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The MOBILE4 Fuel Consumption Model

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DRAFT

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The MOBILE4 Fuel Consumption Model

I. Background

The MOBILE4 Fuel Consumption (M4FC) model was developed to estimate gasoline and diesel fuel used by motor vehicles. It is based on the MOBILE4 mobile source emissions model[1] and predicts the amount of gasoline, diesel and alternative* fuels consumed for each of seven vehicle classes.

M4FC is, in several respects, different from its predecessor, the MOBILE3 Fuel Consumption model (M3FC). Both the registration and vehicle miles traveled distributions have been updated to MOBILE4 levels. Separate city and highway fuel efficiencies have been included and allowance is made for the gradual shift to urban driving. Also, the model now directly reads output from the MOBILE4 emissions model and estimates tons of hydrocarbons (HC), carbon monoxide (CO), oxides of nitrogen (NO_x) and carbon dioxide (CO_2).

Several different fuel consumption models have been developed over the years.[2,3,4,5,6] None, however, is consistent with MOBILE4. Since MOBILE4 is the emission model used to evaluate present and potential motor vehicle regulations, it is desirable to estimate the benefits from those regulations with a fuel consumption model for which the underlying assumptions are the same.

While the primary concern behind the Agency's regulations is the public's health and welfare, these quantities are difficult to measure. Tons of pollutants eliminated and ambient concentrations reduced tend to be easier to estimate. In the past, MOBILE4, in combination with Rollback and EKMA,[7] were sufficient to estimate the surrogates to health and welfare.

MOBILE4 itself estimates grams of carbon monoxide, hydrocarbons and oxides of nitrogen emitted for each mile a vehicle travels. In general, these pollution estimates are not particularly sensitive to fuel economy. This is particularly true with respect to light duty vehicles (LDV) and light duty trucks (LDT).

Refueling emission losses as calculated in MOBILE4,** however, depend on total vehicle miles traveled (VMT) and fuel economy (mpg), as well as many other factors. Further, the benefits from controlling fuel volatility are, in part, a function of the total volume of gasoline consumed. A fuel consumption model based on MOBILE4 lends itself to calculating the fuel consumption benefits of controlling fuel volatility more readily than MOBILE4 used by itself.

The principle of computing fuel consumption is basically simple. Total fuel consumed is a function of the total number of vehicles, the number of miles each vehicle travels, and each vehicle's fuel economy. Therefore, the more vehicles there are and the more miles they travel, the more fuel they will consume. On the other hand, the greater the fuel economy these vehicles obtain, the less fuel they will consume.

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* Since the inputs for the alternative fuels sections of the model are undergoing internal EPA review for the Alternative Motor Fuels report, the scenarios included in this report assume all vehicles are powered by conventional fuels.

** Actual refueling losses depend upon the number of refueling events.

In the sections that follow a detailed description of each model input is presented. Included are registrations, VMT, and mpg for each vehicle class. This discussion of inputs is followed by a presentation of the model's outputs. These outputs include fleet fuel consumption and vehicle miles traveled, road fuel economy, vehicle registrations and total emissions. Also included is a sensitivity analysis that shows how gasoline consumption, vehicle miles traveled and carbon dioxide emissions vary as one changes certain critical input assumptions. Finally, the appendicies display the input data in both table and graphical form as well as explain the prompts proffered by the model during its execution.

II. Inputs

As noted in the introduction, the principle of computing fuel consumption is basically simple. Total fuel consumed is a function of the total number of vehicles, the number of miles each vehicle travels and each vehicle's fuel economy. In mathematical notation it is represented by the following equation:

$$\text{Fuel Consumption}=[\text{Number of Vehicles}] \cdot [\text{VMT}]/[\text{Fuel Economy}]$$

However, this equation assumes that all vehicles have the same age, VMT, and fuel economy. In reality, the vehicles operating in any given calendar year are a mixture of model years. Different model years have different fuel economy characteristics and vehicles of different ages have different travel characteristics. Also, since diesel fuel has a higher heating value than gasoline fuel, fuel type is a factor in fuel consumption estimates. Thus, a more accurate equation is

$$\text{Fuel Consumption}(i,j,k)=[\text{Number of Vehicles}(i,j,k)] \cdot [\text{VMT}(i,j,k)]/[\text{Fuel Economy}(i,j,k)]$$

where i=age, j=fuel type, and k=vehicle class. This is the form of the equation used by the M4FC model. In M4FC age (i) ranges from 1 to 30 years; fuel type (j) represents either gasoline, diesel or one of several alternative fuels and vehicle class (k) represents one of seven vehicle classes.

Further, since M4FC is capable of computing fuel consumption estimates from 1982 to 2020 and, since at least a few vehicles are assumed to remain operational for up to 30 years, most input data must be available from 1953 through 2020. Operationally this has often meant that the time series of a variable remains constant at one level for some very early years and, in most cases, remains constant at a different level for all years beyond the year 2000.

II.A. Vehicle Stock

The first element of the fuel consumption equation is referred to as the vehicle stock, the total number of vehicles operating in a given calendar year. Vehicle stock estimates are required for each vehicle class for every projection year.

The initial step of estimating vehicle stock is to obtain historical total stock estimates. Historical estimates are available principally from two sources, the R.L. Polk Company[8] and the Federal Highway Administration (FHwA).[9]

Although the truck stock estimates from these two sources are similar for all years, car registrations differ markedly. Figures 1-2 show the vehicle stock estimates from these two sources.

Figure 1
Car Registrations

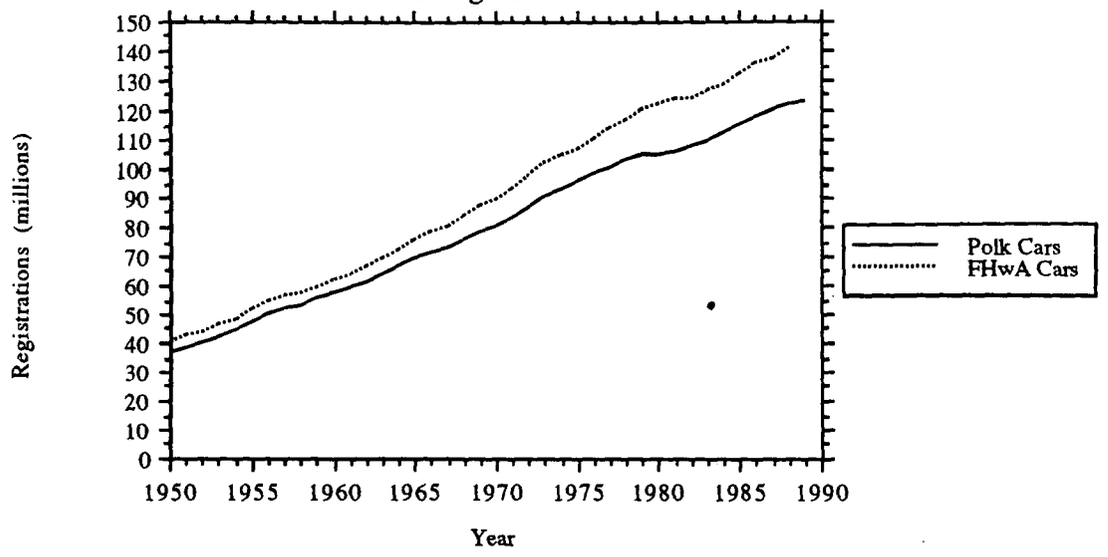
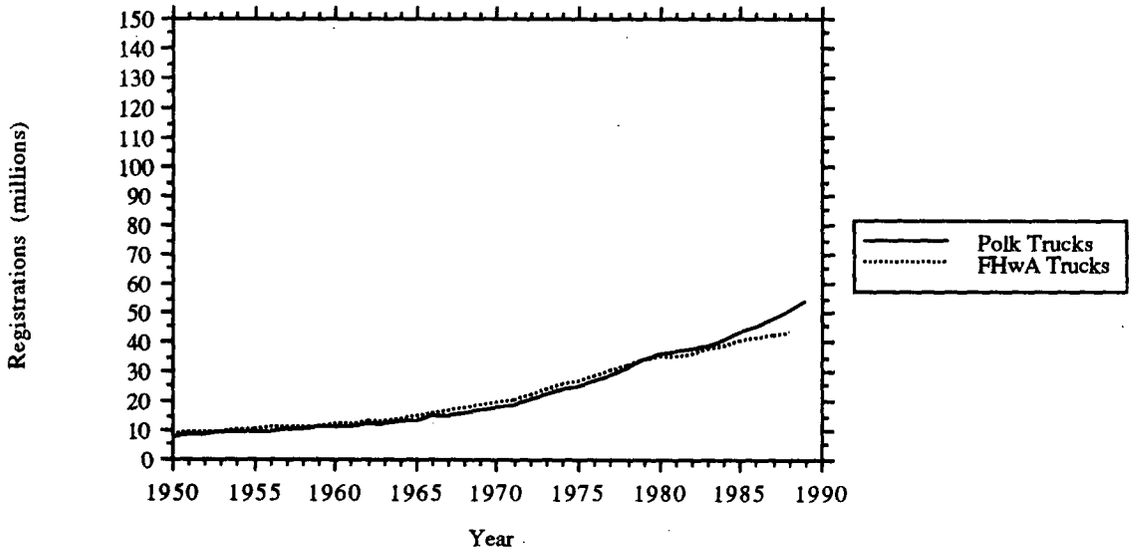


Figure 2
Truck Registrations



According to Oak Ridge National Laboratories (ORNL),[10] there are several reasons for these differences:

1. The FHwA count includes all vehicles that have been registered throughout the calendar year. Therefore, their number includes vehicles retired during the year and double counts vehicles that have been registered twice in either different or possibly the same states. The Polk count only includes vehicles that are registered on July 1, thus factoring in scrappage, to some degree, and avoiding double counting.

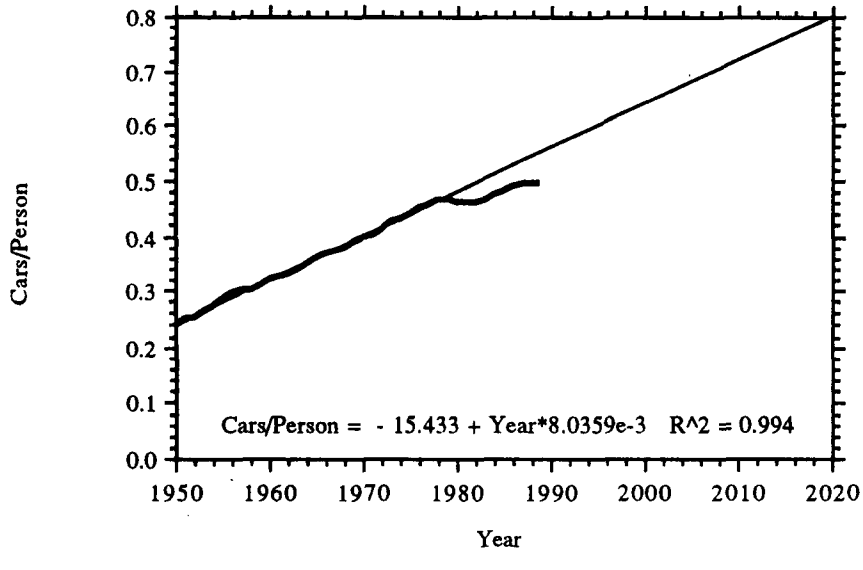
2. Beginning with the 1980 estimate, Polk counts vans as light trucks, rather than passenger cars. The FHwA count includes vans as passenger cars or trucks, depending on individual state classifications.

It is for these reasons that the Polk estimates appear to be a better indicator of the average automobile stock during a calendar year than are the FHwA estimates.

While these same reasons apply to estimates of truck registrations, the two groups' truck estimates are closer, since a truck is less likely to be re-registered within a given calendar year. The M4FC model uses the Polk values as the basis for its historic car and truck vehicle stocks. It also uses Polk values to project the future stock of cars and trucks.

Figure 3 shows that the average number of passenger vehicles per person steadily increased between 1950 and 1979. In 1980 Polk classified 1,310,918 passenger cars as light trucks.[11]

Figure 3
Cars per Person



Classification of light vehicles as cars or trucks has always been difficult. To a certain extent, some have always used light trucks in the same way that they use passenger cars; i.e. as their principal means of personal transportation. This is clearly evident in the use of light pickup trucks and mini-vans today. Since the frequency of this type of truck use may have begun to increase with the introduction of emission standards as early as 1969, the 1960-1969 trends in vehicle ownership are used in the projection methodology described below.

To allow for the shift from light duty vehicles to light duty trucks while at the same time maintaining the historic increase in the number of passenger-type vehicles per person, the model uses the product of expected population[12] and the 1960-1969 trend in passenger vehicles per person to calculate both the historic and the projected stock of cars and light trucks used as cars:

Historic Split (Pre-1990) - Polk registrations are used directly to estimate the total stock of light duty vehicles while the difference between the estimated passenger car stock based on the 1960-1969 trend in the number of passenger vehicles per person and Polk light duty vehicle registrations is used to estimate the number of light duty trucks that are used as light duty vehicles.

Future Split (1990+) - The 1960-1969 trend in the number of passenger vehicles per person is also used to estimate the future stock of light duty vehicles and light duty trucks that are used as light duty vehicles.* The model splits the projected total of passenger-type vehicles into its component parts (LDVs and LDT1s that operate like LDVs) by assuming that the sales fraction of personal vehicles that are trucks remains constant at 1990 levels for all years after 1990.

The sales fraction of personal vehicles that are trucks is calculated in the following manner. First, the 29.6 percent of the light duty fleet that are light duty trucks in 1990[13] is adjusted downward to 27.0 percent to account for the increase in freight carried by trucks between 1969 and 1990.[11] Second, the difference between that value and the imputed 1969 fraction of the light duty fleet that are light trucks is calculated. See Figures 4-5.

The total stock of commercial trucks** is projected in a similar fashion.

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* Light duty trucks that are used as light duty vehicles are assumed to travel and be scrapped at the same rate as light duty vehicles. They are also assumed to reflect the diesel penetration rate of cars.

** Commercial trucks are defined for the purposes of this report as Class 1-8B trucks less those Class 1 and 2 trucks used as passenger vehicles.

Figure 4
LDT Market Fraction

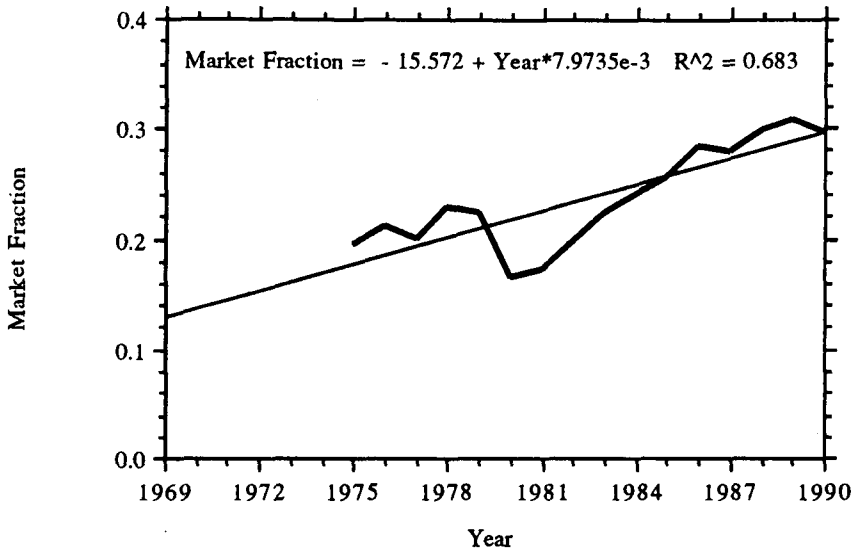
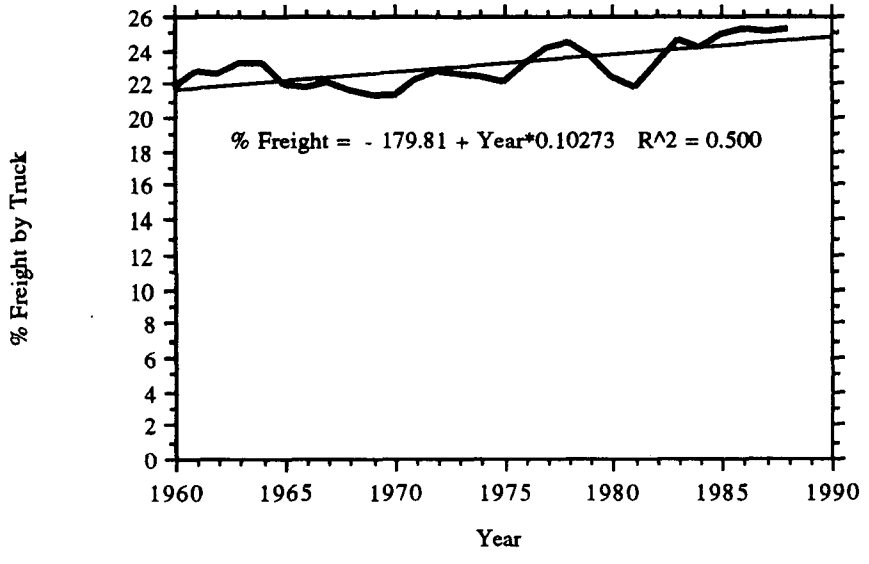
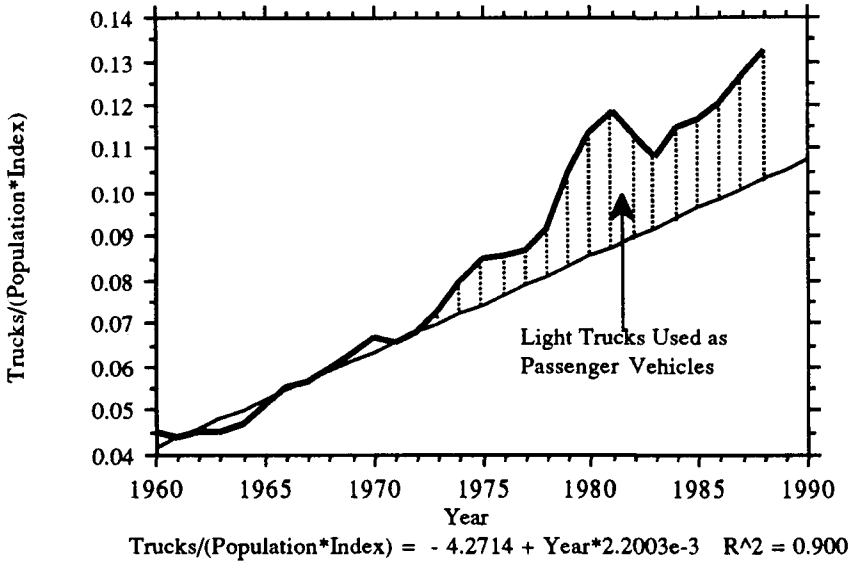


Figure 5
Percent of Total Freight by Truck



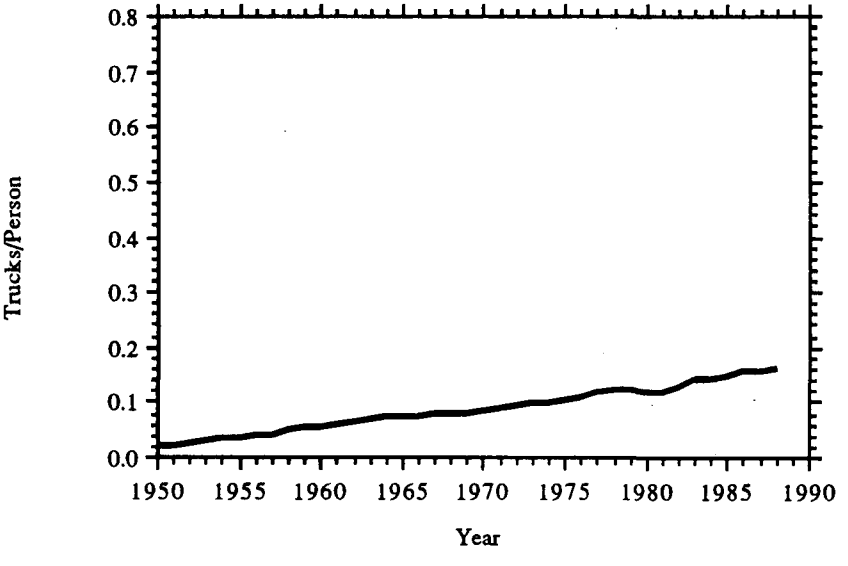
In the case of commercial trucks, account is also taken of the increase in the proportion of freight that is carried by trucks. Figure 5 shows that, since 1960, trucks have increased their share of freight from 21.7% to 25.2%. The 1960-1969 trend in commercial truck stock shown in Figure 6 is expected to continue as the national economy continues to become more of a service economy and as all industries try to reduce their inventory costs through just-in-time ordering techniques. Figure 7 shows the number of commercial trucks per person estimated by this methodology.

