

VISION 2008 User's Guide

Energy Systems Division

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User's Guide by

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October 2008

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List of Abbreviations

AEO	Annual Energy Outlook
AER	All-Electric Range
CNG	Compressed Natural Gas
Dsl	Diesel
E85	Ethanol blend (85% Ethanol)
EtOH	Ethanol
EV	Electric Vehicle
FCV	Fuel Cell Vehicle
FFV	Flex-Fuel Vehicle
F-T	Fischer-Tropsch [Diesel]
H ₂	Hydrogen
HEV	Hybrid Electric Vehicle
ICE	Internal Combustion Engine
LDV	Light-Duty Vehicle
LT	Light Truck
MMTCe	Million Metric Ton Carbon equivalent
MMT CO ₂ e	Million Metric Ton CO ₂ equivalent
MPGGE	Miles per Gasoline Gallon Equivalent
PHEV	Plug-In Hybrid Electric Vehicle
SI	Spark-Ignition
SU	Single Unit
VMT	Vehicle Miles Traveled

Acknowledgments

The development of the VISION model has been funded by the Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. Dr. Philip Patterson has been the primary sponsor of the model and its use, and we wish to thank him for his extensive support. We would also like to thank John Maples, Energy Information Administration, who developed the initial version of the VISION model (approximately seven years ago) and who has helped us substantially in our annual updates.

The VISION model was developed by Argonne National Laboratory (ANL) for the U.S. Department of Energy (DOE). It is designed to estimate national highway vehicle stock energy use, fuel consumption by type and lifecycle carbon emissions as a function of the market uptake of advanced vehicle and fuel technologies. Editions of VISION released in and after 2008 model the period 2000-2100; prior editions reach only to 2050.

1. Introduction

The VISION model has been developed by the U.S. Department of Energy (DOE) to provide estimates of the potential energy use, oil use, and carbon emission impacts to 2100 of advanced light- and heavy-duty highway vehicle technologies and alternative fuels. DOE supports research into advanced transportation technologies (including fuels) and is frequently asked to provide estimates of the potential impacts of successful market penetration of these technologies, sometimes on a relatively quick-turnaround basis.

VISION is a spreadsheet model in Microsoft Excel that can be used to respond rapidly to quick-turnaround requests, as well as for longer-term analyses. It uses vehicle survival and age-dependent usage characteristics to project total light- and heavy-vehicle stock, total vehicle miles of travel (VMT), and total energy use by technology and fuel type by year, given market penetration and vehicle fuel economy assumptions developed exogenously. Total carbon emissions for on-highway vehicles by year are also estimated because life-cycle carbon coefficients for various fuels are included in VISION.

VISION is not a substitute for the transportation component of the Energy Information Administration's (EIA's) National Energy Modeling System (NEMS). NEMS incorporates a consumer choice model to project market penetration of advanced vehicles and alternative fuels. The projections are made within the context of the entire U.S. economy. However, the NEMS model is difficult to use on a quick-turnaround basis and only makes projections to 2030. VISION complements NEMS with its relative "user-friendliness" and by extending the time frame of potential analysis.

The model considers a set of input parameters. Default parameter values taken from the Annual Energy Outlook (AEO) Reference Case are in place. All input values can be changed by the user to customize the simulation. Input parameters include:

- Car market penetration and fuel economy ratio;
- Light truck market penetration and fuel economy ratio;
- Light truck share of total LDV market;
- Fuel type (including hydrogen and ethanol via multiple production pathways) and price;
- Vehicle miles traveled (VMT), including growth rate and elasticity to the cost of driving;
- Heavy vehicle fuel economy, market share, and alternative fuel usage; and
- Light vehicle cost.

The model generates output values, by vehicle type (car, light truck, and heavy truck). The output totals include:

- Energy use by fuel type (oil, compressed natural gas, F-T diesel, bio-diesel, methanol, hydrogen, electricity, ethanol, and other fuels);
- Full fuel cycle carbon emissions (MMTCe);
- Full fuel cycle GHG emissions (MMT CO₂e);
- Fuel expenditures (billion 2005\$);
- Fuel expenditures as a % of GDP; and
- Light vehicle MPGGE.

2. Launching VISION

The VISION software consists of two integrated Excel worksheets:

1. "VISION YYYY AEO Base Case Expanded.xls"
2. "File To Be Copied To All Runs of VISION YYYY Expanded.xls"

where YYYY denotes which edition of VISION and EIA's Annual Energy Outlook are being used. For example, for VISION 2008, the worksheets are named:

1. "VISION 2008 AEO Base Case Expanded.xls"
2. "File To Be Copied To All Runs of VISION 2008 Expanded.xls".

Default values for VISION 2008 are drawn from AEO 2008.

The first file is for user reference only and should not be modified. It contains the inputs and results for the "Base Case" according to projections made by the EIA in the AEO. This Base Case is the scenario against which all hypothetical scenarios are compared.

The second file is the template through which alternative market penetration scenarios can be created. To create a new market penetration scenario, open the file entitled "File To Be Copied To All Runs of VISION YYYY Expanded.xls" and immediately save it under a new name. An unmodified version of the original file should always be available since each new scenario created in VISION should originate with this file.

When the file is opened, Excel will automatically open the workbook to the 'Model Input' worksheet. The first step in data entry using this worksheet should be the replacement of the contents of cell G1 ("File To Be Copied To All Runs of VISION YYYY With PHEV Options") with the new scenario name. Afterwards, proceed to input parameters for the market penetration scenario being modeled, as described in section 3 below.

3. Input

Market penetration scenarios are defined by the input assumptions in the 'Model Input' worksheet. These assumptions guide the calculations in supporting worksheets to generate the results that appear in the 'Model Results' worksheet. By choice, the parameters that appear in the 'Model Input' worksheet match the values published in and/or underlying the Annual Energy Outlook YYYY Reference Case through 2030¹. Post-2030, the inputs are based on a variety of assumptions: e.g., in some cases they are extensions of the AEO values (generally relying on the 2025-2030 growth rates estimated in the AEO); in other cases the inputs may be held constant at the AEO 2030 values; and in still other cases the projections may be made to fit a logit curve.

These parameters can be changed to describe hypothetical scenarios by following the directions in this section. In most cases, a user should change values only in cells shaded light yellow. Cells that are not shaded are for user information and their contents should not be changed.

The 'Model Input' worksheet is organized in two dimensions: by variable type moving down the worksheet and year moving across the worksheet (where applicable). The sequence of the explanations here mirrors the organization of the input worksheet from top to bottom, as follows:

- Automobiles (Cars)
 - o Market Penetration

¹ AEO YYYY Reference.

- o New Auto Fuel Economy (as a Ratio to Base Case ICE)
- Light Trucks
 - o Market Penetration
 - o Light Truck Share of Total Light Duty Vehicle Market
 - o New Light Truck Fuel Economy (as a Ratio to Base Case ICE)
- Technology Fuel Type
- Fuel Price
- Other Key Fuel Input Assumptions
 - o Fuel Blends (ethanol, F-T Diesel, biodiesel)
 - o Extent of E85 Use and Electric Ranges for Multi-Fuel Vehicles
 - o Ethanol Production Feedstocks
 - o Hydrogen Feedstocks
 - o Utility Mix
- Vehicle Miles Traveled (VMT): Growth Rate and Elasticity to the Cost of Driving
- Heavy Vehicles
 - o Fuel Economy
 - o Market Share
 - o Alternative Fuel Usage
- Car Cost
- Light Truck Cost

The following sections include screenshots as illustrative examples of the ‘Model Input’ worksheet. These screenshots, and the column and row numbers associated with each, are from VISION 2008 and could vary slightly in other versions of the model.

