ORNL/TM-11448

OAK RIDGE NATIONAL LABORATORY

MARTIN MARIETTA

ALTERNATIVE MOTOR FUEL USE MODEL
MODEL THEORY AND DESIGN
AND
USER'S GUIDE

March 1990

David L. Greene
Anju Rathi

Prepared for the
Office of Policy, Planning and Analysis
Office of Policy Integration
U.S. Department of Energy
Washington, D.C. 20585

OPERATED BY
MARTIN MARIETTA ENERGY SYSTEMS, INC.
FOR THE UNITED STATES
DEPARTMENT OF ENERGY

ORNL/TM-11448

Energy Division
Transportation and Systems Research Section

ALTERNATIVE MOTOR FUEL USE MODEL MODEL THEORY AND DESIGN AND USER'S GUIDE

David L. Greene
Anju Rathi*

*University of Tennessee, Knoxville

Date Published: March 1990

Research sponsored by
Office of Policy Integration
Office of Policy, Planning and Analysis
U.S. Department of Energy
Washington, D.C.

Prepared by the
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37831-6207
operated by
MARTIN MARIETTA ENERGY SYSTEMS, INC.
for the
U.S. DEPARTMENT OF ENERGY
under contract DE-AC05-84OR21400

TABLE OF CONTENTS

PAGE

LIST OF FIGURES v

LIST OF TABLES vii

ACKNOWLEDGEMENTS ix

ABSTRACT xi

PART I USER'S GUIDE

SECTION 1 INTRODUCTION I-1
1.1 HARDWARE/SOFTWARE REQUIREMENTS I-3
1.1.1 HARDWARE I-3
1.1.2 SOFTWARE I-4

SECTION 2 RUNNING THE MODEL I-4
2.1 THE DISTRIBUTION DISKETTES I-4
2.2 INSTALLATION I-5
2.3 STARTING A MODEL RUN I-7

SECTION 3 MODEL DESCRIPTION I-9
3.1 SPREADSHEETS I-10
3.2 A TOUR OF THE SPREADSHEET I-12
3.2.1 MASTER SPREADSHEET MENUS I-15
3.2.2 VEHICLE SPREADSHEET MENUS I-17

SECTION 4 BACKUP SUGGESTIONS I-27

INDEX OF MODEL MENU OPTIONS I-29

APPENDIX - GLOSSARY OF TECHNICAL TERMS I-31

TABLE OF CONTENTS
(continued)

		PAGE
PART II MODEL THEORY AND DESIGN		
SECTION 1	INTRODUCTION	II-1
SECTION 2	STRUCTURE	II-4
SECTION 3	VEHICLE STOCK DYNAMICS	II-8
SECTION 4	VEHICLE USAGE	II-15
SECTION 5	MOTOR FUEL CHOICE	II-19
SECTION 6	CALCULATION OF FUEL USE	II-23
SECTION 7	DATA	II-25
REFERENCES		II-43
APPENDIX 1	SAMPLE FORECAST REPORTS	
1.1	GROSS FORECAST	A1-1
1.2	PRIMARY REPORT	A1-7
1.3	SECONDARY REPORT	A1-19
APPENDIX 2	AMFU PROGRAM LISTING	

LIST OF FIGURES

PAGE

Figure III-1. Flowchart I-11

Figure 1. Structure of Alternative Motor Fuels Use II-7

Figure 2. Depreciation and Scrappage Curves II-11

LIST OF TABLES

PAGE

Table 1. Forecast Definition II-27

Table 2. Vehicle Type Selection II-27

Table 3. Economic Forecast II-28

Table 4. Definition of Technology - Fuel Types II-30

Table 5. Technology, Use, and Scrappage Parameters II-31

Table 6. New Vehicle Sales Forecast II-32

Table 7. Age Distribution of Vehicles in Base Year II-32

Table 8. Vehicle Efficiency Data II-34

Table 9. Test Cycle vs. On-Road Efficiency Correction Factors II-35

Table 10. Technology Type Market Shares II-36

Table 11. Vehicle Price Index II-37

Table 12. Fuel Prices II-37

Table 13. Base Year Total Fuel Use (for Calibrated Run) II-38

Table 14. Definition of Primary Fuel-Type Blends in Terms of Chemical Fuel Types II-40

Table 15. Fuel Energy Contents II-41

ACKNOWLEDGEMENTS

This report was written by David L. Greene of Oak Ridge National Laboratory and Anju Rathi of the University of Tennessee, under the guidance of Barry McNutt, Office of Policy Integration, PPA, DOE. General questions about the information contained in this report should be referred to Dr. Greene, (615) 574-5963.

ALTERNATIVE MOTOR FUEL USE MODEL
MODEL THEORY AND DESIGN
AND
USER'S GUIDE

D. L. Greene
Anju Rathi

ABSTRACT

The Alternative Motor Fuel Use Model (AMFU) is a tool for the analysis and prediction of motor fuel use by highway vehicles. The model advances the art of vehicle stock modeling by including a representation of the choice of motor fuel for flexible and dual fuel vehicles. Part one of the report is a User's Guide to the operation of the model. Part two describes the model's structure and the theory of vehicle stock modeling of energy use on which it is based. The model is designed for IBM PC, PC/XT, PC/AT, PS/2, and compatibles. It is written in compiled BASIC and data input is via automated, menu driven spreadsheets. From within the spreadsheets users can define the dimensions of a forecast, as well as the types of vehicle technologies and the fuels they use. The AMFU Model can be run for one or many vehicle types (e.g., automobiles, light trucks, heavy trucks) simultaneously. The effort required to create the data tables required for a model run is substantial.

ALTERNATIVE MOTOR FUEL USE MODEL

PART I

USER'S GUIDE

David L. Greene
Anju Rathi

1. INTRODUCTION

This user's guide provides instructions for using the Alternative Motor Fuel Use Model (AMFU) and describes the hardware and software requirements of the model. The AMFU model is a microcomputer based model for forecasting fuel use, vehicle use, and vehicle stock for one to thirty years into the future. It is particularly intended for making energy use forecasts and for analyzing policies which primarily affect the technical characteristics of new vehicles, such as efficiency and fuel type. AMFU allows you to define several different vehicle types and to permit several multi-fuel as well as dedicated fuel technologies for each vehicle type.

AMFU combines the detail of an accounting model of vehicle stock (keeping track of vehicles and their efficiencies by vehicle type, technology type, vintage, and fuel type) and the economic sensitivity of an econometric model (responding to changes in fuel prices and economic activity), with the flexibility of a scenario model (allowing key factors such as future efficiencies and new vehicle registrations to be completely under the user's control). These features make the model useful for a wide range of forecasting and policy analyses.

This User's Guide is intended for use in conjunction with Part 2 of this manual, "Model Theory and Design." The meanings of variables are defined in Part 2 and the model's equations are explained in detail. Questions about the exact meanings of parameters or input data are resolved there. The User's Guide explains the mechanics of using the AMFU model.

The user interface for AMFU consists of LOTUS 123** spreadsheets. Except for the initiation of a model run and printed reports, you interact with the model entirely via menu-driven spreadsheets. The forecaster and report generator are written in Microsoft Quick-Basic 4.0.** The compiled BASIC code performs nearly all of the model's calculations but is almost invisible to the user.

This User's Guide is organized as follows:

Section 2 - Describes the installation process and user interface.

Section 3 - Contains the model description.

Section 4 - Contains backup suggestions for spreadsheets.

We welcome any feedback about problems or suggestions, so that the model can be made more useful. Please feel free to write or call the authors at the following address:

David L. Greene
Transportation and Systems Research
Energy Division
Bldg. 4500N, MS-6207
Oak Ridge National Laboratory
Oak Ridge, TN 37930-6207
(615) 574 - 5963
FTS 624 - 5963

**LOTUS 123 is a trademark of Lotus Development Corp., Cambridge, Mass. Quick-Basic is a trademark of Microsoft, Inc.

1.1 HARDWARE/SOFTWARE REQUIREMENTS

1.1.1 HARDWARE

The following hardware configuration is required for running the AMFU model.

- IBM PC, XT, AT, PS/2 or compatible system
- 640 KB of main memory (RAM) with no memory resident programs
- 8087 or 80287 math co-processor present
- At least one double - sided, low or high density floppy disk drive
- Monochrome or color monitor
- Graphics capable printer
- Parallel or serial port and a cable
- Hard disk with at least 5 MB free space available for this model
- MS-DOS Operating System, Version 2.1 or higher

It is assumed that you have a system like those described above. It is also assumed that you have a basic working knowledge of the MS-DOS operating system. Some familiarity with operations of Lotus 123 will be helpful.

1.1.2 SOFTWARE

The user-interface (input) for the model is written in Lotus 123, Version 2.0 spreadsheet software. The forecaster and report generator are written in a high level language, Microsoft Quick-Basic 4.0. Reports (output) are in the form of ASCII files and printed copies. You must have the Lotus 123 Version 2.0 or 2.01 software installed to run AMFU. It is not necessary for you to have Quick-Basic since the BASIC portion of the model is provided as an executable file.

Once the hardware and software requirements are satisfied, you can start a model run as described in the next section.

2. RUNNING THE MODEL

This section describes the distribution diskettes and installation procedure for the model. It also describes how to start a model run for the first time as well as for successive runs.

2.1 THE DISTRIBUTION DISKETTES

The AMFU model software is distributed on four 5-1/4" Double Density (360 KB), two 3-1/2" Double Density (720 KB), or one 3-1/2 High Density (1.4 MB) floppy diskettes formatted for the MS-DOS 3.0 operating system. The 360KB distribution diskettes contain the following files and spreadsheets.

Disk #1 -	Master spreadsheet, Autos and Light trucks spreadsheets (MASTER.WK1,GROSS.WK1,AUTOS.WK1, LITETRK.WK1).
Disk #2 -	Medium trucks and GVW6 trucks spreadsheets (MEDTRK.WK1,GVW6TRK.WK1).
Disk #3 -	GVW7 trucks and GVW8 trucks spreadsheets (GVW7TRK.WK1,GVWBTRK.WK1).
Disk #4 -	Executable modules MAINFORE.EXE and REPORTS.EXE, source code MAINFORE.BAS and REPORTS.BAS and batch file R.BAT, M.BAT, and MR.BAT.

2.2 INSTALLATION

To use the model it is necessary to install the LOTUS 123 spreadsheet software on the computer. We assume that you have already installed this software. For our examples we will assume that this software is installed in directory C:/LOTUS.

Step 1: For first time installation of this model, you will need to create a directory at the DOS level named FUEL. The command sequence is C:>MD FUEL.

Step 2: To install the model on the hard disk from the 360K distribution diskettes, change directories to work from the directory FUEL. Having done this, copy all the files from the distribution disks to the FUEL directory. Assuming the floppy disk is in the B disk drive, the command sequence is

C:>CD FUEL

C:>COPY B:*.*

Step 3: Repeat the procedure in second step above for each floppy for this model. To install a different version (i.e. an updated version, created by you or restoring a backup), also follow the procedure in second step above.

After completing the steps above, the model will have been installed on drive C. If only a specific file needs to be copied or restored, the procedure is:

C:>CD FUEL

c:>copy B:filename.ext

You should make sure that the version of the file(s) currently on the hard disk (Drive C) are to be replaced before beginning any of the copy procedures above.

Before a model run can be started, the CONFIG.SYS file must contain the following lines as a minimum configuration.

FILES = 20

BUFFERS = 35

The AUTOEXEC.BAT file must include the directory that Lotus 123 software resides in (for example C:/LOTUS) in the PATH statement. If you have changed your AUTOEXEC.BAT or CONFIG.SYS files you will need to reboot your system for DOS to recognize the changes.

2.3 STARTING A MODEL RUN

If you are running this model for the first time then section A and B should be followed else only section B must be followed.

A. FIRST TIME

Step 1: Begin a LOTUS 123 session by typing the following command sequence:

C:/FUEL>123

Step 2: Once the blank LOTUS spreadsheet appears on the screen, you need to change the default directory for Lotus to be the directory in which the AMFU model resides. Invoke the Lotus menu, and select [Worksheet Global Default Directory] options.

The command sequence is as follows:

/

Worksheet

Global

Default

Directory

At this point type C:/FUEL. After entering the directory name, the "Update" option should be selected to save the change. Select option "Quit" to return to main Lotus menu. You have now changed your default directory to C:/FUEL. Whenever you start up Lotus it will assume you want to work from the C:/FUEL directory. If other spreadsheet programs you use require a different directory you will have to change the default setting.

B. SUCCESSIVE RUNS

Once Lotus 123 is invoked from DOS level and the blank LOTUS spreadsheet appears on the screen, the file MASTER.WKI must be retrieved by entering the file retrieve command sequence:

/

File

Retrieve

Type C:/FUEL/MASTER.WKI or highlight this name. After you have entered the file name, the "WAIT" message will flash in the upper right hand corner of the screen while the file is being loaded. Make sure that computer is not in "Scroll Lock" or "Num Lock" mode. At this point the model is started and the rest of the model's operation will be driven by spreadsheet menus.

AMFU provides the user with a menu-driven spreadsheet environment to input the data. The user is expected to select each category presented by a menu, make sure that the correct data is present, and create PRN files (if they don't already exist or any of the data have been changed) before each run. When option "Forecast" is selected from the menu to run the model, the user is presented with an instruction to be carried out at DOS level, and the model goes out to the DOS level. After running the model the results can be viewed by using a text editor or printed from the output file(s) at the DOS level.

At the DOS level you may type either

C:\FUEL> <u>M</u> <<u>ENTER</u>>

which runs the model but does not generate reports which can be printed, or

C:\FUEL> <u>MR</u> <ENTER

which runs the model and generates the reports as requested.

3. MODEL DESCRIPTION

This section describes the model's spreadsheets and the model itself. Included as Figure III-1, is a flowchart graphically depicting the model.

3.1 SPREADSHEETS

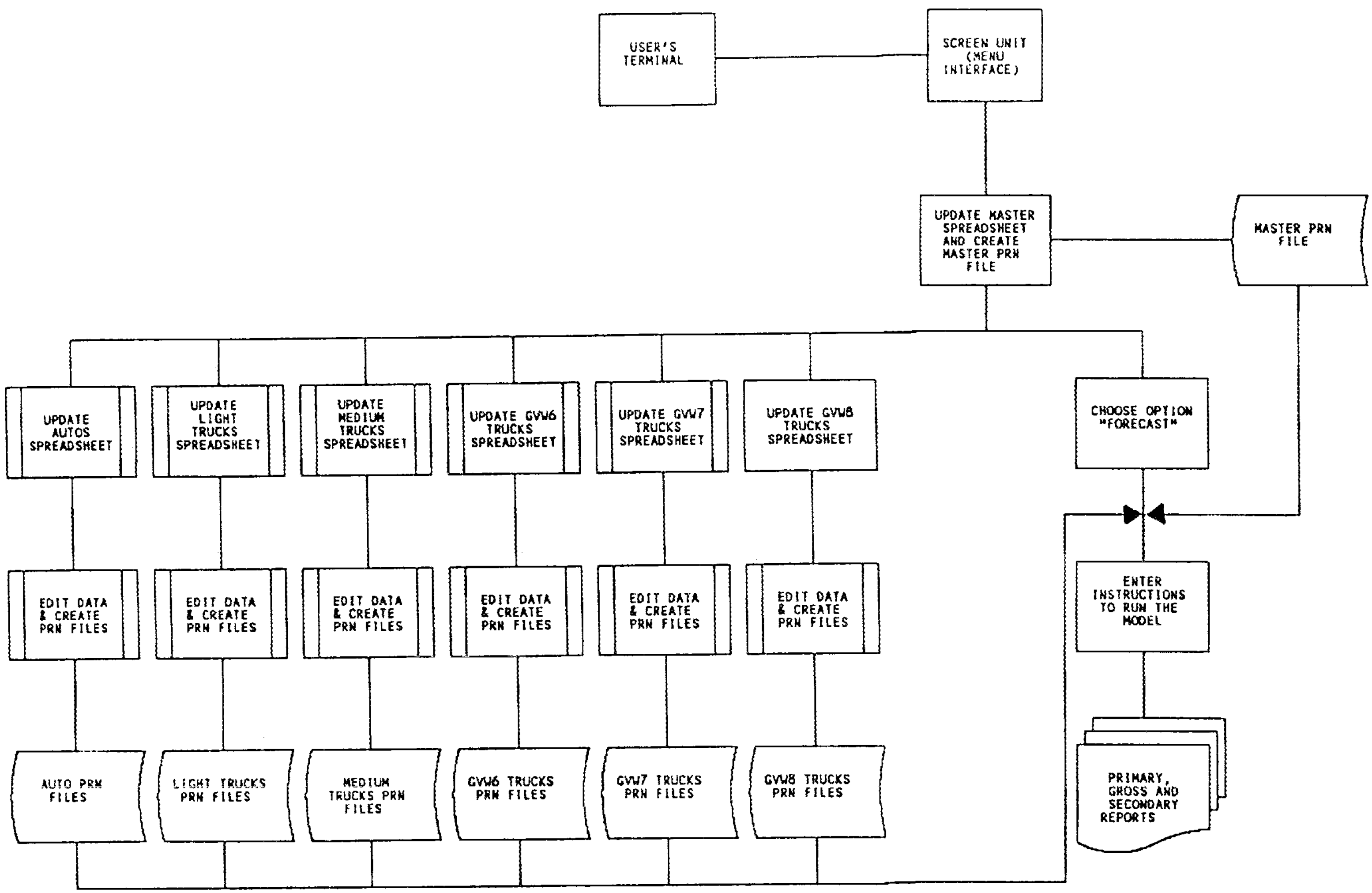
Some information required by the model is identical for all vehicle types. AMFU has one spreadsheet for the global information named MASTER.WK1. It contains the following information:

1. Vehicle Types and Selection Table
2. Forecast Dimensions
3. Economy (Income and GNP) Table
4. Population Table (included in next version of AMFU)

AMFU also has one spreadsheet for each vehicle type consisting of vehicle specific information as follows:

1. Technology Fuel Combination Table
2. Vehicle Technology Input Table
3. Scrappage parameters and Elasticities
4. Base Year Stock
5. New Registrations
6. Miles per gallon (MPG) for each technology fuel type
7. On road vs. Federal Test Procedure MPG coefficient for each technology fuel type
8. Market Shares for each vehicle technology type
9. Vehicle Prices

SYSTEM FLOW
Figure III-1



10. Fuel Prices
11. Base Year Fuel Use
12. Fuel Composition
13. Energy Contents of Fuel Types

You have complete freedom to define vehicle types as you wish by creating new vehicle spreadsheets. AMFU comes with six predefined vehicle type spreadsheets: automobiles and five truck types. The five truck types are differentiated by "manufacturers' gross vehicle weight" (GVW) class. GVW is an indicator of a truck's size and capacity. The five truck types are: Light trucks - GVW classes 1 and 2, 0-10,000 lbs., Medium Trucks - GVW classes 3-5, 10,001 - 19,500 lbs., GVW6 - 19,501 - 26,000 lbs., GVW7 - 26,001 - 33,000 lbs., GVW8 - over 33,000 lbs. These classes are convenient because statistics on new registrations and vehicles in operation by age are readily available.

3.2 A TOUR OF THE SPREADSHEETS

Once the master spreadsheet has been retrieved you will see the introductory screen for the model with the main menu on the top. Some parts of the spreadsheet should appear brighter if a monochrome monitor is used, otherwise in a different color. If this is not the case adjust the brightness of the monitor until the contrast can be seen. The highlighted portions of the spreadsheet are "Unprotected", that is, they can be overwritten.

These are the areas into which you will put data. The rest of the spreadsheet contains protected cells and should not be changed.

When you are in data input mode, your cursor cannot leave the input area and you are restricted to entering data or moving about the input area. You cannot, for example, use the LOTUS copy command to copy a number of formula to a range of cells. Should you want to use this, or other powerful LOTUS commands, you must leave the AMFU menus by pressing the ESC key several times until the menu panel clears and the indicator cell shows "READY." You are now working directly with LOTUS and you must be extremely careful not to alter or destroy formulas in the spreadsheet. To return to the AMFU menu, hold down the "ALT" key and press "M".

You must enter data in each table of the spreadsheet. This is the most time consuming and most important part of executing a forecast. Hours, if not days, may be required especially if you are beginning from a clean slate. By far the most time consuming part of the data entry is the specification of market shares, efficiencies, and MPG correction factors, since they must be entered for all forecast years, all vintage years prior to the first forecast year, and for each vehicle technology type and technology fuel type. Once this has been done, however, you have a valuable data base which you should be careful to save for reuse.

You leave the data entry mode by pressing <Enter> one extra time. This redundant <Enter> is a signal to the spreadsheet to return you to the menu.

After completing data entry you must create the PRN (data) files used by the forecaster and report generator. This is accomplished automatically via menus. If the program detects an error in one of the PRN files, after correcting the error you need to recreate the PRN file for that table only. Make sure that none of the tables have any blank entries, before creating PRN files. Zeros should be inserted instead of blanks to fill in unneeded portions of tables.

For some menus, due to the large amount of processing involved, response time may be slow; in such cases the user may see a message in the upper right hand corner of the screen or will see a message asking him or her to be patient. Do not press <Enter>, <Esc> or other keys while processing is in progress, because it can produce unexpected, undesirable results. If you should lose track of the menus or want to start from the top again, either of the two following command sequences can be used:

<Ctrl><Break> | keep <Ctrl> pressed and hit <Break>.

<Enter> | hit enter key

THEN

<Alt>M | keep <Alt> pressed and hit letter "M"

| to get back to the main menu in master

| or vehicle spreadsheet.

OR

<Alt>E | keep <Alt> pressed and hit letter "E"

| to get back to the edit menu in vehicle

| spreadsheet.

3.2.1 MASTER SPREADSHEET MENUS

The first menu offers options to modify the Master Spreadsheet, Vehicle Spreadsheet or to execute a Forecast. Option **"Master Spreadsheet"** lets you modify the master spreadsheet (global info.). There are three different tables in this spreadsheet.
1) Forecast Dimensions, 2) Vehicle Types, and 3) Economy.

Forecast Dimensions - This option should always be selected first when you wish to change any basic forecast dimensions.
AMFU's spreadsheets are smart enough to re-dimension themselves, using the current forecast dimensions in the MASTER spreadsheet.

Note: Throughout this manual the keyboard characters are represented by notation <>. Example: <Enter> represents ENTER key.

For this to work, you must not only make the changes in the MASTER spreadsheet and create the necessary PRN files, but save the changed spreadsheet, as well.

Upon selection of this option you will see a screen containing the forecast dimensions table, allowing you to specify the **Base Year, Number of Forecast Years** and **Number of Vehicle Vintages.** It is important that this information is specified at the beginning, so that other tables can be set up correctly. Once the data has been entered you must press enter to get back to next menu, which is **Set up spreadsheet** or **Continue.**

Set up Spreadsheet - This option should always be selected if any one of the forecast dimensions was changed, otherwise the changes will not be in effect for the current spreadsheet. Having done this, you are ready to enter the data for this spreadsheet.

Edit Data - This option allows you to edit the Vehicle Types or Economy(Income/GNP) tables.

Vehicle Types - All the vehicles types you wish to include in the next run must have "Y" or "y" for selection, the rest must have "N" or "n" for selection.

Economy - You must be certain that correct data exists for all the years in the table, and none of the entries contain blanks. Select option "**Return**" to get back to the previous menu.

Create PRN File - Select this option to create the master PRN file used by the forecaster and report generator. Select option "Return" to get back to the main menu.

Vehicle Spreadsheets - Upon selection of this option you will be able to choose the vehicle type to be edited. Before the vehicle spreadsheet is retrieved, you will be given an option to save the changes to the master spreadsheet and create a PRN file if you have not already done so. If you have made any changes to the master spreadsheet you should save it. The default name for the vehicle spreadsheet is automatically placed in the command sequence, to be retrieved. The user has an option to change this name to retrieve any other spreadsheet perhaps containing a special scenario for the vehicle type.

3.2.2 VEHICLE SPREADSHEET MENUS

Once the vehicle spreadsheet appears on the screen, make sure that the highlighted vehicle type is correct. The next option is to modify the Technology Combination Table. Since there are dedicated fuel and dual-fuel vehicles and several fuel types we need to clearly define terms. A technology type refers to the capability of a vehicle to use fuel types. For example, a vehicle which can use gasoline only would be a technology type. A dual-fuel vehicle capable of using either nature gas or gasoline would be another. A technology-fuel type combination is a technology type associated with one (and only one) of the fuels it is capable of using. For example, the gasoline/methanol technology type, using methanol would be a technology-fuel combination. Gasoline/methanol using gasoline is another.

Modify Technology Fuel Combinations - This table contains all technical fuel types and possible choices for the fuel. Dedicated, or single, fuel type options as well as dual-fuel, and flexible fuel vehicle technologies may be specified. Each dual-fuel technology must be listed twice (e.g. Gasoline/Methanol using Gasoline, and Gasoline/Methanol using Methanol) but must have the same technology type number. If it's the first time you are running this model you must select this option to enter the correct technical fuel types and possible fuel choices. Rules for Entering Data in the Technology Combination Table are as follows:

1. Technology fuel types must be numbered consecutively, without skipping numbers (e.g., 1,2,3,4 is correct; 1,2,3,5 will not work).
2. List all the single (dedicated) fuel types first in ascending order by user-defined technology fuel number. Note: The way you tell the model that a fuel type exists is to list it as a dedicated fuel technology in this table.
3. For dual-fuel technology types, enter the technology type names in spreadsheet cells X(n), and chosen fuel type in spreadsheet cells Y(n).
4. Every possible fuel type for dual-fuel technologies must be listed as a single fuel type first. That is, there must be two dedicated fuel technologies corresponding to each flexible or duel-fuel technology.
5. Do not erase an entry in the middle of the table, to delete an entry enter "99" for the technology number or replace it with a valid entry. Do not leave blanks. IMPORTANT: Technology types must be numbered consecutively, without gaps. If you delete an entry you will have to renumber subsequent technology types.
6. For dual-fuel technology types, list the chosen fuel with the lower technology number first to maintain consistency (e.g. If the technology number for Gasoline = 1 and Methanol = 3 then the dual-fuel technology type Gasoline/Methanol is correct and Methanol/Gasoline is incorrect).

Note that two dedicated technology fuel types cannot share the same fuel type. That is, one cannot have carburetted gasoline vehicles using only gasoline and fuel injected vehicles using only gasoline. To get around this you can define a second type of gasoline, say "GAS2" for the fuel injected vehicles. Using the "Compositions - Fuel" table described below you may define "GAS2" as 100% gasoline.

Once this table is entered, vehicle technology types, technology fuel types and generic fuel types will be derived from this table automatically by the spreadsheet software and it will set up the rest of tables for this spreadsheet. Therefore, it is necessary to complete this step successfully, before entering data in any other tables.

Set up Spreadsheet - This is a conditional step. If the forecast dimensions for the master spreadsheet are equal to the forecast dimensions for the current spreadsheet then you will not see this menu; otherwise, this menu and an informative screen will be displayed. If you select this option, spreadsheet tables will be reorganized to incorporate the correct Base year, Forecast years and Vehicle vintages. Note: In order to include the current vehicle type in the next run, the current spreadsheet's forecast dimensions must be the same as master spreadsheet's forecast dimensions.

Edit Data - This option allows you to edit data for all the tables in the current spreadsheet. This option should be chosen before creating PRN files.

Parameters:

Technology Combinations - At this point correct technology fuel types should be present. You must make sure that Technology Number, Fuel Number and Other number are correct for all single and dual-fuel technology types. Otherwise, the model will give an error message for some invalid cases, but not for others (e.g., if a fuel number is specified incorrectly for technology types to which it does not apply the model will run but you will notice an excessive amount of fuel use forecast for that fuel type).