Figure 6
Commercial Trucks/(US Population * Freight Index)



Trucks/(Population*Index) = - 4.2714 + Year*2.2003e-3 R^2 = 0.900

Figure 7
Estimated Commercial Trucks per Person



The total stock of commercial trucks is distributed to the various weight classes by projected sales according to the following recursive procedure:

1. Obtain the 1982* Truck Information and Use Survey (TIUS) class-specific truck stocks.[14,15]

2. Scrap a constant 5.7 percent** of vehicles in each weight class.

3. Add 1983 Class 1 sales from MVMA Facts and Figures[11] to obtain a preliminary Class 1 stock estimate for 1983.

4. Subtract 1983 MVMA Class 1 sales from 1983 LDT (Class 1+2A) sales from EPA's Fuel Economy Trends report[13] to obtain 1983 Class 2A sales estimates. Add these to the 2A stock estimate to obtain the preliminary 1983 stock estimate.

5. Subtract the Trends report LDT 1983 sales from the MVMA Class 1+2 sales to obtain Class 2B sales. Add these to the 2B stock estimate to obtain the preliminary 1983 stock estimate.

6. Add Classes 3-8B sales from the Heavy-Duty Vehicle Emission Conversion Factors II report[17] to obtain the preliminary 1983 stock estimates for these classes.

7. After the scrapped vehicles are removed from the fleet and sales are added, the number of light duty trucks that are used as passenger cars is subtracted from Class 1 trucks and the resulting total number of commercial trucks is compared to the projected Polk figures. These are then renormalized by weight class to reflect not only the Polk figures but also follow the vehicle stock trends assumed for MOBILE4.

8. This process is repeated for each subsequent year based on the following sales assumptions:

    - Class 1, 2A and 2B sales estimates are calculated from MVMA Facts and Figures[11] and EPA's Fuel Economy Trends[13] through 1989. The 1982-1989 average class-specific sales are grown at a two percent per year rate thereafter in keeping with the assumption regarding Classes 5-6 sales used in EPA's Conversion Factor report.[17]

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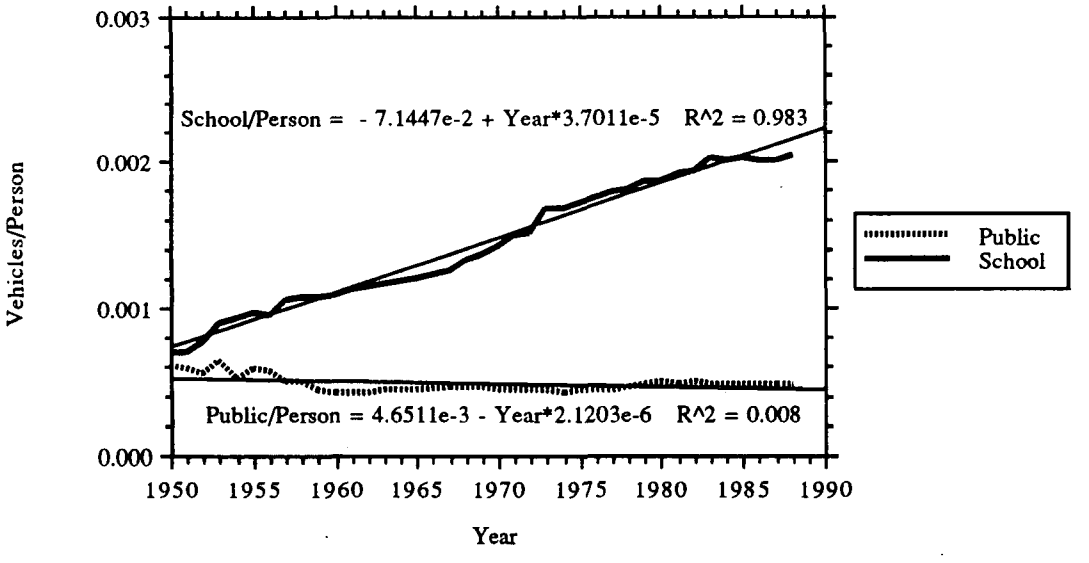
* These are the most recent available data. An updated survey is in the process of being completed by the U.S. Department of Commerce.

** This scrappage rate is an average of the 1950 to 1989 calendar year estimates published in Ward's Automotive Yearbook[16] (Actual sales and scrappage rates are used for 1983-1989. The constant 5.7 percent scrappage rate is used for calendar years 1990 and later.)

° Classes 3-8B sales estimates from the Conversion Factor report[17] are used for the 1982-2000 period. Thereafter, a two percent per year growth rate is also assumed for these classes.

Historical (1950-1988) stocks of both public and school buses were derived from FHwA Highway Statistics[9] Table MV-10. Future stocks were estimated by applying the trend in the number of buses per capita to the expected population.[12] See Figure 8.

Figure 8
Buses per Person



II.B. Registration Distributions

In any calendar year, the total vehicle stock consists of vehicles of different vintages. Since each vintage has its own unique blend of fuel economy and VMT, it is necessary to know how many vehicles there are of each age. The MOBILE4 registration distributions form the basis upon which these estimates are made for M4FC. (For an explanation of these distributions, see "MOBILE4 Travel Characteristics".[18])

However, before the MOBILE4 distributions can be used in the fuel consumption model, certain modifications are needed. The MOBILE4 registration estimates are assumed to be as of July 1 of each year, before the first model year's sales are complete. In addition, all vehicles older than 19 years of age are added together and placed in the 20+ age group. To adjust for these differences, the original MOBILE4 registration equations, covering ages 2 to 19 years, were extrapolated forward to a full first year and extended backward to 30 years of age. The resulting series was then renormalized so that the total adds up to 100 percent.

Since there are eight vehicle class-fuel type combinations in MOBILE4 and many more than that in the M4FC model, the mapping scheme shown in Table 1 is used:

Table 1
Registration Distributions

M4FC Vehicle Class	MOBILE4 Registration Distribution Used	
	Gas	Diesel
LDV	LDV	LDV
LDT1	LDT	LDT
LDT2	LDT	LDT
Class 2B	HDGV	HDDV
Class 3	HDGV	HDDV
Class 4	HDGV	HDDV
Class 5	HDGV	HDDV
Class 6	HDGV	HDDV
Class 7	HDGV	HDDV
Class 8A	HDGV	HDDV
Class 8B	HDGV	HDDV
School Buses	-	-
Public Buses	-	-
Off-Highway	-	-

To actually obtain the number of vehicles of a certain age, the calendar year dependent vehicle stock is multiplied by the fraction of vehicles at that age:

$$\text{Number of Vehicles (age)} = [\text{Vehicle Stock}] \cdot [\text{Registration Distribution(age)}]$$

where age ranges from 1 to 30.

With the exception of buses and off-highway vehicles,* this methodology is used for each year and vehicle class analyzed by the model. The registration data for buses and off-highway vehicles are calendar year dependent rather than age dependent and so do not require registration distributions in their calculations.

II.C. Vehicle Miles Traveled

Total vehicle miles traveled per year is simply the product of the average number of miles each vehicle travels and the total number of vehicles in the fleet. The number of miles traveled per vehicle is dependent on age as well as class. M4FC uses the VMT age curves found in the MOBILE4 model and shown in Table 2 below. (For further detail on these curves, see "MOBILE4 Travel Characteristics".[18]) The mapping scheme is nearly the same as that used for registration distributions.

Table 2
Mileage Accumulation Distributions

M4FC Vehicle Class	MOBILE4 Mileage Accumulation Distribution Used	
	Gas	Diesel
LDV	LDGV	LDDV
LDT1	LDGT1	LDDT
LDT2	LDGT2	LDDT
Class 2B	HDGV	LDGT2
Class 3	HDGV	LHDDV
Class 4	HDGV	LHDDV
Class 5	HDGV	LHDDV
Class 6	HDGV	MHDDV
Class 7	HDGV	MHDDV
Class 8A	HDGV	MHDDV
Class 8B	HDGV	HHDDV

This scheme is fairly straightforward except for Class 2B. The LDGT2 distribution was assigned to Class 2B because this class behaves more like the LDGT2 class than like any of the other heavy duty classes.

For all distributions it is assumed that vehicles over 20 years of age travel annually the same distance as age 20 vehicles.

II.D. Diesel Market Penetration

Each model year a certain number of gas and diesel vehicles are produced. The fraction of diesel vehicles compared to the total number of vehicles produced for a given class is referred to as the diesel market penetration rate. In M4FC, these rates are used to estimate the number of gas and diesel vehicles operating in each model year. This is accomplished by using the following formulas:

$$\text{Number of Diesel Vehicles(year)} = [\text{Number of Vehicles(year)}] \cdot [\text{Diesel Penetration(year)}]$$

$$\text{Number of Gas Vehicles(year)} = [\text{Number of Vehicles(year)}] \cdot [1 - \text{Diesel Penetration(year)}]$$

The diesel penetration rates used in M4FC are the same as those in MOBILE4.[1]

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* The treatment of these vehicle categories is slightly different than the others. Only total VMT and fleet mpg are available for buses. Therefore, individual model year distributions are not included in the model.

At present, the future dieselization of the LDV and LDT fleets is uncertain. To allow for this uncertainty, the model has a provision to place a maximum limit on the LDV and LDT diesel penetration rates after 1988. This rate can be set in the range of 0 to 5 percent for LDVs and from 0 to 15 percent for LDTs.* Operationally, this means that the diesel penetration rate assumed by the MOBILE4 emissions model is replaced by the limit imposed by this option beginning in the year specified.

II.E. Fuel Economy

Fuel economy estimates are derived from a variety of sources. An internal EPA memorandum "Fuel Consumption Model Inputs"[19] provides new vehicle fleet road mpg for LDVs and LDTs for the 1962-1974 period.** EPA's Fuel Economy Trends report[13] provides new vehicle test mpg for LDVs and LDTs for the 1975-1990 period. Absent any changes in the Corporate Average Fuel Economy (CAFE) standards, test fuel economy is assumed to remain constant at 1990 levels for all projection years.

Since these estimates are not fuel type specific, a diesel advantage factor is included to indicate the degree to which diesel fueled vehicles obtain a fuel economy greater than their gasoline counterparts. These two estimates, along with the model year specific diesel penetration rates for each model year, are combined to estimate separate gasoline and diesel fuel economies. See Appendix A. The two equations used are:

$$\text{Gas mpg} = [\text{Fleet mpg}] \cdot ([1 - \text{Diesel Penetration}] + [\text{Diesel Penetration}]/[\text{Diesel Advantage Factor}])$$

$$\text{Diesel mpg} = [\text{Gas mpg}] \cdot [\text{Diesel Advantage Factor}]$$

Test fuel economy is discounted to road fuel economy by applying a constant 0.90 multiplicative factor to city driving and a constant 0.78 factor to highway driving.[20]*** These are weighted together using the calendar-year-specific proportion of urban driving listed in Highway Statistics[9] to arrive at a road fuel economy. See Figure 9. Actual values were used for the period 1968-1988. Beyond 1988, the 1968-1988 trend was linearly extrapolated. This gradual increase in the proportion of all driving that is urban is referred to in this report as "urbanization".

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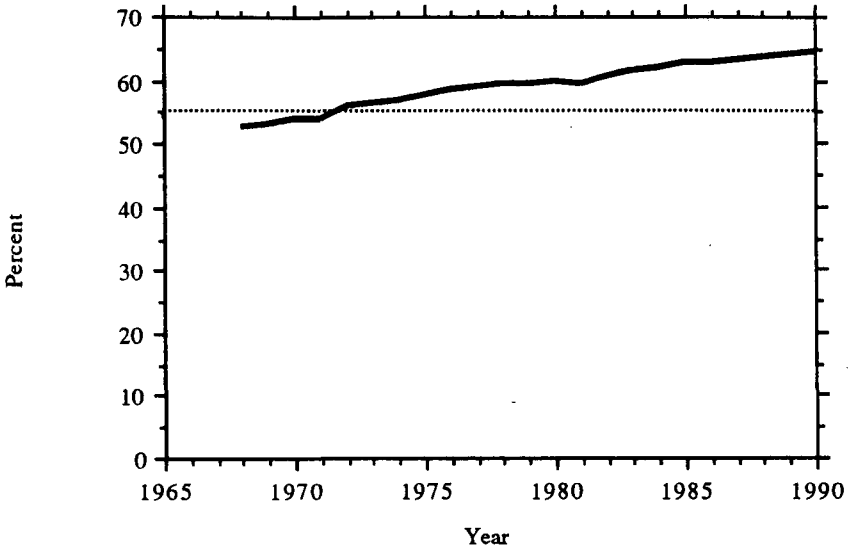
* The 1988 diesel penetration rate for LDVs and LDTs was 0.0% and 0.2%, respectively.

** MPG values prior to 1962 are assumed to be the same as those in 1962.

*** No adjustment was made in this analysis for the CAFE allowance associated with changes in EPA's test procedure. Historically, this has amounted to between 0.0010 and 0.0050.[21,22,23,24,25]

Figure 9
Urban VMT Percentage



EPA's Conversion Factor report[17] provided separate gas and diesel road mpg values for 1962 to 2000 model years for class 2B-8B trucks. As with the light duty classes, mpg values prior to 1962 were assigned the 1962 values.

II.F. Total Emissions

Total highway vehicle hydrocarbon, carbon monoxide and oxides of nitrogen emissions are estimated as simply a product of fleet VMT and MOBILE4[1] emission factors. Carbon dioxide emissions are calculated by using a carbon balance method.[26]

The carbon balance method relies on the assumption that mass, in the form of carbon, is conserved in the combustion process. Therefore, given the amount of carbon in the fuel, one can determine the amount of CO_2 released into the air as the difference between the total amount of carbon in the fuel and the amounts of hydrocarbon and carbon monoxide released in the exhaust and through evaporation.

Three sets of MOBILE4 emissions model input assumptions were used to calculate total emissions:

Projection Year	I/M Program	Gasoline RVP
1975-1988	No I/M	11.5 psi
1989-1991	Standard I/M	10.5 psi
1992+	Standard I/M	9.0 psi

All other MOBILE4 inputs were left at their default settings, including temperature (75°F), speed (19.6 mph) and vehicle operating condition (20.6% VMT in cold start mode, 27.3% VMT in hot start mode and 52.1% VMT in stabilized operating mode). Thus, the HC, CO and NO_X inventories shown will not reflect the full range of input conditions used to model highway mobile source emissions by more refined methods.[27,28,29,30]

Nevertheless, their inclusion in this report allows the model to project CO_2 emissions through the following two carbon balance equations:

$$\text{Gasoline: } CO_2 = \frac{2421 - mpg \cdot (0.866\ HC + 0.429\ CO)}{0.273\ mpg}$$

$$\text{Diesel: } CO_2 = \frac{2778 - mpg \cdot (0.866\ HC + 0.429\ CO)}{0.273\ mpg}$$

The CO_2 emissions inventory is considerably less sensitive than the HC, CO or NO_X inventories to variations in MOBILE4 input assumptions.

III. Outputs

The M4FC model outputs fuel consumption estimates for seven different vehicle classes and seven different fuel types. These classes and their composition are summarized in Tables 3-4.

Table 3
Vehicle Classes

Designation	Description
LDV	Light Duty Vehicles (passenger cars)
LDT	Light Duty Trucks , 0-8500 lbs GVW
Classes 2B-5	Light Heavy Duty Trucks, 8501-19500 lbs GVW
Classes 6-8A	Heavy Heavy Duty Trucks, 19501-50000 lbs GVW
Class 8B	Heavy Heavy Duty Trucks, 50000+lbs GVW
School Buses	
Public Buses	
Off-Highway*	Agricultural, industrial/commercial, construction and marine/recreation vehicles

* Only gasoline fuel consumed by off-highway motor vehicles, such as farm and construction equipment, is estimated. Estimating diesel fuel consumed by off-highway motor vehicles is beyond the scope of this report.

Table 4
Fuel Types

Designation	Description
Gasoline	Gasoline+Gasohol (E10)
Diesel	100% Diesel
E85	85% Ethanol 15% Gasoline
E100	100% Ethanol
M85	85% Methanol 15% Gasoline
M100	100% Methanol
CNG	100% Compressed Natural Gas

Tables 5-9 are copies of the 1990 model output. Several tables are provided for each projection year:

- Fleet Fuel Consumption
- Fleet Vehicle Miles Traveled
- Road MPG
- Vehicle Registrations
- Total Emissions

III.A. Fleet Fuel Consumption

The top one-half of the table lists the diesel and gasoline fuel consumed by light duty vehicles, light duty trucks and by three sets of heavy duty truck classes. Also listed is consumption by school and commercial buses. Finally, off-highway gasoline consumption is included.

Below the conventional fuel consumption estimates are the fuel consumption estimates for alternatively fuel vehicles. These are vehicles designed to run on ethanol (E85 and E100), methanol (M85 and M100) and compressed natural gas (CNG).*

III.B. Fleet Vehicle Miles Traveled

The fleet vehicle miles traveled estimate is formatted in a similar fashion. Diesel and gasoline VMT is listed in the top half of the table while VMT estimates for alternatively fueled vehicles are listed in the bottom half.

III.C. Road MPG

The mpg table lists road mpg both for new vehicles and for the fleet as a whole.

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* Since the inputs for the alternative fuels sections of the model are undergoing internal EPA review for the Alternative Motor Fuels report, the scenarios included in this report assume all vehicles are powered by conventional fuels.

Table 5

MOBILE4 Fuel Consumption Model
1990
Fleet Fuel Consumption
(x 10^9 Gallons/Year, x 10^6 Barrels/Day)

	Diesel		Gasoline	
Vehicle Class	Gallons	BBL/Day	Gallons	BBL/Day
LDV	0.713	0.046	57.217	3.732
LDT	0.568	0.037	29.133	1.900
Classes 2B-5	1.177	0.077	5.717	0.373
Classes 6-8A	4.989	0.325	1.501	0.098
Class 8B	15.383	1.003	0.025	0.002
School Buses	0.264	0.017	0.061	0.004
Public Buses	0.682	0.044	0.000	0.000
Off-Highway	0.000	0.000	3.019	0.197
Total LDV+LDT	1.281	0.084	86.350	5.633
Total HDV	22.494	1.467	7.304	0.476
Total Highway	23.774	1.551	93.654	6.109
Grand Total	23.774	1.551	96.673	6.306

	Alternative Fuels													
	Alcohols								Gases					
	Ethanol			Methanol			Total		CNG		Total		Grand Total	
	E85	E100	Total	M85	M100	Total	Gallons	BBL/Day	CCF	Gallons	CCF	Gallons	Gallons	BBL/Day
LDV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	57.930	3.779
LDT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29.701	1.937
Classes2B-5	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.894	0.450
Classes 6-8A	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	6.489	0.423
Class8B	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	15.407	1.005
School Buses	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.325	0.021
Public Buses	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.682	0.044
Off-Highway	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	3.019	0.197
Total LDV+LDT	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	87.631	5.716
Total HDV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	29.797	1.944
Total Highway	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	117.428	7.660
Grand Total	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	120.448	7.857

Note: This run assumes the following fuel economy adjustments:
Standard Shortfall,
Urbanization,
No CAFE Growth.

Default M4FC

Table 6

MOBILE4 Fuel Consumption Model

1990
Fleet Vehicle Miles Traveled
($x10^9$ Miles/Year)

	Total VMT	
	Diesel	Gasoline
LDV	18.68	1173.31
LDT	14.22	481.24
Classes 2B-5	17.25	58.93
Classes 6-8A	34.46	8.71
Class 8B	83.81	0.09
School Buses	3.11	0.50
Public Buses	3.72	0.00
Total LDV+LDT	32.90	1654.55
Total HDV	142.35	68.23
Grand Total	175.25	1722.77

	Total VMT										
	Alternative Fuels										
	Alcohols										
	Ethanol			Methanol				Gases			
	E85	E100	Total	M85	M100	Total	Total	CNG	Total	Total	Total
LDV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1191.99
LDT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	495.45
Classes 2B-5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	76.18
Classes6-8A	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	43.17
Class 8B	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	83.90
School Buses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.61
Public Buses	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.72
Total LDV+LDT	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1687.44
Total HDV	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	210.58
Grand Total	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1898.02

Default M4FC

Table 7

MOBILE4 Fuel Consumption Model

1990
Road MPG

New Vehicle

			Ethanol		Methanol		CNG
	Diesel	Gas	E85	E100	M85	M100	MPCCF
LDV	27.63	23.03	0.00	0.00	0.00	0.00	0.00
LDT	24.95	17.26	0.00	0.00	0.00	0.00	0.00
Classes 2B-5	14.55	10.62	0.00	0.00	0.00	0.00	0.00
Classes 6-8A	7.01	5.93	0.00	0.00	0.00	0.00	0.00
Class 8B	5.49	0.00	0.00	0.00	0.00	0.00	0.00
School Buses	11.79	8.20	0.00	0.00	0.00	0.00	0.00
Public Buses	5.45	0.00	0.00	0.00	0.00	0.00	0.00
Total LDV+LDT	26.13	20.89	0.00	0.00	0.00	0.00	0.00
Total HDV	6.52	9.65	0.00	0.00	0.00	0.00	0.00
Grand Total	7.24	19.67	0.00	0.00	0.00	0.00	0.00

Fleet

			Ethanol		Methanol		CNG
	Diesel	Gas	E85	E100	M85	M100	MPCCF
LDV	26.21	20.51	0.00	0.00	0.00	0.00	0.00
LDT	25.02	16.52	0.00	0.00	0.00	0.00	0.00
Classes 2B-5	14.66	10.31	0.00	0.00	0.00	0.00	0.00
Classes 6-8A	6.91	5.80	0.00	0.00	0.00	0.00	0.00
Class 8B	5.45	3.46	0.00	0.00	0.00	0.00	0.00
School Buses	11.79	8.20	0.00	0.00	0.00	0.00	0.00
Public Buses	5.45	0.00	0.00	0.00	0.00	0.00	0.00
Total LDV+LDT	25.68	19.16	0.00	0.00	0.00	0.00	0.00
Total HDV	6.33	9.34	0.00	0.00	0.00	0.00	0.00
Grand Total	7.37	18.40	0.00	0.00	0.00	0.00	0.00

Note: This run assumes the following fuel economy adjustments:
Standard Shortfall,
Urbanization,
No CAFE Growth.

