ENERGY OVERVIEW

INTRODUCTION

This report, *Household Vehicles Energy Use: Latest Data & Trends*, provides details on the nation's energy use for passenger travel. Drawing on several databases made available to the Energy Information Administration (EIA) from other federal agencies, and EIA's past Residential Energy Consumption Surveys (RTECS), EIA reports on the number and types of vehicles per household, and for each vehicle: annual miles traveled, gallons of fuel consumed, type of fuel used, price paid for fuel, and fuel economy (see Text Box).

DATA SOURCES

The latest source for vehicle and household estimates and associated public-use files is the January 2004 release of the 2001 National Household Travel Survey (NHTS), a national study funded and coordinated by the U.S. Department of Transportation (DOT), which included the Federal Highway Administration (FHWA), Bureau of Transportation Statistics (BTS), and the National Highway Traffic Safety Administration (NHTSA). The NHTS is the integration of two national travel surveys: the Federal Highway Administration-sponsored Nationwide Personal Transportation Survey (NPTS) and the Bureau of Transportation Statistics-sponsored American Travel Survey (ATS).

For this report, EIA augmented the fundamental household and vehicle data released by the 2001 NHTS, which is the nation's inventory of local and long-distance travel. Between April 2001 and May 2002, roughly 26 thousand sample households[9] were

Author's Note

Estimates of gallons of fuel consumed, type of fuel used, price paid for fuel, and fuel economy are based on data imputed by EIA, using vehicle characteristics and vehicle-miles traveled data collected during the interview process for the 2001 National Household Travel Survey (NHTS). Rather than obtaining that information directly from fuel purchase diaries, EIA exploited its experience and expertise with modeling techniques for transportation studies, filling missing and uncollected data with information reported to other federal agencies, as described in Appendices B and C of this report.

Had these imputed data items been derived from information supplied by respondents directly, it is likely that the systematic and random sources of measurement variability associated with them would have been similar to those found with all NHTS population estimates, thereby capturing the behaviors and patterns associated with a household and its members. Since energy and energy-related data were imputed, these data are subject to additional uncertainty.

[9] The NHTS collected travel data from the civilian, non-institutionalized population of the United States. People living in medical institutions, prisons and in barracks on military bases were excluded from the sample. However, telephone numbers in dormitory rooms, and fraternity and sorority houses were included as long as no more than 10 people shared the same telephone number.

interviewed about their travel based on the use of over 53 thousand light-duty vehicles (referenced hereafter as "vehicles")[10], representing 107.4 million households in the United States, of which 92 percent (98.9 million) actually owned or possessed a vehicle during the survey period.. Although trip and travel data are mandated components of the NHTS, fuel prices and energy consumption are not. Using confidential data collected during those interviews, coupled with EIA's retail fuel prices, external data sources of test[11] fuel economy, and internal procedures for modifying test fuel economy to on-road, in-use fuel economy, EIA extended this inventory to include the energy consumption and expenditures demanded for personal transportation, thereby extending a data series previously based on EIA's Residential Transportation Energy Consumption Survey (RTECS), which was discontinued for budgetary reasons after 1994.

Until it was discontinued, the RTECS surveys provided residential transportation statistics which were summarized in the report series *Household Vehicle Energy Consumption*. Decision- and policy-makers had found such reports and public-use databases useful, for they had coupled vehicle use, travel, consumption, and expenditure information with socio-economic, demographic, and household information.[12] This rich data source tracked the continued dominance of the personal passenger vehicle as the preferred travel mode by the American public, assessed shifts in the nation's vehicle stock and its impact on overall fuel economy and consumption, and enhanced the knowledge of public and policy-

Author's Note (continued)

To measure one aspect of that uncertainty, EIA conducted a sensitivity analysis of imputed fuel economy (i.e., gasoline mileage) values. Schipper and Pinckney (2004) determined that consumption could have been either raised by 7 percent or lowered by 9 percent, if EIA in its cold-deck imputation scheme had always chosen excessively extreme fuel economy values, selecting the 5th percentile (P5) value or the 95th percentile (P95) value as the representative fuel economy for each sampled vehicle.

By using only extreme values - P5 or P95 - results are biased. While these extreme values are not acceptable to a researcher, such biased estimates, to some extent, illustrate the upper and lower uncertainty bounds associated with cold-decked estimates. Given these bounds, along with survey sampling and non-sampling errors, the use and usefulness of an enhanced NHTS should be evaluated against a researcher's project requirements.

[10] To avoid misinterpretation of averages, statistics in this report are based on the domain of households that possessed a light-duty vehicle during the survey period of the 2001 National Household Travel Survey, effectively removing 8.5 million American households that did not possess a vehicle during the survey period.

[11] Federal law, 49 USC § 32908, requires automobile manufacturers to determine the fuel economy of new vehicles offered for sale in the United States. This information is provided on a fuel economy label affixed to each vehicle's window to help consumers make informed decisions regarding fuel economy when purchasing a new vehicle. While these labels may vary somewhat in appearance, they all must provide the same information.

[12] Since 1983, and until it was discontinued after 1994, EIA's survey of residential transportation collected vehicle odometer readings to calculate annual vehicle-miles traveled; however beginning in 1988, instead of collecting fuel purchase diaries for fuel economy and fuel price data, fuel economy values were obtained by linking with EPA's tested fuel economy values; and fuel prices were obtained from a variety of pump price data series.

makers on how variations of use among different socio-economic groups might relate to potential policy initiatives, such as assessing the potential effects of public policy initiatives on lower and higher income households or elderly populations[13] within the nation.

ORGANIZATION OF REPORT

This report is organized as follows:

- **Energy Overview** presents data highlights and an analysis that disaggregates energy use based on relationships among energy-related transportation statistics.
- **Appendix A: Detailed Tables** presents tabular data on the vehicle stock and energy use for personal transportation.
- **Appendix B: Estimation Methodologies** discusses how statistics were estimated, which rely heavily on the methods employed with previous residential transportation surveys conducted by EIA.
- **Appendix C: Quality of the Data** discusses the quality of the reported and imputed vehicle data, including the effects of sampling, non-sampling, and imputations on data quality.
- **Appendix D: Description of Data** describes how researchers can access and manipulate public-use files made available by EIA and U.S. DOT.
- **Appendix E: Chronology of World Oil Market Events** presents major market events in sequence with world oil prices.
- **Glossary** provides a list of key terms used herein.

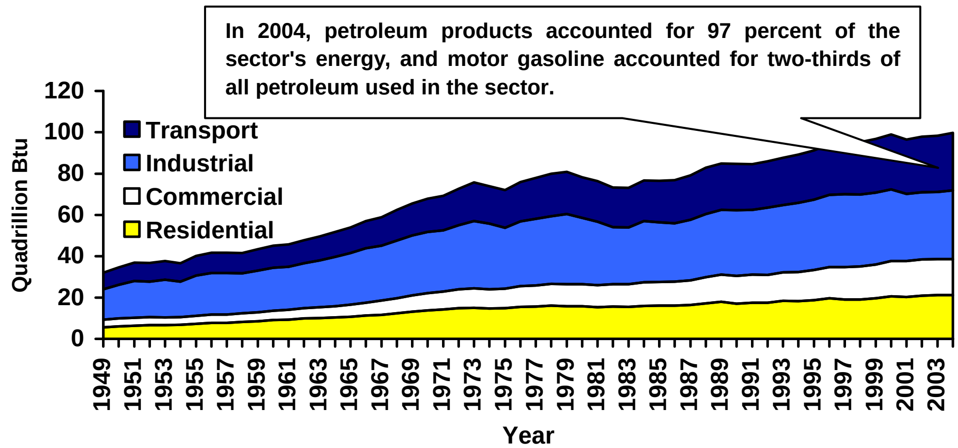
Only light-duty passenger vehicles and recreation vehicles (i.e., motor homes) are included in this report. EIA has excluded motorcycles, mopeds, large trucks, and buses in an effort to maintain consistency with its past residential transportation series, which was discontinued after 1994.

[13] Rosenbloom, S. *Older Drivers: Should We Test Them Off the Road?* University of California, Transportation Center, Access, Fall 2003, Number 23.

ENERGY PROFILE

Based on EIA data, two transportation perspectives can be considered: top-down (representing weekly, monthly, and yearly queries of energy transporters and suppliers) and bottom-up (representing multi-year queries of final consumers).

Figure 1. Total Energy Consumption by End-Use Sector, 1949-2004



Source: Energy Information Administration.

TOP-DOWN VIEW

In 2004, based on EIA's queries of energy transporters and suppliers, the United States consumed 99.7 quadrillion British thermal units (Btu) of energy, 105.2 exajoules (EJ), a slight increase from 103.7 EJ (98.3 quadrillion Btu) in 2003. Of that total amount in 2004, 33.2 quadrillion Btu (33 percent of the total) was categorized as industrial use, 27.8 quadrillion Btu (28 percent) was transportation use for all modes of transport, 21.2 quadrillion Btu (21 percent) was residential use and 17.5 quadrillion Btu (18 percent) was commercial use (see Figure 1). For transport, 97 percent of the energy supplied was petroleum-based.

The nation currently cannot provide for all its petroleum demand with domestically produced crude oil. The decline in domestic oil production, coupled with a rise in oil consumption, resulted in net imports of crude oil and petroleum products surpassing 11.2 million barrels per day in 2003, with imports reaching an all-time high of just over 12.2 million barrels per day, of which over 40 percent had originated at countries belonging to the Organization of Petroleum Exporting Countries (OPEC). Furthermore, motor gasoline accounted for nearly one-half (8.9 million barrels per day) of the 20 million barrels per day of petroleum products consumed domestically in 2003, with 13.2 million barrels per day of that total identified as transport sector use.

Despite the rich accounting of monthly and yearly energy data, sector-level estimates are too broadly defined for demand analyses trying to identify and quantify the impact of factors driving the overall change in consumption. Top-down data reveal few insights into those influences, generally brought about by changing *activity*, *structure*, and *energy intensity* associated with households' vehicles and how the public use their privately owned vehicles (POV) for personal transportation.

BOTTOM-UP VIEW OF PERSONAL TRANSPORTATION

Consumer data fill that gap left by top-down data. Bottom-up data are based on intermittent surveys of the nation's final consumers: manufacturing plants, commercial buildings, households, and, for this report, household vehicles.[14] These consumer-based surveys can provide a wide variety of end-use characteristics that enables the insights not possible with sector-level data.

COSTS RISE FOR U.S. HOUSEHOLDS

For consumers, energy costs are a foremost concern. Transportation costs have increased due to many factors related to travel and prices paid for transportation fuel, while being somewhat offset by improved fuel economy. In 2001, consumers paid nearly equal amounts for energy used for household services (ranging from cooking and water heating to refrigeration and lighting) and for personal transport. The average household spent $1,520 on fuel purchases for transport and remitted $1,493 for household services, just $27 more per year, as measured in nominal dollars.

By contrast, an average household paid $1,174 for passenger travel in 1994, while having paid $1,620 for household services in 1993 – a year in which heating and cooling seasons were well within 30-year norms. It can be argued that, based on those statistics, what America drives on its roadways[15] has become as important energy-wise as what heating equipment it places in its basements and appliances in its electrical sockets.

PRICES EXPECTED TO MOVE HIGHER

Based on expected future energy prices which partially reflect producers' acquisition costs, the gap between transport cost and household services cost may expand. Between 2001 and 2006, expenditures for motor gasoline are expected to increase from $1,370 per household per year to $2,327 in 2006, up nearly $960 per household. For comparison, in 2001, gasoline prices averaged $1.43 per gallon; in 2006, gasoline prices are expected to average $2.43 per gallon (a 71-percent increase in nominal terms and 52-percent increase when adjusted by inflation).[16]

Consumption and expenditures among socioeconomic and demographic groupings of households, as well as geographic zones, differed markedly. For example, household with the presence of children (defined as those ages 17 and under) drove an additional 10 thousand miles and spent $650 more per year in 2001 than those without children. Households without children

[14] See http://www.eia.doe.gov/emeu/consumption/index.html; accessed July 28, 2005.

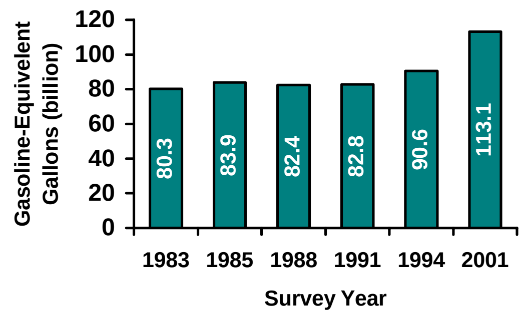
[15] 8.3 million lane-miles. See *Federal Highway Administration*, Highway Statistics 2003 (U.S. Department of Transportation, Washington, DC) table HM-60.

[16] Energy Information Administration, Short-Term Energy Outlook. Accessed http://www.eia.doe.gov/emeu/steo/pub/contents.html on November 14, 2005.

purchased $1,241 worth of transportation fuel to drive 19.6 thousand miles versus $1,902 to drive 29.2 thousand miles for those households having children.

Even though households are affected differently, their use, taken together, contributes significantly to the nation's energy demands, especially the amount of petroleum products needed to move people to and from places to acquire goods and services, as the majority of vehicle engines are fueled with these products. In 2001, the United States consumed 113.1 billion gasoline-equivalent gallons (GEG) to fuel passenger travel by light-duty vehicles, a 3.3 percent per year rise from 1994, when 90.6 billion was consumed (see Figure 2). That fuel consumption by light-duty vehicles, stored in a tank the size of a regulation football field, would require the tank to have walls nearly 50 miles high.[17]

Figure 2. Energy Consumption of Vehicles, Selected Survey Years



Source: Energy Information Administration.

DEMAND ANALYSIS TECHNIQUES

Besides filling the data gap in consumer-based transportation statistics, this report addresses aspects of energy use on which consumers, policy and decision makers often focus – how changing *activity*, *structure*, and *intensity* have affected the growth in energy use. Indeed, the volatility of crude oil prices over the past year has focused attention on the economic condition of the oil and gas industry, the increasing the nation's dependence on foreign oil supplies, and the prospects for reducing reliance on oil imports, all of which are affected to a high degree by transport's intensity of use.

One family of demand analyses – index theory – decomposes value aggregates into their principal components, by examining changes in energy use over time by varying one component and holding all other components constant, a Laspeyres formulation of an index (see Figure 3). Because of its fundamental feature of decomposing aggregates, literature commonly refers to these types of analyses as decomposition analysis. Initiated with the work by Boyd *et al* (1988) which decomposed manufacturing energy use, economic and energy journals, as well as several economy-wide international works[18], now offer a rich resource of literature on decomposition

---

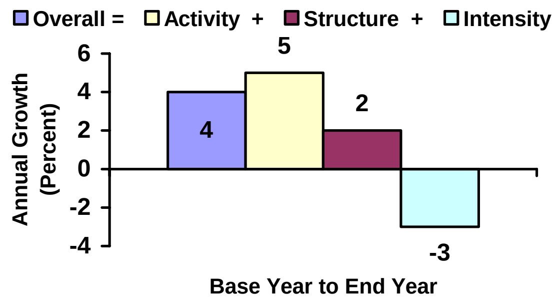
[17] A ft^3 equals 7.48 gallons. See www.ncaa.org/champadmin/football/football_field.gif for field dimensions.