Vehicle Technology Input - Upon selection of this option, you must enter correct data for each of the vehicle technology types(rows) and data types(columns). One important rule to be followed here is that Hedonic Constant 1 represents the fuel type with the lower fuel type number and Hedonic Constant 2 represents the fuel type with higher fuel type number. For example, consider technology type Gasoline/Methanol where fuel type number for Gasoline = 1 and Methanol = 3, clearly Hedonic Constant 1 represents fuel type Gasoline and Hedonic Constant 2 represents fuel type Methanol. The order is important. For a choice between two fuels only one constant is really needed (see PART 2).

Constants - This option allows you to enter scrappage parameters and fuel price and income elasticities of vehicle use. Select option "**Return**" to go back to the previous menu.

Stock:

New Registrations - This option allows you to enter annual registrations of new vehicles starting one year past the Base year.

Base Year Stock - Upon selection of this option, a Base year stock table, in vehicle technology type by vehicle vintages format, is displayed. You should enter the vehicle stock for each vintage in descending order. Once you finish entering data and hit <ENTER>, vehicle stock for each vehicle technology type is calculated. Select option "**Return**" to get back to the previous menu.

Efficiencies:

MPG - This option allows you to enter Miles/Gallon data for each technology fuel type.

Correction Factor - MPG - This option allows you to enter an on-road vs. Federal Test Procedure MPG coefficient. The correction factor is the ratio of in-use to test MPG. The default value for this coefficient is 1. Select option "Return" to go back to the previous menu.

Market Shares - This option allows you to enter the market shares for all vehicle technology types except the first one. Once you finish entering data and hit <ENTER>, market shares for first vehicle technology type are recalculated. Shares must be individually >= 0 and <= 1. You are responsible to see that the sum of the specified shares is = 1. (If you have listed a single fuel technology type in the technology combination table just to allow you to use the fuel type in a dual-fuel technology type, here is the place to nullify that single fuel technology type by making all its market shares = 0.)

V/F Prices:

Vehicle Prices - This option allows you to enter a vehicle price index for the current vehicle type in base year dollars.
See Part 2 for the definition of this price index.

Fuel Prices - This option allows you to enter prices for each generic fuel type used by the current vehicle type. Select option "**Return**" to go back to the previous menu.

Fuel Info:

Base Year Fuel Use - Upon selection of this option, a screen will be displayed where you can enter Base year fuel use for each generic fuel type. If Base year fuel use is unknown for a certain fuel type, then you must enter a value "0" for it. In this case, if a calibrated model run is selected, the model will generate an uncalibrated fuel forecast for this fuel type and calibrated fuel forecast for the ones with known base year fuel use.

Compositions - Fuel - This table allows you to specify that certain fuels are mixtures of other fuels. For example, if two of your primary fuel types are gasoline and methanol, you can define a third, M85, as being composed of 15% gasoline and 85% methanol. Upon selection of this option, a screen will be displayed with an explanation of why this table is required and how the entries should be entered. You must enter the correct percentage for each primary fuel type(row), and be certain that the sum of each row is equal to 100. What the table calls a primary fuel type is a fuel that will be sold to consumers. It may be composed of one or more chemical fuel types (columns). Note that every chemical fuel type must also have been defined as a primary fuel type.

Energy Content - Fuel- Upon selection of this option, a table will be displayed, where you can enter energy conversion factors (e.g., BTUs/Gallon) for each generic fuel type. Select option "Return" until the main menu is retrieved. At this point all the tables should have correct data. Now you may select option **"Create PRN file"** to create PRN files from this spreadsheet.

Create PRN Files - Upon selection of this option, a menu with an informative screen will be displayed. This menu allows you to select either all or any one of the PRN files that can be created. The screen lists vehicle types you have chosen to include and all possible PRN file names. A list of existing PRN files in the current directory can be obtained by using following command sequence:

<Ctrl><Break>

<Enter>

<Alt>F

Display Graphs - This option may be selected to view graphs for Vehicle Prices, Market Shares, Technology MPG, New Registrations and Base Year Stock tables. Only six categories from each table can be included in a graph. Thus some tables, such as MPG and Market Shares, will have two or more graphs. Press the space bar to view the next graph or return to the menu.

Xit - This option allows you to exit from the current spreadsheet and go back to the master spreadsheet.

Save - This option allows you to save the current spreadsheet. You must decide if the existing spreadsheet is to be replaced by the current spreadsheet. If so, confirm the save by hitting <ENTER> on the option "**Replace**". If not you should select option "**Cancel**" to get back to master spreadsheet without saving the current spreadsheet.

Quit - This option takes you back to the master spreadsheet without giving you an option to save the current spreadsheet. Use this option only if you do not want to save the changes you have made. Once you are back in the master spreadsheet option "**Forecast**" may be selected to run the model.

Forecast:

Calibrated Run - This option calibrates the model run by Base year fuel use.

Uncalibrated Run - This option does not calibrate the model run.

After having selected one of the two options above, the report menu will be displayed. Option **"Both"** generates Primary/Gross and Secondary reports; option **"Primary"** generates the Primary/Gross report, and option **"Secondary"** generates.

Secondary Report. These reports will be in the following files:

Primary Report - PRIMARY.PRN

Gross Report - GROSS.PRN

Secondary Report - SECONDa.PRN

SECONDb.PRN

SECONDc.PRN

SECONDd.PRN

Sample tables from PRIMARY, GROSS, and SECONDARY are included in Appendix 1. Since only eight forecast years can fit across a page, the secondary report is split into four or fewer different files, depending upon the number of forecast years. These report files can be either viewed using a text editor or printed at the DOS level. Once one of the report options has been selected, a screen with instructions to run the model will be displayed, and you will leave the spreadsheet environment and return to the DOS level. Now the instructions to run the model can be carried out. Once the model is finished running and report files have been produced, you can go back to the master spreadsheet simply by typing "EXIT".

Print - This option allows you to view or print the GROSS.PRN file from within the familiar spreadsheet environment. This provides a quick way to check a forecast.

Xit - This option allows you to exit from the model.

Save - This option allows you to save the master spreadsheet. It gives you a second chance to confirm the save by hitting
<ENTER> on option "**Replace**" or canceling it by choosing option "Cancel".

Quit - This option takes you out of the model to the DOS level, without giving you an option to save the spreadsheet.

4. BACKUP SUGGESTIONS

1. Keep one backup copy of the master and each vehicle spreadsheet containing data for the maximum number of forecast years (30).
2. To create another spreadsheet for a vehicle type with a different scenario, copy the default spreadsheet for the vehicle type under a different name and then enter the new data, so that PRN file names remain valid for the vehicle type.
3. To keep multiple scenarios for a vehicle type spreadsheet, copy all other scenario spreadsheets under different names, except the current one.

Index of Model Menu Options | Page

Base Year Fuel Use I-22
Base Year Stock I-21
Calibrated Run I-25
Compositions - Fuel I-23
Constants I-20
Correction Factor - MPG I-21
Create PRN Files I-23
Create PRN File I-16,
. . . . . I-23
Display Graphs I-24
Economy I-16
Edit Data I-16
. . . . . I-19
Efficiencies I-21
Energy Content - Fuel I-23
Forecast I-25
Forecast Dimensions I-15
Fuel Prices I-22
Fuel Info I-22
Market Shares I-21
Modify Technology Fuel Combinations I-17
MPG I-21
New Registrations I-21
Parameters I-20
Print I-26
Quit I-24,
. . . . . I-26
Save I-26
Set up spreadsheet I-16,
. . . . . I-19
Stock I-21
Technology Combinations I-20
Uncalibrated Run I-25
V/F Prices I-22
Vehicle Prices I-20
Vehicle Technology Input I-20
Vehicle Types I-16
Vehicle Spreadsheets I-16
Xit I-24,
. . . . . I-26

APPENDIX - Glossary of Technical terms

DOS	- Disk Operating System.
Dual - Fuel Technology Type	- Vehicle technology types with two possible fuel choices.
Forecast Dimensions	- Base Year, Number of forecast years and Vehicle vintages.
GNP	- Gross National Product.
Technology Fuel Type	- The combination of a vehicle technology type with one of the fuels it is capable of using.
Vehicle Technology Type	- Indicates a specific vehicle propulsion technology identified by the single fuel or dual-fuel combination it is capable of using.
VMT	- Vehicle Miles Travelled.

ALTERNATIVE MOTOR FUEL USE MODEL

PART II

MODEL THEORY AND DESIGN

David L. Greene
Anju Rathi

1. INTRODUCTION

Energy is required to produce travel. The amount and types of energy depend on the quantity and nature of the travel and the quantity of energy input necessary per unit of travel output. Energy required per mile of travel is a function of the technology that converts energy into vehicular motion. The capital stock of motor vehicles embodies the energy conversion technology. The vehicle stock approach to modeling energy demand holds that the technical composition of the vehicle stock is the most important factor in analyzing and forecasting transportation energy use.

The average life expectancy of an automobile in the United States is ten years and trucks last longer still (Greene and Chen, 1981). Furthermore, vehicle efficiency and fuel compatibility are essentially fixed at the time of manufacture. Miles per gallon (MPG) varies only slightly with use and age (EEA, 1981) and, although driver behavior and maintenance can alter MPG by 10% or more, in practice MPG is insensitive to fuel prices and other factors. Similarly, while it is possible to convert engines to run on fuels for which they were not originally designed, it has been so costly and the benefits, if any, so slight that such conversions have been limited to experiments and demonstration projects. These postulates imply that a fuel demand model should consist of three basic elements: 1) the number and characteristics of new vehicles, 2) the process of stock aging and retirement, and 3) the determination of usage rates for the different categories of vehicles. To these we add a fourth that may or may not become important in the future: the choice of fuel type for flexible fuel and dual fuel vehicles (FFV, DFV; vehicles technically capable of using more than one type of energy).

One of the first models to recognize the importance of the turnover of vehicle technology to motor fuel demand was developed by Cato, Rodekohr, and Sweeney (1976). Their model did not explicitly represent vehicles of different ages and technologies, but included an incremental process for updating vehicle fleet characteristics as the characteristics of new vehicles changed. Apparently the first model to explicitly keep account of vehicle stock and stock characteristics by model year (vintage) was the Motor Fuel Consumption Model developed for the U.S. Department of Energy (EEA, 1975). This model used constant factors for scrappage rates and use (miles per year) by age and vehicle type (auto, light truck, light-heavy, medium-heavy, and heavy-heavy trucks) to update vehicle stock composition and calculate usage. Sales of new vehicles and their characteristics were inputs supplied to the model. At about the same time, Greene (1981) developed a model for forecasting state-level gasoline demand that also kept track of vehicles by type and age, but predicted scrappage rates using logistic curves (Parks, 1977). The model predicted sales and usage econometrically, but new vehicle characteristics (including efficiencies) were inputs. Several other models of motor fuel demand have used the capital stock modeling approach (e.g., Wheaton, 1982; Kouris, 1983).

The vehicle stock modeling approach has not been limited to fuel demand modeling. The Environmental Protection Agency's MOBILE3 emissions forecasting model and its antecedents also rely on an accounting of the turnover of vehicle stocks (EPA, 1984). EPA's forecasting problem is analogous in that emissions rates depend primarily on the control technology used which, tampering aside, depends on the year of manufacture.

A simplified vehicle stock model has recently been implemented as a spreadsheet program (Greene, Meddeb, and Liu, 1986). This model, on which the model described in this report is based, takes sales, efficiencies, and fuel type shares as inputs, predicts scrappage and use by age and vehicle type by means of parametric equations, and calculates fuel use. The alternative fuels model presented below differs from the spreadsheet model chiefly in its representation of use and scrappage at a greater level of detail and in its ability to accommodate a diversity of vehicle technologies, especially vehicles capable of using two different motor fuels (dual-fuel or flexible-fuel vehicles).

Interest in alternatives to petroleum-based motor fuels motivated the design and development of this new vehicle stock model. The recent development of flexible fuel vehicle (FFV) technology for methanol-gasoline blends made multifuel vehicle technology a reality not just a possibility. Unlike dual-fueled (DFV) gasoline-compressed natural gas (CNG) technology which has been available for some time, FFV technology will likely be both cheap and nearly invisible to the consumer (DeLuchi, Johnston, and Sperling, 1988; EEA, Inc., 1988). Combine this with the intense interest in using alcohol fuels, CNG, or electricity to reduce motor vehicle emissions (Alson, Adler, and Baines, 1988), and the emergence of significant alternative fuels markets in the next decade becomes a real possibility.

Flexible or dual fuel markets will differ in important ways from current motor fuel markets. Whether the fuel is methanol or CNG, it will be derived from a different feedstock. The fuels motorists choose among today, the various octane grades of gasoline, leaded versus unleaded, and diesel, are all derived from petroleum. This gives fuel producers considerable flexibility to adjust to changes in the market using the same stock of refinery equipment. Methanol, in particular, will require a totally different production plant. Significant swings in the methanol market share will put the entire capital stock at risk. Wide swings in demand are possible because FFV's will perform nearly equally well on either fuel. Today's diesel versus gasoline choice is determined at the time of vehicle purchase. Given the number of diesel engines sold, demand for diesel fuel is fairly predictable. Given the number of FFV's sold, one can estimate potential demand but actual sales will depend on prices and consumer perceptions. Because of this, alternative fuels markets created to reduce pollution will require regulation to insure effectiveness.

The essence of a vehicle stock model is a detailed accounting of the technological composition of the vehicle stock. To the extent that the technological composition limits what can happen in the future, this accounting is a useful aid to forecasting and analysis. Previous vehicle stock models have kept track of the number of vehicles by age, efficiency, and fuel type. Age helps determine usage. Initial efficiency strongly constrains future energy intensity, and fuel type compatibility used to determine fuel type choice. In this model a fuel choice behavioral component is added to recognize the fact that initial fuel type compatibility limits but does not determine fuel choice.

2. STRUCTURE

Fuel use in any given year depends on four factors:

1. the technical composition of the vehicle stock by fuel and age ($V_{vfat}=N_{vt}*Q_{vfy}$)
2. the usage rates of vehicles of different types and ages (M_{vfat}),

3. the efficiencies of vehicles of different types and ages (E_{ft}), and
4. the choice of fuel type in the current year by technology type v(F_{vft}).

N = number of new vehicles
Q = market share of sales
V = number of vehicles in operation
M = average annual miles per vehicle
E = average efficiency in gallons per mile
F = fraction of vehicles choosing fuel type f
v = vehicle technology type index
f = fuel type index
a = vehicle age group index
t = forecast year index
y = model year, (a = t - y)

Given the above factors, fuel use G can be calculated at the level of detail of vehicle type, technology type, fuel type, age group, and forecast year by means of the following equation.

$$G_{vfat} = V_{vfat} \cdot F_{vft} \cdot M_{vfat} \cdot E_{vft} \qquad (1)$$

The problem lies in obtaining the values of N, F, and M. With six vehicle types, ten technology types, two fuel types for each, 15 age groups, and a 30-year forecast, N is an 27,000 element array and F and M require 54,000 numbers each. Requiring the user to supply every element of every array would be too tedious for the model to be of any use. The solution to this problem is to specify a small number of systematic relationships that reduce the required data inputs to a manageable number.

The Alternative Motor Fuel Use (AMFU) model comprises three submodels of stock dynamics, vehicle use, and fuel choice. New vehicle demand and the determination of the technical characteristics of new vehicles must be specified by the user. Likewise, the initial distribution of stock by age, as well as current and future efficiencies and fuel types must be supplied to the model as data. The reason for requiring the user to supply base year stock counts and characteristics is clear since these are generally either known or can be estimated from historical statistics. Therefore, there is little reason or justification for having the model predict them. New stock and its characteristics are not predicted for two reasons. The first is the desire to have a flexible analytical tool for evaluating "what if?" questions. Sales, efficiencies, and fuel capabilities are the primary determinants of a fuel use forecast. Allowing the user to specify these without constraint allows any number of alternative scenarios to be explored. The second is the absence of accurate methods for forecasting sales by vehicle type and vehicle technology. There are reasonable approaches, to be sure, but none so clearly correct that one would want to turn over control of the model to it.

The AMFU model sequentially executes each of the three submodels for each vehicle type, forecast year, fuel type, and age category and calculates fuel use by equation (1) (Figure 1). In fact, each vehicle type is treated individually. The model may be run for one or any number of vehicle types. The result is an extremely detailed prediction of fuel use (G_{vfat}). The AMFU model saves the detailed prediction and creates standard forecast summaries from it.

The following sections describe the theory behind each component submodel. Equations are presented and parameters defined. Section III describes the stock dynamics submodel which predicts scrappage rates and updates the vehicle stock each year. Section IV describes the vehicle use submodel that predicts annual miles per vehicle. Section V

STRUCTURE OF ALTERNATIVE MOTOR FUELS USE

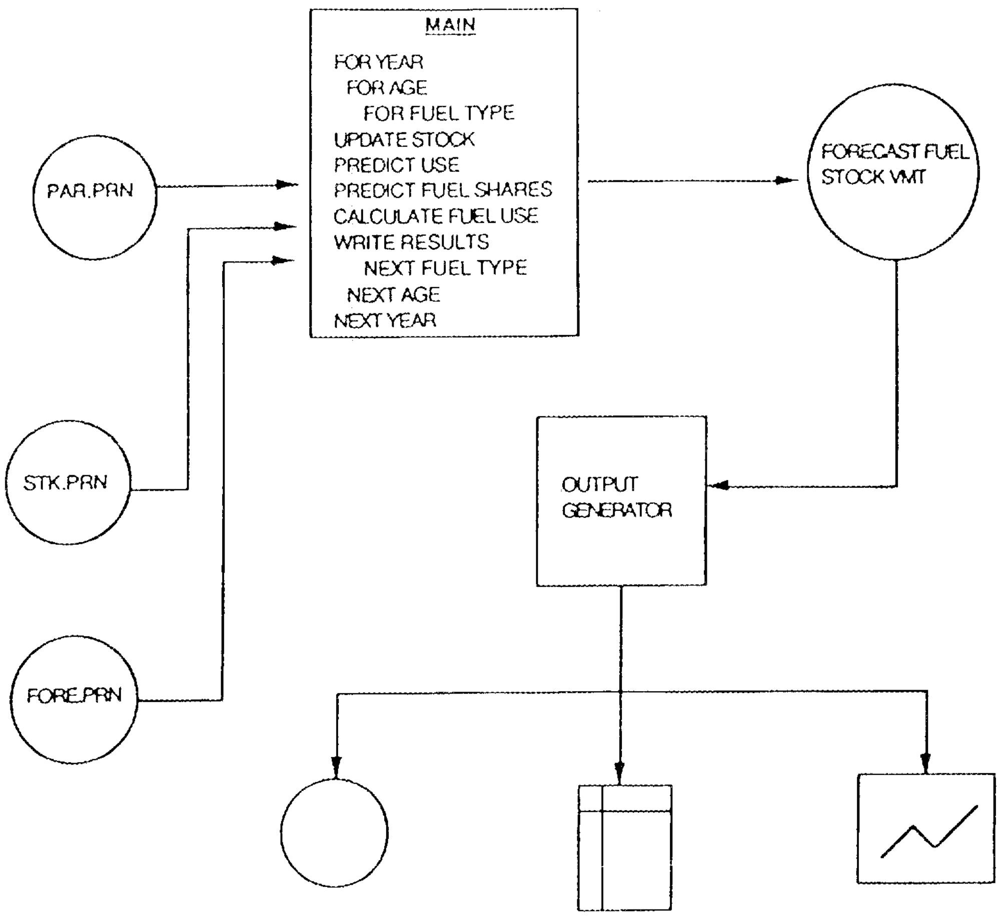


FIGURE 1.

explains how choice of motor fuel is modeled for dual and flexible-fuel vehicles. Section VI explains how fuel use is calculated for each vehicle type, technology type, vintage, and forecast year. Section VII sets forth the model's data requirements.

3. VEHICLE STOCK DYNAMICS

The vehicle stock dynamics submodel forecasts the evolution of the vehicle stock in full detail. This begins with an initial distribution of the number of vehicles by age. New registrations must also be specified for each forecast year, as must efficiencies and market shares for each vintage. If there are 15 age groups, for a 20-year forecast, 15+20 = 35 efficiencies and sets of fuel type market shares must be specified. A logistic scrappage equation proposed by Parks (1977) and modified by Greene (1984) predicts the evolution of the vehicle stock. Parks' model supposes that each year (t) each vehicle incurs a repair of random magnitude, say z(t). If the cost of this repair, $z(t) \cdot M(t)$, M being an index of repair cost, is greater than the value of the vehicle, P(a,t), where a is the vehicles' age, then the vehicle will be scrapped. If z follows a logistic distribution, then Parks shows that the probability of scrappage (or rate of scrappage for a population of cars) will be a logistic curve,

$$L(a,t) = [1 + \exp(A_0 + A_1 P(a,t))]^{-1} \qquad (2)$$

Used vehicle prices by age of vehicle are not generally available, so Parks used the price of new cars together with dummy variables for vehicle age instead.

Greene modified Parks' model by embedding a model of new car price depreciation in the logistic function,

$$P(a,t) = P(0,t) \cdot K^a \qquad (3)$$

where K is a constant equal to one minus the depreciation rate. The AMFU model allows technology-specific depreciation rates and new vehicle prices for each vehicle type and model year. As a result, scrappage rates will differ across technologies and market shares will evolve over time. The resulting equation is,

$$L_f(a,t) = [1 + \exp(A_0 + A_1 P_f(0,t) K_f^a))]^{-1} \ . \ (4)$$

An advantage of this formulation is that the parameters are interpretable, which makes it much easier to guess their values if data are not available from which to estimate them. For example, $1/(1+\exp(A_0))$ is the asymptotic scrappage rate, that is, the rate of scrappage for cars of infinite age (thus having zero market value) and should equal the probability of a significant repair. Obviously, $0<1/(1+\exp(A_0))<1$ and experience with U.S. data suggests that $2<\exp(A_0)<8$. The depreciation rate, K, must also lie between 0 and one, except in the most unusual circumstances (e.g., the Great Depression), and is most likely in the vicinity of 0.8. The remaining parameter, A_1 is somewhat more difficult because it represents the sensitivity of scrappage to vehicle price changes. If P is a new car price index generally between 1 and 2 in magnitude, A_1 probably lies between 5 and 10. The three-parameter scrappage equation is used to update an initial distribution of vehicle stock by multiplying the number of cars in each age group inherited from the previous year by one minus the computed scrappage rate. Since readily available data on U.S. vehicle stocks reports vehicles in operation as of mid-year (July), new registrations are only partly incorporated into the fleet. In the AMFU model 2/3 of new sales is considered the stock of 0-year-old vehicles. The remaining new sales are brought into the fleet as one-year-olds in the following year.

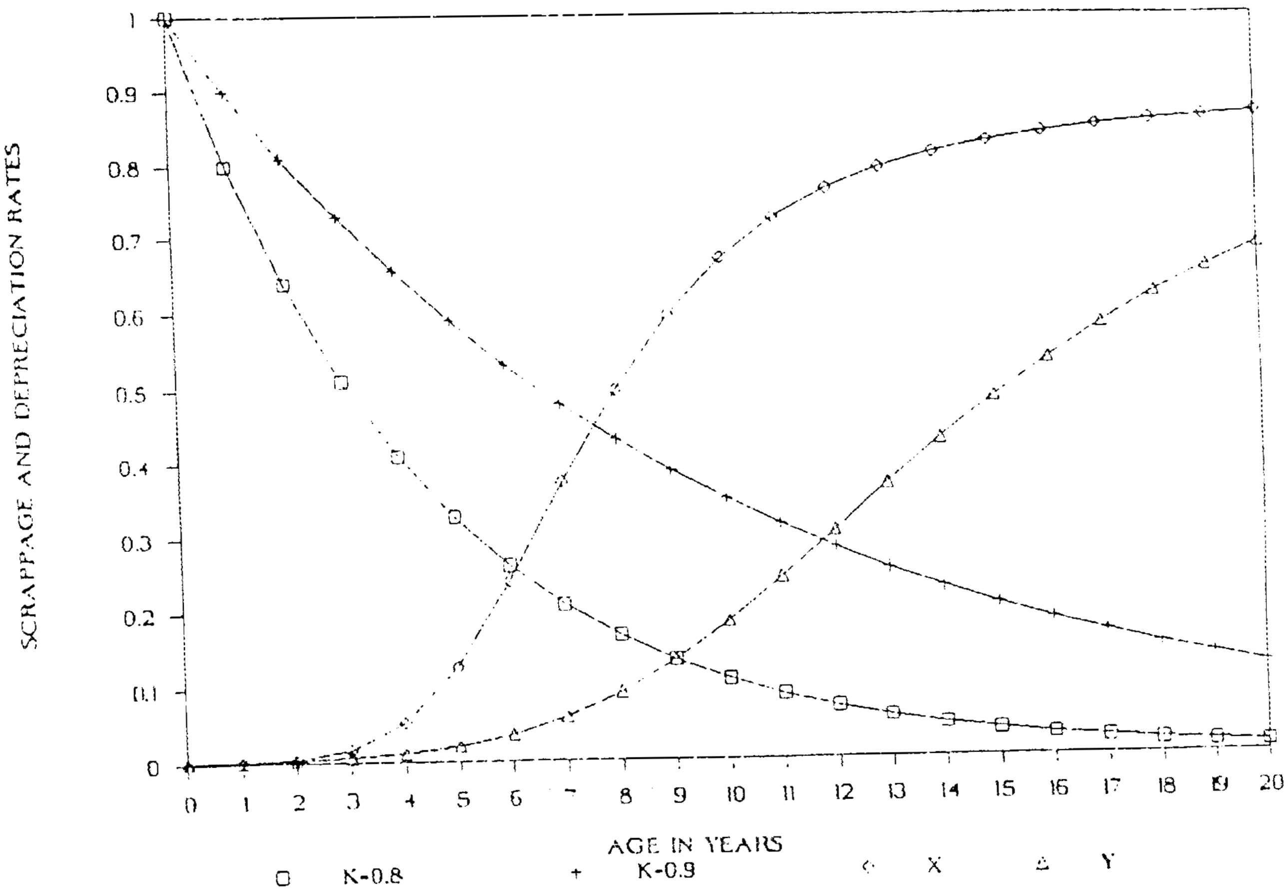
If different depreciation rates are specified for different technologies, scrappage rates will vary and market shares will change over time. For instance, suppose we have reason to believe that vehicles of fuel type X will depreciate twice as fast as those of fuel type Y. If the value of K for type Y is 0.9, then K_x will be 0.8. Let $A_0=2$ and $A_1=-10$, and let vehicle X be 20% more expensive as a new car ($P_x(0,t)=1.2$, $P_y(0,t)=1.0$). Figure 2 shows the depreciation of vehicle prices and the effect on scrappage rates as the two vehicle types age. After 10 years the scrappage rate for vehicles of type X will be over 60%. Annual retirement rates for type Y vehicles will be only 20%. Even small differences in scrappage rates can significantly alter scrappage.

The above discussion adequately describes the stock dynamics submodel in the present version of the AMFU model. Future versions will incorporate greater sensitivity to economic conditions in the stock dynamics model. These changes will be based on the theory of stock depreciation set forth below.

Most of the demand for motor vehicles from one year to the next is supplied by the stock of used vehicles. The well known stock adjustment formulation of motor vehicle

DEPRECIATION AND SCRAPPAGE CURVES

TWO HYPOTHETICAL VEHICLES



demand is based on the assumption that increases in the demand for motor vehicle holdings will be met by new vehicle purchases (Chow, 1957). It is also possible, however, to satisfy increased demand for stock by slowing down the rate of depreciation of used stock by investment in maintenance and repair, for example. This connection between stock demand and depreciation implies that scrappage will be a function of economic growth, as well as vehicle price.