3.1. Auto (Car) Market Penetration

This Auto (Car) Market Penetration module allows a user to define the percentage of the total number of new automobiles (cars) sold by technology type. Technologies include: EV (electric vehicles), E-85 FFV (E85 flex fuel vehicles), Diesel, CNG (compressed natural gas), SI HEV on Gasoline (spark ignition hybrid electric vehicle on gasoline), SI HEV on E85/H2 (spark ignition hybrid electric vehicle on E85 flex fuel or hydrogen internal combustion engine), Diesel HEV, SI PHEV (spark ignition plug-in hybrid electric vehicle), Diesel PHEV, Fuel Cell, and Conventional Vehicles as shown in Figure 1.

Figure 1: Auto (Car) Market Penetration Input

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
5	Auto (Car) Market Penetration													
6	<i>Enter each technology's share of new vehicles market</i>													
7	<i>MUST specify "1st Year" and "1st Yr Shr" for the technology for which either market share or fuel economy change is desired.</i>													
8	Technology	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Shr
9	EV	0.01%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0	0.0%
10	E-85 FFV	0.85%	4.85%	11.01%	9.91%	9.50%	9.18%	9.00%	9.00%	9.00%	9.00%	9.00%	0	0.0%
11	Diesel	0.26%	1.20%	3.26%	4.97%	6.00%	6.60%	6.85%	6.93%	6.97%	6.98%	6.98%	0	0.0%
12	CNG	0.39%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0.02%	0	0.0%
13	SI HEV on Gasoline	0.10%	4.09%	12.01%	13.13%	13.99%	14.22%	14.28%	14.29%	14.29%	14.29%	14.29%	0	0.0%
14	SI HEV on E85/H2	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0	0.0%
15	Diesel HEV	0.00%	0.01%	0.02%	0.02%	0.01%	0.01%	0.01%	0.00%	0.00%	0.00%	0.00%	0	0.0%
16	SI PHEV	0.00%	0.00%	0.01%	0.03%	0.05%	0.08%	0.10%	0.12%	0.14%	0.16%	0.18%	0	0.0%
17	Diesel PHEV	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0	0.0%
18	Fuel Cell	0.00%	0.00%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0.06%	0	0.0%
19	Conventional	98.39%	89.83%	73.61%	71.87%	70.36%	69.84%	69.69%	69.58%	69.51%	69.48%	69.46%	0	0.0%
20	TOTAL	100.0%												

The composition of new market sales to 2030 are, by default, matched to values published in the corresponding Annual Energy Outlook. The market share values for each technology can be changed in three steps:

- 1) Change the cell in-line with the advanced technology for which the market share is to be changed under the heading “1st Year” from 0 to the year at which the market share begins to deviate from the default value. A year in this column is essential for VISION to identify that a market penetration change is desired.

- 2) Change the value of the cell directly to the right, under the heading "1st Yr Shr", to the value of the market share in the year input in step 1 above.
- 3) Change the market share in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left of "1st Year", depending on the year selected for "1st year" in step 1.

Note that Conventional Vehicles are automatically calculated to comprise the proportion of the market that is not made up of one of the preceding advanced technologies.

Market share can be user-specified for the first year and the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for those years between user specifications. For direction on inputting more complex market share patterns, see Advanced Input (Section 4).

3.2. New Auto Fuel Economy (as a Ratio to Base Case ICE)

The new auto fuel economy module allows a user to define the fuel economy of each advanced vehicle technology. These values indicate the ratio of fuel economy per gasoline gallon equivalent to the "Base ICE" fuel economy from the AEO, which appears in row 28 (see Figure 2). Note that the "Conventional" Vehicle in row 41 is, by default, set equivalent to the Base Case via a 1:1 ratio. Any improvement in the conventional ICE vehicle over what AEO projects needs to be input in the "Conventional" row.

Figure 2: New Auto Fuel Economy

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
22	New Auto Fuel Economy Ratio to Base ICE (using gasoline equivalent gallons)													
23	Enter a ratio to Base ICE mpg (listed in the top row).													
24	For Reference Case Fuel Efficiency, enter "1" under "Use Ref. Case MPG"													
25	If a fuel economy change is desired, specify the first year fuel economy (i.e. mpg) in column N.													
26	Enter "0" under "Use Ref. Case MPG" to change Fuel Efficiency Ratio													
27		2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	Use Ref	MPG in
28	Base ICE	28.13	31.04	40.38	40.26	40.26	40.26	40.46	40.66	40.87	41.07	41.28	Case MPG	1st Year
29	EV (1)	2.98	2.98	2.58	2.56	2.56	2.56	2.55	2.54	2.53	2.51	2.50	1	0.00
30	E-85 FFV (2)	0.91	1.00	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1	0.00
31	Diesel (3)	1.45	1.32	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1	0.00
32	CNG	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1.08	1	0.00
33	SI HEV on Gasoline	1.54	1.39	1.34	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1	0.00
34	SI HEV on E85/H2	1.57	1.33	1.04	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1.05	1	0.00
35	Diesel HEV	1.57	1.71	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1.42	1	0.00
36	SI PHEV-on Gasoline/ E85/ H2 (4)	1.47	1.32	1.27	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1.26	1	0.00
37	SI PHEV-on Electricity (4)	3.86	3.47	3.32	3.23	3.23	3.23	3.23	3.23	3.23	3.23	3.23	1	0.00
38	Diesel PHEV- on Diesel (4)	1.49	1.63	1.35	1.35	1.34	1.34	1.34	1.34	1.34	1.34	1.34	1	0.00
39	Diesel PHEV-on Electricity (4)	3.85	4.20	3.47	3.42	3.41	3.39	3.38	3.36	3.35	3.35	3.35	1	0.00
40	Fuel Cell	2.18	1.87	1.33	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1.31	1	0.00
41	Conventional	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1	0.00
42	(1) EV MPG values represent miles per 125000 Btu at the plug.													
43	(2) VISION assumes that fuel ethanol is denatured with 5% gasoline.													
44	(3) Multiply diesel MPG by 0.9012 to compute gasoline gallon equivalent MPG.													
45	(4) Should reflect fuel economy while using this fuel. Please see cells D15-Y16 in worksheet "Light Vehicle MPG (geg)" for combined liquid fuel and electric MPG.													

The technologies for which user-input is possible mostly mirror those in the market penetration module explained above, with the following exceptions. Both SI and diesel PHEV technologies are split across two lines: a first for energy economy on liquid fuel (gasoline, ethanol, or hydrogen for a spark-ignition technology and diesel for a compression ignition technology) and a second for energy economy on electricity within the vehicle's all-electric range.

The fuel economies of advanced technology vehicles to 2030 are, by default, matched to values predicted by the Annual Energy Outlook. Thus, a user can opt to use the AEO Reference Case fuel economies by making no changes in rows 29-41. Changing these default economies requires two preliminary steps in the "Auto (Car) Market Penetration" module because the "Auto (Car) Market Penetration" module and "New Auto Fuel Economy" module are interrelated, even if a user does not wish to change the default technology market penetration values. If changes are already made to the market penetration values in rows 9-19, the steps 1 and 2 below should be skipped.

- 1) Change the cell in-line in rows 9-19 with the advanced technology for which the fuel economy is to be changed under the heading "1st Year" from 0 to the year at which the fuel economy begins to deviate from the default value

- 2) Change the value of the cell directly to the right, under the heading "1st Yr Shr", to the value of the market share in the year input in step 1 above (this year should appear in column with the heading "1st Year" in rows 9-19).