[18] 30 Years of Energy Use in IEA Countries: Oil Crises & Climate Change, *International Energy Agency*, (OECD/IEA, Paris), 2004; Indicators of Energy Use and Efficiency: Understanding the Link Between Energy and Human Activity, *International Energy Agency*, (OECD/IEA, Paris), 1997; and selected references under IEA's indicator work include: Schipper, L., Unander, F., Murtishaw, S. and Ting, M. (2001). Indicators of Energy Use and Carbon Emissions: Explaining the Energy Economy Link, *Annual Review of Energy and Environment*, 26, 49-81; Unander F., Karbuz, S., Schipper, L., Khrushch, M., Ting, M. (2000). Manufacturing Energy Use in OECD Countries: Decomposition of Long-Term Trends, *Energy Policy* 27 (13): 769-778; Preston, J., Adler, R., Schipper, M. (1992). Energy Efficiency in the Manufacturing Sector, *Monthly Energy Review*, DOE/EIA-0035(1992/12).

results and techniques.[19] Another technique (not used here) has been used by Golob and Brownstone (2005) to show that a change in both vehicle-miles traveled and consumption per change in residential density was substantial for households in the State of California, comparing households by residential density, with all else being equal.

Instead of linking residential density with energy use, changes in the *structure* of households in terms of their composition (lifecycle); vehicle ownership; types of vehicles; *activity* in terms of travel, and vehicle fuel *intensities* (the inverse of fuel economy or gasoline mileage) are linked to changing energy use, representing a few components offsetting or supporting the surge in energy use to power vehicles' engines. This report presents analysis on the effects for three time periods: 1988-1991, 1991-1994 and 1994-2001. Both the 1983 and 1985 RTECS are excluded because key lifecycle information is only available from later surveys. Before analyzing those time periods, it is useful to identify variations in how Americans use energy based on the latest consumer data: the 2001 NHTS augmented by EIA.

Figure 3. Example of a Laspeyres Decomposition



PREDICTORS OF ENERGY NEEDS

EIA maintains a focused set of data programs and products, as a crucial part of its efforts to inform and analyze national and international energy demand and supply, with strict adherence to neutrality. Many examine the energy delivered to end-use sectors from the top-down perspective of energy suppliers, while a few examine the energy used from the bottom-up perspective of energy consumers. Whether data originate from final consumers or not distinguishes these products. In most cases, EIA's weekly, monthly, and annual data products are based on queries of energy producers and transporters on their allocation of energy supplies, whereas less frequent but demographically rich data are based on surveys of some of the nation's final consumers: households, manufacturing plants, commercial buildings, and, for this report, household vehicles.

Less frequent studies focusing on final consumers serve as primary sources of predictors of energy needs and, in turn, demands made on energy supplies for purposes of producing manufacturing throughput, conditioning commercial square footage, and fueling passenger travel. While acknowledging that end-use studies are artifacts of the year in which they are conducted, and recognizing that uncertainties remain due to infrequent implementation, summary measures

[19] Ang, B.W. and Pandiyan, G. (1997). Decomposition of Energy-Induced CO2 Emissions in Manufacturing. *Energy Economics*, 19, 363-374; Boyd, G.A., Hanson, D.A., Sterner, T. (1988). Decomposition of Changes in Energy Intensity: A Comparison of the Divisia Index and Other Methods, *Energy Economics*, 10, 309-312; Choi, K.H. and Ang, B.W. (2003). Decomposition of Aggregate Energy Intensity Changes in Two Measures: Ratio and Difference, *Energy Economics*, 25, 615-624; Huang, J. (1992). Industry Energy Use and Structural Change: A Case Study of The People's Republic of China, *Energy Economics*, 15(2), 131-136.

of energy demand are displayed in Tables 1 and 2 (including detailed tables in Appendix A), which present overall energy demand as

$$\text{Energy} = f(\text{Structure, Activity, Energy Intensity}). \quad (1)$$

Table 1. Measures of Energy Demand and Demand Activities, Selected Survey Years

	Survey Year					
	1983	**1985**	**1988**	**1991**	**1994**	**2001**
Number of Households (million)	84.4	87.3	91.6	94.6	97.3	107.4
Number of Households with Vehicles (million)	72.2	77.7	81.3	84.6	84.9	98.9
Real Disposable Personal Income (chained billion $2000)	4177.7	4645.2	5082.6	5351.7	5746.4	7333.3
Population (million)	233.8	237.9	244.5	252.2	260.3	285.1
Number of Vehicles (million)	129.3	137.3	147.5	151.2	156.8	191.0
Number of Vehicles per Household with Vehicles	1.8	1.8	1.8	1.8	1.8	1.9
Number of Vehicles per 1000 Capita	555	577	603	600	602	670
Vehicle-Miles Traveled (VMT) (billion)	1215	1353	1511	1602	1793	2287
VMT per Household with Vehicles (thousand)	16.8	17.4	18.6	18.9	21.1	23.1
VMT per Vehicle (thousand)	9.4	9.9	10.2	10.6	11.4	12.0
Load Factor	1.80	1.74	1.66	1.60	1.60	1.57
Passenger-Miles Traveled (PMT) (billion)	2194	2354	2509	2564	2869	3591
PMT per Household with Vehicles (thousand)	30.2	30.3	30.9	30.2	33.8	36.3
PMT per Vehicle (thousand)	16.9	17.1	17.0	17.0	18.3	18.8
Energy Intensity (equivalent gallons per 1000 miles)	66.2	62.1	54.6	51.8	50.5	49.5
Gasoline-Equivalent Gallons (billion)	80.3	83.9	82.4	82.8	90.6	113.1

Sources: Energy Information Administration, Office of Energy Markets and End Uses, 1983, 1985, 1988, 1991, and 1994 Residential Transportation Energy Consumption Surveys; Federal Highway Administration, U.S. Department of Transportation, 2001 National Household Travel Survey; U.S. Bureau of Economic Analysis, Table 2.1, *Survey of Current Business Population,* revised February 25, 2005; Oak Ridge National Laboratory (ORNL) under contract with the Office of Planning, Budget Formulation, and Analysis, under the Energy Efficiency and Renewable Energy (EERE) program in the U.S. Department of Energy (DOE), *Transportation Energy Data Book: Edition 24*.
Note: * = a recession year. Estimates are displayed as rounded values.

Table 2. Annual Percent Change in Measures of Energy Demand, Selected Survey Years

	Survey-to-Survey Annual Percent Change					
	1983 to 1985	1985 to 1988	1988 to 1991	1991 to 1994	1994 to 2001	1983 to 2001
Number of Households	1.7	1.6	1.1	0.9	1.4	**1.3**
Number of Households with Vehicles	3.7	1.5	1.3	0.1	2.2	**1.8**
Population	0.9	0.9	1.0	1.1	1.3	**1.1**
Real Disposable Personal Income	5.4	3.0	1.7	2.4	3.5	**3.2**
Number of Vehicles	3.0	2.4	0.8	1.2	2.9	**2.2**
Number of Vehicles per Household with Vehicles	0.0	0.0	0.0	0.0	0.8	**0.3**
Number of Vehicles per 1000 Capita	2.0	1.5	(0.2)	0.1	1.5	**1.1**
Vehicle-Miles Traveled (VMT)	5.4	3.8	2.0	3.8	3.5	**3.6**
VMT per Household with Vehicles	1.8	2.2	0.5	3.7	1.3	**1.8**
VMT per Vehicle	2.6	1.0	1.3	2.5	0.7	**1.4**
Load Factor	(1.7)	(1.6)	(1.2)	0.0	(0.3)	**(0.8)**
Passenger-Miles Traveled (PMT)	3.6	2.1	0.7	3.8	3.3	**2.8**
PMT per Household with Vehicles	0.1	0.7	(0.7)	3.7	1.0	**1.0**
PMT per Vehicle	0.7	(0.3)	(0.1)	2.6	0.4	**0.6**
Energy Intensity	(3.2)	(4.2)	(1.8)	(0.8)	(0.3)	**(1.6)**
Gasoline-Equivalent Gallons	2.2	(0.6)	0.2	3.0	3.2	**1.9**

Sources: Energy Information Administration, Office of Energy Markets and End Uses, 1983, 1985, 1988, 1991, and 1994 Residential Transportation Energy Consumption Surveys; Federal Highway Administration, U.S. Department of Transportation, 2001 National Household Travel Survey; U.S. Bureau of Economic Analysis, Table 2.1, *Survey of Current Business Population,* revised February 25, 2005; Oak Ridge National Laboratory (ORNL) under contract with the Office of Planning, Budget Formulation, and Analysis, under the Energy Efficiency and Renewable Energy (EERE) program in the Department of Energy (DOE), *Transportation Energy Data Book: Edition 24*.

STRUCTURE

Structure in transportation is defined as those characteristics that quantify and describe vehicles available for use.

HOUSEHOLDS WITH VEHICLES

In 2001 there were 107.4 million households in the United States, of which nearly 98.9 million (92 percent) actually owned or possessed one or more vehicles, an increase of 1.8 percent per year from 1983, 72.2 million out of 84.4 million households (86 percent) had possessed one or more vehicles. The increasing number of households and a greater fraction of those possessing a vehicle, all else been equal, should result in increased energy needs for the nation. Decomposition analysis, given in later sections, shows this to be true. Indeed, no other predictor is as strong in its link with energy use (see Text Box).

Rest of the World Affects the U.S. Consumer

While the relationship between both population and housing growth and energy is highly correlated, research (Smil 2003; page 63) has concluded that the energy-economy relationship, as measured in Total Primary Energy Supply and Gross Domestic Product (GDP), is neither linear nor simple; rather, it is dynamic and complex, precluding any normative conclusions among industrialized or developing countries.

As evidenced by a parked car or a vacant, shuttered residence, houses and vehicles neither consume energy nor emit greenhouse gases on their own; people do. They do so with the goal of obtaining services in their homes and using vehicles for trips (going to work, church, or obtaining food) in which goods or services are acquired. Thus, population, and especially the driving-age population, plays an important role in predicting the number of households with vehicles, number of vehicles and their resulting energy use.

The ratios of the number of vehicles per capita, per driver, and per household suggest the nation had reached a plateau from 1988 to 1994, when ratios were nearly steady. After 1994, these ratios reinitiated their ascent, returning to the pre-1988 annual growth: 1.5 percent per year. Whether this restart was propelled by the influence of economic growth and its impact on household wealth and income is unknown; however, it arguably has played an important part. To date, unity has never been reached with any ratio discussed here.

Rest of the World Affects the U.S. Consumer (continued)

Yet, the confluence of economic growth and population does affect transport needs, and vice-versa. This is readily apparent with developing and emerging economies, especially China's and India's as their economic opportunities continue to expand.

The developing Chinese and Indian economies, when pooled, encompass half the world's population, but unlike the United States, are nowhere close to any saturation point and far below the POV mobility status seen among the U.S. and other industrialized countries. As both seek higher mobility status (i.e., vehicles per capita), a rise similar to that of industrialized countries in the number of passenger vehicles, all else remaining constant, would put significant upward pressure on global oil demands.

Providing further interest to automakers and policy makers, the Chinese, unlike the Indians, have favored light-duty vehicles over two-wheelers as the first-vehicle-of-choice.

NUMBER OF VEHICLES

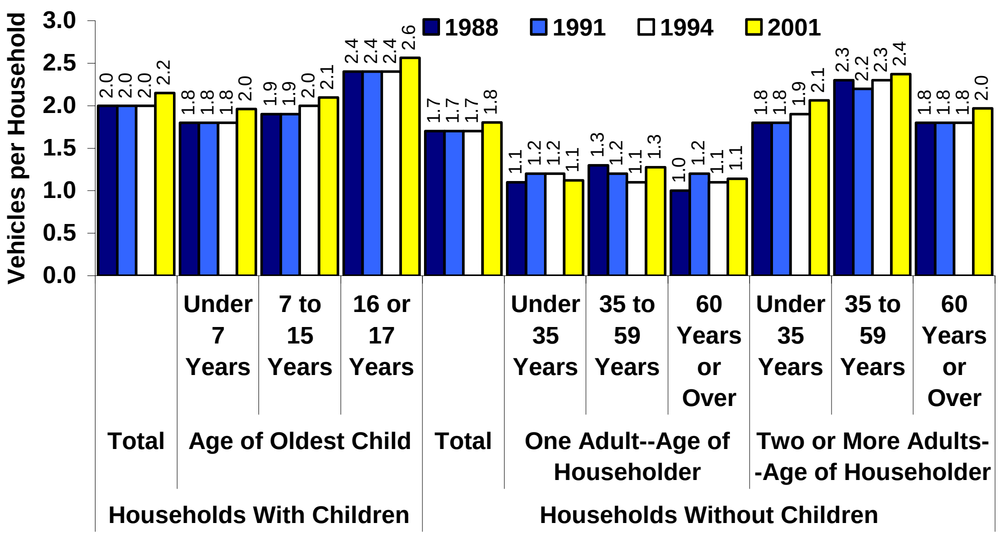
As the use of two-wheelers versus passenger cars is important when assessing POV trends in India and China, the number and types of vehicles operating on our nation's roadways are just as important. In 2001, the average number of vehicles per household increased for the first time since 1983, from 1.8 vehicles per household as reported by EIA in 1983, 1985, 1988, 1991, and 1994 to 1.9 vehicles (see Table 1). In contrast, the average automobile occupancy, as measured by a load factor[20], has continued its downward trend, albeit at a decreasing rate, in which the annual percent change has been a negative 0.3 percent, from 1.6 persons per vehicle in 1994 to 1.57 in 2001. Partially, this is a reflection of the declines in household size, as population has increased at a slightly lower annual rate than housing.

[20] Oak Ridge National Laboratory (ORNL) under contract with the Office of Planning, Budget Formulation, and Analysis, under the Energy Efficiency and Renewable Energy (EERE) program in the Department of Energy (DOE), *Transportation Energy Data Book: Edition 24*. One hundred vehicle miles of travel with a vehicle load factor of 1.80 persons is equivalent to 180 person-miles. If the occupancy falls to 1.57, then 180/1.57 vehicle miles of travel are required for the same person-miles, a 15-percent increase in vehicle miles.

Vehicle ownership varies among the nation's households. Income and lifecycle (defined as the presence and age of children) are strong predictors of the number of vehicles per household (i.e., ownership). Income provides the means for vehicle ownership, while differing lifecycles provide the motivation – thereby, creating pronounced ownership-lifecycle and ownership-income links (see Figures 4 and 5).

Average vehicle ownership rose in nearly every lifecycle category between 1994 and 2001. Not surprisingly, households with children possessed, on average, more vehicles than those without, and ones with a 16- or 17-year child yielded the highest ownership rate (2.6 vehicles per household); this is likely due in part to the effect of teenagers – 16- or 17-year-olds – who are becoming drivers. In 2001, such households recorded the highest vehicle ownership, with an average of 2.6 vehicles per household, up from 2.4 vehicles in 1988, 1991, and 1994. Single-adult childless households registered the lowest vehicle ownership, consistently. Within those households, householders 60 years or older possessed the fewest number of vehicles per household, possessing 1.1 vehicles in both 1994 and 2001. As more retirees return to the workforce, this trend may alter. Childless households with two or more adults, for instance, have reported an increase in average vehicle ownership, increasing 0.2 vehicles, from 1.8 in 1994 to 2.0 vehicles in 2001.

