APPENDIX B: ESTIMATION METHODOLOGIES

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ESTIMATION METHODOLOGIES

INTRODUCTION

The National Household Travel Survey (NHTS) is the nation's inventory of local and long distance travel, according to the U.S. Department of Transportation. Between April 2001 and May 2002, roughly 26 thousand households[41] were interviewed about their travel, based on the use of over 53 thousand vehicles. Using confidential data collected during those interviews, coupled with EIA's retail fuel prices, external data sources of test[42] fuel economy, and internal procedures for modifying test fuel economy to on-road, in-use fuel economy, EIA has extended this inventory to include the energy used for travel, thereby continuing a data series that was discontinued by EIA in 1994. This appendix presents the methods used for each eligible sampled vehicle to

1. provide three fundamental inputs crucial to developing annual household vehicles energy consumption and expenditures information: composite fuel economy, retail fuel price, and in-possession vehicle-miles traveled;

2. adjust imputed composite fuel economy to calculate an on-road fuel economy;

3. adjust on-road fuel economy to calculate an in-use fuel economy based on actual household driving characteristics; and,

4. derive annual energy consumption and motor fuel expenditures information from these adjusted inputs.

Such methods allow EIA to calculate estimates on the amount of and expenditures for energy consumed by the nation's vehicles operated for residential transportation. These estimates also include 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 (gasoline mileage).

DISCLAIMER

[41] 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, fraternity and sorority houses were included so long as no more than 10 people shared the same telephone number.

[42] Federal law requires automobile manufacturers to determine the fuel economy of new vehicles offered for sale in the U.S. 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 must all provide the same information.

Had these results come from information supplied by respondents to the NHTS directly, there would be no reason to provide an explicit warning to users about the uncertainty of these data. Since NHTS did not collect information on fuel economy, retail fuel price, or fuel type, EIA cautions readers that, for every single one of the over 53 thousand sampled vehicles, all energy and energy-related statistics in this report and associated tables, public-use files, and analyses are constructed from imputed information. Only light-duty passenger vehicles are included in this report because EIA has excluded motorcycles, mopeds, large trucks, and buses in an effort to continue its past residential transportation series, which was discontinued in 1994.

In-Scope Households and Vehicles

Not all NHTS sampled vehicles are considered in-scope for this report. For this study, except where noted, we include only those vehicles that (1) fit the definition of light-duty residential passenger vehicles and (2) belong in the sample of households having the "100-percent-household" national weight classification, as defined by the User's Guide of the NHTS.

In 2001, the NHTS interviewed the members of 26,308 households that had 53,275 vehicles at some point during the survey period. Of that vehicle total, about 80 percent, or 42,736 vehicles, conform to EIA's definition of a *vehicle* and also are identified as belonging to a "100-percent household" by the NHTS, which is to say that these households form a national representative sample of respondents whose entire adult members were directly interviewed. Likewise, the sample number of households is reduced to 21,178 from 26,308, after excluding those households where one or more adult members chose not to respond.

The calculation of energy-related statistics – vehicle fuel consumption and expenditures – in this report occurred in several steps. Multiple steps were required because respondents, when completing their NHTS survey questionnaires, were not directly asked to report information necessary to derive their vehicle's on-road, in-use fuel economy, nor were they asked to provide the type or price of the fuel that was used to power their vehicle(s). Without all of these critical components, there is no way to determine a vehicle's consumption of and expenditures for transportation fuel. With the use of confidential NHTS data and other external data sources, EIA's imputation procedures modeled these measures for most sampled vehicles (see "In-Scope Households and Vehicles" text boxes for details).

DATA SOURCES

To derive vehicle-miles traveled (VMT); assign and adjust vehicle fuel economy (given in terms of miles per gasoline equivalent gallon (MPG)); compute vehicle fuel consumption, and assign fuel prices to calculate vehicle fuel expenditures, EIA relied on data from several federal agencies. These statistical procedures relied on confidential data from the U.S. Federal Highway Administration's (FHWA) 2001 National Household Travel Survey (NHTS); the EIA's 1985, 1988, and 1991 Residential Transportation Energy Consumption Survey (RTECS)[43]; the U.S.

[43] This series was discontinued after EIA conducted the 1994 Residential Transportation Energy Consumption survey.

Environmental Protection Agency's (EPA) fuel economy test results[44]; and the EIA's retail pump price series[45] for 2001 and 2002.

In-Scope Households and Vehicles (Continued)

The NHTS has recommended that some data applications, such as planning models, use only the national sample of "100-percent households." EIA has kept with that recommendation for this report.

For the definition of a light-duty residential passenger vehicle used in this report, see *vehicle* in the "Glossary" of this report.

PROCEDURES AND DEFINITIONS

EIA's purpose in partnering with the U.S. Department of Transportation was to enhance the use and usefulness of the January 2004 release of the 2001 NHTS public-use file, augmenting it with energy-related data. Figure B1 depicts the estimation of those energy-related statistics: VMT, vehicle fuel economy, vehicle fuel consumption, and vehicle fuel expenditures. These steps were initially applied to each vehicle reported by households in the national sample of the NHTS. However, item nonresponse (mostly of crucial vehicle characteristics), incomplete fuel economy and sales data (generally for those vehicles having a gross vehicle weight rating heavier than 8,500 lbs), and the goal to update national estimates that conceptually compare to those found in EIA's previous residential transportation studies – 1985, 1988, 1991, and 1994 RTECS – guided the scope of EIA's augmented vehicle data. The effect of those inter-dependent challenges resulted in methodologies that applied only to light-duty passenger vehicles in households that are nationally weighted as "100-percent-household" by the NHTS.

First, the annual VMT was derived from the vehicle's two odometer readings or imputed using modeled data (see the NHTS User's Guide 2-B.5. ODOMETER READING and APPENDIX J). Moreover, because vehicles are acquired and disposed of by sample households during the survey year, the annual VMT were subsequently adjusted to reflect the period of the survey year in which the household "owned or used" the vehicle.[46] Second, the annual on-road

[44] Fuel economy test values and vehicle production sales data were received from the U.S. Department of Transportation, National Highway and Traffic Safety Administration for model year's 1978 through 2002.

[45] Energy Information Administration. Forms EIA-782A, "Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales report," and EIA-782B, "Resellers'/Retailers' Monthly Petroleum Product Sales Report." Form EIA-888, "On-Highway Diesel Fuel Price Survey." Form EIA-895, "Monthly Quantity and Value of Natural Gas Report." Form EIA-826, "Monthly Electric Utility Sales and Revenue Report with State Distributions."

[46] Thus, "number of vehicles" and "per vehicle" statistics in this report are displayed in units of vehicle-years. For example, if a vehicle was sold half-way through the survey year (i.e., household "owned" vehicle for six months of the year), then this vehicle is counted as 0.5 vehicle-years, while a vehicle "owned" for 365 days would equate to 1 vehicle-year. Likewise, a vehicle purchased during the survey period would also be prorated to its time of household use, as measured from its acquisition date and the end of the survey year. These dates are available from odometer reading flags. Hence, vehicle statistics in this report will differ from those published directly from NHTS public-use data because the duration of a vehicle's possession by a household is taken into account, calculating an accurate level of energy and vehicle use. Since NHTS did not collect an end-of-year vehicle inventory, a disposition date for each vehicle is not known.

fuel economy, reported in terms of MPG, was estimated using questionnaire responses[47], EPA fuel economy test results, and the period between May 1, 2001 and April 30, 2002 that the vehicle was in use.[48] The MPG values were adjusted to account for the difference between EPA test values and on-road, in-use values. Third, estimated vehicle fuel consumption was derived by dividing the prorated VMT by the estimated MPG. Then, multiplying the vehicle's fuel consumption by its fuel price, on a monthly basis, derives motor fuel expenditures. Unfortunately, the NHTS did not collect the vehicle's motor fuel prices via fuel purchase diaries. Instead, each NHTS vehicle was assigned a retail price based on its imputed fuel type. All price information, with the notable exception of fuel tax rates for gasoline obtained from FHWA's *Highway Statistic* reports, was obtained from the EIA's transportation fuel price series.