After completing the preliminary steps in the "Auto (Car) Market Penetration" module, the fuel economies can be changed in three steps:

- 3) Change the cell in-line with the advanced technology (in rows 29-41) for which the fuel economy ratio is to be changed under the heading "Use Ref Case MPG" from 1 to 0.
- 4) Change the value of the cell directly to the right, under the heading "MPG in 1st Year", to the desired fuel economy in the year input in rows 9-19 while changing market penetration above. Please note that the desired MPGGE should be entered here instead of fuel economy ratio because the corresponding base fuel economy may not be known for the year of interest.
- 5) Change the fuel economy ratio in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left of the column marked "Use Ref Case MPG", depending on the year selected for "1st year" in step 1 above or in the "Auto (Car) Market Penetration" module.

When changed, the fuel economy is user-specified for the first year and fuel economy ratios are user-specified for the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for those years between user specifications. For direction on inputting more complex fuel economy ratio patterns, see Advanced Input (Section 4).

3.3. Light Truck Market Penetration

The Light Truck Market Penetration module allows a user to define the percentage of the total number of new light trucks sold by technology type. This module is analogous to the Auto (Car) Market Penetration module described on Section 4. In the 'Model Input' worksheet, rows 51 – 62, which comprise the light truck market penetration module, are exact copies of rows 6 – 20, which comprise the Auto (Car) Market Penetration module. The three-step process for modifying the Auto (Car) Market Penetration module is also applicable for modifying this Light Truck module; see Section 3.1 for details.

3.4. Light Truck Share of Total Light Duty Vehicle Market

The Light Truck Share of Total Light Duty Vehicle Market module allows a user to define the percentage of all new light duty vehicles sold that are light trucks. Changing the light duty vehicle market share requires 4 steps:

- 1) Alert VISION to changes in the module by changing the "NO" in cell A69 to "YES".
- 2) Change the value of cell under the heading "1st Year" to the first year in which the total light truck market share deviates from the default value.
- 3) Change the value of the cell directly to the right, under the heading "1st Yr Shr", to the value of the market share in the year input in step 2 above.
- 4) Change the total light truck market share in all subsequent years ending in zero to the values associated with your user-defined scenario.

3.5. New Light Truck Fuel Economy (as a Ratio to Base Case ICE)

The New Light Truck Fuel Economy allows a user to define the fuel economy of each advanced vehicle technology. This module is analogous to the New Auto Fuel Economy module described in Section 3.2. In the 'Model Input' worksheet, rows 73–95, which comprise the New Light Truck Fuel Economy module, are exact copies of rows 23–45, which comprise the New Auto Fuel Economy module. The five-step process for modifying the New Auto Fuel Economy module is also applicable for modifying this Light Truck module; see Section 3.2 for details.

3.6. Technology Fuel Type

The Technology Fuel Type module allows a user to specify the fuel used in flex-fuel HEVs, PHEVs, and fuel cell vehicles. A user can modify the fuel assigned to these technologies in column B by inputting a number representing another fuel type using the appropriate legend in column F. Note that only ethanol (E85) and hydrogen are valid for HEV. Only gasoline, ethanol (E85), and hydrogen are valid for PHEVs. Gasoline, diesel, natural gas, ethanol (E100), hydrogen, and methanol are valid for fuel cell vehicles. The legends in column F clearly indicate fuels that are valid for modeling each vehicle technology for which multiple options are available.

3.7. Fuel Price

This Fuel Price module (see Figure 3) allows a user to define the price of various fuels, including: gasoline, diesel, natural gas, ethanol (E85), hydrogen, F-T (Fischer-Tropsch) diesel, bio-diesel, methanol, and electricity. Note that fuel prices should be interpreted and input in constant 2005 dollars per gasoline gallon equivalent. Also note that prices for F-T- and bio-diesel should reflect the price of the pure fuel. Fuel blends can be specified in the module immediately following the Fuel Price module.

Figure 3: Fuel Price

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
110	<i>VISION uses fuel price projections by the Dept of Energy allowing user specification only for the shaded area in the table below. The DOE projections include federal and state taxes, where applicable. If you are simulating a fuel price scenario, type "1" in the box below and specify your prices. Fuel Prices are in 2005 dollars; dollars per gasoline gallon equivalent.</i>													
111		CHANGE FUEL PRICES?	0	1=Yes										
112														
113	Fuel Prices	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Price
114	Gasoline	1.70	2.57	2.38	2.47	2.64	2.81	2.98	3.15	3.32	3.49	3.66	0	0.00
115	Diesel	1.52	2.38	2.21	2.37	2.63	2.88	3.14	3.39	3.64	3.90	4.15	0	0.00
116	Natural Gas	1.16	1.65	1.47	1.56	1.69	1.82	1.96	2.09	2.23	2.36	2.49	0	0.00
117	Ethanol (E85)	2.23	2.86	2.20	2.38	2.65	2.92	3.19	3.46	3.73	4.01	4.28	0	0.00
118	Hydrogen	14.53	10.90	5.81	4.36	4.20	4.24	4.28	4.33	4.37	4.41	4.45	0	0.00
119	F-T Diesel	2.18	2.36	2.02	2.12	2.26	2.39	2.52	2.66	2.79	2.93	3.06	0	0.00
120	Bio-Diesel	2.24	2.47	2.19	2.18	2.45	2.73	3.00	3.27	3.54	3.81	4.08	0	0.00
121	Methanol	1.94	2.88	2.43	2.57	2.79	3.01	3.23	3.45	3.67	3.89	4.11	0	0.00
122	Electricity	2.04	2.29	2.20	2.23	2.28	2.32	2.36	2.41	2.45	2.49	2.54	0	0.00
123														

Fuel prices are, by default, matched to values published in the Annual Energy Outlook up to the year 2030 and extrapolated after that. The price of each fuel can be changed in four steps:

- 1) Alert VISION to changes in the module by changing the “0” in cell next to “Change Fuel Prices?” to “1”.
- 2) Change the cell in-line with the fuel for which the price is to be changed under the heading “1st Year” from 0 to the year at which the price begins to deviate from the default value.
- 4) Change the value of the cell directly to the right, under the heading “1st Yr Price”, to the price in the year input in step 2.
- 5) Change the fuel price in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns on the left, depending on the year selected for “1st year” in step 2.

Fuel prices can be user-specified for the first year and the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for years between user specifications. For direction on inputting more complex fuel price patterns, see Advanced Input (Section 4).

3.8. Other Key Fuel Input Assumptions

3.8.1. Share, by volume, in Blended Fuels

VISION offers three options to incorporate fuel blends: ethanol in conventional gasoline, F-T diesel in conventional diesel, and bio-diesel in conventional diesel. Fuel blends are, by default, matched to values published in the Annual Energy Outlook to 2030 and held constant after that. VISION allows a user to

specify the percentage of an alternative fuel that is blended with the conventional fuel by following three steps:

- 1) Change the cell in-line with the fuel for which the blend is to be changed under the heading "1st Year" from 0 to the year at which the blend begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading "1st Yr Shr", to the percentage of the fuel that is added to the base blend in the year input in step 1.
- 3) Change the blend in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left, depending on the year selected for "1st year" in step 1.

Fuel blends can be user-specified for the first year and the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for years between user specifications. For direction on inputting more complex fuel blend patterns, see Advanced Input (Section 4).