The total value of the motor vehicle stock in year t can be represented as the sum (or integral) of the numbers of vehicles by age, $N_t(a)$, times their value, $P_a(a,u,m)$, where u represents accumulated usage, and m represents investment in renovation (maintenance and repair).

$$S_t = \sum_{a=0}^{L} N_t(a) \cdot P_t(a,u,m) \quad , \qquad (5)$$

where S is the value of vehicle stock and L is an age large enough to include essentially all of the stock at time t. The rate of change in value, or depreciation, of total stock over time is the derivative of S with respect to t.

$$\frac{dS}{dt} = \sum_{a=0}^{L} \left\{ \frac{dN_t(a)}{dt} \cdot P_t(a,u,m) + N_t(a) \cdot \frac{dP}{dt} \right\} \qquad (6)$$

The first term on the righthand side of (6) represents the loss of value due to the loss of vehicles (scrappage). The second term represents the loss of value due to the change in value of existing vehicles.

$$\frac{d}{dt} P_t(a,u,m,E,T) = \left[\frac{dP}{da} + \frac{dP}{du} \cdot \frac{du}{dt} + \frac{dP}{dm} \cdot \frac{dm}{dt} + \frac{dP}{dE} \cdot \frac{dE}{dt} + \frac{dP}{dT} \cdot \frac{dT}{dt} \right] \quad (7)$$

The price change derivative in square brackets in equation (5) is equivalent to the rate of depreciation, (1-K), above. It has five components: 1) price change due to aging alone (note that da/dt = 1), 2) price change due to additional usage (du/dt is the rate of vehicle use), 3) price change due to the rate of maintenance, 4) price change due to change in the operating cost difference between old and new stock, E (to be defined), and 5) price change due to the improvement of technology, T, in new cars. The rate of aging cannot be altered, as we all know. The rate of usage can but we will consider it fixed for the time being. The change in operating cost difference between new and used cars we will represent as the difference in fuel cost per mile (fuel price times the difference in efficiencies measured in gallons per mile). The improvement in technology represents other technological improvements either offering features not previously available or changing the trade-off rates between such features as performance and price. We will now focus on the rate of maintenance.

The level of maintenance of stock at any point in time expresses the demand for used stock. That is, if demand for used stock increases either to supply economic expansion or because preferences for used versus new stock shift, this should be expressed in a change in investment in the maintenance of used stock. Therefore we express the level of maintenance as a function of income (Y) and the cost of maintenance (C). The derivative of price with respect to maintenance becomes,

$$\frac{dP}{dm} \cdot \frac{dm}{dt} = \frac{dP}{dm} \left(\frac{dm}{dY} \cdot \frac{dY}{dt} + \frac{dm}{dC} \cdot \frac{dC}{dt} \right) \qquad (8)$$

We may assume that the effect of maintenance on price is positive ($dP/dm > 0$) and also that the effect of maintenance cost on the level of maintenance is negative ($dm/dC < 0$). The effect of income on maintenance depends on whether income growth generates increased or decreased demand for used stock. If used stock is an inferior substitute for new stock, as has been asserted by Wykoff (1973) for example, then we would expect $dm/dY < 0$. If used stock is considered an equal substitute for new stock then we would expect $dm/dY > 0$.

The rate of price depreciation (1-K), therefore, depends on the rate of income growth, the rate of change in the price of maintenance, the rate of change in operating costs for old and new cars, and the rate of change of technology. These relationships allow considerable economic sensitivity to be built into a fairly simple scrappage model. The present version of the AMFU model includes constant depreciation rates so that scrappage is sensitive only to new vehicle price. Future versions will include at a minimum sensitivity to the rate of income growth. Greene (1987) has shown that the income growth rate is a significant determinant of the rate of depreciation.

4. VEHICLE USAGE

Over time a vehicle's annual usage changes as external conditions change. In the short run, changes in vehicle operating costs and economic growth are the primary influences. In the long run, the demand for travel changes with population growth, changes in the demographic structure of the population, and changes in the supply of infrastructure: highways, bridges, airports, etc. that affect both the amount and mode of travel. The primary long-run constraint on travel appears to be the availability of time and, therefore, demographic factors are most important (Greene, 1988). In the very long run (several decades), the evolution of society in space will change the geography in which travel decisions are made. Changes in social and economic organization also must play a role. The AMFU model responds to long run changes via changes in the size and composition of the vehicle stock. It responds to shortrun changes in fuel costs per mile and income via changes in annual miles per vehicle.

Usage of a given model year or vintage changes as it grows older. Newer vehicles tend to be driven more miles than older vehicles. This phenomenon, seen time and again in travel surveys, is due both to the fact that older vehicles are less productive because they are partially worn out and to the fact that there is a tendency for persons or firms with greater demand for travel to own newer vehicles.

A simple exponential relationship describes the relationship between use and age quite well (Kulp and Holcomb, 1982).

$$R_v(a) = \exp(-r_v a) \qquad (9)$$

R_v is the relative usage rate for a-year-old vehicles of type v, and r_v is the rate of decline of use with age which is generally about 0.05 (5%/year). Note that the relative usage of a 0-year-old vehicle is 1. Because of relative usage rates new vehicles will have a greater impact on fleet fuel use and fleet efficiency than their numbers alone would suggest. Likewise, older vehicles will have a less than proportionate impact.

As fuel efficiencies or fuel prices change the fuel cost per mile will change accordingly. Numerous studies of motor fuel and vehicle travel demand have shown that vehicle use will decrease in response to an increase in the fuel cost per mile of driving and increase when increased efficiency lowers the fuel cost of driving. For most policy analyses the response of vehicle use to cost per mile ought to be taken into account because it tends to offset, in a small way, the effect of fuel efficiency improvements on energy use. For example, A consensus estimate of the short-run elasticity of travel demand with respect to cost per mile is about -0.2 (Morlan, Skelly, and Reznek, 1981; Greene, 1981). By noting that fuel demand is travel divided by miles per gallon it is easy to show that the short run elasticity of fuel demand with respect to MPG must be -0.8. Thus a 10% improvement in MPG does not reduce fuel demand by 10% but by 8% since about 2% more driving will be done.

Travel demand is also responsive to income, both for individuals and freight. The short-run effect of income is represented by means of a constant elasticity of travel with respect to income. Constant elasticity demand models have been shown to fit gasoline demand well and thus are a good choice for travel demand as well (Danielson and Agarwal, 1976; Greene and Hu, 1986). The long-run effect of income on travel demand occurs via an increase in vehicle stock. The current AMFUS model assumes that each new vehicle added to the fleet will be driven the same number of miles as the one before it. That is, average annual miles per vehicle will not decline as the number of vehicles per capita increases.

The assumption of constant annual miles is likely to cause an overestimate of travel as the fleet grows for the following reason. Consider the following constant elasticity equation for the demand for travel,

$$M/p = M_0 \cdot (Y/p)^{\beta 1} \cdot (P \cdot E)^{\beta 2} \cdot (S/p)^{\beta 3} \qquad (10)$$

where p is population (M/p = miles per capita), M_0 is constant, P is fuel price, and $\beta 1$, $\beta 2$, $\beta 3$ are elasticities. Dividing both sides through by stock per capita (S/p) gives an equation in terms of average miles per vehicle,

$$M/S = M_0 \cdot (Y/p)^{\beta 1} \cdot (P \cdot E)^{\beta 2} \cdot (S/p)^{\beta 3-1} \ . \qquad (11)$$

If the per capita demand for travel is inelastic with respect to vehicle stock (β_3<1), the elasticity of average use per vehicle with respect to stock per capita (β_3-1) will be negative. That is, use per vehicle will decline as stock per capita increases.

The current version of the AMFU model does not require population forecasts. As a result, it does not adjust for declining use per vehicle as vehicle ownership rates increase. A future version of the model will include this adjustment.

The estimation of miles per vehicle takes into account the efficiency of each vintage and the price of each fuel type. The equation for annual miles for vehicle type v, fuel type f, and age a, in year t is,

$$M_{vfat} = M_{vf} \cdot \left(k_f \cdot \left(\frac{P_{ft}/P_{f0}}{[D_{vfy} \cdot E_{vfy}/D_{vf0} \cdot E_{vf0}]}\right)^{\beta_1} \cdot (Y_t/Y_0)^{\beta_2}\right) \qquad (12)$$

where P is fuel price, D is an adjustment factor that, in case test cycle efficiency data are used, permits adjustment to on-road conditions, and k is a calibration constant for fuel type f. The calibration constant, k_f allows the user to scale the model's predictions to match some initial year level of fuel use. Prices and income are normalized relative to the initial year of the forecast. The on-road efficiency adjustment factor and vehicle efficiency are normalized to those of a zero-year-old vehicle in the initial year. This obviates the need to develop calibration constants to normalize equation (9) to equal M_{vf} for zero year old vehicles in the initial year for each vehicle and fuel type. Note that in equation (9) the relative usage of vehicles of different ages will not be constant over time as equation (6) might seem to imply. Usage rates will vary with model year efficiencies.

5. MOTOR FUEL CHOICE

Today's motorists face a choice of fuels each time they refuel. The choice is among different grades of gasoline and may include whether or not to obey the law prohibiting the refueling of an "unleaded" vehicle with leaded fuel. For most motorists the various grades of gasoline are indistinguishable but for those with high compression engines the choice of fuel may significantly affect performance. Future drivers of FFV's will face a more defined choice between methanol and gasoline, or gasoline and CNG. Choice of fuel will likely affect performance, driving range, and ease of refueling. It is also likely that price differences will be even greater than those among the various octane grades of gasoline. How much of each fuel is chosen will depend on the cost differences and on the perceived attractiveness of each. The AMFU model represents this as a probabilistic choice by means of a logit equation.

The logit formulation is extremely general. To derive it we need only assume that the probability that any particular alternative is chosen is some quantifiable function of measurable variables (the derivation of the logit model follows Train, 1986, p. 21).

$$P_{fn} = \Phi(z_{fn}, z_{gn}, \text{for all } g \text{ not equal to } f) \qquad (13)$$

P = probability of choice

Φ = a real-valued function of measured variables

z = variables describing the fuel or consumer

n = an indicator of which consumer is choosing

f,g = indices of fuel type.

Though very general, equation (10) contains two important assumptions. First, it portrays the consumer's choice as probabilistic, at least from the model's perspective. In fact, a particular consumer's choice may be deterministic. That is, given certain prices, etc. he will always choose fuel always choose fuel f, but it appears to the model to be probabilistic because of all the factors that bear on the decision that are outside the scope of the model. Second, this formulation implies that the choice is systematic. The probability function depends in a fixed way on certain measurable variables. Given values for those variables, the probability is determined.

Let $W_{fn} = \log_e(P_{fn}) = \log_e(\Phi)$. We now substitute W_{fn} into the logit equation and show that it gives back exactly P_{fn}, proving that the logit model is consistent with the very general formulation of the choice problem set forth above. That is, any model for which choice probabilities are a function of measured variables is a logit model.

$$\frac{\exp(W_{fn})}{\sum_g \exp(W_{gn})} = \frac{\exp(\log_e(P_{fn}))}{\sum_g \exp(\log_e(P_{fn}))}$$

$$= \frac{P_{fn}}{\Sigma P_{gn}} = P_{fn} \ , \qquad (14)$$

Since we assume that $\Sigma_g Pgn = 1$, some choice will be made.

The function Φ must be a quantification of the factors consumers will use in deciding which fuel to buy for their FFV. In econometric studies Φ is assumed to be the consumer's indirect utility function, which is to say that it translates the attributes of a good into a quantitative measure of its desirability, or utility (e.g., McFadden, 1974). Φ is often assumed to be linear, a reasonable choice because the "true" functional form is not known and a linear function is a first-order approximation to any continuous function. So long as changes in characteristics are reasonably small, a simple linear function should be a reasonable approximation. If β_i is the weight, or relative value, of attribute i, then Φ is,

$$\Phi_{fn} = \Sigma \beta_i \cdot z_{ifn} \qquad (15)$$

What attributes Φ should comprise and what their weights should be is a difficult and important question. Since we are considering choices among fuels which are not yet in the marketplace and, therefore, with which consumers are not familiar, it is more difficult still. Previous research on fuel purchasing behavior (e.g., Kitamura and Sperling, 1987; Sperling and Kurani, 1987) and reflection suggest that the following factors will be important:

1. price differences,
2. effect on vehicle performance (e.g. octane) or reliability,
3. availability (number of retail outlets),
4. refueling frequency (e.g., because of lower energy density),
5. refueling convenience,
6. manufacturers' recommendation or warranty constraints,
7. other consumer perceptions,
8. legal restrictions (e.g., such as on unleaded gasoline).

A recent econometric analysis provides estimates of the sensitivity of gasoline grade choice to price and also sheds some light on the importance of octane, legal restrictions, and to some extent availability (Greene, 1988). Some information about the importance of availability and perceptions of quality can be gleaned form the studies cited above.

Motor fuel choice depends directly on fuel price differences in the AMFU model. All other fuel characteristics are lumped together into a "hedonic constant" term, B1, which represents a fuel's relative desirability when all prices are equal. Thus Φ is,

$$\Phi_{fn} = \beta 1_f + \beta 2(\text{PRICE})_f \qquad (16)$$

A reasonable value of $\beta 2$ can be obtained from Greene's (1988) econometric study. Two reasonable methods for guessing the $\beta 1_f$'s are: 1) build up an estimate by guessing the values of the individual component weights, multiplying by the respective fuel characteristics and adding these for each fuel type, and 2) hypothesizing a set of market shares at equal price and solving algebraically for the $\beta 1_f$'s. The second method may sound like cheating, but it is at the very least a good way to check that the estimates derived by method 1 are intuitively satisfying. Since FFV owners have only two fuel choices in the AMFU model, we need only $\beta 1_1$ and $\beta 1_2$. If s_1 and s_2 are the market shares of the two fuel choices (note that s_f=P_f) and we normalize the $\beta 1$'s so that $\beta 1_1+\beta 1_2=0$, then it is easy to show that,

$$\beta 1_1 = -\beta 1_2 = \tfrac{1}{2} \cdot (\log_e(s_1) - \log_e(s_2)) \quad . \quad (17)$$

One important aspect of fuel choice that the current version of the AMFU model will not handle well is availability. Availability cannot be adequately represented by a constant term since it will most likely be changing over time. Studies of diesel fuel refueling behavior indicate that the difficulty or cost of obtaining a sparsely available fuel is less than one might expect since consumers learn the locations of stations and plan their refueling accordingly (Kitamura and Sperling, 1987). Thus, with as few as 10% of stations offering an alternative fuel, availability costs can be quite small. Availability for FFV's also cannot be represented as a simple function of the number of FFV's in the fleet, since demand will depend strongly on relative prices as well as vehicle technology. Availability will also depend on the dynamics of the market. If fuel prices and demand fluctuate too widely and too frequently suppliers may be unwilling to risk supplying the alternative fuel. Availability is a key topic for future research.

6. CALCULATION OF FUEL USE

Fuel use is calculated in four steps:

1. Update the vehicle stock.
2. Estimate fuel type shares for FFVs.
3. Estimate vehicle miles.
4. Calculate fuel use.

First, vehicle stock is updated to the current year by introducing new sales and reducing the number of used vehicles by vintage to account for scrappage. In the first forecast year and for new vehicles in every forecast year, market shares supplied by the user determine the market share of each technology. In succeeding years, used stock of age a and technology type f is determined by applying a survival rate (1-scrappage rate) to the previous years stock of age a-1 and technology type f. Since scrappage rates depend on technology-specific depreciation rates and prices, market shares for a particular model year will change over time.

Second, fuel shares are estimated for FFVs and DFVs. Third, vehicle miles for each technology and vintage are predicted. Vehicle miles by technology, vintage, and fuel type are obtained by multiplying the fuel share (for fuel type f, technology type g, and vintage a) times the stock of vehicles (of technology type g and vintage a) times the relative miles (for vintage a, technology type g) times the miles for a "zero-year-old vehicle" (of technology type g, using fuel type f, and of model year y). Zero-year-old is in quotes since it is an artificial construct representing the miles a particular model year would have been driven in a particular forecast year if it were brand new. The relative miles factor, in effect, discounts this to the current age of the vehicle. By applying the fuel type market share to vehicle miles we are defining the fuel choice decision to be a choice of vehicle miles traveled using a particular fuel. This is not generally the same thing as the share of refuelings with that type of fuel because fuels generally have different energy densities and, therefore, different miles per tankful.

Fourth and finally, fuel use is computed by multiplying vehicle miles times efficiency in volumetric units per mile, divided by an on-road versus test cycle correction factor. The volumetric units will be those in which efficiency has been specified. This might be gallons for liquid fuel, cubic feet for gaseous fuel, and watt-hours (in the absence of a volumetric unit) for electricity. In setting up a run the user must supply factors to convert volumes to energy for each fuel type.

The model computes fuel use and VMT at a fine level of detail. If there are six vehicle types, 15 vintages, and 15 technology-fuel type combinations, a 30 year forecast will produce 40,500 fuel use numbers and an equal number of vehicle travel estimates. Similarly, vehicle stock is kept track of by vehicle type, technology type, vintage, and forecast year. For an equivalent forecast with 10 technology types 27,000 stock estimates are generated. The model writes all of these projections, in full detail, to data files. A report generator program then summarizes the results to produce two standard format summary files. In the future, we intend to add a relational data base management capability so forecasters can explore the full information content of a forecast with relative ease.

7. DATA

There is no question. The AMFU model has an appetite for data. Preparing the data is the most critical, important, and time consuming step in the forecasting process. We have attempted to ease this burden on the user by using automated spreadsheets for data input. Even so, it should take days to set up a complete run involving several vehicle types, 15 vintages, a dozen or more technology types, and a 20-30 year forecast period. Significant modifications to a previously established data set will still take hours. Only minor modifications can be completed in minutes. Thought and care are the most important inputs. With the AMFU model it is strictly "Garbage in, garbage out."

Master Data

The first task is to define the forecast. This is done in a Master spreadsheet program by specifying the base, or initial, forecast year, the number of years ahead to be forecasted, and the number of age groups or vintages which must be kept track of. The oldest vintage, 15 in table 1, always includes all vehicles of the specified age and older. Next, the vehicle types to be included in the model run must be specified. One or any number of vehicle types can be used at the same time. Up to ten vehicle types are allowed (table 2).

Economic data are also common to all vehicle types. The data shown in table 3 are disposable personal income per capita in thousands of constant dollars and total Gross National Product in trillions of constant dollars. Except for being in constant dollars, the units are not important since the data are normalized to their base year value when used in forecasting vehicle usage. When population is introduced into the model in a future version, it will also be included in the Master spreadsheet.

Vehicle Type Data

All of the remaining data are contained in separate spreadsheets for each vehicle type. Vehicle type-specific data can be divided into three groups:

1. Parameters
2. Stock data
3. Efficiency data
4. Market shares
5. Fuel data.

Table 1. Forecast Definition

MAXIMUM LIMITS	
Base Year:	NONE
Forecast Years:	30
Vehicle Vintages:	20

MASTER FORECAST DIMENSIONS	
Base Year:	1985
Forecast Years:	30
Vehicle Vintages:	15

Table 2. Vehicle Type Selection

VEHICLE TYPES

Vehicle type		Selection (Y/N)
Autos	,	Y
Light Trucks	,	N
Medium Trucks	,	N
GVW6 Trucks	,	N
GVW7 Trucks	,	N
GVW8 Trucks	,	N
	,	
	,	
	,	
	,	

Table 3. Economic Forecast

ECONOMY

30 (DISPOSABLE PERSONAL INCOME PER CAPITA IN $1000, GNP IN TRILLIONS OF $$)

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Income:,	11.872	12.18	12.496	12.821	13.154	13.496	13.847	14.207	14.577	14.956	15.345	15.744	16.153	16.573	17.004	17.446
GNP: ,	4.01	4.12	4.2312	4.3454	4.4628	4.5833	4.7070	4.8341	4.9646	5.0987	5.2363	5.3777	5.5229	5.6720	5.8252	5.9825

1. Parameters include the definition of the technology-fuel combinations. Table 4, for example, contains ten technology types but fourteen technology-fuel combinations. A dual fuel gasoline and CNG vehicle, for instance, is one technology type but two technology-fuel types: 1) gasoline/CNG using gasoline and 2) gasoline/CNG using CNG. Each fuel a technology-fuel type can use is identified by a fuel number. For example, gasoline is fuel number 1, methanol is number 3. A dedicated gasoline vehicle has fuel number = 1, and other number = 1. A gasoline/methanol FFV using methanol has fuel number = 3 and other number = 1. For reasons of program logic, only one dedicated vehicle type can be defined per fuel type. That is, we cannot have a dedicated methanol vehicle using methanol (fuel number = 3) and a fuel cell vehicle also using exclusively fuel type 3. To the model, these two technology types are redundant. There is an easy way around this problem, however. We can simply define a new fuel, type 6, which we know is methanol but which we tell the model is M100, or whatever name we wish to call it. The model will not be confused by this and, as will be seen below, we can define the fuel by its content of methanol to get correct forecasts of total methanol use.

Parameters needed for equations of scrappage, vehicle use, relative vehicle use and fuel choice are contained in table 5. Hedonic constant 1 is reserved for future use in case we should want to consider vehicles capable of using 3 fuel types. Hedonic constant 2 is referred to as $\beta 1$ above. Marginal utility is $\beta 2$.

2. Stock data consist of new registrations (table 6) and the base year stock (table 7), both in thousands. In this table one enters only the total base year stock distribution, not

Table 4. Definition of Technology - Fuel Types

TECHNICAL COMBINATIONS

14

Tech. Fuel			Tech. Number	Fuel Number	Other Number
Gasoline		,	1	1	1
Diesel		,	2	2	2
Methanol		,	3	3	3
CNG		,	4	4	4
Electricity		,	5	5	5
Gas/Meth	Gasoline	,	6	1	3
Gas/Meth	Methanol	,	6	3	1
Gas/CNG	Gasoline	,	7	1	4
Gas/CNG	CNG	,	7	4	1
Gas/Elec.	Gasoline	,	8	1	5
Gas/Elec.	Electricity	,	8	5	1
Gas/Meth HP	Gasoline	,	9	1	3
Gas/Meth HP	Methanol	,	9	3	1
FuelCell	M100	,	10	6	6
		,			
		,			
		,			
		,			
		,			
		,================================			

Table 5. Technology, Use, and Scrappage Parameters

VEHICLE TECHNOLOGY INPUT

10 Technology Type		Depreciation Rate	Use Rate Decline	New Veh. Miles	Price Difference ($10,000)	Hedonic Constant1	Hedonic Constant2	Marginal Utility
Gasoline	,	0.8418	-0.0521	14442	0.000	0	0	-100
Diesel	,	0.8418	-0.0521	14442	0.000	0	0	-100
Methanol	,	0.8418	-0.0521	14442	0.020	0	0	-100
CNG	,	0.8418	-0.0521	14442	0.000	0	0	-100
Electricity	,	0.8418	-0.0521	14442	0.000	0	0	-100
Gas/Meth	,	0.8418	-0.0521	14442	0.010	0	-2.21428	-100
Gas/CNG	,	0.8418	-0.0521	14442	0.000	0	-3.29574	-100
Gas/Elec.	,	0.8418	-0.0521	14442	0.000	0	-5.49290	-100
Gas/Meth HP	,	0.8418	-0.0521	18000	0.000	0	-0.42857	-100
FuelCell	,	0.8418	-0.0600	10000	0.000	0	0	-100
	,							
	,							
	,							
	,							
	,							
	,							
	,							
	,							
	,							
	,							
	,							

ELASTICITIES

Cost/Mile	,	-0.2
Income	,	0.5

SCRAPPAGE PARAMETERS

a0	,	0.7355
a1	,	6.0917

Table 6. New Vehicle Sales Forecast

30 NEW REGISTRATIONS (1000s)

1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
11140	10122	10999	10300	10500	10700	10900	11200	11400	11600	11700	11900	12000	12100	12200

Table 7. Age Distribution of Vehicles in Base Year

BASE YEAR STOCK
1985

STOCK BY AGE (1000s)

		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
	ALL	9815	2534	3713	4883	5196	4836	7195	8735	9503	9602	8502	8039	7322	7716	10401	6662
10																	
STOCK,	1	9815	2534	3713	4883	5196	4836	7195	8735	9408	9410	8162	7557	7029	7562	10297	6609
,	2	0	0	0	0	0	0	0	0	95	192	340	482	293	154	104	53
BY ,	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
,	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TECH.,	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
,	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
TYPES,	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
,	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
,	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
,	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

the stock broken down by technology type. The breakdown shown here is computed by the spreadsheet based on market shares described below.

3. Two types of fuel efficiency data must be supplied. The first is miles per gallon, or equivalent (table 8). For fuels like natural gas or electricity, any customary units can be used since conversion factors for energy content per unit must be specified below, in any case. Note that fuel efficiencies of the same technology type using different fuels may be different. For instance, the gasoline/methanol technology gets 27 MPG on gasoline and 15.9 MPG on methanol for model year 1983. Test cycle to on-road correction factors may also be specified if the original MPG estimates are not based on actual in-use estimates (table 9).

4. Market shares for each technology type and model year must also be provided (table 10). These are the market shares for each model year for new vehicle sales. The model will compute the evolution of market shares over time.

A vehicle price index (table 11) completes the list of vehicle data. This index is the Bureau of Labor Statistics price index for automobiles, light trucks, or heavy trucks (used for all but light trucks), divided by the implicit price deflator of the GNP. The vehicle price indices used in estimating the coefficients were indexed to 1967=100, whereas the GNP price deflator was indexed to 1972=100. The resulting price indexes have magnitudes of about 1.3 in 1984.

Table 8. Vehicle Efficiency Data

E
E 14

MPG:		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Gasoline		14.85	14.4	14.5	14.2	14.2	15.8	17.5	18.3	19.9	20.5	23.5	25.3	26.4	27	27.5	28	28.2	28.4	28.6	28.86
Diesel		14.85	14.4	14.5	14.2	14.2	15.8	17.5	18.3	32	30.2	29.6	29.4	30.6	31.8	36.2	36.2	35	33	32	30.21
Methanol		8.7352	8.4705	8.5294	8.3529	8.3529	9.2941	10.294	10.764	11.705	12.058	13.823	14.882	15.529	15.882	16.176	16.470	16.588	16.705	16.823	16.976
CNG		5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Electricity		0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gas/Meth	Gasoline	14.85	14.4	14.5	14.2	14.2	15.8	17.5	18.3	19.9	20.5	23.5	25.3	26.4	27	27.5	28	28.2	28.4	28.6	28.86
Gas/Meth	Methanol	8.7352	8.4705	8.5294	8.3529	8.3529	9.2941	10.294	10.764	11.705	12.058	13.823	14.882	15.529	15.882	16.176	16.470	16.588	16.705	16.823	16.976
Gas/CNG	Gasoline	14.85	14.4	14.5	14.2	14.2	15.8	17.5	18.3	19.9	20.5	23.5	25.3	26.4	27	27.5	28	28.2	28.4	28.6	28.86
Gas/CNG	CNG	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5
Gas/Elec.	Gasoline	14.85	14.4	14.5	14.2	14.2	15.8	17.5	18.3	19.9	20.5	23.5	25.3	26.4	27	27.5	28	28.2	28.4	28.6	28.86
Gas/Elec.	Electricity	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gas/Meth HP	Gasoline	14.85	14.4	14.5	14.2	14.2	15.8	17.5	18.3	19.9	20.5	23.5	25.3	26.4	27	27.5	28	28.2	28.4	28.6	28.86
Gas/Meth HP	Methanol	8.7352	8.4705	8.5294	8.3529	8.3529	9.2941	10.294	10.764	11.705	12.058	13.823	14.882	15.529	15.882	16.176	16.470	16.588	16.705	16.823	16.976
FuelCell	M100	10	10	10	10	10	10	10	10	10	10	10	12	14	15	16	17	18	18	18	20

Table 9. Test Cycle vs. On-Road Efficiency Correction Factors

14

MPG CORRECTION:		1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Gasoline		0.85	0.85	0.85	0.85	0.85	0.86	0.85	0.85	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Diesel		0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.92	0.93	0.91	0.94	0.92	0.92	0.91	0.92	0.92	0.92	0.92	0.92	0.92
Methanol		0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
CNG		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Electricity		1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gas/Meth	Gasoline	0.85	0.85	0.85	0.85	0.85	0.86	0.85	0.85	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Gas/Meth	Methanol	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
Gas/CNG	Gasoline	0.85	0.85	0.85	0.85	0.85	0.86	0.85	0.85	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Gas/CNG	CNG	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gas/Elec.	Gasoline	0.85	0.85	0.85	0.85	0.85	0.86	0.85	0.85	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Gas/Elec.	Electricity	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Gas/Meth HP	Gasoline	0.85	0.85	0.85	0.85	0.85	0.86	0.85	0.85	0.84	0.85	0.85	0.85	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Gas/Meth HP	Methanol	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
FuelCell	M100	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 10. Technology Type Market Shares

E 10

MARKET SHARES:	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Gasoline	100%	100%	100%	100%	100%	100%	100%	100%	99%	98%	96%	94%	96%	98%	99%	99%	100%	99%	99%	99%
Diesel	0%	0%	0%	0%	0%	0%	0%	0%	1%	2%	4%	6%	4%	2%	1%	1%	0%	1%	1%	1%
Methanol	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
CNG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Electricity	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gas/Meth	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gas/CNG	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gas/Elec.	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Gas/Meth HP	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
FuelCell	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

Table 11. Vehicle Price Index

VEHICLE PRICES
(UNIT = $10,000 in Base Year $)

1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

Table 12. Fuel Prices

FUEL PRICES (In Base Year $)

6

TECH. FUEL	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline ,	1.15	1.19	0.82	0.85	0.89	0.92	0.98	1.06	1.15	1.19	1.23	1.26	1.31	1.36	1.41	1.44
Diesel ,	0.78	1.16	0.87	0.91	0.95	1	1.09	1.17	1.24	1.37	1.46	1.51	1.59	1.66	1.74	1.81
Methanol ,	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
CNG ,	0.44	0.44	0.43	0.42	0.43	0.45	0.46	0.51	0.53	0.55	0.57	0.57	0.57	0.57	0.57	0.57
Electricity,	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07	0.07
FuelCell ,	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65

Table 13. Base Year Total Fuel Use
(for Calibrated Run)

```
BASE YEAR,          6
FUEL USE
----------TECH. FUEL
 71626400  Gasoline
   868060  Diesel
        0  Methanol
        0  CNG
        0  Electricity
        0  FuelCell

=====================
```

5. Information on fuels is the final ingredient in the model's data requirements. Fuel prices for each fuel type and forecast year must be entered (table 12). Note that these must be in the same units as the efficiency data. That is, if CNG vehicle efficiency is defined in cubic feet per mile then price must be in dollars per cubic foot. Next, total fuel use in the base year may be entered (table 13). This is needed only if a run calibrated to match the given base year fuel use is desired.