The following sections of this appendix describe the estimation procedures used for calculating a vehicle's monthly VMT, MPG, fuel consumption, fuel price, and fuel expenditure.

The following terms are used throughout this report:

Fuel Economy Term	Definition
EPA Composite MPG	The EPA dynamometer test procedure, performed on pre-production prototype vehicles, yields separate test values for EPA city and highway MPG. These city and highway MPG are often combined to form the "composite" MPG.
On-Road MPG	A Composite MPG that was adjusted to account for the shortfall between the test value and the fuel economy actually obtained on the road. The adjustment did not take into account the driving patterns of individual drivers and seasonal differences.
In-Use MPG	MPG that were adjusted for seasonal differences and annual miles driven. Vehicles that are driven relatively few miles during the year are assumed to be driven mostly on short trips that involve frequent stops. Vehicles that are driven relatively many miles are assumed to be driven mostly on long trips where few stops are needed.
MPG Shortfall	A measure of the difference between actual on-road MPG and the EPA laboratory test MPG, expressed as the ratio of test MPG to on-road MPG.

[47] FHWA/BTS collected make (MAKECODE), model (MODLCODE), model year (VEHYEAR), and 8 categories of vehicle type (VEHTYPE), as given in *Section B: Vehicle Data* of the 2001 NHTS questionnaire. The collection of Vehicle Identification Numbers (VIN) would have provided a more accurate and richer source of vehicle characteristics. It is not known whether VINs will be collected in future survey cycles of the NHTS.

[48] For 2002 model year vehicles, the NHTS calculates odometer-based VMT (BESTMILE) for the entire 12-month time period. EIA, however, adjusts all in scope, odometer-based VMT estimates to represent the time period in which the vehicle was "owned" by the household; this is an adjustment that serves to equate both travel and energy use with the vehicle's availability.

EPA test value data from NHTSA are restricted to vehicles that are used to derive Corporate Average Fuel Economy under Title V of the Motor Vehicle Information and Cost Savings Act (15 U.S.C. 1901, et seq.) with subsequent amendments and Subtitle VI (49 U.S.C. 329). Corporate Average Fuel Economy (CAFE) is the sales-weighted average fuel economy, expressed in miles per gallon, of a manufacturer's fleet of passenger cars or light trucks with a gross vehicle weight rating (GVWR) of 8,500 lbs. or less, manufactured for sale in the United States, for any given model year.[49] Fuel economy is defined as the average mileage traveled by a vehicle per gallon of gasoline (or equivalent amount of other fuel) consumed as measured in accordance with the testing and evaluation protocol set forth by Environmental Protection Agency (EPA).

Manufacturers also perform their own fuel economy tests of new vehicle models and submit the results to EPA. EPA is responsible for conducting its own tests or verifying the manufacturers' dynamometer tests. EPA also is responsible for compiling the production data from manufacturers' reports and furnishing CAFE results to NHTSA.

Fuel economy test data from the manufacturers and EPA serves as the starting point for both CAFE values and real-world fuel economy projections. For CAFE, the test data are adjusted upward to account for any credits for dual-fuel alternative fuel vehicles (AFV) and dedicated AFV, and for passenger cars only, is also adjusted upward for credits available to manufacturers to account for test procedure changes since the CAFE program was established. For NHTS and this report, such credits and their associated upward adjustments were removed, if indicated by NHTSA.

Table B1. Sample Counts of Residential Passenger Vehicles by Type and Model Year, 2001

Vehicle Type	NHTS Vehicle Type Code	Model Year				Total
		Pre-1978	1978 - 2001	2002	Not Ascertained	
Automobile	01	842	22,468	381	571	24,262
Van	02	41	3,885	72	108	4,106
Sport Utility Vehicle	03	73	4,958	221	120	5,372
Pickup Truck	04	510	7,692	140	259	8,601
Recreation Vehicle	06	49	330	2	14	395
Total		1,515	39,333	816	1,072	42,736

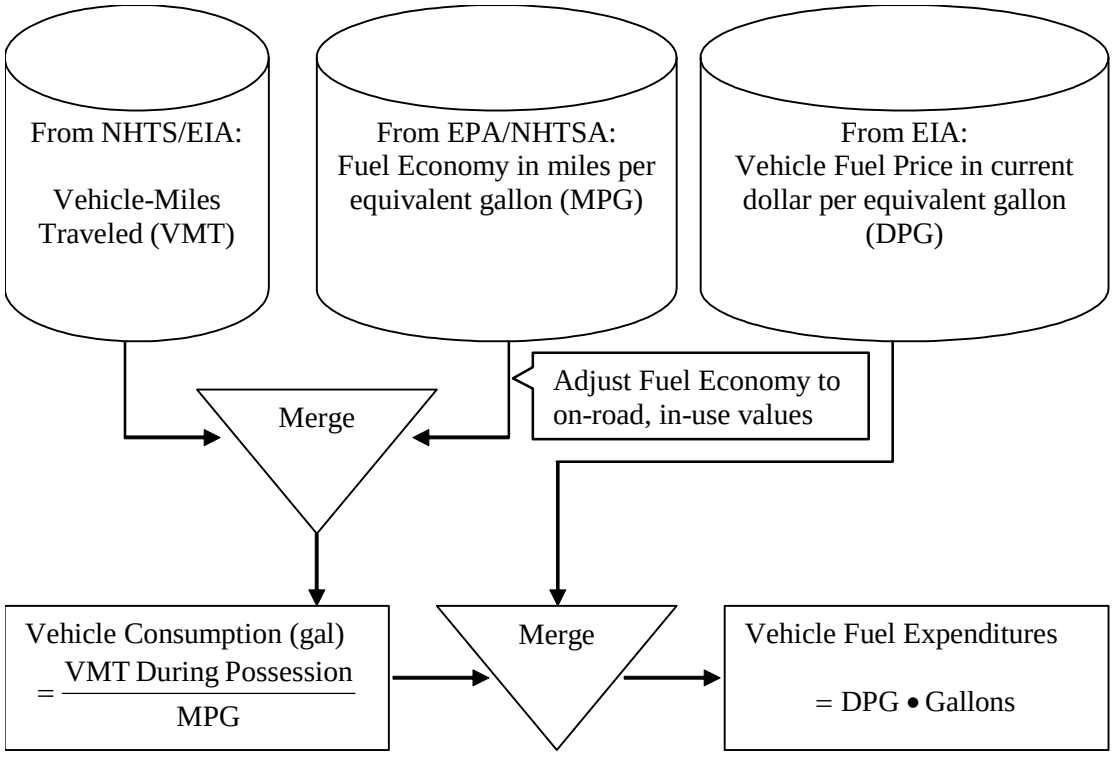
Source: U.S. Department of Transportation, Federal Highway Administration, *2001 National Household Travel Survey*, January 2004 release. (Washington, DC). Note: Not all NHTS sampled vehicles are displayed -- only *light-duty residential passenger vehicles* are tabulated here, fitting this report's definition of a *vehicle* (see "Glossary" for details).

Since the NHTS is a national survey, it collected data from a nationally representative sample of households to derive statistically reliable travel estimates at the national, region (4) and division (9) levels. Sample data in the NHTS are generally not adequate to provide state or smaller area-specific estimates. However, the 2001 NHTS sample included several jurisdictions

[49] These vehicles are conceptually consistent with 2001 NHTS sample vehicles having a vehicle type of "01" (Automobile), "02" (Van), "03" (Sport Utility Vehicle), "04" (Pickup Truck). EPA does not provide test data for vehicles such as the Ford Excursion, Hummer H1 and Hummer H2 because they have a GVWR greater than 8,500 lbs.

where additional sample households were purchased and interviewed. The jurisdictions that purchased these additional samples are referred to as the "add-on" areas. There are nine add-on areas: Baltimore Metropolitan Planning Organization (MPO), Maryland; Des Moines MPO, Iowa; Edmonson, Carter, Pulaski, and Scott Counties, Kentucky; Lancaster MPO, Pennsylvania; Oahu MPO, Hawaii; State of Hawaii, except Oahu; State of New York; State of Texas; and State of Wisconsin.[50] These additional sample cases were not included in developing the energy consumption and expenditures data, nor were any data developed for or applied to these vehicles.

