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ANL-08/06

Vehicle Technologies Heavy Vehicle Program: FY 2007 Benefits Analysis, Methodology and Results—Final Report

Energy Systems Division

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Vehicle Technologies Heavy Vehicle Program: FY 2007 Benefits Analysis, Methodology and Results— Final Report

for
U.S. Department of Energy
Energy Efficiency and Renewable Energy
Office of Planning, Budget, & Analysis

by
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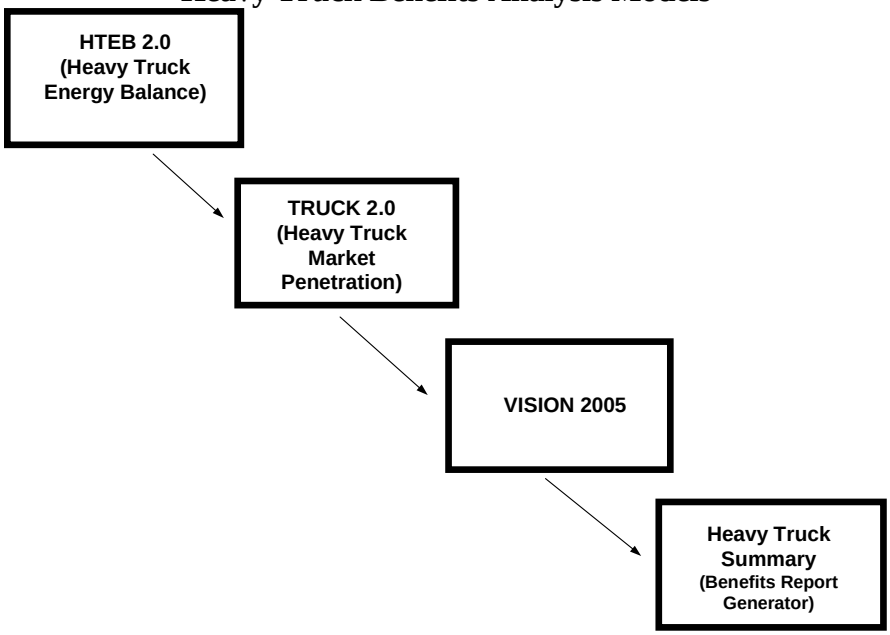
Executive Summary

An analysis of the petroleum and carbon reduction benefits associated with Heavy Vehicle technologies supported by the FutureCar and Vehicle Technologies Program has been completed for the FY 2007 Budget request. The analysis utilizes a series of spreadsheet models to characterize the fuel economy of various vehicle configurations, estimate market penetration, calculate energy and emissions effects to 2050, and generate reports explaining the benefits and how they relate to the various truck market sectors.

Exhibit ES-1:
Heavy Truck Benefits Analysis Models



The four models used to complete the analysis and their relationships are indicated in Exhibit ES-1. As the exhibit shows, the models are used sequentially beginning with the Heavy Truck Energy Balance model. This tool enables the systematic analysis of energy conservation techniques that affect the engine as well as other elements of the vehicle system.

The Heavy Vehicle market characteristics used in the analysis disaggregates Class 7 and 8 vehicles into three "Types" based on similarities in duty cycle. In addition, the benefits analysis addresses Class 3 through 6 Medium Trucks. Key characteristics of the market segmentation are indicated in Exhibit ES-2. Truck configurations represented by the three Heavy Truck Types are briefly described in the table notes.

Exhibit ES-2: Heavy Vehicle Characteristics (1997)

Vehicle Type	Class 7 & 8, Type 1	Class 7 & 8, Type 2	Class 7 & 8, Type 3	Class 3 through 6	Comments
Body Types	**Note 1**	**Note 2**	**Note 3**		
Fuel Economy (Baseline)	5.60	5.60	5.90	8.90	
Fuel Economy Improvement, %	146%	164%	179%	170%	Combined effect of FCVT Technologies, 2020; Class 3 thru 6 is w/o Hybrid
Average Miles Traveled, miles	40,043	74,066	92,434	20,126	
Portion of Heavy Truck Fuel Use, %	11.2%	19.6%	52.9%	4.3%	Estimated--Year 2005
Portion of Vehicle Travel < 50 k Miles,	47%	14.3%	1.6%	73.6%	
Portion of Vehicle Travel 50 k to 100 k	44%	43.5%	35.7%	24.4%	
Portion of Vehicle Travel >100 k	9%	42.2%	53.8%	2.0%	

Note 1: Local Use (Type 1) – multi-stop, step van, beverage, utility, winch, crane, wrecker, logging, pipe, garbage collection, dump, and concrete delivery
Note 2: Intermediate Use (Type 2) – platform, livestock, auto transport, oil-field, grain, and tank;
Note 3: Long-Haul (Type 3) – refrigerated van, drop frame van, open top van, and basic enclosed van.

The principal inputs required to conduct the analysis are: changes in fuel economy—expressed as 'multipliers' compared to the baseline vehicles, and the incremental cost of the technology. Factors used for the FY 2007 analysis are summarized in Exhibit ES-3.

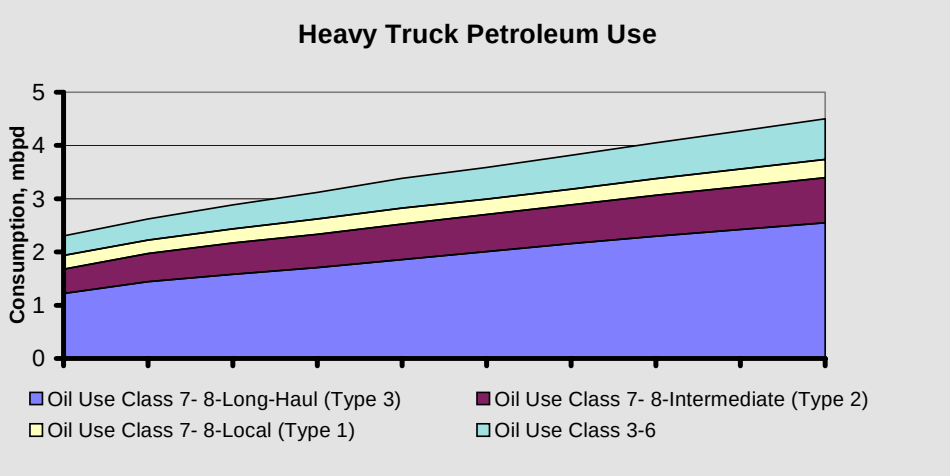
Exhibit ES-3: Fuel Economy Improvement and Cost Assumptions

	Characteristic	2010	2020	2030	2040	2050
1	Fuel Economy Class 7-8, Local Travel (Type 1) mpg Multiplier	1.20	1.51	1.53	1.54	1.54
2	Fuel Economy Class 7-8, Intermediate Travel (Type 2) mpg Multiplier	1.21	1.53	1.56	1.57	1.57
3	Fuel Economy Class 7-8, Long Haul Travel (Type 3) mpg Multiplier	1.25	1.59	1.63	1.63	1.63
4	Fuel Economy Class 3-6-Hybrid, mpg Multiplier	1.41	1.61	1.61	1.61	1.61
5	Fuel Economy Class 3-6-Non-hybrid, mpg Multiplier	1.20	1.46	1.48	1.48	1.48
6	Class 7-8, Iincremental Cost, $	$ 40,000	$ 20,000	$ 10,000	$ 7,000	$ 7,000
7	Class 3-6 Hybrid, Incremental Cost, $	$ 19,000	$ 5,400	$ 2,700	$ 2,700	$ 2,700
8	Class 3-6 Nonhybrid, Incremental Cost, $	$ 5,400	$ 1,700	$ 1,700	$ 1,700	$ 1,700

Total current and estimated future petroleum use by Heavy Vehicles is quantified as part of the analysis. Estimated Heavy and Medium Truck use to 2050 is indicated in Exhibit ES-4.

Exhibit- ES-4: Heavy Vehicle Petroleum Use before FCVT Program Benefits (MBPD)

Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Oil Use Class 7- 8-Local (Type 1)	0.260	0.246	0.270	0.288	0.300	0.291	0.293	0.311	0.328	0.345
Oil Use Class 7- 8-Intermediate (Type 2)	0.454	0.534	0.586	0.626	0.670	0.696	0.732	0.770	0.808	0.848
Oil Use Class 7- 8-Long-Haul (Type 3)	1.224	1.441	1.582	1.707	1.859	2.008	2.157	2.296	2.422	2.548
Oil Use Class 3-6	0.363	0.404	0.449	0.502	0.559	0.597	0.637	0.679	0.718	0.759
Total:	2.301	2.626	2.886	3.123	3.387	3.592	3.819	4.057	4.277	4.501

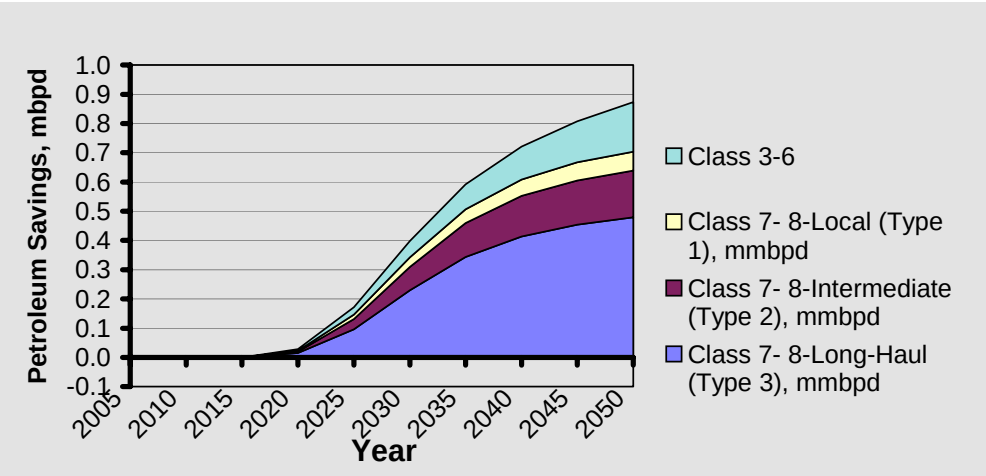


From the graph it is apparent that Heavy Vehicle energy currently is dominated by trucks in Long-Haul duty, and that this will continue throughout the analysis period. The information in Exhibit ES-4 indicates expected consumption absent the effects of the DOE program.

Petroleum reductions expected due to the FCVT program were analyzed from several perspectives. Exhibit ES-5 illustrates expected savings to 2050 by market segment.

Exhibit ES-5:
Petroleum Savings due to FCVT Technologies by Market Segment (MBPD)

Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Class 7- 8-Local (Type 1), mmbpd	0.00	0.00	0.00	0.00	0.02	0.03	0.05	0.06	0.06	0.06
Class 7- 8-Intermediate (Type 2), mmbpd	0.00	0.00	0.00	0.01	0.03	0.08	0.12	0.14	0.15	0.16
Class 7- 8-Long-Haul (Type 3), mmbpd	0.00	0.00	0.00	0.01	0.10	0.23	0.34	0.41	0.45	0.48
Class 3-6	0.00	0.00	0.00	0.01	0.03	0.05	0.09	0.11	0.14	0.17
Totals:	0.00	0.00	0.00	0.03	0.17	0.40	0.59	0.72	0.81	0.87



Not surprisingly, most of the savings occur in the Class 7 and 8 Long-Haul (Type 3) segment. The market segment with next highest level of savings is Intermediate Use (Class 7 and 8). The savings in that sector are only slightly greater than in the Class 3-6 (Medium Truck) market.

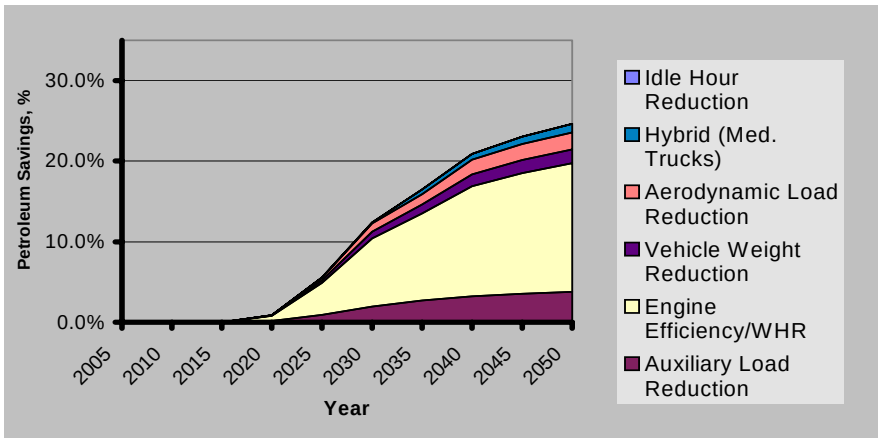
Local-use (Type 1) trucks have limited annual miles and lower speeds than the other Class 7 and 8 segments which explain the relatively low contribution to total savings from this segment.

Benefits also were evaluated in relation to the characteristics of the technology (or technical opportunity) considered. Benefits by technology will be affected by both the estimated efficiency benefit and the vehicle use characteristics of the Market Segment.

Exhibit ES-6 presents petroleum savings as a percent of total baseline petroleum use for all Heavy Vehicles. Engine efficiency (with Waste Heat Reduction and Parasitic Load Reduction) is estimated to have a per-vehicle benefit of up to thirty eight percent (38%), and is the principal contributor to the overall savings. The exhibit indicates that the potential exists to reduce Heavy Vehicle petroleum use by one-third by 2050.

Exhibit ES-6:
Petroleum Reduction due to FCVT Technologies as a Percentage of Base Consumption

Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Load Reduction	0.0%	0.0%	0.0%	0.1%	0.9%	2.0%	2.7%	3.2%	3.5%	3.8%
Idle Hour Reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Engine Efficiency/WHR	0.0%	0.0%	0.0%	0.6%	4.0%	8.4%	10.8%	13.7%	15.0%	16.0%
Vehicle Weight Reduction	0%	0.0%	0.0%	0.0%	0.3%	0.8%	1.1%	1.5%	1.6%	1.7%
Aerodynamic Load Reductior	0%	0.0%	0.0%	0.1%	0.3%	1.1%	1.3%	1.8%	2.0%	2.1%
Hybrid (Med. Trucks)	0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.6%	0.7%	0.9%	1.0%
Totals:	0%	0%	0%	1%	6%	12%	16%	21%	23%	25%

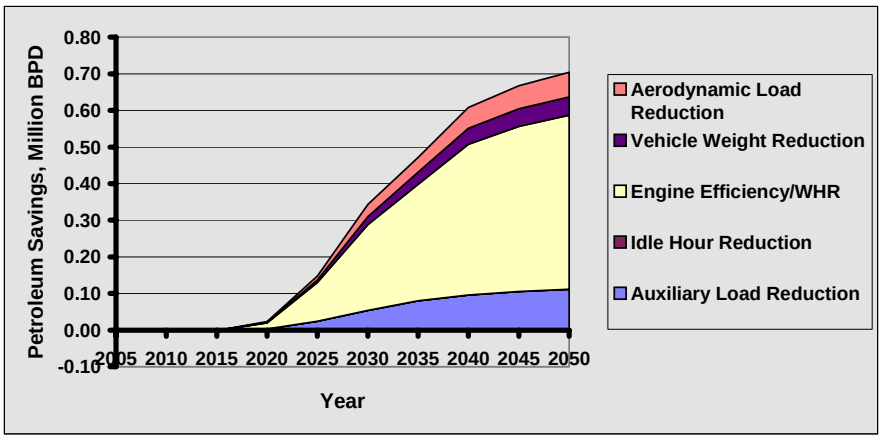


The effects of the FCVT technologies were also analyzed to estimate petroleum savings potential by Market Segment. Exhibit ES-7 summarizes the potential in the Long-Haul Segment.