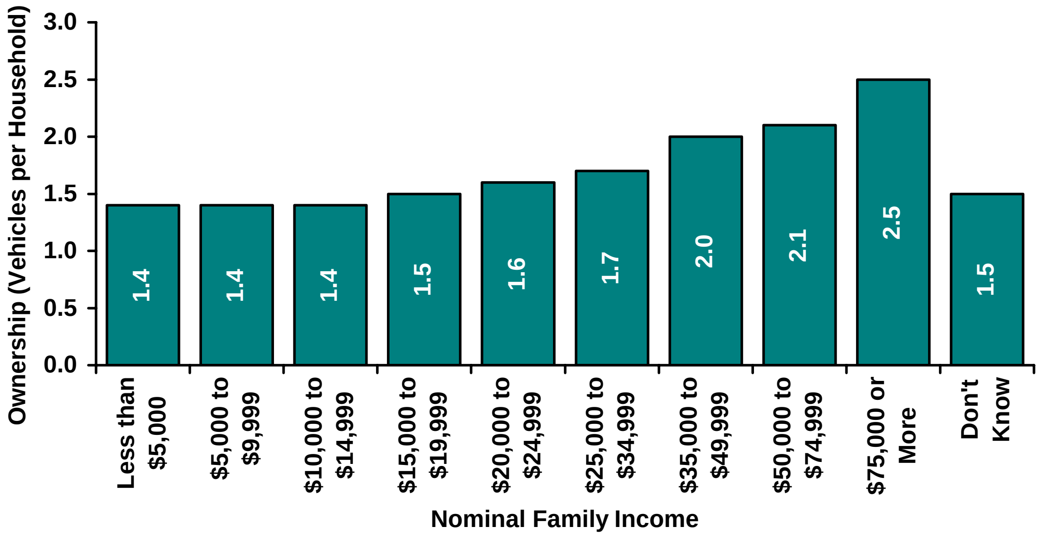
*Figure 4. Vehicle Ownership by Household Composition (**Lifecycle**), Selected Survey Years*



Source: Energy Information Administration.

Income also has a dramatic effect on vehicle ownership. Higher income translated into higher ownership rates in 2001. Ownership at lower income levels (poverty or near poverty) is remarkably stable. There are, on average, 1.4 vehicles per household for those households having a family income of less than $15 thousand. Moreover, though not universal, higher nominal family income levels (i.e., $10,000 or more) correlate with steadily larger number of vehicles per household, at a rate of about 0.1 additional vehicles per $5 thousand of additional income.

Figure 5. Vehicle Ownership by Nominal Family Income, 2001



Source: Energy Information Administration, tables in this report.

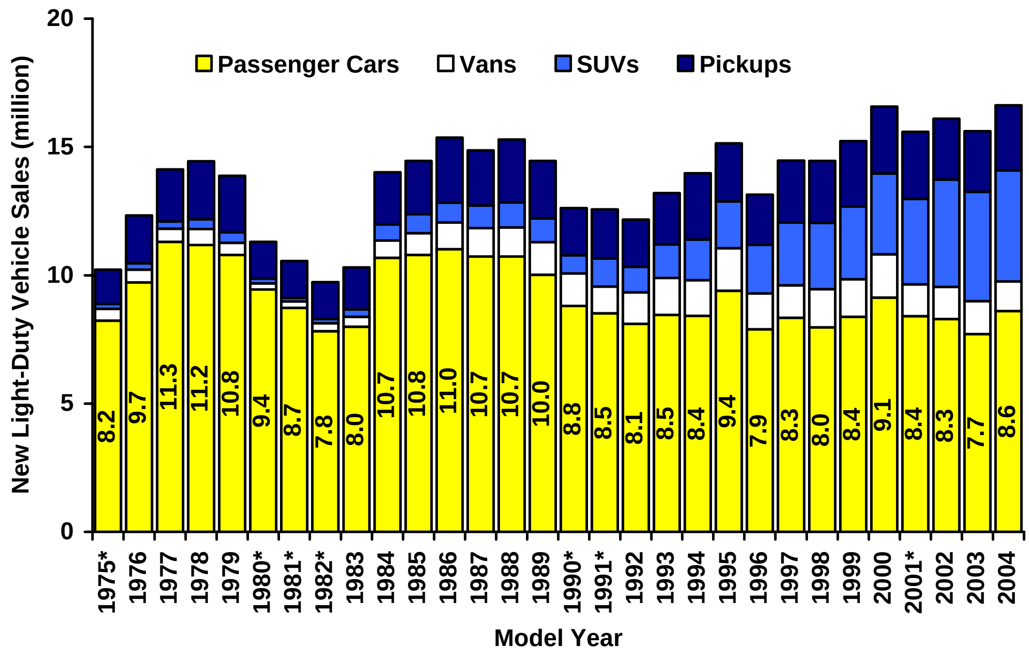
TYPES OF VEHICLES

Americans have demonstrated a preference in the vehicles they purchase for their travel needs. New vehicle sales suggest a shifting in vehicle preference away from passenger cars as automakers introduced and intensely marketed sports-utility vehicles (SUVs).[21] They are increasing in popularity as passenger cars (including cars and stations wagons) are declining in market share of the new light-duty vehicle market. In 2004, SUVs captured 26 percent (4.3 million of the 16.6 million light-duty sales) of the new vehicle market, up from 11 percent (1.6 million of the 14.0 million light-duty sales) in 1994. Passenger cars accounted for 52 percent (8.6 million); vans accounted for 7.0 percent (1.2 million); and, pickups accounted for 15 percent (2.5 million) of the remaining vehicles sold in 2004 (see Figure 6).

Even though SUVs are increasingly popular among Americans, passenger cars still rank as their overall vehicle of choice, as they make up the majority of vehicles on America's roadways. Cars, including station wagons, represented just over 50 percent of new vehicle purchases in 2001, according to the sales figures from EPA's latest *Fuel Economy Trends* report, though in each of the subsequent years they have lost market share to SUVs. As of 2001, a recession year, the distribution of sales and scrappage rates had resulted in a household vehicle fleet of 191.0 million vehicles: 112.4 million (58 percent) passenger cars, 18.4 million (10 percent) vans, 23.2 million (12 percent) SUVs, 35.6 million (19 percent) pickups, and 1.4 million (1 percent) recreational vehicles (see Figure 7).

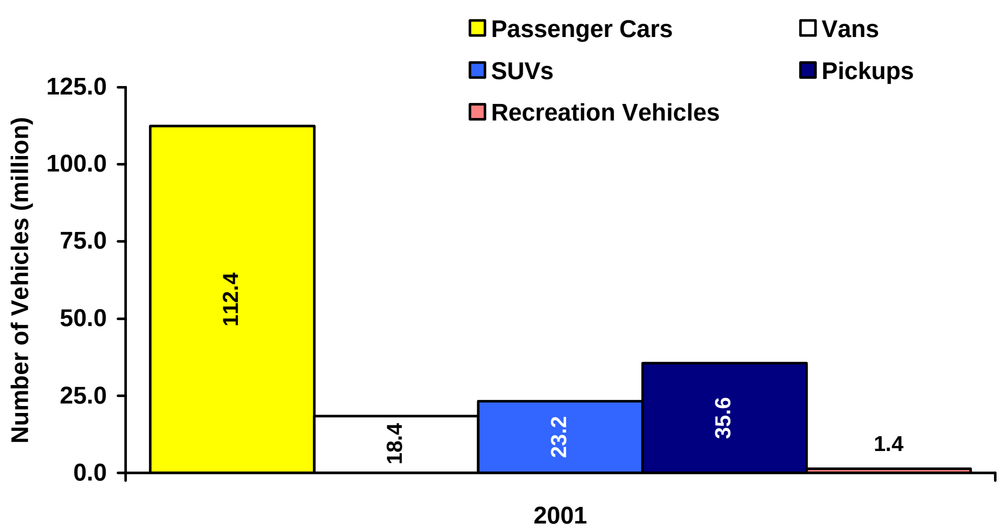
[21] How consumers chose vehicles and their components follows a complex decision process which is beyond the scope of this report.

Figure 6. Number and Share of New Vehicles Sold in the United States by Vehicle Type and Year



*Source: U.S. Environmental Protection Agency, Fuel Economy Trends, 2004; Note * = recession year.*

Figure 7. Distribution of Vehicle Stock, 2001



Source: Energy Information Administration, tables in this report.

ACTIVITY

Activity reflects the use of vehicles, as measured by annual vehicle-miles traveled, average number of trips per year, and average trip distances.

VEHICLE-MILES TRAVELED

Travel activity (How many miles do the nation's vehicles travel?) is a key factor in determining motor fuel consumption, roadway congestion and impacts on the environment. In an environment of little-to-no change in gasoline mileage, energy use is directly proportional to travel; and, likewise, most emissions are directly proportional to energy use. In 2001, light-duty vehicles accumulated over 2.2 trillion vehicle-miles, up 3.5 percent per year from 1994, when EIA reported that light-duty vehicles traveled 1.8 trillion vehicle-miles. For perspective, that's enough miles to travel 25,000 times between the Sun and the Earth.[22]

Over time, numerous factors have affected travel activity, though the presence of children in a household has continued to show a sharp effect. In 2001, average household driving varied extensively depending on the makeup (i.e., lifecycle) of a household:

- Households with children averaged 29.2 thousand miles compared with 19.6 thousand miles in households with no children;

- Households with 16- or 17-year-olds children drove more than any other (34.0 thousand miles), about 6 thousand miles more than households with younger children;

- For households without children, vehicle-miles traveled ranged from 12 thousand miles in single-adult households to 24.8 thousand miles in households with two or more adults; and,

- For single-driver households without children, vehicle-miles traveled ranged from a low of 8.0 thousand miles for drivers at least 60 years of age to 14.4 thousand miles for drivers under 35 years of age.

Roadway congestion affects all households, and it is a growing problem in urban areas. Congestion (defined by the relationship between urban vehicle-miles traveled and urban road miles or urban throughput) on the nation's roadways has risen, as evidenced by urban road miles increasing 36 percent between 1980 and 2000, while urban vehicle-miles traveled increased 95 percent.[23]

---

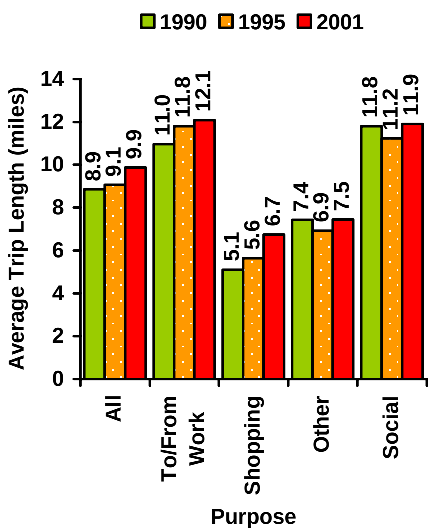
[22] An Astronomical Unit is the average distance between the Sun and the Earth. Its value is 149,597,870 km (93 million miles).

[23] U.S. Department of Transportation, Federal Highway Administration. Accessed on the world-wide web at http://www.fhwa.dot.gov/environment/cmaqpgs/amaq/03cmaq1fig3.htm on July 11, 2005.

ONE-WAY TRIPS PER YEAR AND AVERAGE ONE-WAY TRIP DISTANCES

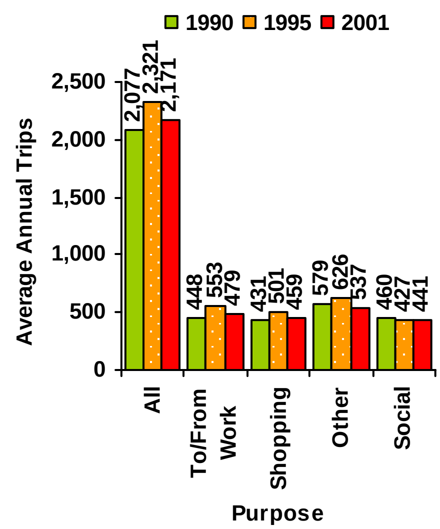
Yet, neither congestion nor higher prices have frustrated motorists to the extent that travel plans have been disrupted, as year-to-year demand for total transport fuel continues to increase even as prices continue to rise; survey-to-survey load factors have declined; and, survey-to-survey trip[24] lengths have increased to their highest levels since 1990 (see Figures 8 and 9). Such national statistics provide evidence that behavior changes are slow to come about, because vehicle stock changes occur slowly and Americans still need to carry out their lives, traveling back and forth to work, church, or the local grocery store as needed. Figure 10 provides further explanation: depressed motor gasoline prices coupled with a steady rise in income.

Figure 8. Average Vehicle Trip Length, Selected Survey Years



Source: Federal Highway Administration, Summary of Travel Trends (December 2004).

Figure 9. Average Annual Vehicle Trips per Household, Selected Survey Years



Source: Federal Highway Administration, Summary of Travel Trends (December 2004).

Whether American consumers are immune to price increases or any change in vehicle stock or travel heretofore is not sufficient to affect travel, it is seemingly inevitable that price signals, if the price of gasoline moves sharply higher than previously experienced, should generate a measurable change in travel behavior.[25]

---

[24] A trip is defined as any time the respondent went from one address to another by private motor vehicle, public transportation, bicycle, walking, or other means. A trip purpose is the main reason that motivates a trip.

[25] "The energy intensity of the United States economy has been reduced by about half since the early 1970s in response to sharply higher prices. Much of the displacement was achieved by 1985. Progress in reducing energy intensity has continued since then, but at a lessened pace. This more-modest rate of decline in intensity should not be surprising, given the generally lower level of real oil prices that prevailed between 1985 and 2000. With real energy prices again on the rise, more rapid decreases in the intensity of use in the years ahead seem virtually inevitable." Quoted from a speech by Allan Greenspan, Chairman, U.S. Federal Reserves (April 5, 2005).

As gasoline prices rise on the heels of a decade or more of depressed prices, what are the signals to which consumers have been listening? While the real retail price of gasoline has risen and fallen over the past two decades, there has been an overall decline of 1.3 percent per year between 1983 and 2001, with substantial drops in 1986 and 1998 and somewhat smaller ones in 1991 and 2001 (see Figure E1 for a Chronology of World Oil Prices). In contrast, the prices of other consumer products[26] have risen dramatically, taking a higher real percentage of consumers' budgets (see Figure 10). Given the minor role fuel prices have played in determining vehicle use, there is little surprise that vehicle-miles traveled is better correlated with disposable income than retail prices; furthermore, the improvement in energy intensity, though unexceptional, might have further weakened a diminished price signal by mitigating the effect of fuel prices, where consumers could travel further on $1 of transportation fuel. Given that retail price is primarily based on the price paid for crude oil[27], price signals to consumers should mimic world crude oil prices, which have exceeded $50 per barrel (bbl) – at times surpassing $60 per bbl.

Retail prices include Federal, State, and Local excise taxes. Hence, fuel taxes represent yet another signal to consumers. Federal excise taxes are 18.4 cents per gallon and State excise taxes average about 21 cents per gallon.[28] Since 1988, Federal and State excise taxes on gasoline have been collected at the wholesale level, not the retail level. This means that retailers must pay all taxes at the terminal[29] when they purchase fuel through a truckload sale. This protects the U.S. Treasury from missing any uncollected taxes and any need to conduct audits of gas station owners. It is the retailers' responsibility to recover their expense; that is why when the consumer purchases fuel they see only the total cost. The retailer is not remitting any funds to a governmental entity when a consumer makes a purchase; consequently, final purchase receipts exclude any listing of fuel tax . Though consumers would still react to retail prices, uncertainty exists with the measured impact from excise taxes, as the lack of visibility might partially dampen the impact such taxes could have on the demand for gasoline.