Figure B1. Estimation Schematic



Note: NHTS – National Household Travel Survey, EPA – Environmental Protection Agency, EIA – Energy Information Administration, and NHTSA – National Highway Transportation Safety Administration.

VEHICLE MILES TRAVELED

When possible, VMT of sample vehicles were determined by taking the difference between two odometer readings, which spanned a period of time, and expanding this difference to cover the year, or 365 days. The exact methods for deriving annual VMT are discussed in Appendix J in the NHTS User's Guide, as written by the Oak Ridge National Laboratory (ORNL), Engineering Science Technology Division, Center for Transportation Analysis.

For 1,262 vehicles, the work conducted by ORNL did not result in a viable annual VMT estimate. The lack of such a VMT value is indicated in the NHTS public-use file with an insertion of negative value codes for these vehicles' value of "BESTMILE," which is the public-

[50] See http://www.bts.gov/external_links/government/metropolitan_planning_organizations.html for a complete list.

use variable denoting ORNL's annual VMT estimate. According to the NHTS public-use data, roughly 3 percent of the 42,736 vehicles deemed in-scope lack annual VMT estimates, all of which are coded as "8" or "9" in the January 2004 NHTS public-use data by the "*BEST_FLG"* public-use variable. To derive annual VMT estimates for these 1,262 vehicles, two methods were employed by EIA: (1) a standard annualization procedure to inflate spanned odometer readings (used for 626 vehicles) and simple multiple regression models (used for 636 vehicles).

For 626 vehicles, the NHTS public-use data file contains both valid odometer readings and dates (month, day and year) and, more importantly, these vehicles' reading dates spanned a period greater than 60 days. Thus, VMT for nearly half of the 1,262 vehicles were derived from EIA's standard annualization procedure. This procedure has been employed by previous EIA studies: RTECS in the years 1985, 1988, 1991, and 1994. Specifically, the annual VMT for vehicle *i* was computed by dividing the reported span of odometer readings with the monthly VMT fractions, F_j, of the time period covered by the i^{th} vehicle's travel, as determined from the standard distribution given in Table B2 of this appendix. Because odometer readings were recorded with the exact day of the month, some monthly VMT fractions were prorated to correspond to the exact span of odometer readings.[51] Generally, this resulted in prorated VMT fractions values of both starting and ending monthly fractions. Moreover, for vehicles reporting a span of odometer readings greater than 365 days, annual VMT were reduced by these same monthly driving fractions, which were prorated, as needed. It is important to point out that exact odometer reading dates were not released in the NHTS public-use files; rather, EIA accessed confidential NHTS data for assigning odometer reading dates.

For 636 vehicles, no odometer information was available. For most of these vehicles, annual VMT were imputed using multiple linear regressions in which the independent variable was the respondent's self-reported estimate of annual VMT obtained during the NHTS interview. If, on the other hand, the NHTS did not collect the vehicle's self-reported annual VMT, then EIA used a selection of predictors drawn from the household and vehicle's characteristics, which include the number of drivers, ratio of the number of vehicles per driver, household income, age of vehicle, type of vehicle, and household composition.

IN-POSSESSION VEHICLE-MILES TRAVELED

EIA also extended the logic of computing a vehicle's VMT by estimating the period of time that the vehicle was in the household's possession. This was done in multiple steps using public-use data provided by FHWA. Once annual VMT were obtained either through the work completed by ORNL or the two approaches (i.e., standard annualization or multiple regressions) undertaken by EIA, each vehicle's annual VMT value was adjusted to correspond to the time period that the vehicle was in the possession of the sample household during the survey year, which started on May 1, 2001 and ended on April 30,2002. Using a vehicle's acquisition and disposition dates, as derived from NHTS interview contact and odometer reading dates or other relevant contact information on survey follow-up procedures[52], an in-possession VMT value was

[51] Based on an EIA review of the NHTS public-use file that was released in January 2004, only month and year dates are available for odometer readings. However, EIA was provided access to actual odometer reading dates, including month, day and year of these readings.

[52] Follow-up contacts with NHTS respondents were undertaken within a set procedure, according to correspondences with NHTS contractor, Mark Freedman of Westat.

calculated based on standard monthly driving fractions, F_j.[53] By simply multiplying the annual VMT by the sum of the monthly driving fraction, prorated as needed, a *VMT during possession* was computed. Only 38,639 vehicles, or 90 percent of the eligible 42,736 vehicles, were retained for the entire survey period (365 days). As discussed later in this appendix, these *VMT-during-possession* values form the basis of both energy consumption and expenditures for residential passenger vehicle use.

VEHICLE FUEL ECONOMY

Fuel economy (MPG) must be estimated for each NHTS sample vehicle in order to estimate each vehicle's fuel consumption for the survey year. Then, fuel consumption is estimated by dividing the VMT for time of possession[54] by the MPG.[55] The NHTS neither obtained actual fuel consumption data nor on-road MPG from fuel purchase diaries maintained by the respondents. Because NHTS did not require these data or diaries, MPG values were estimated using EPA laboratory test MPG that were adjusted to account for differences between actual on-road MPG and the EPA test MPG. This difference is known as MPG "shortfall." Lax, 1987[56]; Mintz, 1993[57]; and Reichert, 2000[58], investigated the feasibility of using shortfall-adjusted MPG in a household survey. The Lax study verified that the method yielded unbiased MPG, when using a database from a 1984 fuel purchase diary study performed by NPD Research, Inc. The adequacy of current shortfall adjustment methods is sufficient for late 1980 through early 1993's motor vehicle model years also (RTECS Technical Note 5).[59] For the 2001 NHTS, the adequacy of shortfall adjustments has been presumed for 1994 through 2002's motor vehicle model years.

[53] To ensure that the distribution of average monthly vehicle miles traveled given in Table B2 reflected 2001 driving patterns, EIA compared those fractions with the 2001 FHWA's highway-based values. No significant differences were found; however, the events occurring in September 2001 and soon thereafter may have unknown contributions to travel behavior patterns not shown here.

[54] While the NHTS public-use data, which was released on January 2004, assumes a fixed 12-month period (starting on May 1, 2001 and ending April 30, 2002) EIA has modified these same data in an attempt to compute the fraction of the year in which the household had "actual" possession of the vehicle. Because NHTS did not conduct an end-of-year audit of a household's vehicle stock, not all changes in vehicle stock are known.

[55] 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.

[56] Lax, D. 1987. "Feasibility of Estimating In-Use Vehicle Fuel Efficiency from Household Survey Data." Research performed under contract for ORNL/DOE/EIA. Energy and Environmental Analysis Inc., Arlington, VA.

[57] Mintz, M., A. Vyas, and L. Conley, 1993. "Differences Between EPA-Test and In-Use Fuel Economy: Are the Correction Factors Correct?" Transportation Research Record 1416, pp. 124-130, Transportation Research Board, National Research Council, Washington, DC.

[58] Reichert, J. 2000. "Change in Method for Estimating Fuel Economy for the Residential Transportation Energy Consumption Survey," Energy Information Administration on www.eia.doe.gov/emeu/rtecs/contents.html.

[59] Harrison, I.M. "VMT 1991 Patterns," Residential Transportation Energy Consumption Survey Technical Note 5, unpublished document. (Washington, DC).