Exhibit ES-7: Benefits in Long-Haul (Type 3) Segment of FCVT Technologies (MBPD)

Class 7 & 8

Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Load Reduction	0.00	0.00	0.00	0.00	0.02	0.05	0.08	0.10	0.11	0.11
Idle Hour Reduction	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Engine Efficiency/WHR	0.00	0.00	0.00	0.02	0.11	0.23	0.32	0.41	0.45	0.48
Vehicle Weight Reduction	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.05	0.05
Aerodynamic Load Reductior	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0.06	0.06	0.07
Total Class 7-8, mmbpd	0.00	0.00	0.00	0.02	0.15	0.34	0.51	0.61	0.67	0.70

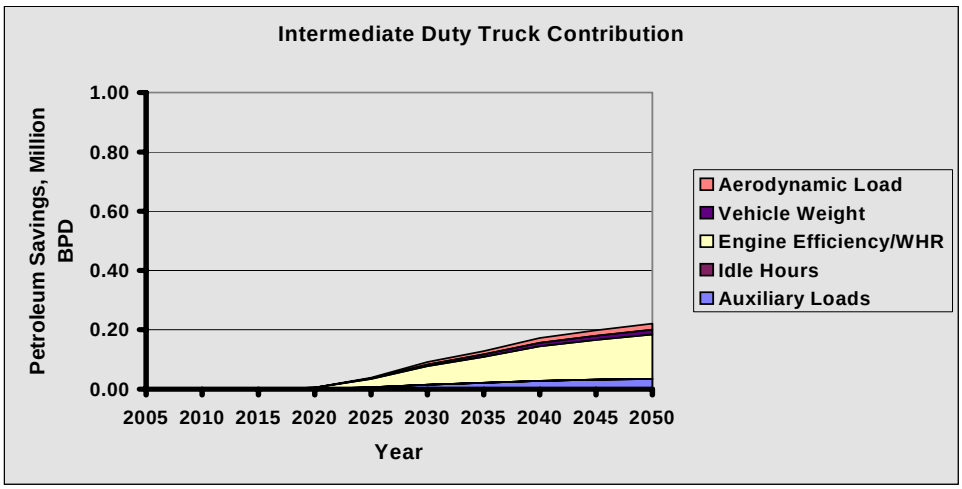


For the long-haul segment in a given year, engine efficiency represents about sixty percent (60%) of the savings opportunity. Auxiliary Load reduction by electrification is the next most significant contributing technology, but represents less than twenty percent (20%) of the expected savings. The other technologies combined represent around twenty percent (20%) of the savings.

Petroleum savings expectations relative to the Intermediate Use Heavy Truck Market Segment are summarized in ES-8:

Exhibit ES-8: Benefits in Intermediate Duty (Type 2) Segment of FCVT Technologies (MBPD)

	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Loads	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.03
Idle Hours	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Engine Efficiency/WHR	0.00	0.00	0.00	0.00	0.03	0.06	0.09	0.12	0.13	0.15
Vehicle Weight	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02
Aerodynamic Load	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02
Total, Type 2	0.00	0.00	0.00	0.01	0.04	0.09	0.14	0.17	0.20	0.22



This segment is expected to account for less than forty percent (40%) of the savings that will occur in the Long Haul segment. The relative contributions by technology are similar to the patterns for the Type 3 trucks.

Savings expected for the Local Use Market Segment are indicated in Exhibit ES-9. For a given year this Segment is expected to account for less than twenty percent (20%) of Long Haul trucks.

Exhibit ES-9: Benefits in Local Use (Type 1) Segment of FCVT Technologies (MBPD)

	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Loads	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Idle Hours	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Engine Efficiency/WHR	0.00	0.00	0.00	0.00	0.01	0.03	0.03	0.05	0.05	0.06
Vehicle Weight	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
Aerodynamic Load	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Total, Type 1	0.00	0.00	0.00	0.00	0.02	0.04	0.06	0.07	0.08	0.09

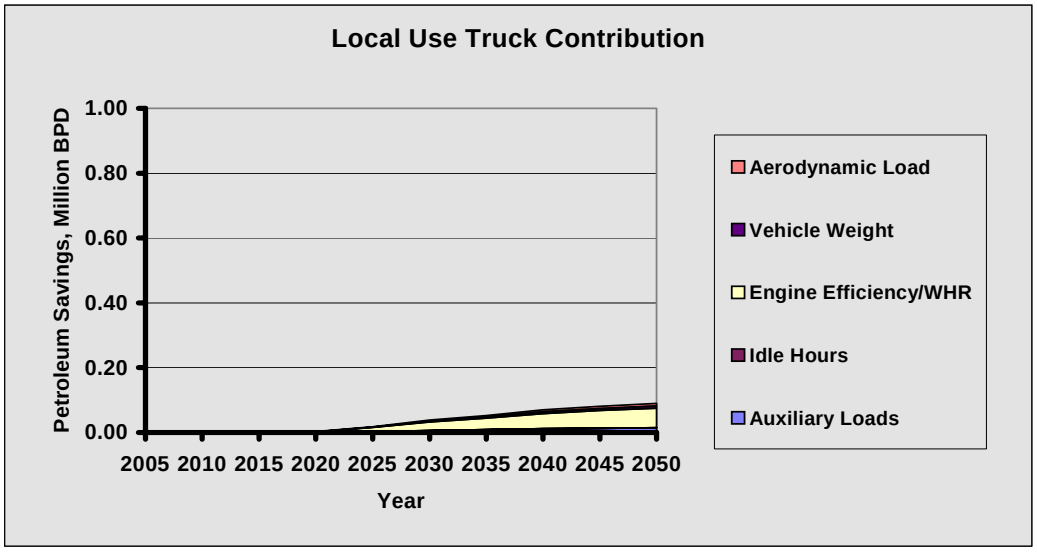


Exhibit ES-10 is a tabular summary of the program benefits analysis results for the years 2010, 2020, 2030, 2040, and 2050. Information contained in the table includes the following:

- Rows 1-6: total oil use before conservation by Market Segment
- Rows 7-12: Total Savings by Market Segment
- Rows 13-15: Percent reductions in oil use for Class 7 and 8 and Classes 3 through 6
- Rows 16-23: Carbon emissions summary; including total generated, savings by Market Segment, Total savings, and percentage savings. These are full fuel cycle savings.
- Rows 24-29: Vehicle Miles Traveled by Market Segment
- Rows 30-34: Future fuel economy for all new truck sales by Market Segment
- Rows 35-40: Technology market penetrations by segment, based on vehicle miles traveled.
- Rows 41-46: “Fleet” or Vehicle Stocks by Market Segment.

Exhibit ES-10: FCVT Benefits Results in Tabular Format

	Characteristic	2005	2010	2020	2030	2040	2050	Notes
1	Oil Use Class 7- 8-Local, mmbpd	0.260	0.246	0.288	0.291	0.311	0.345	
2	Oil Use Class 7- 8-Intermediate, mmbpd	0.454	0.534	0.626	0.696	0.770	0.848	
3	Oil Use Class 7- 8-Long-Haul, mmbpd	1.224	1.441	1.707	2.008	2.296	2.548	
4	Total Class 7-8, mmbpd	1.938	2.221	2.621	2.995	3.378	3.742	
5	Oil Use Class 3-6, mmbpd	0.363	0.404	0.502	0.597	0.679	0.759	
6	Total Oil Use, mmbpd	2.301	2.626	3.123	3.592	4.057	4.501	
7	Class 7- 8-Local (Type 1), mmbpd reduction	0	0.000	0.003	0.033	0.056	0.065	
8	Class 7- 8-Intermediate (Type 2), mmbpd reduction	0	0.000	0.005	0.080	0.139	0.160	
9	Class 7- 8-Long-Haul (Type 3), mmbpd reduction	0	0.000	0.015	0.230	0.414	0.479	
10	Total Class 7-8, mmbpd reduction	0	0.000	0.023	0.343	0.609	0.704	
11	Oil Reduction Class 3-6, mmbpd reduction	0	0.000	0.005	0.055	0.113	0.170	
12	Total Oil Reduction, mmbpd		0.000	0.028	0.398	0.722	0.874	
13	Oil Reduction Class 7-8, %	0%	0%	1%	11%	18%	19%	
14	Oil Reduction Class 3-6, %	0%	0%	1%	9%	17%	22%	
15	Total Oil Reduction, %	0%	0%	1%	11%	18%	19%	
16	Total Carbon Emissions, mmtce	132.88	151.75	180.54	207.78	234.98	261.02	
17	Carbon Reduction Class 7- 8-Local, mmtce	0	0.000	0.389	5.521	10.008	12.117	
18	Carbon Reduction Class 7- 8-Intermediate, mmtce	0	0.000	0.486	6.901	12.510	15.146	
19	Carbon Reduction Class 7- 8-Long-Haul, mmtce	0	0.000	0.762	10.811	19.599	23.729	
20	Total Carbon Reduction Class 7-8, mmtce	0	0.000	1.620	23.003	41.700	50.487	
21	Carbon Reduction Class 3-6, mmtce	0	0.000	0.005	0.055	0.113	0.170	
22	Total Carbon Reduction, mmtce	0.000	0.000	1.625	23.058	41.813	50.657	
23	Total Carbon Reduction, %	0%	0%	1%	11%	18%	19%	
24	Vehicle Miles Traveled Class 7-8, Local; milliions	16,217	18,625	23,399	27,970	32,495	36,947	
25	Vehicle Miles Traveled Class 7-8, Intermediate; mllions	38,369	44,068	55,363	66,178	76,884	87,418	
26	Vehicle Miles Traveled Class 7-8, Long-Haul; millions	128,511	147,600	185,429	221,654	257,511	292,793	
27	Total Class 7-8, millions	183,096	210,293	264,191	315,802	366,889	417,158	
28	Vehicle Miles Traveled Class 3-6; millions	51,532	57,749	72,303	86,405	98,385	110,174	
29	Total Vehicle Miles Traveled , millions	234,628	268,042	336,494	402,207	465,274	527,333	
30	Fuel Economy Class 7-8, Local, mpg	5.6	5.6	5.7	6.6	7.0	7.1	
31	Fuel Economy Class 7-8, Intermediate, mpg	5.6	5.6	5.8	7.1	7.5	7.7	
32	Fuel Economy Class 7-8, Long-Haul, mpg	6.0	6.0	6.3	8.1	8.6	8.7	
33	Average, Class 7-8, mpg	5.8	5.8	6.1	7.7	8.2	8.3	
34	Fuel Economy Class 3-6, mpg	8.9	8.9	9.5	10.9	11.5	12.7	
35	Market Penetration Class 7-8, Local, % VMT	0.0%	0.0%	3.2%	13.1%	13.1%	13.1%	
36	Market Penetration Class 7-8 Hybrid, Local, % VMT	0.0%	0.0%	2.4%	10.2%	10.2%	10.2%	
37	Market Penetration Class 7-8, Intermediate, % VMT	0.0%	0.0%	7.9%	57.8%	70.0%	73.9%	
38	Market Penetration Class 7-8, Long Haul, % VMT	0.0%	0.0%	14.7%	67.3%	78.8%	82.2%	
39	Market Penetration--All Types, Class 7-8, % VMT	0.0%	0.0%	12.2%	60.5%	71.2%	74.3%	
40	Market Penetration Hybrid Class 3-6, % VMT	0.0%	0.0%	0.0%	6.9%	28.9%	39.8%	
41	Vehicle Stock Class 7-8, Local, vehicles x 1000	863	939	1,063	1,189	1,352	1,513	
42	Vehicle Stock Class 7-8, Intermediate, Vehicles x 1000	1,093	1,190	1,347	1,506	1,713	1,917	
43	Vehicle Stock Class 7-8, Long-Haul, Vehicles x 1000	2,884	3,141	3,554	3,974	4,521	5,058	
44	Total Vehicle Stock Class 7-8, Vehicles X 1000	4,840	5,271	5,965	6,670	7,586	8,488	
45	Vehicle Stock Class 3-6, Vehicles x 1000	51,532	57,749	72,303	86,405	98,385	110,174	
46	Total Vehicle Stock Class 3-8, Vehicles X 1000	56,372	63,020	78,268	93,074	105,972	118,663	

Exhibit ES-11 is a similar summary of results. Consumption and Carbon emissions effects are shown by Technology contribution.