Fuels may be defined as being composed of other elementary, chemical fuels (table 14). For example, the primary fuel type methanol is defined as 15% gasoline, 85% methanol (i.e. M85). "Fuel cell" is defined as 100% methanol. The sum of percentages across a row must equal 100. These blend percentages are used to compute the total amount of chemical methanol consumed, as opposed to M85. Last but not least, the energy content of each elementary chemical fuel type must be defined (table 15). Again, these numbers are used by the report generator to compute total energy use as opposed to the volumes of fuel consumed.

This completes the items of data required for a model run. Note that most data will have to be separately entered for each vehicle type. As a result, setting up the first model run will be very time consuming. Fortunately, succeeding forecasts should be much easier since a great deal of data will not need to be changed.

Table 14. Definition of Primary Fuel-Type Blends
in Terms of Chemical Fuel Types

Since some fuels are a blend of only a certain percentage of itself plus some other available fuels, there is a table that shows each fuel's composition. The fuel name in each row represents primary fuel type, and fuel name in each column represents the blended fuel type.

FUEL BLEND COMPOSITIONS

6

		Gasoline	Diesel	Methanol	CNG	Electricity	FuelCell
Gasoline	,	100%	0%	0%	0%	0%	0%
Diesel	,	0%	100%	0%	0%	0%	0%
Methanol	,	15%	0%	85%	0%	0%	0%
CNG	,	0%	0%	0%	100%	0%	0%
Electricity	,	0%	0%	0%	0%	100%	0%
FuelCell	,	0%	0%	100%	0%	0%	0%
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						
	,						

Table 15.

FUEL ENERGY CONTENTS
6

FUEL TYPE		BTUs/GALLON
Gasoline	,	125000
Diesel	,	138100
Methanol	,	64600
CNG	,	1030
Electricity	,	3412
FuelCell	,	64600
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	
	,	

REFERENCES

1. Alson, J.A., J.M. Adler, and T.M. Baines, 1988. "The Motor Vehicle Emission Characteristics and Air Quality Impacts of Methanol and Compressed Natural Gas," presented at the Symposium on Transportation Fuels in the 1990's and Beyond, Monterey, California, July 17-19, 1988.

2. Cato, D., M. Rodekohr, and J. Sweeney, 1976. "The Capital Stock Adjustment Process and the Demand for Gasoline: A Market Share Approach," in Econometric Dimensions of Energy Demand and Supply, Askin and Kraft, eds., D.C. Heath and Co., Lexington, MA.

3. Chow, G.C. 1957. Demand for Automobiles in the United States, North Holland Publishing Co., Amsterdam.

4. Danielson, A.L. and M.L. Agarwal, 1976. "A Functional Form Analysis of the Demand for Refined Petroleum Products," Proceedings of the Third Annual UMR-MEC Conference on Energy, University of Missouri, Rolla, October 12-14, 1975.

5. DeLuchi, M.A., R.A. Johnston, and D. Sperling, 1988. "Methanol vs. Natural Gas Vehicles: A Comparison of Resource Supply, Performance, Emissions, Fuel Storage, Safety, Costs, and Transitions," SAE Technical Paper Series 881656, Society of Automotive Engineers, Warrendale, PA.

6. Energy and Environmental Analysis, Inc., 1975. "Gasoline Consumption Model," prepared for the Federal Energy Administration, Washington, D.C. by EEA, Inc., Arlington, VA.

7. Energy and Environmental Analysis, Inc., 198X. "Regional and Seasonal

8. Energy and Environmental Analysis, Inc., 1988. "Characterization of Future Flexible Fuel Vehicle Attributes," prepared for the Office of Policy Integration, U.S. Department of Energy, October, 1988.

9. Environmental Protection Agency, Office of Air and Radiation, Office of Mobile Sources, Emission Control Technology Division, Test and Evaluation Branch, 1984. "User's Guide to MOBILE3," EPA 460/3-84-002, Ann Arbor, Michigan, June, 1984.

10. Greene, D.L., 1981. "The Aggregate Demand for Gasoline and Highway Passenger Vehicles in the United States: A Review of the Literature 1938-1978," ORNL-5728, Oak Ridge National Laboratory, Oak Ridge, TN.

11. Greene, D.L., 1981. "State-Level Stock System Model of Gasoline Demand," Transportation Research Record, no. 801, Transportation Research Board, National Research Council, Washington, D.C.

12. Greene, D.L., 1984. "A Derived Demand Model of Regional Highway Diesel Fuel Use," Transportation Research, B vol. 18B, no. 1, pp. 43-61, 1984.

13. Greene, D.L., 1987. "Depreciation & Scrappage

14. Greene, D.L. 1987. "Long-Run Vehicle Travel Predictions from Demographic Trends," presented at the 66th Annual Meeting of the Transportation Research Board, January 12-15, Washington, D.C., and forthcoming, Transportation Research Record.

15. Greene, D.L., 1988. "Motor Fuel Choice: An Econometric Analysis," forthcoming, Transportation Research A.

16. Greene, D.L., and C.K. Chen, 1981. "Scrappage and Survival Rates of Passenger Cars and Trucks in the U.S., 1966-77," Transportation Research A, vol. 15A, no. 5, pp. 383-389, October, 1981.

17. Greene, D.L. and P.S. Hu, "A Functional Form Analysis of the Short-Run Demand for Travel and Gasoline by One-Vehicle Households," Transportation Research Record, 1092, pp. 10-15, Transportation Research Board, Washington, D.C.

18. Greene, D.L., N. Meddeb, and J.T. Liu, 1986. "Vehicle Stock Modeling of Highway Energy Use: Tunisian and U.S. Applications," Energy Policy, pp. 437-446, October, 1986.

19. Kitamura, R. and D. Sperling, 1987. "Refueling Behavior of Automobile Drivers," Transportation Research A, vol. 21A, no. 3, pp. 235-245.

20. Kouris, G., 1983. "Fuel Consumption for Road Transport in the USA," Energy Economics, vol. 5, no. 2, pp. 89-99.

21. Kulp, G. and M.C. Holcomb, 1982, Transportation Energy Data Book, Edition 6, ORNL-5883, p. 67, Oak Ridge National Laboratory, Oak Ridge, TN.

22. McFadden, D., 1974. "Conditional Logit Analysis of Qualitative Choice Behavior," in Frontiers of Econometrics, P. Zarembka, ed., Academic Press, NY.

23. Morlan, T.H., D.H. Skelly, and A.P. Reznek, 1981. "Price Elasticities of Demand for Motor Gasoline and Other Petroleum Products," DOE/EIA-0291, U.S. Department of Energy, Energy Information Administration, Washington, D.C., May.

24. Parks, R.W., 1977. "Determinants of Scrapping Rates for Postwar Vintage Automobiles," Econometrica, vol. 45, pp. 1099-1115.

25. Sperling, D. and K.S. Kurani, 1987. "Refueling and the Vehicle Purchase Decision: the Diesel Car Case," SAE Technical Paper Series, 870644, Society of Automotive Engineers, Warrendale, PA.

26. Train, K., 1986. Qualitative Choice Analysis, The MIT Press, Cambridge, MA.

27. Wheaton, W.C., 1982. "The Long-Run Structure of Transportation and Gasoline Demand," The Bell Journal of Economics, vol. 13, no. 2, Autumn, pp. 439-454.

28. Wykoff, F., 1973. "A User Cost Approach to New Automobile Purchases," The Review of Economic Studies, vol. 40, no. 123, pp. 377-390.

APPENDIX 1 SAMPLE FORECAST REPORTS

PAGE

1.1 GROSS FORECAST A1-1

1.2 PRIMARY OUTPUT REPORT A1-7

1.3 SECONDARY OUTPUT REPORT A1-17

A1.1 GROSS FORECAST

YEAR	ENERGY USE	VMT	NUM. VEHICLES	FUEL USE		
1985	7842669002752	1132429952	114654	Gasoline		61977496
				Diesel		691394
				Methanol		0
				CNG		0
				Electricity		0
				FuelCell	M1	0
				TOTAL:		62668890
1986	7579212185600	1151134464	113871	Gasoline		59969408
				Diesel		601276
				Methanol		0
				CNG		0
				Electricity		0
				FuelCell	M1	0
				TOTAL:		60570684
1987	7955321192448	1266880512	113151	Gasoline		62966012
				Diesel		612380
				Methanol		0
				CNG		0
				Electricity		0
				FuelCell	M1	0
				TOTAL:		63578392
1988	7773579902976	1290221056	112984	Gasoline		61530380
				Diesel		595815
				Methanol		0
				CNG		0
				Electricity		0
				FuelCell	M1	0
				TOTAL:		62126195
1989	7600768286720	1308954368	112916	Gasoline		60169524
				Diesel		576236
				Methanol		0
				CNG		0
				Electricity		0
				FuelCell	M1	0
				TOTAL:		60745760

1990	7431095058432	1331303808	113000	Gasoline	58816304
				Diesel	554428
				Methanol	38550
				CNG	0
				Electricity	0
				FuelCell M1	0
				****************************	
				TOTAL:	59409282
1991	7281321181184	1348602752	113490	Gasoline	57617224
				Diesel	530289
				Methanol	91876
				CNG	0
				Electricity	0
				FuelCell M1	0
				****************************	
				TOTAL:	58239389
1992	7167368757248	1364255488	114296	Gasoline	56676104
				Diesel	509545
				Methanol	193307
				CNG	0
				Electricity	0
				FuelCell M1	0
				****************************	
				TOTAL:	57378956
1993	7078561185792	1382513408	115422	Gasoline	55803796
				Diesel	492684
				Methanol	542524
				CNG	0
				Electricity	0
				FuelCell M1	0
				****************************	
				TOTAL:	56839004
1994	7089907302400	1415341824	116784	Gasoline	55579460
				Diesel	472518
				Methanol	1195351
				CNG	0
				Electricity	0
				FuelCell M1	0
				****************************	
				TOTAL:	57247329
1995	7098144915456	1451163648	118324	Gasoline	55136824
				Diesel	458391
				Methanol	2209576
				CNG	0
				Electricity	0
				FuelCell M1	0
				****************************	
				TOTAL:	57804791

1996	7149410320384	1489260288	119940	Gasoline	54858308
				Diesel	451464
				Methanol	3556881
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	58866653
1997	7201911472128	1524365824	121645	Gasoline	54194312
				Diesel	444968
				Methanol	5668303
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	60307583
1998	7276683853824	1560857088	123371	Gasoline	53387716
				Diesel	442531
				Methanol	8391736
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	62221983
1999	7364488462336	1598607232	125085	Gasoline	52377064
				Diesel	439715
				Methanol	11712553
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	64529332
2000	7482305937408	1640846464	126735	Gasoline	51634496
				Diesel	442282
				Methanol	14967724
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	67044502
2001	7592402747392	1680887296	128345	Gasoline	50169904
				Diesel	445132
				Methanol	19499876
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	70114912

2002	7706597916672	1721261568	129899	Gasoline	48572084
				Diesel	448483
				Methanol	24352196
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	73372763
2003	7824042622976	1761659008	131415	Gasoline	46979192
				Diesel	451831
				Methanol	29245298
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	76676321
2004	7924253982720	1808886144	132871	Gasoline	45334488
				Diesel	455802
				Methanol	33970540
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	79760830
2005	8034412134400	1852930560	134291	Gasoline	43570016
				Diesel	459650
				Methanol	39081772
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	83111438
2006	8165683363840	1893625344	135658	Gasoline	42013196
				Diesel	463710
				Methanol	44117584
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	86594490
2007	8301869268992	1934444160	136985	Gasoline	40748076
				Diesel	467628
				Methanol	48665336
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	89881040

2008	8445064904704	1976040448	138275	Gasoline	39562940
				Diesel	471965
				Methanol	53165928
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	93200833
2009	8595288096768	2018128128	139533	Gasoline	38548948
				Diesel	475795
				Methanol	57445236
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	96469979
2010	8748785467392	2060488448	140770	Gasoline	37753640
				Diesel	481251
				Methanol	61348600
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	99583491
2011	8911249735680	2102972544	141988	Gasoline	37192296
				Diesel	486734
				Methanol	64938000
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	102617030
2012	9077497266176	2145846784	143193	Gasoline	36812936
				Diesel	492230
				Methanol	68233792
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	105538958
2013	9251984506880	2190479872	144400	Gasoline	36379472
				Diesel	497770
				Methanol	71761736
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	108638978

2014	9433053659136	2236274432	145592	Gasoline	35994624
				Diesel	503347
				Methanol	75297424
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	111795395
2015	9619137101824	2282795264	146798	Gasoline	35752448
				Diesel	508976
				Methanol	78634544
				CNG	0
				Electricity	0
				FuelCell M1	0
				TOTAL:	114895968

END OF REPORT

A1.2 PRIMARY OUTPUT REPORT

1985

"Autos "

STOCK

TECHNOLOGY TYPES	NEW REGISTRATIONS	TOTAL STOCK
Gasoline	0	112941
Diesel	0	1713
Methanol	0	0
CNG	0	0
Electricity	0	0
Gas/Meth	0	0
Gas/CNG	0	0
Gas/Elec.	0	0
Gas/Meth HP	0	0
FuelCell	0	0
TOTAL:	0	114654

TECHNOLOGY FUEL TYPES		VMT
Gasoline		1112835456
Diesel		19594434
Methanol		0
CNG		0
Electricity		0
Gas/Meth	Gasoline	0
Gas/Meth	Methanol	0
Gas/CNG	Gasoline	0
Gas/CNG	CNG	0
Gas/Elec.	Gasoline	0
Gas/Elec.	Electricity	0
Gas/Meth HP	Gasoline	0
Gas/Meth HP	Methanol	0
FuelCell	M100	0
TOTAL:		1132429952

TECHNOLOGY FUEL TYPES (Blends are not disaggregated)		FUEL	GENERIC FUEL TYPES (Blends are disaggregated)		FUEL
Gasoline		61977496	Gasoline		61977496
Diesel		691394	Diesel		691394
Methanol		0	Methanol		0
CNG		0	CNG		0
Electricity		0	Electricity		0
Gas/Meth	Gasoline	0	FuelCell	M1	0
Gas/Meth	Methanol	0			
Gas/CNG	Gasoline	0			
Gas/CNG	CNG	0			
Gas/Elec.	Gasoline	0			
Gas/Elec.	Electricity	0			
Gas/Meth HP	Gasoline	0			
Gas/Meth HP	Methanol	0			
FuelCell	M100	0			
TOTAL:		62668888	TOTAL:		62668888

TECHNOLOGY FUEL TYPES		EFFICIENCY (MPG)
Gasoline		18.0
Diesel		28.0
Methanol		0.0
CNG		0.0
Electricity		0.0
Gas/Meth	Gasoline	0.0
Gas/Meth	Methanol	0.0
Gas/CNG	Gasoline	0.0
Gas/CNG	CNG	0.0
Gas/Elec.	Gasoline	0.0
Gas/Elec.	Electricity	0.0
Gas/Meth HP	Gasoline	0.0
Gas/Meth HP	Methanol	0.0
FuelCell	M100	0.0
AVERAGE (BTUs/MILE): (In thousands)		6.93

TOTALS ------

NEW REGISTRATIONS	STOCK	VMT	FUEL USE		
0	114654	1132429952	Gasoline		61977496
			Diesel		691394
			Methanol		0
			CNG		0
			Electricity		0
			FuelCell	M1	0
			TOTAL:		62668890

1990

"Autos "

STOCK

TECHNOLOGY TYPES	NEW REGISTRATIONS	TOTAL STOCK
Gasoline	10290	111356
Diesel	105	1574
Methanol	0	0
CNG	0	0
Electricity	0	0
Gas/Meth	0	0
Gas/CNG	0	0
Gas/Elec.	0	0
Gas/Meth HP	0	0
FuelCell	105	70
TOTAL:	10500	113000

TECHNOLOGY FUEL TYPES		VMT
Gasoline		1314651648
Diesel		15881229
Methanol		0
CNG		0
Electricity		0
Gas/Meth	Gasoline	0
Gas/Meth	Methanol	0
Gas/CNG	Gasoline	0
Gas/CNG	CNG	0
Gas/Elec.	Gasoline	0
Gas/Elec.	Electricity	0
Gas/Meth HP	Gasoline	0
Gas/Meth HP	Methanol	0
FuelCell	M100	771001
TOTAL:		1331303808

TECHNOLOGY FUEL TYPES (Blends are not disaggregated)		FUEL	GENERIC FUEL TYPES (Blends are disaggregated)		FUEL
Gasoline		58816304	Gasoline		58816304
Diesel		554428	Diesel		554428
Methanol		0	Methanol		38550
CNG		0	CNG		0
Electricity		0	Electricity		0
Gas/Meth	Gasoline	0	FuelCell	M1	0
Gas/Meth	Methanol	0			
Gas/CNG	Gasoline	0			
Gas/CNG	CNG	0			
Gas/Elec.	Gasoline	0			
Gas/Elec.	Electricity	0			
Gas/Meth HP	Gasoline	0			
Gas/Meth HP	Methanol	0			
FuelCell	M100	38550			
TOTAL:		59409280	TOTAL:		59409280

TECHNOLOGY FUEL TYPES		EFFICIENCY (MPG)
Gasoline		22.0
Diesel		29.0
Methanol		0.0
CNG		0.0
Electricity		0.0
Gas/Meth	Gasoline	0.0
Gas/Meth	Methanol	0.0
Gas/CNG	Gasoline	0.0
Gas/CNG	CNG	0.0
Gas/Elec.	Gasoline	0.0
Gas/Elec.	Electricity	0.0
Gas/Meth HP	Gasoline	0.0
Gas/Meth HP	Methanol	0.0
FuelCell	M100	20.0
AVERAGE (BTUs/MILE): (In thousands)		5.58

TOTALS ------

NEW REGISTRATIONS	STOCK	VMT	FUEL USE		
10500	113000	1331303808	Gasoline		58816304
			Diesel		554428
			Methanol		38550
			CNG		0
			Electricity		0
			FuelCell	M1	0
			TOTAL:		59409282

1995

"Autos "

STOCK

TECHNOLOGY TYPES	NEW REGISTRATIONS	TOTAL STOCK
Gasoline	7656	107096
Diesel	116	1337
Methanol	0	0
CNG	0	0
Electricity	0	0
Gas/Meth	2900	7734
Gas/CNG	0	0
Gas/Elec.	0	0
Gas/Meth HP	464	979
FuelCell	464	1178
TOTAL:	11600	118324

TECHNOLOGY FUEL TYPES		VMT
Gasoline		1284875136
Diesel		13460070
Methanol		0
CNG		0
Electricity		0
Gas/Meth	Gasoline	98811152
Gas/Meth	Methanol	21741372
Gas/CNG	Gasoline	0
Gas/CNG	CNG	0
Gas/Elec.	Gasoline	0
Gas/Elec.	Electricity	0
Gas/Meth HP	Gasoline	8331894
Gas/Meth HP	Methanol	10919746
FuelCell	M100	13024193
TOTAL:		1451163648

TECHNOLOGY FUEL TYPES (Blends are not disaggregated)		FUEL	GENERIC FUEL TYPES (Blends are disaggregated)		FUEL
Gasoline		50880444	Gasoline		55136824
Diesel		458391	Diesel		458391
Methanol		0	Methanol		2209576
CNG		0	CNG		0
Electricity		0	Electricity		0
Gas/Meth	Gasoline	3654570	FuelCell	M1	0
Gas/Meth	Methanol	1306414			
Gas/CNG	Gasoline	0			
Gas/CNG	CNG	0			
Gas/Elec.	Gasoline	0			
Gas/Elec.	Electricity	0			
Gas/Meth HP	Gasoline	307600			
Gas/Meth HP	Methanol	654969			
FuelCell	M100	542400			
TOTAL:		57804792	TOTAL:		57804792

TECHNOLOGY FUEL TYPES		EFFICIENCY (MPG)
Gasoline		25.0
Diesel		29.0
Methanol		0.0
CNG		0.0
Electricity		0.0
Gas/Meth	Gasoline	27.0
Gas/Meth	Methanol	17.0
Gas/CNG	Gasoline	0.0
Gas/CNG	CNG	0.0
Gas/Elec.	Gasoline	0.0
Gas/Elec.	Electricity	0.0
Gas/Meth HP	Gasoline	27.0
Gas/Meth HP	Methanol	17.0
FuelCell	M100	24.0
AVERAGE (BTUs/MILE): (In thousands)		4.89

TOTALS ------

NEW REGISTRATIONS	STOCK	VMT	FUEL USE		
11600	118324	1451163648	Gasoline		55136824
			Diesel		458391
			Methanol		2209576
			CNG		0
			Electricity		0
			FuelCell	M1	0
			TOTAL:		57804791

2000

"Autos "

STOCK

TECHNOLOGY TYPES	NEW REGISTRATIONS	TOTAL STOCK
Gasoline	6100	92353
Diesel	122	1286
Methanol	0	0
CNG	0	0
Electricity	0	0
Gas/Meth	4270	24455
Gas/CNG	0	0
Gas/Elec.	0	0
Gas/Meth HP	1098	4777
FuelCell	610	3864
TOTAL:	12200	126735

TECHNOLOGY FUEL TYPES		VMT
Gasoline		1126797312
Diesel		14068903
Methanol		0
CNG		0
Electricity		0
Gas/Meth	Gasoline	178535808
Gas/Meth	Methanol	185904240
Gas/CNG	Gasoline	0
Gas/CNG	CNG	0
Gas/Elec.	Gasoline	0
Gas/Elec.	Electricity	0
Gas/Meth HP	Gasoline	12943106
Gas/Meth HP	Methanol	80065168
FuelCell	M100	42531912
TOTAL:		1640846464

TECHNOLOGY FUEL TYPES (Blends are not disaggregated)		FUEL	GENERIC FUEL TYPES (Blends are disaggregated)		FUEL
Gasoline		42287112	Gasoline		51634496
Diesel		442282	Diesel		442282
Methanol		0	Methanol		14967724
CNG		0	CNG		0
Electricity		0	Electricity		0
Gas/Meth	Gasoline	6512712	FuelCell	M1	0
Gas/Meth	Methanol	11018605			
Gas/CNG	Gasoline	0			
Gas/CNG	CNG	0			
Gas/Elec.	Gasoline	0			
Gas/Elec.	Electricity	0			
Gas/Meth HP	Gasoline	471335			
Gas/Meth HP	Methanol	4736963			
FuelCell	M100	1575491			
TOTAL:		67044500	TOTAL:		67044500

TECHNOLOGY FUEL TYPES		EFFICIENCY (MPG)
Gasoline		27.0
Diesel		32.0
Methanol		0.0
CNG		0.0
Electricity		0.0
Gas/Meth	Gasoline	27.0
Gas/Meth	Methanol	17.0
Gas/CNG	Gasoline	0.0
Gas/CNG	CNG	0.0
Gas/Elec.	Gasoline	0.0
Gas/Elec.	Electricity	0.0
Gas/Meth HP	Gasoline	27.0
Gas/Meth HP	Methanol	17.0
FuelCell	M100	27.0
AVERAGE (BTUs/MILE): (In thousands)		4.56

TOTALS ------

NEW REGISTRATIONS	STOCK	VMT	FUEL USE		
12200	126735	1640846464	Gasoline		51634496
			Diesel		442282
			Methanol		14967724
			CNG		0
			Electricity		0
			FuelCell	M1	0
			TOTAL:		67044502

2005

"Autos "

STOCK

TECHNOLOGY TYPES	NEW REGISTRATIONS	TOTAL STOCK
Gasoline	4317	75061
Diesel	127	1347
Methanol	0	0
CNG	0	0
Electricity	0	0
Gas/Meth	5713	40656
Gas/CNG	0	0
Gas/Elec.	0	0
Gas/Meth HP	1270	9721
FuelCell	1270	7506
TOTAL:	12697	134291

TECHNOLOGY FUEL TYPES		VMT
Gasoline		938899520
Diesel		15069962
Methanol		0
CNG		0
Electricity		0
Gas/Meth	Gasoline	71153848
Gas/Meth	Methanol	543735168
Gas/CNG	Gasoline	0
Gas/CNG	CNG	0
Gas/Elec.	Gasoline	0
Gas/Elec.	Electricity	0
Gas/Meth HP	Gasoline	4061724
Gas/Meth HP	Methanol	184721744
FuelCell	M100	95288528
TOTAL:		1852930560

TECHNOLOGY FUEL TYPES (Blends are not disaggregated)		FUEL	GENERIC FUEL TYPES (Blends are disaggregated)		FUEL
Gasoline		34379040	Gasoline		43570016
Diesel		459650	Diesel		459650
Methanol		0	Methanol		39081772
CNG		0	CNG		0
Electricity		0	Electricity		0
Gas/Meth	Gasoline	2587818	FuelCell	M1	0
Gas/Meth	Methanol	32127776			
Gas/CNG	Gasoline	0			
Gas/CNG	CNG	0			
Gas/Elec.	Gasoline	0			
Gas/Elec.	Electricity	0			
Gas/Meth HP	Gasoline	147652			
Gas/Meth HP	Methanol	10908944			
FuelCell	M100	2500559			
TOTAL:		83111440	TOTAL:		83111440

TECHNOLOGY FUEL TYPES		EFFICIENCY (MPG)
Gasoline		27.0
Diesel		33.0
Methanol		0.0
CNG		0.0
Electricity		0.0
Gas/Meth	Gasoline	27.0
Gas/Meth	Methanol	17.0
Gas/CNG	Gasoline	0.0
Gas/CNG	CNG	0.0
Gas/Elec.	Gasoline	0.0
Gas/Elec.	Electricity	0.0
Gas/Meth HP	Gasoline	28.0
Gas/Meth HP	Methanol	17.0
FuelCell	M100	38.0
AVERAGE (BTUs/MILE): (In thousands)		4.34