The NHTS sample vehicles were assigned EPA test MPG from the NHTSA Corporate Average Fuel Economy files. Each record of the NHTSA files contained an EPA Composite MPG (i.e., an unadjusted 45 percent highway and 55 percent city weighted estimate) for each unique combination of vehicle attributes within a given manufacture, model/carline, type and model year. These attributes included (1) number of cylinders, (2) cubic inches of engine displacement (CID), (3) type of transmission (manual or automatic), and (4) fuel metering (gasoline, diesel, electric, natural gas, duel-, or flexible-fuel vehicle).[60] Each record of the NHTSA files also contained the number of vehicles sold, in thousands of vehicles, for each unique combination of attributes. The vehicle attributes available to assign a Composite MPG for sample vehicles were the ones collected for each NHTS vehicle. Specifically, NHTS queried respondents on their vehicle's make, model, vehicle type, and model year attributes. Hence, merging, assigning and statistical linking to NHTSA's Corporate Average Fuel Economy files were restricted to those four attributes. If, in the future, NHTS were to collect Vehicle Identification Numbers (VIN), then these linking procedures might be performed on a more robust set of vehicle attributes.[61]

NHTSA files served multiple purposes. In addition to assigning a Composite MPG, the NHTSA files were used to impute "missing" vehicle attributes: fuel metering and engine type for purposes of assigning an appropriate fuel price. Based on the limited set of vehicle attributes obtained from the NHTS questionnaire, several records from the NHTSA files were usually found to be potential "matches" to a given sample vehicle. A matching record was chosen from among the several applicable ones, with probability proportional to sales, using the sales figures on the NHTSA files. Once chosen, a record provided (1) EPA Composite MPG, (2) fuel metering, and (3) engine type. Although more attributes were available for selection, EIA limited its matched attributes to those required to assign an appropriate fuel price to a sample vehicle. Of the 42,736 eligible vehicles, EIA selected a matching record for 39,879 vehicle, or 93 percent. This matching routine commonly resulted in 1-to-many record linkages (see Figure C1 for more details).

For the remaining 7 percent of in-scope sample vehicles, EIA employed expert knowledge and hot decking of median Composite MPG values for assigning on-road, in-use MPG values to 510 vehicles and Composite MPG to 2,347, respectively. Hot-decking techniques were sequentially executed, based on the vehicle's characteristics, such as make, model, model year, and vehicle type.

The EPA Composite MPG are just the starting point for fuel economy computations. For the 2001 NHTS, EIA employs a sequential adjustment procedure in which the EPA Composite MPG are adjusted first to an on-road MPG, and then to an in-use MPG.

[60] NHTSA file records do not include whether the vehicle's emissions control package met Federal or California standards.

[61] VINs may be decoded to yield the vehicle attributes, by use of the Highway Loss Data Institute's "Vindicator" software.

THE EPA COMPOSITE MPG

Beginning in the early 1970's, EPA measured fuel economy from tests that were conducted on a dynamometer to simulate actual driving conditions. By 1975, EPA had incorporated separate "city" and "highway" driving cycles into the test. The city and highway MPG were combined to form a "composite" MPG that was then weighted according to sales of the production vehicles in order to assess compliance with Corporate Average Fuel Economy (CAFE) standards. The EPA Composite MPG is based on the assumption of a "typical" vehicle-use pattern of 55 percent city driving and 45 percent highway driving, and has become a convenient single fuel economy measure for analytical and regulatory purposes.

The EPA Composite MPG[62] is defined as:

$$MPG_{(EPA\ 55/45)} = \frac{1}{0.55 \bullet \frac{1}{MPG_{(EPA\ city)}} + 0.45 \bullet \frac{1}{MPG_{(EPA\ hwy)}}} \qquad (1)$$

where:

$MPG_{(EPA\ 55/45)}$ denotes the composite MPG; $MPG_{(EPA\ city)}$ denotes the fuel economy when vehicle use pattern is city driving only; and, $MPG_{(EPA\ hwy)}$ denotes the fuel economy when vehicle use pattern is highway driving only.

Because separate city and highway fuel economy estimates were not available on the NHTSA files, a single "shortfall" adjustment factor was derived, approximating the adjustments given in the following sections.

FUEL ECONOMY SHORTFALL

Fuel economy shortfall occurs when the fuel economy that is actually obtained while using the vehicle is lower than the EPA test results. Reasons for this shortfall are (1) a result of the differences between EPA test vehicles and the vehicles actually in use and (2) the differences between EPA procedures for simulated driving conditions and actual driving conditions. For example, EPA test vehicles are prototypes that do not contain the wide variety of power-consuming accessories often found on vehicles sold to consumers. The test procedures also do not simulate the actual driving conditions that affect fuel economy such as speed and acceleration of individual drivers, road conditions, weather, and traffic. In the 2001 NHTS, adjustments for this fuel economy shortfall were made to the composite MPG ($MPG_{(EPA\ 55/45)}$) that were assigned to the sample vehicles.

Fuel economy shortfall was expressed in terms of the "Gallons per Mile Ratio" or GPMR:

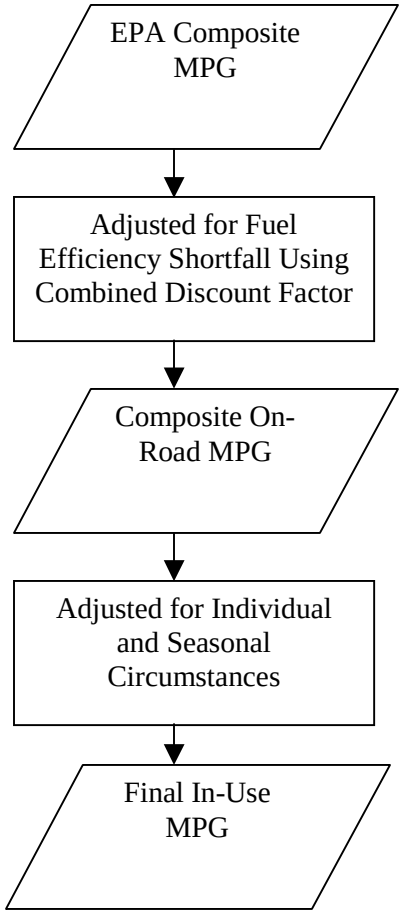
$$GPMR_i = \frac{MPG_{i\,(EPA55/45)}}{MPG_i} \qquad (2)$$

[62] Specifically, the following formulas, as stated in Part 600, Subpart F, §600.207-86, §600.208-77, §600.209-85, §600.510-86 of the 7-1-1994 edition of the 40 CFR, are identified for these calculations.

where:

$GPMR_i$ denotes Gallons per Mile Ratio for the i^{th} vehicle; MPG_i denotes the on-road MPG or in-use MPG for the i^{th} vehicle, depending on the analysis; and, $MPG_{i\ (EPA\ 55/45)}$ denotes the EPA Composite MPG applicable to the i^{th} vehicle.

Figure B2. Miles per Gasoline Equivalent Gallon Adjustment Procedures



If $GPMR_i = 1$ then there is no perceived shortfall. If $GPMR_i > 1$ then there is a shortfall for vehicle *i*. That is, the on-road or in-use fuel economy is less than the fuel economy indicated by the EPA Composite MPG. Note that $GPMR_i$ can represent shortfall with respect to either the on-road or in-use MPG_i, depending on the analysis being performed. $GPMR_i$ is commonly chosen as a measure of shortfall as opposed to MPG_i for the following reasons:

- A shortfall adjustment is most often thought of as a correction factor, or multiplicative constant, rather than as an additive correction. $GPMR_i$ satisfies this convention.

- Shortfall is usually dependent on a vehicle's fuel economy level. That is, shortfall is usually higher at high levels of $MPG_{(EPA\ 55/45)}$ than at low levels of $MPG_{(EPA\ 55/45)}$.

Therefore, it is more informative to express the amount of shortfall relative to $MPG_{(EPA\ 55/45)}$ rather than as an absolute quantity.

- $GPMR_i$ is a linear function of $MPG_{(EPA\ 55/45)}$ and can be modeled using ordinary least squares linear regression.

- $GPMR_i$ is a transformation that stabilizes error variances for the purposes of least squares linear regression.

THE ON-ROAD MPG

On-road MPG is a composite MPG that was adjusted to account for the shortfall between the EPA fuel economy and the actual fuel economy obtained on the road.