Default M4FC

Table 8

MOBILE4 Fuel Consumption Model

1990
Vehicle Registrations
(x 10^6 Vehicles)

			Ethanol		Methanol			
	Diesel	Gas	E85	E100	M85	M100	CNG	Total
LDV	1.968	122.690	0.000	0.000	0.000	0.000	0.000	124.658
LDT	1.247	43.384	0.000	0.000	0.000	0.000	0.000	44.631
Classes 2B-5	1.156	5.102	0.000	0.000	0.000	0.000	0.000	6.258
Classes 6-8A	1.396	0.797	0.000	0.000	0.000	0.000	0.000	2.193
Class 8B	1.386	0.021	0.000	0.000	0.000	0.000	0.000	1.407
School Buses	0.454	0.073	0.000	0.000	0.000	0.000	0.000	0.527
Public Buses	0.118	0.000	0.000	0.000	0.000	0.000	0.000	0.118
Total LDV+LDT	3.215	166.074	0.000	0.000	0.000	0.000	0.000	169.289
Total HDV	4.510	5.992	0.000	0.000	0.000	0.000	0.000	10.503
Grand Total	7.725	172.066	0.000	0.000	0.000	0.000	0.000	179.791

Table 9

Mobile4 Fuel Consumption Model

Total Emissions
(x 10^6 Metric Tons/Year)

	HC	CO	NOx	CO2
LDV	3.058	19.208	1.889	474.777
LDT	1.575	10.912	0.940	241.990
Classes 2B-5	0.243	1.602	0.165	59.383
Classes 6-8A	0.148	0.955	0.683	62.104
Class 8B	0.218	1.014	1.541	154.465
School Buses	0.011	0.069	0.060	3.082
Public Buses	0.010	0.045	0.068	6.841
Total LDV+LDT	4.634	30.120	2.829	716.766
Total HDV	0.630	3.685	2.517	285.874
Grand Total	5.263	33.804	5.346	1002.638

Default M4FC

MOBILE4 RUN: 1975-1988: no IM 11.5 RVP/1989-1991: std IM 10.5 RVP/1992-2020: std IM 9.0 RVP

III.D. Vehicle Registrations and Total Emissions

The top half of last table lists total registrations by vehicle and fuel type. Total HC, CO, NO_X and CO_2 emissions are listed in the second half of the table.

IV. Sensitivity

Figures 10-12 show the sensitivity gasoline consumption, VMT and CO_2 emissions to two of the most significant MOBILE4 input assumptions: diesel penetration and VMT per vehicle.[31]

The "Limited Diesel" case shows the difference in gasoline consumption that would result by assuming that the fractions of new model year light duty vehicles and trucks that are diesel powered remain constant at 1988 levels (0.0%, 0.2%).[13]

The "VMT Growth" case shows the difference in consumption that would result by assuming that VMT per vehicle increases at 1.0% per year for light duty vehicles and light duty trucks that operate as passenger vehicles.

Finally, "Diesel & Growth" case shows the effect of combining the two assumptions, of constant diesel penetration rates and increasing VMT per passenger-type vehicle.

As can be seen from the figures, gasoline consumption increases as diesel penetration declines and as VMT per vehicle increases. Both VMT and CO_2 increase as VMT per vehicle increases.

Figure 10
Gasoline Consumption

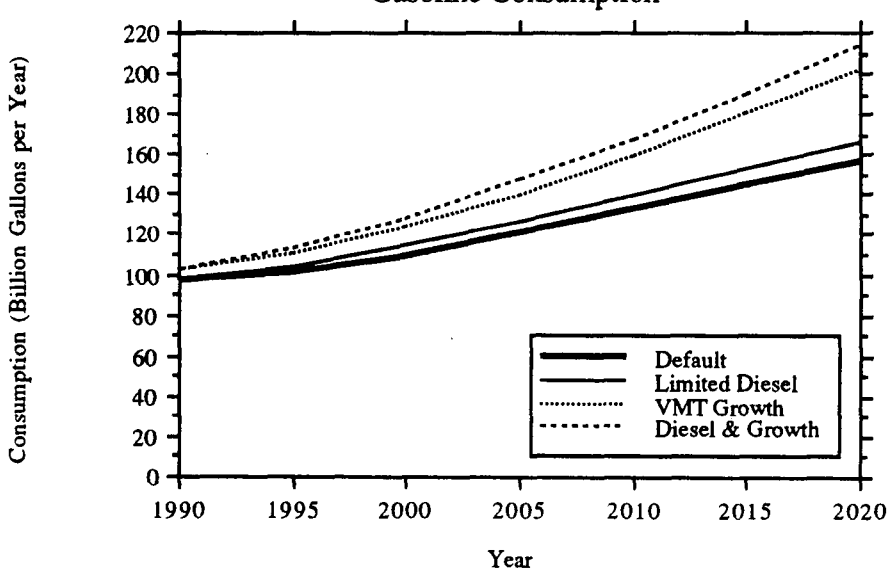


Figure 11
Total VMT

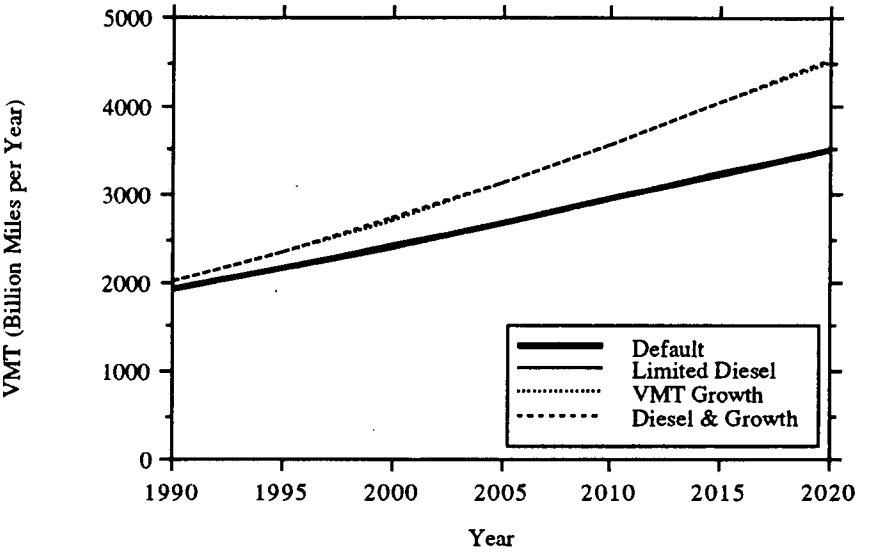
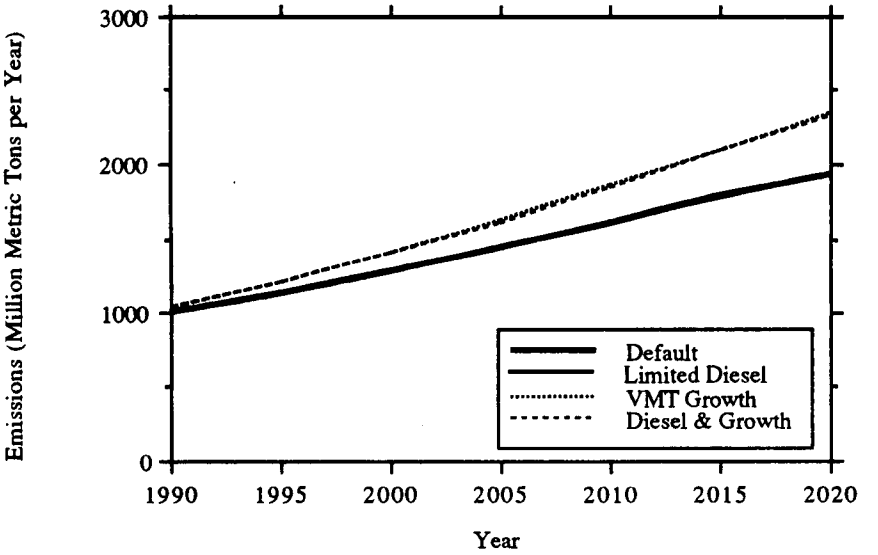


Figure 12
Carbon Dioxide Emissions



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Appendix A

Model Input Tables

Historical and Predicted Vehicle Stock
(millions of vehicles)

Year	Polk Cars	FHwA Cars	M4FC Cars	Polk Trucks	FHwA Trucks	M4FC Trucks	Year	Polk Cars	FHwA Cars	M4FC Cars	Polk Trucks	FHwA Trucks	M4FC Trucks
1950	35.924	40.339		7.577	8.457		1986	117.268	135.431	117.268	44.827	40.663	44.827
1951	38.516	42.688		8.065	8.847		1987	119.849	137.208	119.849	47.343	41.747	47.343
1952	39.770	43.823		8.420	9.049		1988	121.519	141.252	121.519	50.223	43.145	50.223
1953	42.202	46.429		8.693	9.375		1989	122.758		122.758	53.201	53.201	
1954	44.387	48.468		8.800	9.610		1990			124.658	54.937		
1955	47.378	52.145		9.162	10.101		1991			126.556	57.490		
1956	49.804	54.211		9.544	10.476		1992			128.535	60.018		
1957	51.432	55.918		9.776	10.711		1993			130.591	62.524		
1958	52.493	56.891		10.057	10.878		1994			132.720	65.014		
1959	55.087	59.454		10.532	11.343		1995			134.918	67.487		
1960	57.103	61.671		10.803	11.601		1996			137.031	69.865		
1961	58.854	63.421		11.043	11.919		1997			139.203	72.228		
1962	60.920	66.085		11.463	12.406		1998			141.431	74.588		
1963	63.493	69.038		11.902	12.957		1999			143.712	76.940		
1964	66.051	71.995		12.445	13.588		2000			146.044	79.291		
1965	68.940	75.258		13.127	14.340		2001			148.353	81.597		
1966	71.264	78.125		14.357	15.029		2002			150.707	83.907		
1967	72.968	80.414		14.988	16.531		2003			153.104	86.220		
1968	75.358	83.693		15.685	17.347		2004			155.542	88.539		
1969	78.495	86.861		16.586	18.235		2005			158.020	90.860		
1970	80.448	89.280		17.688	19.127		2006			160.496	93.166		
1971	83.137	92.799		18.462	20.200		2007			163.007	95.484		
1972	86.439	96.860		19.773	21.646		2008			165.554	97.808		
1973	89.805	101.762		21.412	23.233		2009			168.133	100.146		
1974	92.608	104.856		23.312	25.077		2010			170.745	102.494		
1975	95.241	106.713		24.813	26.238		2011			173.389	104.857		
1976	97.818	110.189		26.560	28.257		2012			176.062	107.236		
1977	99.904	113.696		28.222	30.054		2013			178.765	109.631		
1978	102.957	116.575		30.565	32.203		2014			181.497	112.040		
1979	104.677	120.248		33.894	33.870		2015			184.257	114.468		
1980	104.564	121.724		35.268	34.166		2016			186.638	116.656		
1981	105.839	123.291		36.069	34.995		2017			189.037	118.853		
1982	106.867	123.746	106.867	36.986	35.703	36.986	2018			191.454	121.065		
1983	108.961	126.138	108.961	38.144	37.671	38.144	2019			193.887	123.287		
1984	112.019	128.271	112.019	40.144	37.978	40.144	2020			196.338	125.525		
1985	114.662	131.864	114.662	42.389	39.790	42.389							

Vehicle Stock
(millions of vehicles)

Year	LDV	Car-Like LDT1	Commrcl LDT1	LDT2	Class 2B	Class 3	Class 4	Class 5	Class 6	Class 7	Class 8A	Class 8B	School Buses	Public Buses
1982	106.867	7.598	13.063	10.299	2.471	0.092	0.237	0.407	0.639	0.359	0.404	0.858	0.446	0.113
1983	108.961	8.563	12.286	10.622	3.042	0.090	0.231	0.399	0.649	0.401	0.410	0.904	0.433	0.114
1984	112.019	8.492	13.229	11.151	3.436	0.088	0.227	0.396	0.666	0.467	0.425	1.006	0.446	0.115
1985	114.662	8.871	14.010	11.428	4.053	0.105	0.221	0.392	0.676	0.536	0.438	1.085	0.459	0.115
1986	117.268	9.322	15.009	12.129	4.195	0.102	0.216	0.388	0.679	0.600	0.456	1.143	0.472	0.116
1987	119.849	9.832	15.915	12.636	4.601	0.101	0.213	0.388	0.695	0.677	0.467	1.217	0.485	0.116
1988	121.519	11.289	15.911	13.632	4.808	0.100	0.212	0.392	0.717	0.764	0.483	1.299	0.499	0.117
1989	122.758	13.211	15.809	14.184	5.219	0.098	0.208	0.391	0.733	0.851	0.495	1.372	0.513	0.117
1990	124.658	14.507	15.831	14.293	5.464	0.094	0.198	0.379	0.727	0.912	0.491	1.396	0.527	0.118
1991	126.556	15.732	16.222	14.713	5.827	0.091	0.192	0.375	0.736	0.995	0.498	1.451	0.540	0.118
1992	128.535	16.907	16.622	15.141	6.191	0.088	0.187	0.371	0.746	1.079	0.506	1.507	0.554	0.119
1993	130.591	18.036	17.031	15.578	6.557	0.086	0.182	0.367	0.758	1.165	0.514	1.563	0.568	0.119
1994	132.720	19.125	17.450	16.022	6.925	0.084	0.177	0.364	0.769	1.253	0.523	1.621	0.582	0.119
1995	134.918	20.175	17.877	16.474	7.295	0.081	0.172	0.361	0.782	1.341	0.532	1.681	0.596	0.120
1996	137.031	21.161	18.313	16.903	7.652	0.079	0.167	0.358	0.793	1.428	0.541	1.740	0.610	0.120
1997	139.203	22.115	18.759	17.337	8.011	0.077	0.162	0.354	0.805	1.514	0.550	1.801	0.623	0.120
1998	141.431	23.040	19.218	17.778	8.372	0.074	0.158	0.351	0.818	1.600	0.559	1.862	0.637	0.121
1999	143.712	23.938	19.688	18.224	8.733	0.072	0.153	0.349	0.832	1.686	0.568	1.925	0.651	0.121
2000	146.044	24.812	20.171	18.677	9.096	0.070	0.149	0.346	0.847	1.771	0.578	1.988	0.665	0.121
2001	148.353	25.650	20.666	19.120	9.453	0.068	0.144	0.344	0.861	1.854	0.587	2.050	0.679	0.121
2002	150.707	26.468	21.174	19.569	9.812	0.066	0.140	0.341	0.876	1.938	0.597	2.112	0.693	0.121
2003	153.104	27.268	21.696	20.022	10.171	0.064	0.136	0.339	0.892	2.022	0.607	2.175	0.707	0.121
2004	155.542	28.051	22.232	20.481	10.531	0.062	0.132	0.337	0.907	2.106	0.617	2.239	0.722	0.122
2005	158.020	28.820	22.782	20.943	10.892	0.060	0.128	0.335	0.923	2.190	0.627	2.302	0.736	0.122
2006	160.496	29.567	23.346	21.402	11.250	0.058	0.124	0.334	0.938	2.273	0.637	2.365	0.750	0.122
2007	163.007	30.302	23.926	21.865	11.609	0.057	0.120	0.332	0.954	2.356	0.648	2.428	0.765	0.122
2008	165.554	31.026	24.521	22.331	11.968	0.055	0.116	0.331	0.970	2.439	0.658	2.492	0.779	0.122
2009	168.133	31.741	25.131	22.801	12.328	0.053	0.112	0.329	0.987	2.523	0.669	2.556	0.794	0.122
2010	170.745	32.447	25.758	23.275	12.688	0.051	0.109	0.328	1.003	2.606	0.679	2.620	0.808	0.122
2011	173.389	33.145	26.401	23.752	13.049	0.050	0.105	0.327	1.020	2.689	0.690	2.684	0.823	0.122
2012	176.062	33.837	27.061	24.232	13.411	0.048	0.102	0.326	1.037	2.772	0.701	2.749	0.838	0.122
2013	178.765	34.523	27.737	24.716	13.773	0.047	0.099	0.326	1.054	2.855	0.712	2.814	0.853	0.122
2014	181.497	35.203	28.431	25.202	14.136	0.045	0.096	0.325	1.071	2.938	0.723	2.879	0.868	0.123
2015	184.257	35.879	29.142	25.692	14.499	0.044	0.092	0.325	1.088	3.022	0.735	2.944	0.883	0.123
2016	186.638	36.470	29.859	26.099	14.814	0.042	0.089	0.323	1.102	3.095	0.744	3.000	0.897	0.122
2017	189.037	37.055	30.594	26.505	15.127	0.041	0.086	0.322	1.116	3.167	0.753	3.055	0.910	0.122
2018	191.454	37.636	31.349	26.911	15.439	0.039	0.083	0.321	1.130	3.239	0.762	3.110	0.924	0.122
2019	193.887	38.213	32.122	27.316	15.748	0.038	0.080	0.320	1.144	3.311	0.771	3.165	0.937	0.122
2020	196.338	38.788	32.916	27.720	16.056	0.036	0.077	0.319	1.158	3.382	0.780	3.220	0.951	0.122

Registration Distributions

Classes 2B-8B

Age	LDV	LDT	Gas	Diesel
1	0.084	0.100	0.140	0.179
2	0.080	0.095	0.120	0.147
3	0.077	0.089	0.104	0.121
4	0.073	0.084	0.090	0.099
5	0.069	0.079	0.077	0.082
6	0.066	0.074	0.066	0.067
7	0.062	0.068	0.057	0.055
8	0.058	0.063	0.049	0.045
9	0.055	0.058	0.043	0.037
10	0.051	0.053	0.037	0.031
11	0.047	0.047	0.032	0.025
12	0.043	0.042	0.027	0.021
13	0.040	0.037	0.024	0.017
14	0.036	0.032	0.020	0.014
15	0.032	0.026	0.017	0.011
16	0.029	0.021	0.015	0.009
17	0.025	0.016	0.013	0.008
18	0.021	0.011	0.011	0.006
19	0.018	0.005	0.010	0.005
20	0.014	0.000	0.008	0.004
21	0.010	0.000	0.007	0.003
22	0.007	0.000	0.006	0.003
23	0.003	0.000	0.005	0.002
24	0.000	0.000	0.005	0.002
25	0.000	0.000	0.004	0.002
26	0.000	0.000	0.003	0.001
27	0.000	0.000	0.003	0.001
28	0.000	0.000	0.003	0.001
29	0.000	0.000	0.002	0.001
30	0.000	0.000	0.002	0.001

VMT Distributions
(thousands of miles/year)

	LDV and Car-Like LDT1		Commrcl LDT1		LDT2		Class 2B		Classes 3-5	
Age	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel
1	13.118	17.825	15.640	20.140	17.608	20.140	18.211	17.608	18.211	23.611
2	12.408	16.478	14.590	17.572	16.217	17.572	16.767	16.217	16.767	20.947
3	11.737	15.233	13.610	15.432	14.937	15.432	15.437	14.937	15.437	18.583
4	11.103	14.081	12.696	13.639	13.758	13.639	14.213	13.758	14.213	16.486
5	10.503	13.017	11.843	12.133	12.671	12.133	13.086	12.671	13.086	14.625
6	9.935	12.033	11.048	10.863	11.671	10.863	12.048	11.671	12.048	12.975
7	9.398	11.124	10.306	9.788	10.749	9.788	11.093	10.749	11.093	11.511
8	8.889	10.283	9.614	8.877	9.901	8.877	10.213	9.901	10.213	10.212
9	8.409	9.506	8.968	8.103	9.119	8.103	9.403	9.119	9.403	9.059
10	7.954	8.788	8.366	7.444	8.399	7.444	8.657	8.399	8.657	8.037
11	7.524	8.123	7.804	6.883	7.736	6.883	7.971	7.736	7.971	7.130
12	7.117	7.509	7.280	6.405	7.125	6.405	7.339	7.125	7.339	6.325
13	6.733	6.942	6.791	5.999	6.562	5.999	6.757	6.562	6.757	5.612
14	6.369	6.417	6.335	5.655	6.044	5.655	6.221	6.044	6.221	4.978
15	6.024	5.932	5.909	5.365	5.567	5.365	5.728	5.567	5.728	4.416
16	5.698	5.484	5.512	5.123	5.127	5.123	5.273	5.127	5.273	3.918
17	5.390	5.069	5.142	4.924	4.723	4.924	4.855	4.723	4.855	3.476
18	5.099	4.686	4.797	4.763	4.350	4.763	4.470	4.350	4.470	3.084
19	4.823	4.332	4.475	4.637	4.006	4.637	4.116	4.006	4.116	2.736
20	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
21	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
22	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
23	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
24	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
25	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
26	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
27	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
28	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
29	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427
30	4.562	4.005	4.174	4.543	3.690	4.543	3.789	3.690	3.789	2.427

