TON-MILE (AIRCRAFT): One short ton (2,000 pounds) transported one statute mile (5,280 feet). Ton-miles are computed by multiplying the aircraft miles flown on each interairport hop by the number of tons carried on that hop.

TON-MILES (TRUCK, RAIL, MARINE PIPELINE): The transportation of one short ton (2,000 lb) of freight a distance of one mile generates a one ton-mile.

TON-MILE TRAVELED (TMT): Refer to TON-MILE.

TOTAL VEHICLE-MILES OPERATED: Sum of all passenger vehicle-miles operated in line (regular) service, special (charter) service, and nonrevenue service. When vehicles are operated in trains, each vehicle is counted separately: an eight-vehicle train operating for one mile equals eight vehicle-miles.

TOWBOATS: Diesel-powered vessels used in inland waterways to push a flotilla of barges.

TRAIN-MILE (RAILROAD): A complete train moved one mile.

TRANSPORTATION EFFICIENCY: The development, design, construction, and operation of more efficient transport systems. The technology focuses on autos, trucks, planes, trains, pipelines, and ships as well as on the power systems involved.

TRANSPORTATION SECTOR: Consists of both private and public passenger and freight transportation as well as government transportation, including military operations.

TRUCK SIZE CLASSES: The Bureau of Census has categorized trucks according to gross vehicle weight: the empty weight of the vehicle plus maximum anticipated load weight.

Light — gross vehicle weight of 10,000 lb or less.
Medium — gross vehicle weight of 10,001 to 20,000 lb.

Light-heavy — gross vehicle weight of 20,001 to 26,000 lb.
Heavy-heavy — gross vehicle weight of 26,001 lb or more.

TURBINE-POWERED AIRCRAFT: Includes aircraft with either turbojet, turbofan, turboprop, or turboshaft engines.

TURBOJET: Aircraft operated by jet engines incorporating a turbine-driven air compressor to take in and compress the air for the combustion of fuel, the gases of combustion (or the heated air) expelled being used both to rotate the turbine and to create a thrust-producing jet.

TURBOPROP: Aircraft in which the main propulsive force is supplied by a gas-turbine-driven conventional propeller. Additional propulsive force may be supplied from the discharged turbine exhaust gas.

URBAN: Usually refers to places with population of 5,000 or greater, unless otherwise specified.

USED-VEHICLE SALES: Reflect retail and wholesale used-car sales only, not sales between private individuals.

UTILITY: Firms operating as a service company in a community (primarily electrical, telephone, gas, and related services).

VAN: A vehicle used to carry bulky loads that must be sheltered from the weather. They are used of late as recreational vehicles and for van pooling in commuting.

VEHICLE-MILE (ALSO REFERRED TO AS VMT — VEHICLE-MILES TRAVELED): One vehicle traveling one mile. Total vehicle-miles, thus, gives the total mileage traveled by all vehicles.

VEHICLE YEARS: The equivalent total years of operation of an agency's fleet. It is calculated by summing the total months of actual operation of all vehicles (or vehicles of a specific type) and dividing by 12.

VOLATILIZATION: The process of converting a chemical substance from a liquid or solid state to a gaseous or vapor state. In the internal combustion engine, this occurs when gasoline is injected into the cylinder and mixed with air just prior to ignition.

WAXES: Derivatives of petroleum which are extracted from lubricating oil fractions by chilling, filtering, and solvent washing. There are two types: paraffin and microcrystalline.

WELL: A hole drilled for the purpose of finding or producing crude oil or natural gas or providing services related to the production of crude oil or natural gas. Wells are classified as oil wells, gas wells, dry holes, stratigraphic tests, or service wells. This is a standard definition of the American Petroleum Institute.

WELLHEAD VALUE: A value expressed in either dollars per barrel (oil), or cents per thousand cubic feet (natural gas) of production.

WHOLESALE PRICE INDEX: Adjusts wholesale nominal prices to real terms by an average weight which is determined by the base year prices of a basket of wholesale goods.

Matrices

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Transportation Energy Conservation Data Book, Edition 3

Mode-Specific Cross-Reference

This cross-reference matrix was designed as a general standard for categorizing transportation energy data and, specifically, as a guide to modal information included in Edition 3 of the *Transportation Energy Conservation Data Book*. This chart, to be used in conjunction with the index, references pages where modal CHARACTERISTICS and DATA may be found. For any mode, data or a specific characteristic is referenced by the page number given in the appropriate matrix cell. For example, "Automobile, number of vehicles" disaggregated by a characteristic — "Vehicle size" — is represented by the appropriate page number (1-36) in the respective matrix cells.

<u>Legend</u>

— following a page number entry indicates historical data.

+ following a page number entry indicates projected data.

∿ following a page number entry indicates the results of a model.

In many cases, data in a figure will be duplicated on an adjoining page. In these cases, only the first page is noted in this cross-reference.

"Aggregated" indicates that aggregated but not detailed data about individual modes are provided.

Source: The matrix was developed by Dr. Margaret F. Fels, Center for Environmental Studies, Princeton University, August 1977.