The EPA developed two general procedures for adjusting $MPG_{(EPA\ 55/45)}$ to an on-road value. One procedure bases the size of the adjustment on specific technology features of the vehicle. The other procedure uses just two MPG discount factors, one to adjust the EPA highway estimate, the other to adjust the city estimate. These two factors are used for all vehicles, regardless of technology class. For our purposes, we approximated the earlier procedure with a single adjustment factor.

Either of these procedures could have been approximated to adjust $MPG_{(EPA\ 55/45)}$ to an on-road MPG value for use in the 2001 NHTS. Since both procedures were unbiased for trucks, the choice as to which to employ in the 2001 NHTS should be based on their performance with cars. According to the 1994 RTECS, the adjustment based on discount factors seemed to be less biased than the Technology-Specific Adjustment. Further, the discount factors are also less expensive since they do not require collection or imputation of information on fuel delivery system and drive-train. Because of these reasons the Discount Factors Adjustment Method was selected for approximation.

SHORTFALL ADJUSTMENT BASED ON DISCOUNT FACTORS

EPA's discount factors have widespread appeal because of their simplicity (Hellman and Murrell, 1985[63]; Hellman and Murrell, 1984[64]). The factors are 10 percent for city MPG and 22 percent for highway MPG. That is, for any vehicle *i*,

$$\begin{aligned} MPG_{i(on\text{ - }road,\ EPA\ city)} &= 0.90 \bullet MPG_{i(epa\ city)} \\ MPG_{i(on\text{ - }road,\ EPA\ hwy)} &= 0.78 \bullet MPG_{i(EPA\ hwy)} \end{aligned} \qquad (3)$$

These discount factors are the ones used to produce the "sticker" MPG figures seen on vehicles on dealer lots, and are used to produce the DOE/EPA Gas Mileage Guide. The analysis

[63] Hellman, K.H., and Murrell, J.D. 1985. "On the Stability of the EPA MPG Adjustment Factors." Society of Automotive Engineers Technical Paper Series, SAE Paper No. 851216, Warrendale, PA.

[64] Hellman, K.H., and Murrell, J.D. 1984. "Development of Adjustment Factors for the EPA City and Highway MPG Values." Society of Automotive Engineers Technical Paper Series, SAE Paper No. 840496, Warrendale, PA.

behind the development of these factors was performed on a conglomerate database with data from Ford Motor Company, General Motors, Chrysler Corporation, DOE, and EPA. The database contained approximately 38,000 vehicle records with model years from 1979 through 1981 with some 1982 models included. The database contained predominately American-made vehicles, but also included foreign vehicles as well. The technology mix was dominated by rear-wheel drive and carbureted vehicles, but contained some vehicles with front-wheel drive or fuel injection. Vehicle records contained make, model, year, vehicle characteristics, the MPG as measured on the road, $MPG_{(EPA\ city)}$, and $MPG_{(EPA\ highway)}$. The database also included the driver's perceptions of the proportion of their travel that was mostly urban (so called "city fraction"), and their average miles driven per day (AMPD).

Fuel economy shortfall is affected by the vehicle use pattern: frequent starts and short trip lengths characterize city-driving pattern, while highway-driving pattern is characterized by infrequent starts and long trips. AMPD is a good surrogate variable for representing these different driving patterns.

The city-driving pattern was characterized by AMPD from 5 to 22 miles per day, while the highway-driving pattern was characterized by AMPD's from 15 to 105 miles per day (Hellman and Murrell, 1984). City fraction and AMPD were used to split the data into two sets, one for development of the city discount factor, the other for development of the highway factor. The "city" and "highway" data sets were each stratified by vehicle technology classes. Linear regression was performed within each stratum. GPMR was regressed on city fraction, AMPD, $MPG_{(EPA\ 55/45)}$, odometer reading, and average temperature. The fitted models were then weighted and combined across vehicle technology strata, to produce a single "city" shortfall model and a single "highway" shortfall model. The weights were used to increase the influence of those models that represented technology mixes expected to become more prominent in the future (e.g., front-wheel drive and fuel-injected vehicles). The discount factors were derived from the two weighted models set at average or typical values of the independent variables.

For each NHTS vehicle, if and only if separate city and highway MPG were available, discounted city and highway on-road MPG may be computed and then combined to form an on-road 55/45 composite as follows:

$$MPG_{(on\text{ - }road,\,55/45)} = \frac{1}{0.55 \bullet \frac{1}{MPG_{(on\text{ - }road,\,EPA\ city)}} + 0.45 \bullet \frac{1}{MPG_{(on\text{ - }road,\,EPA\ hwy)}}} \qquad (4)$$

Then, a shortfall ratio based on EPA discount factors would be computed for each NHTS vehicle as follows:

$$GPMR_{i(on\text{ - }road)} = \frac{MPG_{i(EPA\ 55/45)}}{MPG_{i(on\text{ - }road,55/45)}} \qquad (5)$$

Unfortunately, separate on-road city and highway test MPG were not available from the NHTSA Corporate Average Fuel Economy files. Although a literature review reveals that shortfalls vary for particular vehicles or groups of vehicles, we have used a combined shortfall

estimate of 15 percent, equating to a $GMPR_{i(on\text{-}road)}$ of 1/0.85, which may also be written to reveal that $MPG_{i(on\text{-}road,\ 55/45)} = 0.85 \bullet MPG_{i(EPA55/45)}$.[65]

THE IN-USE MPG

In-use MPG are MPG that are adjusted for individual driving circumstances. The on-road adjustments to $MPG_{(EPA\ 55/45)}$ discussed in the previous sections were "general" in that they did not take into account any effects on fuel economy that are due to the driver's individual circumstances. They, instead, utilized general attributes such as the technology features of the vehicle and average driving conditions. Fuel economy shortfall estimates can be refined for an individual vehicle by taking into account the following "in-use" effects.

- Urban versus rural driving pattern. That is, frequent starts and short trips as opposed to infrequent starts and longer trips. As mentioned in the previous section, a useful single variable for representing this effect is AMPD. High AMPD's usually represent mileage accumulated on the highway.
- Traffic congestion, which increases with population density.
- Seasonal temperature variations, especially for gasoline-carbureted vehicles.
- Humidity, which together with temperature affects air-conditioner use.
- Differences among geographic areas of the country.
- Altitude.
- Wind.
- Road gradient and road surface conditions.

Additionally, the seasonal change in gasoline composition and the mechanical condition of the sample vehicles affect on-road fuel economy. Both of these effects are unknown. More importantly, EIA has made no attempt to account for these unknown effects.

However, this appendix does address some of the individual vehicle influences. In general, the first four items are considered the most significant in-use influences (Crawford, 1983).[66] In the cited study, shortfall variations as high as 25 percent or more occurred over the range of typical AMPD. Shortfall was 16 percent higher in urban areas than in completely uncongested areas, and was 12 percent higher in suburban areas. Shortfall varied seasonally (i.e., monthly) by 7 percent in the South and by 13 percent in the North.

[65] Hellman, K.H. and Murrell J.D., June 1982. "Why Vehicles Don't Achieve EPA MPG On the Road and How That Shortfall Can Be Accounted For," Society of Automotive Engineers Technical Paper Series, SAE Paper 820791.

[66] Crawford, R. 1983. "Seasonal and Regional MPG as Influenced by Environmental Conditions and Travel Patterns." Research performed under contract for U.S. DOE. Energy and Environmental Analysis, Inc., Arlington, VA.

Regression models were developed (Crawford, 1983) for use in adjusting $GPMR_{i(on\text{-}road)}$ to an in-use shortfall employing measurements of several in-use effects as the independent variables.

The regressions yielded a shortfall adjustment that was an additive one, which may be written as follows:

$$GPMR_{ij(in\ -\ use)} = GPMR_{i(on\ -\ road)} + \delta_{ij} \quad (6)$$

where GPMRij(in-use) denotes the in-use shortfall ratio estimate for the i^{th} vehicle during the j^{th} month (j = 1, 2, … 12); GPMRi(on-road) denotes the combined shortfall ratio fixed for the i^{th} vehicle; and, δ_{ij} denotes the adjustment calculated for the i^{th} vehicle during month j, from the a regression model.