VMT Distributions
(thousands of miles/year)

	Class 6		Class 7		Class 8A		Class 8B		Buses			
									School		Public	
Age	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel	Gas	Diesel
1	18.211	43.946	18.211	43.946	18.211	43.946	18.211	86.375	6.853	6.853	31.525	31.525
2	16.767	40.504	16.767	40.504	16.767	40.504	16.767	79.434	-----	-----	-----	-----
3	15.437	37.332	15.437	37.332	15.437	37.332	15.437	73.051	-----	-----	-----	-----
4	14.213	34.408	14.213	34.408	14.213	34.408	14.213	67.181	-----	-----	-----	-----
5	13.086	31.713	13.086	31.713	13.086	31.713	13.086	61.782	-----	-----	-----	-----
6	12.048	29.229	12.048	29.229	12.048	29.229	12.048	56.817	-----	-----	-----	-----
7	11.093	26.939	11.093	26.939	11.093	26.939	11.093	52.252	-----	-----	-----	-----
8	10.213	24.829	10.213	24.829	10.213	24.829	10.213	48.053	-----	-----	-----	-----
9	9.403	22.885	9.403	22.885	9.403	22.885	9.403	44.191	-----	-----	-----	-----
10	8.657	21.092	8.657	21.092	8.657	21.092	8.657	40.640	-----	-----	-----	-----
11	7.971	19.440	7.971	19.440	7.971	19.440	7.971	37.374	-----	-----	-----	-----
12	7.339	17.918	7.339	17.918	7.339	17.918	7.339	34.371	-----	-----	-----	-----
13	6.757	16.514	6.757	16.514	6.757	16.514	6.757	31.609	-----	-----	-----	-----
14	6.221	15.221	6.221	15.221	6.221	15.221	6.221	29.069	-----	-----	-----	-----
15	5.728	14.029	5.728	14.029	5.728	14.029	5.728	26.733	-----	-----	-----	-----
16	5.273	12.930	5.273	12.930	5.273	12.930	5.273	24.585	-----	-----	-----	-----
17	4.855	11.917	4.855	11.917	4.855	11.917	4.855	22.609	-----	-----	-----	-----
18	4.470	10.984	4.470	10.984	4.470	10.984	4.470	20.792	-----	-----	-----	-----
19	4.116	10.123	4.116	10.123	4.116	10.123	4.116	19.121	-----	-----	-----	-----
20	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
21	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
22	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
23	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
24	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
25	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
26	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
27	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
28	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
29	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----
30	3.789	9.331	3.789	9.331	3.789	9.331	3.789	17.585	-----	-----	-----	-----

Diesel Penetration Rates

Year	LDV & Car-Like LDT1	Commrcl LDT1 & LDT2	Class 2B	Classes 3-5	Class 6	Class 7	Class 8A	Class 8B	Buses School	Buses Public
1962-	0.000	0.000	0.000	0.014	0.042	0.421	0.600	0.547	0.000	0.547
1963	0.000	0.000	0.001	0.018	0.063	0.436	0.616	0.595	0.000	0.595
1964	0.000	0.000	0.001	0.022	0.084	0.442	0.624	0.642	0.000	0.642
1965	0.000	0.000	0.002	0.026	0.105	0.447	0.632	0.690	0.000	0.690
1966	0.000	0.000	0.003	0.029	0.100	0.413	0.583	0.721	0.000	0.721
1967	0.000	0.000	0.002	0.031	0.094	0.379	0.535	0.751	0.000	0.751
1968	0.000	0.000	0.001	0.022	0.088	0.364	0.514	0.809	0.000	0.809
1969	0.000	0.000	0.000	0.012	0.082	0.348	0.492	0.867	0.000	0.867
1970	0.000	0.000	0.000	0.003	0.076	0.333	0.470	0.925	0.000	0.925
1971	0.000	0.000	0.000	0.003	0.054	0.341	0.482	0.923	0.000	0.923
1972	0.000	0.000	0.000	0.003	0.031	0.348	0.492	0.923	0.000	0.923
1973	0.000	0.000	0.000	0.004	0.034	0.382	0.540	0.921	0.000	0.921
1974	0.000	0.000	0.000	0.004	0.038	0.415	0.586	0.920	0.000	0.920
1975	0.000	0.000	0.000	0.005	0.041	0.449	0.634	0.920	0.000	0.914
1976	0.000	0.000	0.000	0.003	0.071	0.514	0.726	0.960	0.000	0.919
1977	0.000	0.000	0.001	0.000	0.100	0.578	0.770	1.000	0.001	0.943
1978	0.000	0.010	0.000	0.000	0.106	0.615	0.794	1.000	0.011	0.943
1979	0.025	0.015	0.041	0.000	0.174	0.606	0.818	1.000	0.051	0.965
1980	0.048	0.048	0.081	0.000	0.242	0.598	0.841	1.000	0.116	0.979
1981	0.062	0.082	0.122	0.000	0.309	0.589	0.865	1.000	0.291	1.000
1982	0.032	0.092	0.162	0.000	0.377	0.580	0.899	1.000	0.316	1.000
1983	0.012	0.042	0.184	0.000	0.399	0.617	0.962	1.000	0.342	1.000
1984	0.016	0.026	0.198	0.000	0.493	0.589	0.962	1.000	0.350	1.000
1985	0.001	0.011	0.216	0.000	0.579	0.627	0.973	1.000	0.589	1.000
1986	0.000	0.020	0.232	0.000	0.527	0.617	0.981	1.000	0.690	1.000
1987	0.009	0.009	0.250	0.000	0.590	0.635	0.989	1.000	0.745	1.000
1988	0.017	0.027	0.260	0.000	0.610	0.646	0.994	1.000	0.794	1.000
1989	0.014	0.044	0.270	0.000	0.626	0.655	1.000	1.000	0.830	1.000
1990	0.022	0.062	0.280	0.000	0.642	0.662	1.000	1.000	0.861	1.000
1991	0.020	0.080	0.290	0.000	0.656	0.670	1.000	1.000	0.886	1.000
1992	0.037	0.097	0.300	0.000	0.668	0.677	1.000	1.000	0.910	1.000
1993	0.035	0.115	0.300	0.000	0.679	0.684	1.000	1.000	0.929	1.000
1994	0.042	0.132	0.300	0.000	0.688	0.689	1.000	1.000	0.946	1.000
1995	0.050	0.150	0.300	0.000	0.695	0.694	1.000	1.000	0.961	1.000
1996	0.050	0.150	0.300	0.000	0.699	0.698	1.000	1.000	0.972	1.000
1997	0.050	0.150	0.300	0.000	0.700	0.700	1.000	1.000	0.983	1.000
1998	0.050	0.150	0.300	0.000	0.700	0.700	1.000	1.000	0.994	1.000
1999	0.050	0.150	0.300	0.000	0.700	0.700	1.000	1.000	1.000	1.000
2000+	0.050	0.150	0.300	0.000	0.700	0.700	1.000	1.000	1.000	1.000

Fuel Economies and Diesel Advantage Factors

	LDV			LDT			Class 2B		Classes 3-4		Class 5	
Year	City Gas	Hwy Gas	Dsl Fctr	City Gas	Hwy Gas	Dsl Fctr	Gas	Dsl	Gas	Dsl	Gas	Dsl
1962-	13.01	18.52	1.73	11.67	15.63	1.73	10.76	---	7.64	7.66	7.64	7.66
1963	13.01	18.52	1.73	11.67	15.63	1.73	10.76	---	7.64	7.66	7.64	7.66
1964	13.01	18.52	1.73	11.67	15.63	1.73	10.76	---	7.64	7.66	7.64	7.66
1965	13.01	18.52	1.73	11.67	15.63	1.73	10.76	---	7.64	7.66	7.64	7.66
1966	13.01	18.52	1.73	11.67	15.63	1.73	10.76	---	7.64	7.66	7.64	7.66
1967	13.01	18.52	1.73	11.67	15.63	1.73	10.76	---	7.64	7.66	7.64	7.66
1968	12.81	18.23	1.73	11.46	15.35	1.73	10.76	---	7.64	7.66	7.64	7.66
1969	12.91	18.37	1.73	11.57	15.49	1.73	10.76	---	7.64	7.66	7.64	7.66
1970	12.91	18.37	1.73	11.57	15.49	1.73	10.76	---	7.64	7.66	7.64	7.66
1971	12.50	17.80	1.73	11.15	14.93	1.73	10.76	---	7.64	7.66	7.64	7.66
1972	12.60	17.94	1.73	11.25	15.07	1.73	10.76	---	7.64	7.66	7.64	7.66
1973	12.40	17.65	1.73	11.05	14.79	1.73	10.76	---	7.64	7.66	7.64	7.66
1974	12.40	17.65	1.73	11.05	14.79	1.73	11.02	---	7.66	8.24	7.66	8.24
1975	13.70	19.50	1.73	12.10	16.20	1.73	11.27	---	7.69	8.82	7.69	8.82
1976	15.20	21.30	1.62	12.80	16.90	1.62	11.54	---	7.71	9.40	7.71	9.40
1977	16.00	22.30	1.51	14.00	18.10	1.51	11.79	---	7.73	---	7.73	---
1978	17.20	24.50	1.42	13.80	17.50	1.42	12.05	---	7.76	---	7.76	---
1979	17.70	24.60	1.35	13.40	16.80	1.35	12.30	---	7.78	---	7.81	---
1980	20.30	29.00	1.26	16.50	21.90	1.26	12.56	---	7.81	---	7.81	---
1981	21.70	31.10	1.23	17.80	23.90	1.23	12.81	16.61	7.83	---	7.83	---
1982	22.30	32.70	1.22	18.10	24.40	1.22	13.07	16.94	7.85	---	7.85	---
1983	22.10	32.70	1.21	18.30	25.20	1.21	13.08	16.95	7.86	---	7.86	---
1984	22.40	33.30	1.20	17.90	24.80	1.20	13.09	16.98	7.86	---	7.88	---
1985	23.00	34.30	1.20	18.00	24.90	1.20	13.12	17.42	7.88	---	7.90	---
1986	23.70	35.50	1.20	18.80	25.90	1.20	13.16	17.05	7.90	---	7.94	---
1987	23.90	35.90	1.20	18.80	26.50	1.20	13.16	17.05	7.90	---	7.94	---
1988	24.20	36.60	1.20	18.30	26.20	1.20	13.16	17.05	7.90	---	7.94	---
1989	23.70	36.30	1.20	18.10	25.70	1.20	13.16	17.05	7.90	---	7.94	---
1990	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1991	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1992	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1993	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1994	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1995	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1996	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1997	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1998	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
1999	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---
2000+	23.40	36.00	1.20	18.10	26.10	1.20	13.16	17.05	7.90	---	7.94	---

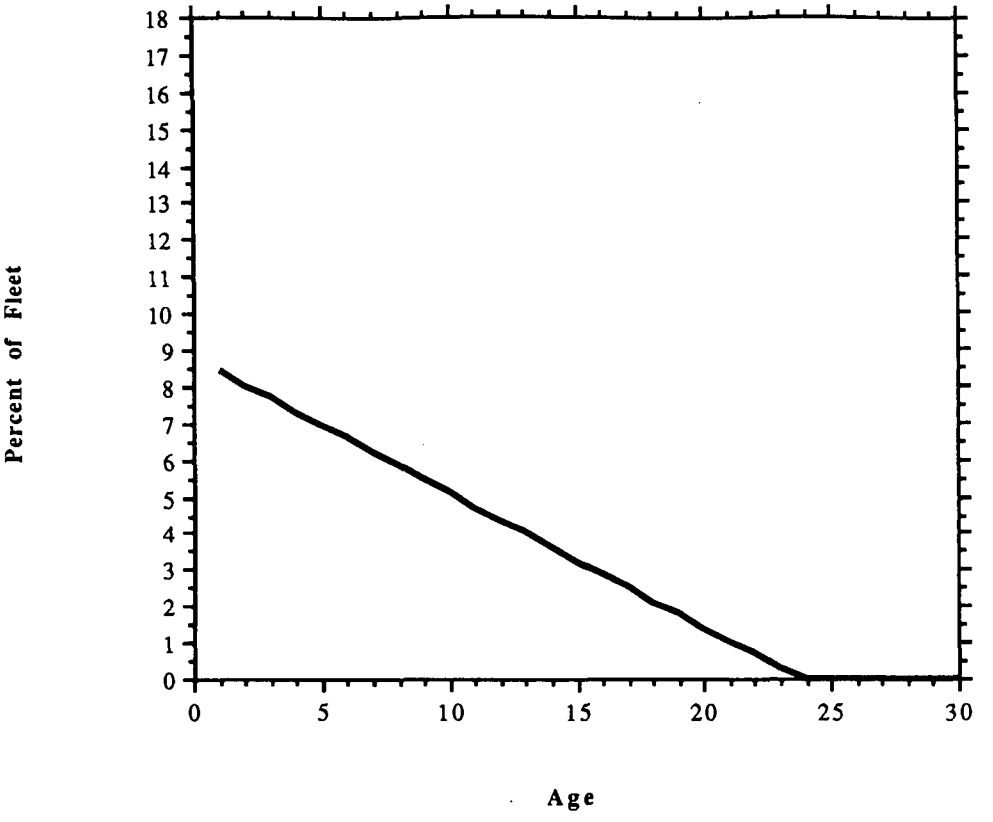
Fuel Economies and Diesel Advantage Factors

	Class 6		Class 7		Class 8A		Class 8B		School Bus		Public Bus	
Year	Gas	Dsl	Gas	Dsl	Gas	Dsl	Gas	Dsl	Gas	Dsl	Gas	Dsl
1962-	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1963	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1964	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1965	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1966	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1967	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1968	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1969	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1970	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1971	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1972	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1973	6.83	6.89	5.44	6.65	5.04	6.06	3.98	5.61	---	---	---	---
1974	6.71	7.20	5.46	6.62	5.19	6.05	4.16	5.64	---	---	---	---
1975	6.65	7.52	5.48	6.61	5.33	6.06	4.32	5.69	8.68	---	---	5.69
1976	6.66	7.84	5.50	6.65	5.24	6.08	4.50	5.73	8.72	---	---	6.00
1977	6.72	8.15	5.55	6.82	5.62	6.18	---	5.77	8.73	---	---	5.99
1978	6.81	8.47	5.70	7.18	5.77	6.28	---	5.85	8.73	---	---	5.96
1979	6.93	8.79	5.90	7.78	5.92	6.37	---	5.94	8.74	---	---	6.01
1980	7.12	9.11	6.06	8.33	6.06	6.42	---	6.04	9.08	---	---	5.98
1981	7.39	9.42	6.13	8.61	6.20	6.47	---	6.18	9.09	---	---	5.92
1982	7.72	9.74	6.12	8.76	6.36	6.51	---	6.38	9.12	12.62	---	5.89
1983	7.78	9.83	6.17	8.83	6.40	6.57	5.12	6.38	9.18	12.77	---	5.95
1984	7.84	9.92	6.20	8.89	6.44	6.63	5.14	6.40	9.24	12.91	---	6.01
1985	7.90	10.00	6.25	8.96	6.49	6.68	5.18	6.40	9.30	13.07	---	6.08
1986	7.96	10.06	6.28	9.03	6.53	6.74	5.20	6.43	9.36	13.22	---	6.14
1987	7.96	10.06	6.28	9.03	6.53	6.74	5.24	6.43	9.43	13.37	---	6.20
1988	7.96	10.06	6.28	9.03	6.53	6.74	5.26	6.43	9.49	13.52	---	6.26
1989	7.96	10.06	6.28	9.03	6.53	6.74	5.29	6.43	9.55	13.67	---	6.33
1990	7.96	10.06	6.28	9.03	6.53	6.74	5.30	6.43	9.61	13.82	---	6.39
1991	7.96	10.06	6.28	9.03	6.53	6.74	5.32	6.43	9.67	13.97	---	6.45
1992	7.96	10.06	6.28	9.03	6.53	6.74	5.35	6.43	9.73	14.13	---	6.51
1993	7.96	10.06	6.28	9.03	6.53	6.74	5.37	6.43	9.79	14.27	---	6.57
1994	7.96	10.06	6.28	9.03	6.53	6.74	5.38	6.43	9.85	14.42	---	6.64
1995	7.96	10.06	6.28	9.03	6.53	6.74	5.41	6.43	9.91	14.58	---	6.70
1996	7.96	10.06	6.28	9.03	6.53	6.74	5.42	6.43	9.98	14.72	---	6.76
1997	7.96	10.06	6.28	9.03	6.53	6.74	5.44	6.43	10.04	14.87	---	6.82
1998	7.96	10.06	6.28	9.03	6.53	6.74	5.46	6.43	10.10	15.03	---	6.89
1999	7.96	10.06	6.28	9.03	6.53	6.74	5.48	6.43	10.16	15.17	---	6.95
2000+	7.96	10.06	6.28	9.03	6.53	6.74	5.50	6.43	10.22	15.33	---	7.01

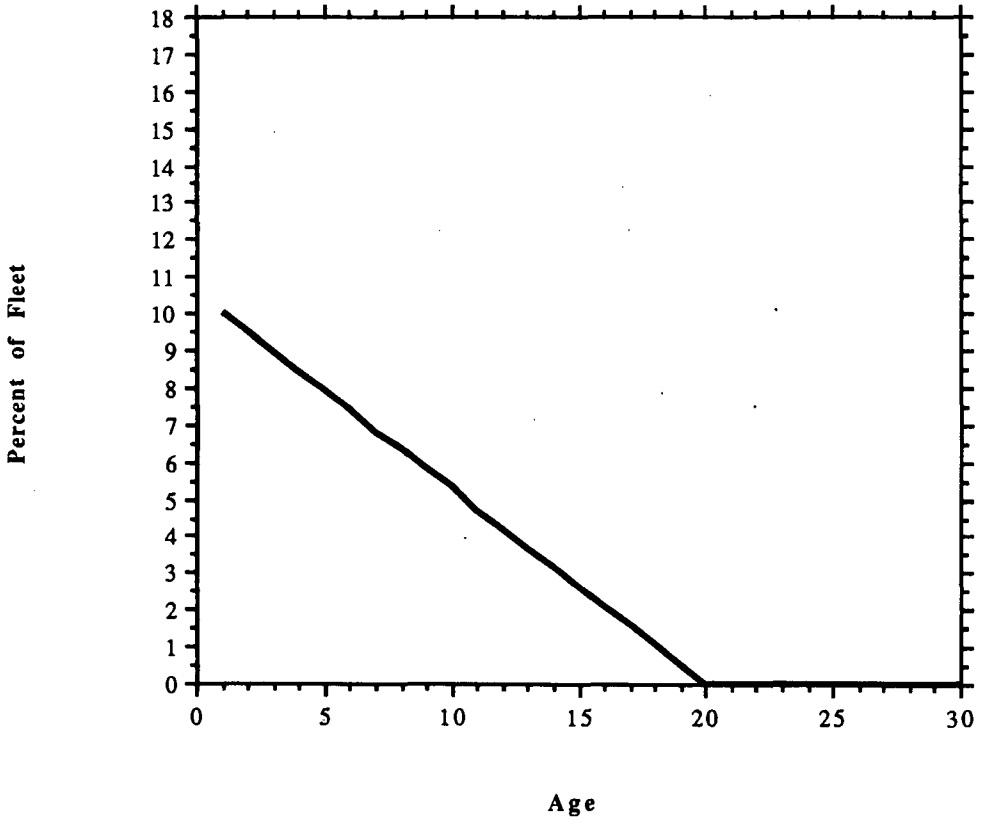
Appendix B

Model Input Figures

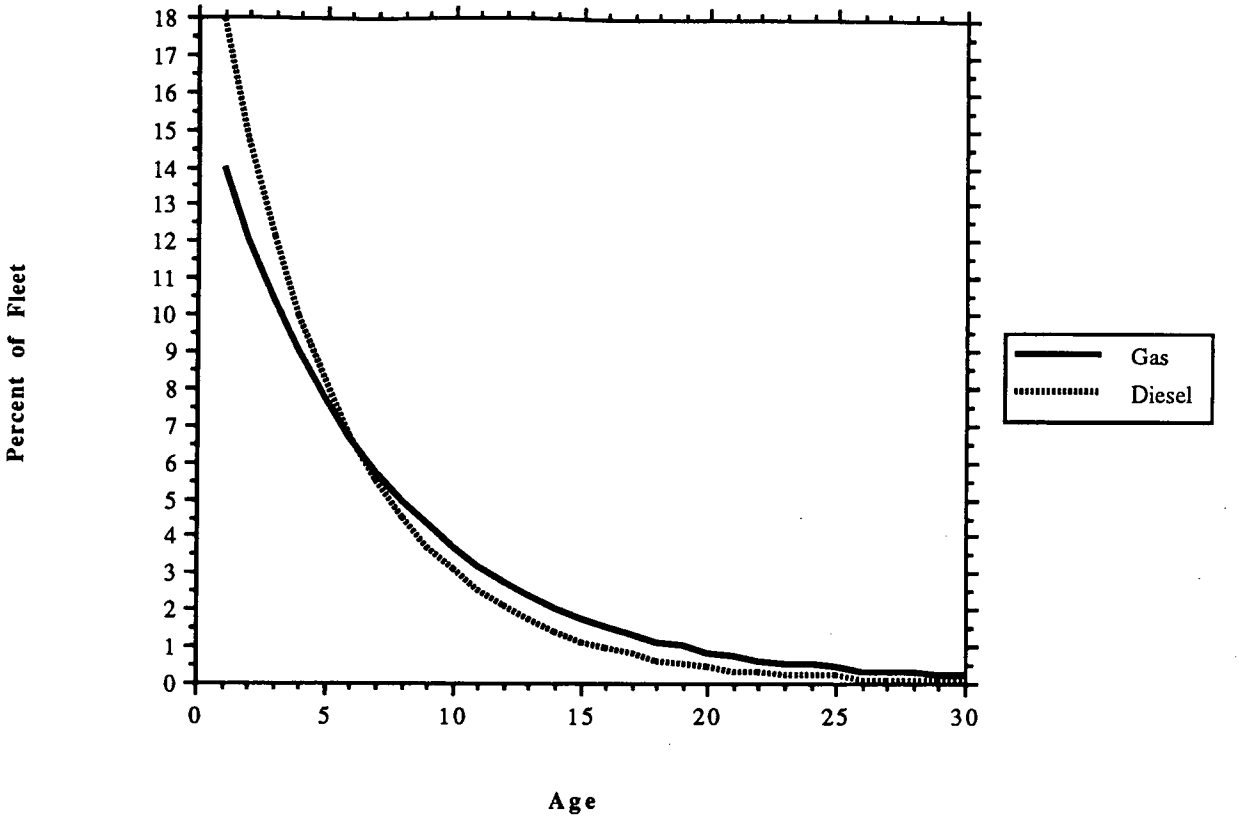
MOBILE4 Fuel Consumption Model
LDV Registration Distributions