Besides fuel price, which signals do consumers recognize? Statistically, real disposable income[30] is one such signal. Based on 1983, 1985, 1988, 1991, 1994, and 2001 point estimates, it can explain 99 percent of the variation in vehicle-miles traveled. From such a result, it could be argued that the change in vehicle-miles per unit change of real disposable income, as measured in chained dollars, is 0.3, the estimate of the slope, β_1, of the regression $Y = \beta_0 + \beta_1 X$, with Y denoting travel and X denoting real disposable income. Since 1983, with some minor deviations, the growth in vehicle-miles traveled has mirrored the increases in real disposable income. For instance, between 1983 and 1985, when annual real gasoline prices dropped 4.4 percent per year,

[26] See components of the Consumer Price Index conducted by the U.S. Bureau of Labor Statistics.

[27] See *Federal Trade Commission*, Gasoline Price Changes: the Dynamic of Supply, Demand, and Competition, July 5, 2005, Washington, DC. Accessed http://www.ftc.gov/opa/2005/07/gaspricefactor.htm on July 25, 2005.

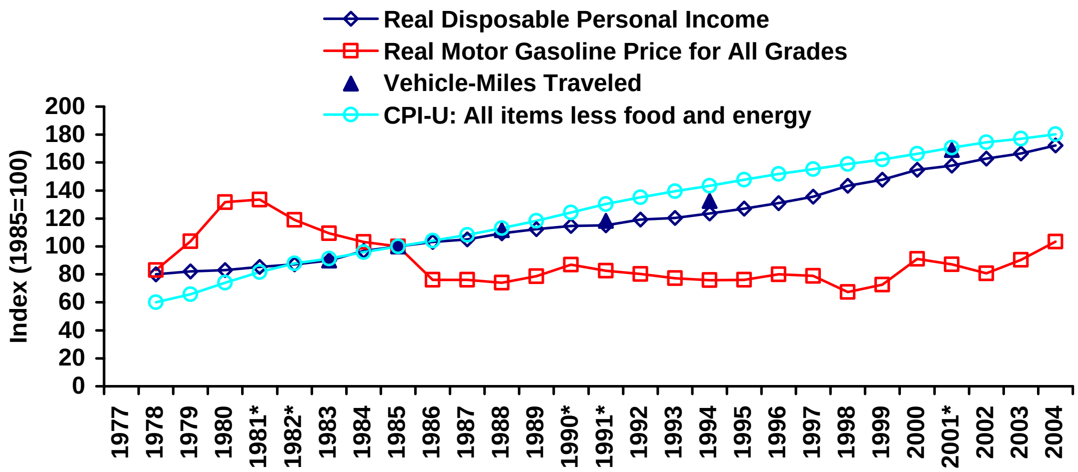
[28] See Energy Information Administration, Petroleum Marketing Monthly June 2004, Table EN1. Note: 90 percent or more of Federal excise taxes are returned to States.

[29] Terminal, or "rack" – sales of product by the truckload (typically about 8,000 gallons) at the loading rack of a product terminal, supplied from a refinery, pipeline, or port.

[30] Total after-tax income, as measured in chained dollars, received by persons; it is the income available to persons for spending or saving.

the annual growth of vehicle-miles traveled (i.e., overall travel) and disposable income rose 5.4 and 5.5 percent, respectively. Despite some inconsistencies when travel activity grew faster than disposable income, their overall growth between 1983 and 2001 is in near lock-step formation, with real disposable income registering a rise of 3.2 percent per year and travel activity growing at an annual rate of 3.6 percent.

Figure 10. Annual Indices of Real Disposable Income, Vehicle-Miles Traveled, Consumer Price Index (CPI-U), and Real Average Retail Gasoline Price, 1978-2004, 1985=100



*Sources: Energy Information Administration, Annual Energy Review 2004; Bureau of Economic Analysis. Note * = recession year.*

ENERGY INTENSITY

Energy intensity indicates the energy performance of the nation's vehicle stock.

ENERGY PERFORMANCE: GALLONS PER VEHICLE-MILE TRAVELED

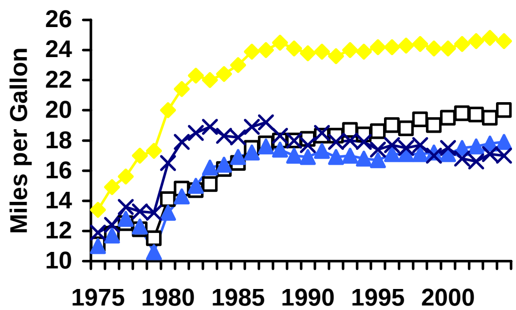
Tracking an economy's energy intensity – its energy performance – as the ratio of energy per GDP (or the environmentally based intensity of carbon dioxide per GDP[31]) is common in energy economics, and such a technique can be applied to transport. Instead of a ratio of economy-wide energy use per GDP, one can use a ratio of gasoline-equivalent gallons (GEG) per vehicle-miles traveled for the *entire* vehicle stock (see Figures 11-14). This intensity has steadily improved since 1983, though the greatest strives toward lowering (improving) energy intensity had occurred before 1991. Post-1991 improvements (i.e., energy performance) slowed dramatically, yielding an overall annual improvement of 1.6 percent between 1983 and 2001, as compared to the 3.2 and 4.2 percent gains seen in the 1983-1985 and 1985-1988 time periods, respectively.

No other vehicle energy predictor seems to draw as much public scrutiny. There is some justification behind this: it is one of the most visible measures used by decision and policy makers to regulate energy use and consumers to identify a vehicle's energy performance. From "stickers"

[31] Greenhouse gas emissions from petroleum-powered vehicles are directly proportional~~ly~~ to energy use.

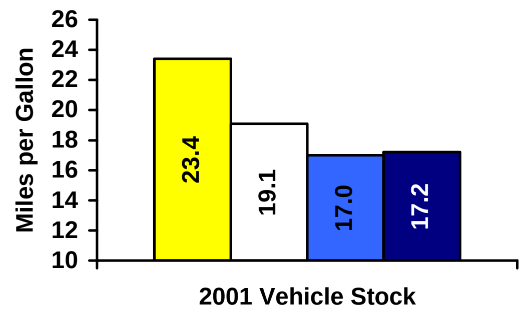
on each new vehicle to identify its on-road fuel economy and the joint publication of fuel economies by the U.S. DOE and U.S. EPA at www.fueleconomy.gov to the Gas Guzzler tax (USC 26 § 4064) based on these same "sticker" values and NHTSA's Corporate Average Fuel Economy (CAFE) program, progress on energy intensity (measured as GEG per mile), the inverse of fuel economy (measured as miles per GEG) is one measure of which the public is highly informed and concerned, where even the plans to revise EPA's measurement tests for determining on-road fuel economy create national interest.[32]

Figure 11. Sales-Weighted On-Road Fuel Economy by Vehicle Type, 1975-2004 Model Years



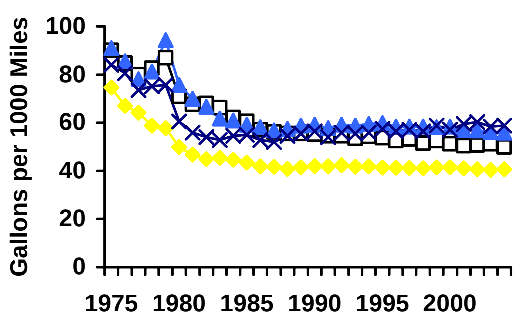
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 12. Average On-Road, In-Use Fuel Economy by Vehicle Type, 2001



Source: Energy Information Administration, tables in this report.

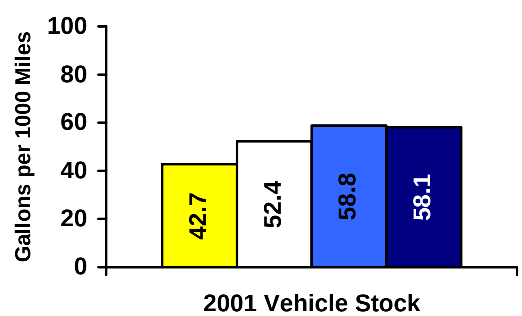
Figure 13. Sales-Weighted On-Road Energy Intensity by Vehicle Type, 1975-2004 Model Years



Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Passenger Cars, Vans, SUVs, Pickups

Figure 14. Average On-Road, In-Use Energy Intensity by Vehicle Type, 2001



Source: Energy Information Administration, tables in this report.

Passenger Cars, Vans, SUVs, Pickup Trucks

[32] See Fialka, J., *The Wall Street Journal*; page D1, May 12, 2005.

While changes in energy intensity are often used to *suggest* efficiency, care should be used to avoid any confusion with technical efficiency and economic efficiency. Technical efficiency is where the maximum output is achieved with minimal input; economic efficiency is the production and distribution of goods or services at the lowest possible cost. Thus, technical efficiency is not necessarily a sufficient condition for economic efficiency, or vice-versa. For example, an engine developed for superior technical efficiency might require a fuel that utterly violates economic efficiency; and an economically efficient engine might be far from technically efficient.

Propulsion efficiency of jet engines is one technology area in which technical efficiency seems to have gone hand-in-hand with economic efficiency, as the ratio of thrust-aircraft velocity per heat added has steadily improved.[33] This efficacy, especially with respect to thrust, has enabled larger aircraft for airline passenger travel, all at a significant decrease in heat added, which translates into less fuel consumed per passenger-mile.[34]

Propulsion efficiency of vehicles has trod a highly similar path; engine efficacy (as suggested by horsepower (HP)) of each succeeding models years has generally increased, as suggested by the trajectories of the sales-weighted on-road fuel economy values presented in Figures 17, 19, 21, and 23. For a number of reasons beyond the scope of this report, that progress mostly excluded improvements in energy intensity, as energy performance (as measured by energy intensity) only slightly improved. Even though automakers have continued to make improvements in technology, "consumer preference over the past 15 or 20 years has led automakers to increase vehicle size, weight, and horsepower while holding gasoline mileage [the inverse of energy intensity] more or less constant," though vans do show some improvement (see Figures 18, 20, 22, and 24).[35] As load factors for vehicles deteriorated over the 1983 to 2001 time period, fewer people were transported in heavier, more powerful, slightly more-fuel-efficient vehicles.

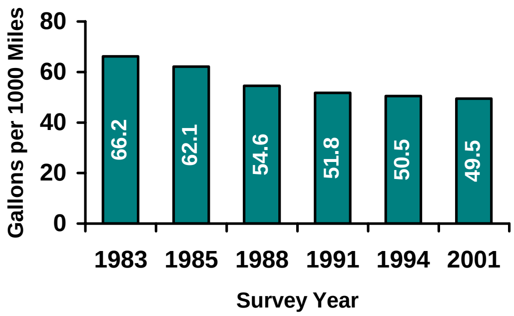
Automakers did increase vehicles' energy performance but that has been offset by consumers' increased travel needs. Energy intensity improved 1.6 percent per year, from 66.2 GEG per 1000 miles in 1983 to 49.5 GEG in 2001, while per-vehicle travel offset this improvement by increasing 1.4 percent per year, from 9.4 thousand miles per vehicle to 12.0 thousand miles, as the number of vehicles in total increased 2.2 percent per year – simply put, more vehicles are traveling farther. Hence, travel activity is a much better predictor of future energy needs than energy intensity, as fuel economy of vehicles sold in America is relatively stable, though pickups do exhibit a trajectory of declining sales-weighted fuel economy.

[33] Edwards, C.F., Technological Potential and Challenges to Low GHG Transportation, International Petroleum IPECA Transportation and Climate Change Conference, October 13, 2004. See http://www.ipieca.org/ for details.

[34] Mattingly, J.D., Elements of Gas Turbine Propulsion, McGraw Hill (1996), as presented by C.F. Edwards at the IPIECA Transportation and Climate Change Conference, October 13, 2004.

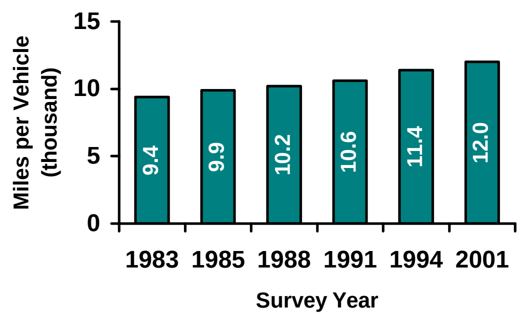
[35] See Congress of the United States, Congressional Budget Office, The Economic Costs of Fuel Economy Standards Versus a Gasoline Tax, December 2003.

Figure 15. Average On-Road, In-Use Energy Intensity, Selected Survey Years



Source: Energy Information Administration.

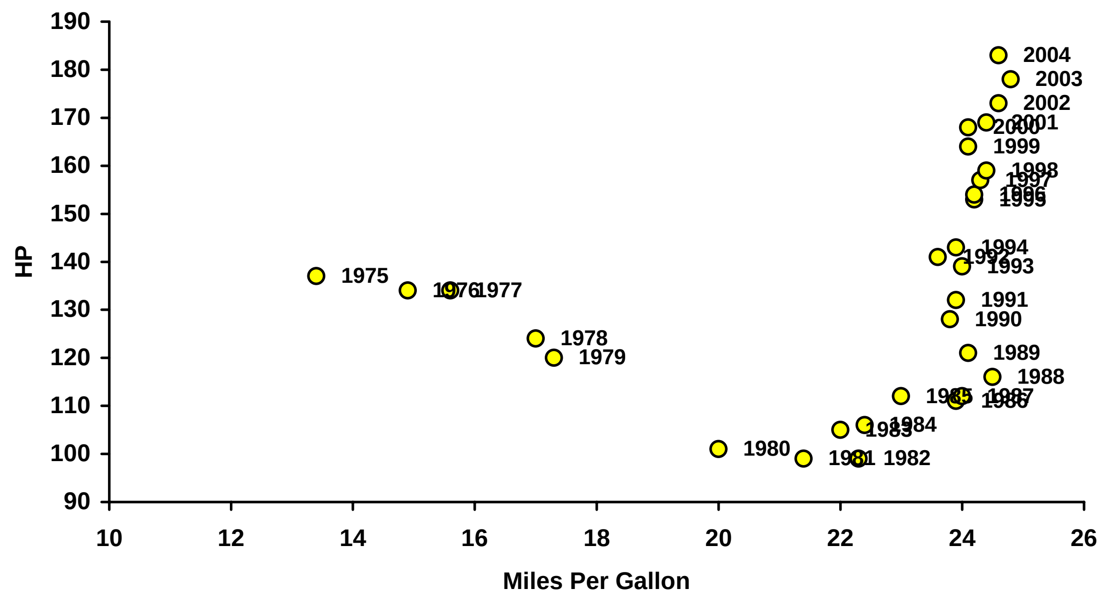
Figure 16. Average Vehicle-Miles Traveled per Vehicle, Selected Survey Years



Source: Energy Information Administration.