One regression model from the Crawford reference that is appropriate for use in NHTS is as follows:

$$\delta_{ij} = 3.296 \bullet \left[\left(\frac{1}{AMPD_{ij}}\right) - \left(\frac{1}{35.6}\right)\right] + NORTH \bullet \left[0.050 \bullet \sin\left(\frac{j\pi}{6}\right) + 0.075 \bullet \cos\left(\frac{j\pi}{6}\right)\right] + SOUTH \bullet \left[0.030 \bullet \sin\left(\frac{j\pi}{6}\right) + 0.031 \bullet \cos\left(\frac{j\pi}{6}\right)\right] \quad (7)$$

where $AMPD_{ij}$ = Average Miles per Day for vehicle *i* and month *j*, typically 35.6 (i.e., 13,000 miles per year); NORTH = 1 if the household is in the North, otherwise NORTH = 0 if the household is not in the North; and, SOUTH = 1 if the household is in the South, otherwise SOUTH = 0 if the household is not in the South.

This regression model was chosen because the independent variables that are important in explaining shortfall were readily available from the 2001 NHTS data, using BESTMILE and the distribution of average monthly vehicle miles travel fractions found in Table B2. The model had two components. One component involved $AMPD_{ij}$ and represented the influence of individual driving patterns for a given vehicle and month. The other component represented the change in shortfall that occurred throughout the seasons, due to the annual temperature cycle. The original regression equation also contained a minor term that accounted for the influence of air-conditioner use during hot, humid weather. This term was dropped in the estimations because it involved the rather complex computation of "Discomfort Index" from NOAA weather records, and the slight additional precision was judged insufficient to warrant the additional processing expense. Additional terms representing geographic regional effects, and the natural logarithm of population density (people per square mile, to represent the influence of traffic congestion) were not considered because of the computational cost.

Once a $GPMR_{ij(in\text{-}use)}$ was estimated it was used to estimate the final in-use fuel economy for vehicle *i* and month *j* as follows:

$$MPG_{ij(in\ -\ use)} = \frac{MPG_{i(EPA\ 55/45)}}{GPMR_{ij(in\ -\ use)}} \quad (8)$$

The regression equation had separate seasonal components for the "North" and "South" because the difference between the winter shortfall and the summer shortfall was greater in the North than in the South. This difference can be seen in the model parameters. To define the North and South geographic areas the continental United States were divided into 97 two-digit ZIP Code regions. These regions were grouped to form two aggregate regions ("North" and "South") according to average winter and summer temperatures, and seasonal shortfall trends.

ANNUAL VEHICLE FUEL CONSUMPTION

In the 2001 NHTS, annual consumption was calculated by dividing the annual VMT by the annual MPG. The derivation of the "annualized" VMT is given in Appendix J of the NHTS User's Guide.

The $MPG_{ij(in\text{-}use)}$ shown in the above section about fuel economy estimation procedures were final estimates of monthly in-use fuel economies for vehicle *i*, and could have been used for estimating monthly fuel consumptions and expenditures, if monthly VMT were known. Unfortunately, NHTS only collected data to annualize VMT. Nevertheless, the 2001 NHTS still made use of the $MPG_{ij(in\text{-}use)}$ by disaggregating the annualized VMT of sample vehicles into monthly VMT, using monthly VMT driving fractions from the standard distribution in Table B2.[67]

Table B2. Distribution of Average Monthly Vehicle-Miles Traveled Fractions

$Month_j$	Average VMT per Vehicle	F_j
January	688	0.0728
February	697	0.0738
March	771	0.0816
April	783	0.0829
May	832	0.0880
June	847	0.0896
July	868	0.0919
August	872	0.0923
September	800	0.0847
October	802	0.0849
November	756	0.0800
December	734	0.0777
Total	9,450	1.0000

[67] Following the quality controls used in past RTECS surveys, EIA investigated the possibility that monthly travel patterns had changed based on a comparison of estimates between those found in Table B2 and the highway usage estimates from the Federal Highway Administration's *Traffic Volume Trends* data. The differences were negligible; thus, EIA applied the distribution given in Table B2 in order to compute annualized VMT. Some would argue that a update of Table B2 is needed; unfortunately, a reasonable travel diary study has not been conducted to EIA's knowledge that would provide such an update.

Source: 1984 Petroleum Marketing Index (PMI) Survey, NPD Research Inc. The survey is a demographically and geographically balanced-quota sample of 4,100 households. Respondents maintained fuel purchase diaries for an average of 10 months. As part of the survey, information was collected on the characteristics of trips taken in vehicles during a designated day. Trip lengths were recorded as respondent perception rather than from odometer readings. The distribution of monthly mileage fractions has been obtained from this survey.

The annual consumption for vehicle *i* can be thought of as the sum of the individual monthly consumptions:

$$C_i = \sum_{j=1}^{12} c_{ij} \qquad (9)$$

where C_i denotes annual consumption of vehicle fuel for the i^{th} vehicle, in gasoline equivalent gallons and c_{ij} denotes consumption of vehicle motor fuel for the i^{th} vehicle during the j^{th} month.

Because the VMT values – as computed by ORNL and discussed in the NHTS User's Guide – in the January 2004 public-use file provided by NHTS assume each vehicle was available for the *entire* 12-month period of the survey year, consumption and expenditure values for vehicle use are over-estimated. To eliminate, where possible, such over-estimation, EIA has provided another public-use file in which the annual consumption for vehicle *i* can be thought of as the sum of the monthly consumption values, where the period covered equals the possession time of vehicles. Thus, the starting and ending months refer to the possession time of vehicle *i* by the household.

In EIA's public-use file, consumption is calculated only over those months that vehicle *i* was derived to be owned or used by the household. In this sense, "annual" does not necessarily mean a full 12-month period. This is an important point since fuel economy varies seasonally.

Consumption for each month may be expressed in terms of monthly VMT and monthly in-use fuel economy:

$$c_{ij} = \frac{m_{ij}}{mpg_{ij}}, \forall\ j = 1, 2, \ldots, 12 \qquad (10)$$

where m_{ij} denotes VMT for the i^{th} vehicle during the j^{th} month and mpg_{ij} denotes fuel economy in miles per gasoline equivalent gallon for the i^{th} vehicle during the j^{th} month. Now, Equation 10 can be rewritten as:

$$C_i = \sum_{j \in used} \frac{m_{ij}}{mpg_{ij}} \qquad (11)$$

ORNL (41,474 vehicles) and EIA (1,262 vehicles) provided the annualized VMT estimate (i.e., owned or available for use for the entire year) for NHTS that was used to calculate monthly VMT values. Given that value, a monthly VMT was derived for each annualized vehicle VMT as:

$$m_{ij} = M_i \bullet f(i, j) \qquad (12)$$

where M_i denotes for the i^{th} vehicle, calculated using odometer readings and procedures discussed in Appendix J and f_{ij} denotes the average fraction of "annual" VMT that was driven during the j^{th} month, estimate for the i^{th} vehicle. For all sample vehicles, $f_{(i,j)}$ is a function of the average fractions, F_j, found in Table B2.