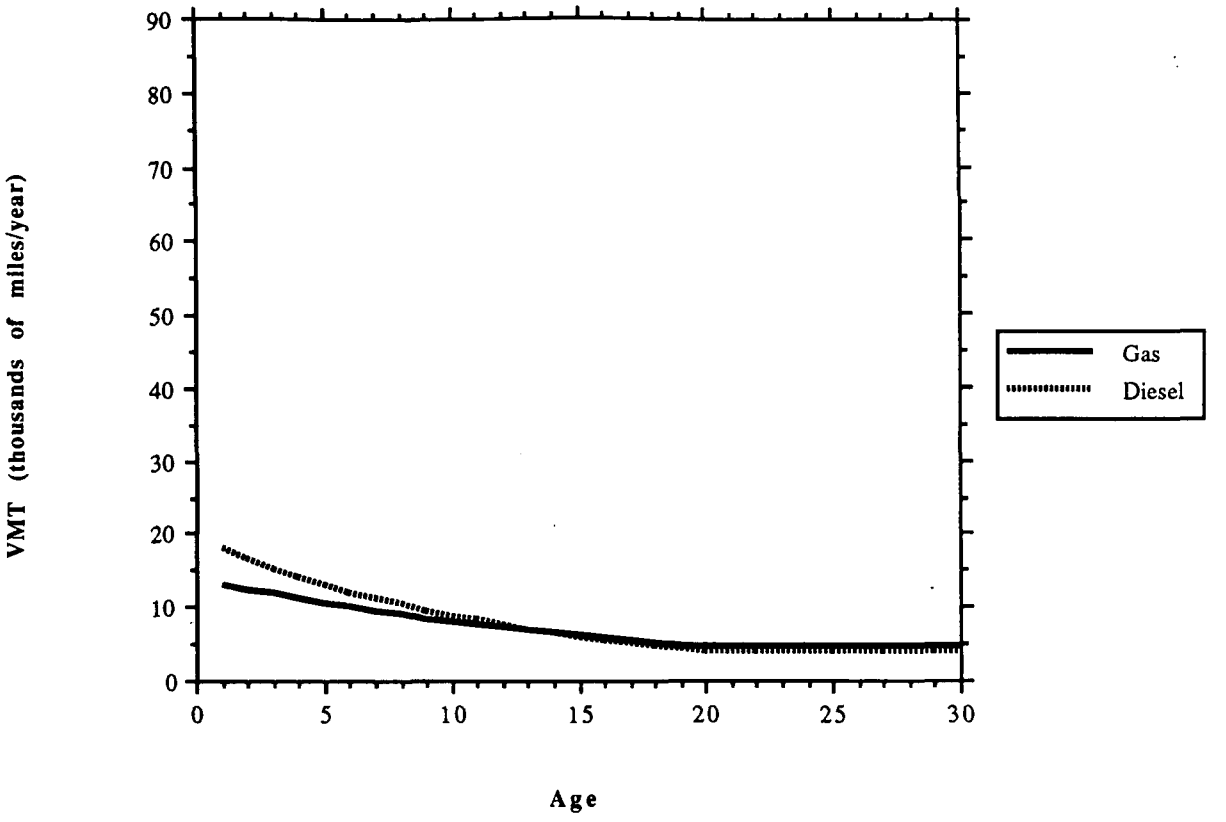
MOBILE4 Fuel Consumption Model
LDT1-LDT2 Registration Distributions



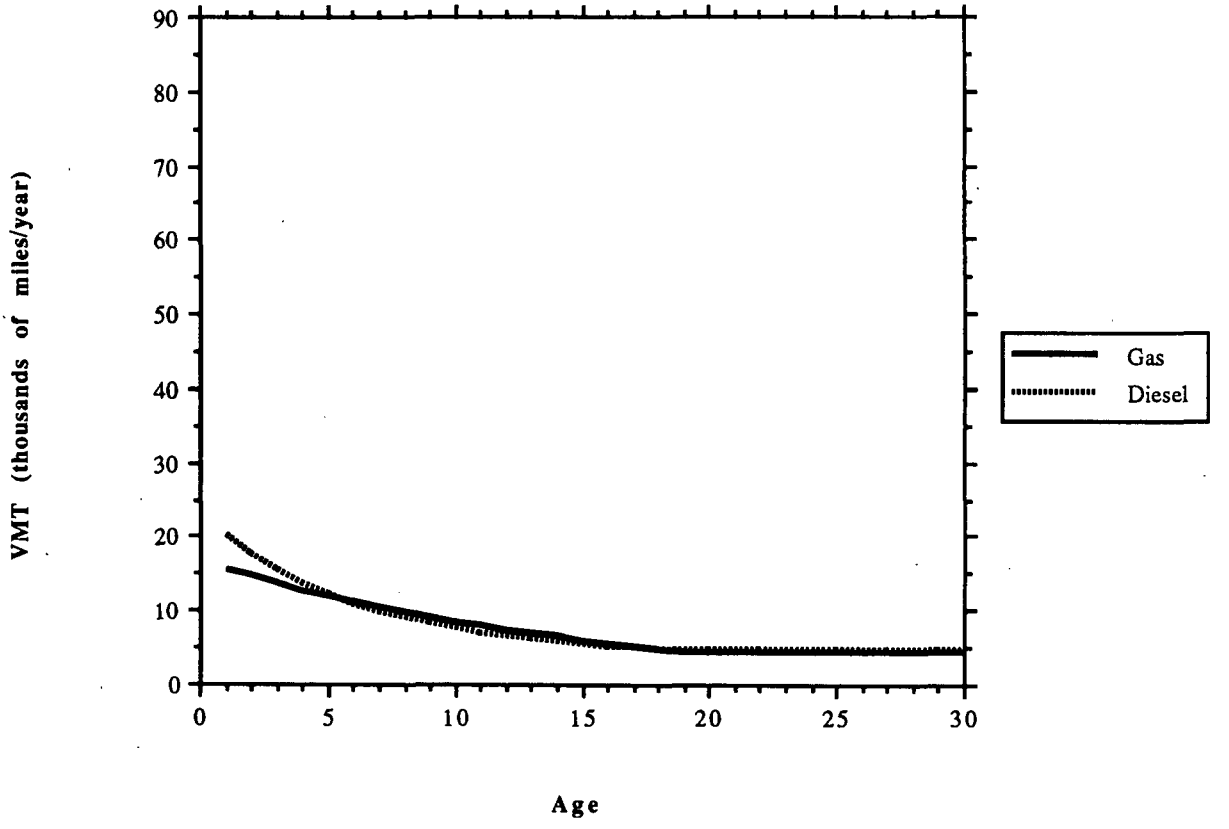
MOBILE4 Fuel Consumption Model
Classes 2B-8B Registration Distributions



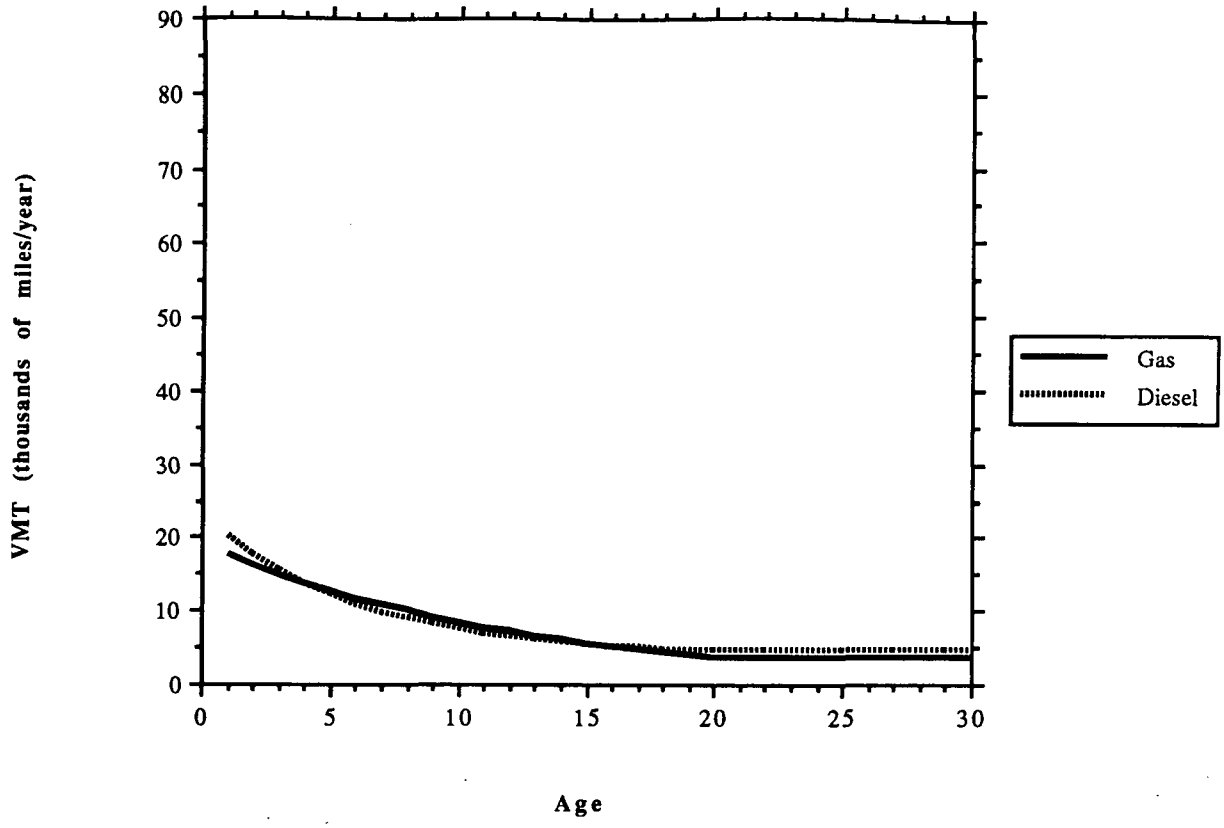
MOBILE4 Fuel Consumption Model
LDV VMT



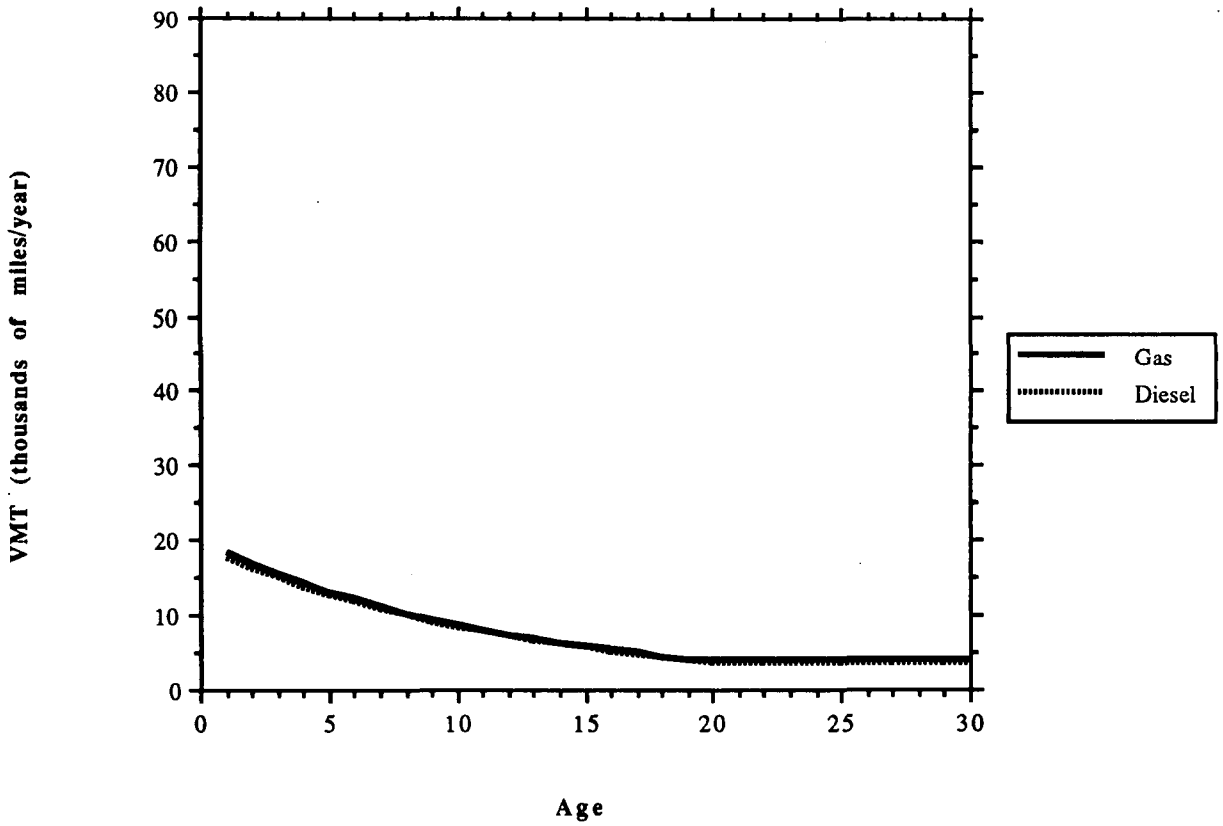
MOBILE4 Fuel Consumption Model
LDT1 VMT



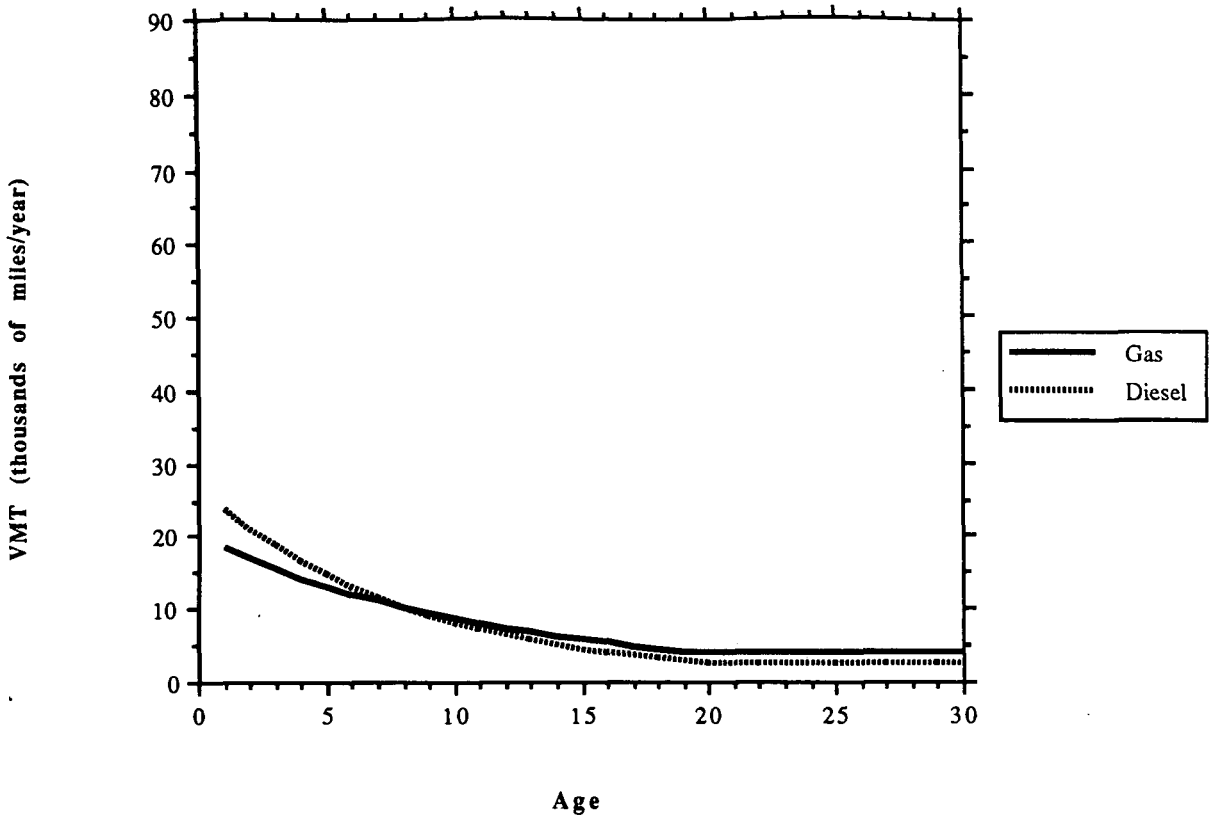
MOBILE4 Fuel Consumption Model
LDT2 VMT



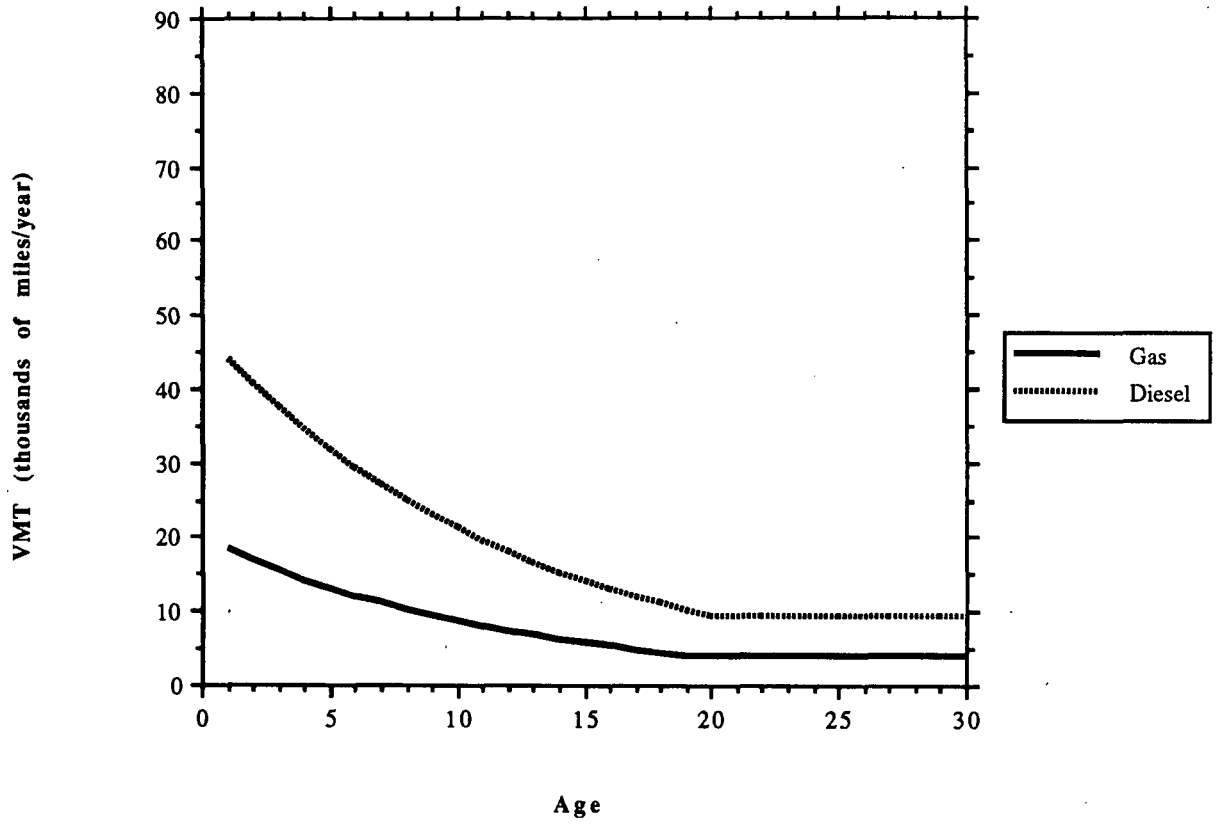
MOBILE4 Fuel Consumption Model
Class 2B VMT