Exhibit ES-11: FCVT Benefits Results Showing Effects by Technology

	Characteristic	2005	2010	2020	2030	2040	2050	Notes
	Consumption Breakdown, mmbpd							
i	Oil Use Class 7- 8-Local (Type 1)	0.260	0.246	0.288	0.291	0.311	0.345	
ii	Oil Use Class 7- 8-Intermediate (Type 2)	0.454	0.534	0.626	0.696	0.770	0.848	
iii	Oil Use Class 7- 8-Long-Haul (Type 3)	1.224	1.441	1.707	2.008	2.296	2.548	
1	Total Class 7-8	1.938	2.221	2.621	2.995	3.378	3.742	
2	Oil Use Class 3-6	0.363	0.404	0.502	0.597	0.679	0.759	
3	Total Oil Use, mmbpd	2.301	2.626	3.123	3.592	4.057	4.501	
4	Class 7 & 8 Savings Breakdown, mmbpd							
5	Oil Reduction Class 7- 8-Auxiliary Load Reduction	0	0.000	0.004	0.054	0.096	0.111	
6	Idle Hour Reduction	0	0.000	0.000	0.000	0.000	0.000	
7	Oil Reduction Class 7- 8--Engine Efficiency/WHR	0	0.000	0.016	0.234	0.411	0.476	
9	Oil Reduction Class 7- 8--Vehicle Weight Reduction	0	0.000	0.001	0.022	0.043	0.050	
10	Oil Reduction Class 7- 8-Aerodynamic Load Reduction	0	0.000	0.002	0.033	0.058	0.067	
11	Total Class 7-8, mmbpd	0	0.0000	0.023	0.343	0.608	0.704	
12	Oil Reduction Class 3-6-Auxiliary Load Reduction	0	0.0000	0.001	0.010	0.020	0.030	
13	Oil Reduction Class 3-6--Engine Efficiency/WHR	0	0.0000	0.004	0.039	0.079	0.119	
15	Oil Reduction Class 3-6--Vehicle Weight Reduction	0	0.0000	0.000	0.004	0.010	0.015	
16	Oil Reduction Class 3-6-Aerodynamic Load Reduction	0	0.0000	0.000	0.001	0.004	0.006	
17	Oil Reduction Class 3-6-Hybrid	0	0.0000	0.003	0.029	0.059	0.089	
18	Oil Reduction Class 3-6, mmbpd	0	0.000	0.005	0.055	0.113	0.170	
19	Total Oil Reduction, mmbpd	0.000	0.000	0.028	0.398	0.722	0.874	
24	Oil Reduction-Auxiliary Load Reduction	0.0%	0.0%	0.2%	1.8%	2.9%	3.1%	
25	Idle Hour Reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
26	Oil Reduction--Engine Efficiency/WHR	0.0%	0.0%	0.6%	7.6%	12.1%	13.2%	
28	Oil Reduction--Vehicle Weight Reduction	0.0%	0.0%	0.1%	0.7%	1.3%	1.4%	
29	Oil Reduction-Aerodynamic Load Reduction	0.0%	0.0%	0.1%	0.9%	1.5%	1.6%	
30	Oil Reduction-Hybrid	0.0%	0.0%	0.1%	0.8%	1.5%	2.0%	
31	Total Oil Reduction, %	0%	0%	1%	11%	18%	19%	
32	Total Carbon Emissions, Class 7-8, mmtce	66.572	131.07	154.71	175.65	198.24	219.42	
33	Total Carbon Emissions, Class 3-6, mmtce	10.549	20.682	25.835	32.134	36.743	41.604	
34	Total Carbon Emissions, mmtce	132.88	151.75	180.54	207.78	234.98	261.02	
35	Carbon Emissions-Auxiliary Load Reduction, mmtce	-	-	0.27	3.66	6.61	8.01	
36	Carbon Reduction--Engine Efficiency/WHR, mmtce	-	-	1.16	5.43	28.26	34.23	
38	Carbon Reduction--Vehicle Weight Reduction, mmtce	-	-	0.09	1.50	2.97	3.60	
39	Carbonl Reduction-Aerodynamic Load Reduction, mmtce	-	-	0.11	2.19	3.98	4.82	
40	Carbon Reduction-Hybrid, mmtce	-	-	-	-	-	-	
41	Total Carbon Reduction, mmtce	0.000	0.000	1.625	23.058	41.813	50.657	
42	Total Carbon Reduction, %	0%	0%	1%	11%	18%	19%	

1.0 Introduction

This report describes the approach to estimating the benefits and analysis results for the Heavy Vehicle Technologies activities of the FreedomCar and Vehicle Technologies (FCVT) Program of EERE. The scope of the effort includes:

- Characterizing baseline and advanced technology vehicles for Class 3 – 6 and Class 7 and 8 trucks,
- Identifying technology goals associated with the DOE EERE programs,
- Estimating the market potential of technologies that improve fuel efficiency and/or use alternative fuels,
- Determining the petroleum and greenhouse gas emissions reductions associated with the advanced technologies.

In FY 05 the Heavy Vehicles program activity expanded its technical involvement to more broadly address various sources of energy loss as compared to focusing more narrowly on engine efficiency and alternative fuels. This broadening of focus has continued in subsequent activities. These changes are the result of a planning effort that occurred during FY 04 and 05. (Ref. 1)

This narrative describes characteristics of the heavy truck market as they relate to the analysis, a description of the analysis methodology (including a discussion of the models used to estimate market potential and benefits), and a presentation of the benefits estimated as a result of the adoption of the advanced technologies. The market penetrations are used as part of the EERE-wide integrated analysis to provide final benefit estimates reported in the FY07 Budget Request. The energy savings models are utilized by the FCVT program for internal project management purposes.

2.0 Background

This analysis of the benefits expected from achieving the Heavy Vehicle Technologies Program goals was developed based on three primary reference sources:

- Vehicle characteristics and use information—as obtained from the 1997 Vehicle Inventory and Use Survey (VIUS). This provides information on both vehicle performance characteristics, such as fuel economy and vehicle use patterns such as miles traveled per year. (Ref. 2)
- Truck operator investment decision criteria—as provided by a survey of Owner-Operators performed by the American Trucking Associations in 1995. (Ref. 3)
- Vehicle performance and cost characteristics for advanced technologies—as identified by the EERE Program Managers.

Important "background" information such as energy prices and baseline technology fuel economies are based on the Annual Energy Outlook (Reference Case) prepared by the Energy Information Administration (Ref. 4).

3.0 Target Markets

The analysis considers trucks included in the standard gross vehicle weight classes 3 through 8 (10,001 lb. to greater than 33,001 lb.). These are generally referred to as "Heavy Vehicles". For purposes of analysis, these trucks are grouped into two *classifications*: those within Classes 3 through 6, which are designated Medium Trucks and those within Classes 7 and 8 which are designated Heavy Trucks. Medium Trucks include all highway trucks in the weight range of 10,001 lb to 26,000 lb. Heavy Trucks include all heavier trucks used on highways. While there is a wide diversity of truck sizes and weights, nearly 70% of all Class 3-6 trucks are in Class 6 and over 91% of Class 7&8 trucks are in Class 8.

VIUS data were examined for all vehicles in use and vehicles two years old or less. The Heavy Truck market (Classes 7 and 8) was parsed by the Analysis and Program Management Teams into three types. The specific vehicle configurations (or end use types) grouped within each of the three Types have similar usage and annual vehicle miles traveled patterns. The vehicle type segments are made up of the vehicle configurations listed below:

- Local Use (Type 1) – multi-stop, step van, beverage, utility, winch, crane, wrecker, logging, pipe, garbage collection, dump, and concrete delivery;
- Intermediate Use (Type 2) – platform, livestock, auto transport, oil-field, grain, and tank;
- Long-Haul (Type 3) – refrigerated van, drop frame van, open top van, and basic enclosed van.

While heavy vehicle sales data and sales projections are available, projections of sales by Type are not available. The estimates used in this analysis are based on a survey of current uses and assumes that future uses will remain approximately the same. In actual practice the use of a vehicle may migrate from one Type to another. For example a new truck used in Long Haul duty, will often be used in Intermediate or Local Use as it ages. This characteristic of the Heavy Vehicles market is not considered in the analysis.

The lower average speed and 'stop and start' duty characteristics of Type 1 trucks greatly reduce the potential efficiency benefits in that sector compared to Types 2 and 3. For similar reasons, fuel economy improvements due to speed-dependent measures such as improved aerodynamics and tires will have lower benefit in Type 1 than in the other two Types.

As compared to long haul, over the road travel, Type 2 vehicles tend to be used in a mix of local and regional delivery; and, as a result, will also realize greater fuel economy benefit from aerodynamic improvements than Type 1, but not as great as Type 3. Distances traveled by Type 2 vehicles are typically greater than Type 1, which infers that the typical speeds are higher. These characteristics make them a somewhat better market sector for measures that perform in relation to speed such as advanced tires. In general, Type 3 vehicles are the best candidates for technologies that reduce drive train or vehicle losses.

Refueling characteristics; i.e. central-source refueling or non-central source also are considered in the market characteristics, as centrally-refueled vehicles would find an alternative fuel source more practical than vehicles that always refuel at road-side facilities.

Eleven travel distance categories for medium trucks and twenty-one for heavy trucks are represented in the model. These categories were determined using travel distributions developed with the VIUS data by ORNL (Refs. 2, 5).

Exhibit 1 shows the distribution of annual travel for Class 3 through 6 and the three types of Class 7 & 8 vehicles. Type 3 vehicles display the greatest amount of annual travel of all heavy vehicle classes as is evidenced in part by the curve's peaking in the 120,000 to 139,000 mile segment.

Exhibit 1:
Annual Travel Patterns—Type 1, 2 & 3 Heavy Trucks

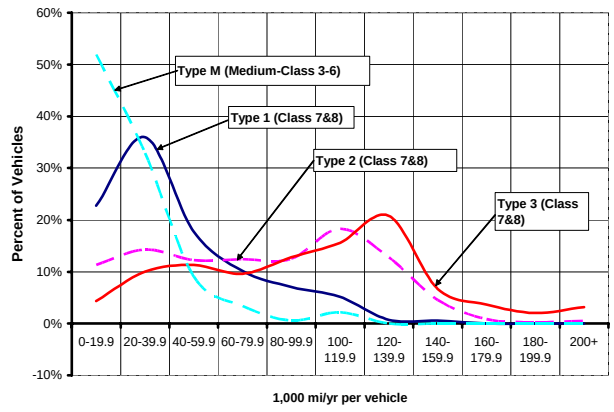
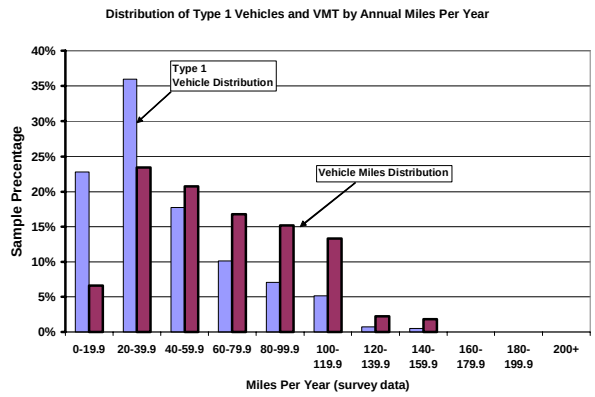


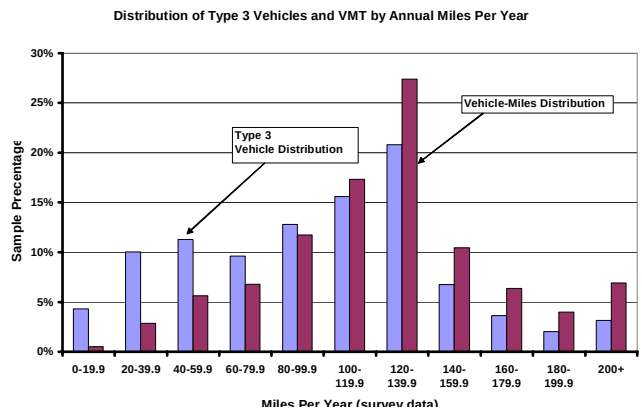
Exhibit 2 shows the vehicle use pattern for Local or Type 1 Heavy trucks. The distribution based both on vehicles and vehicle-miles traveled are indicated.

Exhibit 2:
Type 1 Vehicle Use



The contrast in distribution by type is evident when Exhibits 2 and 3 are compared. Exhibit 3 shows the same information as Exhibit 2—but for Type 3 trucks. For Type 1 the distribution peaks in the 20,000 to 39,000 mile segment. For Type 3, the peak distribution shows annual travel of 100,000 miles greater than Type 1—120,000 to 139,000 miles.

Exhibit 3:
Type 3 Vehicle Use



Centrally-refueled and non-centrally fueled vehicle use characteristics have also been analyzed. Centrally refueled vehicles travel less per year than non-centrally refueled vehicles. In the non-centrally refueled vehicle segment, the majority of travel occurs from 100,000 to 140,000 miles per year. In the central refueling segment, the majority of travel occurs in a more even distribution between 20,000 and 140,000 miles per year.

3.1 Key Factors Affecting Market Adoption of Technology

Based on a survey conducted by the American Trucking Associations in 1997, energy conservation purchase decisions for this sector are significantly affected by economic viability—specifically the payback of the investment (Ref. 3). The survey of 224 motor carriers revealed that paybacks of one to four years were acceptable for energy conserving technologies. Based on those findings, we model the market acceptance of the various technologies based on payback performance.

3.1.1 Effects of Lower Emissions on Heavy Vehicle Fuel Economy

The Environmental Protection Agency (EPA) regulates emissions from heavy-duty engines and trucks. This is changing engine technology. Some reduction in fuel economy with the new engines is expected as the combustion process is optimized to address emissions reduction. These changes will impose both operating and capital costs on truck operators. Emissions standards for diesel engines used in heavy trucks in 2004 were 4 g/bhp-hr for NO_x and 1.3 g/bhp-hr for Hydrocarbons (HC).

Major elements of the EPA rules include the following:

- Reduction of nitrogen oxides (NOx) and fine particulate matter $PM_{2.5}$ from new heavy-duty highway diesels (e.g., trucks and buses) by about 90%, effective in 2007 for PM and 2007-2010 for NOx.
- Reduction of the sulfur content in highway diesel fuel to 15 ppm ("ultra-low sulfur diesel" fuel, or "ULSD" fuel) beginning in late 2006.
- Similar reductions of nitrogen oxides (NOx) and fine particulate matter $PM_{2.5}$ from new heavy-duty non-road diesels (e.g., construction, farming and logging equipment) will be required in the 2011-2014 timeframe.
- Reduction of the sulfur content in diesel fuel used in stationary engines will occur in two steps, to 500 ppm in 2007 and 15 ppm beginning in 2010. Sulphur in fuel for locomotive and many marine engines will be reduced to the same levels in two steps. However, the date for making the 15 ppm fuel available is 2012.

The EPA rule-making process includes a cost analysis for the technologies required to meet the new standards. The cost estimates for the new emission control technologies for the 2004 models assumed that fuel injection and turbocharger improvements needed would happen without the new standards. So in estimating increases in engine costs, the EPA excluded 50 percent of the technology cost from the total estimated cost. Thus the EPA estimated that the incremental costs for heavy-duty engines to meet the standard would be at $803 in 2004, decreasing to $368 in 2009. The EPA also estimated the increase in annual operating cost for heavy-duty engines to be $104 for the maintenance of the exhaust gas recirculation (EGR).

The effect of additional equipment that is used for treating emissions was also considered. The added weight of the equipment requires additional horsepower output from the engine, which results in a reduction in fuel efficiency. The EPA expects NOx adsorbers to be the most likely emission control technology applied by the industry. NOx adsorber regeneration will require small injections of diesel fuel for ‘light off’ and desorption of stored NO for downstream catalysis under rich-burn conditions. This is expected to result in additional fuel use beyond combustion for propulsion of 2-4%. Additional reduction in efficiency is anticipated due to control of sulfur-containing emissions (Refs. 7, 8, 9).

The effects of the more stringent regulations are considered implicitly in the fuel economy assumptions for the baseline engines, which affects the payback analysis.

3.2 Market Segmentation Analysis

Exhibit 4: Heavy Vehicle Characteristics

Vehicle Type	Class 7 & 8, Type 1	Class 7 & 8, Type 2	Class 7 & 8, Type 3	Class 3 through 6	Comments
Body Types	**Note 1**	**Note 2**	**Note 3**		
Fuel Economy (Baseline)	5.60	5.60	5.90	8.90	
Fuel Economy Improvement, %	146%	164%	179%	170%	Combined effect of FCVT Technologies, 2020; Class 3 thru 6 is w/o Hybrid
Average Miles Traveled, miles	40,043	74,066	92,434	20,126	
Portion of Heavy Truck Fuel Use, %	11.2%	19.6%	52.9%	4.3%	Estimated--Year 2005
Portion of Vehicle Travel < 50 k Miles,	47%	14.3%	1.6%	73.6%	
Portion of Vehicle Travel 50 k to 100 k	44%	43.5%	35.7%	24.4%	
Portion of Vehicle Travel >100 k	9%	42.2%	53.8%	2.0%	

Note 1: Local Use (Type 1) – multi-stop, step van, beverage, utility, winch, crane, wrecker, logging, pipe, garbage collection, dump, and concrete delivery

Note 2: Intermediate Use (Type 2) – platform, livestock, auto transport, oil-field, grain, and tank;

Note 3: Long-Haul (Type 3) – refrigerated van, drop frame van, open top van, and basic enclosed van.