TOTALS ------

NEW REGISTRATIONS	STOCK	VMT	FUEL USE		
12697	134291	1852930560	Gasoline		43570016
			Diesel		459650
			Methanol		39081772
			CNG		0
			Electricity		0
			FuelCell	M1	0
			TOTAL:		83111438

SECONDARY OUTPUT REPORT

NEW REGISTRATIONS

"Autos "

	1985	1986	1987	1988	1989	1990	1991	1992
Gasoline	0	11140	10021	10889	10197	10290	10486	9592
Diesel	0	0	101	110	103	105	107	109
Methanol	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Gas/Meth	0	0	0	0	0	0	0	981
Gas/CNG	0	0	0	0	0	0	0	0
Gas/Elec.	0	0	0	0	0	0	0	0
Gas/Meth HP	0	0	0	0	0	0	0	109
FuelCell	0	0	0	0	0	105	107	109
TOTAL:	0	11140	10122	10999	10300	10500	10700	10900
GRAND TOTAL:	0	11140	10122	10999	10300	10500	10700	10900

VEHICLE STOCK

"Autos "

	1985	1986	1987	1988	1989	1990	1991	1992
Gasoline	112941	112199	111500	111338	111297	111356	111792	111816
Diesel	1713	1672	1651	1646	1619	1574	1522	1469
Methanol	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Gas/Meth	0	0	0	0	0	0	0	654
Gas/CNG	0	0	0	0	0	0	0	0
Gas/Elec.	0	0	0	0	0	0	0	0
Gas/Meth HP	0	0	0	0	0	0	0	73
FuelCell	0	0	0	0	0	70	176	284
TOTAL:	114654	113871	113151	112984	112916	113000	113490	114296
GRAND TOTAL:	114654	113871	113151	112984	112916	113000	113490	114296

FUEL USE

"Autos "

		1985	1986	1987	1988	1989	1990	1991	1992
Gasoline		61977496	59969408	62966012	61530380	60169524	58816304	57617224	56245044
Diesel		691394	601276	612380	595815	576236	554428	530289	509545
Methanol		0	0	0	0	0	0	0	0
CNG		0	0	0	0	0	0	0	0
Electricity		0	0	0	0	0	0	0	0
Gas/Meth	Gasoline	0	0	0	0	0	0	0	380877
Gas/Meth	Methanol	0	0	0	0	0	0	0	37135
Gas/CNG	Gasoline	0	0	0	0	0	0	0	0
Gas/CNG	CNG	0	0	0	0	0	0	0	0
Gas/Elec.	Gasoline	0	0	0	0	0	0	0	0
Gas/Elec.	Electricity	0	0	0	0	0	0	0	0
Gas/Meth HP	Gasoline	0	0	0	0	0	0	0	41035
Gas/Meth HP	Methanol	0	0	0	0	0	0	0	23860
FuelCell	M100	0	0	0	0	0	38550	91876	141461
TOTAL:		62668888	60570684	63578392	62126196	60745760	59409280	58239388	57378956
GRAND TOTAL:		62668888	60570684	63578392	62126196	60745760	59409280	58239388	57378956

VMT BY TECHNOLOGY TYPES

"Autos "

	1985	1986	1987	1988	1989	1990	1991	1992
Gasoline	1112835456	1134033536	1249386880	1273120000	1292405504	1314651648	1331564672	1334536192
Diesel	19594434	17100948	17493644	17101064	16548817	15881229	15126807	14504604
Methanol	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Gas/Meth	0	0	0	0	0	0	0	10694178
Gas/CNG	0	0	0	0	0	0	0	0
Gas/Elec.	0	0	0	0	0	0	0	0
Gas/Meth HP	0	0	0	0	0	0	0	1475968
FuelCell	0	0	0	0	0	771001	1911252	3044594
TOTAL:	1132429952	1151134464	1266880512	1290221056	1308954368	1331303808	1348602752	1364255488
GRAND TOTAL:	1132429952	1151134464	1266880512	1290221056	1308954368	1331303808	1348602752	1364255488

END OF REPORT

SECONDARY OUTPUT REPORT

NEW REGISTRATIONS

"Autos "

	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	8624	7752	7656	6903	6902	6840	6776	6100
Diesel	112	114	116	117	119	120	121	122
Methanol	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Gas/Meth	2016	2850	2900	3510	3570	3600	3630	4270
Gas/CNG	0	0	0	0	0	0	0	0
Gas/Elec.	0	0	0	0	0	0	0	0
Gas/Meth HP	224	342	464	585	714	840	968	1098
FuelCell	224	342	464	585	595	600	605	610
TOTAL:	11200	11400	11600	11700	11900	12000	12100	12200
GRAND TOTAL:	11200	11400	11600	11700	11900	12000	12100	12200

VEHICLE STOCK

"Autos "

	1993	1994	1995	1996	1997	1998	1999	2000
Gasoline	110955	109206	107096	104437	101527	98597	95666	92353
Diesel	1420	1372	1337	1311	1293	1281	1282	1286
Methanol	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Gas/Meth	2322	4883	7734	10971	14387	17738	20975	24455
Gas/CNG	0	0	0	0	0	0	0	0
Gas/Elec.	0	0	0	0	0	0	0	0
Gas/Meth HP	258	559	979	1515	2169	2935	3807	4777
FuelCell	467	764	1178	1706	2269	2820	3355	3864
TOTAL:	115422	116784	118324	119940	121645	123371	125085	126735
GRAND TOTAL:	115422	116784	118324	119940	121645	123371	125085	126735

FUEL USE

		"Autos 1993	" 1994	1995	1996	1997	1998	1999	2000
Gasoline		54393972	52751300	50880444	49066864	47156512	45438196	43859020	42287112
Diesel		492684	472518	458391	451464	444968	442531	439715	442282
Methanol		0	0	0	0	0	0	0	0
CNG		0	0	0	0	0	0	0	0
Electricity		0	0	0	0	0	0	0	0
Gas/Meth	Gasoline	1241664	2471642	3654570	4886352	5754248	6211088	6245590	6512712
Gas/Meth	Methanol	242581	654740	1306414	2180120	3722073	5820250	8473737	11018605
Gas/CNG	Gasoline	0	0	0	0	0	0	0	0
Gas/CNG	CNG	0	0	0	0	0	0	0	0
Gas/Elec.	Gasoline	0	0	0	0	0	0	0	0
Gas/Elec.	Electricity	0	0	0	0	0	0	0	0
Gas/Meth HP	Gasoline	112169	208826	307600	413399	459892	471538	453386	471335
Gas/Meth HP	Methanol	130693	329880	654969	1097815	1769003	2625686	3653399	4736963
FuelCell	M100	225241	358424	542400	770636	1000888	1212691	1404487	1575491
TOTAL:		56839000	57247328	57804792	58866652	60307584	62221980	64529336	67044500
GRAND TOTAL:		56839000	57247328	57804792	58866652	60307584	62221980	64529336	67044500

VMT BY TECHNOLOGY TYPES

	"Autos 1993	" 1994	1995	1996	1997	1998	1999	2000
Gasoline	1321140352	1305119360	1284875136	1257787776	1223776512	1190963840	1159751552	1126797312
Diesel	14048500	13634877	13460070	13463654	13520236	13664595	13856580	14068903
Methanol	0	0	0	0	0	0	0	0
CNG	0	0	0	0	0	0	0	0
Electricity	0	0	0	0	0	0	0	0
Gas/Meth	37126292	77146072	120552536	169366752	219500368	267756064	313810112	364440064
Gas/CNG	0	0	0	0	0	0	0	0
Gas/Elec.	0	0	0	0	0	0	0	0
Gas/Meth HP	5141134	11055815	19251638	29681184	42348524	57201304	74133760	93008264
FuelCell	5057189	8385872	13024193	18960864	25220068	31271212	37055132	42531912
TOTAL:	1382513408	1415342080	1451163648	1489260288	1524365824	1560856960	1598607232	1640846464
GRAND TOTAL:	1382513408	1415342080	1451163648	1489260288	1524365824	1560856960	1598607232	1640846464