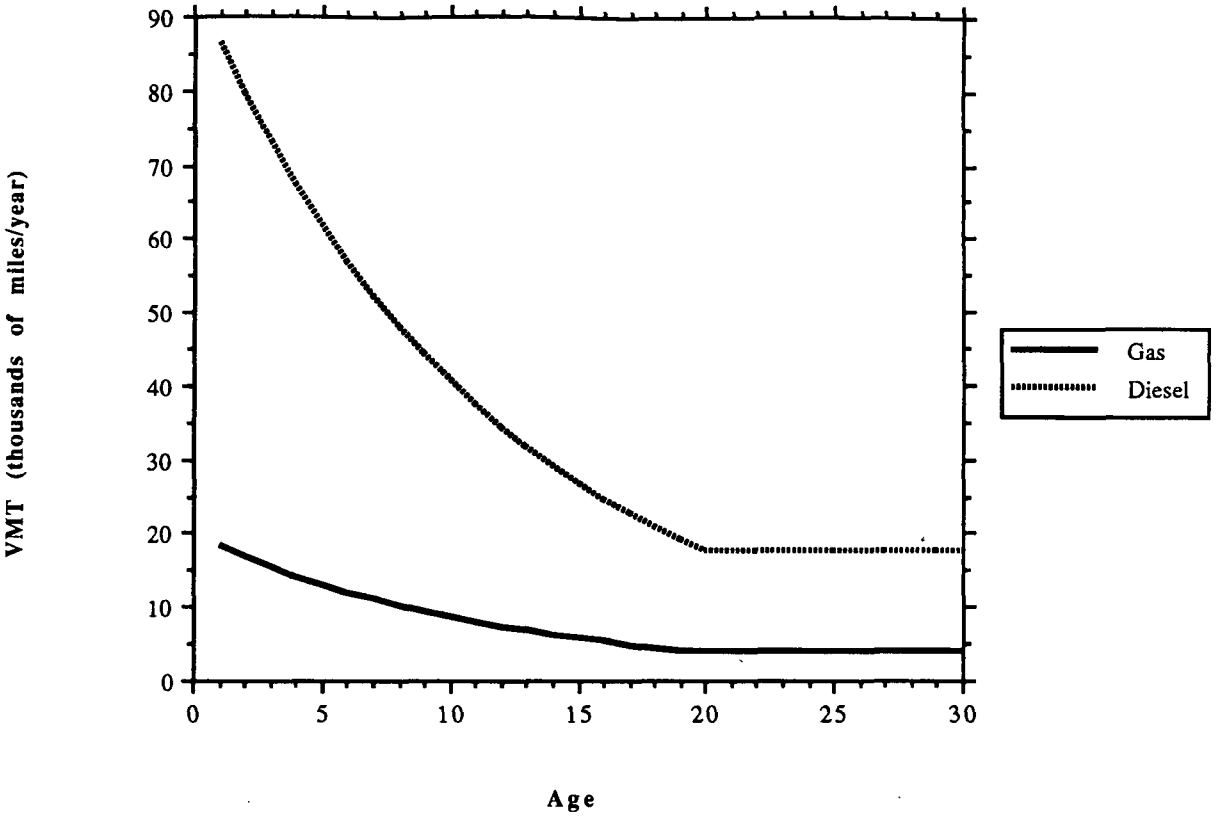
MOBILE4 Fuel Consumption Model
Classes 3-5 VMT



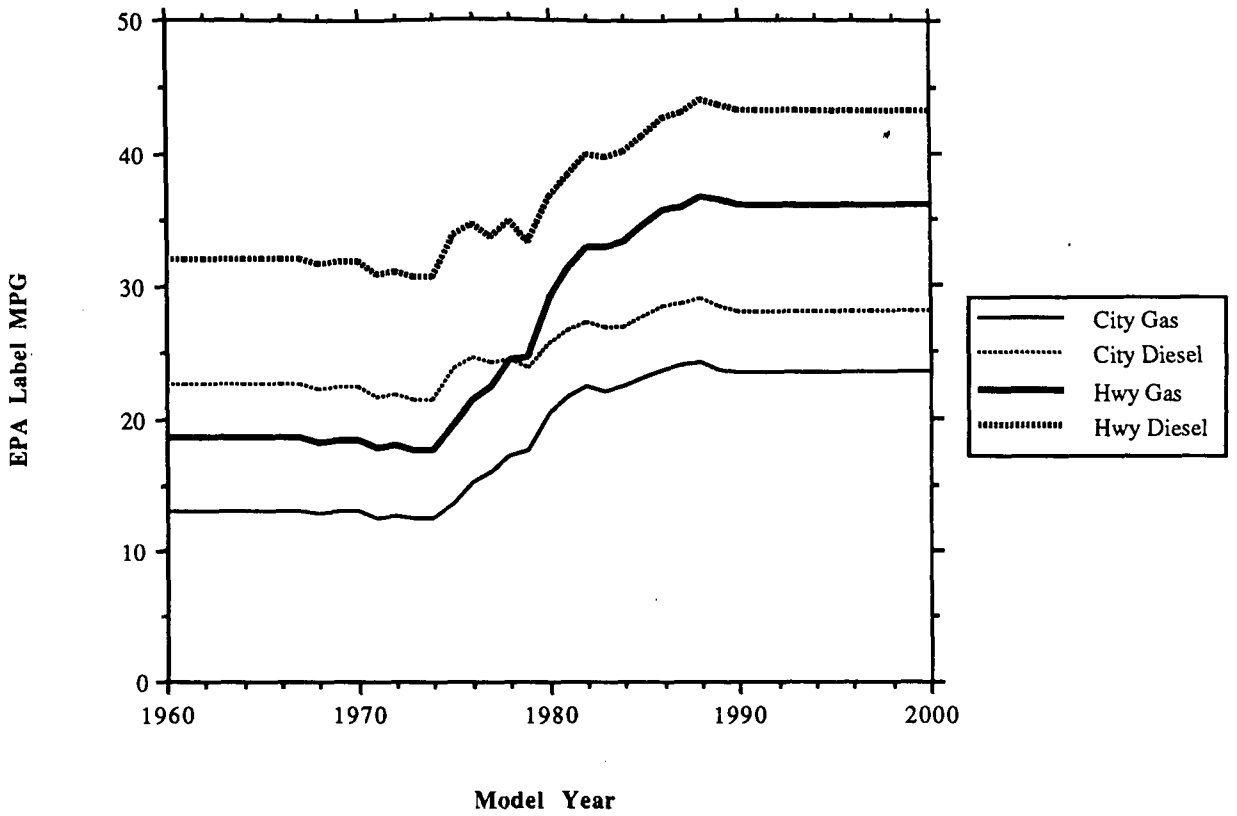
MOBILE4 Fuel Consumption Model
Classes 6-8A VMT



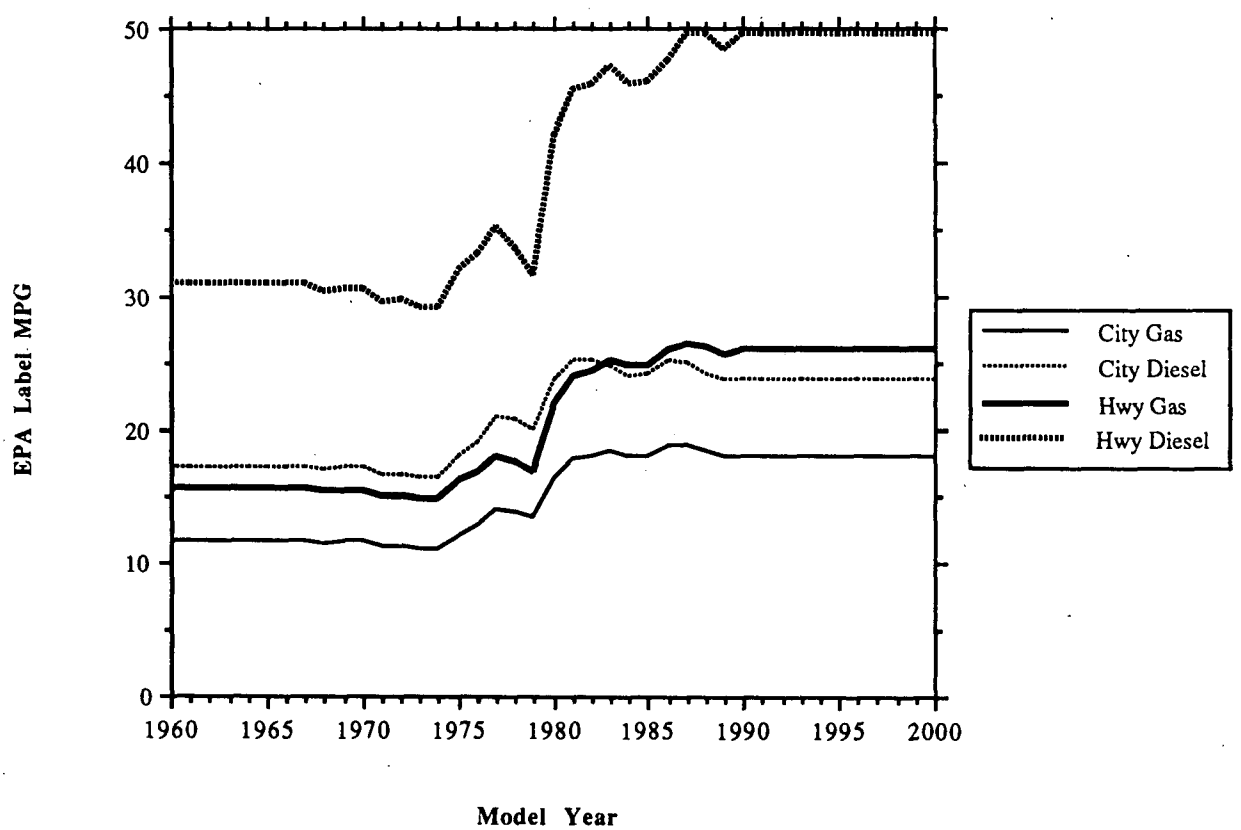
MOBILE4 Fuel Consumption Model
Class 8B VMT



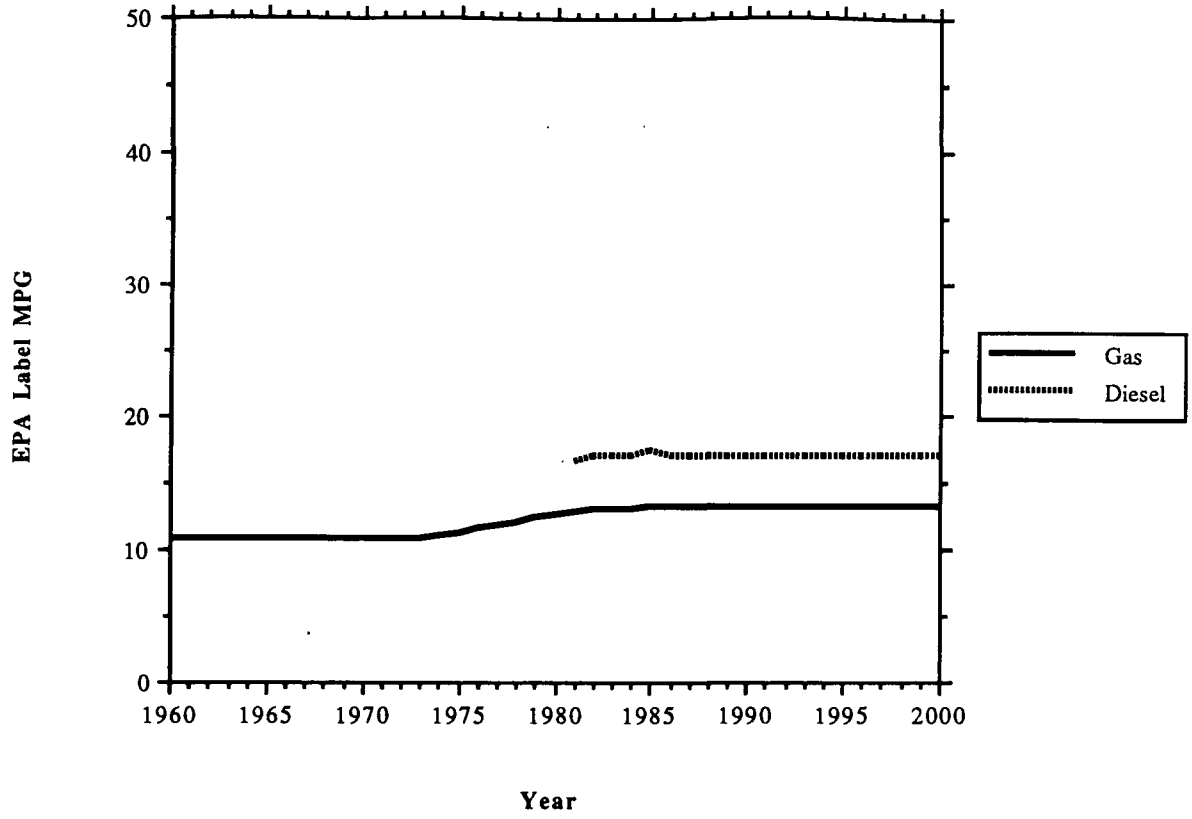
MOBILE4 Fuel Consumption Model
LDV City and Highway Fuel Economy



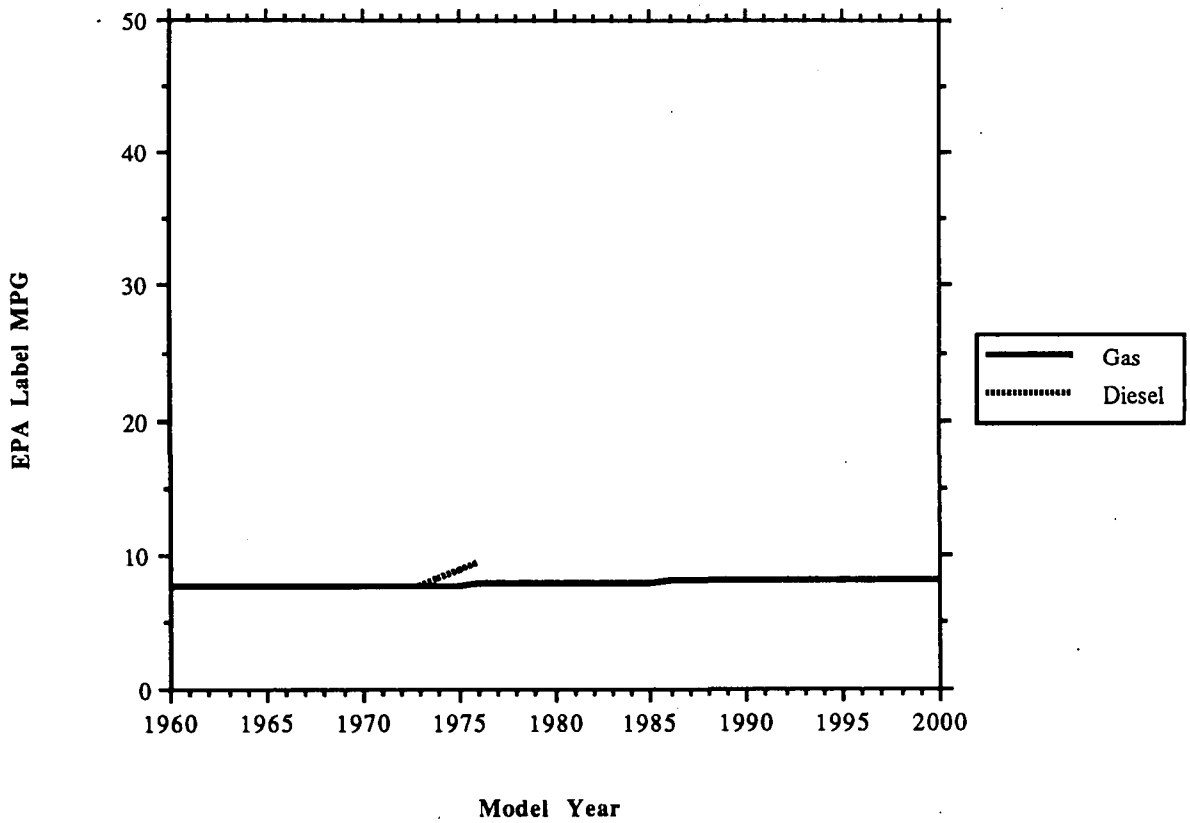
MOBILE4 Fuel Consumption Model
LDT1-LDT2 City and Highway Fuel Economy



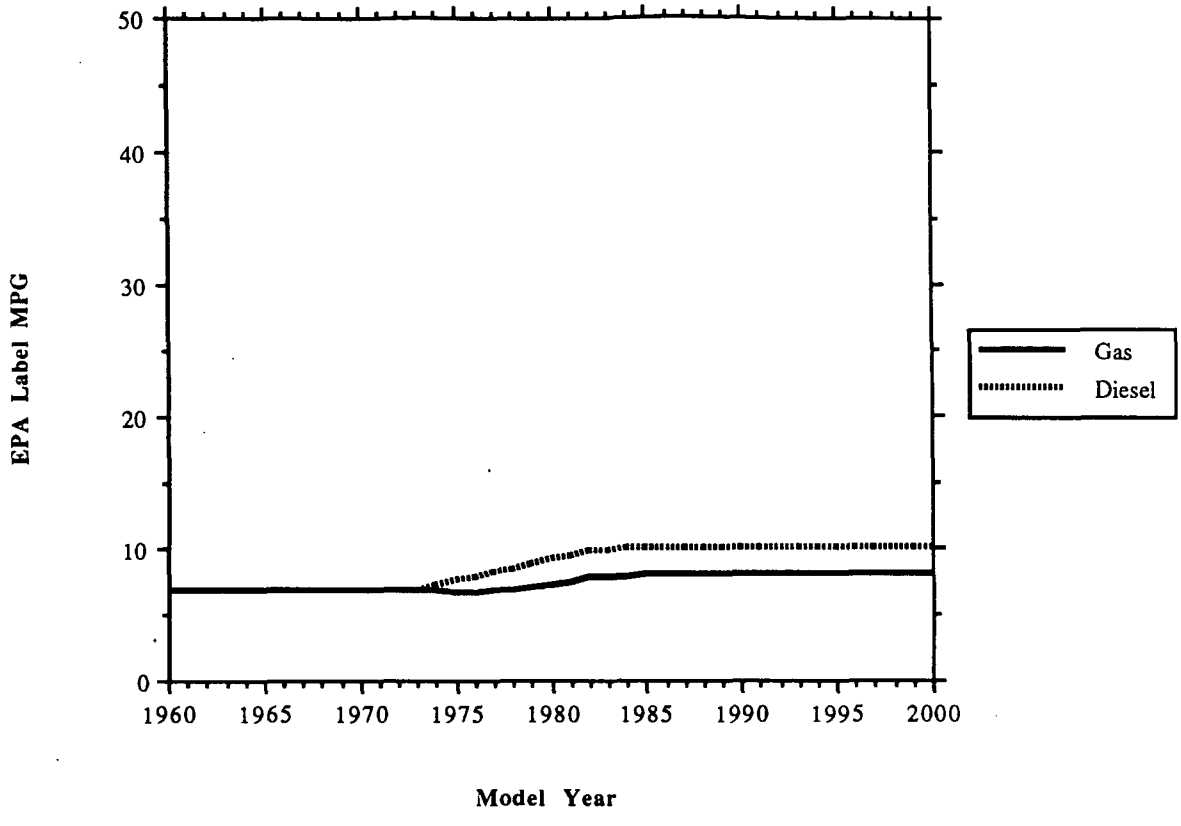
MOBILE4 Fuel Consumption Model
Class 2B Fuel Economy