3.8.2. FFV VMT Share by Fuel and All-electric Range for New PHEV

The Flex-Fuel Vehicle Vehicle-Miles-Traveled Share by Fuel and All-electric Range for New PHEVs module provides a mechanism for defining the details for vehicles with multiple power sources. This module (see Figure 4) consists of three sections: specifications for flex-fuel vehicles, specifications for PHEV electric range, and override specifications for PHEV electric range. Note that for PHEVs, VISION automatically calculates the percentage of vehicle miles traveled based on the all-electric range using a mathematical formula unless override specifications are input.

In the first section, specifications for flex-fuel vehicles, a user can define the percentage of total vehicle miles traveled using E85 ethanol, instead of conventional gasoline, in each of three flex-fuel vehicles. These specifications can be made in three steps:

- 1) Change the cell in-line with the flex-fuel vehicle for which the percentage of travel made using E85 is to be changed under the heading "1st Year" from 0 to the year at which the blend begins to deviate from the default value.
- 2) Change the value of the cell directly to the right of "1st Year", under the heading "1st Yr Value", to the percentage of travel made using E85 in the year input in step 1.
- 3) Change the percentage of travel made using E85 in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left of "1st Year", depending on the year selected for "1st year" in step 1.

Figure 4: Fuel Input Assumptions

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
132	FFV VMT Share by Fuel and All-electric Range for New PHEV													
133	<i>Enter percent of miles by FFV that will be on E85 fuel (rest of the miles are assumed to be on ethanol & gasoline blend)</i>													
134		2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Value
135	E85 VMT Share for E85 FFV (1)	0.3%	0.3%	35.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	39.9%	0	0.0%
136	E85 VMT Share for SI HEV on E85 (1)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
137	E85 VMT Share for SI PHEV (2) (excluding Electric Mode VMT)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
138	Electric Range for PHEV in Miles (3)													
139	Auto SI PHEV	5	8	13	25	25	25	25	25	25	25	25	0	0
140	Auto D PHEV	5	5	12	20	22	24	26	28	30	30	30	0	0
141	Lt Truck SI PHEV	5	6	10	20	20	20	24	25	25	25	25	0	0
142	Lt Truck D PHEV	5	5	12	20	20	20	23	25	27	29	30	0	0
143	Electricity VMT Share of PHEV VMT (for user information only; can be changed by changing range in rows 139-142.)													
144	Auto SI PHEV	9.2%	14.3%	21.2%	37.1%	37.1%	37.1%	37.1%	37.1%	37.1%	37.1%	37.1%		
145	Auto D PHEV	9.2%	9.2%	20.5%	31.3%	33.7%	36.0%	38.2%	40.2%	42.2%	42.2%	42.2%		
146	Lt Truck SI PHEV	9.2%	10.1%	17.4%	31.3%	31.3%	31.3%	35.0%	37.1%	37.1%	37.1%	37.1%		
147	Lt Truck D PHEV	9.2%	9.2%	20.5%	31.3%	31.3%	31.3%	34.8%	37.1%	39.2%	41.2%	42.2%		
148	<small>(1) VISION assumes that ethanol is denatured with 5% gasoline.</small>													
149	<small>(2) Electric share will be calculated internally based on electric range. The share specified here is of non-electric VMT.</small>													
150	<small>(3) PHEV VMT % on electricity is computed by using an equation based on SAE J1711. A user may accept it, change electric range, or replace the computed VMT %.</small>													

In the second section, specifications for PHEV electric range, a user can define the all-electric range of PHEVs in three steps:

- 1) Change the cell in-line with the PHEV for which the all-electric range is to be changed under the heading "1st Year" from 0 to the year at which the blend begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading "1st Yr Value", to the all-electric range in the year input in step 1.
- 3) Change the all-electric range in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left, depending on the year selected for "1st year" in step 1.

As mentioned above, VISION uses the user-defined all-electric range to calculate the percentage of vehicle miles traveled using electricity based on a mathematical formula². These override values should be changed per the directions in the following paragraph if the user wishes to manually input a different percentage of total VMT on electricity than the VISION-calculated value.

In the third section, override specifications for PHEV electric range, a user can specify the percentage of total vehicle miles traveled in a PHEV's all-electric range. These specifications are calculated automatically based on the all-electric ranges input in the preceding section. To override the calculated value, the user should simply input the percentage of total VMT for the PHEV technology in a given year. (Please note that the rows in which percentages of total miles on electricity appear are not shaded. Unless the user has a basis for changing the values, only the equation parameters should be changed with own justification. The equation in these rows is based on the data from a national survey.)

Note that in each of these cases, parameters can be user-specified for the first year and the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for years between user specifications. For direction on inputting more complex patterns, see Advanced Input (Section 4).

3.8.3. Ethanol and Hydrogen Production Share by Feedstock and Utility Mix

The Production Share by Feedstocks module provides a mechanism for defining the details for the production of alternative fuel production. This module consists of three sections: specifications for ethanol production share by feedstock, specifications for hydrogen production share by feedstock, and utility scenario.

In the first section, specifications for ethanol production share by feedstock, a user can define the percentage of ethanol produced using five feedstocks in three steps:

- 1) Change the cell in-line with the feedstock (corn stover, switchgrass, woody biomass, forest residue) for which the feedstock is to be changed under the heading "1st Year" from 0 to the year at which the feedstock share of ethanol production begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading "1st Yr Shr", to the percentage of ethanol produced using the specified feedstock in the year input in step 1.
- 3) Change the percentage of ethanol produced using the specified feedstock in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left, depending on the year selected for "1st year" in step 1.

Note that the percentage of ethanol produced using corn is automatically calculated to comprise the proportion of the market that is not made up of one of the other feedstocks.

² $\%VMT = 0.00049 + 0.0194148 * AER - 0.000214596 * AER^2 + 0.00000130166 * AER^3 - 0.00000000327902 * AER^4$

Figure 5: Energy Pathways

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
152	Ethanol Production Share by Feedstock													
153	<i>Enter percent of ethanol produced from the following feedstock</i>													
154	Ethanol feedstock	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Shr
155	Corn (1)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%		
156	Corn stover	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
157	Switchgrass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
158	Woody biomass	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
159	Forest residue	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		
160	(1) Computed as 100 minus the sum of other feedstock.													
161														
162	Hydrogen Production Share by Feedstock													
163	<i>Enter percent of hydrogen produced from the following feedstock</i>													
164	Hydrogen feedstock	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Shr
165	HG- Station (1)	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%		
166	Electrolysis - Station	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
167	HG - Central	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
168	Coal - Central (2)	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
169	Biomass - Central	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
170	High Temp. Electro. - Central	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
171	TC Conversion of Water - Central	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
172	Solar - Central	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
173	(1) Computed as 100 minus the sum of other feedstock.													
174	(2) With CO2 sequestration													
175	Utility Scenario ==>		1	Select from one of the follow				1 - Reference Case (AEO) 2 - Renewable Scenario 3 - Natural Gas Scenario 4 - Nuclear Scenario						
176														
177														
178														

In the second section, specifications for hydrogen production share by feedstock, a user can define the percentage of hydrogen produced using eight feedstocks. Note that the percentage of hydrogen produced via “natural gas - station” is automatically calculated to comprise the proportion of the market that is not made up of one of the other feedstocks. The other feedstocks can be defined in three steps:

- 1) Change the cell in-line with the feedstock (electrolysis – station, natural gas – central, coal – central, biomass – central, high temperature electrolysis – central, TC conversion of water – central, solar – central) for which the feedstock share of hydrogen production is to be changed under the heading “1st Year” from 0 to the year at which the blend begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading “1st Yr Shr”, to the percentage of hydrogen produced using the specified feedstock in the year input in step 1.
- 3) Change the percentage of hydrogen produced using the specified feedstock in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left, depending on the year selected for “1st year” in step 1.