There is no single distribution of average monthly VMT fractions, $f_{(i,j)}$. Rather, there was a family of distributions, depending on which particular months a vehicle was owned or used by a household. Because the monthly VMT fractions for a given vehicle *i* always sums to one – no matter the timeframe in which the vehicle was owned or used by the household – the following identity is always true:

$$\sum_{j \in used} f(i,j) = 1, \forall = 1,2,3,\ldots,n \tag{13}$$

The i^{th} vehicle's $f_{(i,j)}$ were derived from F_j values found in Table B2 as follows:

$$f(i,j) = \frac{F_j}{\sum_{j \in used} F_j} \tag{14}$$

If we assume that each and every vehicle is owned or used by its sampled household, then substituting $mpg_{ij} = MPG_{ij(in\text{-}use)}$ and m_{ij} from Equation 12 into Equation 11 yields the following estimate of annual consumption for the i^{th} vehicle:

$$C_i = \sum_{j=1}^{12} \frac{M_i \bullet F_{ij}}{MPG_{ij(in\text{ - }use)}} \tag{15}$$

The public-use file disseminated by NHTS (January 2004) makes the above assumption on the timeframe for vehicle use. While the NHTS public-use file provide estimates based on the assumption that each and every sample vehicle was present in the sample household for 12 months, EIA's created an alternate estimator for consumption, $C_i^{(EIA)}$, in which acquired and disposed vehicles during the survey period are accounted for. This estimator is written as:

$$C_i^{(EIA)} = \sum_{j \in used} \frac{M_i \bullet f(i,j)}{MPG_{ij(in\text{ - }use)}} \tag{16}$$

To simply calculations, a single "annualized" fuel economy, analogous to the "annualized" MPG_i from previous EIA surveys of the residential transportation sector, was estimated as:

$$MPG_{i(annualized)} = \frac{MPG_{i(EPA\ 55/45)}}{\sum_{j \in used} f(i,j) \bullet GPMR_{ij(in\text{ - }use)}} \tag{17}$$

Thus, annual consumption equals:

$$C_i = \frac{M_i}{MPG_{i(annualized)}}. \quad (18)$$

ANNUAL VEHICLE FUEL EXPENDITURES AND PRICE

VEHICLE FUEL EXPENDITURES

In the 2001 NHTS, fuel expenditures were calculated by multiplying the vehicle-fuel consumption by the price of the vehicle fuel. The 2001 NHTS did not collect vehicle fuel prices via fuel purchase diaries. Instead, each NHTS sample vehicle was assigned a price based on imputed engine type and fuel metering values obtained from the NHTSA Corporate Average Fuel Economy files for model year's 1978-2001. For pre-1978 model year vehicles, otto engine and gasoline were imputed for engine type and fuel metering, respectively. Fuel prices, by month, were obtained from the following Energy Information Administration survey questionnaires:

- Form EIA-782A[68] "Refiners'/Gas Plant Operators' Monthly Petroleum Product Sales Report."
- Form EIA-782B[69] "Resellers'/Retailers' Monthly Petroleum Product Sales Report."
- Form EIA-888[70] "On-Highway Diesel Fuel Price Survey."
- Form EIA-895[71] "Monthly Quantity and Value of Natural Gas Report."
- Form EIA-826[72] "Monthly Electric Utility Sales and Revenue Report with State Distributions."

It is important to define the transportation fuels included in each of these prices. See the following sections for further details on transportation fuel prices.

[68] Price and volume data at a State level for 14 petroleum products for various retail and wholesale marketing categories are reported by the universe of refiners and gas plant operators.

[69] Price and volume data at the State level for gasoline, No. 2 distillate, propane, and residual fuel are reported by a sample of distillate fuel oil resellers and retailers, motor gasoline wholesalers, and residual fuel oil resellers and retailers.

[70] The Form EIA-888 survey collects data on the National and Petroleum Administration for Defense (PAD) District level cash price of self-serve, motor vehicle diesel fuel. The data are used to monitor changes in motor vehicle diesel fuel prices and to report to the Congress and others when requested. Respondents are a scientifically selected sample of companies owning retail outlets which sell motor vehicle diesel fuel.

[71] Monthly and annual production data are collected from the appropriate agencies of the natural gas producing States.

[72] Form EIA-826 collects information from regulated and unregulated companies that sell or deliver electric power to end users, including electric utilities, energy service providers, and distribution companies..

It is also important to point out that the NHTS did not collect information on the use of alternate fuels. Because of that omission, it was not possible to properly assign fuel consumption for dual-fuel (or flexible-fuel) vehicles. While these supplemental data do not explicitly account for alternative fuel use, the supplemental NHTS data should allow for a user to freely assign an alternative fuel use fraction. For example, one common assumption is to assign an operating scenario where 50 percent of the time the vehicle runs on alternative fuel (e.g., E85) and 50 percent of the time on conventional fuel (i.e., gasoline). Using the supplemental data and VMT estimate, in conjunction with EIA's fuel economy adjustment methodology, a user may make their own assignment of alternative fuel use. Because allowances have been made for self-estimating alternate fuel use and, more importantly, the NHTS collected no data to verify any method for assigning alternative fuel use, all consumption and expenditures supplemental data are based on a dedicated use of motor gasoline, diesel, natural gas, or electricity. That is, all flexible-fuel vehicles are assumed to operate on 100 percent gasoline. Thus, estimates for flexible-fuel vehicles are accurate to the extent that this assumption is valid.

Unfortunately, respondents were not asked the type of fuel purchased for their transportation demands. Further, respondents were not queried on the grade of their purchased fuels. Thus, fuel type was imputed to a sample vehicle based on its representative "match" with the selected vehicle from the NHTSA files. A matching record was chosen from among the several applicable ones, with probability proportional to sales, using the sales figures on the NHTSA files. Once chosen, a record provided (1) EPA Composite MPG, (2) fuel metering, and (3) engine type. The later two items provided enough information to impute a fuel type to a "matched" sample vehicle.

The EIA price series are published by month, by State, 5 PAD districts (PADD), and by type and grade of fuel. For the 2001 NHTS, annual fuel expenditures, E_i, was estimated by multiplying monthly gasoline prices by monthly consumption to produce monthly expenditures, summing over the monthly expenditures derived annual expenditures.

TYPE OF FUEL USED

Table B3 provides the percentage distribution of RTECS vehicles by fuel type categories. In 1994, the latest year for which RTECS estimates are available, 97.9 percent of the 156.8 million RTECS vehicles used gasoline. The remaining 2.1 percent of vehicles used diesel fuel or other fuel types.

Table B3. Distribution of Residential Transportation Energy Consumption Survey Vehicles by Type of Fuel Used, 1994

Type of Vehicle Fuel	Number of Vehicles	Percent of Vehicles
Total	156.8	100.0
Gasoline	153.4	97.9
Leaded	Q	Q
Unleaded	151.5	96.7
Regular	14.2	66.4
Premium	26.7	17.1
Intermediate	20.6	13.2

Table B3. Distribution of Residential Transportation Energy Consumption Survey Vehicles by Type of Fuel Used, 1994

Type of Vehicle Fuel	Number of Vehicles	Percent of Vehicles
Diesel	1.8	1.1
Gasohol	1.4	0.9

Notes: Because of rounding, data may not sum to totals. Q = Data withheld either because the Relative Standard Error (RSE) was greater than 50 percent or fewer than 10 households were sampled. Source: Energy Information Administration, Office of Energy Markets and End Use, *1994 Residential Transportation Energy Consumption Survey*.

Comparing the 1994 RTECS and augmented 2001 NHTS estimates is not advisable because of the differences in data collected by the RTECS and the imputed information for the NHTS. Unfortunately, no fuel metering or fuel type information was collected on the NHTS for such a comparison.

GASOLINE PRICES

Prices published by the EIA supplier surveys are pre-tax prices for conventional, oxygenated, and reformulated motor gasoline. Pre-tax prices were supplemented with Federal and State tax rates, by month, to derive retail motor gasoline prices; information on tax rates for gasoline are available from the Federal Highway Administration's web site. These pre-tax prices are published monthly, by State, in EIA's *Petroleum Marketing Monthly*, which includes price (excluding taxes) and volume data at a State level for 14 petroleum products for various retail and wholesale marketing categories are reported by the universe of refiners and gas plant operators.

Because the NHTS did not collect the type or grade of gasoline consumed in each sample vehicle, gasoline price was assigned a monthly fuel price that represents a State's volume-weighted average of gasoline. The below is an excerpt from the glossary of the *Petroleum Marketing Monthly*, as reported by EIA, which identifies the composition of the motor gasoline prices used in this appendix.