Heavy vehicle characteristics for the four vehicle Types are summarized in Exhibit 4. In the medium truck market segment, Classes 3 through 6, all vehicle types, with the exception of auto transport, on average travel about 20,000 miles per year. Heavy trucks, depending on type, travel an average of 40,000 miles to 92,000 miles per year. From the 2002 VIUS data,

Type 3 heavy vehicles exhibit an average fuel economy somewhat higher than Type 1 and 2 heavy vehicles (5.9 vs. 5.6 MPG). The values in Exhibit 4 are for vehicles two years old and newer. Thus we assume they are the fuel economies of “new vehicles” in our model.

In addition to the market characterization, historical market penetration data was obtained from VIUS surveys for energy conserving technologies including radial tires, aerodynamic devices, and fan clutches. This data was utilized in the calibration of the rate of efficiency technology adoption in the models discussed in Section 4.

4.0 Heavy Vehicle Benefits Analysis

4.1 Vehicle Technology Characterizations

The TRUCK Model which is used to estimate the market penetration of heavy vehicle technologies supported by DOE, uses a payback algorithm. The model, which is further described in Section 4.4, requires inputs of fuel efficiency improvement and technology cost on an annual basis. The model estimates market penetrations over a fifty (50) year period.

Fuel economy improvements were quantified in an iterative process that started with a review of the Freedom Car and Vehicle Technologies (FCVT) Program Plan (Ref. 1). Technologies that address engine efficiency, auxiliary and accessory load reduction, vehicle system improvements (e.g. improved aerodynamics and tires) are included in the FCVT program. The program plan provides estimates of the potential fuel economy benefits of various technologies individually, but it does not address the expected interactions between the various technologies as they are grouped together in various vehicles and end-use applications. For that, we use the Heavy Truck Energy Balance Model (HTEB) further described in Section 4.3

The program plan further does not provide technology cost estimates. Therefore, a 'price goal' approach was used by the project team in which incremental cost equivalent to a two-year payback for the technology was used as the basis for the cost inputs. Price reductions were assumed over time as the technology matures and production levels increase.

Exhibit 5 summarizes the fuel economy improvement and price assumptions used for the Benefits Analysis.

Exhibit 5: TRUCK 2.0 Inputs for FY 07 Benefits Analysis

	Characteristic	2010	2020	2030	2040	2050
1	Fuel Economy Class 7-8, Local Travel (Type 1) mpg Multiplier	1.20	1.51	1.53	1.54	1.54
2	Fuel Economy Class 7-8, Intermediate Travel (Type 2) mpg Multiplier	1.21	1.53	1.56	1.57	1.57
3	Fuel Economy Class 7-8, Long Haul Travel (Type 3) mpg Multiplier	1.25	1.59	1.63	1.63	1.63
4	Fuel Economy Class 3-6-Hybrid, mpg Multiplier	1.41	1.61	1.61	1.61	1.61
5	Fuel Economy Class 3-6-Non-hybrid, mpg Multiplier	1.20	1.46	1.48	1.48	1.48
6	Class 7-8, Iincremental Cost, $	$ 40,000	$ 20,000	$ 10,000	$ 7,000	$ 7,000
7	Class 3-6 Hybrid, Incremental Cost, $	$ 19,000	$ 5,400	$ 2,700	$ 2,700	$ 2,700
8	Class 3-6 Nonhybrid, Incremental Cost, $	$ 5,400	$ 1,700	$ 1,700	$ 1,700	$ 1,700

4.2 Overview of Models and Analysis Methodology

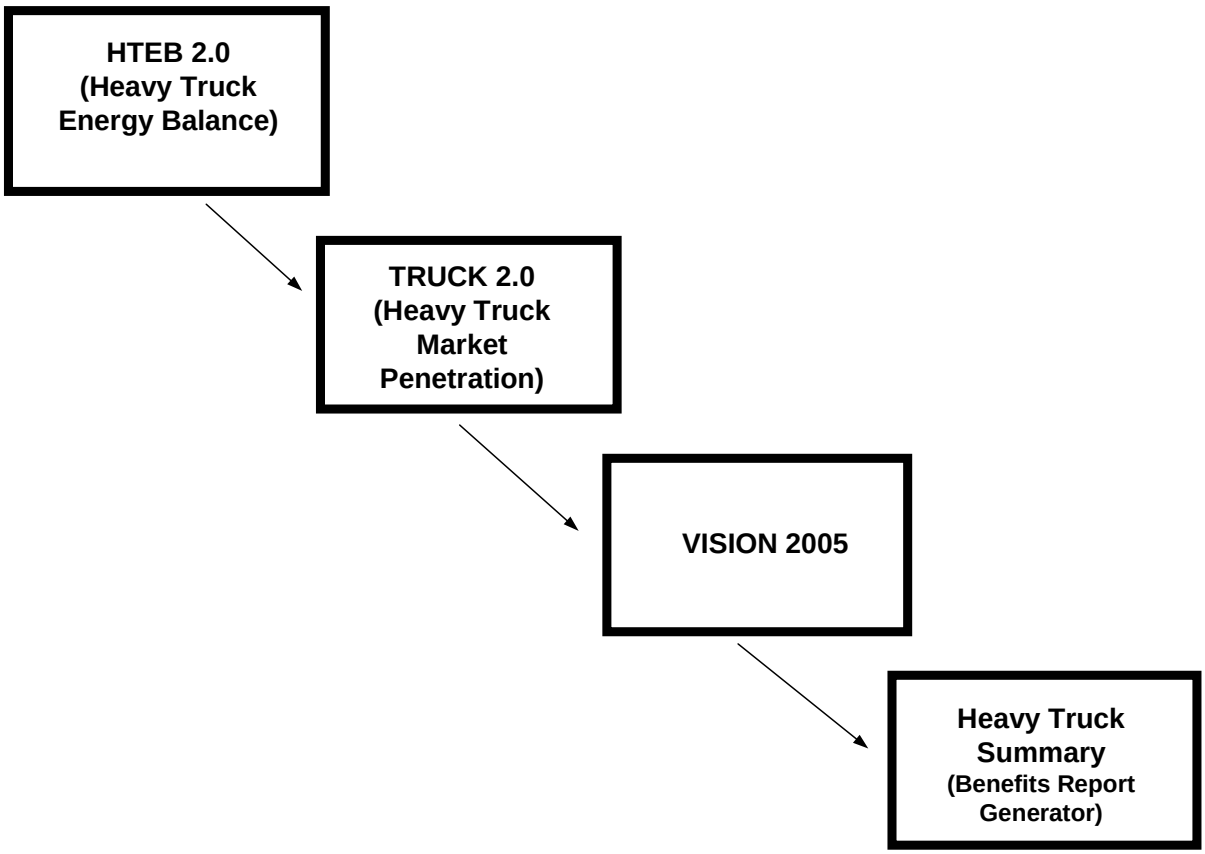
The analysis of the benefits expected from achieving the Heavy Vehicle technologies program goals is described in this section.

Initial benefits estimates are generated through the linkage of four spreadsheet models:

- HTEB--Heavy Truck Energy Balance Model (enhanced for the 2007 analysis)
- TRUCK 2.0--Heavy Vehicle Market Penetration Model. Pages from this model are reproduced in the Appendix
- VISION 2005, and
- Heavy Truck Summary (HvyTrkSum) report generator.

The relationship of these four models is indicated in Exhibit 6[1].

Exhibit 6: Heavy Truck Benefits Analysis Models



[1] The HTEB was developed by William Shadis and James Moore of TA Engineering.

The TRUCK (2.0) Model was developed as a collaborative effort, initially by John Maples of Oak Ridge National Laboratory (ORNL), with assistance from James Moore, of TA Engineering, Inc. Subsequent enhancements have been performed by Moore and Shadis (TA Engineering).

The VISION model was developed by Margaret Singh and Anant Vyas of ANL.

The Heavy Vehicle Summary Model is a report generating spreadsheet. It was initially developed by Maples, and has subsequently been modified by Analysts at the National Renewable Energy Laboratory, and TA Engineering.

4.3 Heavy Truck Energy Balance Model (HTEB)

The Heavy Truck Energy Balance Model was developed to assess the overall fuel economy effect of several changes to the vehicle involving the engine, drive train and other elements. It was developed by TA Engineering after initial investigations and conversations with FCVT personnel confirmed that vehicle simulation models for heavy trucks were not available in the public domain. The spreadsheet model considers energy losses based on user-selected inputs of vehicle characteristics and use. It is a steady-state model.

Analyses were performed and HTEB Models compatible with the vehicle characteristics for the Type 1, Type 2 and Type 3 Class 7 & 8, and Class 3 through 6 vehicles were developed. Vehicle characteristics and use parameters evaluated in the development of the model include the following:

- Truck weight
- VIUS fuel economy values for Types 1, 2 and 3, and Medium Trucks using estimates of average speed and average stops/hour.
- Aero CD reductions (7.5%, 15%, and 30%)
- Engine efficiency increases of 10% and 37.5%. Engine efficiency was assumed to be the net output from the engine including the effects of internal friction as well as normal engine accessories (fuel pump, water pump, etc.).
- Engine-driven accessories (fuel pump, oil pump, coolant pump, fan)-the average load was decreased 80% to account for the fact that these units can be energized electrically to avoid over-powering what occurs with engine drive belts at normal engine speeds,
- Regenerative Braking for Hybrid vehicles in Classes 3 through 6 and Type 1, Class 7-8.
- Weight reduction-a 5,000 lb weight reduction for a 60,000 lb GVW, was judged to be practical maximum.

Users can specify truck power to solve for energy balance (engine energy output adequate to overcome losses and driving loads), and therefore fuel economy. The Model calculates part-load efficiency effects, and includes an idling energy calculation (percent of operating hours—a user definable input). Aerodynamic and Rolling resistance calculations are included in the model based on the selected vehicle characteristics. Braking energy use and recovery calculations are also performed.

For each Class 7 and 8 Type and for Medium Trucks, the VIUS fuel economy was replicated and used as the baseline to which the program technologies were applied. Individual technology areas were modeled as ‘single’ point changes, and all improvements were combined. The vehicle system and driving loads act in a multiplicative manner, so the product of the individual benefits assumed is the overall benefit. This is how the fuel economy multipliers shown previously in Exhibit 5 were determined.

The principal user spreadsheet of the Heavy Truck Energy Benefits Model is reproduced as Exhibit 7. Additional information on this model is presented in Reference 12.

Exhibit 7: Truck Energy Balance Model

Truck Energy Balance Model Version 2.0 (User's may input alternative values to default items in Blue Font)					
TRUCK POWER TRAIN ENERGY ITEM			Value	Units	Notes
Class 7-8 Type 1 Case:					
Engine Peak Power Rating			150	kW	1. Set 'Average Power' = 'Peak Power' 2. Perform 'Goal Seek 1' Operation as described below. 3. Perform 'Goal Seek 2' Operation to make Remainder = 0 ('H-86) by changine Average Power Rating (H-87).
Estimated Engine Average Power Rating			78	kW	
Assumed Average Truck Speed			24.06	MPH	This is the average speed of the truck for the driving cycle assumed. Linked to 'Type Info' 2. Perform 'Goal Seek 1' Operation as described below.
Estimated Effective Truck Speed			36.00	MPH	See Look-up Table on 'Aero & Tires'
Fuel Energy Content-LHV			128,700	BTU/gal-LHV	from Transportation Energy Databook
Fuel Energy Content-HHV			138,700	BTU/gal-HHV	from Transportation Energy Databook
Engine Peak Frictionless Efficiency			49.25%		'Goal Seek 1' Result. Used to determine 'Gross Power Output Efficiency at Full Load. (Determine 'G40' by varying 'G17'.)
Percent Full Load			52%		
Cycle Efficiency Factor			96.4%		Accounts for engine efficiency variation at part load
Average Frictionless Cycle Efficiency:			47.5%		Assumed engine efficiency at the expected average load-, discounting all friction & based on HHV
Fuel Consumption Rate			561,053	BTU/hr	
Fuel Consumption Rate			4.0	gal/hr	
Non-Idle Fuel Economy			5.95	MPG	Calculated
Average Workday Length:			8.00	hr	
Percent of Normal Time Idling			20%		From 'Type Info' page
idle Fuel Consumption Rate:			1.00	gal/hr	
Idle Fuel Consumption:			1.60	gal/day	
Non-Idle Fuel Consumption			25.89	gal/day	
Total Fuel Consumption			27.49	gal/day	
Overal Average Fuel Economy			5.60	MPG	
Internal Engine Parasitics	Factor	1.00	Efficiency	Power Consumed (kW)	
	% of Engine Full Load Capacity				
Pistons & Rings	0.50%			0.8	"
Connecting rod and crankshaft bearings	1.00%			1.5	"
Valvetrain/camshaft	1.00%			1.5	"
Less Total Internal Engine Parasitics				3.8	Calculated
= Gross Engine-Out Power				74.3	Calculated
Gross Power-Out Engine Efficiency				45.2%	This is the nominal "engine efficiency" value
Engine Accessory Loads	Factor	1.00	Efficiency	Power Consumed (kW)	
	% of Engine Full Load Capacity				Based on Gross Engine-Out Power
Fuel injector pump	1.0%			1.5	"
Power Steering	1.0%			1.5	
Oil pump	0.5%			0.8	"
Coolant pump	1.0%			1.5	"
Fan	1.0%			1.5	"
					Based on Gross Power--Not in electrification program
Less Total Engine Aux Loads				6.8	Calculated
= Net Engine-Out Power				67.6	Calculated
Net Engine-Out Power Efficiency				41.1%	Calculated
Vehicle Auxiliary Loads	Avg Load	Units	Efficiency/ COP	Power Consumed (kW)	
	Factor	1.00			
Alternator	50	amp	0.8	1.0	Capacities & efficiencies assumed, loads calculated
Air Conditioner	1	ton	2	1.8	"
Air Brake Compressor	0.75	HP	0.5	1.1	"
Less Total Veh. Aux. Loads				3.9	Calculated
= Net Available Engine Power				63.7	Calculated
Net Eff				38.7%	
Drivetrain Parasitics	1.00		Efficiency	Power Consumed (kW)	
Transmission	1.00%	of max power		1.5	Based on net available engine-out power
Drivesaft	0.50%	of net power		0.4	"
Axle/Transaxle	0.50%	of net power		0.4	Select axle/transaxle or differential, but not both
Differential	0.00%	of net power		0.0	"
Axle & Wheel Bearings	0.25%	of net power		0.2	"
Brake Drag	0.25%	of net power		0.2	"
Less Total Drivetrain Parasitics				2.7	Calculated
= Net Available Power to Tires				61.0	Calculated
Net Engine-Out Power Efficiency				37.1%	Calculated
Driving Loads (See 'Aero & Tires' Sheet)				Power Consumed (kW)	
Aerodynamic Load				9.9	See Aero & Tires Sheet
Tire Rolling Resistance				11.8	See Aero & Tires Sheet
Acceleration/Braking Energy				39.3	Cycle energy consumed by the brakes divided by the driving cycle time. See 'Braking Power' Sheet.
= Total Non-Hybrid Driving Loads				61.0	Calculated
Hybrid Power System					
Percent braking energy recovery				0.0%	assumed-includes in/out motor/generator and battery charge/discharge efficiency
Net Braking energy lost				39.3	calculated
Adjusted (Hybrid) Total Driving Load				61.02	calculated
'Goal Seek' Balancing Value			Remainder	0.0	This value must = 0 for an energy balance to occur using Excel "goal seek" to solve for = 0
		5.60	mpg	78.1	'Goal Seek' Results (Cell 'G-11' Value)

4.4 TRUCK Model Version 2.0

Excerpts from the inputs used to generate the market penetration estimates are summarized in Exhibit 8. Values for fuel economy improvement and cost are input into **TRUCK (Version 2.0)**. As an example, the TRUCK model input schedule for Type 3 trucks is indicated in Exhibit 8. The first cost of the technology is assumed to reduce, over time, to a two-year payback level as a program goal. The model was developed to estimate the potential market impacts of new technologies.