Finally, in the third section, a user can specify one of four scenarios that describe the future of the power sources for the U.S. electric grid. The Reference Case presumes business as usual, the Renewable Scenario presumes significant increases in renewable energy are incorporated to power the grid, the Natural Gas presumes significant increases in natural gas, and the Nuclear Scenario presumes significant increases in nuclear energy. The “Util Mix” sheet presents precisely what is assumed. To toggle between scenarios, a user should input the number of the desired scenario from the legend in column G (as shown in Figure 5).

3.9. LDV VMT Growth Rate and Elasticity to the Cost of Driving

The Vehicle Miles Traveled (VMT) module allows a user to estimate VMT based on one of two prediction algorithms: a mathematical VMT growth function or manually entered growth factors. The worksheet contains a mechanism for selecting which algorithm to use in the cell next to “Select LDV VMT growth method”. A ‘1’ in this cell alerts VISION to use the mathematical growth function; a ‘2’ tells VISION to use manually entered growth factors; a ‘3’ triggers a hybrid mode, in which the formula is used until a ‘1st year’, specified by the user, after which manually entered growth factors are used; and a ‘4’ tells VISION to use annual VMT/car and VMT/LT estimates. Modifications to simulated scenarios

using the VMT module depends on the value inputted to cell next to “Selected LDV VMT growth method”, as follows:

‘1’, signaling use of the mathematical algorithm, $VMT\ growth = \exp(rt + at^2)$, where

- r = rate of growth,
- t = year at start, and
- a = the discount rate.

The growth parameters can be entered in column C, in rows following “VMT Growth Function”. The equation also considers elasticity to cost of driving—that is, the percent change in VMT resulting from a 100 percent change in fuel cost per mile from the Base Case value—in cell D189. The growth rate can be modified by adjusting at least two values:

- 1) rate of growth, and
- 2) years to zero growth
- 3) elasticity to cost of driving (optional)

The discount rate will be calculated automatically.

‘2’, signaling use of manually entered growth factors.

A ‘2’ in column C next to “Select LDV VMT growth method” tells VISION to use manually entered values for VMT growth factors (where a growth factor is the proportion of VMT in a given year compared to that of the year prior). A user can control automobile (car) VMT over time in 2 steps:

- 1) Inputting a value for the “1st Year” that manually entered VMT growth factors should be considered in the simulation and the VMT growth factor for that year in cell next to it with heading “VMT Factor” (note: the year should be 2000 if a VMT growth factor is input for all years in the simulation), and
- 2) Manually entering a value for each year in the simulation covering all years, beginning with the column C (as shown in Figure 6).

Light truck VMT growth can be controlled using the above process in the appropriate cells just beneath the cells used for automobile (car) manual entry.

‘3’, indicating a mixture of the preceding methods.

The same procedure described for “‘2’, signaling use of manually entered values” above is applicable here. The only difference between a mixture of VMT growth calculation methods and purely manual entry is the ‘1st Year’ values for cars and for light trucks, which determines the transition point between the two methods.

‘4’, which uses annual VMT/car and VMT/LT estimates based on AEO data and extension to the last year of VISION simulations.

EIA does not publish the annual VMT/car and VMT/LT estimates. For VISION, these are derived from the AEO projections of car and LT energy use, vehicle stock and stock fuel economy. They are then extended to 2100. Note that the annual VMT/car and VMT/LT estimates are consistent with the default annual growth factors in the ‘Model Input’ worksheet.

Figure 6: Vehicle Miles Traveled

179	LDV VMT Growth Rate															
180	<i>Four options: 1=use exponential function $Exp(rt+at^2)$ for all years; 2=user specified fixed rates by year (see rows 191-219);</i>															
181	<i>3=combination of two, option 1 applied until the "1st Year" (in M195 and M210) and option 2 after that; or 4=use AEO extended (see worksheet "Auto-LT data").</i>															
182	Selected LDV VMT growth method		1													
183	VMT Growth Function ~ $e^{(rt+at^2)}$															
184	r = rate of growth		0.0081													
185	t = time at start		2000													
186	a = discount rate		-0.000051													
187	years to zero growth		200													
188																
189	VMT Elasticity to Cost of Driving (cents/mile)					-0.1	<i>Use only when VMT Growth Methods 1</i>									
190																
191	VMT Growth Factors for Cars															
192	<i>Input VMT growth factors for cars when the selected VMT Growth Method is 2 or 3.</i>															
193	<i>MUST specify the first year and first year VMT factor.</i>															
194	Car VMT Factor for the Decade Year	2000	2001 - 2010	2011 - 2020	2021 - 2030	2031 - 2040	2041 - 2050	2051 - 2060	2061 - 2070	2071 - 2080	2081 - 2090	2091 - 2100	1st Year	VMT Factor		
195	1			1.0111	1.0098	1.0063	1.0042	1.0039	1.0040	1.0031	1.0025	1.0027	2006	0.8893		
196	2			1.0142	1.0095	1.0051	1.0041	1.0039	1.0040	1.0031	1.0025	1.0028				
197	3			1.0138	1.0104	1.0050	1.0040	1.0039	1.0040	1.0031	1.0026	1.0028				
198	4		1.0166	1.0120	1.0111	1.0051	1.0041	1.0039	1.0040	1.0032	1.0026	1.0028				
199	5		1.0050	1.0102	1.0118	1.0049	1.0039	1.0039	1.0040	1.0032	1.0026	1.0028				
200	6		0.8893	1.0086	1.0124	1.0049	1.0042	1.0039	1.0030	1.0032	1.0026	1.0029				
201	7		0.9777	1.0077	1.0129	1.0047	1.0044	1.0039	1.0030	1.0032	1.0027	1.0029				
202	8		0.9996	1.0068	1.0135	1.0045	1.0046	1.0039	1.0030	1.0033	1.0027	1.0029				
203	9		1.0102	1.0086	1.0142	1.0044	1.0047	1.0039	1.0031	1.0033	1.0027	1.0029				
204	0		1.0082	1.0099	1.0149	1.0041	1.0049	1.0040	1.0031	1.0033	1.0027	1.0030				

3.10. New Heavy Vehicle MPG Ratio to Reference Gasoline

The New Heavy Vehicle MPG Ratio to Reference Gasoline module allows a user to define the fuel economy of heavy truck technologies. The values in this module indicate the ratio of volumetric fuel economy to the "Reference Gasoline and Diesel Fuel Economy", as shown in Figure 7. The vehicles for which Reference values are provided are: Class 3–6 Gasoline, Class 3–6 Diesel, Class 3–6 Diesel HEV, Class 7&8 Single Unit Conventional Gasoline, Class 7&8 Single Unit Diesel HEV, and Class 7&8 Combination. These reference values, not shaded in yellow, are for reference only and should not be changed by the user.

A user can customize heavy truck fuel economy by altering the fuel ratios in the rows following "Reference Gasoline and Diesel Fuel Economy". Changing the economy that is used in the scenario requires three steps:

- 1) Change the cell in-line with the truck and engine type for which the fuel economy ratio is to be changed under the heading "1st Year of Change" from 0 to the year at which the fuel economy begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading "MPG in 1st Year", to fuel economy for the year input in step 1 above. Please note that actual MPG should be entered here instead of fuel economy ratio because the corresponding base fuel economy may not be known for the year of interest.
- 3) Change the fuel economy ratios in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left, depending on the year selected for "1st year of Change" in step 1.

Note that this process is analogous to changing adjusting the New Auto Fuel Economy module, described and pictured in Section 3.2, except that the fuel economies are not in gasoline gallon equivalent.