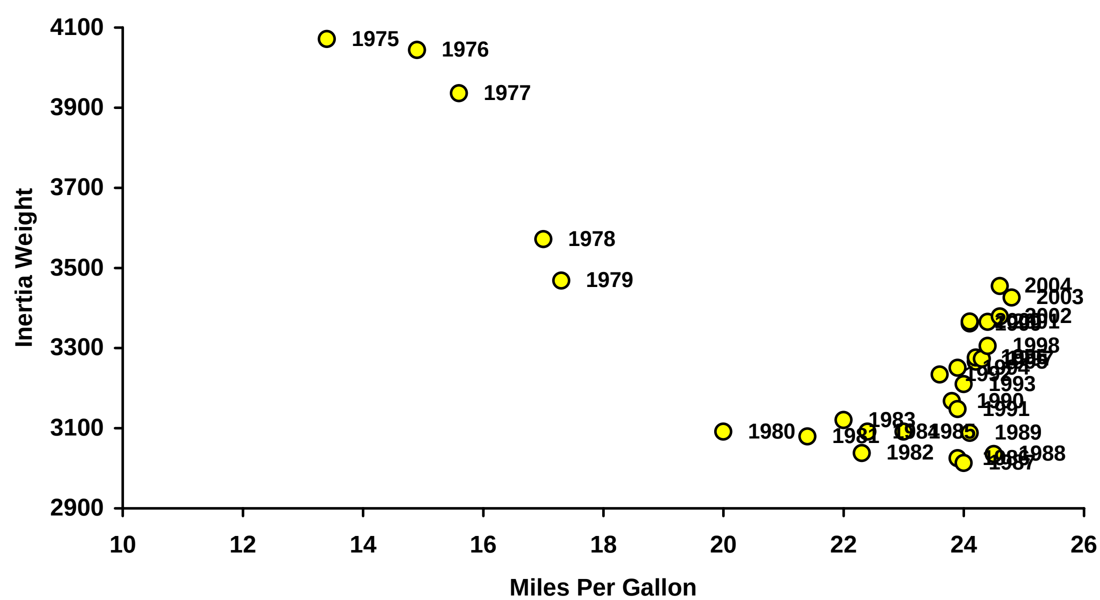
Is this increased travel an effect of the exurbanization in America and its associated upward pressure on increased trip lengths? Are Americans increasingly on the move? How much does vehicles' energy performance and Americans' travel affect overall energy use? Decomposition analysis provides some answers for the latter questions, while the first is decidedly more intractable given the lack of sub-national data on travel and energy use.

Figure 17. Sales-Weighted Horsepower and On-Road Fuel Economy for Passenger Cars, 1975-2004 Model Years



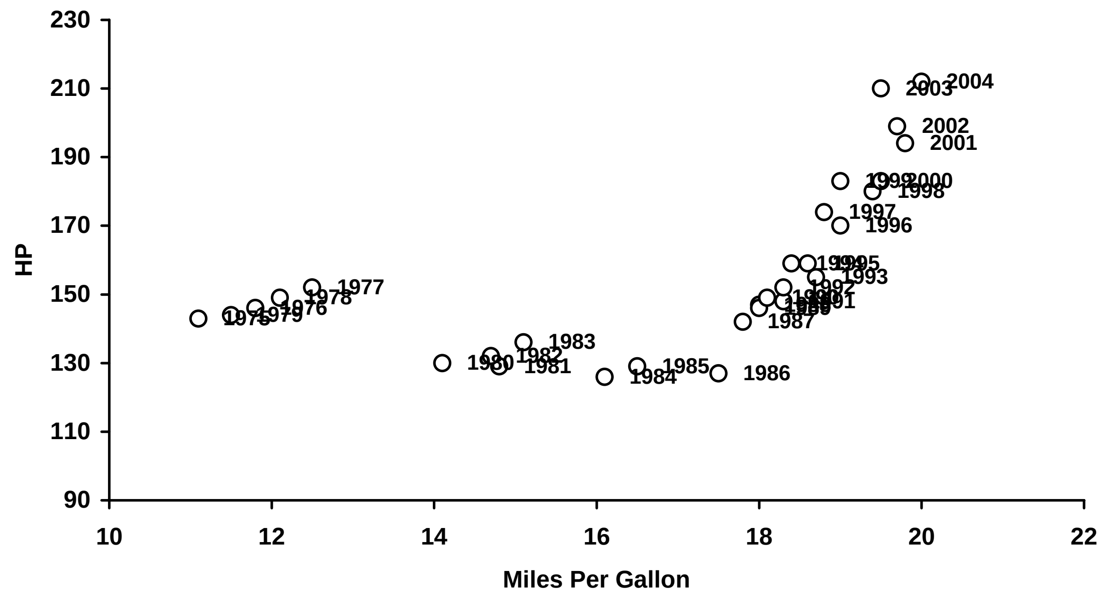
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 18. Sales-Weighted Vehicle Weight and On-Road Fuel Economy for Passenger Cars, 1975-2004 Model Years



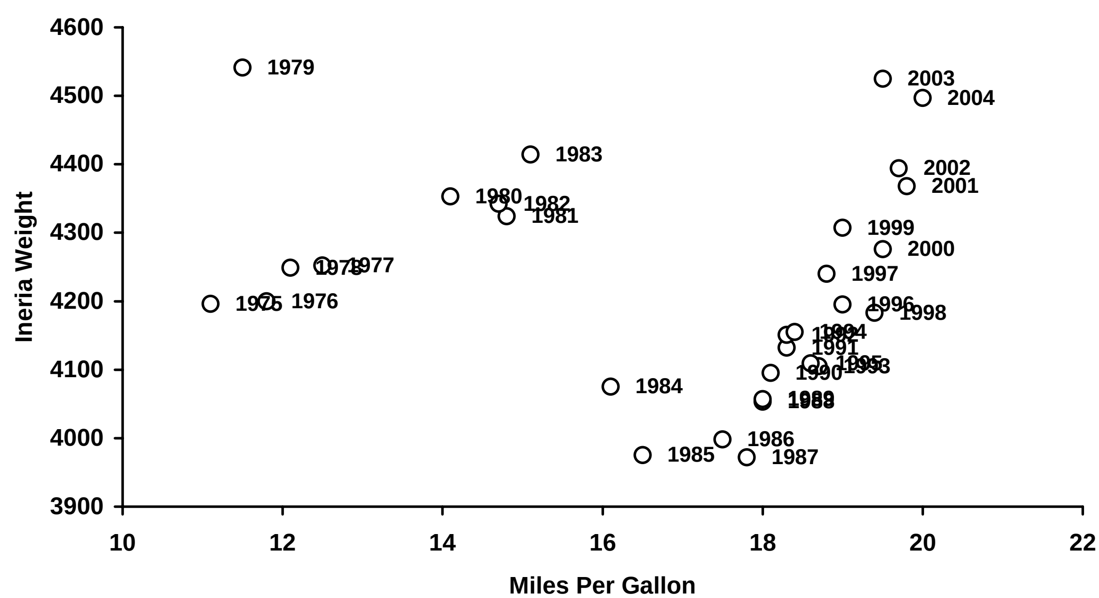
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 19. Sales-Weighted Horsepower and On-Road Fuel Economy for Vans, 1975-2004 Model Years



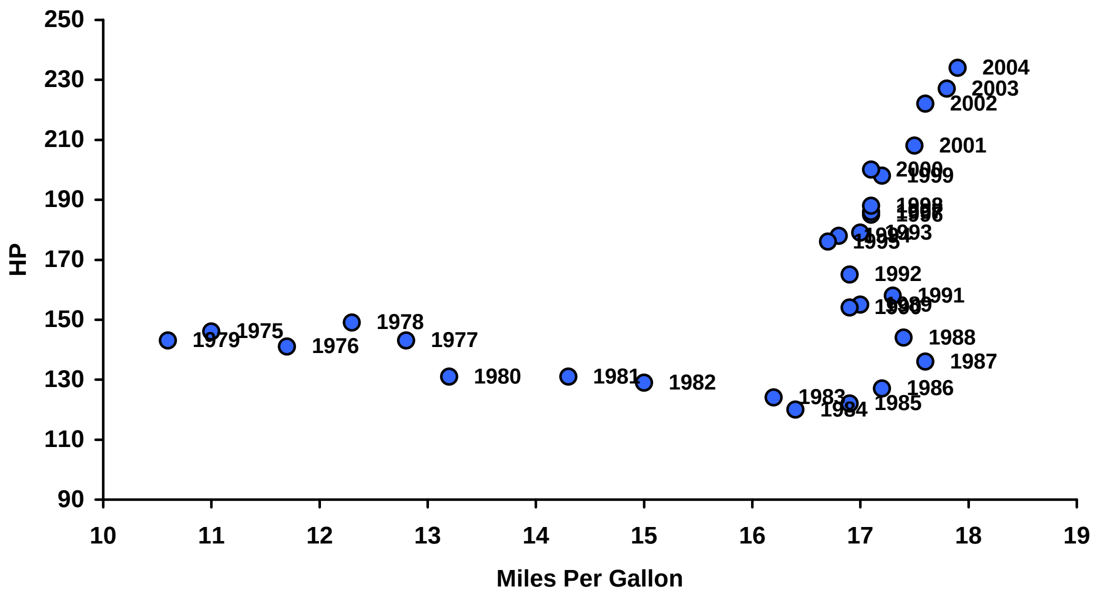
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 20. Sales-Weighted Vehicle Weight and On-Road Fuel Economy for Vans, 1975-2004 Model Years



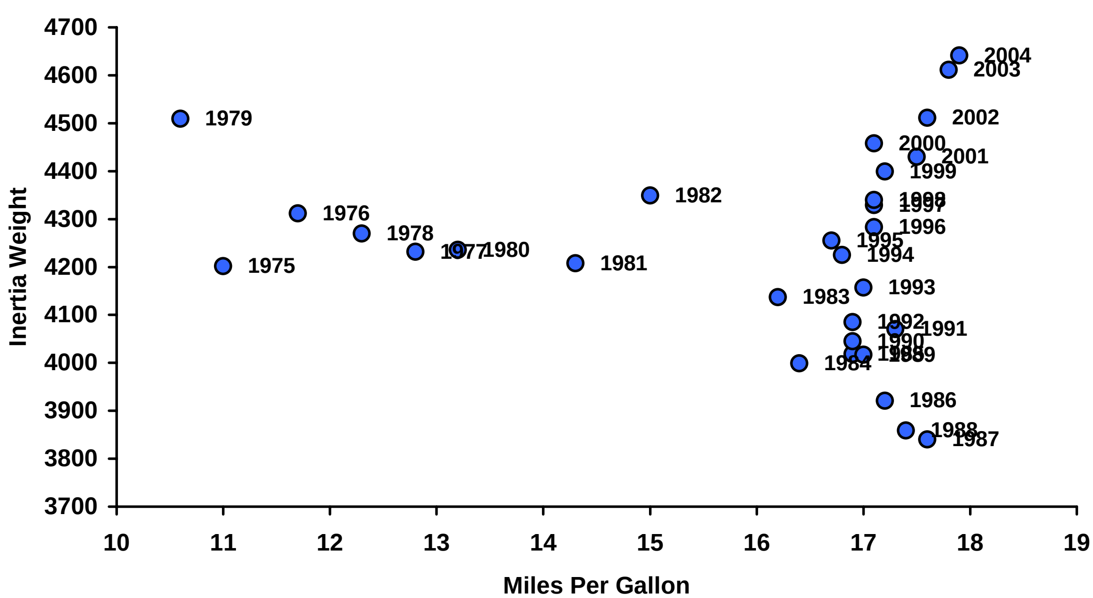
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 21. Sales-Weighted Horsepower and On-Road Fuel Economy for SUVs, 1975-2004 Model Years



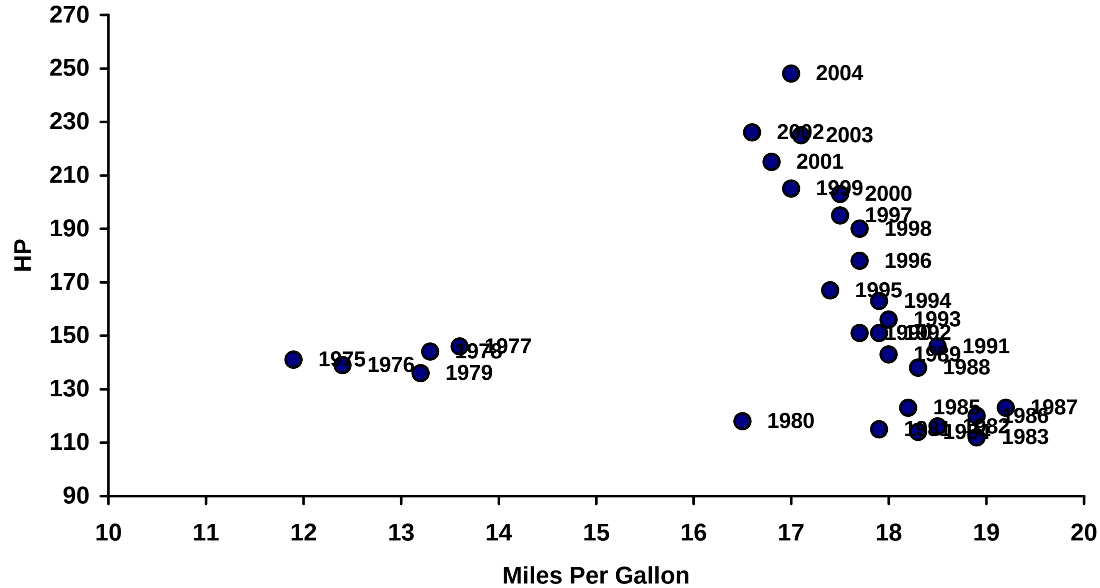
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 22. Sales-Weighted Vehicle Weight and On-Road Fuel Economy for SUVs, 1975-2004 Model Years



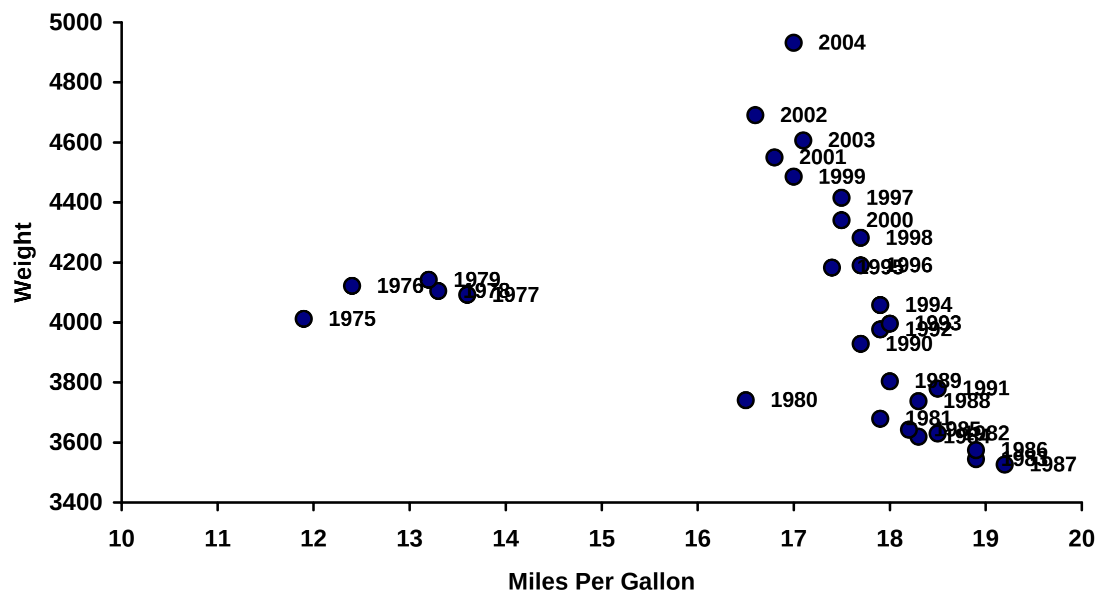
Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 23. Sales-Weighted Horsepower and On-Road Fuel Economy for Pickups, 1975-2004 Model Years



Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

Figure 24. Sales-Weighted Vehicle Weight and On-Road Fuel Economy for Pickups, 1975-2004 Model Years



Source: U.S. Environmental Protection Agency, Fuel Economy Trends 2004.