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

TITLE INDEX

KEYWORD INDEX

SUBJECT INDEX OF ORNL-5493

TRANSPORTATION ENERGY CONSERVATION DATA BOOK,
EDITION 3

Prepared By:

L. Lieberman, Department of Energy, Technical Information Center
Oak Ridge, Tennessee

Index of Surveys and Special Studies from Transportation Energy Conservation Data Book, Edition 2 (ORNL-5320)

not Updated or Revised for Transportation Energy Conservation Data, Edition 3 (ORNL-5493)

Data on these pages are related to, but not included in, TEC Data Book, Edition 3

NOTE: Page Numbers refer to TEC Data Book, Edition 2 (ORNL-5320)

Prepared By:

L. Lieberman, Department of Energy, Technical Information Center
Oak Ridge, Tennessee

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Volume Conversions

From \ To	in.^{3}	ft^3	U.S. gal	Imp. gal	liter	bbl
in.^{3}	1	5.787×10^{-4}	4.329×10^{-3}	3.605×10^{-3}	0.01639	1.031×10^{-4}
ft^3	1728	1	7.481	6.2292	28.32	0.1781
U.S. gal	231	0.1337	1	0 8327	3.785	2.381×10^{-2}
Imp. gal	277.4	0.1606	1.201	1	4.545	2.859×10^{-2}
liter	61.02	3.531×10^{-2}	0.2642	0.2200	1	6.29×10^{-3}
bbl	9702	5.615	42	34.972	158.97	1

Mass Conversions

From \ To	lb (avoirdupois)	kg	Short ton	Long ton	Metric ton
lb (avoirdupois)	1	0.4536	5.0×10^{-4}	4.4643×10^{-4}	4.5362×10^{-4}
kg	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

Length Conversions

From \ To	cm	in.	ft	yd	m	mile	km
cm	1	0.3937	3.281×10^{-2}	1.0936×10^{-2}	1.0×10^{-2}	6.214×10^{-6}	1.0×10^{-5}
in.	2.54	1	8.333×10^{-2}	2.778×10^{-2}	2.54×10^{-2}	1.578×10^{-5}	2.54×10^{-5}
ft	30.48	12	1	0.333	0.3048	1.894×10^{-4}	3.048×10^{-4}
yd	91.44	36	3	1	0.9144	5.682×10^{-4}	9.144×10^{-4}
m	100	39.37	3.281	1.0936	1	6.214×10^{-4}	1.0×10^{-3}
mile	160,934	63,360	5280	1760	1609	1	1.609
km	100,000	39,370	3281	1093.6	1000	0.6214	1

Energy Conversions

From \ To	ft-lb	kg-m	hp-hr	Metric hp-hr	Btu	kWhr	Joule
Ft-lb	1	0.1383	5.0505×10^{-7}	5.12×10^{-7}	1.285×10^{-3}	3.766×10^{-7}	1.356
kg-m	7.233	1	3.653×10^{-6}	3.704×10^{-6}	9.295×10^{-3}	2.724×10^{-6}	9.80665
hp-hr	1.98×10^{6}	2.7375×10^{5}	1	1.0139	2544	0.7457	2.6845×10^{6}
Metric hp-hr	1.953×10^{6}	270,000	0.9863	1	2510	0.7355	2.648×10^{6}
Btu	778.2	107.6	3.93×10^{-4}	3.985×10^{-4}	1	2.931×10^{-4}	1055
kWhr	2.655×10^{6}	3.671×10^{5}	1.341	1.3596	3412	1	3.6×10^{6}
Joule	0.7376	0.10197	0.3725×10^{-6}	0.3777×10^{-6}	0.9478×10^{-3}	$0,2778 \times 10^{-6}$	1

1 quad Btu = .4724 million bbl crude per day = .1724 billion barrels crude per year

Heat Content for Various Fuels

Fuel oils			Natural gas		
Crude	138,100	Btu/gal	Liquid	95,800	Btu/gal
Residual	149,700	Btu/gal	Wet	1,095	Btu/ft^3
Distillate	138,700	Btu/gal	Dry	1,021	Btu/ft^3
Automotive gasoline	125,000	Btu/gal	Coal		
AVGAS	124,000	Btu/gal	Anthracite	25.4×10^{6}	Btu/short ton
Jet fuel (kerosine)	135,000	Btu/gal	Bituminous	26.2×10^{6}	Btu/short ton
Jet fuel (naphta)	127,500	Btu/gal	Lignite	13.4×10^{6}	Btu/short ton
Diesel oil (#2)	138,700	Btu/gal	(Electrical generation and distribution efficiency)		≈30%
Coal products			Lubricants	144,405	Btu/gal
Crude light oil	130,000	Btu/gal	Waxes	155,643	Btu/gal
Crude coal tar	150,000	Btu/gal	Petroleum coke	143,423	Btu/gal
Crude petroleum	138,100	Btu/gal	Asphalt and road oil	158,000	Btu/gal
Ethane	73,390	Btu/gal	Natural gasoline and cycle products	110,000	Btu/gal
Still gas	142,286	Btu/gal			

1 Btu/gal = 278.7 joule/liter = 2.787×10^{5} joule/m^3

1 Btu/short ton = 942.0 joule/metric ton

*See Appendix for expanded conversion tables.