When changed, the fuel economy is user-specified for the first year and fuel economy ratios are user-specified for the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for those years between user specifications. For direction on inputting more complex fuel economy ratio patterns, see Advanced Input (Section 4).

Figure 7: New Truck MPG and Market Share

	A	B	C	D	E	F	G	H	I	J	K	L	M	N
233														
234			2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year of Change	MPG in 1st Year
235	1.2 New Class 3-6 Truck MPG Ratio to Reference Gasoline													
236	Class 3-6: Gasoline		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0	0.00
237	Class 3-6: Diesel		1.06	1.04	1.09	1.09	1.09	1.09	1.09	1.09	1.09	1.09	0	0.00
238	Class 3-6: Diesel HEV		1.14	1.15	1.16	1.17	1.18	1.18	1.18	1.18	1.18	1.18	0	0.00
239	1.3 New Class 7 & 8 Single Unit Truck MPG Ratio to Reference SU Conventional													
240	Class 7&8: Single Unit Conventional		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0	0.00
241	Class 7&8: SU Diesel HEV		1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	0	0.00
242	1.4 New Class 7&8 Comb. Truck MPG Ratio to Reference													
243	Class 7 & 8: Combination		1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0	0.00
244	<small>Note: Gasoline and diesel truck MPG are per gallon of respective fuel. MPG of Class 7&8 single unit trucks represent VMT weighted harmonic means.</small>													
245														
246	2. New Truck Market Share													
247	2.1 Class 3-6 Truck Market Shares													
248		2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Shr
249	Class 3-6: Conv. Gas.	49.2%	32.4%	32.7%	32.4%	30.3%	30.0%	29.9%	29.8%	29.7%	29.6%	29.5%	0	0.0%
250	Class 3-6: Conv. Diesel	50.8%	67.6%	67.3%	67.6%	69.7%	70.0%	70.1%	70.2%	70.3%	70.4%	70.5%	0	0.0%
251	Class 3-6: HEV Diesel		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
252	<small>Note: Market Share of Class 3-6 Conventional Gasoline Truck is Calculated Automatically</small>													
253														
254	2.2 Class 7&8 Truck Market Shares													
255		2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100	1st Year	1st Yr Shr
256	Class 7&8: Conv Single Unit	28.6%	24.6%	23.6%	22.5%	22.5%	22.4%	22.4%	22.3%	22.3%	22.2%	22.2%	0	0.0%
257	Class 7&8: HEV Single Unit		0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0	0.0%
258	Class 7&8: Conv Comb.	71.4%	75.4%	76.4%	77.5%	77.6%	77.6%	77.7%	77.7%	77.8%	77.8%	77.8%	0	0.0%
259	<small>Note: Market Share of Class 7&8 Conventional Combination Truck is Calculated Automatically</small>													

3.11. New Heavy Truck Market Share

The New Heavy truck Market Share module is divided into two parts—class 3–6 and class 7&8—that allow a user to define the percentage of the total number of new trucks sold by engine type. This division is shown in Figure 7. Technologies include: Class 3–6 Conventional Gasoline, Class 3–6 Conventional Diesel, Class 3–6 Diesel HEV, Class 7&8 Single-Unit Conventional Gasoline, Class 7&8 Single-Unit HEV, and Class 7&8 Combination.

The composition of new market sales are, by default, matched to values published in the Annual Energy Outlook and the 2002 Vehicle Inventory and Use Survey (because the latter provides additional detail). Note that Class 3–6 Conventional trucks and Class 7&8 Conventional Combination trucks are automatically calculated to comprise the proportion of the market that is not made up by other technologies; therefore, user input should include only those other technologies (in the rows that are shaded yellow). The market share values for each technology can be changed in three steps:

- 1) Change the cell in-line with the advanced technology for which the market share is to be changed under the heading “1st Year” from 0 to the year at which the market share begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading “1st Yr Shr”, to the value of the market share in the year input in step 1 above.
- 3) Change the market share in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left of column with heading “1st Year”, depending on the year selected for “1st year” in step 1.

Market share can be user-specified for the first year and the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for those years between user specifications. For direction on inputting more complex market share patterns, see Advanced Input (Section 4).

3.12. Diesel Share of Class 7&8 Single Unit Truck VMT

Because class 7&8 gasoline and diesel single unit trucks are simulated together, Section 3 of Heavy Vehicles enables a user to specify the percentage of heavy trucks running on diesel. The default values are derived from the past Vehicle Inventory and Use Surveys and the resulting trend is extrapolated. To change these percentages from the default values:

- 1) Change the cell under the heading “1st Year of Change” from 0 to the year at which the percentage of diesel trucks deviates from the default value.

- 2) Change the value of the cell under the heading "Share in 1st Year" to the VMT by diesel trucks, as a percentage of the total.
- 3) Change the percentage of diesel truck VMT in all subsequent years ending in zero to the values associated with your user-defined scenario. These years appear in some portion of columns to the left of "1st Year of Change", depending on the year selected for "1st Year of Change" in step 1.

3.13. Share of Alternative Fuels

VISION offers two options to incorporate diesel fuel blends for heavy trucks: bio-diesel and Fischer-Tropsch Diesel. Fuel blends are, by default, matched to values published in the Annual Energy Outlook. They are the same as those developed for light vehicles. Because many class 3-8 diesel trucks are fueled at truck owners' facilities, their average diesel fuel blend shares can be different than those for the light duty vehicles. VISION allows a user to specify own composition of diesel blend for class 3-8 trucks. The user should change the blend shares here only if they are different from those for the light duty vehicles. A user can specify the percentage of an alternative fuel that is blended with the conventional diesel fuel for use by class 3-8 trucks by following three steps:

- 1) Change the cell in-line with the fuel for which the blend is to be changed under the heading "1st Year" from 0 to the year at which the blend begins to deviate from the default value.
- 2) Change the value of the cell directly to the right, under the heading "1st Yr Shr", to the percentage of the fuel by volume that is added to conventional diesel fuel in the year input in step 1.
- 3) Change the shares in all subsequent years ending in zero to the values associated with your user-defined scenario.

Fuel blends can be user-specified for the first year and the year ending in zero of each subsequent decade. VISION automatically linearly interpolates for years between user specifications. For direction on inputting more complex alternative fuel blending patterns, see Advanced Input (Section 4).

3.14. Light Vehicle Cost Ratio

VISION enables a user to make future projections regarding the incremental vehicle costs of each advanced light vehicle technology included in a scenario: EV (electric vehicles), E-85 FFV (E85 flex fuel vehicles), Diesel, CNG (compressed natural gas), SI HEV on Gasoline (spark ignition hybrid electric vehicle on gasoline), SI HEV on E85/H2 (spark ignition hybrid electric vehicle on E85 flex fuel or hydrogen ICE), Diesel HEV, SI PHEV (spark ignition plug-in hybrid electric vehicle), Diesel PHEV, and Fuel Cell Vehicles. These options are shown in Figure 8.

The prices of these vehicles are indexed to a base price—input in column B for cars and light trucks—for an ICE vehicle of each type in the year 2000, where the index is the ratio of the advanced vehicle technology price to the Base ICE price (e.g., by default, an electric car costs 155% of a conventional ICE in the year 2000). A user should first verify that the base price is appropriate for the scenario or change it, if necessary. Subsequently, the user can adjust the price of advanced technology vehicles by manually entering new price ratios in the car price ratio grid and the light truck price ratio grid.