END OF REPORT

APPENDIX 2. AMFU PROGRAM LISTING

```
'****************************************************************************
'****************************************************************************
'**                                                                        **
'** TITLE:        VEHICLE STOCK AND ALTERNATIVE FUEL USE FORECAST MODEL    **
'**                                                                        **
'** DESCRIPTION:  This model estimates alternative fuel demand and vehicle**
'**               stock under various market development scenarios, for   **
'**               any given number of Vehicle types, Fuel types, Vintages **
'**               and Technology types.  It is also capable of handling    **
'**               Flexible Fuel Technology Types.                          **
'**                                                                        **
'** DEVELOPED BY: ANJU RATHI                                               **
'**               DAVID L. GREENE      FEB. 1988                           **
'**                                                                        **
'****************************************************************************
'****************************************************************************

'***************************************************
'**   SUBROUTINE DECLARATION SECTION             **
'***************************************************
DECLARE SUB ReplaceVmatrix ()
DECLARE SUB WriteVstock (t%, v%)
DECLARE SUB InitFuelCalibConst ()
DECLARE SUB SetupCalibConst (v%)
DECLARE SUB WriteNewReg (t%, v%)
DECLARE SUB GetInput (ErrorCode%)
DECLARE SUB WriteVMT (a%, t%, v%)
DECLARE SUB GetVinput (v%, ErrorCode%)
DECLARE SUB WriteFUELandVMT (a%, t%, v%)
DECLARE SUB Forecast (Iteration%, Calibrated%, ErrorCode%)

'***************************************************
'**  FUNCTION DECLARATION SECTION                **
'***************************************************
DECLARE FUNCTION Scrappage! (h%, a%, t%)
DECLARE FUNCTION RelativeMiles! (h%, a%)
DECLARE FUNCTION Ratio! (f%, o%, h%, t%)
DECLARE FUNCTION TotalMiles! (v%, f%, g%, h%, a%, t%)

'***************************************************
'**  VARIABLE TYPES SECTION                      **
'***************************************************

TYPE VehRec
    VehicleName      AS STRING * 17
    SelectionFlag    AS STRING * 10
END TYPE

TYPE VehTechRec
    TechName         AS STRING * 23
    DeprecRate       AS SINGLE
    DeclinUse        AS SINGLE
    PriceDiff        AS SINGLE
    Miles0YrOld      AS SINGLE
    HedonicConst1    AS SINGLE
```

```
    HedonicConst2     AS SINGLE
    MarginalUtil      AS SINGLE
END TYPE

TYPE FuelRec
    FuelName          AS STRING * 15
    BaseYearFuelUse   AS SINGLE
END TYPE

TYPE EfficiencyRec
    GPM               AS SINGLE
    GPMcorrection     AS SINGLE
END TYPE

TYPE TechCombRec
    TechFuelName      AS STRING * 22
    Tech              AS INTEGER
    Chosen            AS INTEGER
    Other             AS INTEGER
END TYPE

TYPE EconomyRec
    Income            AS SINGLE
    GNP               AS SINGLE
END TYPE

TYPE ForeRec
    Fuel              AS SINGLE
    VMT               AS SINGLE
END TYPE

DEFINT A-Z          'Default variable type is integer
CONST true = -1, false = 0

OPEN "OPTN.PRN" FOR INPUT AS #8          'Run type (calibrated/uncalibrated)

'**************************************************
'**  ARRAY DIMENSIONS SECTION                   **
'**************************************************
DIM SHARED NumFuel%          ' Number of Fuel types
DIM SHARED NumVeh%           ' Number of Vehicle types
DIM SHARED NumAge%           ' Number of Vintages
DIM SHARED NumYear%          ' Number of Years
DIM SHARED SaveNumYear%      ' Store number of years for second run
DIM SHARED NumTech%          ' Number of Technology types
DIM SHARED NumTechFuel%      ' Number of Technology Fuel types

NumFuel% = 1
NumVeh% = 1
NumAge% = 1
NumYear% = 1
NumTech% = 1
NumTechFuel% = 1

'****************************************************************************
```

```
'** INPUT VARIABLES AND ARRAYS SECTION                                    *
'*************************************************************************

'       ***************************************
'       * Parameters from PARS.PRN File       *
'       ***************************************

DIM SHARED ParameterA0!          ' Asymptotic scrappage rate
DIM SHARED ParameterA1!          ' Effect of vehicle price on scrappage rate
DIM SHARED Cost1MileElasticity!  ' Cost per mile Elasticity
DIM SHARED IncomeElasticity!     ' Cost per mile Elasticity
DIM SHARED BaseYear%             ' Base Year

'Contains Vehicle names and a Selection Flag
DIM SHARED VehicleTypes(1 TO NumVeh)    AS VehRec

'Contains Technology Name, Depreciation rate, DeclinInUse rate, Price Difference for Vehicle,
'Miles for 0 yr old vehicle, Hedonic Constant for current and Alterate Fuel and Cost per mile elasticity.
DIM SHARED VehTech(1 TO NumTech)        AS VehTechRec

'Contains Technical Fuel Name, Chosen Fuel Type and  Alternative Fuel Type.
DIM SHARED TechComb(1 TO NumTechFuel)   AS TechCombRec

'       ***************************************
'       * Stock Data from STK.PRN File        *
'       ***************************************

'New Registration for forecast years
DIM SHARED NewRegistration(1 TO NumYear)                      AS SINGLE

'Current year's Vehicle Stock by vintage and Technology Types.
DIM SHARED Vstock(0 TO NumAge, 1 TO NumTech)                  AS SINGLE

'Last year's Vehicle Stock by vintage and Technology Types.
DIM SHARED LVstock(0 TO NumAge, 1 TO NumTech)                 AS SINGLE

'Market Shares for Technology Type, Vintage and Forcast Years.
DIM SHARED MarketShare(1 TO NumTech, (0 - NumAge) TO NumYear)    AS SINGLE

'Contains GPM and GPM correction factor for Technical Fuel Types, Vintages and Forecast Years. fuel type
X vintage + 1 + forecast years)
DIM SHARED Efficiency(1 TO NumTechFuel, (0 - NumAge) TO NumYear)  AS EfficiencyRec

'       ***************************************
'       * Forecast Data from FORE.PRN File *
'       ***************************************

'Fuel prices for Generic Fuel types by Forecast Years.
DIM SHARED FuelPrice(1 TO NumFuel, 0 TO NumYear) AS SINGLE

'Contains Fuel name and Base Year Fuel Use.
DIM SHARED Fuel(1 TO NumFuel)               AS FuelRec

'Income and GNP for Forecast Years.
DIM SHARED Economy(0 TO NumYear)            AS EconomyRec
```

```
'Price of a new vehicle for Forecast Years.
DIM SHARED VehiclePrice(0 TO NumYear)          AS SINGLE

'**************************************************************************
'**  OUTPUT ARRAYS SECTION                                                **
'**************************************************************************

'VMT for Technology Types.
DIM SHARED ForeVMT(1 TO NumTech)                 AS SINGLE

'Total Fuel Use and VMT for Technology Fuel Types.
DIM SHARED FUELandVMT(1 TO NumTechFuel)          AS ForeRec

'Total New Registrations for Technology Types.
DIM SHARED TechNewReg(1 TO NumTech)              AS SINGLE

'Generic Fuel Use for each vehicle.
DIM SHARED CalibFuelUse(1 TO NumFuel)            AS SINGLE

'Generic Fuel Calibration Constant for each Vehicle Type.
DIM SHARED CalibFuelConst(1 TO NumVeh, 1 TO NumFuel) AS SINGLE


'**************************************************************************
'**                                                                      **
'** CODE BEGINS HERE !!                                                  **
'**                        INPUT FILE                                    **
'** OPTN.PRN - Contains run type (calibrated or uncalibrated).           **
'**                                                                      **
'**************************************************************************

Start:  INPUT #8, Option$
        Option$ = LTRIM$(RTRIM$(UCASE$(Option$)))

        ErrorCode% = 0
        Iteration% = 1

        SELECT CASE Option$
           CASE "UNCALIBRATED"

              Calibrated% = false
              CALL Forecast(Iteration%, Calibrated%, ErrorCode%)

              SELECT CASE ErrorCode%

                 CASE 0
                    COLOR 7, 0: PRINT "Uncalibrated Run Completed "; : COLOR 2, 0: PRINT "SUCCESSFULLY!!!"

                 CASE ELSE
                    COLOR 7, 0: PRINT "Uncalibrated Run Completed "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"

              END SELECT

           CASE "CALIBRATED"
```

```
                Calibrated% = true
                CALL Forecast(Iteration%, Calibrated%, ErrorCode%)

                IF ErrorCode% = 0 THEN
                   Iteration% = 2

                   CALL Forecast(Iteration%, Calibrated%, ErrorCode%)
                   SELECT CASE ErrorCode%

                      CASE 0
                          COLOR 7, 0: PRINT "Calibrated Run Completed "; : COLOR 2, 0: PRINT "SUCCESSFULLY!!!"

                      CASE ELSE
                          COLOR 7, 0: PRINT "Calibrated Run Completed "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"

                   END SELECT
                ELSE
                   COLOR 7, 0: PRINT "Calibrated Run Completed "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"
                END IF

             CASE "EXIT"
                GOTO DONE

             CASE ELSE

                PRINT "Valid Selections are: 'uncalibrated', 'calibrated' or 'exit'"

             END SELECT

             BEEP

             FOR i% = 1 TO 4
               FOR j% = 1 TO 3000
               ' WAIT LOOP
               NEXT j%
             NEXT i%


DONE:  CLOSE #8
       END

DEFSNG A-Z
'**************************************************************************
'*                       SUB PROCEDURE ** Forecast **                     *
'*                                                                        *
'* Operation:  This Subroutine Forecasts Vehicle Stock, Fuel Use and      *
'*                 Vehicle Miles Travelled.  It calls subroutine          *
'*                 "GetInput" to read global data, and calls              *
'*                 "GetVinput" to read data pertaining a specific         *
'*                 vehicle type.                                          *
'* Calibrated Run:  It runs only for base year during the first           *
'*                 iteration, and sets up the Fuel calibration            *
'*                 constant table for each vehicle type; during the       *
'*                 second iteration it runs for desired number of         *
```

```
'*                  years.                                              *
'*                                                                      *
'* Uncalibrated Run:  It runs for desired number of years during        *
'*                    the first iteration, with Fuel calibration        *
'*                    constant = 1.                                     *
'*                                                                      *
'* Input:       Reads the following files, which may be created from    *
'*              Lotus-123 spreadsheets.                                 *
'* MASTER.PRN - Contains Vehicle Types, Forecast Dimensions, Economy    *
'*              (Income and GNP) figures and Base year fuel use.        *
'* PARS.PRN -   Contains all the parameters for a specific Vehicle      *
'*              type.                                                   *
'* STKS.PRN -   Contains Base year stock, New Registrations,            *
'*              Efficiencies and Market Shares for a specific vehicle   *
'*              type.                                                   *
'* FORE.PRN -   Contains Vehicle, Fuel Prices and Base Year Fuel Use.   *
'*                                                                      *
'* Output:      Creates the following Files.                            *
'* FUEL.PRN   - Contains Fuel use.                                      *
'* VMT.PRN    - Contains Vehicle Miles Travelled for technology types.  *
'* VMTFUEL.PRN- Contains Vehicle Miles Travelled for tech. fuel types.  *
'* STOCK.PRN  - Contains Vehicle Stock.                                 *
'* NEWREG.PRN - Contains New Registrations.                             *
'*                                                                      *
'* Parameter(s):  Iteration number  -  Iteration%                       *
'*                Calibrated??      -  Calibrated%                      *
'*                Error Code        -  ErrorCode%                       *
'*                                                                      *
'* Subroutine(s)  GetInput                                              *
'* Called:        GetVinput                                             *
'*                InitFuelCalibConst                                    *
'*                Ratio                                                 *
'*                RelativeMiles                                         *
'*                ReplaceVmatrix                                        *
'*                Scrappage                                             *
'*                SetupFuelCalibConst                                   *
'*                TotalMiles                                            *
'*                WriteFUELandVMT                                       *
'*                WriteVMT                                              *
'*                WriteNewReg                                           *
'*                WriteVstock                                           *
'*                                                                      *
'* Routine(s)     Mainfore.bas                                          *
'* Called by:                                                           *
'*                                                                      *
'************************************************************************
SUB Forecast (Iteration%, Calibrated%, ErrorCode%)

DEFINT A-Z               ' Default variable type is integer

CONST true = -1, false = 0

OPEN "FUEL.PRN" FOR OUTPUT AS #4        ' Forecast Fuel USE.
OPEN "VMT.PRN" FOR OUTPUT AS #5         ' Forecast VMT by Tech types.
OPEN "STOCK.PRN" FOR OUTPUT AS #6       ' Forecast Vehicle Stock.
```

```
OPEN "VMTFUEL.PRN" FOR OUTPUT AS #9       ' Forecast VMT by Tech Fuel types.
OPEN "NEWREG.PRN" FOR OUTPUT AS #10       ' New Registration by Tech. types.

IF Iteration% = 1 THEN   ' Need to read Master information only once.

    OPEN "MASTER.PRN" FOR INPUT AS #7   ' Input independent of vehicle type.

    CALL GetInput(ErrorCode%)

    IF ErrorCode <> 0 THEN
        GOTO Finished
    END IF

    CLOSE #7
END IF

ProcVehNum% = 0
FOR v% = 1 TO NumVeh                                ' Loop over vehicle types

    IF LTRIM$(RTRIM$(UCASE$(VehicleTypes(v%).SelectionFlag))) = "Y" THEN
        OPEN "V" + LTRIM$(RTRIM$(STR$(v%))) + "PARS.PRN" FOR INPUT AS #1      'Parameters file
        OPEN "V" + LTRIM$(RTRIM$(STR$(v%))) + "STKS.PRN" FOR INPUT AS #2      'Stock Data file
        OPEN "V" + LTRIM$(RTRIM$(STR$(v%))) + "FORE.PRN" FOR INPUT AS #3      'Fuel and Vehicle prices file
        ProcVehNum% = ProcVehNum% + 1
    ELSE
        GOTO NextVeh
    END IF



    IF (Calibrated% = false) AND (Iteration% = 1) THEN   ' for uncalibrated run veh. info. needs to be read only once.
        CALL GetVinput(v%, ErrorCode%)
        IF ErrorCode <> 0 THEN
            GOTO Finished
        END IF
    END IF

    IF Calibrated% = true THEN
        IF (Iteration% = 1) AND (ProcVehNum% > 1) THEN  ' Restore NumYear% for rest of the vehicle types.
            NumYear% = SaveNumYear%
        END IF

        IF Iteration% = 2 THEN
            NumYear% = SaveNumYear%
        END IF

        CALL GetVinput(v%, ErrorCode%)
        IF ErrorCode <> 0 THEN
            GOTO Finished
        END IF
    END IF

    IF (Iteration% = 1) AND (ProcVehNum% = 1) THEN
        REDIM CalibFuelConst(1 TO NumVeh, 1 TO NumFuel)        AS SINGLE
        CALL InitFuelCalibConst
```

```
END IF

IF (Calibrated% = true) AND (Iteration% = 1) THEN
    SaveNumYear% = NumYear%
    NumYear% = 0
END IF

FOR t% = 0 TO NumYear                           ' Loop over forecast years

    REDIM CalibFuelUse(1 TO NumFuel)            AS SINGLE

    REDIM TechNewReg(1 TO NumTech)              AS SINGLE

    FOR a% = 0 TO NumAge                        ' Loop over vintages

        REDIM FUELandVMT(1 TO NumTechFuel)      AS ForeRec
        REDIM ForeVMT(1 TO NumTech)             AS SINGLE

        FOR g% = 1 TO NumTechFuel               ' Loop over Technology fuel types

            f% = TechComb(g).Chosen
            h% = TechComb(g).Tech

            IF TechComb(g).Chosen = TechComb(g).Other THEN
                FlexFuel = false
            ELSE
                FlexFuel = true
                o% = TechComb(g).Other
            END IF

            Scrap! = Scrappage(h%, a%, t%)

            ' COMPUTE STOCK
            IF t% > 0 THEN
                SELECT CASE a%
                    CASE 0
                        Vstock(a%, h%) = NewRegistration(t%) * MarketShare(h%, t% - a%) / 100 * 2 / 3
                        TechNewReg(h%) = NewRegistration(t%) * MarketShare(h%, t% - a%) / 100
                    CASE 1
                        Vstock(a%, h%) = LVstock(a% - 1, h%) * (1 - Scrap!) * 3 / 2

                    CASE NumAge    'Scrappage rate with age 20 is being used for vehicles 15 and over years old.
                        Scrap2! = Scrappage(h%, 20, t%)
                        Vstock(a%, h%) = (LVstock(a% - 1, h%) * (1 - Scrap!)) + (LVstock(a%, h%) * (1 - Scrap2!))

                    CASE ELSE
                        Vstock(a%, h%) = LVstock(a% - 1, h%) * (1 - Scrap!)

                END SELECT
            END IF

            RelMiles! = RelativeMiles(h%, a%)
```

```
                NewVehMiles! = TotalMiles(v%, f%, g%, h%, a%, t%)

                IF FlexFuel = true THEN
                   FuelRatio! = Ratio(f%, o%, h%, t%)
                ELSE
                   FuelRatio! = 1!
                END IF

                VehMiles! = FuelRatio! * Vstock(a%, h%) * RelMiles! * NewVehMiles!
                TotalFuelUse! = VehMiles! * (Efficiency(g%, t% - a%).GPM / Efficiency(g%, t% - a%).GPMcorrection)

                ForeVMT(h%) = VehMiles! + ForeVMT(h%)

                FUELandVMT(g%).Fuel = TotalFuelUse!
                FUELandVMT(g%).VMT = VehMiles!

                CalibFuelUse(f%) = CalibFuelUse(f%) + TotalFuelUse!
             NEXT g%
             'total by age

             CALL WriteFUELandVMT(a%, t%, v%)
             CALL WriteVMT(a%, t%, v%)
          NEXT a%
          'total by year

          CALL WriteNewReg(t%, v%)
          CALL WriteVstock(t%, v%)
          CALL ReplaceVmatrix
       NEXT t%
           'total by vehicle type

          IF (Calibrated% = true) AND (Iteration% = 1) THEN
             CALL SetupCalibConst(v%)
          END IF
          CLOSE #1
          CLOSE #2
          CLOSE #3
NextVeh:
NEXT v%

Finished:  CLOSE #4
           CLOSE #5
           CLOSE #6
           CLOSE #9
           CLOSE #10

END SUB

'***********************************************************************
'*                      SUB PROCEDURE GetInput                         *
'*                                                                     *
'* Operation:     Reads all of the input that is independent of vehicle*
'*                type.                                                *
'*                                                                     *
'* Parameter(s):  ErrorCode%                                           *
```

```
'*                                                                        *
'**************************************************************************
SUB GetInput (ErrorCode%)

'******************************************************
'* Read Vehicle Types Table                           *
'******************************************************
LINE INPUT #7, BlankLine$
INPUT #7, NumVeh%: INPUT #7, heading$
LINE INPUT #7, BalnkLine$
LINE INPUT #7, DashLine$: LINE INPUT #7, heading$: LINE INPUT #7, DashLine$

REDIM VehicleTypes(1 TO NumVeh)                          AS VehRec
FOR k% = 1 TO NumVeh%
   INPUT #7, VehicleTypes(k%).VehicleName
   INPUT #7, VehicleTypes(k%).SelectionFlag
NEXT k%

FOR k% = 1 TO (10 - NumVeh)
   LINE INPUT #7, nothing$
NEXT k%
LINE INPUT #7, DashLine$

'******************************************************
'* Read Base Year, Num of Forecast Years and Vintages*
'******************************************************
FOR AdvanceLine% = 1 TO 4
   LINE INPUT #7, BlankLine$
NEXT AdvanceLine%

LINE INPUT #7, heading$
LINE INPUT #7, DashLine$: LINE INPUT #7, BlankLine$
INPUT #7, BaseYear$: INPUT #7, BaseYear%
INPUT #7, NumForeYears$: INPUT #7, NumYear%
INPUT #7, NumVintage$: INPUT #7, NumAge%

'******************************************************
'* Read Income by Year                                *
'******************************************************
FOR AdvanceLine% = 1 TO 15
   LINE INPUT #7, BlankLine$
NEXT AdvanceLine%

INPUT #7, NumYear%: INPUT #7, heading$
LINE INPUT #7, BlankLine$
LINE INPUT #7, years$
LINE INPUT #7, DashLine$

REDIM Economy(0 TO NumYear)                              AS EconomyRec

INPUT #7, Names$
FOR k% = 0 TO NumYear
   INPUT #7, Economy(k%).Income
NEXT k%
```

```
'*******************************************************
'* Read GNP by Year                                    *
'*******************************************************
INPUT #7, Names$

FOR k% = 0 TO NumYear
    INPUT #7, Economy(k%).GNP
NEXT k%

END SUB

'*************************************************************************
'*                    SUB PROCEDURE GetVinput                            *
'*                                                                       *
'* Operation:     Reads all of the input for a specific vehicle type.    *
'*                                                                       *
'* Parameter(s):  Vehicle Type - v%                                      *
'*                Error Code   - ErrorCode%                              *
'*                                                                       *
'*************************************************************************
SUB GetVinput (v%, ErrorCode%)

'*******************************************************
'* Load Technology Combination Table                   *
'*******************************************************
LINE INPUT #1, BlankLine$
LINE INPUT #1, heading$: LINE INPUT #1, BlankLine$
INPUT #1, NumTechFuel%
LINE INPUT #1, heading$

REDIM TechComb(1 TO NumTechFuel)                            AS TechCombRec

FOR k% = 1 TO NumTechFuel
    INPUT #1, TechComb(k%).TechFuelName
    INPUT #1, TechComb(k%).Tech
    INPUT #1, TechComb(k%).Chosen
    INPUT #1, TechComb(k%).Other
NEXT k%
FOR k% = 1 TO (20 - NumTechFuel)
   LINE INPUT #1, nothing$
NEXT k%
LINE INPUT #1, DashLine$


'*******************************************************
'* Load VehTech array                                  *
'*******************************************************
FOR AdvanceLine% = 1 TO 4
    LINE INPUT #1, BlankLine$
NEXT AdvanceLine%

LINE INPUT #1, heading$
INPUT #1, NumTech%
LINE INPUT #1, heading$: LINE INPUT #1, heading$: LINE INPUT #1, DashLine$
```

```
REDIM VehTech(1 TO NumTech)                         AS VehTechRec

FOR k% = 1 TO NumTech
    INPUT #1, VehTech(k%).TechName
    INPUT #1, VehTech(k%).DeprecRate
    INPUT #1, VehTech(k%).DeclinUse
    INPUT #1, VehTech(k%).MilesOYrOld
    INPUT #1, VehTech(k%).PriceDiff
    INPUT #1, VehTech(k%).HedonicConst1
    INPUT #1, VehTech(k%).HedonicConst2
    INPUT #1, VehTech(k%).MarginalUtil
NEXT k%
FOR k% = 1 TO (21 - NumTech)
    LINE INPUT #1, nothing$
NEXT k%
LINE INPUT #1, DashLine$

'*****************************************************
'* Read rest of the parameters for this vehicle type *
'*****************************************************
FOR AdvanceLine% = 1 TO 3
    LINE INPUT #1, BlankLine$
NEXT AdvanceLine%

LINE INPUT #1, heading$: LINE INPUT #1, DashLine$
INPUT #1, Names$
INPUT #1, Cost1MileElasticity!
INPUT #1, Names$
INPUT #1, IncomeElasticity!

LINE INPUT #1, DashLine$: LINE INPUT #1, BlankLine$
LINE INPUT #1, heading$: LINE INPUT #1, DashLine$
INPUT #1, Names$
INPUT #1, ParameterA0!
INPUT #1, Names$
INPUT #1, ParameterA1!
LINE INPUT #1, DashLine$


'*****************************************************
'* Load Base Year Stock                              *
'*****************************************************
LINE INPUT #2, BlankLine$
LINE INPUT #2, heading$: INPUT #2, BaseYear%
LINE INPUT #2, BlankLine$: LINE INPUT #2, heading$: LINE INPUT #2, BlankLine$
LINE INPUT #2, Vintages$
LINE INPUT #2, DashLine$
LINE INPUT #2, TotalStock$
INPUT #2, tNumTech%

REDIM Vstock(0 TO NumAge, 1 TO NumTech)  AS SINGLE
REDIM LVstock(0 TO NumAge, 1 TO NumTech) AS SINGLE

IF tNumTech% <> NumTech% THEN
```

```
    ErrorCode% = 1
    PRINT "Vehicle Type:  "; VehicleTypes(v%).VehicleName
    PRINT "Inconsistant Number of Technologies for Base Year Stock"
ELSE
    FOR technum% = 1 TO NumTech
        INPUT #2, headline$: INPUT #2, techtype%

        FOR vintage% = NumAge TO 0 STEP -1
            INPUT #2, Vstock(vintage%, technum%)
            LVstock(vintage%, technum%) = Vstock(vintage%, technum%)
        NEXT vintage%
    NEXT technum%
    FOR k% = 1 TO (20 - NumTech)
        LINE INPUT #2, nothing$
    NEXT k%
    LINE INPUT #2, DashLine$
END IF


'*****************************************************
'* Load New Registration array                       *
'*****************************************************
FOR AdvanceLine% = 1 TO 11
    LINE INPUT #2, BlankLine$
NEXT AdvanceLine%

INPUT #2, tNumYear%
INPUT #2, heading$
LINE INPUT #2, BlankLine$
LINE INPUT #2, years$
LINE INPUT #2, DashLine$

REDIM NewRegistration(1 TO NumYear%)                        AS SINGLE

IF tNumYear% <> NumYear% THEN
    ErrorCode% = 2
    PRINT "Vehicle Type:  "; VehicleTypes(v%).VehicleName
    PRINT "Inconsistant Number of Forecast Years for New Registrations"
ELSE
    FOR NewReg% = 1 TO NumYear
        INPUT #2, NewRegistration(NewReg%)
    NEXT NewReg%
END IF


'*****************************************************
'* Load Gallon per Mile Array                        *
'*****************************************************
FOR AdvanceLine% = 1 TO 3
    LINE INPUT #2, BlankLine$
NEXT AdvanceLine%

INPUT #2, tNumTechFuel%: INPUT #2, FuelTypes$
LINE INPUT #2, FuelTypes$
LINE INPUT #2, Commas$
```

```
REDIM Efficiency(1 TO NumTechFuel, (0 - NumAge) TO NumYear) AS EfficiencyRec

IF tNumTechFuel% <> NumTechFuel% THEN
    ErrorCode% = 3
    PRINT "Vehicle Type:  "; VehicleTypes(v%).VehicleName
    PRINT "Inconsistant Number of Technology Fuels for MPG"
ELSE
    FOR vintage% = (0 - NumAge) TO NumYear
        FOR TechFuel% = 1 TO NumTechFuel
            INPUT #2, MPG!

            IF MPG! = 0 THEN
                MPG! = 1
            END IF

            Efficiency(TechFuel%, vintage%).GPM = 1 / MPG!
        NEXT TechFuel%
    NEXT vintage%
    FOR k% = 1 TO (50 - (NumYear + NumAge))
        LINE INPUT #2, nothing$
    NEXT k%

END IF


'*******************************************************
'* Load Gallons per mile correction factor Array      *
'*******************************************************
FOR AdvanceLine% = 1 TO 1
    LINE INPUT #2, BlankLine$
NEXT AdvanceLine%

INPUT #2, tNumTechFuel%: INPUT #2, FuelTypes$
LINE INPUT #2, FuelTypes$
LINE INPUT #2, Commas$

IF tNumTechFuel% <> NumTechFuel% THEN
    ErrorCode% = 4
    PRINT "Vehicle Type:  "; VehicleTypes(v%).VehicleName
    PRINT "Inconsistant Number of Technology Fuels for MPG correction factor"
ELSE
    FOR vintage% = (0 - NumAge) TO NumYear
        FOR TechFuel% = 1 TO NumTechFuel
            INPUT #2, Efficiency(TechFuel%, vintage%).GPMcorrection
        NEXT TechFuel%
    NEXT vintage%

    FOR k% = 1 TO (50 - (NumYear + NumAge))
        LINE INPUT #2, nothing$
    NEXT k%
END IF


'*******************************************************
```

```
'* Load Market Share array                              *
'*******************************************************
FOR AdvanceLine% = 1 TO 1
   LINE INPUT #2, BlankLine$
NEXT AdvanceLine%

INPUT #2, tNumTech%: INPUT #2, TechTypes$
LINE INPUT #2, BlankLine$
LINE INPUT #2, Commas$

REDIM MarketShare(1 TO NumTech, (0 - NumAge) TO NumYear)    AS SINGLE

IF tNumTech% <> NumTech% THEN
   ErrorCode% = 5
   PRINT "Vehicle Type:  "; VehicleTypes(v%).VehicleName
   PRINT "Inconsistant Number of Technology Types for Market Shares"
ELSE
   FOR vintage% = (0 - NumAge) TO NumYear
      FOR techtype% = 1 TO NumTech
         INPUT #2, MarketShare(techtype%, vintage%)
      NEXT techtype%
   NEXT vintage%

END IF


'*******************************************************
'* Load Fuel Prices                                     *
'*******************************************************
LINE INPUT #3, BlankLine$
LINE INPUT #3, heading$: INPUT #3, nothing$: INPUT #3, NumFuel%
LINE INPUT #3, years$:
LINE INPUT #3, DashLine$

REDIM Fuel(1 TO NumFuel)                                    AS FuelRec
REDIM FuelPrice(1 TO NumFuel, 0 TO NumYear)                 AS SINGLE

NumFlexTech = NumTech - NumFuel
IF NumTechFuel <> NumFuel + NumFlexTech * 2 THEN
   ErrorCode% = 6
   PRINT "Vehicle Type:  "; VehicleTypes(v%).VehicleName
   PRINT "Incorrect Number of Fuels for Fuel Prices"
ELSE
   FOR k% = 1 TO NumFuel

      INPUT #3, Fuel(k%).BaseYearFuelUse

      INPUT #3, Fuel(k%).FuelName

      FOR year% = 0 TO NumYear
         INPUT #3, FuelPrice(k%, year%)
      NEXT year%

   NEXT k%
```

```
    FOR k% = 1 TO (20 - NumFuel)
        LINE INPUT #3, nothing$
    NEXT k%
    LINE INPUT #3, DashLine$
END IF


'*****************************************************
'* Load Vehicle Prices                               *
'*****************************************************
FOR AdvanceLine% = 1 TO 15
   LINE INPUT #3, BlankLine$
NEXT AdvanceLine%

LINE INPUT #3, heading$
LINE INPUT #3, BlankLine$
LINE INPUT #3, years$
LINE INPUT #3, DashLine$

REDIM VehiclePrice(0 TO NumYear)                    AS SINGLE

FOR year% = 0 TO NumYear
   INPUT #3, VehiclePrice(year%)
NEXT year%
LINE INPUT #3, DashLine$

END SUB

'**********************************************************************
'*                 SUB PROCEDURE InitFuelCalibConst                   *
'*                                                                    *
'* Operation:     Initializes all Fuel Calibration Constants to 1, for *
'*                each vehicle type.                                  *
'*                                                                    *
'* Parameter(s):  none.                                               *
'*                                                                    *
'**********************************************************************
SUB InitFuelCalibConst

FOR i% = 1 TO NumVeh%
   FOR j% = 1 TO NumFuel%
      CalibFuelConst(i%, j%) = 1
   NEXT j%
NEXT i%

END SUB

DEFSNG A-Z
'**********************************************************************
'*                    FUNCTION Ratio                                  *
'*                                                                    *
'* Operation:     Calculates the Choice Ratio for the given fuel type *
'*                over the other fuel type.                           *
'*                                                                    *
'* Parameter(s):  Fuel type          f%                               *
```

```
'*              Other Fuel type  -  o%                                *
'*              Technology type  -  h%                                *
'*              Current year     -  t%                                *
'*                                                                    *
'**********************************************************************
FUNCTION Ratio (f%, o%, h%, t%)

'*************************************************************************
'* Rule for determining which of two fuel choices is the current one:     *
'*                                                                         *
'*        If Chosen Fuel type#  < Other Fuel type# in Tech. Fuel Comb. table*
'*           Then HedonicConstant1 represents Chosen Fuel type   and       *
'*                HedonicConstant2 represents Other Fuel type.             *
'*                                                                         *
'*        If Chosen Fuel type#  > Other Fuel type# in Tech. Fuel Comb. table*
'*           Then HedonicConstant2 represents Chosen Fuel type   and       *
'*                HedonicConstant1 represents Other Fuel type.             *
'*************************************************************************

IF f% < o% THEN
   HedonicDiff! = VehTech(h%).HedonicConst2 - VehTech(h%).HedonicConst1
ELSE
   HedonicDiff! = VehTech(h%).HedonicConst1 - VehTech(h%).HedonicConst2
END IF

Temp! = 2 * VehTech(h%).MarginalUtil * (FuelPrice(f%, t%) - FuelPrice(o%, t%))

Ratio! = 1 / (1 + EXP(HedonicDiff! - Temp!))

END FUNCTION

'**********************************************************************
'*                    FUNCTION RelativeMiles                          *
'*                                                                    *
'* Operation:     Calculates the Ratio for the miles driven by a      *
'*                vehicle of age a%, vs. a vehicle of age 0.          *
'*                                                                    *
'* Parameter(s):  Technology type  -  h%                              *
'*                Vehicle Age      -  a%                              *
'*                                                                    *
'**********************************************************************
FUNCTION RelativeMiles (h%, a%)

RelativeMiles! = EXP(VehTech(h%).DeclinUse * a%)

END FUNCTION

'**********************************************************************
'*                    SUB PROCEDURE ReplaceVmatrix                    *
'*                                                                    *
'* Operation:     Replaces Last Year's Stock Matrix with Current Year's*
'*                Stock Matrix.                                       *
'*                                                                    *
'* Parameter(s):  none                                                *
'*                                                                    *
```

```
'*************************************************************************
SUB ReplaceVmatrix

FOR row% = 0 TO NumAge%

   FOR col% = 1 TO NumTech%
      LVstock(row%, col%) = Vstock(row%, col%)
   NEXT col%

NEXT row%

END SUB

'*************************************************************************
'*                  FUNCTION Scrappage                                   *
'*                                                                       *
'* Operation:     Calculates Scrappage rate for a vehicle of technology*
'*                type h% and age a% in year t%.                         *
'*                                                                       *
'* Parameter(s):  Technology type  -  h%                                 *
'*                Vehicle age      -  a%                                 *
'*                Current year     -  t%                                 *
'*                                                                       *
'*************************************************************************
FUNCTION Scrappage (h%, a%, t%)

CurrPrice! = (VehTech(h%).DeprecRate ^ a%) * (VehiclePrice(t%) + VehTech(h%).PriceDiff)

AdjustedPrice! = ParameterA0! + ParameterA1! * CurrPrice!

Scrappage! = 1 / (1 + EXP(AdjustedPrice!))

END FUNCTION

'*************************************************************************
'*                  SUB PROCEDURE SetupFuelCalibConst                    *
'*                                                                       *
'* Operation:     Sets Fuel Calibration Constant for all fuel types      *
'*                for given vehicle type by using this formula:          *
'*                                                                       *
'*                                         Estimated Fuel Gallons        *
'*                  Calibration const.(f) = ----------------------       *
'*                                         Forecasted Fuel Gallons       *
'*                                                                       *
'* Parameter(s):  vehicle type  -  v%                                    *
'*                                                                       *
'*************************************************************************
SUB SetupCalibConst (v%)

FOR calibfuel% = 1 TO NumFuel%

   IF (CalibFuelUse(calibfuel%) <> 0) AND (Fuel(calibfuel%).BaseYearFuelUse <> 0) THEN
      CalibFuelConst(v%, calibfuel%) = Fuel(calibfuel%).BaseYearFuelUse / CalibFuelUse(calibfuel%)
   END IF
NEXT calibfuel%
```

```
END SUB

'****************************************************************************
'*                    FUNCTION TotalMiles                                   *
'*                                                                          *
'* Operation:     Calculates average miles driven by a vehicle of           *
'*                technology type h% and vintage y% = t% - a%.              *
'*                                                                          *
'* Parameter(s):  Vehicle type           - v%                               *
'*                Fuel type              - f%                               *
'*                Technology fuel type   - g%                               *
'*                Technology type        - h%                               *
'*                Vehicle Age            - a%                               *
'*                Current year           - t%                               *
'*                                                                          *
'****************************************************************************
FUNCTION TotalMiles (v%, f%, g%, h%, a%, t%)

DollarPerMile! = FuelPrice(f%, t%) * Efficiency(g%, t% - a%).GPM

AdjustDollarMile! = CalibFuelConst(v%, f%) * ((DollarPerMile! / Efficiency(g%, t% - a%).GPMcorrection) ^ Cost1
MileElasticity!)
CalibrationFactor! = (FuelPrice(f%, 0) * Efficiency(g%, 0).GPM / Efficiency(g%, 0).GPMcorrection) ^ Cost1Mile
Elasticity!
Year0GNP! = Economy(0).GNP ^ IncomeElasticity!

Year0Income! = Economy(0).Income ^ IncomeElasticity!

IF LTRIM$(RTRIM$(UCASE$(VehicleTypes(v%).VehicleName))) = "GVW6 TRUCKS" OR LTRIM$(RTRIM$(UCASE$(VehicleTypes
              (V%).VehicleName)))) = "GVM7 TRUCKS" OR LTRIM$(R
TRIM$(UCASE$(VehicleTypes(v%).VehicleName))) = "GVW8 TRUCKS" THEN

   'For Heavy Trucks, use GNP

   AdjustedGNP! = Economy(t%).GNP ^ IncomeElasticity!

   TotalMiles! = (VehTech(h%).Miles0YrOld * AdjustDollarMile! * AdjustedGNP!) / (CalibrationFactor! * Year0GNP!)

   'For Light Trucks, Medium trucks or Cars use Income
ELSE

   AdjustedIncome! = Economy(t%).Income ^ IncomeElasticity!

   TotalMiles! = (VehTech(h%).Miles0YrOld * AdjustDollarMile! * AdjustedIncome!) / (CalibrationFactor!
        Year0Income!) END IF

END FUNCTION

DEFINT A-Z
'****************************************************************************
'*                    SUB PROCEDURE WriteFUELandVMT                         *
'*                                                                          *
'* Operation:  Creates FUEL USE file and VMT for tech. fuel types file*
'*             using the following format.                          *      *
'*                                                                          *
```

```
'*          (year)   (age)   (technology fuel type)                *
'*                            1    2    3  ...  NumTechFuel        *
'*        BaseYear     0      #    #    #  ...       #             *
'*                     1      #    #    #  ...       #             *
'*            .        .      .    .    .                          *
'*            .        .      .    .    .                          *
'*            .        .      .    .    .                          *
'*                  NumAge    #    #    #  ...       #             *
'*                                                                 *
'*                                                                 *
'*  BaseYear+NumYear   0      #    #    #  ...       #             *
'*                     1      #    #    #  ...       #             *
'*                     .      .    .    .                          *
'*                     .      .    .    .                          *
'*                     .      .    .    .                          *
'*                  NumAge    #    #    #  ...       #             *
'*                                                                 *
'* Parameter(s):  Vehicle Age  -  a%                               *
'*                Current year -  t%                               *
'*                Vehicle type -  v%                               *
'*                                                                 *
'*******************************************************************
SUB WriteFUELandVMT (a%, t%, v%)


IF (a% = 0) AND (t% = 0) THEN

   WRITE #4, " "
   WRITE #4, NumYear%
   WRITE #4, NumAge%
   WRITE #4, NumTechFuel%
   WRITE #4, " "

   WRITE #9, " "
   WRITE #9, NumYear%
   WRITE #9, NumAge%
   WRITE #9, NumTechFuel%
   WRITE #9, " "


   WRITE #4, "    FUEL USE    "
   WRITE #9, "    VMT BY TECHNOLOGY FUEL TYPES "

   WRITE #4, " "
   WRITE #4, VehicleTypes(v%).VehicleName

   WRITE #9, " "
   WRITE #9, VehicleTypes(v%).VehicleName

   WRITE #4, " "
   WRITE #4, " YEAR     AGE     TECHNOLOGY FUEL TYPES "

   WRITE #9, " "
   WRITE #9, " YEAR     AGE     TECHNOLOGY FUEL TYPES "
```

```
    PRINT #4, STRING$(4, " ");
    PRINT #9, STRING$(4, " ");

    FOR i% = 1 TO NumTechFuel%
        PRINT #4, USING "###############"; i%;
        PRINT #9, USING "###############"; i%;
    NEXT i%

    PRINT #4, " "
    PRINT #9, " "

END IF

FOR j% = 1 TO NumTechFuel%

    IF (a% = 0) AND (j% = 1) THEN
       PRINT #4, "      "
       PRINT #4, USING "######"; BaseYear + t%;

       PRINT #9, "      "
       PRINT #9, USING "######"; BaseYear + t%;
    ELSE
       PRINT #4, "      ";
       PRINT #9, "      ";
    END IF

    IF j% = 1 THEN
       PRINT #4, USING "######"; a%;
       PRINT #9, USING "######"; a%;
    END IF

    PRINT #4, USING "##########"; FUELandVMT(j%).Fuel;
    PRINT #9, USING "##########"; FUELandVMT(j%).VMT;

    IF j% = NumTechFuel% THEN
       PRINT #4, " "
       PRINT #9, " "
    END IF

NEXT j

IF a% = NumAge% THEN
   PRINT #4, " ": PRINT #4, " "
   PRINT #9, " ": PRINT #9, " "
END IF

END SUB

'*************************************************************************
'*                  SUB PROCEDURE WriteNewReg                            *
'*                                                                       *
'* Operation:  Creates New Registrations file using the following        *
'*             format.                                                   *
'*                                                                       *
'*             (year)  (age)  (technology types)                         *
```

```
'*                              1    2    3  ...    NumTech           *
'*          BaseYear      0     #    #    #  ...       #              *
'*                        1     #    #    #  ...       #              *
'*                 .      .                                           *
'*                 .      .                                           *
'*                 .      .                                           *
'*                     NumAge   #    #    #  ...       #              *
'*                                                                    *
'*                                                                    *
'*  BaseYear+NumYear      0     #    #    #  ...       #              *
'*                        1     #    #    #  ...       #              *
'*                 .      .                                           *
'*                 .      .                                           *
'*                 .      .                                           *
'*                     NumAge   #    #    #  ...       #              *
'*                                                                    *
'* Parameter(s):  Current year  -  t%                                 *
'*                Vehicle type  -  v%                                 *
'*                                                                    *
'**********************************************************************
SUB WriteNewReg (t%, v%)

IF t% = 0 THEN
   WRITE #10, " "
   WRITE #10, NumYear%
   WRITE #10, 0
   WRITE #10, NumTech%
   WRITE #10, " "

   WRITE #10, "          NEW REGISTRATIONS "
   WRITE #10, " "
   WRITE #10, VehicleTypes(v%).VehicleName
   WRITE #10, " "
   WRITE #10, "YEAR    AGE     TECHNOLOGY TYPES  "

   FOR i% = 1 TO NumTech
      PRINT #10, USING "############"; i%;
   NEXT i%
   PRINT #10, " "
END IF


FOR col% = 1 TO NumTech%
   IF col% = 1 THEN
      PRINT #10, "      "
      PRINT #10, USING "######"; BaseYear + t%;
      PRINT #10, USING "######"; 0;
   ELSE
      PRINT #10, "      ";
   END IF

   PRINT #10, USING "#########"; TechNewReg(col%);
NEXT col%
PRINT #10, " "
PRINT #10, " ": PRINT #10, " "
```

```
END SUB

'****************************************************************************
'*                    SUB PROCEDURE WriteVMT                                *
'*                                                                          *
'* Operation:  Creates VMT for technology types file using the              *
'*             following format.                                            *
'*                                                                          *
'*             (year)   (age)   (technology type)                           *
'*                                1    2    3  ...    NumTech               *
'*          BaseYear       0      #    #    #  ...       #                  *
'*                         1      #    #    #  ...       #                  *
'*               .         .      .    .    .                               *
'*               .         .      .    .    .                               *
'*               .         .      .    .    .                               *
'*                      NumAge    #    #    #  ...       #                  *
'*                                                                          *
'*                                                                          *
'*  BaseYear+NumYear       0      #    #    #  ...       #                  *
'*                         1      #    #    #  ...       #                  *
'*               .         .      .    .    .                               *
'*               .         .      .    .    .                               *
'*               .         .      .    .    .                               *
'*                      NumAge    #    #    #  ...       #                  *
'*                                                                          *
'* Parameter(s):  Vehicle Age  -  a%                                        *
'*                Current year -  t%                                        *
'*                Vehicle type -  v%                                        *
'*                                                                          *
'****************************************************************************
SUB WriteVMT (a%, t%, v%)

IF (a% = 0) AND (t% = 0) THEN
   WRITE #5, " "
   WRITE #5, NumYear%
   WRITE #5, NumAge%
   WRITE #5, NumTech%
   WRITE #5, " "

   WRITE #5, "    VMT        "

   WRITE #5, " "
   WRITE #5, VehicleTypes(v%).VehicleName

   WRITE #5, " "
   WRITE #5, " YEAR     AGE     TECHNOLOGY TYPES "

   PRINT #5, STRING$(4, " ");
   FOR i% = 1 TO NumTech%
      PRINT #5, USING "################"; i%;
   NEXT i%

   PRINT #5, " "
```

```
END IF

FOR j% = 1 TO NumTech%

   IF (a% = 0) AND (j% = 1) THEN
      PRINT #5, "      "
      PRINT #5, USING "######"; BaseYear + t%;
   ELSE
      PRINT #5, "      ";
   END IF

   IF j% = 1 THEN
      PRINT #5, USING "######"; a%;
   END IF

   PRINT #5, USING "###########"; ForeVMT(j%);

   IF j% = NumTech% THEN
      PRINT #5, " "
   END IF
NEXT j

IF a% = NumAge% THEN
   PRINT #5, " ": PRINT #5, " "
END IF

END SUB

'****************************************************************************
'*                  SUB PROCEDURE WriteVstock                               *
'*                                                                          *
'* Operation:  Creates Stock file using the following format.               *
'*                                                                          *
'*            (year)   (age)   (technology types)                           *
'*                               1    2    3  ...    NumTech                *
'*          BaseYear     0       #    #    #  ...       #                   *
'*                       1       #    #    #  ...       #                   *
'*               .       .                                                  *
'*               .       .                                                  *
'*               .       .                                                  *
'*                     NumAge    #    #    #  ...       #                   *
'*                                                                          *
'*                                                                          *
'*  BaseYear+NumYear     0       #    #    #  ...       #                   *
'*                       1       #    #    #  ...       #                   *
'*               .       .                                                  *
'*               .       .                                                  *
'*               .       .                                                  *
'*                     NumAge    #    #    #  ...       #                   *
'*                                                                          *
'* Parameter(s):  Current year  -  t%                                       *
'*                Vehicle type  -  v%                                       *
'*                                                                          *
'****************************************************************************
SUB WriteVstock (t%, v%)
```

```
 IF t% = 0 THEN

     WRITE #6, " "
     WRITE #6, NumYear%
     WRITE #6, NumAge%
     WRITE #6, NumTech%
     WRITE #6, " "

     WRITE #6, "            AUTOMOBILE STOCK  "
     WRITE #6, "   "
     WRITE #6, VehicleTypes(v%).VehicleName
     WRITE #6, "   "
     WRITE #6, "YEAR    AGE     TECHNOLOGY TYPES  "


     PRINT #6, STRINGS(7, " ");
     FOR i% = 1 TO NumTech
         PRINT #6, USING "########"; i%;