Exhibit 8: Example First Cost and Efficiency Schedule for Advanced Technologies (Type 3 Vehicles)

Year	Baseline Vehicle Cost ($)	*Non-Hybrid Technologies*	
		Diesel Fuel (only)	
		Gross 1st Cost ($)	Efficiency Ratio
2000	150,000	0	1.000
2005	150,000	45,000	1.200
2010	150,000	40000	1.250
2015	150,000	30000	1.350
2020	150,000	20000	1.590
2025	150,000	15000	1.610
2030	150,000	10000	1.630
2035	150,000	7,600	1.630
2040	150,000	7,000	1.630
2045	150,000	7,000	1.630
2050	150,000	7,000	1.630

The results generated by this model are:

- Market penetrations, in units of percent of new vehicles sold for each type and class of vehicle, vehicle miles, and
- Composite fuel economy rating (new mpg) of the vehicles sold.

The relative market penetration rates of the advanced technology vehicle increases with the relative economic benefit and decreases with increases in relative price.

Within the TRUCK model, the scope of economic benefit is limited to the promised or potential fuel cost savings derived from improvements in fuel economy or to the switching to a new fuel. Other potential benefits or negative effects, such as a lengthening or shorting of engine or vehicle life, increased or decreased maintenance costs, or changes in the vehicle resale value and the like are not considered within the structure of the model, although it is possible to manually account for such effects within the calculations.

The model includes Class 3-6 (light and medium) trucks as well as Class 7&8 (heavy) trucks. As discussed previously, Class 7&8 trucks are further subdivided into three subclasses (Types 1, 2 and 3) to account for different travel patterns (urban, mixed, and highway) and different usage patterns. Each of these four vehicle groups (Class 3-6, Class 7&8-Types 1, 2, and 3) are further analyzed based on the eleven miles/year statistical cohorts representing categories from 0-20,000 mi/year to 200,000+ mi/year of vehicle travel. In addition, each class and subclass is further subdivided into cohorts that are separately refueled (in dedicated non-public stations) and those that are refueled at public stations. The percentages of vehicles in each type and mileage cohort are used in this analysis.

The annual fuel savings for each class, type, and mileage cohort is calculated for each of the analysis years for a total of eighty-eight separate calculations for each analysis year. The model can simultaneously analyze the baseline fuel economy and up to two additional fuel-savings improvements. Each savings value is then compared to the projected technology cost to determine its payback and market penetration potential. The market penetration potentials of the two improvements are then compared and apportioned based on an assumption of mutual interaction (the purchase of one technology may exclude or reduce the economic benefit of the

second technology). All of these calculations are performed on an iterative basis through the use of Excel macros (stored automatic calculation routines).

The overall market penetration rates for each of the two fuel-savings technologies in each analysis year are then calculated based on the percent of vehicles and vehicle-miles in each subgroup.

Exhibit 9 shows the payback distribution assumed in the TRUCK model. This payback distribution was generated from the American Trucking Associations' survey described above (Ref. 3).

Exhibit 9: Heavy Vehicle Payback Period Market Distribution

Number of Years	Percent of Motor Carriers
1	16.4%
2	61.7%
3	15.5%
4	6.4%

TRUCK is a spreadsheet model that currently operates in Excel (Office XP and associated versions). It consists of multiple spreadsheets linked to other models. It is operated by user specifying inputs and then initiating macros that perform iterative calculations to determine market shares by technology in percents of new vehicle sales. The principal model calculation pages are listed below. These are also reproduced in Appendix A. Of the Type 1, Type 2 and Type 3 calculations, only the Type 3 pages are copied, as the kinds of information are the same for Types 1 and 2. Based on energy use, Type 3 is the market segment of greatest interest.

1. **Inputs**-user specifies incremental technology cost and relative fuel efficiency for current and advanced technology (ies). These inputs are specified by year to 2035 and separately for Class 7 & 8 and Classes 3 through 6 vehicles.
2. **Fuel Prices**—array of fuel price information. Typically linked to other AEO-source files.
3. **Market Data** —Distribution of vehicle usage patterns from 1997 VIUS
4. **Type 1**—Utilizes an Excel macro in which calculations are performed to determine market distribution of conventional and new technologies for "Type 1" Class 7 and 8 vehicles. Calculations are performed separately for centrally refueled and non-centrally refueled vehicles.
5. **Type 2**—Utilizes an Excel macro in which calculations are performed to determine market distribution of conventional and new technologies for "Type 2" Class 7 and 8 vehicles. Calculations are performed separately for centrally refueled and non-centrally refueled vehicles.
6. **Type 3**—Utilizes an Excel macro in which calculations are performed to determine market distribution of conventional and new technologies for "Type 3" Class 7 and 8 vehicles. Calculations are performed separately for centrally refueled and non-centrally refueled vehicles.
7. **Med (Medium Truck)**—Utilizes an Excel macro in which calculations are performed to determine market distribution of conventional and new technologies for "Medium", i.e.,

Class 3 through 6 vehicles. Calculations are performed separately for centrally refueled and non-centrally refueled vehicles.

8. **New MPG**—Shows the effect of new technology penetrations on fuel economy by vehicle class. Fuel economy values by type and class for 2036 to 2050 are extrapolated based on trends during the 2030 to 2035 period.
9. **Market Vehicle Penetration**—Summarizes the market penetration of new technologies in units of new vehicle sales percentage. Lists market shares for each Class 7 & 8 vehicle type, Class 7 & 8 composite and Classes 3 through 6 (composite). Vehicle market penetration estimates are based on VIUS survey data of vehicles of up to two years in age. Market penetrations post 2035 are extrapolated to 2050 based on trends during the 2030 to 2035 period.
10. **Market Vehicle-Miles Penetration** (VMT) - Market penetration based on percent of annual vehicle miles traveled. Due to the nature of the VIUS data and the payback calculation methodology this provides a somewhat different and more representative market penetration estimate—for purposes of estimating energy savings. The DOE sponsored technologies penetrate in vehicles used more than average, even in the first years of operation.
11. **Detailed Inputs** - Link to **VISION** Model. This is discussed in Section 4.5. Detailed Inputs page are included for both the market penetrations based on 'vehicles sold' and 'vehicle miles'.
12. **Run Macro** – This page shows the sheet at which the users instruct the model to exercise the macros to estimate market penetrations for each of the market segments.

Note that the model calculates two market penetration rates. The first is the percent of vehicles within the class/type category that are expected to be equipped with the new fuel-saving technology. This permits an estimate of the total economic cost impact of the technology (= No. of units x cost/unit). The second is the percent of vehicle-miles affected. Since vehicles which preferentially travel greater miles/yr are more likely to be equipped with energy-saving features, the percent of vehicle-miles/year penetration tends to be higher than the percent of number of vehicles penetration, leading to a higher estimate of economic benefit than would have been obtained otherwise.

4.5 VISION Model

The **VISION** model is used to estimate oil/energy use, and CO_2 emissions from highway vehicles through 2050 (Ref. 13). The model includes Class 3 through 6 and 7 and 8 vehicles—both gasoline and diesel fueled. One can model the potential benefits of various alternative fuel vehicles and enhanced efficiency technologies. The technology market penetration rates calculated in the TRUCK model, based on **vehicle miles,** are used to calculate new vehicle fleet-average fuel economy values (including the effects of new technology for each of the truck classes and types analyzed in TRUCK). The model is used to convert the market penetration results (using the vehicle miles traveled basis) from the TRUCK model into energy and carbon reduction benefits.

A vintaging algorithm accumulates new vehicle sales in the heavy vehicle fleet. The model calculates both baseline and advanced technology vehicle performance and benefits are

determined by the differences between the two scenarios. The calculation methodology spans a 50-year analysis period.

For GPRA purposes we also had to adjust the NEMS baseline which is used in VISION to subtract out the effects of DOE supported technologies, specifically for Class 7-8. (We refer to it below as the "adjusted VISION" baseline.)

Exhibit 10: GPRA 07 Heavy Vehicle Benefits Results for NEMS Modeling

Class 7-8							Class 3-6							
Year	Combined Market Penetration, % VMT	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy Multiplier only for trucks with new techology which achieve the market penetration shown in Column 2 and relative to a 2005 base truck	Fuel Economy for All New Technology Sales, mpg	Estimate of fuel economy for all new 7-8 trucks	Estimate of X factor to input to VISION (only those for 2010, 2020, 2030, 2040 + 2050 are input): X factor for all new trucks	Efficiency, % VMT	Hybrid, % VMT	Combined Market Penetration, % VMT	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy Multiplier only for trucks with new techology which achieve the market penetration shown in Column 10 and relative to a 2005 base truck	Fuel Economy for All New Technology Sales, mpg	Estimate of fuel economy for all new 3-6 trucks	Estimate of X factor to input to VISION (only those for 2010, 2020, 2030, 2040 + 2050 are input): X factor for all new trucks
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2010	0%	5.64	1.24	6.97	5.639	**1.00**	0%	0%	0%	8.54	1.20	10.27	8.54	**1.00**
2011	0%	5.69	1.27	7.15	5.69	1.00	0%	0%	0%	8.55	1.22	10.49	8.55	1.00
2012	0%	5.76	1.30	7.34	5.76	1.00	0%	0%	0%	8.55	1.25	10.72	8.55	1.00
2013	0%	5.85	1.34	7.53	5.85	1.00	0%	0%	0%	8.55	1.28	10.94	8.55	1.00
2014	0%	5.96	1.37	7.71	5.97	1.00	0%	0%	0%	8.55	1.30	11.17	8.56	1.00
2015	1%	6.08	1.40	7.90	6.09	1.00	1%	0%	1%	8.56	1.33	11.40	8.58	1.00
2016	2%	6.12	1.43	8.08	6.15	1.00	1%	0%	1%	8.57	1.35	11.62	8.60	1.00
2017	2%	6.18	1.47	8.27	6.22	1.01	3%	0%	3%	8.58	1.38	11.85	8.65	1.01
2018	4%	6.25	1.50	8.46	6.31	1.01	4%	0%	4%	8.58	1.41	12.07	8.69	1.01
2019	7%	6.25	1.53	8.64	6.36	1.02	13%	0%	13%	8.58	1.43	12.30	8.93	1.04
2020	12%	6.25	1.57	8.83	6.48	**1.04**	15%	0%	15%	8.59	1.46	12.53	9.02	**1.05**
2021	14%	6.40	1.57	8.85	6.66	1.04	17%	0%	17%	8.59	1.46	12.54	9.08	1.06
2022	18%	6.40	1.57	8.87	6.74	1.05	22%	0%	22%	8.59	1.46	12.56	9.24	1.08
2023	21%	6.43	1.58	8.89	6.83	1.06	24%	0%	24%	8.59	1.47	12.57	9.30	1.08
2024	24%	6.44	1.58	8.91	6.90	1.07	23%	1%	24%	8.59	1.47	12.59	9.31	1.08
2025	31%	6.45	1.58	8.93	7.05	1.09	23%	2%	25%	8.59	1.47	12.60	9.34	1.09
2026	32%	6.49	1.59	8.95	7.12	1.10	25%	2%	27%	8.59	1.47	12.62	9.41	1.09
2027	47%	6.53	1.59	8.97	7.49	1.15	29%	3%	32%	8.59	1.47	12.64	9.56	1.11
2028	48%	6.57	1.60	8.99	7.55	1.15	35%	6%	40%	8.59	1.47	12.65	9.87	1.15
2029	59%	6.61	1.60	9.01	7.83	1.19	35%	7%	41%	8.59	1.48	12.67	9.91	1.15
2030	61%	6.65	1.60	9.03	7.91	**1.19**	40%	7%	47%	8.59	1.48	12.68	10.13	**1.18**
2031	62%	6.69	1.60	9.04	7.98	1.19	40%	8%	47%	8.59	1.48	12.69	10.14	1.18
2032	68%	6.74	1.60	9.04	8.14	1.21	36%	12%	48%	8.60	1.48	12.69	10.18	1.18
2033	68%	6.78	1.60	9.04	8.17	1.21	36%	13%	48%	8.60	1.48	12.70	10.19	1.19
2034	70%	6.82	1.60	9.05	8.23	1.21	34%	17%	51%	8.60	1.48	12.70	10.28	1.20
2035	70%	6.86	1.61	9.05	8.27	1.21	29%	25%	54%	8.60	1.48	12.71	10.43	1.21
2036	71%	6.91	1.61	9.05	8.29	1.20	29%	28%	57%	8.60	1.48	12.71	10.55	1.23
2037	71%	6.95	1.61	9.06	8.32	1.20	29%	28%	57%	8.60	1.48	12.72	10.57	1.23
2038	71%	6.99	1.61	9.06	8.34	1.19	29%	29%	58%	8.60	1.48	12.72	10.59	1.23
2039	71%	7.04	1.61	9.06	8.37	1.19	30%	29%	59%	8.60	1.48	12.73	10.63	1.24
2040	71%	7.08	1.61	9.07	8.39	**1.18**	33%	29%	62%	8.60	1.48	12.73	10.76	**1.25**
2041	71%	7.13	1.61	9.07	8.41	1.18	48%	27%	76%	8.60	1.48	12.73	11.39	1.32
2042	72%	7.17	1.61	9.07	8.43	1.18	43%	35%	78%	8.60	1.48	12.73	11.51	1.34
2043	72%	7.22	1.61	9.07	8.45	1.17	41%	38%	79%	8.60	1.48	12.73	11.58	1.35
2044	72%	7.26	1.61	9.07	8.48	1.17	40%	39%	79%	8.61	1.48	12.73	11.58	1.35
2045	72%	7.31	1.61	9.07	8.50	1.16	40%	39%	79%	8.61	1.48	12.73	11.59	1.35
2046	73%	7.35	1.61	9.07	8.53	1.16	40%	39%	79%	8.61	1.48	12.73	11.59	1.35
2047	73%	7.40	1.61	9.07	8.55	1.16	40%	40%	80%	8.61	1.48	12.73	11.59	1.35
2048	74%	7.45	1.61	9.07	8.58	1.15	40%	40%	80%	8.61	1.48	12.73	11.60	1.35
2049	74%	7.49	1.61	9.07	8.60	1.15	40%	40%	80%	8.61	1.48	12.73	11.61	1.35
2050	74%	7.54	1.61	9.07	8.62	**1.14**	41%	40%	81%	8.61	1.48	12.73	11.65	**1.35**

For Class 7 and 8 vehicles, the market penetration of new technology trucks for each year is linked to the Truck 2.0 Model results and is shown in Column 2. The adjusted VISION baseline fuel economy factors are shown in Column 3. The fuel economy multipliers in Column 5 are those of the two-year and newer vehicles with energy conserving technology as calculated by the Truck model. These multipliers are relative to the year 2005 baseline truck in TRUCK. Column 4 shows the actual fuel economy of the new technology vehicles; they are the result of the multiplication of the multipliers times the year 2005 baseline truck in VISION (5.64). The average fuel economy of all new trucks including those with and without new technology is indicated in Column 6. The ratio or 'X' factor used in VISION is shown in Column 7 and it is the ratio of Column 6 to Column 3.