Figure 8: Light Vehicle Cost Ratio

	A	B	C	D	E	F	G	H	I	J	K	L
272	Light Vehicle Cost Ratio											
273	<i>User may change the Base Price and/or cost ratios.</i>											
274												
275	Car Base ICE Price in 2005 dollars	23,510	(Midsize Year 2000 price)									
276												
277	Technology	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
278	EV	1.65	1.63	1.60	1.59	1.55	1.50	1.48	1.46	1.44	1.42	1.40
279	E-85	1.01	1.01	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
280	Diesel	1.11	1.10	1.09	1.09	1.08	1.08	1.08	1.07	1.07	1.07	1.07
281	CNG	1.39	1.38	1.37	1.36	1.35	1.34	1.33	1.33	1.33	1.33	1.33
282	SI HEV on Gas	1.20	1.15	1.14	1.13	1.12	1.12	1.12	1.12	1.12	1.12	1.12
283	SI HEV on E85/H2	1.21	1.16	1.16	1.15	1.13	1.13	1.13	1.13	1.13	1.13	1.13
284	Diesel HEV	1.33	1.26	1.24	1.23	1.21	1.21	1.21	1.20	1.20	1.20	1.20
285	SI PHEV	1.80	1.38	1.30	1.27	1.25	1.23	1.21	1.20	1.20	1.20	1.20
286	Diesel PHEV	1.99	1.51	1.42	1.38	1.35	1.33	1.30	1.29	1.29	1.29	1.29
287	Fuel Cell	4.00	3.07	2.43	2.03	1.80	1.60	1.55	1.53	1.50	1.48	1.45
288												
289												
290	Lt Trk Base ICE Price in 2005 dollars	23,120	(Year 2000 price -- Avg of small van and small SUV)									
291												
292	Technology	2000	2010	2020	2030	2040	2050	2060	2070	2080	2090	2100
293	EV	1.85	1.80	1.79	1.78	1.75	1.70	1.68	1.66	1.64	1.62	1.60
294	E-85	1.02	1.01	1.02	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
295	Diesel	1.11	1.11	1.09	1.09	1.09	1.09	1.08	1.08	1.08	1.08	1.08
296	CNG	1.35	1.34	1.33	1.33	1.32	1.32	1.31	1.31	1.30	1.30	1.30
297	SI HEV on Gas	1.25	1.18	1.17	1.16	1.15	1.14	1.13	1.13	1.13	1.13	1.13
298	SI HEV on E85/H2	1.28	1.19	1.19	1.18	1.16	1.15	1.14	1.14	1.14	1.14	1.14
299	Diesel HEV	1.40	1.33	1.30	1.27	1.27	1.26	1.25	1.24	1.24	1.24	1.24
300	SI PHEV	1.88	1.52	1.45	1.38	1.30	1.27	1.25	1.25	1.25	1.25	1.25
301	Diesel PHEV	2.20	2.00	1.65	1.45	1.38	1.33	1.32	1.32	1.31	1.31	1.31
302	Fuel Cell	4.00	3.10	2.50	2.20	2.00	1.80	1.75	1.73	1.70	1.69	1.68

As with other variables, light vehicle prices can be user-specified for the first year ending in zero of each decade. VISION automatically linearly interpolates for years between user specifications. For direction on inputting more complex price patterns, see Advanced Input (Section 4).

4. Advanced Input

This section details the location into which a user can manually input (i.e., hard-wire) parameters to describe more complex patterns over time than the decadal interpolation that VISION uses by default. Advanced data entry is possible for all variables discussed in section 3 except for 2: “Technology Fuel Type” and “LDV VMT Growth Rate and Elasticity to the Cost of Driving”. For the first of these, complex entry is unnecessary; for the second, annual entry is also facilitated by the existing ‘Model Input’ worksheet.

Auto (Car) Market Penetration AM40:AM140 in multiple tabs: ‘auto XX’ where XX indicates the type of car for which a modification is to be made (EV, EtOH, Dsl, CNG, SI HEV Gas, SI HEV E85, D HEV, SI PHEV, D PHEV, FCV). Market penetration of conventional cars in worksheet ‘auto ICE’ is computed automatically as the remainder.

New Auto Fuel Economy (in miles per gasoline gallon equivalent) AO40:AO140 in multiple tabs: ‘auto XX’ where XX indicates the type of car for which a modification is to be made (ICE, EV, EtOH, Dsl, CNG, SI HEV Gas, SI HEV E85, D HEV, SI PHEV, D PHEV, FCV). PHEV fuel economies on electricity are in column BE in worksheets ‘auto SI PHEV’ and ‘auto D PHEV’.

Light Truck Market Penetration..... AM40:AM140 in multiple tabs: ‘LT XX’ where XX indicates the type of car for which a modification is to be made (EV, EtOH, Dsl, CNG, SI HEV Gas, SI HEV E85, D HEV, SI PHEV, D PHEV, FCV).

- Market penetration of conventional light trucks in worksheet 'LT ICE' is computed automatically as the remainder.
- Light Truck Share of Total Light Duty Vehicle Market J40:J140 in 'Auto-LT data'. If these values are changed, the option to change "Light Truck Share of Total LDV Market" in the worksheet "Model Input" should be set to "No".
- New Light Truck Fuel Economy (in mpgge) AO40:AO140 in multiple tabs: 'LT XX' where XX indicates the type of car for which a modification is to be made (ICE, EV, EtOH, Dsl, CNG, SI HEV Gas, SI HEV E85, D HEV, SI PHEV, D PHEV, FCV). PHEV fuel economies on electricity are in column BE in worksheets 'LT SI PHEV' and 'LT D PHEV'.
- Fuel Price L40:T140 in 'Fuel \$ Data'.
- Ethanol Share, by volume, in Blended Gasoline M40:M90 in 'Carbon Coefficients'.
- F-T Diesel Share, by volume, in Blended Diesel..... F40:F140 in 'Carbon Coefficients'.
- Bio-diesel Share, by volume, in Blended Diesel H40:H140 in 'Carbon Coefficients'.
- E85 VMT Share of Flexible Fuel Vehicles (FFV)..... R40:R140 in 'Carbon Coefficients'.
- E85 VMT Share of Flexible Fuel SI HEV W40:W140 in 'Carbon Coefficients'.
- E85 VMT Share of Flexible Fuel SI PHEV..... AB40:AB140 in 'Carbon Coefficients'.
- % VMT on Electricity for New PHEV AW40:AW140 in multiple tabs: 'auto XX' and 'LT XX' where XX indicates the PHEV type for which a modification is to be made (SI PHEV, D PHEV)
- Ethanol and Hydrogen Production Share by Feedstock..... AE40:AL140 in 'Carbon Coefficients' for hydrogen and AP40:AS140 in 'Carbon Coefficients' for ethanol.
- New Medium Truck MPG (miles per gallon of gasoline or diesel)..... AM50:AM150 in multiple tabs: 'Class XX', where XX indicates the types of truck (3-6G, 3-6D, 3-6 HEV, 7&8SU, 7&8C, 7&8SU HEV)
- New Truck Market Share..... AJ50:AJ150 in multiple tabs: 'Class XX', where XX indicates the types of truck (3-6D, 3-6 HEV, 7&8SU, 7&8SU HEV). Note that Class 3-6G and 7&8C are calculated automatically as the market share not comprised by other medium and heavy duty trucks, respectively.
- Diesel Share of 7&8 Single Unit Truck VMT AS50:AS150 in 'Class 7&8 SU'
- Diesel Share of F-T Diesel or Bio Diesel O50:P150 in 'HVY TRK ENERGY'
- Light Vehicle Cost Ratio AT40:AT14 in multiple tabs: 'auto XX' where XX indicates the type of car for which a modification is to be made (EV, EtOH, Dsl, CNG, SI HEV Gas, SI HEV E85, D HEV, SI PHEV, D PHEV, FCV)

Carbon coefficient for each advanced technology C4:C14, C16:G16, and C18:J18 in 'Carbon Coefficients'. Note that these values are, by default, derived from Argonne National Lab's GREET model, version 1.7. These coefficients can be seen in the 'Carbon Coefficients' worksheet by selecting "Unfreeze Panes" from Microsoft Excel's "Window" Menu.