DECOMPOSING ENERGY NEEDS

Decomposition analysis is a logical means to link changes *structure*, *activity* and *energy intensity* to changes in energy use. These links should not to be confused with total energy efficiency, economic or technical efficiency to changes in energy use. To decompose energy use, a few of the demand predictors available in this report are linked to energy, effectively creating structure-energy, activity-energy, and intensity-energy links.

Unfortunately, restrictions on the data limit the scope of this work. Had greater sample sizes been available in the RTECS conducted in 1983 through 1994, it might have been possible to analytically link a wider array of measures. The sample sizes of RTECS, though, rarely supported point estimates crossed on more than a few characteristics. Because survey sample sizes – generally on the order of 3,000 households and 6,000 vehicles – become exceedingly thin as one calculates energy and energy-related statistics by household and vehicle characteristics – such as lifecycle, vehicle type, geographic region (e.g., urban versus rural), and income – decomposition of energy needs is limited to only a few key components (see Tables 4 through 9).

Decomposition is a means of analyzing an overall change over time. The key is identifying intermediate predictors that are measurable and dimensionally intertwined with each other in ratios such that an overall statistic can be "decomposed" into the product of two or more "effects," effectively linking them together. It is then possible to examine a change over time in the overall statistics (in this case, energy use) in terms of changes in the component ratios. Note that the use of the term “predictor” has been replaced by “effect” to emphasize that conclusions are statistical in nature, not causal. The multiplied components in Equation 2 are one example of the decomposition process.

Key Terms

These terms and general formulation for quantifying concluding effects on the changes in energy use were adapted from *Oil Crises & Climate Challenges: 30 Years of Energy Use in IEA Countries*, an economy-wide decomposition conducted by the Paris-based International Energy Agency, using Laspeyeres indices.

***Activity**: Basic unit of accounting for which energy is used, which, in this report, is the amount of travel, as measured by miles per vehicle.*

***Energy Intensity**: Energy consumed per unit of activity; gasoline-equivalent gallons per vehicle-mile traveled, as measured on-road and in-use..*

***Structure**: Refers to the mix of activities within the residential transportation sector; for example, number of households, fraction of housing belonging to a given lifecycle category, average number of vehicles owned per household, and fraction of vehicles in the nation’s vehicle stock by type.*

$$Gallons_{\ldots} = Households_{\ldots} \bullet \sum_i \left(\frac{Households_{i..}}{Households_{\ldots}} \bullet \frac{Vehicles_{i..}}{Households_{i..}} \bullet \left(\sum_j \frac{Vehicles_{ij.}}{Vehicles_{i..}} \bullet \sum_k \left(\frac{Vehicles_{ijk}}{Vehicles_{ij.}} \bullet \frac{Miles_{ijk}}{Vehicles_{ijk}} \bullet \frac{Gallons_{ijk}}{Miles_{ijk}} \right) \right) \right) \quad (2)$$

Equation 3 presents a simplified form of Equation 2.

$$Gallons_{\ldots} = Households_{\ldots} \bullet \sum_i \sum_j \sum_k \frac{Households_{i..}}{Households_{\ldots}} \bullet \frac{Vehicles_{i..}}{Households_{i..}} \bullet \frac{Vehicles_{ij.}}{Vehicles_{i..}} \bullet \frac{Vehicles_{ijk}}{Vehicles_{ij.}} \bullet \frac{Miles_{ijk}}{Vehicles_{ijk}} \bullet \frac{Gallons_{ijk}}{Miles_{ijk}} \tag{3}$$

where *i* denotes a household lifecycle (up to 9 categories), *j* denotes vehicle type (up to 4 types), and *k* identifies a vintage category of vehicles (up to 2 categories). In the following analysis, combinations of years of survey data, household lifecycle, vehicle type, and vintage are explored to partition the overall change in energy needs. To avoid any confusion with the combinations, a mnemonic – *Decomposition* *# Survey Years* *# Lifecycles* *# Vehicle Types* *# Vintages* – serves to identify each combination under analysis.

- *Decomposition 4942* represents a decomposition covering 4 years of survey data, 9 categories of household lifecycle, 4 vehicle types and 2 vintage groupings (new versus old);

- *Decomposition 4941* represents a decomposition covering 4 years of survey data, 9 categories of household lifecycle, 4 vehicle types, and no vintage categorization; and

- *Decomposition 4921* represents a decomposition covering 4 years of survey data, 9 categories of household lifecycle, 2 vehicle types (e.g., cars versus all other vehicle types) and no categorization of vintage.

Using EIA data, seventy-two (9 x 4 x 2) separate decompositions can be completed for each base and end year combination. Because most of those decompositions give similar results, only a few have been completed and displayed.

In decompositions found herein, 4 years of survey data – 1988, 1991, 1994, and 2001 – are deemed eligible for use because necessary data (e.g., household lifecycle details) were not obtained in 1983 and 1985. For vehicle-possessing households, lifecycles are restricted to 9 categories:

1. Age of oldest child is younger than 7 years of age,

2. Age of oldest child is 7 to 15 years,

3. Age of oldest child is 16 or 17 years,

4. Householder is younger than 35 years in a household with one adult and no children,

5. Householder is 35 to 59 years of age in a household with one adult and no children,

6. Householder is 60 years or older in a household with one adult and no children,

7. Householder is younger than 35 years in a household with two or more adults and no children,

8. Householder is 35 to 59 years of age in a household with two or more adults and no children, and

9. Householder is 60 years or older in a household with two or more adults and no children.

Vehicle types are grouped as passenger cars, vans, SUVs, and pickups (defined as recreational vehicles and pickup trucks).

MEASURING AN EFFECT

To assess the effects of each component, one only needs to calculate the ratio of the overall energy use based on varying only one component (*activity*, *structure*, or *energy intensity*) to the actual amount in a given year. This is typically done using the earlier year (base year) for comparison. For example, the energy intensity effect is assessed for a base year, 0, and end year, t, by the following:

$$\text{Energy Intensity Effect} = \frac{Gallons_{\ldots t} \left| Activity_0, Structure_0, Intensity_t \right.}{Gallons_{\ldots 0} \left| Activity_0, Structure_0, Intensity_0 \right.} \tag{4}$$

Base years given herein are 1988, 1991, or 1994. They are denoted as *0*; while an end year (*t*) is defined as any survey fielded in a succeeding year (e.g., 1991 for 1988, 1994 for 1991 and so on).

Given the formulation of the Energy Intensity Effect denoted in Equation 4, calculations are analogous for the other remaining effects:

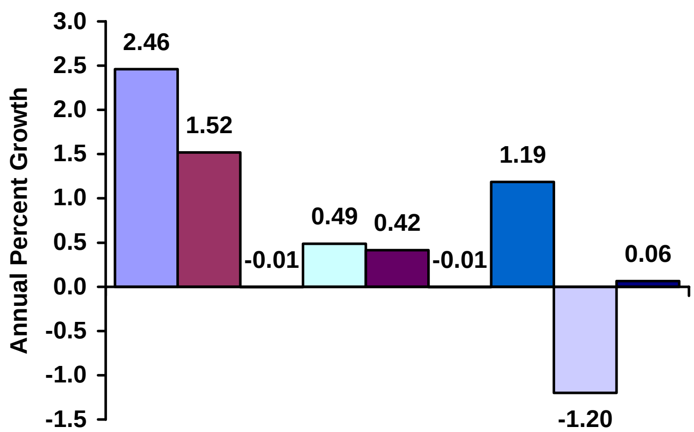
- Housing Effect,
- Lifecycle Effect,
- Ownership Effect,
- Vehicle Type Effect,
- Vintage Effect, and
- Vehicle Use Effect.

Interactions are difficult to interpret, because they represent all possible combinations of the above listed effects. Typically, Interactions are minor and may, in some analyses, be excluded from calculation, because they can be calculated by subtraction. As evidence of the minor interactions among effects, literature has shown that vehicle travel is relatively insensitive to energy intensity improvements, explaining that a "10 percent increase in fuel economy would lead to a 1 to 2 percent increase in vehicle travel."[36] For completeness, all Interaction Effects, though small, are displayed in this report. The limited ability to interpret interactions is commonly cited as a justification for using Divisia Indices, rather than Laspeyres. Given the

[36] Greene, D. and Schafer, A., Reducing Greenhouse Gas Emissions from U.S. Transportation, *Pew Center*, May 2003.

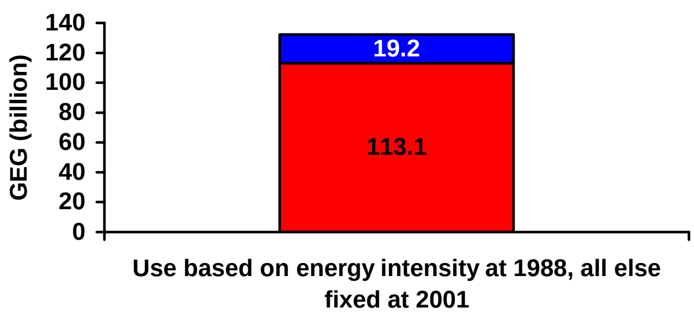
small contributions from Interactions during the time periods of interest, especially after annualizing its value to make assessments, the Laspeyres computation is used in this report.

Figure 25. Decomposition 4942 of Energy Needs, 1988 and 2001



Source: Calculated by Energy Information Administration.

Figure 26. Energy Savings from Energy Intensity Effect, 2001



Source: Calculated by Energy Information Administration.

Decomposition 4942

2.46 PERCENT PER YEAR
OVERALL ENERGY GROWTH

1.52 PERCENT PER YEAR
HOUSING EFFECT

-0.01 PERCENT PER YEAR
LIFECYCLE EFFECT

0.49 PERCENT PER YEAR
OWNERSHIP EFFECT

0.42 PERCENT PER YEAR
VEHICLE TYPE EFFECT

-0.01 PERCENT PER YEAR
VINTAGE EFFECT

1.19 PERCENT PER YEAR
VEHICLE USE EFFECT

-1.20 PERCENT PER YEAR
ENERGY INTENSITY EFFECT

0.06 PERCENT PER YEAR
INTERACTIONS

Concluded Energy Savings based on the Intensity Effect

19.2 million gasoline-equivalent gallons (GEG)

SUMMARY OF DECOMPOSTION 4942

Decomposition provides a cleaner view of changes in energy use, helping to quantify effects and drive further analyses by assessing the relative importance of each component. First, the vehicle vintage shows limited impact on the change in energy use, meaning the proportion of vehicles, by vintage categories, is unchanging from survey to survey, as no variation in energy use is readily detectable by Equation 4, which calculates a -0.01 percent per year effect for Vintage. Based on vehicle sales figures and assuming a steady-state in the scrappage of vehicles, it is not surprising that vintage is less important to the nation's energy use than energy intensity, given that the sales figures for the past decade show that the nation's yearly purchases averaged 15.2 million vehicles with a standard deviation of 1.1 million vehicles, meaning new vehicle sales levels have been relatively constant, even for the 2001 recession year. Vintage categories, therefore, are dropped for all remaining decomposition analyses, which are denoted as *Decomposition ###1*.

Second, the Energy Intensity Effect (-1.2 percent per year) played a significant part in reducing the nation's energy use between 1988 and 2001. That improvement, however, was offset by 1 activity and 3 structural effects: Vehicle Use (1.19 percent), Housing (1.52 percent), Ownership (0.49 percent), and Vehicle Type (0.42 percent) – combined, they account for 3.61 percent per year growth in energy use. Even though the Lifecycle Effect is seemingly equivalent to the minimal influence shown by vehicle vintages, this effect is carried forward to further analyses because of the substantial changes occurring in the nation's population mix, such as the elderly tending to stay closer to their family members.[37]

Energy savings is one measure that quantifies the Energy Intensity Effect. The IEA defines concluded "energy savings" as the difference between the hypothetical amount of energy that would have been used in a given year if energy intensities had remained at base-year values and the actual energy use. From 1988 to 2001, the improvement in energy intensity, all else being equal, would have resulted in an energy savings of 19.2 billion gallons, meaning the nation would have consumed 132.3 billion gallons if energy intensities had remained fixed at base-year values. Because the nation actually consumed 113.1 billion gallons, improvements to energy intensity "saved" 19.2 billion gallons.

SUMMARY OF DECOMPOSTION 4941

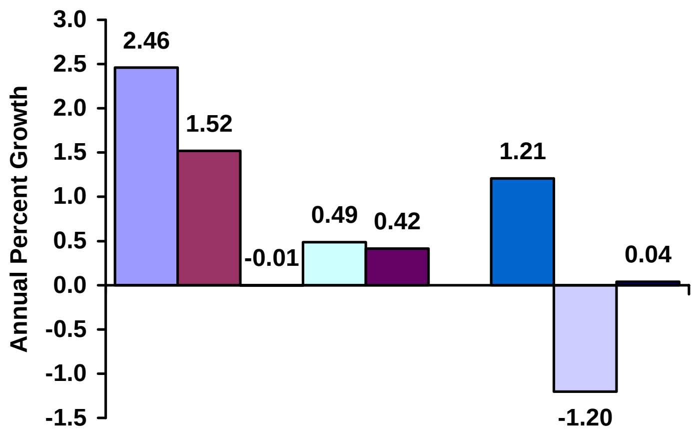
As expected, given the results of the *Decomposition 4942*, dropping vintage categories (denoted as *Decomposition 4941* shown in Figure 27) from the decomposition had little impact on partitioning out effects, meaning the proportion of vehicles (defined by vintage) in the end year (2001) is markedly similar to the base year (1988). In contrast, the Energy Intensity Effect still played a significant part in reducing the nation's energy use between 1988 and 2001. The improvement in energy intensity, all else being equal, would have resulted in an energy savings of 19.3 billion gallons, meaning the nation would have consumed 132.4 billion gallons if energy intensities had remained fixed at 1988 levels. Comparing effects between *Decompostions 4942* and *4941* on a one-to-one basis yields:

- Housing Effect having no measurable difference,
- Lifecycle Effect having no measurable difference,
- Ownership Effect having no measurable difference,
- Vehicle Type Effect having no measurable difference,
- Vehicle Use Effect having a 0.02 percent per year difference,

[37] Wellner, A.S., Is 'Increasing Mobility' a Threat to U.S. Elder Care?, accessed online at www.prb.org on August 10, 2005; Douglas A. Wolf and Charles F. Longino, Jr., Our 'Increasingly Mobile Society'? The Curious Persistence of a False Belief, *The Gerontologist* 45, no. 1 (2005): 5-11.