The adjustments between the TRUCK model results and VISION for Class 3 through 6 vehicles is analogous to what is described above and also are shown in Exhibit 10, Column 15.

4.6 Heavy Truck Summary

The **Heavy Truck Summary** report generator summarizes the first order benefits for the period covering 2000 through 2050 at the program element level. Benefits are reported as follows:

- Heavy Vehicle Technology GPRA 06 Inputs
- Heavy Truck Petroleum Use
- Oil Benefits by Program Type
- Energy Carbon & Stock
- Benefits Contribution Worksheet—by program element.

These outputs were presented in the Executive Summary and in Section 5.

4.7 List of Key Assumptions

A list of key assumptions is contained in Exhibit 11. Additional assumptions can be seen by reviewing Appendix A—especially Inputs, Fuel Prices, and Market Data pages, and by reviewing Reference 12.

Exhibit 11: List of Key Assumptions

Item	Value	Comments
Type 1 Vehicles		
Vehicle Miles	3,911,030,000	
Enhanced Fuel Economy, MPG	6.6	From HTEB Model
Gallons	595,921,073	
Baseline Fuel Economy, MPG	5.6	VIUS 2002
Drag Coefficient Improvement, %	7.5%	
Engine Efficiency Improvement, %	30	
Engine Peak Output, kW	200	
Engine Average Output, kW	85	Enhanced vehicles
Weight Reduction, lb.	6000	
Type 2 Vehicles		
Vehicle Miles	9,253,572,500	
Enhanced Fuel Economy, MPG	9.9	From HTEB Model
Gallons	936,122,661	
Baseline Fuel Economy, MPG	5.6	VIUS 2002
Drag Coefficient Improvement, %	15.0%	
Engine Efficiency Improvement, %	37.5%	
Engine Peak Output, kW	250	
Engine Average Output, kW	78	Enhanced vehicles
Weight Reduction, lb.	6000	
Type 3 Vehicles		
Vehicle Miles	30,993,527,500	
Enhanced Fuel Economy, MPG	13.2	From HTEB Model
Gallons	2,345,329,361	
Baseline Fuel Economy, MPG	5.9	VIUS 2002
Fuel Economy with Improvements, MPG	13.6	
Drag Coefficient Improvement, %	15.0%	
Engine Efficiency Improvement, %	37.5%	
Engine Peak Output, kW	250	
Engine Average Output, kW	93	Enhanced vehicles
Weight Reduction, lb.	6000	
Total Fleet-Class 7&8 Vehicles		
Total Vehicle Miles	44,158,130,000	VIUS < 2 yr. old vehicles
Total Gallons	3,877,373,094	
Fuel Economy MPG	11.4	
Total Vehicles	548,005	VIUS < 2 yr. old vehicles
Average Gallons	7,075	
Two Year Consumption:	14,151	
Diesel Fuel Price (2005) $/million BTU	9.68	AEO 2004
Fuel Economy Improvement:	60%	
Percent Fuel Savings	37.5%	
Value of Savings-2 yr payback, $	7,111	Used to Determine Technology Cost
Type M Vehicles		
Total Vehicle Miles	8,189,310,000	VIUS < 2 yr. old vehicles
MPG	8.9	
Gallons	920,147,191	
Baseline Fuel Economy, MPG	8.9	
Total Vehicle	373,223	
Fuel Economy with Improvements, MPG	12.2	
Drag Coefficient Improvement, %	15.0%	
Engine Efficiency Improvement, %	37.5%	
Engine Peak Output, kW	125	
Engine Average Output, kW	20	
Weight Reduction, lb.	1600	
Gallons/veh	2,465	
Two Year Consumption	4,931	
Fuel Economy Improvement:	70%	
Value of Savings-2 yr payback, $	2,721	Used to determine technology cost

5.0 Results

Selected results from the Heavy Truck summary report are presented in the following pages. The market penetrations and savings are based on vehicle miles traveled

Exhibit 12: Heavy Vehicle Technologies GPRA 07 Results

Heavy Vehicle Technologies GPRA 07 Results

	Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Notes
1	Oil Use Class 7- 8-Local, mmbpd	0.260	0.246	0.270	0.288	0.300	0.291	0.293	0.311	0.328	0.345	
2	Oil Use Class 7- 8-Intermediate, mmbpd	0.454	0.534	0.586	0.626	0.670	0.696	0.732	0.770	0.808	0.848	
3	Oil Use Class 7- 8-Long-Haul, mmbpd	1.224	1.441	1.582	1.707	1.859	2.008	2.157	2.296	2.422	2.548	
4	Total Class 7-8, mmbpd	1.938	2.221	2.437	2.621	2.828	2.995	3.182	3.378	3.558	3.742	
5	Oil Use Class 3-6, mmbpd	0.363	0.404	0.449	0.502	0.559	0.597	0.637	0.679	0.718	0.759	
6	Total Oil Use, mmbpd	2.301	2.626	2.886	3.123	3.387	3.592	3.819	4.057	4.277	4.501	
7	Class 7- 8-Local (Type 1), mmbpd reduction	0	0.000	0.000	0.003	0.016	0.033	0.047	0.056	0.062	0.065	
8	Class 7- 8-Intermediate (Type 2), mmbpd reduction	0	0.000	0.000	0.005	0.035	0.080	0.116	0.139	0.152	0.160	
9	Class 7- 8-Long-Haul (Type 3), mmbpd reduction	0	0.000	0.000	0.015	0.097	0.230	0.344	0.414	0.454	0.479	
10	Total Class 7-8, mmbpd reduction	0	0.000	(0.001)	0.023	0.147	0.343	0.507	0.609	0.668	0.704	
11	Oil Reduction Class 3-6, mmbpd reduction	0	0.000	0.000	0.005	0.025	0.055	0.086	0.113	0.140	0.170	
12	Total Oil Reduction, mmbpd		0.000	(0.001)	0.028	0.172	0.398	0.592	0.722	0.808	0.874	
13	Oil Reduction Class 7-8, %	0%	0%	0%	1%	5%	11%	16%	18%	19%	19%	
14	Oil Reduction Class 3-6, %	0%	0%	0%	1%	5%	9%	13%	17%	20%	22%	
15	Total Oil Reduction, %	0%	0%	0%	1%	5%	11%	16%	18%	19%	19%	
16	Total Carbon Emissions, mmtce	132.88	151.75	166.88	180.54	195.85	207.78	221.06	234.98	247.86	261.02	
17	Carbon Reduction Class 7- 8-Local, mmtce	0	0.000	-0.009	0.389	2.389	5.521	8.214	10.008	11.202	12.117	
18	Carbon Reduction Class 7- 8-Intermediate, mmtce	0	0.000	(0.011)	0.486	2.986	6.901	10.267	12.510	14.003	15.146	
19	Carbon Reduction Class 7- 8-Long-Haul, mmtce	0	0.000	(0.017)	0.762	4.678	10.811	16.086	19.599	21.937	23.729	
20	Total Carbon Reduction Class 7-8, mmtce	0	0.000	(0.037)	1.620	9.952	23.003	34.225	41.700	46.676	50.487	
21	Carbon Reduction Class 3-6, mmtce	0	0.000	0.000	0.005	0.025	0.055	0.086	0.113	0.140	0.170	
22	Total Carbon Reduction, mmtce	0.000	0.000	(0.037)	1.625	9.978	23.058	34.310	41.813	46.816	50.657	
23	Total Carbon Reduction, %	0%	0%	0%	1%	5%	11%	16%	18%	19%	19%	
24	Vehicle Miles Traveled Class 7-8, Local; milliions	16,217	18,625	20,900	23,399	25,904	27,970	30,190	32,495	34,683	36,947	
25	Vehicle Miles Traveled Class 7-8, Intermediate; mllions	38,369	44,068	49,449	55,363	61,291	66,178	71,430	76,884	82,060	87,418	
26	Vehicle Miles Traveled Class 7-8, Long-Haul; millions	128,511	147,600	165,622	185,429	205,284	221,654	239,246	257,511	274,850	292,793	
27	Total Class 7-8, millions	183,096	210,293	235,971	264,191	292,479	315,802	340,866	366,889	391,593	417,158	
28	Vehicle Miles Traveled Class 3-6; millions	51,532	57,749	64,383	72,303	80,935	86,405	92,283	98,385	104,179	110,174	
29	Total Vehicle Miles Traveled , millions	234,628	268,042	300,354	336,494	373,414	402,207	433,149	465,274	495,772	527,333	
30	Fuel Economy Class 7-8, Local, mpg	5.6	5.6	5.6	5.7	5.9	6.6	7.0	7.0	7.0	7.1	
31	Fuel Economy Class 7-8, Intermediate, mpg	5.6	5.6	5.6	5.8	6.1	7.1	7.5	7.5	7.6	7.7	
32	Fuel Economy Class 7-8, Long-Haul, mpg	6.0	6.0	6.0	6.3	6.9	8.1	8.5	8.6	8.6	8.7	
33	Average, Class 7-8, mpg	5.8	5.8	5.9	6.1	6.6	7.7	8.1	8.2	8.2	8.3	
34	Fuel Economy Class 3-6, mpg	8.9	8.9	8.9	9.5	9.9	10.9	11.1	11.5	12.6	12.7	
35	Market Penetration Class 7-8, Local, % VMT	0.0%	0.0%	0.2%	3.2%	13.1%	13.1%	13.1%	13.1%	13.1%	13.1%	
36	Market Penetration Class 7-8 Hybrid, Local, % VMT	0.0%	0.0%	0.2%	2.4%	10.2%	10.2%	10.2%	10.2%	10.2%	10.2%	
37	Market Penetration Class 7-8, Intermediate, % VMT	0.0%	0.0%	0.3%	7.9%	23.9%	57.8%	69.4%	70.0%	71.4%	73.9%	
38	Market Penetration Class 7-8, Long Haul, % VMT	0.0%	0.0%	1.0%	14.7%	35.2%	67.3%	78.0%	78.8%	80.2%	82.2%	
39	Market Penetration--All Types, Class 7-8, % VMT	0.0%	0.0%	0.8%	12.2%	30.9%	60.5%	70.4%	71.2%	72.4%	74.3%	
40	Market Penetration Hybrid Class 3-6, % VMT	0.0%	0.0%	0.0%	0.0%	2.2%	6.9%	24.7%	28.9%	39.4%	39.8%	
41	Vehicle Stock Class 7-8, Local, vehicles x 1000	863	939	1,007	1,063	1,114	1,189	1,269	1,352	1,431	1,513	
42	Vehicle Stock Class 7-8, Intermediate, Vehicles x 1000	1,093	1,190	1,276	1,347	1,412	1,506	1,608	1,713	1,814	1,917	
43	Vehicle Stock Class 7-8, Long-Haul, Vehicles x 1000	2,884	3,141	3,365	3,554	3,725	3,974	4,242	4,521	4,785	5,058	
44	Total Vehicle Stock Class 7-8, Vehicles X 1000	4,840	5,271	5,648	5,965	6,251	6,670	7,119	7,586	8,030	8,488	
45	Vehicle Stock Class 3-6, Vehicles x 1000	51,532	57,749	64,383	72,303	80,935	86,405	92,283	98,385	104,179	110,174	
46	Total Vehicle Stock Class 3-8, Vehicles X 1000	56,372	63,020	70,031	78,268	87,186	93,074	99,402	105,972	112,209	118,663	