5. Summary Results

5.1. Model Results

The 'Model Results' worksheet is the primary source for VISION output. It summarizes energy consumption in two scenarios: the Base Case scenario, which uses estimates from the corresponding AEO and its extension, and the scenario defined by the parameters in the 'Model Input' worksheet. Output for the Base Case scenario appears in columns to the left; output for the user-defined scenario appears immediately to the right. Results for the Base Case and user-defined scenarios are analogous except for the "Percent Oil Reduction" that appears for the user-defined scenario. This value captures the reduction in oil consumption in the user-defined scenario relative to the base case.

Key results are displayed twice: once in units of energy (quadrillion Btu), oil use, and CO₂ emissions distinguished by headings with yellow backgrounds, and once in physical units (Bbl, gallons, and kWh), indicated by headings with green backgrounds. Within each of these sections, the results for each scenario are displayed by vehicle type: total light duty vehicles (cars and light trucks), cars, light trucks, heavy vehicles, and total (cars, light trucks, and heavy vehicles).

The summary results worksheet only displays estimates for the first year of each decade in the period 2000–2100. VISION calculates energy consumption at annual intervals, so more detailed results can be obtained. Year-by-year estimates can be viewed by following directions in Extracting Detailed Results (Section 5.4).

5.2. Light Vehicle MPG (gge)

The 'Light Vehicle MPG (gge)' is a second important source for VISION output. It summarizes the new vehicle fuel economy, in miles per gallon of gasoline equivalent, for each vehicle and technology type. Vehicles types are cars and light trucks and technologies included are: conventional internal combustion engine, electric vehicle, E85 flex-fuel vehicle, diesel, compressed natural gas, spark-ignition hybrid electric vehicle on gasoline, spark-ignition hybrid electric vehicle on E85 or hydrogen, diesel hybrid electric vehicle, spark-ignition plug-in hybrid electric vehicle, diesel plug-in hybrid electric vehicle, and fuel cell vehicle.

As in the 'Model Results' worksheet, this worksheet summarizes fuel economies in two scenarios: the Base Case scenario, which uses estimates from AEO and its extension, and the scenario defined by the parameters in the 'Model Input' worksheet. Output for the Base Case scenario appears in columns to the left; output for the user-defined scenario appears immediately to the right.

In addition to new vehicle fuel economies for each individual vehicle technology, the worksheet displays sales-weighted estimates for fuel economy across all vehicle technologies for new vehicles. The "CAFE" line-item displays the estimated corporate average fuel economy (harmonic mean) for all new vehicles in a given year. These values appear row 18 for cars, row 32 for light trucks, and row 35 for total light duty vehicles). The "Fleet On-Road Average" line-item displays the estimated average fuel economy for all technologies and vintages, both new vehicles and older vehicle still in operation, on the road in a given year. These values appear row 19 for cars, row 33 for light trucks, and row 36 for total light duty

vehicles). Because on-road degradation factors are applied to new vehicle dynamometer test fuel economies, the on-road fuel economies are much lower.

These summary results only display estimates for the first year of each decade in the analysis period beginning with 2000. VISION calculates fuel economy at annual intervals, so more detailed results can be obtained. Year-by-year estimates can be viewed by following directions in the Extracting Detailed Results section (Section 5.4).

5.3. Lt Veh Incremental Cost Summary

The 'Lt Veh Incremental Cost Summary' worksheet displays the aggregate incremental vehicle cost for each advanced vehicle technology for cars, light trucks, and light vehicles (the sum total of cars and light trucks). The incremental vehicle cost is the additional cost of an advanced technology, or, on other words, the difference in cost between an advanced technology vehicle and a conventional vehicle of the same make and model. The aggregate incremental vehicle cost is the additional expenditure on all advanced technology vehicles of a particular type (hybrid vehicles, for example) over and above the cost of a conventional vehicle.

The summary worksheet contains annual estimates values for aggregate incremental vehicle cost for advanced technology (electric, flex-fuel, diesel, compressed natural gas, hybrid, and fuel cell), annual total aggregate incremental vehicle cost, and cumulative aggregate vehicle cost since the year 2000.

5.4. Extracting Detailed Results

This section details the location from which a user can extract annual results (rather than using the decadal summary estimates described in the preceding section). The cells and worksheets mentioned for each of the following variables describe the locations at which annual estimates can be found. Similar information for the Base Case—which can be useful for comparative purposes—can be found in the other VISION model file.

For **Annual LV energy usage data** (e.g. those results that appear in summary form in the 'Model Results' worksheet), annual estimates are available in the 'Lt Veh Energy by Fuel Type'. Annual energy consumption estimates are broken down by vehicle type (car, light truck, and heavy truck) and vehicle technology. Each vehicle technology listed below contains estimates for energy broken down by fuel type, as follows:

- Internal combustion engine: gasoline, ethanol
- Electric vehicle: electricity
- E85 flex-fuel vehicle: gasoline, ethanol
- Diesel: diesel, Fischer-Tropsch, biodiesel
- Compressed natural gas: compressed natural gas
- Hybrids:
 - o Low-ethanol gasoline: gasoline, ethanol, diesel, Fisher-Tropsch Diesel, biodiesel, electricity
 - o E85: gasoline, ethanol
 - o Hydrogen
- Fuel Cell: gasoline, diesel, Fischer-Tropsch diesel, biodiesel, compressed natural gas, ethanol, hydrogen, methanol, and the total consumed

The preceding estimates are aggregated into total energy consumed across all light vehicles (cars and light trucks); these data are presented as energy consumed by fuel type: gasoline, diesel, compressed natural gas, Fischer-Tropsch diesel, biodiesel, methanol, hydrogen, electric, and ethanol. The 'Lt Veh Energy by Fuel Type' worksheet also estimates **annual on-road fuel economy** in columns AP (cars), CE (light trucks), and CQ (LDV).

Annual LV carbon emissions are summarized in the 'Lt Veh Energy by Fuel Type' worksheet, columns CR–CV. The details underpinning these aggregated values are embedded in the 'LDV C & Energy by Vehicle Tech' worksheet, in columns B–R. These estimates are presented by vehicle type (car, light truck, and total) and vehicle technology (gasoline, electricity, ethanol, diesel, compressed natural gas, hybrid, and fuel cell). Note that these estimates are based on hard-wired emissions rates for each fuel and advanced technology. These default emissions rates are based on Argonne National Lab's GREET model, version 1.7, and can be changed by following the directions in Advanced Input section (Section 4). Annual carbon coefficients for each fuel and technology, computed within the 'Carbon Coefficients' worksheet based on these emissions rates and fuel composition (default or user-specified), are used by individual technology worksheets and consolidated in the 'LDV C & Energy by Vehicle Tech'.

Total annual vehicle stock and VMT for each technology by car and LT type are available on each technology's individual sheet. But the totals for all technologies combined, by year, are also available on the worksheet entitled 'LV VMT Data'.

Annual heavy truck energy use (by type), fuel economy, stock, VMT and carbon emissions are also available. The sheet is 'Hvy Trk Energy'.



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