     NEXT i%
     PRINT #6, " "
 END IF

 FOR row% = 0 TO NumAge%
     IF row% = 0 THEN
         PRINT #6, "       "
         PRINT #6, USING "######"; BaseYear + t%;
     ELSE
         PRINT #6, "       ";
     END IF

     FOR col% = 1 TO NumTech%
         IF col% = 1 THEN
             PRINT #6, USING "######"; row%;
         END IF

         PRINT #6, USING "#########"; Vstock(row%, col%);
     NEXT col%
     PRINT #6, " "
 NEXT row%
 PRINT #6, " ": PRINT #6, " "

 END SUB
```

```
'****************************************************************************
'****************************************************************************
'**                                                                        **
'** TITLE:        VEHICLE STOCK AND ALTERNATIVE FUEL USE REPORTS           **
'**                                                                        **
'** DESCRIPTION:  This program generates two types of reports, Primary     **
'**               and Secondary.                                           **
'**                                                                        **
'** DEVELOPED BY: ANJU RATHI                                                **
'**               DAVID L. GREENE      FEB. 1988                           **
'**                                                                        **
'****************************************************************************
'****************************************************************************

DECLARE SUB ReadMaster ()

'*********************************************************
'**   SUBROUTINE DECLARATIONS  FOR PRIMARY REPORTS     **
'*********************************************************

DECLARE SUB ReadCombTable (v%)
DECLARE SUB Primary (ErrorCode%)
DECLARE SUB PrintPrimFuel (Year%, v%)
DECLARE SUB ReadMatrix (FileNum%, v%)
DECLARE SUB PrintPrimStock (Year%, v%)
DECLARE SUB ReadHeadings (FileNum%, v%)
DECLARE SUB pSetGenericFuels (Year%, v%, pv%)
DECLARE SUB ReadBlendComp (v%, ErroCode%)
DECLARE SUB PrintPrimary (NumVeh%, ErrorCode%)
DECLARE SUB PrintPrimVatEff (FileNum%, Year%, v%)

'*********************************************************
'**   SUBROUTINE DECLARATIONS  FOR SECONDARY REPORTS   **
'*********************************************************
DECLARE SUB SecReport (FileNum%)
DECLARE SUB SetUpPrintTotals (v%)
DECLARE SUB Secondary (ErrorCode%)
DECLARE SUB SetUpMatrix (v%, FileNum%)
DECLARE SUB sPrintMatrix (v%, FileNum%)
DECLARE SUB sPrintGrandTotals (NumVeh%)
DECLARE FUNCTION Pnumber% (col%)

'************************************************
'**  VARIABLE TYPES SECTION                    **
'************************************************

TYPE VehRec
    VehicleName       AS STRING * 17
    SelectionFlag     AS STRING * 10
END TYPE

TYPE TechCombRec
    TechFuelName      AS STRING * 24
    tech              AS INTEGER
    Chosen            AS INTEGER
```

```
    Other            AS INTEGER
END TYPE

TYPE StockRec
   NewReg            AS SINGLE
   Stock             AS SINGLE
END TYPE

TYPE FuelRec
   FuelName          AS STRING * 15
   Fuel              AS SINGLE
END TYPE

TYPE VehDimRec
   VehicleName       AS STRING * 20
   NumAge            AS INTEGER
   NumTech           AS INTEGER
   NumTechFuel       AS INTEGER
   NumFuel           AS INTEGER
END TYPE


DEFINT A-Z        'Default variable type is integer
CONST True = -1, False = 0

'************************************************
'** ARRAY DIMENSIONS SECTION                   **
'************************************************
DIM SHARED NumVehTypes%       ' Number of vehicle types
DIM SHARED NumYear%           ' Number of Years
DIM SHARED NumAge%            ' Number of vintages
DIM SHARED NumTech%           ' Number of Technology types
DIM SHARED NumTechFuel%       ' Number of Technology Fuel types
DIM SHARED NumFuel%           ' Number of Fuel types
DIM SHARED TotNumFuel%        ' Number of Fuel types
DIM SHARED VehicleName$       ' Vehicle Name
DIM SHARED BaseYear%          ' Base Year

NumYear% = 1
NumTech% = 1
NumFuel% = 1
TotNumFuel% = 1
NumTechFuel% = 1

'************************************************************************
'** INPUT ARRAYS AND VARIABLES SECTION                                  *
'************************************************************************

'Contains Technical fuel name, Technology type, Chosen fuel type and other fuel type.
DIM SHARED TechComb(1 TO 10, 1 TO 20)                   AS TechCombRec

'Contains Vehicle types and associated selection flag.
DIM SHARED VehicleTypes(1 TO 10)                        AS VehRec

'Contains Blend Composition for each generic fuel.
```

```
DIM SHARED BlendComp(1 TO 20, 1 TO 20)                    AS SINGLE

'Contains Energy Contents for each generic fuel.
DIM SHARED EnergyCont(1 TO 20)                            AS SINGLE

'Contains Veh. Name, Number of vintages, techs, tech.fuels and generic fuels for each vehicle type.
DIM SHARED PrimDim(1 TO 10)                               AS VehDimRec

'*************************************************************************
'** PRIMARY REPORT OUTPUT ARRAYS AND VARIABLES SECTION                  **
'*************************************************************************

'Keeps Stock for Primary Report.
DIM SHARED PrimaryStock(1 TO 10, 0 TO NumYear, 1 TO 20)      AS StockRec

'Keeps Vehicle Miles Travelled for Primary Report.
DIM SHARED PrimaryVMT(1 TO 10, 0 TO NumYear, 1 TO 20)        AS SINGLE

'Keeps Technical Fuel Use for Primary Report.
DIM SHARED PrimaryFuelUse(1 TO 10, 0 TO NumYear, 1 TO 20)    AS SINGLE

'Keeps Generic Fuel Use for Primary Report.
DIM SHARED GenericFuelUse(1 TO 20)                           AS FuelRec

'Keeps Total Generic Fuel Use for all the Generic Fuel types for given year and vehicle type.
DIM SHARED TotalGenFuelUse(1 TO TotNumFuel)                  AS FuelRec


'Keeps Total Stock and New Reg. for all the Technology types for given year and vehicle type.
DIM SHARED TotStocks                                         AS StockRec

'Keeps Total VMT/Technical Fuel/Efficiency for all the Technology fuel types for given year and vehicle type.
DIM SHARED TotvVMT                                           AS SINGLE
DIM SHARED Totvfuel                                          AS SINGLE
DIM SHARED TotvEff                                           AS SINGLE
DIM SHARED TotvEnergy                                        AS SINGLE

'Keeps Total Generic Fuel Use for all the Generic Fuel types for given year and vehicle type.
DIM SHARED TotGenfuel                                        AS SINGLE

'Keeps Total New Registrations for all the vehicle types for given year.
DIM SHARED TotNewReg                                         AS DOUBLE

'Keeps Total Stock for all the vehicle types for given year.
DIM SHARED TotStock                                          AS DOUBLE

'Keeps Total Vehicle Miles Travelled for all the vehicle types for given year.
DIM SHARED TotVMT                                            AS DOUBLE

'Keeps Total Energy Used for all the vehicle types for given year.
DIM SHARED TotEnergy                                         AS DOUBLE

'Keeps Total Generic Fuel Use for all the vehicle types for given year.
DIM SHARED TotVehGenFuelUse                                  AS DOUBLE
```

```
'**************************************************************************
'**  SECONDARY REPORT OUTPUT ARRAYS SECTION                              **
'**************************************************************************

DIM SHARED SecondaryOutput(1 TO NumTech, 0 TO NumYear)     AS SINGLE

DIM SHARED SecondaryTotals(1 TO 10, 0 TO NumYear)          AS SINGLE


'**************************************************************************
'** CODE BEGINS HERE !!                                                  **
'**************************************************************************

Start:  OPEN "C:\FUEL\ROPTN.PRN" FOR INPUT AS #5        'Report Type(s).
        OPEN "C:\FUEL\MASTER.PRN" FOR INPUT AS #14      'Master File.

        INPUT #5, Option$
        Option$ = LTRIM$(RTRIM$(UCASE$(Option$)))

        ErrorCode% = 0

        CALL ReadMaster

        SELECT CASE Option$
           CASE "BOTH"

              CALL Primary(ErrorCode%)

              IF ErrorCode% = 0 THEN
                 COLOR 7, 0: PRINT "Primary Report Generated "; : COLOR 2, 0: PRINT "SUCCESSFULLY!!!"
              ELSE
                 COLOR 7, 0: PRINT "Primary Report Generated "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"
              END IF

              CALL Secondary(ErrorCode%)

              IF ErrorCode% = 0 THEN
                 COLOR 7, 0: PRINT "Secondary Report Generated "; : COLOR 2, 0: PRINT "SUCCESSFULLY!!!"
              ELSE
                 COLOR 7, 0: PRINT "Secondary Report Generated "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"
              END IF

           CASE "PRIMARY"

              CALL Primary(ErrorCode%)

              IF ErrorCode% = 0 THEN
                 COLOR 7, 0: PRINT "Primary Reports Generated "; : COLOR 2, 0: PRINT "SUCCESSFULLY!!!"
              ELSE
                 COLOR 7, 0: PRINT "Primary Reports Generated "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"
              END IF

           CASE "SECONDARY"

              CALL Secondary(ErrorCode%)
```

```
            IF ErrorCode% = 0 THEN
               COLOR 7, 0: PRINT "Secondary Reports Generated "; : COLOR 2, 0: PRINT "SUCCESSFULLY!!!"
            ELSE
               COLOR 7, 0: PRINT "Secondary Reports Generated "; : COLOR 4, 0: PRINT "Unsuccessfully!!!"
            END IF

         CASE "EXIT"
            GOTO DONE

         CASE ELSE

            PRINT "Valid Selections are: 'Primary', 'Secondary', 'Both' or 'exit'"

         END SELECT

         BEEP

         FOR I% = 1 TO 4
           FOR j% = 1 TO 3000
           ' WAIT LOOP
           NEXT j%
         NEXT I%

DONE:  CLOSE #5
END

FUNCTION Pnumber (col%)

Pnumber = 8

IF col% > 7 THEN
   Pnumber = 11
END IF

IF col% > 15 THEN
   Pnumber = 12
END IF

IF col% > 23 THEN
   Pnumber = 13
END IF

END FUNCTION

DEFSNG A-Z
SUB Primary (ErrorCode%)
'*************************************************************************
'*                 SUB PROCEDURE ** Primary **                           *
'*                                                                       *
'* Operation:  This Subroutine reads the following files in seperate     *
'*             arrays and call subprocedure PrintPrimary to print the    *
'*             primary report.                                           *
'*                                                                       *
'* Input:      Reads the following Files.                                *
```

```
'* NEWREG.PRN  -  Contains New Registrations.                          *
'* FUEL.PRN    -  Contains Fuel use.                                   *
'* VMTFUEL.PRN -  Contains Vehicle Miles Travelled for Tech. Fuels.    *
'* STOCK.PRN   -  Contains Vehicle Stock.                              *
'*                                                                     *
'* Output:     Creates file PRIMARY.PRN.                               *
'*                                                                     *
'* Parameter(s):  Error Code        -  ErrorCode%                      *
'*                                                                     *
'* Subroutine(s)                                                       *
'* Called:        ReadCombTable                                        *
'*                ReadHeadings                                         *
'*                ReadMatrix                                           *
'*                PrintPrimary                                         *
'*                                                                     *
'* Routine(s)                                                          *
'* Called by:     Reports.bas                                          *
'*                                                                     *
'***********************************************************************
DEFINT A-Z          'Default Variable type is an integer.

'************************************************************************
'**                 OPEN FILES SECTION                                 **
'************************************************************************

OPEN "C:\FUEL\NEWREG.PRN" FOR INPUT AS #1     'New Registrations.
OPEN "C:\FUEL\STOCK.PRN" FOR INPUT AS #2      'Vehicle Stock.
OPEN "C:\FUEL\VMTFUEL.PRN" FOR INPUT AS #3    'Vehicle Miles Travelled for technology fuel types.
OPEN "C:\FUEL\FUEL.PRN" FOR INPUT AS #4       'Fuel Use.
OPEN "C:\FUEL\PRIMARY.PRN" FOR OUTPUT AS #7   'Primary Report.
OPEN "C:\FUEL\GROSS.PRN" FOR OUTPUT AS #15    'Gross Report.


PRINT #7, STRING$(1, " ")
PRINT #7, STRING$(14, " "), "PRIMARY OUTPUT REPORT"
PRINT #7, STRING$(14, " "), STRING$(21, "-")


ProcVehNum% = 0
VehNum% = 0
DO WHILE NOT (EOF(1) OR EOF(2) OR EOF(3) OR EOF(4))

   VehNum% = VehNum% + 1
   IF LTRIM$(RTRIM$(UCASE$(VehicleTypes(VehNum%).SelectionFlag))) = "N" THEN
      GOTO NextVeh
   ELSE
      ProcVehNum% = ProcVehNum% + 1
   END IF

   CALL ReadCombTable(VehNum%)

   '********************************
   '**      New Registrations     **
   '********************************
```

```
    Inpfile% = 1
    CALL ReadHeadings(Inpfile%, VehNum%)

    PrimDim(VehNum%).VehicleName = VehicleName$
    IF ProcVehNum% = 1 THEN
        REDIM PrimaryStock(1 TO 10, 0 TO NumYear%, 1 TO 20)   AS StockRec
    END IF

    CALL ReadMatrix(Inpfile%, VehNum%)


    '********************************
    '**        Stock              **
    '********************************
    Inpfile% = 2
    CALL ReadHeadings(Inpfile%, VehNum%)
    CALL ReadMatrix(Inpfile%, VehNum%)


    '********************************
    '**          VMT              **
    '********************************
    Inpfile% = 3
    CALL ReadHeadings(Inpfile%, VehNum%)

    IF ProcVehNum% = 1 THEN
        REDIM PrimaryVMT(1 TO 10, 0 TO NumYear%, 1 TO 20)     AS SINGLE
    END IF
    CALL ReadMatrix(Inpfile%, VehNum%)


    '********************************
    '**      Fuel Use             **
    '********************************
    Inpfile% = 4
    CALL ReadHeadings(Inpfile%, VehNum%)

    IF ProcVehNum% = 1 THEN
        REDIM PrimaryFuelUse(1 TO 10, 0 TO NumYear%, 1 TO 20) AS SINGLE
    END IF
    CALL ReadMatrix(Inpfile%, VehNum%)

NextVeh:
LOOP
CALL PrintPrimary(VehNum%, ErrorCode%)

CLOSE #1
CLOSE #2
CLOSE #3
CLOSE #4
CLOSE #7

END SUB

'*********************************************************************************
```

```
'*                    SUB PROCEDURE PrintPrimary                          *
'*                                                                        *
'* Operation:  Prints New Registrations, Stock, VMT, Fuel Use (for tech.  *
'*             fuel types and Generic fuel types) and Efficiency for each *
'*             year and vehicle type.  It also prints out a summary (total *
'*             for all vehicle types) for each year.                      *
'*                                                                        *
'* Parameter(s):  Number of vehicle types - NumVeh%                       *
'*                Error Code for input    - ErrorCode%                    *
'*                                                                        *
'* Subroutine(s)                                                          *
'* Called:        PrintPrimStock                                          *
'*                PrintPrimVMTEff                                         *
'*                ReadBlendComp                                           *
'*                pSetGenericFuels                                        *
'*                PrimFuel                                                *
'*                                                                        *
'* Routine(s)                                                             *
'* Called by:     Primary                                                 *
'*                                                                        *
'**************************************************************************
SUB PrintPrimary (NumVeh%, ErrorCode%)

'********** Print out headings for the GROSS Report         **************

PRINT #15, STRING$(45, " "), "GROSS FORECAST"
PRINT #15, STRING$(45, " "), "--------------"
PRINT #15, STRING$(1, " ")

PRINT #15, STRING$(5, " ");
PRINT #15, "YEAR"; STRING$(9, " ");
PRINT #15, "ENERGY USE", STRING$(1, " ");
PRINT #15, "VMT", STRING$(5, " ");
PRINT #15, "NUM. VEHICLES", STRING$(6, " ");
PRINT #15, "FUEL USE"
PRINT #15, STRING$(130, "-")


FOR Year% = 0 TO NumYear
   TotNewReg = 0
   TotStock = 0
   TotVMT = 0
   TotEnergy = 0

   PRINT #7, STRING$(23, " "), BaseYear + Year%
   PRINT #7, STRING$(26, " "), STRING$(6, "-")
   PRINT #7, " "

   ProcVehNum% = 0
   FOR v% = 1 TO NumVeh%

      IF LTRIM$(RTRIM$(UCASE$(VehicleTypes(v%).SelectionFlag))) = "N" THEN
         GOTO SkipVeh
      ELSE
         ProcVehNum% = ProcVehNum% + 1
```

```
        END IF

        PRINT #7, " "
        PRINT #7, STRING$(26, " "), PrimDim(v%).VehicleName: PRINT #7, " "

        PRINT #7, STRING$(26, " "), "STOCK"
        PRINT #7, STRING$(26, " "), "-----"
        PRINT #7, "TECHNOLOGY TYPES", "NEW REGISTRATIONS", "    TOTAL STOCK"
        PRINT #7, STRING$(71, "- ")

        CALL PrintPrimStock(Year%, v%)

        Inpfile% = 3
        PRINT #7, "TECHNOLOGY FUEL TYPES      ", "      VMT"
        PRINT #7, STRING$(42, "- ")
        CALL PrintPrimVmtEff(Inpfile%, Year%, v%)



        PRINT #7, "TECHNOLOGY FUEL TYPES      ", "        FUEL", "   FUEL TYPES", "                 FUEL"
        PRINT #7, STRING$(80, "- ")

        CALL ReadBlendComp(v%, ErrorCode%)
        IF ErrorCode% > 0 THEN
           GOTO GETOUT
        END IF

        CALL pSetGenericFuels(Year%, v%, ProcVehNum%)
        CALL PrintPrimFuel(Year%, v%)


        Inpfile% = 5
        PRINT #7, "TECHNOLOGY FUEL TYPES      ", "EFFICIENCY"
        PRINT #7, STRING$(40, "- ")

        CALL PrintPrimVmtEff(Inpfile%, Year%, v%)
SkipVeh:
NEXT v%

    PRINT #15, STRING$(4, " ");
    PRINT #15, BaseYear% + Year%;
    PRINT #15, USING "####################"; TotEnergy;
    PRINT #15, USING "####################"; TotVMT;
    PRINT #15, STRING$(6, " ");
    PRINT #15, USING "##############"; TotStock;


    PRINT #7, "TOTALS"
    PRINT #7, STRING$(6, "-")
    PRINT #7, " "
    PRINT #7, "    NEW"
    PRINT #7, "REGISTRATIONS", "  STOCK", "  VMT", "      FUEL USE"
    PRINT #7, STRING$(80, "-")

    PRINT #7, USING "########"; TotNewReg;
```

```
    PRINT #7, USING "#############"; TotStock;
    PRINT #7, USING "################"; TotVMT;

    'Print Generic Fuel Use for all the vehicles.
    TotVehGenFuelUse = 0
    FOR k% = 1 TO TotNumFuel
        IF k% > 1 THEN
            PRINT #7, STRING$(38, " ");
            PRINT #15, STRING$(70, " ");
        END IF

        PRINT #7, STRING$(7, " ");
        PRINT #15, STRING$(10, " ");

        PRINT #7, TotalGenFuelUse(k%).FuelName;
        PRINT #15, TotalGenFuelUse(k%).FuelName;

        PRINT #7, USING "##############"; TotalGenFuelUse(k%).Fuel
        PRINT #15, USING "##############"; TotalGenFuelUse(k%).Fuel

        TotVehGenFuelUse = TotVehGenFuelUse + TotalGenFuelUse(k%).Fuel
    NEXT k%

    PRINT #7, STRING$(45, " ");
    PRINT #7, STRING$(34, "=")

    PRINT #15, STRING$(80, " ");
    PRINT #15, STRING$(30, "=")

    PRINT #7, STRING$(45, " ");
    PRINT #7, "TOTAL:         ";
    PRINT #7, USING "#############"; TotVehGenFuelUse

    PRINT #15, STRING$(80, " ");
    PRINT #15, "TOTAL:         ";
    PRINT #15, USING "##############"; TotVehGenFuelUse

    PRINT #7, " ": PRINT #7, " ": PRINT #7, " "

    PRINT #15, " "

NEXT Year%

PRINT #7, STRING$(45, " "), "END OF REPORT"
PRINT #7, STRING$(130, "=")
PRINT #15, STRING$(45, " "), "END OF REPORT"
PRINT #15, STRING$(130, "=")

GETOUT:
END SUB

DEFSNG A-Z
'*****************************************************************************
'*                    SUB PROCEDURE PrintPrimFuel                            *
'*                                                                           *
```

```
'* Operation:  Prints the fuel use for given year and vehicle type.          *
'*                                                                            *
'* Parameter(s):  Given Year  -  Year%                                        *
'*                Vehicle Type - v%                                           *
'*                                                                            *
'******************************************************************************
SUB PrintPrimFuel (Year%, v%)
DEFINT A-Z

Totvfuel = 0
TotGenfuel = 0
TotvEnergy = 0

FOR row% = 1 TO PrimDim(v%).NumTechFuel%

    PRINT #7, TechComb(v%, row%).TechFuelName;
    IF row% <= PrimDim(v%).NumFuel% THEN
        PRINT #7, USING "################"; PrimaryFuelUse(v%, Year%, row);
        PRINT #7, "    ";
        PRINT #7, GenericFuelUse(row).FuelName;
        PRINT #7, USING "#################"; GenericFuelUse(row).Fuel
        TotGenfuel = TotGenfuel + GenericFuelUse(row).Fuel
        TotvEnergy = TotvEnergy + GenericFuelUse(row).Fuel * EnergyCont(row)
    ELSE
        PRINT #7, USING "################"; PrimaryFuelUse(v%, Year%, row)
    END IF


    Totvfuel = Totvfuel + PrimaryFuelUse(v%, Year%, row)
NEXT row%

TotEnergy = TotEnergy + TotvEnergy

'*** PRINT OUT TOTALS FOR ALL TECHNOLOGY FUEL & GENERIC FUEL TYPES   ***

PRINT #7, STRING$(80, "=")
PRINT #7, "TOTAL:              ";
PRINT #7, USING "#####################"; Totvfuel;
PRINT #7, "    TOTAL:          ";
PRINT #7, USING "#################"; TotGenfuel

PRINT #7, " ": PRINT #7, " ": PRINT #7, " ": PRINT #7, " "

END SUB

'******************************************************************************
'*                   SUB PROCEDURE PrintPrimStock                             *
'*                                                                            *
'* Operation:  Prints the New Registations and Vehicle Stock for given year*
'*             and vehicle type.                                              *
'*                                                                            *
'* Parameter(s):  Given Year   -  Year%                                       *
'*                Vehicle Type -  v%                                          *
'*                                                                            *
'******************************************************************************
```

```
SUB PrintPrimStock (Year%, v%)

DIM Descrp      AS STRING * 17

TotStocks.NewReg = 0
TotStocks.Stock = 0

FOR row% = 1 TO PrimDim(v%).NumTech
    IF TechComb(v%, row%).Chosen = TechComb(v%, row%).Other THEN
        Descrp = TechComb(v%, row%).TechFuelName
    ELSE
        rowindex = row
        DO WHILE row <> TechComb(v%, rowindex).tech
            rowindex = rowindex + 1
        LOOP
        Descrp = MID$(TechComb(v%, rowindex).TechFuelName, 1, 13)
    END IF

    PRINT #7, Descrp;
    PRINT #7, USING "##################"; PrimaryStock(v%, Year%, row).NewReg;
    PRINT #7, "                  ";
    PRINT #7, USING "##################"; PrimaryStock(v%, Year%, row).Stock

    TotStocks.NewReg = TotStocks.NewReg + PrimaryStock(v%, Year%, row%).NewReg
    TotStocks.Stock = TotStocks.Stock + PrimaryStock(v%, Year%, row%).Stock
NEXT row%


'**** PRINT OUT TOTALS FOR ALL TECHNOLOGY TYPES   ********

PRINT #7, STRING$(71, "=")
PRINT #7, "TOTAL:            ";
PRINT #7, USING "##################"; TotStocks.NewReg;
PRINT #7, "                  ";
PRINT #7, USING "##################"; TotStocks.Stock

PRINT #7, " ": PRINT #7, " ": PRINT #7, " ": PRINT #7, " "


'**** UPDATE TOTALS FOR ALL VEHICLE TYPES   ********

TotNewReg = TotNewReg + TotStocks.NewReg
TotStock = TotStock + TotStocks.Stock

END SUB

'***************************************************************************
'*                  SUB PROCEDURE PrintPrimVMTEff                          *
'*                                                                         *
'* Operation:  Prints either Vehicle miles travelled or Efficiency         *
'*             depending upon the FileNum%, for given year and vehicle type*
'*                                                                         *
'* Parameter(s):  Input File Number                                        *
'*                (3 for VMT and 5 for Efficiency) - FileNum%              *
'*                Given Year                       - Year%                 *
```

```
'*              Vehicle Type                    - v%                    *
'*                                                                      *
'************************************************************************
SUB PrintPrimVmtEff (FileNum%, Year%, v%)

IF FileNum% = 3 THEN
   TotvVMT = 0
END IF

FOR row% = 1 TO PrimDim(v%).NumTechFuel%
   PRINT #7, TechComb(v%, row%).TechFuelName;
   IF FileNum% = 3 THEN
      PRINT #7, USING "################"; PrimaryVMT(v%, Year%, row)
      TotvVMT = TotvVMT + PrimaryVMT(v%, Year%, row)
   ELSE
      IF PrimaryFuelUse(v%, Year%, row) <> 0 THEN
         PrimaryEfficiency& = PrimaryVMT(v%, Year%, row) / PrimaryFuelUse(v%, Year%, row)
      ELSE
         PrimaryEfficiency& = 0
      END IF

      PRINT #7, USING "#############"; PrimaryEfficiency&
   END IF
NEXT row%


'**** PRINT OUT TOTALS FOR ALL TECHNOLOGY FUEL TYPES & UPDATE TOTALS FOR ALL VEH. TYPES ********

IF FileNum% = 3 THEN
   PRINT #7, STRING$(42, "=")
   PRINT #7, "TOTAL:              ";
   PRINT #7, USING "######################"; TotvVMT
   TotVMT = TotVMT + TotvVMT
ELSE
   PRINT #7, STRING$(40, "=")
   PRINT #7, "AVERAGE (BTUs/MILE):    ";
   TotvEff = TotvEnergy / TotvVMT / 1000
   PRINT #7, USING "#############.##"; TotvEff
   PRINT #7, "(In thousands)"
END IF

PRINT #7, " ": PRINT #7, " ": PRINT #7, " ": PRINT #7, " "

END SUB

'************************************************************************
'*                     SUB PROCEDURE pSetGenericFuels                   *
'*                                                                      *
'* Operation:  It sets up generic fuel types from technology fuel types for*
'*             given vehicle type and computes the fuel use for generic   *
'*             fuels.  It also adjusts the quantity of generic fuel use by *
'*             taking the fuel composition into account.  Finally it      *
'*             updates generic fuel type and fuel use for all vehicles.   *
'*                                                                      *
'* Parameter(s):  Given Year               - Year%                      *
```

```
'*               Vehicle Type             - v%                          *
'*               Processed Vehicle number - pv%                         *
'*                                                                      *
'************************************************************************
SUB pSetGenericFuels (Year%, v%, pv%)

CONST True = -1, False = 0

'******* INITIALIZE GENERIC FUEL ARRAY FOR CURRENT VEHICLE TYPE      *********

FOR k% = 1 TO 20
   GenericFuelUse(k%).FuelName = STRING$(20, " ")
   GenericFuelUse(k%).Fuel = 0
NEXT k%


'*****   SET UP FUEL TABLE FOR CURRENT VEHICLE TYPE  ******

gf% = 1
FOR k% = 1 TO PrimDim(v%).NumTechFuel
   IF TechComb(v%, k%).Chosen = TechComb(v%, k%).Other THEN
      GenericFuelUse(gf%).FuelName = TechComb(v%, k%).TechFuelName
      gf% = gf% + 1
   END IF
NEXT k%

'*****   CONVERT FUEL USE FROM TECHNOLOGY FUEL TYPES TO REAL FUEL TYPES  ******

FOR tf% = 1 TO PrimDim(v%).NumTechFuel
   GenericFuelUse(TechComb(v%, tf%).Chosen).Fuel = PrimaryFuelUse(v%, Year%, tf%) + GenericFuelUse(Tech-
   Comb (v%, tf%).Chosen)Fuel
NEXT tf%


'******   ADJUST THE QUANTITY OF REAL FUEL USING BLEND COMPOSITIONS     ******

FOR row% = 1 TO PrimDim(v%).NumFuel
   IF BlendComp(row%, row%) <> 100 THEN

      FOR col% = 1 TO PrimDim(v%).NumFuel
         IF row% = col% THEN
            GenericFuelUse(col).Fuel = GenericFuelUse(col).Fuel - GenericFuelUse(col).Fuel * ((100 -
            BlendComp(row, col))100)
         ELSE
            GenericFuelUse(col).Fuel = GenericFuelUse(col).Fuel + GenericFuelUse(row).Fuel * BlendComp
               (row, col)/100 END IF
      NEXT col%
   END IF
NEXT row%

'*****   SET UP FUEL TABLE FOR ALL VEHICLE TYPES ******

IF pv% = 1 THEN
   TotNumFuel = PrimDim(v%).NumFuel * 3
   REDIM TotalGenFuelUse(1 TO TotNumFuel)     AS FuelRec
   TotNumFuel = PrimDim(v%).NumFuel
```

```
    FOR j = 1 TO PrimDim(v%).NumFuel
        TotalGenFuelUse(j%).FuelName = GenericFuelUse(j%).FuelName
        TotalGenFuelUse(j%).Fuel = GenericFuelUse(j%).Fuel
    NEXT j
ELSE
    FOR j = 1 TO PrimDim(v%).NumFuel
        FuelExists = False

        FOR k% = 1 TO TotNumFuel
            IF GenericFuelUse(j%).FuelName = TotalGenFuelUse(k%).FuelName THEN
                FuelExists = True
                TotalGenFuelUse(k%).Fuel = TotalGenFuelUse(k%).Fuel + GenericFuelUse(j%).Fuel
            END IF
        NEXT k%

        IF FuelExists = False THEN
            TotNumFuel = TotNumFuel + 1
            TotalGenFuelUse(TotNumFuel).FuelName = GenericFuelUse(j%).FuelName
            TotalGenFuelUse(TotNumFuel).Fuel = GenericFuelUse(j%).Fuel
        END IF
    NEXT j%
END IF
END SUB

'***************************************************************************
'*                    SUB PROCEDURE ReadBlendComp                          *
'*                                                                         *
'* Operation:  Reads Fuel Blend Composition from file V(vehicle#).BLEND.PRN*
'*                                                                         *
'* Parameter(s): Vehicle Type     - v%                                     *
'*               Input Error code - ErrorCode%                             *
'***************************************************************************
SUB ReadBlendComp (v%, ErrorCode%)

'*******************************************************
'* Read Fuel Blend Combination Table                   *
'*******************************************************

OPEN "C:\FUEL\V" + LTRIM$(RTRIM$(STR$(v%))) + "BLEND.PRN" FOR INPUT AS #10          'Fuel Blend combinations.
LINE INPUT #10, Blankline$
LINE INPUT #10, heading$
INPUT #10, PrimDim(v%).NumFuel
LINE INPUT #10, heading$
LINE INPUT #10, Dashline$


FOR row% = 1 TO PrimDim(v%).NumFuel
    BlendSum% = 0
    INPUT #10, FuelName$

    FOR col% = 1 TO PrimDim(v%).NumFuel
        INPUT #10, BlendComp(row, col)
        BlendSum% = BlendSum% + BlendComp(row, col)
    NEXT col%
```

```
    IF BlendSum% <> 100 THEN
       ErrorCode% = 1
       PRINT "Vehicle Type:"; PrimDim(v%).VehicleName: PRINT "Fuel name:"; FuelName$
       PRINT "Sum of Fuel Blend Combination is not = 100"
       GOTO SKIPREST
    END IF
NEXT row%

FOR AdvanceLine% = 1 TO (21 - PrimDim(v%).NumFuel)
    LINE INPUT #10, Blankline$
NEXT AdvanceLine%

LINE INPUT #10, Dashline$

FOR AdvanceLine% = 1 TO 12
    LINE INPUT #10, Blankline$
NEXT AdvanceLine%

LINE INPUT #10, heading$
INPUT #10, tNumFuel%
IF tNumFuel% <> PrimDim(v%).NumFuel THEN
    ErrorCode% = 2
    PRINT "Vehicle Type:"; PrimDim(v%).VehicleName
    PRINT "Inconsitent number of fuels between Blend Combination and Energy Content"
    GOTO SKIPREST
END IF

LINE INPUT #10, heading$
LINE INPUT #10, Dashline$

FOR row% = 1 TO PrimDim(v%).NumFuel
    INPUT #10, FuelName$
    INPUT #10, EnergyCont(row)
NEXT row%

SKIPREST:
CLOSE #10
END SUB

'***********************************************************************
'*                    SUB PROCEDURE ReadCombTable                      *
'*                                                                     *
'* Operation:     Reads V(vehicle#)PARS.PRN which contains Generic Fuel*
'*                Composition Table.                                   *
'*                                                                     *
'* Parameter(s):  Vehicle Type - v%                                    *
'*                                                                     *
'***********************************************************************
SUB ReadCombTable (v%)

OPEN "C:\FUEL\V" + LTRIM$(RTRIM$(STR$(v%))) + "PARS.PRN" FOR INPUT AS #9

LINE INPUT #9, Blankline$
LINE INPUT #9, heading$: LINE INPUT #9, Blankline$
INPUT #9, NumTechFuel%
```

```
PrimDim(v%).NumTechFuel% = NumTechFuel%
LINE INPUT #9, heading$


FOR k% = 1 TO NumTechFuel
    INPUT #9, TechComb(v%, k%).TechFuelName
    INPUT #9, TechComb(v%, k%).tech
    INPUT #9, TechComb(v%, k%).Chosen
    INPUT #9, TechComb(v%, k%).Other
NEXT k%
FOR k% = 1 TO (20 - NumTechFuel)
   LINE INPUT #9, nothing$
NEXT k%
LINE INPUT #9, Dashline$

CLOSE #9
END SUB

'****************************************************************************
'*                    SUB PROCEDURE ReadHeadings                             *
'*                                                                           *
'* Operation:  Reads Header information for given file, for given file      *
'*             number and vehicle type.                                      *
'*                                                                           *
'* Parameter(s):  File Number  - FileNum%                                    *
'*                Vehicle type - v%                                          *
'****************************************************************************
SUB ReadHeadings (FileNum%, v%)

LINE INPUT #FileNum%, Blankline$
INPUT #FileNum%, NumYear%
INPUT #FileNum%, PrimDim(v%).NumAge

IF FileNum% = 1 OR FileNum% = 2 THEN
   INPUT #FileNum%, PrimDim(v%).NumTech
ELSE
   INPUT #FileNum%, PrimDim(v%).NumTechFuel%
END IF

LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, heading$
LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, VehicleName$
LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, heading$
LINE INPUT #FileNum%, heading$
LINE INPUT #FileNum%, Blankline$
INPUT #FileNum%, BaseYear%

END SUB

SUB ReadMaster

LINE INPUT #14, Blankline$
INPUT #14, NumVeh%: INPUT #14, heading$
```

```
LINE INPUT #14, Blankline$
LINE INPUT #14, Dashline$: LINE INPUT #14, heading$: LINE INPUT #14, Dashline$

FOR k% = 1 TO NumVeh%
    INPUT #14, VehicleTypes(k%).VehicleName
    INPUT #14, VehicleTypes(k%).SelectionFlag
NEXT k%
END SUB

'**************************************************************************
'*                    SUB PROCEDURE ReadMatrix                            *
'*                                                                        *
'* Operation:  Reads input for given File and Vehicle type into Arrays.   *
'*                                                                        *
'* Parameter(s):  Input File Number - FileNum%                            *
'*                Vehicle Type      - v%                                  *
'*                                                                        *
'**************************************************************************
SUB ReadMatrix (FileNum%, v%)

FOR Year% = 0 TO NumYear%
    IF Year% > 0 THEN
        LINE INPUT #FileNum%, Blankline$
        LINE INPUT #FileNum%, Blankline$
        LINE INPUT #FileNum%, Blankline$
        INPUT #FileNum%, CurrYear%
    END IF

    IF FileNum% = 1 OR FileNum% = 2 THEN
        TechOrTechFuel% = PrimDim(v%).NumTech
    ELSE
        TechOrTechFuel% = PrimDim(v%).NumTechFuel
    END IF

    FOR vintages% = 0 TO PrimDim(v%).NumAge

        INPUT #FileNum%, Age%
        FOR tech% = 1 TO TechOrTechFuel%
            INPUT #FileNum%, figure&

            SELECT CASE FileNum%
            CASE 1
                PrimaryStock(v%, Year%, tech%).NewReg = PrimaryStock(v%, Year%, tech%).NewReg + figure&
            CASE 2
                PrimaryStock(v%, Year%, tech%).Stock = PrimaryStock(v%, Year%, tech%).Stock + figure&
            CASE 3
                PrimaryVMT(v%, Year%, tech%) = PrimaryVMT(v%, Year%, tech%) + figure&
            CASE 4
                PrimaryFuelUse(v%, Year%, tech%) = PrimaryFuelUse(v%, Year%, tech%) + figure&
            CASE ELSE
                PRINT "Invalid file number:  "; FileNum%
            END SELECT

        NEXT tech%
    NEXT vintages%
```

```
NEXT Year%

LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, Blankline$

END SUB


DEFSNG A-Z
'****************************************************************************
'*                 SUB PROCEDURE ** Secondary **                            *
'*                                                                          *
'* Operation:  This Subroutine creates Secondary Report.                    *
'*                                                                          *
'* Input:      Reads the following Files.                                   *
'* NEWREG.PRN -  Contains New Registrations.                                *
'* FUEL.PRN   -  Contains Fuel use.                                         *
'* VMT.PRN    -  Contains Vehicle Miles Travelled for each tech. types.*
'* STOCK.PRN  -  Contains Vehicle Stock.                                    *
'*                                                                          *
'* Output:     Creates file SECONDRY.PRN.                                   *
'*                                                                          *
'* Parameter(s):  Error Code       -  ErrorCode%                            *
'*                                                                          *
'* Subroutine(s)                                                            *
'* Called:        SecReport                                                 *
'*                                                                          *
'* Routine(s)                                                               *
'* Called by:     Reports.bas                                               *
'*                                                                          *
'****************************************************************************
SUB Secondary (ErrorCode%)

DEFINT A-Z              ' Default variable type is integer

CONST True = -1, False = 0

'*****************************************************************************
'**                 OPEN FILES SECTION                                     **
'*****************************************************************************

OPEN "C:\FUEL\NEWREG.PRN" FOR INPUT AS #1              'New Registrations.
OPEN "C:\FUEL\STOCK.PRN" FOR INPUT AS #2               'Vehicle Stock.
OPEN "C:\FUEL\FUEL.PRN" FOR INPUT AS #3                'Fuel Use.
OPEN "C:\FUEL\VMT.PRN" FOR INPUT AS #4                 'Vehicle Miles Travelled for tech types.
OPEN "C:\FUEL\SECONDa.PRN" FOR OUTPUT AS #8            'Secondary Report.
OPEN "C:\FUEL\SECONDb.PRN" FOR OUTPUT AS #11           'Secondary Report.
OPEN "C:\FUEL\SECONDc.PRN" FOR OUTPUT AS #12           'Secondary Report.
OPEN "C:\FUEL\SECONDd.PRN" FOR OUTPUT AS #13           'Secondary Report.

PRINT #8, STRING$(50, " "), "SECONDARY OUTPUT REPORT"
PRINT #8, STRING$(50, " "), STRING$(23, "-")
PRINT #8, STRING$(1, " ")

PRINT #11, STRING$(50, " "), "SECONDARY OUTPUT REPORT"
```

```
PRINT #11, STRING$(50, " "), STRING$(23, "-")
PRINT #11, STRING$(1, " ")

PRINT #12, STRING$(50, " "), "SECONDARY OUTPUT REPORT"
PRINT #12, STRING$(50, " "), STRING$(23, "-")
PRINT #12, STRING$(1, " ")

PRINT #13, STRING$(50, " "), "SECONDARY OUTPUT REPORT"
PRINT #13, STRING$(50, " "), STRING$(23, "-")
PRINT #13, STRING$(1, " ")

Inpfile% = 1
PRINT #8, STRING$(53, " "), "NEW REGISTRATIONS"
CALL SecReport(Inpfile)

Inpfile% = 2
PRINT #8, STRING$(55, " "), "VEHICLE STOCK"
CALL SecReport(Inpfile)

Inpfile% = 3
PRINT #8, STRING$(58, " "), "FUEL USE"
CALL SecReport(Inpfile)

Inpfile% = 4
PRINT #8, STRING$(50, " "), "VMT BY TECHNOLOGY TYPES"
CALL SecReport(Inpfile)

PRINT #8, STRING$(45, " "), "END OF REPORT"
PRINT #11, STRING$(45, " "), "END OF REPORT"
PRINT #12, STRING$(45, " "), "END OF REPORT"
PRINT #13, STRING$(45, " "), "END OF REPORT"

PRINT #8, STRING$(130, "=")
PRINT #11, STRING$(130, "=")
PRINT #12, STRING$(130, "=")
PRINT #13, STRING$(130, "=")

CLOSE #1
CLOSE #2
CLOSE #3
CLOSE #4
CLOSE #8
CLOSE #11
CLOSE #12
CLOSE #13

END SUB

'****************************************************************************
'*                        SUB PROCEDURE SecReport                          *
'*                                                                          *
'* Operation:  Reads Technical combination table for each vehicle type and *
'*             calls other subroutines with the file number to generate the*
'*             part of the secondary report.                                *
'*                                                                          *
```

```
'* Parameter(s): File Number (e.g. 1 for New Registrations)  - FileNum%    *
'*                                                                          *
'****************************************************************************
SUB SecReport (FileNum%)

VehNum% = 0
DO WHILE NOT EOF(FileNum%)

    VehNum% = VehNum% + 1
    IF LTRIM$(RTRIM$(UCASE$(VehicleTypes(VehNum%).SelectionFlag))) = "N" THEN
        GOTO Skip
    END IF

    IF FileNum% = 1 THEN
        CALL ReadCombTable(VehNum%)
    END IF

    CALL SetUpMatrix(VehNum%, FileNum%)
    CALL sPrintMatrix(VehNum%, FileNum%)
    CALL SetUpPrintTotals(VehNum%)
Skip:
LOOP

CALL sPrintGrandTotals(VehNum%)

END SUB




'****************************************************************************
'*                      SUB PROCEDURE SetUpMatrix                           *
'*                                                                          *
'* Operation:  Reads appropriate input file specified by the FileNum% and   *
'*             sets up the matrix to be printed out.                        *
'*                                                                          *
'* Parameter(s): Vehicle Type  -  v%                                        *
'*               File Number (e.g. 1 for New Registrations)  - FileNum%    *
'****************************************************************************
SUB SetUpMatrix (v%, FileNum%)

LINE INPUT #FileNum%, Blankline$
INPUT #FileNum%, NumYear%
INPUT #FileNum%, NumAge%
INPUT #FileNum%, NumTech%
LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, heading$
LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, VehicleName$
LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, heading$
LINE INPUT #FileNum%, heading$
```

```
LINE INPUT #FileNum%, Blankline$
INPUT #FileNum%, BaseYear%

REDIM SecondaryOutput(1 TO NumTech, 0 TO NumYear)  AS SINGLE

FOR Year = 0 TO NumYear%
    IF Year > 0 THEN
        LINE INPUT #FileNum%, Blankline$
        LINE INPUT #FileNum%, Blankline$
        LINE INPUT #FileNum%, Blankline$
        INPUT #FileNum%, CurrYear%
    END IF

    FOR vintages% = 0 TO NumAge

        INPUT #FileNum%, Age%
        FOR tech% = 1 TO NumTech
            INPUT #FileNum%, figure&
            SecondaryOutput(tech, Year) = SecondaryOutput(tech, Year) + figure&
        NEXT tech%
    NEXT vintages%

NEXT Year%
LINE INPUT #FileNum%, Blankline$
LINE INPUT #FileNum%, Blankline$

IF (NumYear% > 7) AND (v% = 1) THEN

    SELECT CASE FileNum%
        CASE 1
            PRINT #11, STRING$(53, " "), "NEW REGISTRATIONS"
        CASE 2
            PRINT #11, STRING$(55, " "), "VEHICLE STOCK"
        CASE 3
            PRINT #11, STRING$(58, " "), "FUEL USE"
        CASE 4
            PRINT #11, STRING$(50, " "), "VMT BY TECHNOLOGY TYPES"
    END SELECT
END IF

IF (NumYear% > 15) AND (v% = 1) THEN

    SELECT CASE FileNum%
        CASE 1
            PRINT #12, STRING$(53, " "), "NEW REGISTRATIONS"
        CASE 2
            PRINT #12, STRING$(55, " "), "VEHICLE STOCK"
        CASE 3
            PRINT #12, STRING$(58, " "), "FUEL USE"
        CASE 4
            PRINT #12, STRING$(50, " "), "VMT BY TECHNOLOGY TYPES"
    END SELECT
END IF

IF (NumYear% > 23) AND (v% = 1) THEN
```

```
    SELECT CASE FileNum%
        CASE 1
            PRINT #13, STRING$(53, " "), "NEW REGISTRATIONS"
        CASE 2
            PRINT #13, STRING$(55, " "), "VEHICLE STOCK"
        CASE 3
            PRINT #13, STRING$(58, " "), "FUEL USE"
        CASE 4
            PRINT #13, STRING$(50, " "), "VMT BY TECHNOLOGY TYPES"
    END SELECT
END IF


END SUB

'***************************************************************************
'*                    SUB PROCEDURE SetupPrintTotals                      *
'*                                                                        *
'* Operation:  Sets up current vehicle's totals in all vehicle totals     *
'*             matrix and prints out current vehicle's totals.            *
'*                                                                        *
'* Parameter(s): Vehicle number - v%                                      *
'***************************************************************************
SUB SetUpPrintTotals (v%)

DIM PNum          AS INTEGER

'            **** Initialize ****
IF v% = 1 THEN
   REDIM SecondaryTotals(1 TO 10, 0 TO NumYear)   AS SINGLE
END IF

'            **** Set Up Totals for Vehicle Type v% ****
FOR row% = 1 TO NumTech%
   FOR col% = 0 TO NumYear%
      SecondaryTotals(v%, col%) = SecondaryOutput(row%, col%) + SecondaryTotals(v%, col
   NEXT col%
NEXT row%


'            **** Print Totals for Vehicle Type v% ****

PRINT #8, STRING$(13, " "), STRING$((8 * 15), "=")
PRINT #8, "TOTAL:                    ";

IF NumYear% > 7 THEN
   PRINT #11, STRING$(13, " "), STRING$((8 * 15), "=")
   PRINT #11, "TOTAL:                    ";
END IF

IF NumYear% > 15 THEN
   PRINT #12, STRING$(13, " "), STRING$((8 * 15), "=")
   PRINT #12, "TOTAL:                    ";
END IF
```

```
IF NumYear% > 23 THEN
    PRINT #13, STRING$(13, " "), STRING$((8 * 15), "=")
    PRINT #13, "TOTAL:                    ";
END IF

FOR col% = 0 TO NumYear%
    PNum = Pnumber(col%)
    PRINT #PNum, USING "############"; SecondaryTotals(v%, col%);
NEXT col%

PRINT #8, " ": PRINT #8, " "
IF NumYear% > 7 THEN
    PRINT #11, " ": PRINT #11, " "
END IF

IF NumYear% > 15 THEN
    PRINT #12, " ": PRINT #12, " "
END IF

IF NumYear% > 23 THEN
    PRINT #13, " ": PRINT #13, " "
END IF

END SUB

'******************************************************************************
'*                    SUB PROCEDURE sPrintGrandTotals                         *
'*                                                                            *
'* Operation:  Prints Grand total for all vehicles created by subroutine      *
'*             SetupsPrintMatrix.                                             *
'*                                                                            *
'* Parameter(s): Number of Vehicles - NumVeh%                                 *
'******************************************************************************
SUB sPrintGrandTotals (NumVeh%)

DIM GrandTotal      AS DOUBLE
DIM PNum            AS INTEGER

PRINT #8, " "
PRINT #8, STRING$(13, " "), STRING$((8 * 15), "=")
PRINT #8, "GRAND TOTAL:     ";

IF NumYear% > 7 THEN
    PRINT #11, " "
    PRINT #11, STRING$(13, " "), STRING$((8 * 15), "=")
    PRINT #11, "GRAND TOTAL:     ";
END IF

IF NumYear% > 15 THEN
    PRINT #12, " "
    PRINT #12, STRING$(13, " "), STRING$((8 * 15), "=")
    PRINT #12, "GRAND TOTAL:     ";
END IF
```

```
IF NumYear% > 23 THEN
   PRINT #13, " "
   PRINT #13, STRING$(13, " "), STRING$((8 * 15), "=")
   PRINT #13, "GRAND TOTAL:                    ";
END IF


FOR col% = 0 TO NumYear%
   GrandTotal = 0

   FOR row% = 1 TO NumVeh%
      GrandTotal = GrandTotal + SecondaryTotals(row%, col%)
   NEXT row%

   PNum = Pnumber(col%)
   PRINT #PNum, USING "############"; GrandTotal;
NEXT col%

PRINT #8, " ": PRINT #8, " ": PRINT #8, " ": PRINT #8, " ": PRINT #8, " "

IF NumYear% > 7 THEN
   PRINT #11, " ": PRINT #11, " ": PRINT #11, " ": PRINT #11, " ": PRINT #11, " "
END IF

IF NumYear% > 15 THEN
   PRINT #12, " ": PRINT #12, " ": PRINT #12, " ": PRINT #12, " ": PRINT #12, " "
END IF

IF NumYear% > 23 THEN
   PRINT #13, " ": PRINT #13, " ": PRINT #13, " ": PRINT #13, " ": PRINT #13, " "
END IF

END SUB

'****************************************************************************
'*                      SUB PROCEDURE sPrintMatrix                          *
'*                                                                          *
'* Operation:  Formats report layout, uses Technology combination table to *
'*             get Technology fuel type and technology types, and prints    *
'*             the matrix created by subroutine SetupMatrix.                *
'*                                                                          *
'* Parameter(s): File Number (e.g. 1 for New Registrations)  - FileNum%     *
'*                                                                          *
'****************************************************************************
SUB sPrintMatrix (v%, FileNum%)

DIM Descrp     AS STRING * 24
DIM PNum       AS INTEGER

PRINT #8, " "
PRINT #8, STRING$(20, " "), VehicleName$: PRINT #8, " "
PRINT #8, STRING$(28, " ");

IF NumYear% > 7 THEN
   PRINT #11, " "
```

```
    PRINT #11, STRING$(20, " "), VehicleName$: PRINT #11, " "
    PRINT #11, STRING$(28, " ");
 END IF

 IF NumYear% > 15 THEN
    PRINT #12, " "
    PRINT #12, STRING$(20, " "), VehicleName$: PRINT #12, " "
    PRINT #12, STRING$(28, " ");
 END IF

 IF NumYear% > 23 THEN
    PRINT #13, " "
    PRINT #13, STRING$(20, " "), VehicleName$: PRINT #13, " "
    PRINT #13, STRING$(28, " ");
 END IF

 FOR I% = 0 TO NumYear%
    PNum = Pnumber(I%)
    PRINT #PNum, USING "############"; BaseYear% + I;
 NEXT I%

 PRINT #8, " ": PRINT #8, STRING$(13, " "), STRING$((8 * 15), "-")

 IF NumYear% > 7 THEN
    PRINT #11, " ": PRINT #11, STRING$(13, " "), STRING$((8 * 15), "-")
 END IF

 IF NumYear% > 15 THEN
    PRINT #12, " ": PRINT #12, STRING$(13, " "), STRING$((8 * 15), "-")
 END IF

 IF NumYear% > 23 THEN
    PRINT #13, " ": PRINT #13, STRING$(13, " "), STRING$((8 * 15), "-")
 END IF

 FOR row% = 1 TO NumTech%
    IF FileNum% = 3 THEN
       Descrp = TechComb(v%, row%).TechFuelName
    ELSE
       IF TechComb(v%, row%).Chosen = TechComb(v%, row%).Other THEN
          Descrp = TechComb(v%, row%).TechFuelName
       ELSE
          rowindex = row
          DO WHILE row <> TechComb(v%, rowindex).tech
             rowindex = rowindex + 1
          LOOP
          Descrp = MID$(TechComb(v%, rowindex).TechFuelName, 1, 13)
       END IF
    END IF

    PRINT #8, Descrp;
    IF NumYear% > 7 THEN
       PRINT #11, Descrp;
    END IF
```

```
    IF NumYear% > 15 THEN
        PRINT #12, Descrp;
    END IF

    IF NumYear% > 23 THEN
        PRINT #13, Descrp;
    END IF

    FOR col% = 0 TO NumYear%
        PNum = Pnumber(col%)
        PRINT #PNum, USING "############"; SecondaryOutput(row, col);
    NEXT col%

    PRINT #8, " "
    IF NumYear% > 7 THEN
        PRINT #11, " "
    END IF
    IF NumYear% > 15 THEN
        PRINT #12, " "
    END IF
    IF NumYear% > 23 THEN
        PRINT #13, " "
    END IF
NEXT row%

END SUB
```