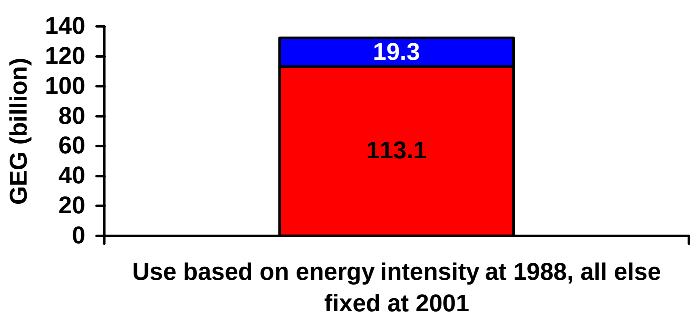
- Energy Intensity Effect having no measurable difference, and
- Interactions balance out numerically with the Vehicle Use Effect, a negative -0.02 percent difference.

Figure 27. Decomposition 4941 of Energy Needs, 1988 and 2001



Source: Calculated by Energy Information Administration.

Figure 28. Energy Savings from Energy Intensity, 2001



Source: Calculated by Energy Information Administration.

Decomposition 4941

2.46 PERCENT PER YEAR
OVERALL ENERGY GROWTH

1.52 PERCENT PER YEAR
HOUSING EFFECT

-0.01 PERCENT PER YEAR
LIFECYCLE EFFECT

0.49 PERCENT PER YEAR
OWNERSHIP EFFECT

0.42 PERCENT PER YEAR
VEHICLE TYPE EFFECT

-- PERCENT PER YEAR
VINTAGE EFFECT

1.21 PERCENT PER YEAR
VEHICLE USE EFFECT

-1.20 PERCENT PER YEAR
ENERGY INTENSITY EFFECT

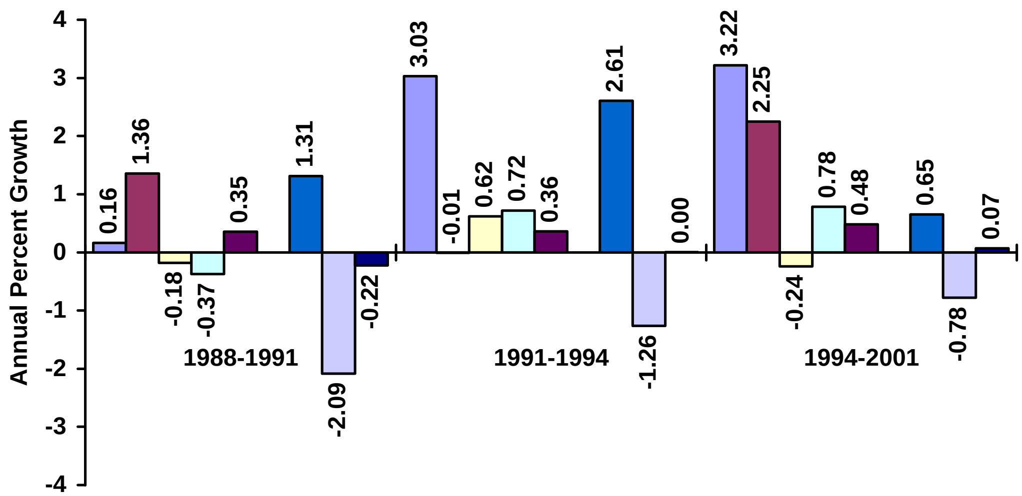
0.04 PERCENT PER YEAR
INTERACTIONS

Concluded Energy Savings based on the Intensity Effect

19.3 million gasoline-equivalent gallons (GEG)

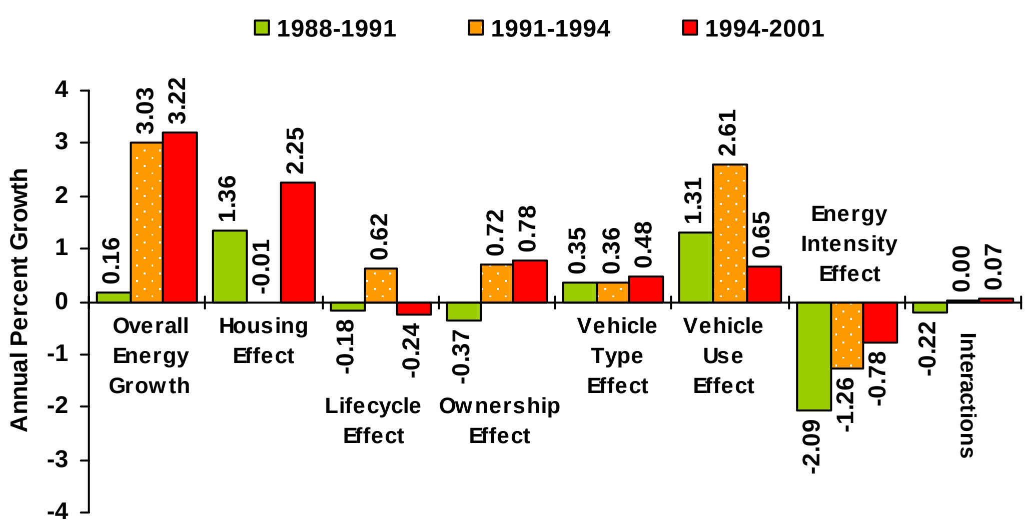
Decomposing survey-to-survey energy use is yet another approach. While a longer term view on changes in energy use provides insights into energy "savings" from a slowly changing vehicle stock, it precludes shorter term views. Additional insights are obtained by decomposing energy use using Equation 4 for shorter time periods: 1988-1991, 1991-1994, and 1994-2001 (see Figures 29 and 30).

Figure 29. Decomposition 4941 of Energy Use, 1988-1991, 1991-1994, and 1994-2001



Grouping effects from *Decomposition 4941* by time period provides a much cleaner comparison of the magnitude of the trends occurring between 1988 and 2001 (see Figure 30).

Figure 30. Decomposition 4941 of Energy Use by Effect, 1988-1991, 1991-1994, and 1994-2001



Source: Calculated by Energy Information Administration.

Growth in energy use is uneven over the three time periods: 1988-1991, 1991-1994, and 1994-2001. Even though energy use grew 2.46 percent per year between 1988 and 2001, it was much slower between 1988 and 1991 (0.16 percent per year) than in subsequent years, which experienced much stronger growth, up over 3 percent per year between 1991 and 2001.

Clearly, not all years are the same. One artifact of intermittent end-use data collection is jumps and drops in statistics due to the economic activity or national hardship events occurring during the survey years.[38] For instance, it could be argued that the recession between July 1990 and March 1991 resulted in a retreat of energy use in 1991; however, teasing out the effects on energy use shows that several factors offset energy use: the Energy Intensity Effect (-2.09 percent per year) the Lifecycle Effect (-0.18 percent per year) and the Ownership Effect (-0.37 percent per year). Without these effects, growth in energy use would have been over 3 percent per year, even with a recession, all else remaining constant. Given the expected impacts on economic wealth and financial security during a recession, a negative contribution to energy use between 1988 and 1991 from vehicle ownership is not surprising.

Table 3. Comparing Component Effects, 1988-1991, 1991-1994, and 1994-2001

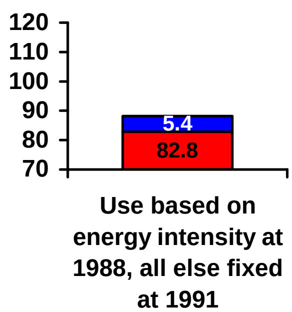
1988 – 1991	1991-1994	1994-2001
0.16 PERCENT PER YEAR OVERALL ENERGY GROWTH	3.03 PERCENT PER YEAR OVERALL ENERGY GROWTH	3.22 PERCENT PER YEAR OVERALL ENERGY GROWTH
1.36 PERCENT PER YEAR HOUSING EFFECT	-0.01 PERCENT PER YEAR HOUSING EFFECT	2.25 PERCENT PER YEAR HOUSING EFFECT
-0.18 PERCENT PER YEAR LIFECYCLE EFFECT	0.62 PERCENT PER YEAR LIFECYCLE EFFECT	-0.24 PERCENT PER YEAR LIFECYCLE EFFECT
-0.37 PERCENT PER YEAR OWNERSHIP EFFECT	0.72 PERCENT PER YEAR OWNERSHIP EFFECT	0.78 PERCENT PER YEAR OWNERSHIP EFFECT
0.35 PERCENT PER YEAR VEHICLE TYPE EFFECT	0.36 PERCENT PER YEAR VEHICLE TYPE EFFECT	0.48 PERCENT PER YEAR VEHICLE TYPE EFFECT
-- PERCENT PER YEAR VINTAGE EFFECT	-- PERCENT PER YEAR VINTAGE EFFECT	-- PERCENT PER YEAR VINTAGE EFFECT
1.31 PERCENT PER YEAR VEHICLE USE EFFECT	2.61 PERCENT PER YEAR VEHICLE USE EFFECT	0.65 PERCENT PER YEAR VEHICLE USE EFFECT
-2.09 PERCENT PER YEAR ENERGY INTENSITY EFFECT	-1.26 PERCENT PER YEAR ENERGY INTENSITY EFFECT	-0.78 PERCENT PER YEAR ENERGY INTENSITY EFFECT
-0.22 PERCENT PER YEAR INTERACTIONS	0.00 PERCENT PER YEAR INTERACTIONS	0.07 PERCENT PER YEAR INTERACTIONS

[38] The 2001 NHTS was conducted over the 14-month period from March 2001 to May 2002. Unfortunately, that timing turned out to be problematic due to the September 11, 2001 terrorist attacks on the World Trade Center in New York and the Pentagon in Washington, DC. These attacks disrupted transport services for months, especially curtailing long-distance travel. It is not certain what impacts the attacks had on urban travel, but it seems likely that both the amount of travel and modal choice were affected. That may have distorted the survey results to some unknown extent. Information courtesy of John Pucher and John L. Renne, *Transportation Quarterly*, Vol. 57, No. 3, 2003.

ENERGY SAVINGS

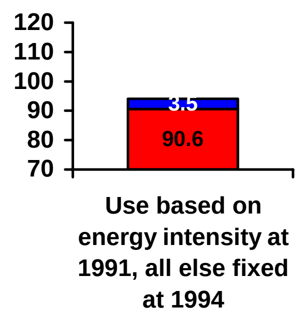
Based on the Intensity Effects, the nation has "saved" several billions of gallons of fuel from its deployment of less fuel intensive vehicles. That effect, however, has been offset in the United States., as newer vehicles sought by consumers have become heavier, more powerful, and faster, while only moderately less fuel intensive.

Figure 31. Concluded Energy Savings, 1991 (Billion GEG)



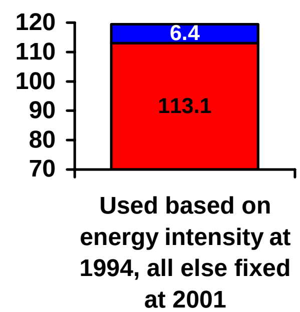
TIME DURATION FOR INTENSITY EFFECT: **3 YEARS**; FROM 1988 TO 1991

Figure 32. Concluded Energy Savings, 1994 (Billion GEG)



TIME DURATION FOR INTENSITY EFFECT: **3 YEARS**; FROM 1991 TO 1994

Figure 33. Concluded Energy Savings, 2001 (Billion GEG)



TIME DURATION FOR INTENSITY EFFECT: **7 YEARS**; FROM 1994 TO 2001

Figures 31, 32, and 33 track the concluded energy savings by the nation's vehicle stock due to lower energy intensities (i.e., improved energy performance). Over those times, energy was saved because automakers had produced vehicles with greater energy performance. The savings, however, are not equally dispersed. In terms of volumes, the nation "saved" the greatest amount of fuel between 1994 and 2001 because of improved energy performance; yet, those improvements took 7 years, whereas the period between 1988 and 1991, in which vehicles also achieved significant savings, improved such that 5.4 billion gallons was saved in only 3 years. Based on those savings, the nation experienced a diminished efficacy of energy performance, with superior achievements occurring prior to 1991. Indeed, the energy savings registered with 1991 energy intensities (see Figure 32) further illustrates the downward trend in savings due to energy performance of vehicles, with much less than the early period's saved amount (3.5 billion versus 5.4 billion), over the same time duration: 3 years.

COMPARING EFFECTS OVER TIME AND INTO THE FUTURE

Trends in the use of energy have been uneven for transport, as evidenced by the comparison of effects over time. Given the economic growth of the United States, as measured by GDP and real personal disposable income, the surge in energy use for transport is not particularly difficult to imagine – increased travel, increased ownership of vehicles that are heavier and more powerful than their predecessors, and shifts in vehicle stock toward SUVs would seemly point to increased energy use. But, some effects – even offsetting ones – have shown some variations which could point the way toward better managing future energy use:

- The number of households with vehicles continues to increase, exhibiting an upward pressure on transport's energy use, as measured by the Housing Effect. This effect is expected to continue, depending on the population growth and life expectancy of the nation.

- As the nation becomes populated with increasing number of elderly, the composition of households may prove to be a significant offset to energy use, as the decomposition of Lifecycle Effect between 1994 and 2001 does impart some evidence that an aging population might continue to play an offsetting role.

- As economic growth spreads among households, increasing the amount of real disposable income, the number of vehicles per household (Ownership Effect) should continue to move energy use higher, though some saturation point in vehicle stock is inevitable, effectively leveling this effect.

- Gains in the use of energy for transport have mimicked consumers' desire for heavier and more powerful vehicles, as the Vehicle Type Effect revealed a consistent pressure on energy use. Based on 2001 to 2004 new vehicle purchases, it is highly likely this effect will continue in the nearer term, though recent trends in fuel prices could eventually dampen this effect.

- In an environment in which Americans have increasingly moved to the exurbs, vehicle use continues to rise with people simply driving longer distances, though the dip assessed in the 1994 to 2001 time period could be tied to the lingering effects from the events occurring in September 2001. As the willingness of Americans to walk, share a commute, or take advantage of other forms of higher load sharing vehicles (e.g., buses) changes, this trend may fluctuate.

- The nation's growth in energy use was reduced 2.09 percent per year, 1.26 percent per year, and 0.78 percent per year for the time periods 1988-1991, 1991-1994, and 1994-2001, respectively. Lowering energy intensity has proven to be one of the largest, and most consistent, effects working to reduce the energy used by the nation for transport, though the greatest strives toward lowering energy intensity occurred before 1991. Post-1991 intensity improvements slowed dramatically. As new vehicles enter the vehicle stock, they will most likely dictate the future impact on energy use. Based on sales-weighted fuel mileage estimated by the EPA, it is highly likely that impact on lessening energy use will further erode, as the fuel mileage is relatively unchanging or decreasing.

This report has touched on only a few of the possible structure-energy, activity-energy, and intensity-energy links possible. Indeed, other reports and economic research have included vehicle occupancy as another effect, determining whether vehicles are transporting more or less people in their everyday use. As evidenced by the growth of GDP and transport use, economic growth is tied to the consumer's ability to acquire goods and services; doing so in a sustainable manner – whether fuel prices are rising to record levels or not – is a worthwhile goal for the strategic use of energy by the nation's 296 million final consumers.