Exhibit 13: Heavy Vehicle Technologies GPRA 07 Results by Program Element

Heavy Vehicle Technologies GPRA 07 Results by Program Element

	Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Notes
	Consumption Breakdown, mmbpd											
i	Oil Use Class 7- 8-Local (Type 1)	0.260	0.246	0.270	0.288	0.300	0.291	0.293	0.311	0.328	0.345	
ii	Oil Use Class 7- 8-Intermediate (Type 2)	0.454	0.534	0.586	0.626	0.670	0.696	0.732	0.770	0.808	0.848	
iii	Oil Use Class 7- 8-Long-Haul (Type 3)	1.224	1.441	1.582	1.707	1.859	2.008	2.157	2.296	2.422	2.548	
1	Total Class 7-8	1.938	2.221	2.437	2.621	2.828	2.995	3.182	3.378	3.558	3.742	
2	Oil Use Class 3-6	0.363	0.404	0.449	0.502	0.559	0.597	0.637	0.679	0.718	0.759	
3	Total Oil Use, mmbpd	2.301	2.626	2.886	3.123	3.387	3.592	3.819	4.057	4.277	4.501	
4	Class 7 & 8 Savings Breakdown, mmbpd											
5	Oil Reduction Class 7- 8-Auxiliary Load Reduction	0	0.000	(0.000)	0.004	0.024	0.054	0.081	0.096	0.105	0.111	
6	Idle Hour Reduction	0	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
7	Oil Reduction Class 7- 8--Engine Efficiency/WHR	0	0.000	(0.000)	0.016	0.105	0.234	0.318	0.411	0.451	0.476	
9	Oil Reduction Class 7- 8--Vehicle Weight Reduction	0	0.000	(0.000)	0.001	0.008	0.022	0.033	0.043	0.047	0.050	
10	Oil Reduction Class 7- 8-Aerodynamic Load Reduction	0	0.000	(0.000)	0.002	0.010	0.033	0.040	0.058	0.064	0.067	
11	Total Class 7-8, mmbpd	0	0.0000	(0.001)	0.023	0.147	0.343	0.507	0.608	0.667	0.704	
12	Oil Reduction Class 3-6-Auxiliary Load Reduction	0	0.0000	0.000	0.001	0.005	0.010	0.015	0.020	0.025	0.030	
13	Oil Reduction Class 3-6--Engine Efficiency/WHR	0	0.0000	0.000	0.004	0.018	0.039	0.061	0.079	0.099	0.119	
15	Oil Reduction Class 3-6--Vehicle Weight Reduction	0	0.0000	0.000	0.000	0.002	0.004	0.007	0.010	0.012	0.015	
16	Oil Reduction Class 3-6-Aerodynamic Load Reduction	0	0.0000	0.000	0.000	0.001	0.001	0.002	0.004	0.005	0.006	
17	Oil Reduction Class 3-6-Hybrid	0	0.0000	0.000	0.003	0.025	0.029	0.045	0.059	0.073	0.089	
18	Oil Reduction Class 3-6, mmbpd	0	0.000	0.000	0.005	0.025	0.055	0.086	0.113	0.140	0.170	
19	Total Oil Reduction, mmbpd	0.000	0.000	(0.001)	0.028	0.172	0.398	0.592	0.722	0.808	0.874	
24	Oil Reduction-Auxiliary Load Reduction	0.0%	0.0%	0.0%	0.2%	0.9%	1.8%	2.5%	2.9%	3.0%	3.1%	
25	Idle Hour Reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
26	Oil Reduction--Engine Efficiency/WHR	0.0%	0.0%	0.0%	0.6%	3.6%	7.6%	9.9%	12.1%	12.9%	13.2%	
28	Oil Reduction--Vehicle Weight Reduction	0.0%	0.0%	0.0%	0.1%	0.3%	0.7%	1.0%	1.3%	1.4%	1.4%	
29	Oil Reduction-Aerodynamic Load Reduction	0.0%	0.0%	0.0%	0.1%	0.3%	0.9%	1.1%	1.5%	1.6%	1.6%	
30	Oil Reduction-Hybrid	0.0%	0.0%	0.0%	0.1%	0.7%	0.8%	1.2%	1.5%	1.7%	2.0%	
31	Total Oil Reduction, %	0%	0%	0%	1%	5%	11%	16%	18%	19%	19%	
32	Total Carbon Emissions, Class 7-8, mmtce	66.572	131.07	143.68	154.71	167.02	175.65	186.70	198.24	208.63	219.42	
33	Total Carbon Emissions, Class 3-6, mmtce	10.549	20.682	23.195	25.835	28.837	32.134	34.352	36.743	39.231	41.604	
34	Total Carbon Emissions, mmtce	132.88	151.75	166.88	180.54	195.85	207.78	221.06	234.98	247.86	261.02	
35	Carbon Emissions-Auxiliary Load Reduction, mmtce	-	-	(0.01)	0.27	1.66	3.66	5.46	6.61	7.40	8.01	
36	Carbon Reduction--Engine Efficiency/WHR, mmtce	-	-	(0.02)	1.16	7.13	5.43	23.35	28.26	31.64	34.23	
38	Carbon Reduction--Vehicle Weight Reduction, mmtce	-	-	(0.00)	0.09	0.54	1.50	2.22	2.97	3.32	3.60	
39	Carbonl Reduction-Aerodynamic Load Reduction, mmtce	-	-	(0.00)	0.11	0.66	2.19	3.28	3.98	4.46	4.82	
40	Carbon Reduction-Hybrid, mmtce	-	-	-	-	-	-	-	-	-	-	
41	Total Carbon Reduction, mmtce	0.000	0.000	(0.037)	1.625	9.978	23.058	34.310	41.813	46.816	50.657	
42	Total Carbon Reduction, %	0%	0%	0%	1%	5%	11%	16%	18%	19%	19%	

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Appendix A

TRUCK 2.0 Model

Inputs

		CLASS 7 & 8 Type 2			
		Non-Hybrid Technologies			
		Diesel Fuel (only)			
		Subsidy =			
Year	Baseline Vehicle Cost ($)	Gross 1st Cost ($)	0%	Net Cost ($)	Efficiency Ratio
2000	150,000	0	0	0	1.000
2001	150,000	0	0	0	1.000
2002	150,000	0	0	0	1.000
2003	150,000	0	0	0	1.000
2004	150,000	90,000	0	90,000	1.100
2005	150,000	45,000	0	45,000	1.200
2006	150,000	44000	0	44,000	1.210
2007	150,000	43000	0	43,000	1.220
2008	150,000	42000	0	42,000	1.230
2009	150,000	41000	0	41,000	1.240
2010	150,000	40000	0	40,000	1.250
2011	150,000	38000	0	38,000	1.270
2012	150,000	36000	0	36,000	1.290
2013	150,000	34000	0	34,000	1.310
2014	150,000	32000	0	32,000	1.330
2015	150,000	30000	0	30,000	1.350
2016	150,000	28000	0	28,000	1.398
2017	150,000	26000	0	26,000	1.446
2018	150,000	24000	0	24,000	1.494
2019	150,000	22000	0	22,000	1.542
2020	150,000	20000	0	20,000	1.590
2021	150,000	19000	0	19,000	1.594
2022	150,000	18000	0	18,000	1.598
2023	150,000	17000	0	17,000	1.602
2024	150,000	16000	0	16,000	1.606
2025	150,000	15000	0	15,000	1.610
2026	150,000	14000	0	14,000	1.614
2027	150,000	13000	0	13,000	1.618
2028	150,000	12000	0	12,000	1.622
2029	150,000	11000	0	11,000	1.626
2030	150,000	10000	0	10,000	1.630
2031	150,000	9520	0	9,520	1.630
2032	150,000	9040	0	9,040	1.630
2033	150,000	8560	0	8,560	1.630
2034	150,000	8080	0	8,080	1.630
2035	150,000	7,600	0	7,600	1.630

Fuel Prices

Transportation Energy Prices
AEO'05 ***Last Update: 6/30/05*** by: Laura Wontrop/WJS
AEO Input Values in Yellow Boxes
Old Values from previous AEO Reports in Grey Boxes **Extrapolated Values are in Blue Font**
Reference values are highlighted. All others are by linear interpolation

	2003 Dollars per Million BTU						**2003 Dollars Per Gallon-Gasoline Equivalent** (except Diesel Fuel which is in $/gal of diesel fuel)					
Year	Gasoline	Diesel	LPG	CNG	Electricity	Ethanol	Gasoline	Diesel	LPG	CNG	Electricity	Ethanol
1995												
1996												
1997												
1998												
1999												
2000	12.42	10.99	16.45	6.76	22.07	17.72	1.55	1.52	2.06	0.85	2.76	2.22
2001	11.99	10.16	17.12	8.69	21.58	16.56	1.50	1.41	2.14	1.09	2.70	2.07
2002	11.32	9.55	15.15	7.23	20.03	14.65	1.42	1.33	1.89	0.90	2.50	1.83
2003	12.93	10.92	16.65	9.04	20.64	16.23	1.62	1.51	2.08	1.13	2.58	2.03
2004	14.65	12.02	20.60	9.71	21.20	19.66	1.83	1.67	2.58	1.21	2.65	2.46
2005	14.35	11.55	20.42	9.80	20.92	19.59	1.79	1.60	2.55	1.22	2.62	2.45
2006	13.63	11.29	16.38	9.30	19.97	19.47	1.70	1.57	2.05	1.16	2.50	2.43
2007	12.94	11.00	15.82	8.98	19.09	18.31	1.62	1.53	1.98	1.12	2.39	2.29
2008	12.72	10.85	15.60	8.72	18.80	18.15	1.59	1.50	1.95	1.09	2.35	2.27
2009	12.44	10.68	15.31	8.63	18.83	17.74	1.56	1.48	1.91	1.08	2.35	2.22
2010	12.32	10.76	15.24	8.56	18.81	17.11	1.54	1.49	1.91	1.07	2.35	2.14
2011	12.33	10.82	15.18	8.62	18.83	16.99	1.54	1.50	1.90	1.08	2.35	2.12
2012	12.23	10.81	15.20	8.71	19.02	16.89	1.53	1.50	1.90	1.09	2.38	2.11
2013	12.22	10.79	15.25	8.83	19.23	17.11	1.53	1.50	1.91	1.10	2.40	2.14
2014	12.23	10.74	15.18	8.99	19.52	17.30	1.53	1.49	1.90	1.12	2.44	2.16
2015	12.26	10.71	15.28	9.11	19.59	17.37	1.53	1.49	1.91	1.14	2.45	2.17
2016	12.32	10.70	15.38	9.10	19.54	17.40	1.54	1.48	1.92	1.14	2.44	2.18
2017	12.39	10.72	15.37	9.10	19.58	17.43	1.55	1.49	1.92	1.14	2.45	2.18
2018	12.41	10.72	15.39	9.20	19.71	17.50	1.55	1.49	1.92	1.15	2.46	2.19
2019	12.45	10.72	15.51	9.34	19.90	17.11	1.56	1.49	1.94	1.17	2.49	2.14
2020	12.52	10.66	15.66	9.45	19.99	17.22	1.57	1.48	1.96	1.18	2.50	2.15
2021	12.56	10.69	15.77	9.54	20.05	17.67	1.57	1.48	1.97	1.19	2.51	2.21
2022	12.62	10.71	15.85	9.58	19.98	17.68	1.58	1.49	1.98	1.20	2.50	2.21
2023	12.72	10.64	16.04	9.58	19.89	17.87	1.59	1.48	2.00	1.20	2.49	2.23
2024	12.72	10.68	16.11	9.64	19.92	17.99	1.59	1.48	2.01	1.21	2.49	2.25
2025	12.81	10.85	16.24	9.69	19.96	18.13	1.60	1.50	2.03	1.21	2.49	2.27
2026	12.87	10.88	16.36	9.74	19.95	18.32	1.61	1.51	2.05	1.22	2.49	2.29
2027	12.93	10.92	16.49	9.79	19.95	18.50	1.62	1.51	2.06	1.22	2.49	2.31
2028	12.99	10.96	16.61	9.85	19.94	18.70	1.62	1.52	2.08	1.23	2.49	2.34
2029	13.05	11.00	16.73	9.90	19.94	18.89	1.63	1.53	2.09	1.24	2.49	2.36
2030	13.11	11.04	16.85	9.95	19.93	19.08	1.64	1.53	2.11	1.24	2.49	2.39
2031	13.17	11.08	16.98	10.00	19.92	19.28	1.65	1.54	2.12	1.25	2.49	2.41
2032	13.24	11.12	17.10	10.05	19.92	19.48	1.65	1.54	2.14	1.26	2.49	2.43
2033	13.30	11.15	17.23	10.10	19.91	19.68	1.66	1.55	2.15	1.26	2.49	2.46
2034	13.36	11.19	17.35	10.16	19.91	19.88	1.67	1.55	2.17	1.27	2.49	2.49
2035	13.42	11.23	17.48	10.21	19.90	20.09	1.68	1.56	2.19	1.28	2.49	2.51
2036	13.48	11.27	17.61	10.26	19.90	20.30	1.69	1.56	2.20	1.28	2.49	2.54
2037	13.55	11.31	17.74	10.32	19.89	20.51	1.69	1.57	2.22	1.29	2.49	2.56
2038	13.61	11.35	17.87	10.37	19.88	20.72	1.70	1.57	2.23	1.30	2.49	2.59
2039	13.67	11.39	18.00	10.42	19.88	20.93	1.71	1.58	2.25	1.30	2.48	2.62
2040	13.74	11.43	18.14	10.48	19.87	21.15	1.72	1.59	2.27	1.31	2.48	2.64
2041	13.80	11.47	18.27	10.53	19.87	21.37	1.72	1.59	2.28	1.32	2.48	2.67

Market Data

Class 7 & 8 Vehicle Distribution by Annual VMT and Type 1
Vehicle Age 2 or Less
Ref: 1997 VIUS Runs - Stacy Davis ORNL - 5/19/00

	Vehicles				Percent			
VMT (1000)	Central	Central Veh-Miles	Non-Centra	Non-Central Veh-Miles	Central	Central Veh-Miles	Non-Central	Non-Central Veh-Miles
0	0	0	0	0	0.00%	0.00%	0.00%	0.00%
5	2095	10475	1126	5630	2.14%	0.27%	1.15%	0.14%
10	5085	50850	3421	34210	5.21%	1.30%	3.50%	0.87%
15	6669	100035	3807	57105	6.83%	2.56%	3.90%	1.46%
20	8260	165200	3799	75980	8.46%	4.22%	3.89%	1.94%
25	5560	139000	3003	75075	5.69%	3.55%	3.07%	1.92%
30	6042	181260	3743	112290	6.19%	4.63%	3.83%	2.87%
35	2646	92610	2094	73290	2.71%	2.37%	2.14%	1.87%
40	2728	109120	2095	83800	2.79%	2.79%	2.14%	2.14%
45	2230	100350	1957	88065	2.28%	2.57%	2.00%	2.25%
50	3432	171600	1853	92650	3.51%	4.39%	1.90%	2.37%
55	1922	105710	1092	60060	1.97%	2.70%	1.12%	1.54%
60	2167	130020	1445	86700	2.22%	3.32%	1.48%	2.22%
65	950	61750	1281	83265	0.97%	1.58%	1.31%	2.13%
70	1280	89600	862	60340	1.31%	2.29%	0.88%	1.54%
75	1166	87450	745	55875	1.19%	2.24%	0.76%	1.43%
80	1156	92480	1160	92800	1.18%	2.36%	1.19%	2.37%
85	606	51510	768	65280	0.62%	1.32%	0.79%	1.67%
90	1084	97560	1148	103320	1.11%	2.49%	1.18%	2.64%
95	474	45030	474	45030	0.49%	1.15%	0.49%	1.15%
100	1643	164300	1582	158200	1.68%	4.20%	1.62%	4.04%
105	320	33600		0	0.33%	0.86%	0.00%	0.00%
110	456	50160	668	73480	0.47%	1.28%	0.68%	1.88%
115		0	342	39330	0.00%	0.00%	0.35%	1.01%
120	155	18600	329	39480	0.16%	0.48%	0.34%	1.01%
125	233	29125		0	0.24%	0.74%	0.00%	0.00%
130				0	0.00%	0.00%	0.00%	0.00%
135				0	0.00%	0.00%	0.00%	0.00%
140			517	72380	0.00%	0.00%	0.53%	1.85%
145					0.00%	0.00%	0.00%	0.00%
150					0.00%	0.00%	0.00%	0.00%
155					0.00%	0.00%	0.00%	0.00%
160					0.00%	0.00%	0.00%	0.00%
165					0.00%	0.00%	0.00%	0.00%
170					0.00%	0.00%	0.00%	0.00%
175					0.00%	0.00%	0.00%	0.00%
180					0.00%	0.00%	0.00%	0.00%
185					0.00%	0.00%	0.00%	0.00%
190					0.00%	0.00%	0.00%	0.00%
195					0.00%	0.00%	0.00%	0.00%
200					0.00%	0.00%	0.00%	0.00%
212.5					0.00%	0.00%	0.00%	0.00%
Total	58359	2177395	39311	1733635	59.8%	55.7%	40.2%	44.3%

1

Class 7 & 8 Vehicle Distribution by Annual VMT and Type 2
Vehicle Age 2 or Less
Ref: 1997 VIUS Runs - Stacy Davis ORNL - 5/19/00