INTERNAL DISTRIBUTION

1. R. G. Edwards
2. P. S. Gillis
3. D. L. Greene
4. G. R. Hadder
5. C. W. Hagan
6. E. L. Hillsman
7. H. L. Hwang
8. B. N. Janson
9. J. Kelb
10. P. N. Leiby
11. Anju Rathi
12. D. E. Reichle
13. E. T. Rogers
14. R. B. Shelton
15. F. Southworth
16. G. G. Stevenson
17. D. P. Vogt
18. T. J. Wilbanks
19. ORNL Patent Office
20. Central Research Library
21. Document Reference Section

22-24. Laboratory Records

25. Laboratory Records - RC

EXTERNAL DISTRIBUTION

26. B. Buchanan, Computer Science Department, University of Pittsburgh, 206 Mineral Industries Building, Pittsburgh, PA 15260
27. J. J. Cuttica, Vice President, End Use Research and Development, Gas Research Institute, 8600 W. Bryn Mawr Avenue, Chicago, IL 60631
28. D. E. Morrison, Professor of Sociology, Michigan State University, 201 Berkey Hall, East Lansing, MI 48824-1111
29. R. L. Perrine, Professor of Engineering and Applied Science, Engineering I, Room 2066, 405 Hilgard Avenue, University of California, Los Angeles, CA 90024-1600
30. M. Williams, Professor, Department of Economics, Northern Illinois University, DeKalb, IL 60115

31-60. Transportation and Systems Research Distribution, Energy Division

61. Office of Assistant Manager for Energy Research and Development, DOE-ORO, P.O. Box 2001, Oak Ridge, TN 37831-8600

62-72. OSTI, U.S. Department of Energy, P.O. Box 62, Oak Ridge, TN 37831

*U.S. GOVERNMENT PRINTING OFFICE: 1990--748-114/20009