Motor Gasoline (Finished)*: A complex mixture of relatively volatile hydrocarbons with or without small quantities of additives, blended to form a fuel suitable for use in spark-ignition engines. Motor gasoline, as defined in ASTM Specification D-4814 or Federal Specification VV-G-1690B, is characterized as having a boiling range of 122 to 158 degrees Fahrenheit at the 10 percent recovery point to 365 to 374 degrees Fahrenheit at the 90 percent recovery point. "Motor Gasoline" includes conventional gasoline; all types of oxygenated gasoline, including gasohol; and reformulated gasoline, but excludes aviation gasoline.*

Conventional Gasoline*: Motor gasoline not included in the oxygenated or reformulated gasoline categories. Excludes reformulated gasoline blendstock for oxygenate blending (RBOB).*

***Oxygenated Gasoline**: Finished motor gasoline, other than reformulated gasoline, having an oxygen content of 2.7 percent or higher by weight and required by the U.S. Environmental Protection Agency (EPA) to be sold in areas designated by EPA as carbon monoxide (CO) nonattainment areas. Note: Oxygenated gasoline excludes oxygenated fuels program reformulated gasoline (OPRG) and reformulated gasoline blendstock for oxygenate blending (RBOB). Data on gasohol that has at least 2.7 percent oxygen, by weight, and is intended for sale inside CO nonattainment areas are included in data on oxygenated gasoline. Other data on gasohol are included in data on conventional gasoline.*

***Reformulated Gasoline**: Finished motor gasoline formulated for use in motor vehicles, the composition and properties of which meet the requirements of the reformulated gasoline regulations promulgated by the U.S. Environmental Protection Agency under Section 211(k) of the Clean Air Act. Note: This category includes oxygenated fuels program reformulated gasoline (OPRG) but excludes reformulated gasoline blendstock for oxygenate blending (RBOB).*

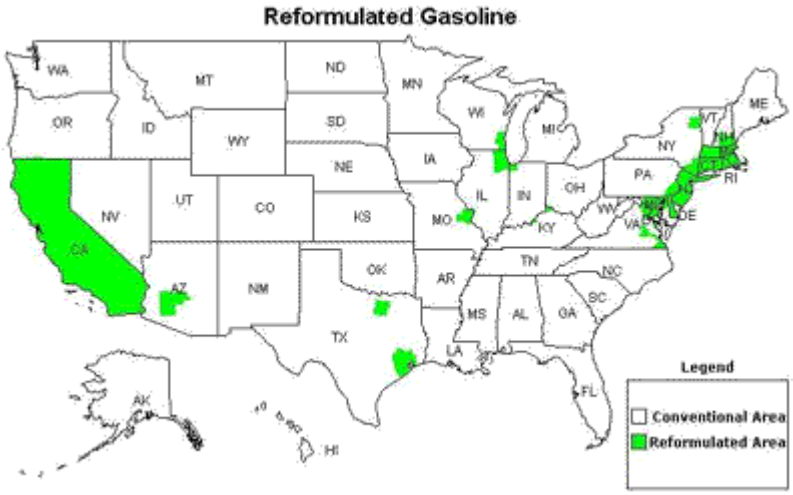
Further, EIA classifies gasoline by octane ratings, where each type of gasoline (conventional, oxygenated, and reformulated) is classified by three grades:

1) Regular Gasoline: Gasoline having an antiknock index (i.e., octane rating) greater than or equal to 85 and less than 88. Note: Octane requirements may vary by altitude.

2) Midgrade Gasoline: Gasoline having an antiknock index (i.e., octane rating) greater than or equal to 88 and less than or equal to 90. Note: Octane requirements may vary by altitude.

3) Premium Gasoline: Gasoline having an antiknock index (i.e., octane rating) greater than 90. Note: Octane requirements may vary by altitude.

Figure B3. Area Map for Reformulated Gasoline



Source: Energy Information Administration, website www.eia.doe.gov/oil_gas/petroleum/data_publications/wrgp/reformulated_map.html.

DIESEL FUEL PRICES

Prices published by the EIA supplier surveys are at the retail level for diesel fuel. The form EIA-888 survey collects data on the National and Petroleum Administration for Defense (PAD) District[73] level cash price of self-serve, motor vehicle diesel fuel. The data are used to monitor changes in motor vehicle diesel fuel prices and to report to the Congress and others when requested. Respondents are a scientifically selected sample of companies owning retail outlets that sell motor vehicle diesel fuel. Prices are published on http://tonto.eia.doe.gov/oog/info/wohdp/diesel.asp by EIA.

EIA conducts weekly Computer Assisted Telephone Interview surveys that collect prices at the outlet level. The EIA-888 collects prices of diesel fuel from truck stops and service stations across the country each Monday morning. Average prices of diesel fuel through outlets at the five Petroleum Administration for Defense District (PADD) levels, regions of the country, sub-PADD levels, and the state of California are released by the end of the day through Listserv, the Web, Fax, and telephone hotline.

Because the NHTS did not collect the type or grade of diesel consumed in each sample vehicle, diesel price was assigned to a diesel-powered vehicle based on a monthly fuel price

[73] PAD District 1 (East Coast) is composed of the following three subdistricts: Subdistrict 1A (New England): Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont. Subdistrict 1B (Central Atlantic): Delaware, District of Columbia, Maryland, New Jersey, New York, Pennsylvania. Subdistrict 1C (Lower Atlantic): Florida, Georgia, North Carolina, South Carolina, Virginia, West Virginia. PAD District 2 (Midwest): Illinois, Indiana, Iowa, Kansas, Kentucky, Michigan, Minnesota, Missouri, Nebraska, North Dakota, South Dakota, Ohio, Oklahoma, Tennessee, Wisconsin. PAD District 3 (Gulf Coast): Alabama, Arkansas, Louisiana, Mississippi, New Mexico, Texas. PAD District 4 (Rocky Mountain): Colorado Idaho, Montana, Utah, Wyoming. PAD District 5 (West Coast): Alaska, Arizona, California, Hawaii, Nevada, Oregon, and Washington.

represented by a PAD that includes the State in which the sample vehicle resides, according to NHTS, with the notable exception of the state of California where assignment was completed within state geographic boundaries.

Figure B4. Map of Petroleum Administration for Defense Districts

OTHER FUEL TYPE PRICES

According to the 1994 RTECS, approximately 1.4 million vehicles were reported using gasohol. Unfortunately, in the 2001 NHTS, there is no comparable statistic because alternative-fuel vehicles were imputed as dedicated gasoline vehicles. That imputation rule was applied because (1) NHTS did not collect fuel type information on its survey questionnaire and (2) the majority of owners of vehicles capable of being powered by methanol, ethanol, and other alternative fuels are consuming motor gasoline since alternative fueling stations do not serve large areas of the nation.[74]

While the NHTS cannot delineate gasohol use, this appendix does address dedicated compressed natural gas (CNG) and electric vehicles.[75] For CNG, retail prices were obtained from form EIA-895, "Monthly Quantity and Value of Natural Gas Report". The EIA-895 collects monthly information from the applicable State agencies that collect data concerning natural gas production. Data are published in several of EIA's monthly and annual reports. For electricity, retail prices were obtained from form EIA-826, "Monthly Electric Utility Sales and Revenue Report with State Distributions." Form EIA-826 collects information from regulated and unregulated companies that sell or deliver electric power to end users. While three customer groups were available, residential customers were selected to represent electric prices because

[74] U.S. Department of Energy, Energy Efficiency and Renewable Energy, Alternative Fuels Data Center reports that nearly 5 thousand fueling stations dispense alternative fuels (see listing details on http://www.eere.energy.gov/afdc/infrastructure/station_counts.html, accessed March 9, 2005).

[75] Propane vehicles are not included in the NHTSA files. Thus, no propane-fuel vehicles are found in the additions made by EIA to NHTS data.

this group most accurately reflected the retail electric price for NHTS households. State and regional summaries of these data are published by EIA and used by public and private analysts.