DATA FOR DECOMPOSITION 4941

*Table 4. Number of Households with Vehicles by Household Composition (**Lifecycle**), Selected Survey Years*

	Survey Year							
	1988		1991		1994		2001	
	Number of HH (million)	Share	Number of HH (million)	Share	Number of HH (million)	Share	Number of HH (million)	Share
Total	81.3	100.0	84.6	100.0	84.6	100.0	98.9	100.0
With Children								
Eldest Child < 7	9.5	11.7	10.6	12.5	9.2	10.9	10.2	10.3
Eldest Child 7 to 15	14.7	18.1	16.7	19.8	16.4	19.4	19.8	20.0
Eldest Child 16 or 17	5.7	7.0	5.7	6.8	6.4	7.6	7.1	7.2
Without Children								
Two Adults, < 35	8.1	9.9	7.4	8.8	7.2	8.5	6.5	6.6
Two Adults, 35 to 59	12.8	15.8	12.5	14.7	15	17.7	17.3	17.5
Two Adults, 60 plus	13.5	16.6	13.1	15.4	13.6	16.1	15.4	15.6
One Adult ,< 35	5.0	6.1	4.2	4.9	3.4	4.0	3.3	3.4
One Adult, 35 to 59	5.3	6.5	6.5	7.7	6.6	7.8	9.0	9.1
One Adult, 60 plus	6.7	8.2	8.0	9.4	7.0	8.2	10.0	10.2

*Table 5. Number of Vehicles and Vehicle Ownership by Household Composition (**Lifecycle**), Selected Survey Years*

	Survey Year							
	1988		1991		1994		2001	
	Number of Vehicles (million)	Vehicles per HH	Number of Vehicles (million)	Vehicles per HH	Number of Vehicles (million)	Vehicles per HH	Number of Vehicles (million)	Vehicles per HH
Total	147.5	1.8	151.2	1.8	156.8	1.9	191.0	1.9
With Children								
Eldest Child < 7	17.3	1.8	19.0	1.8	17.1	1.9	20.0	2.0
Eldest Child 7 to 15	28.7	1.9	32.3	1.9	32.3	2.0	41.5	2.1
Eldest Child 16 or 17	13.8	2.4	13.8	2.4	15.2	2.4	18.2	2.6
Without Children								
Two Adults, < 35	14.3	1.8	13.2	1.8	13.8	1.9	13.4	2.1
Two Adults, 35 to 59	29.4	2.3	27.8	2.2	33.9	2.3	41.0	2.4
Two Adults, 60 plus	24.2	1.8	23.1	1.8	24.9	1.8	30.3	2.0
One Adult ,< 35	5.7	1.1	5.0	1.2	4.1	1.2	3.7	1.1
One Adult, 35 to 59	7.1	1.3	7.6	1.2	7.6	1.2	11.5	1.3
One Adult, 60 plus	7.0	1.0	9.6	1.2	7.9	1.1	11.4	1.1

*Table 6. Shares of Vehicles by Type and Household Composition (**Lifecycle**), Selected Survey Years*

	Vehicle Shares			
	1988	**1991**	**1994**	**2001**
Households with Children, Eldest < 7	100.0	100.0	100.0	100.0
Passenger Cars	73.6	70.8	65.4	55.5
Vans	5.4	8.3	8.9	10.8
SUV	3.4	6.2	8.6	16.0
Pickups	17.7	14.6	17.1	17.8
Households with Children, Eldest 7 to 15	100.0	100.0	100.0	100.0
Passenger Cars	70.1	63.8	58.6	49.7
Vans	7.7	10.4	14.8	16.1
SUV	4.0	6.3	7.6	15.4
Pickups	18.3	19.5	18.9	18.8
Households with Children, Eldest 16 or 17	100.0	100.0	100.0	100.0
Passenger Cars	73.4	66.1	64.2	55.0
Vans	6.1	8.4	9.9	13.0
SUV	3.5	4.4	5.7	13.3
Pickups	16.9	21.1	20.2	18.7
Households without Children, Two Adults, < 35	100.0	100.0	100.0	100.0
Passenger Cars	75.4	77.4	74.2	67.7
Vans	2.3	1.5	1.9	2.7
SUV	4.0	5.5	8.5	13.3
Pickups	18.3	15.6	15.3	16.3
Households without Children, Two Adults, 35 to 59	100.0	100.0	100.0	100.0
Passenger Cars	71.1	69.3	66.7	56.7
Vans	4.2	4.4	4.1	6.9
SUV	3.6	5.1	6.4	12.5
Pickups	21.1	21.3	22.8	23.9
Households without Children, Two Adults, 60 plus	100.0	100.0	100.0	100.0
Passenger Cars	75.8	75.2	72.6	63.2
Vans	3.6	4.5	5.6	9.1
SUV	1.7	2.5	3.1	6.9
Pickups	18.9	17.7	18.7	20.8
Households without Children, One Adult, < 35	100.0	100.0	100.0	100.0
Passenger Cars	80.3	79	73.6	68.8
Vans	2.9	1.6	2.5	1.7
SUV	4.5	8.1	6.3	12.9
Pickups	12.3	11.3	17.6	16.6
Households without Children, One Adult, 35 to 59	100.0	100.0	100.0	100.0
Passenger Cars	77.5	78.2	74.2	63.4
Vans	4.2	4.6	6.0	5.6
SUV	1.7	2.7	4.3	11.4
Pickups	16.6	14.5	15.5	19.6
Households without Children, One Adult, 60 plus	100.0	100.0	100.0	100.0
Passenger Cars	89.0	88.0	88.7	82.2
Vans	0.1	0.8	0.4	4.3
SUV	1.8	1.3	0.7	3.8
Pickups	9.0	9.8	10.2	9.7
All Households	100.0	100.0	100.0	100.0
Passenger Cars	74.1	71.6	67.9	58.8
Vans	4.7	6.0	7.3	9.6
SUV	3.2	4.8	6.1	12.2
Pickups	18.0	17.6	18.7	19.4

*Table 7. Vehicle-Miles Traveled per Vehicle by Type and Household Composition (**Lifecycle**), Selected Survey Years*

	Vehicle-Miles Traveled per Vehicle (thousand)			
	1988	**1991**	**1994**	**2001**
Households with Children, Eldest < 7	11.3	11.2	12.1	13.7
Passenger Cars	11.5	11.2	12.0	12.9
Vans	11.5	10.8	12.2	16.4
SUV	13.5	12.5	12.7	14.2
Pickups	9.9	11.0	12.0	14.1
Households with Children, Eldest 7 to 15	10.9	11.7	12.3	13.5
Passenger Cars	11.1	11.9	12.1	13.3
Vans	11.8	13.0	13.9	13.9
SUV	12.3	11.6	13.0	14.5
Pickups	9.6	10.6	11.4	12.7
Households with Children, Eldest 16 or 17	11.9	11.7	12.5	13.4
Passenger Cars	12.3	11.7	12.8	12.8
Vans	13.2	10.6	13.6	14.2
SUV	11.9	16.9	11.8	14.9
Pickups	9.4	11.3	11.5	13.3
Households without Children, Two Adults, < 35	11.4	11.9	12.7	13.7
Passenger Cars	11.2	12.1	12.5	13.6
Vans	9.7	14.7	15.6	15.6
SUV	14.3	9.4	13.1	13.8
Pickups	11.9	11.4	12.6	13.9
Households without Children, Two Adults, 35 to 59	10.2	10.7	11.6	11.8
Passenger Cars	10.3	10.9	11.5	11.5
Vans	9.2	10.7	12.3	12.3
SUV	10.5	11.5	12.6	13.1
Pickups	10.2	10.0	11.5	11.8
Households without Children, Two Adults, 60 plus	7.9	8.5	9.3	9.5
Passenger Cars	8.2	8.8	9.3	9.3
Vans	8.4	10.8	10.4	10.4
SUV	8.4	8.7	12.7	11.0
Pickups	6.5	6.8	8.5	9.1
Households without Children, One Adult, < 35	12.1	11.9	13.0	13.2
Passenger Cars	12.2	12.1	13.2	12.5
Vans	9.8	12.5	12.0	14.3
SUV	13.7	10.5	15.3	14.6
Pickups	11.1	11.9	11.5	15.0
Households without Children, One Adult, 35 to 59	9.3	10.7	11.2	10.9
Passenger Cars	9.8	10.9	11.2	10.3
Vans	7.3	8.3	10.5	10.9
SUV	10.1	14.8	10.3	12.9
Pickups	7.4	9.4	12.0	11.3
Households without Children, One Adult, 60 plus	6.9	6.1	7.6	7.1
Passenger Cars	6.7	6.1	7.6	6.8
Vans	22.1	7.9	6.2	8.3
SUV	10.1	4.9	7.2	10.1
Pickups	7.5	5.3	7.5	8.0

*Table 8. Gasoline-Equivalent Gallons per 1000 Miles by Type and Household Composition (**Lifecycle**), Selected Survey Years*

	Gasoline-Equivalent Gallons per 1000 Mile			
	1988	1991	1994	2001
Households with Children, Eldest < 7	52.3	49.9	50.1	48.5
Passenger Cars	48.4	45.1	44.4	41.4
Vans	66.0	60.7	54.8	50.9
SUV	60.2	61.3	63.9	58.3
Pickups	63.8	61.9	62.0	58.1
Households with Children, Eldest 7 to 15	55.8	52.2	51.3	49.6
Passenger Cars	51.5	47.2	45.6	41.8
Vans	64.0	56.4	53.9	51.8
SUV	66.3	62.7	62.2	59.7
Pickups	67.9	64.1	62.8	59.9
Households with Children, Eldest 16 or 17	52.7	52.4	50.2	49.1
Passenger Cars	49.1	46.5	45.3	42.2
Vans	63.8	62.2	58.3	52.3
SUV	64.6	61.9	59.2	59.1
Pickups	64.7	64.5	60.4	58.2
Households without Children, Two Adults, < 35	50.7	47.4	46.2	46.1
Passenger Cars	47.3	44.1	42.0	40.7
Vans	76.5	55.3	53.2	52.6
SUV	58.7	61.2	59.9	58.4
Pickups	59.1	59.3	57.3	57.0
Households without Children, Two Adults, 35 to 59	55.4	51.9	51.3	50.1
Passenger Cars	50.9	47.6	45.5	43.3
Vans	70.3	62.8	62.3	53.3
SUV	67.6	56.6	58.6	58.1
Pickups	66.2	63.2	63.9	60.3
Households without Children, Two Adults, 60 plus	58.6	54.6	53.2	52.1
Passenger Cars	55.6	50.8	49.6	45.7
Vans	73.7	58.9	58.5	52.8
SUV	65.5	68.4	64.5	59.8
Pickups	69.7	71.3	63.7	68.4
Households without Children, One Adult, < 35	49.2	48.3	46.2	46.9
Passenger Cars	46.1	43.7	41.8	40.9
Vans	58.3	69.3	71.9	54.7
SUV	66.1	72.0	57.7	56.5
Pickups	61.7	62.7	58.0	59.7
Households without Children, One Adult, 35 to 59	55.2	51.5	48.8	48.5
Passenger Cars	51.9	48.0	44.5	42.7
Vans	78.9	68.5	66.6	54.7
SUV	91.1	56.2	68.5	56.4
Pickups	65.4	67.3	57.3	58.9
Households without Children, One Adult, 60 plus	60.0	57.2	50.7	49.3
Passenger Cars	56.7	55.1	49.5	46.6
Vans	51.6	64.9	55.2	53.6
SUV	60.6	81.4	63.8	57.2
Pickups	88.6	75.0	60.8	63.6

*Table 9. Number of Sampled Vehicles by Type and Household Composition (**Lifecycle**), Selected Survey Years*

	Number of Sampled Vehicles			
	1988	**1991**	**1994**	**2001**
Households with Children, Eldest < 7	796	802	629	3,852
Passenger Cars	578	557	414	1,995
Vans	45	60	55	451
SUV	27	48	54	644
Pickups	146	137	106	762
Households with Children, Eldest 7 to 15	1,265	1,350	1,168	8,446
Passenger Cars	870	864	683	3,933
Vans	97	134	168	1,385
SUV	55	85	87	1,367
Pickups	243	267	230	1,761
Households with Children, Eldest 16 or 17	639	582	547	3,900
Passenger Cars	474	385	356	2,090
Vans	36	44	48	495
SUV	22	23	32	548
Pickups	107	130	111	767
Households without Children, Two Adults, < 35	655	529	505	2,418
Passenger Cars	494	392	378	1,543
Vans	14	9	9	74
SUV	24	34	37	359
Pickups	123	94	81	442
Households without Children, Two Adults, 35 to 59	1,265	1,183	1,219	10,124
Passenger Cars	903	829	812	5,595
Vans	53	50	53	703
SUV	45	60	76	1,344
Pickups	264	244	278	2,482
Households without Children, Two Adults, 60 plus	924	914	851	8,068
Passenger Cars	700	675	619	4,950
Vans	36	43	49	719
SUV	15	28	25	594
Pickups	173	168	158	1,805
Households without Children, One Adult, < 35	187	198	136	668
Passenger Cars	148	142	103	433
Vans	4	5	3	15
SUV	8	13	8	96
Pickups	27	38	22	124
Households without Children, One Adult, 35 to 59	220	251	236	2,527
Passenger Cars	177	193	178	1,531
Vans	8	10	15	141
SUV	4	9	9	301
Pickups	31	39	34	554
Households without Children, One Adult, < 60 plus	218	275	262	2,733
Passenger Cars	194	240	231	2,192
Vans	1	5	1	123
SUV	4	4	2	119
Pickups	19	26	28	299

REFERENCES

Boyd, G.A., Hanson D.A., and Sterner, T. "Decomposition of Changes in Energy Intensity: A Comparison of the Divisia Index and Other Methods." Energy Economics, 10 (1988): 309-312.

Golob T. and Brownstone D. "The Impact of Residential Density on Vehicle Usage and Energy Consumption." University of California (Irvine), Institute of Transportation Studies, February 2005.

Schipper, L. and Ng, W. "Rapid Motorization in China: Environmental and Social Challenges." World Resources Institute, EMBARQ, ADB-JBIC-World Bank East Asia and Pacific Infrastructure Flagship Study, October 18, 2004.

Schipper, M. and Pinckney, D. "Supplementing The 2001 National Household Travel Survey With Energy-Related Data." National Academy of Sciences, 83rd Transportation Research Board (TRB) Annual Meeting, National Data Requirements Programs Committee, January 14, 2004.

Smil V. Energy at the Crossroads: Global Perspectives and Uncertainties. The MIT Press, 2003.

Unander, F., Ting, M., Fulton, L., Justus, D., and Karbuz, S. 30 Years of Energy Use in IEA Countries: Oil Crises & Climate Change, International Energy Agency (Paris), 2004.

ABBREVIATIONS

ATS	American Travel Survey
EIA	Energy Information Administration
EPA	Environmental Protection Agency
BBL	Barrel
BEA	Bureau of Economic Analysis
BLS	Bureau of Labor Statistics
BTS	Bureau of Transportation Statistics
BTU	British Thermal Unit
CAFE	Corporate Average Fuel Economy
CPI-U	Consumer Price Index for Urban Areas
DOE	Department of Energy
DOT	Department of Transportation
FHWA	Federal Highway Administration
GEG	Gasoline-Equivalent Gallon
GHG	Greenhouse Gases
HP	Horsepower
IEA	International Energy Agency
NHTS	National Household Travel Survey
NHTSA	National Highway Traffic Safety Administration
NPTS	Nationwide Personal Transportation Survey
MPG	Miles per Gallon
ORNL	Oak Ridge National Laboratory
PMT	Passenger-Miles Traveled
POV	Privately Owned Vehicle
RTECS	Residential Energy Transportation Survey
VMT	Vehicle-Miles Traveled