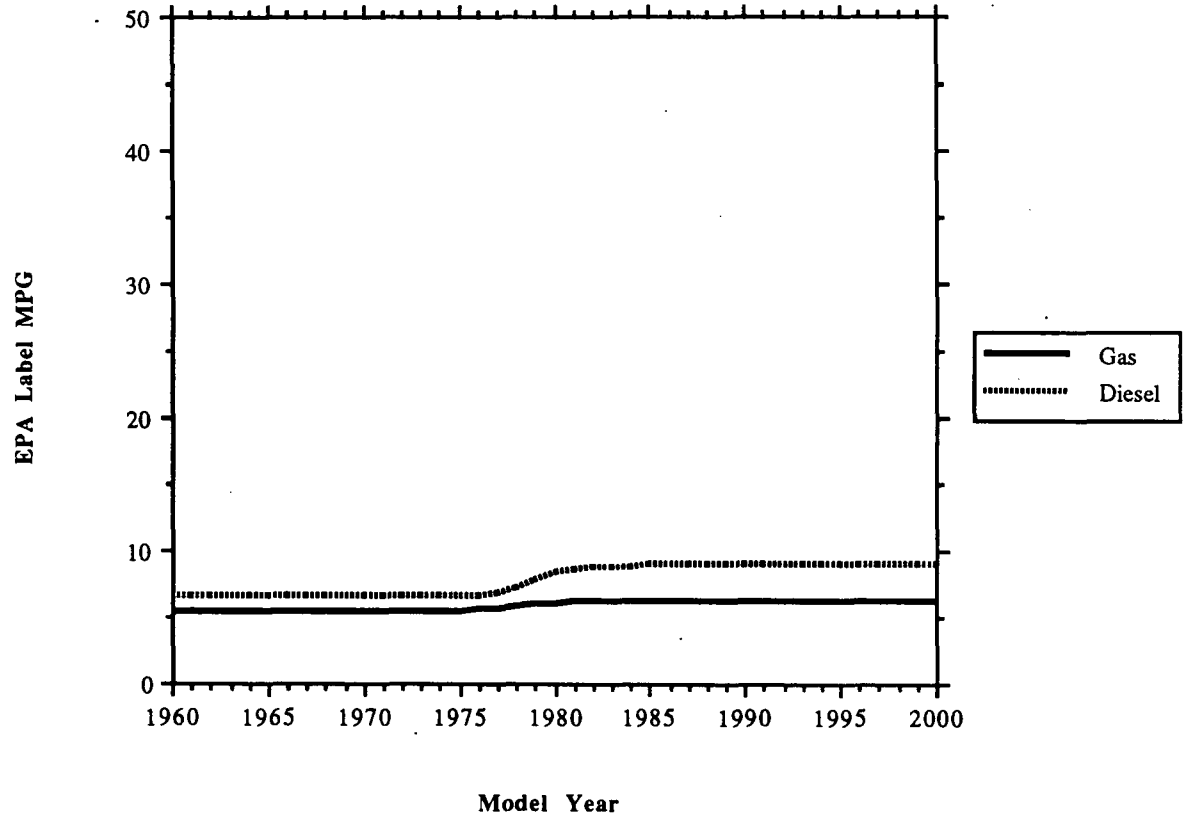
MOBILE4 Fuel Consumption Model
Classes 3-5 Fuel Economy



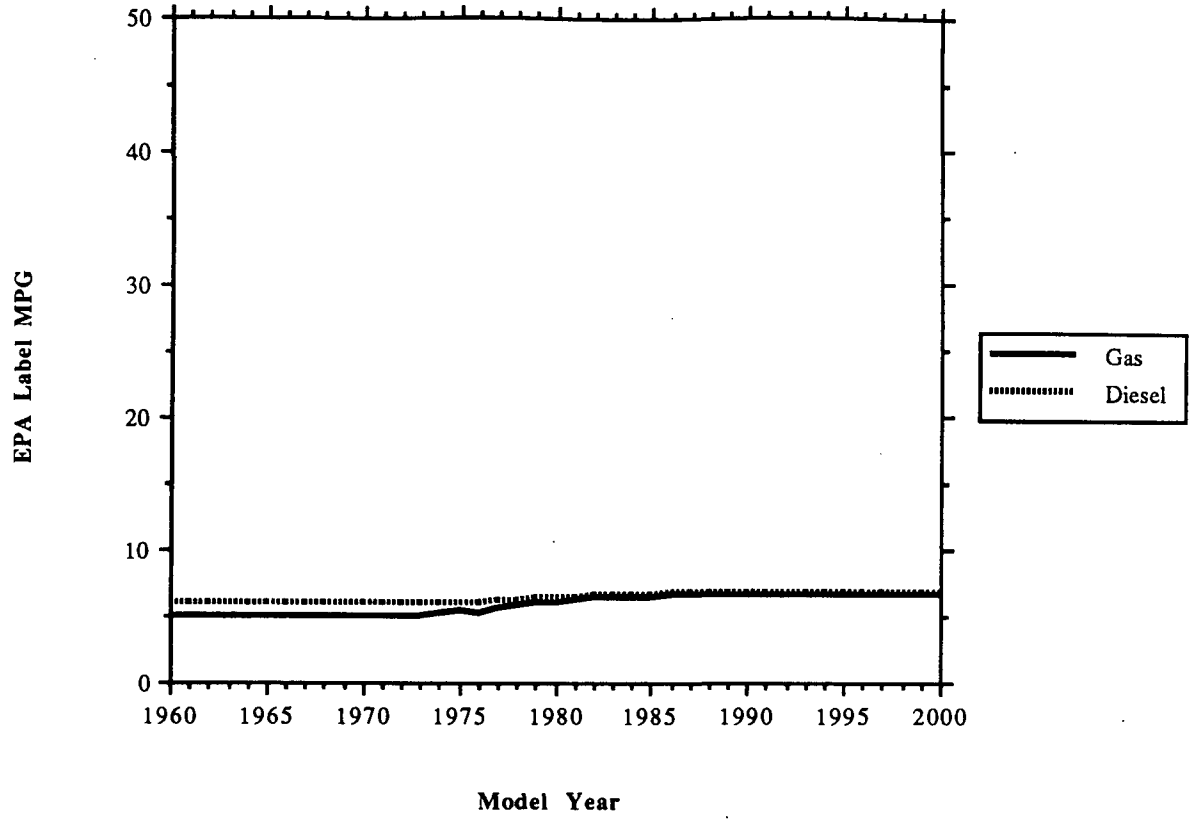
MOBILE4 Fuel Consumption Model
Class 6 Fuel Economy



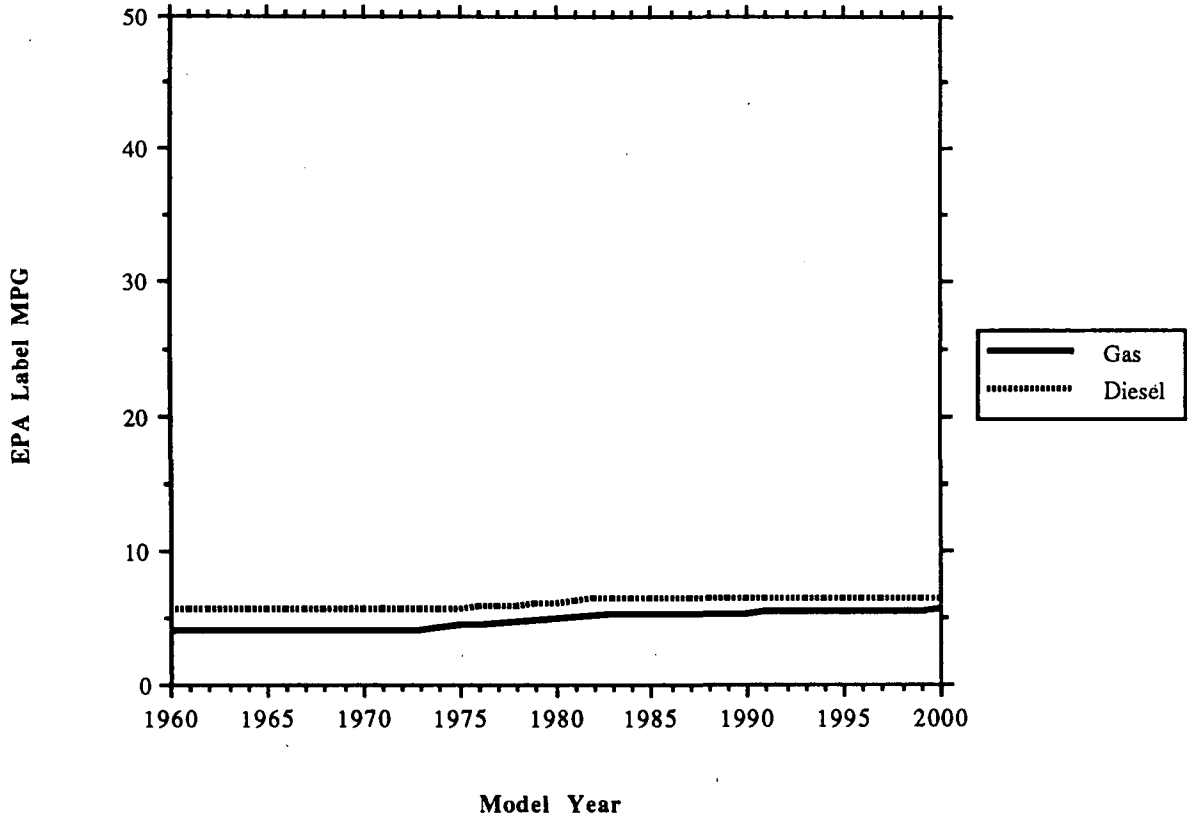
MOBILE4 Fuel Consumption Model
Class 7 Fuel Economy



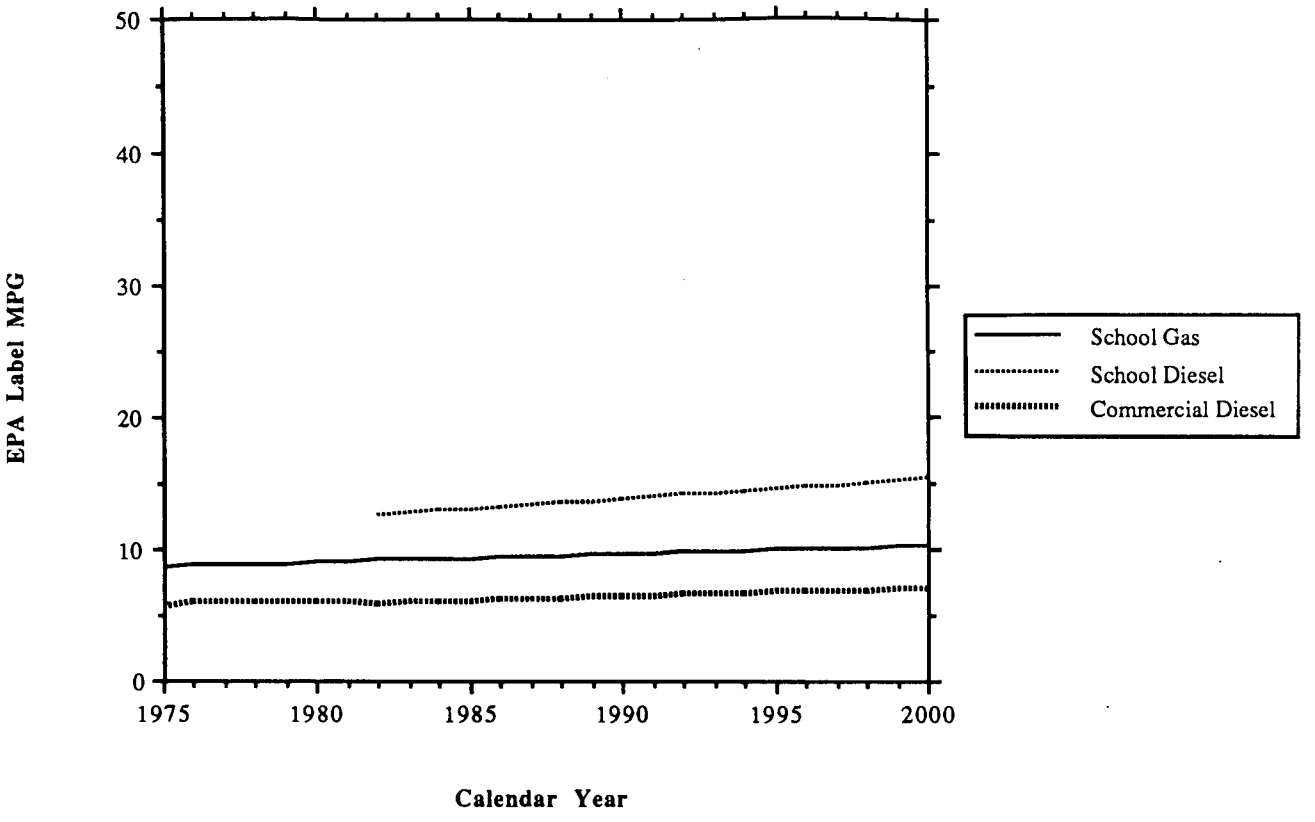
MOBILE4 Fuel Consumption Model
Class 8A Fuel Economy



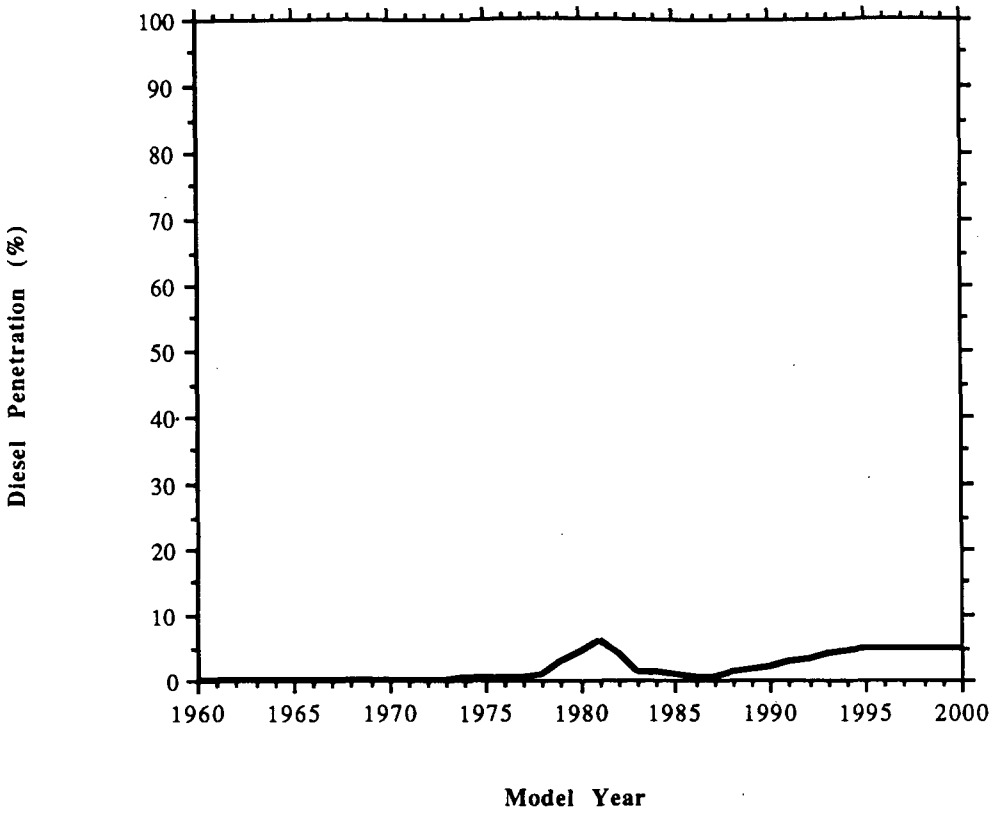
MOBILE4 Fuel Consumption Model
Class 8B Fuel Economy



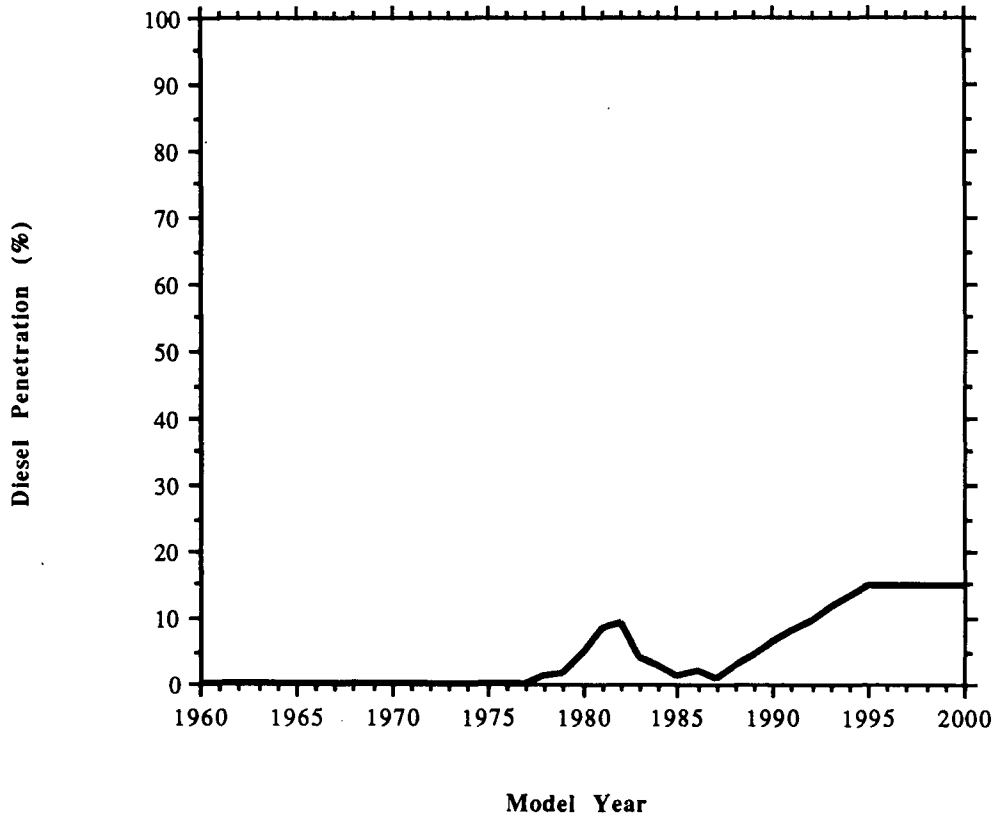
MOBILE4 Fuel Consumption Model
Bus Fuel Economy



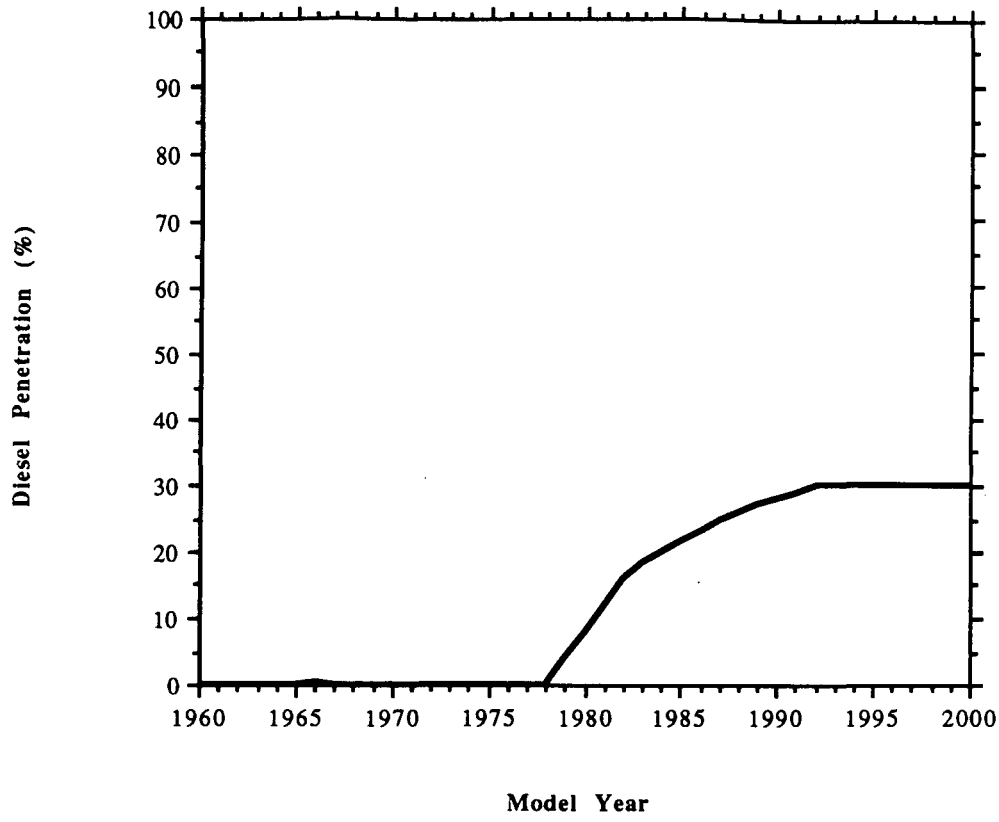
MOBILE4 Fuel Consumption Model
LDV Diesel Penetration



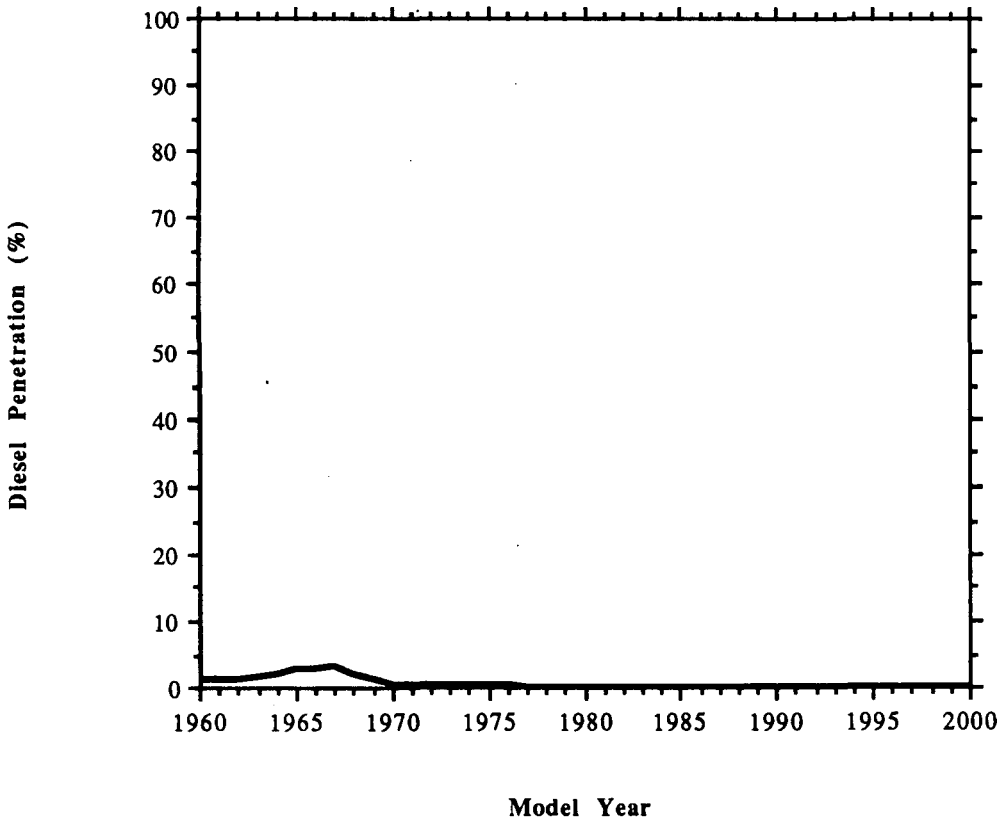
MOBILE4 Fuel Consumption Model
LDT1-LDT2 Diesel Penetration



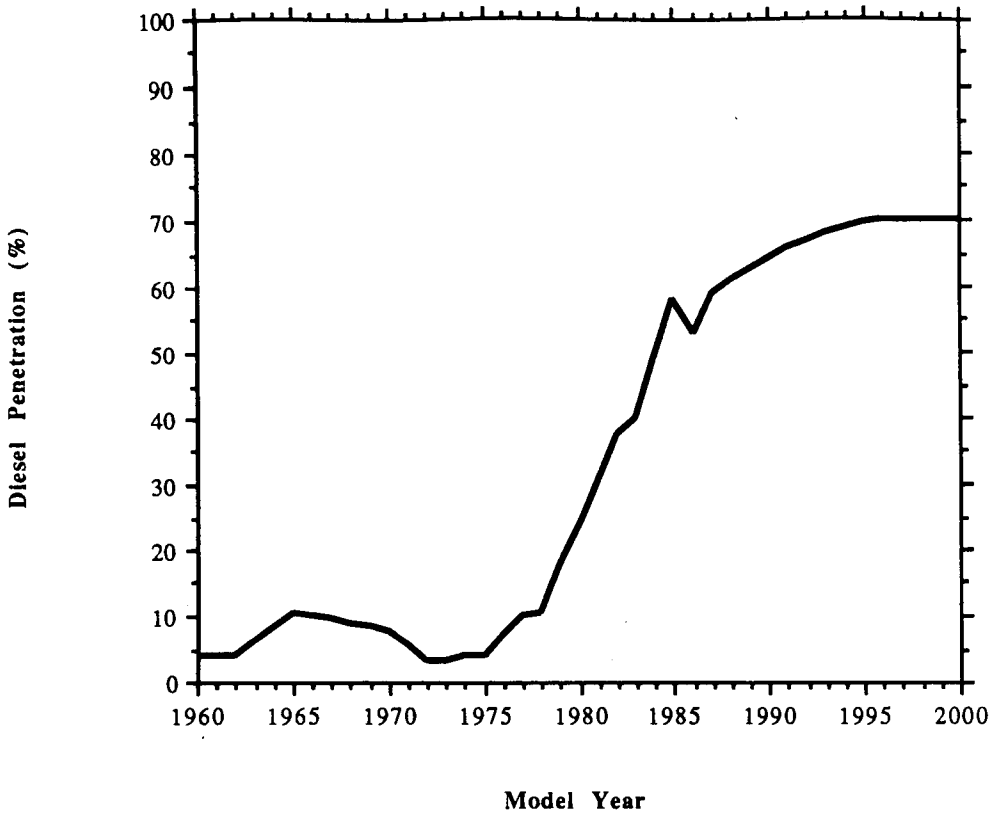
MOBILE4 Fuel Consumption Model
Class 2B Diesel Penetration



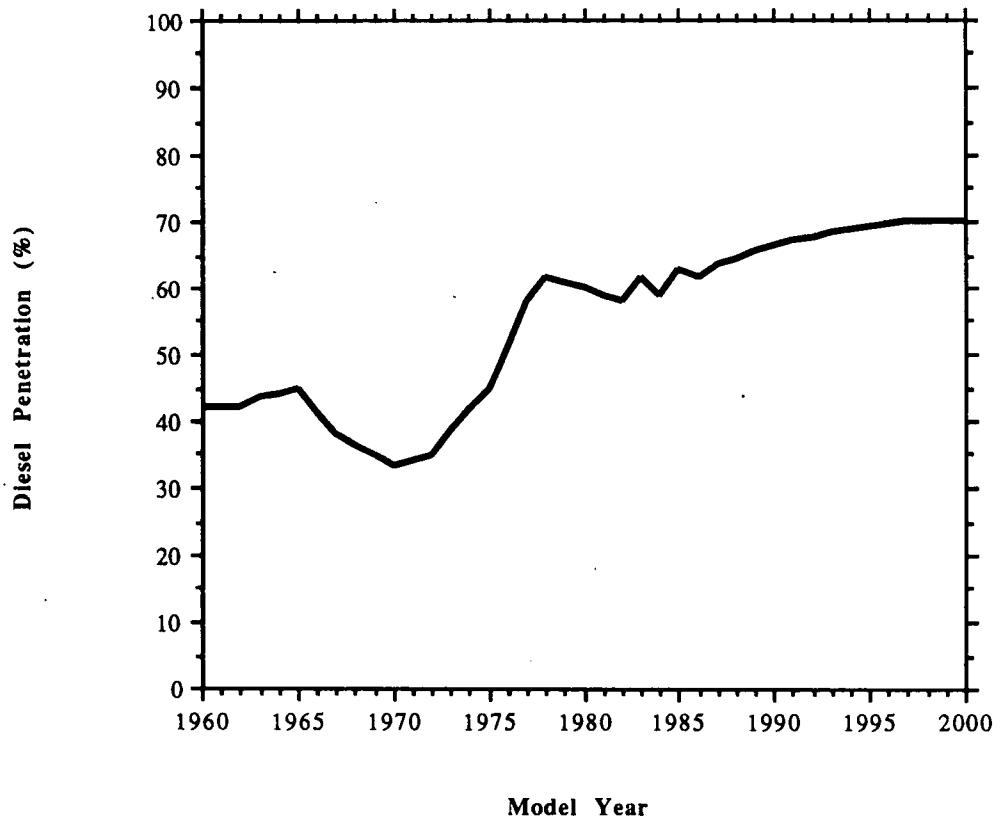
MOBILE4 Fuel Consumption Model
Classes 3-5 Diesel Penetration



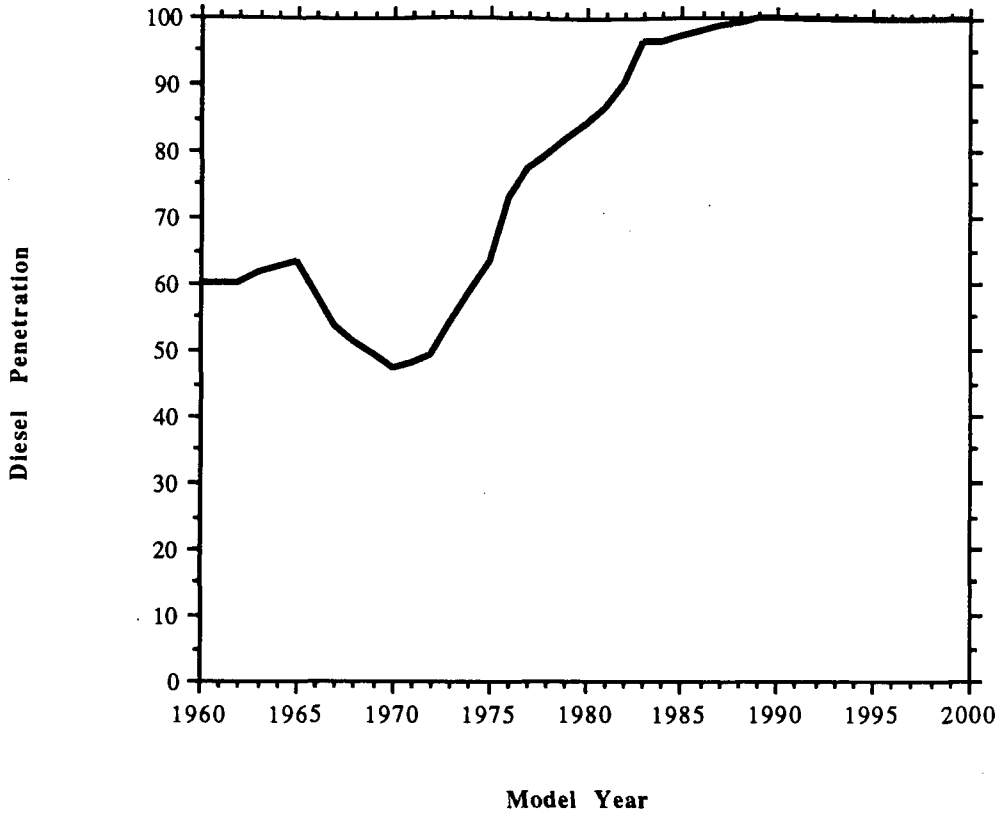
MOBILE4 Fuel Consumption Model
Class 6 Diesel Penetration



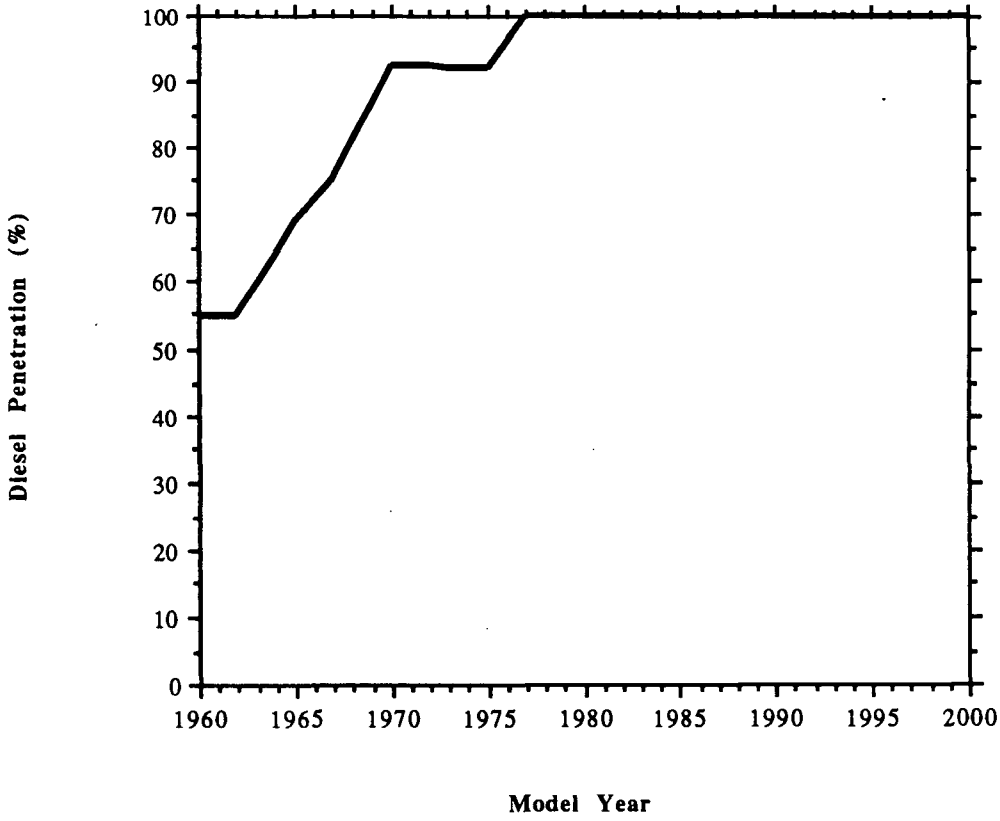
MOBILE4 Fuel Consumption Model
Class 7 Diesel Penetration



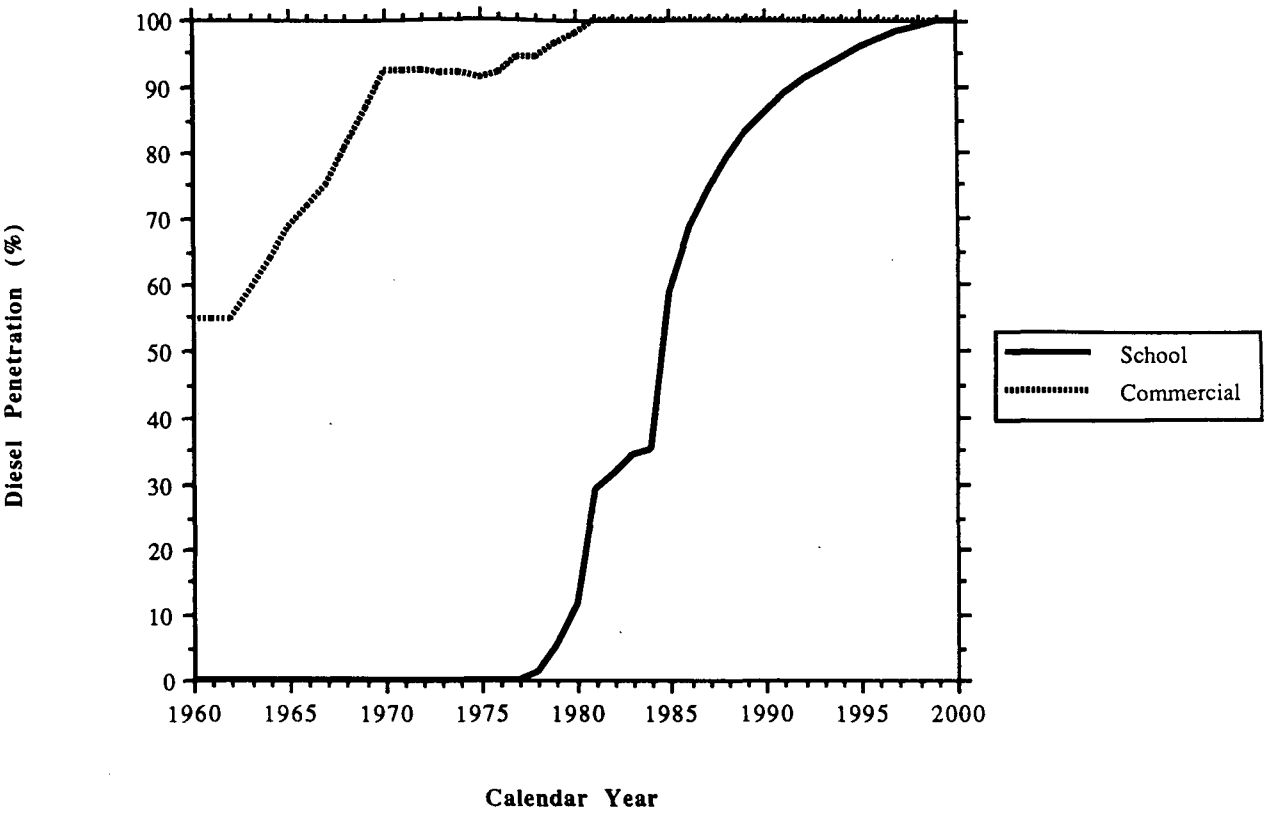
MOBILE4 Fuel Consumption Model
Class 8A Diesel Penetration



MOBILE4 Fuel Consumption Model
Class 8B Diesel Penetration



MOBILE4 Fuel Consumption Model
Bus Diesel Penetration



Appendix C

Model Input Prompts

Input Prompts

The MOBILE4 Fuel Consumption model interactively asks for the following inputs pertaining to the scenario being run:

Prompt: PLEASE ENTER THE SCENARIO DESCRIPTION

Response: Enter an 80-character description of the scenario being run.

Prompt: PLEASE ENTER THE START YEAR AS A 2-DIGIT NUMBER

Response: Enter the beginning year of the run. Enter only the last two digits of the year. Thus, "10" will be interpreted as 2010.

Any year between 1982 and 2020 may be entered.

Prompt: PLEASE ENTER THE 2-DIGIT ENDING YEAR

Response: Enter the ending year of the run. As before, enter only the last two digits of the year.

Any year between 1982 and 2020 may be entered. However, the ending year must be equal to or greater than the starting year.

Prompt: PLEASE ENTER THE INCREMENT YEAR FACTOR AS INTEGER VALUE

Response: Enter the yearly increment. This value is the step size, in years, between the beginning and ending years.

For example, if the increment is 1, then every year between the starting and ending year, inclusive, is output. If the increment is 5, then every fifth year is produced.

Prompt: DO YOU WANT TO REPLACE THE LDV AND/OR LDT DIESELIZATION RATES? (1=YES, 2=NO)

Response: The model is asking whether to override the MOBILE4 emissions model diesel penetration rates.

If answered affirmatively, the model will produce the following prompts. Otherwise, it will skip to the VMT ADJUSTMENT prompt below.

Prompt: PLEASE ENTER THE NEW LDV & CAR-LIKE LDT1 DIESELIZATION RATE (.000-.005)

Response: Enter a constant, replacement diesel penetration rate for LDVs and car-like LDT1s. The rate must lie in the range .00-.05 (0-5%), inclusive.

Prompt: PLEASE ENTER THE 2-DIGIT STARTING YEAR FOR THE NEW LDV & CAR-LIKE LDT1 DIESELIZATION RATE (82+)

Response: Input the year in which the new diesel penetration rate becomes effective. The rate will become effective that year and continue at a constant value thereafter. As before, enter only the last 2 digits of the year.

The year must be no earlier than 1982.

Prompt: PLEASE ENTER THE COMMERCIAL LDT1-LDT2 DIESELIZATION RATE (.000-.150)

Response: Enter the replacement diesel penetration rate for commercial LDT1 and LDT2. The rate must lie in the range .00-.15 (0-15%), inclusive.

Prompt: PLEASE ENTER THE 2-DIGIT STARTING YEAR FOR THE COMMERCIAL LDT1-LDT2 DIESELIZATION RATE (82+)

This input is analogous to that entered for LDV & car-like LDT1.

Prompt: PLEASE SELECT THE VMT ADJUSTMENT METHOD
1 - NO ADJUSTMENT
2 - VMT/VEH GROWTH RATE

Response: This prompt asks whether you want to increase the amount of miles vehicles travel per year. If answered affirmatively, the following prompts are displayed. Otherwise, the CHANGE SCENARIO prompt will appear next.

Prompt: PLEASE ENTER THE LDV & CAR-LIKE LDT1 VMT/VEH GROWTH RATE (%/YEAR)

Response: Enter the VMT growth rate, in percent per year, for LDV and car-like LDT1.

The rate can be any decimal value, positive or negative; (e.g., 1.0).

Prompt: PLEASE ENTER THE TRUCK VMT/VEH GROWTH RATE (%/YEAR)

Response: Enter the VMT growth rate, in percent per year, for all remaining trucks (commercial LDT1 and heavier).

The rate can be any decimal value, positive or negative; (e.g., 1.0).

Prompt: PLEASE ENTER THE 2-DIGIT VMT ADJUSTMENT BASE YEAR

Response: Enter the base year for the VMT per vehicle growth calculations is entered in the usual digit fashion. Any year from 1982 through 2020 is allowed.

Only those years after the base year are affected.

Prompt: DO YOU WANT TO CHANGE SCENARIO PARAMETERS? (1=YES, 2=NO)

Response: If a mistake was made in entering the scenario input values, this prompt allows you to abort the run and re-enter the correct values.

Prompt: DO YOU WANT TO RUN ANOTHER SCENARIO? (1=YES, 2=NO)

Response: This prompt allows you to run multiple scenarios. If answered affirmatively, you will be returned to the SCENARIO DESCRIPTION prompt. Otherwise the run will end.