	Vehicles				Percent			
VMT (1000)	Central	Central Veh-Miles	Non-Centra	Non-Central	Central	Central Veh-Miles	Non-Centra	Non-Central
0	0	0	0	0	0.00%	0.00%	0.00%	0.00%
5	970	4850	1488	7440	0.78%	0.05%	1.20%	0.08%
10	2156	21560	2814	28140	1.74%	0.23%	2.27%	0.30%
15	2410	36150	4169	62535	1.95%	0.39%	3.37%	0.68%
20	1572	31440	2699	53980	1.27%	0.34%	2.18%	0.58%
25	3204	80100	2357	58925	2.59%	0.87%	1.90%	0.64%
30	2054	61620	2286	68580	1.66%	0.67%	1.85%	0.74%
35	2077	72695	1453	50855	1.68%	0.79%	1.17%	0.55%
40	2057	82280	2285	91400	1.66%	0.89%	1.85%	0.99%
45	2370	106650	1211	54495	1.91%	1.15%	0.98%	0.59%
50	1892	94600	2537	126850	1.53%	1.02%	2.05%	1.37%
55	1812	99660	966	53130	1.46%	1.08%	0.78%	0.57%
60	3026	181560	1940	116400	2.44%	1.96%	1.57%	1.26%
65	2423	157495	1833	119145	1.96%	1.70%	1.48%	1.29%
70	1441	100870	1812	126840	1.16%	1.09%	1.46%	1.37%
75	1648	123600	1261	94575	1.33%	1.34%	1.02%	1.02%
80	1732	138560	3003	240240	1.40%	1.50%	2.43%	2.60%
85	1306	111010	1311	111435	1.06%	1.20%	1.06%	1.20%
90	1734	156060	2642	237780	1.40%	1.69%	2.13%	2.57%
95	1450	137750	2314	219830	1.17%	1.49%	1.87%	2.38%
100	3201	320100	7882	788200	2.59%	3.46%	6.37%	8.52%
105	924	97020	2386	250530	0.75%	1.05%	1.93%	2.71%
110	1126	123860	3835	421850	0.91%	1.34%	3.10%	4.56%
115	1387	159505	1902	218730	1.12%	1.72%	1.54%	2.36%
120	1935	232200	5453	654360	1.56%	2.51%	4.41%	7.07%
125	941	117625	2464	308000	0.76%	1.27%	1.99%	3.33%
130	657	85410	2841	369330	0.53%	0.92%	2.30%	3.99%
135	219	29565	1269	171315	0.18%	0.32%	1.03%	1.85%
140	701	98140	1342	187880	0.57%	1.06%	1.08%	2.03%
145	185	26825	551	79895	0.15%	0.29%	0.45%	0.86%
150	585	87750	1353	202950	0.47%	0.95%	1.09%	2.19%
155	575	89125	349	54095	0.46%	0.96%	0.28%	0.58%
160	550	88000	506	80960	0.44%	0.95%	0.41%	0.87%
165		0		0	0.00%	0.00%	0.00%	0.00%
170		0		0	0.00%	0.00%	0.00%	0.00%
175		0		0	0.00%	0.00%	0.00%	0.00%
180		0	316	56880	0.00%	0.00%	0.26%	0.61%
185		0		0	0.00%	0.00%	0.00%	0.00%
190		0		0	0.00%	0.00%	0.00%	0.00%
195		0		0	0.00%	0.00%	0.00%	0.00%
200		0		0	0.00%	0.00%	0.00%	0.00%
212.5	461	97962.5	162	34425	0.37%	1.06%	0.13%	0.37%
Total	50781	3451598	72992	5801975	41.0%	37.3%	59.0%	62.7%

Market Data
Continued

Class 7 & 8 Vehicle Distribution by Annual VMT and Type 3
Vehicle Age 2 or Less
Ref: 1997 VIUS Runs - Stacy Davis ORNL - 5/19/00

	Vehicles				Percent			
VMT (1000)	Central	Central Veh-Miles	Non-Central	Non-Central	Central	Central Veh-Miles	Non-Centra	Non-Central
0	0	0	0	0	0.00%	0.00%	0.00%	0.00%
5	992	4960	2415	12075	0.30%	0.02%	0.74%	0.04%
10	1668	16680	2540	25400	0.51%	0.05%	0.78%	0.08%
15	2253	33795	4249	63735	0.69%	0.11%	1.30%	0.21%
20	5372	107440	3213	64260	1.65%	0.35%	0.98%	0.21%
25	3705	92625	4804	120100	1.13%	0.30%	1.47%	0.39%
30	4236	127080	4181	125430	1.30%	0.41%	1.28%	0.40%
35	4565	159775	2671	93485	1.40%	0.52%	0.82%	0.30%
40	5572	222880	3484	139360	1.71%	0.72%	1.07%	0.45%
45	3993	179685	3862	173790	1.22%	0.58%	1.18%	0.56%
50	4782	239100	9041	452050	1.46%	0.77%	2.77%	1.46%
55	3047	167585	3080	169400	0.93%	0.54%	0.94%	0.55%
60	4099	245940	4511	270660	1.26%	0.79%	1.38%	0.87%
65	3120	202800	2385	155025	0.96%	0.65%	0.73%	0.50%
70	8200	574000	3590	251300	2.51%	1.85%	1.10%	0.81%
75	2998	224850	2473	185475	0.92%	0.73%	0.76%	0.60%
80	5837	466960	5536	442880	1.79%	1.51%	1.70%	1.43%
85	3746	318410	6443	547655	1.15%	1.03%	1.97%	1.77%
90	4599	413910	7105	639450	1.41%	1.34%	2.18%	2.06%
95	4050	384750	4488	426360	1.24%	1.24%	1.37%	1.38%
100	9632	963200	12363	1236300	2.95%	3.11%	3.79%	3.99%
105	5394	566370	3439	361095	1.65%	1.83%	1.05%	1.17%
110	4371	480810	8494	934340	1.34%	1.55%	2.60%	3.01%
115	2009	231035	5211	599265	0.62%	0.75%	1.60%	1.93%
120	12702	1524240	17135	2056200	3.89%	4.92%	5.25%	6.63%
125	4001	500125	10150	1268750	1.23%	1.61%	3.11%	4.09%
130	4358	566540	13665	1776450	1.33%	1.83%	4.18%	5.73%
135	2412	325620	3467	468045	0.74%	1.05%	1.06%	1.51%
140	1899	265860	4071	569940	0.58%	0.86%	1.25%	1.84%
145	1205	174725	1632	236640	0.37%	0.56%	0.50%	0.76%
150	1094	164100	9778	1466700	0.34%	0.53%	2.99%	4.73%
155	906	140430	1378	213590	0.28%	0.45%	0.42%	0.69%
160	2027	324320	2619	419040	0.62%	1.05%	0.80%	1.35%
165	678	111870	1325	218625	0.21%	0.36%	0.41%	0.71%
170	831	141270	2235	379950	0.25%	0.46%	0.68%	1.23%
175	689	120575	1478	258650	0.21%	0.39%	0.45%	0.83%
180	949	170820	2309	415620	0.29%	0.55%	0.71%	1.34%
185	516	95460	601	111185	0.16%	0.31%	0.18%	0.36%
190		0	958	182020	0.00%	0.00%	0.29%	0.59%
195	1340	261300		0	0.41%	0.84%	0.00%	0.00%
200	1639	327800	1966	393200	0.50%	1.06%	0.60%	1.27%
212.5	1560	331500	5171	1098838	0.48%	1.07%	1.58%	3.55%
Total	137046	11971195	189516	19022333	42.0%	38.6%	58.0%	61.4%

Class 3-6 Vehicle Distribution by Annual VMT and Primary Refueling
Vehicle Age 2 or Less
Ref: 1997 VIUS Runs - Stacy Davis ORNL - 5/19/00

	Vehicles				Percent			
VMT (1000)	Central	Central veh-miles	Non-Centra	Non-Central	Central	Central Veh-Miles	Non-Centra	Non-Central Veh-Miles
0	11054	0	18352	0	2.96%	0.00%	4.92%	0.00%
5	16924	84620	40557	202785	4.53%	1.03%	10.87%	2.48%
10	19827	198270	36129	361290	5.31%	2.42%	9.68%	4.41%
15	20225	303375	30780	461700	5.42%	3.70%	8.25%	5.64%
20	19598	391960	19704	394080	5.25%	4.79%	5.28%	4.81%
25	17261	431525	29072	726800	4.62%	5.27%	7.79%	8.87%
30	9028	270840	8932	267960	2.42%	3.31%	2.39%	3.27%
35	7313	255955	11853	414855	1.96%	3.13%	3.18%	5.07%
40	5152	206080	8780	351200	1.38%	2.52%	2.35%	4.29%
45	3318	149310	7572	340740	0.89%	1.82%	2.03%	4.16%
50	1790	89500	2504	125200	0.48%	1.09%	0.67%	1.53%
55	2611	143605	2031	111705	0.70%	1.75%	0.54%	1.36%
60	2827	169620		0	0.76%	2.07%	0.00%	0.00%
65	2390	155350	1118	72670	0.64%	1.90%	0.30%	0.89%
70	904	63280		0	0.24%	0.77%	0.00%	0.00%
75	3241	243075	2078	155850	0.87%	2.97%	0.56%	1.90%
80		0		0	0.00%	0.00%	0.00%	0.00%
85	462	39270		0	0.12%	0.48%	0.00%	0.00%
90		0		0	0.00%	0.00%	0.00%	0.00%
95	849	80655	903	85785	0.23%	0.98%	0.24%	1.05%
100	3841	384100	2963	296300	1.03%	4.69%	0.79%	3.62%
125	980	122500	300	37500	0.26%	1.50%	0.08%	0.46%
Total	149595	3782890	223628	4406420	40.08%	46.19%	59.92%	53.81%
	373223	8189310			100.00%	100.00%		

TYPE 3: Insulated; Non-refrigerated; Insulated Refrigerated; Drop Frame, Open Top, Basic Enclosed Pipe; Service; Garbage; Dump; Cement Mixer; Yard Tractor and Other

Enhancement B Fuel Type Diesel Fuel (Enhancemant A Default Fuel Type = Diesel Fuel)
Discount Rate 8%
Annual VMT 218113 Not including first cost of enhancement
Fuel Efficiency Escalator 1.000
MPg Incr/yr: 1

Year	Baseline Fuel Efficiency MPG	Enhancement A Efficiency Improvement	Enhancement A Adjusted MPG	Enhancement B Efficiency Improvement	Enhancement B Adjusted MPG	Enhancement B Fuel Cost ($/gal-ge)	ANNUAL OPERATING COST OF ALL OPTIONS Baseline	Enhancement A	Enhancement B
1995	5.90	1.000	5.90	1.000	5.90	$0.00	$0	$0	$0
1996	5.93	1.000	5.93	1.000	5.93	$0.00	$0	$0	$0
1997	5.96	1.000	5.96	1.000	5.96	$0.00	$0	$0	$0
1998	5.96	1.000	5.96	1.000	5.96	$0.00	$0	$0	$0
1999	5.96	1.000	5.96	1.000	5.96	$0.00	$0	$0	$0
2000	5.96	1.000	5.96	1.000	5.96	$1.52	$55,791	$55,791	$55,791
2001	5.96	1.000	5.96	1.000	5.96	$1.41	$51,577	$51,577	$51,577
2002	5.96	1.000	5.96	1.000	5.96	$1.33	$48,498	$48,498	$48,498
2003	5.96	1.000	5.96	1.000	5.96	$1.51	$55,436	$55,436	$55,436
2004	5.96	1.100	6.56	1.000	5.96	$1.67	$61,024	$55,476	$61,024
2005	5.96	1.200	7.15	1.000	5.96	$1.60	$58,614	$48,845	$58,614
2006	5.96	1.210	7.21	1.000	5.96	$1.57	$57,297	$47,353	$57,297
2007	5.96	1.220	7.27	1.000	5.96	$1.53	$55,861	$45,787	$55,861
2008	5.96	1.230	7.33	1.000	5.96	$1.50	$55,068	$44,771	$55,068
2009	5.96	1.240	7.39	1.000	5.96	$1.48	$54,193	$43,704	$54,193
2010	5.96	1.250	7.45	1.000	5.96	$1.49	$54,622	$43,698	$54,622
2011	5.96	1.270	7.57	1.000	5.96	$1.50	$54,950	$43,268	$54,950
2012	5.96	1.290	7.69	1.000	5.96	$1.50	$54,862	$42,529	$54,862
2013	5.96	1.310	7.81	1.000	5.96	$1.50	$54,770	$41,809	$54,770
2014	5.96	1.330	7.93	1.000	5.96	$1.49	$54,501	$40,978	$54,501
2015	5.96	1.350	8.04	1.000	5.96	$1.49	$54,374	$40,277	$54,374
2016	5.96	1.398	8.33	1.000	5.96	$1.48	$54,308	$38,847	$54,308
2017	5.96	1.446	8.62	1.000	5.96	$1.49	$54,422	$37,636	$54,422
2018	5.96	1.494	8.90	1.000	5.96	$1.49	$54,395	$36,409	$54,395
2019	5.96	1.542	9.19	1.000	5.96	$1.49	$54,439	$35,304	$54,439
2020	5.96	1.590	9.48	1.000	5.96	$1.48	$54,108	$34,030	$54,108
2021	5.96	1.594	9.50	1.000	5.96	$1.48	$54,266	$34,044	$54,266
2022	5.96	1.598	9.52	1.000	5.96	$1.49	$54,386	$34,034	$54,386
2023	5.96	1.602	9.55	1.000	5.96	$1.48	$54,012	$33,715	$54,012
2024	5.96	1.606	9.57	1.000	5.96	$1.48	$54,224	$33,764	$54,224
2025	5.96	1.610	9.59	1.000	5.96	$1.50	$55,063	$34,201	$55,063
2026	5.96	1.614	9.62	1.000	5.96	$1.51	$55,256	$34,235	$55,256
2027	5.96	1.618	9.64	1.000	5.96	$1.51	$55,450	$34,270	$55,450
2028	5.96	1.622	9.67	1.000	5.96	$1.52	$55,644	$34,306	$55,644
2029	5.96	1.626	9.69	1.000	5.96	$1.53	$55,839	$34,341	$55,839
2030	5.96	1.630	9.71	1.000	5.96	$1.53	$56,035	$34,377	$56,035

Type 3

Type 3 Continued

ANNUAL DOLLAR SAVINGS OF ENHANCEMENTS		INCREMENTAL COST OF ENHANCEMENT A Payback Periods (years)				INCREMENTAL COST OF ENHANCEMENT B Payback Periods (years)				Cost Effectiveness Factor ENHANCEI Payback Periods (years)		
Enhancement A	Enhancement B	1	2	3	4	1	2	3	4	1	2	3
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$0	$0	$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$5,548	$0	$9,087	$17,692	$25,801	$33,512	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$9,769	$0	$9,250	$17,967	$26,256	$34,110	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$9,944	$0	$9,018	$17,289	$24,860	$31,958	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$10,073	$0	$9,237	$17,694	$25,623	$33,043	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$10,297	$0	$9,427	$18,265	$26,536	$34,218	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$10,489	$0	$9,835	$19,038	$27,585	$35,523	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$10,924	$0	$10,223	$19,718	$28,536	$36,698	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$11,682	$0	$10,850	$20,926	$30,253	$38,909	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$12,333	$0	$11,454	$22,056	$31,895	$41,037	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$12,961	$0	$11,997	$23,132	$33,476	$43,120	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00
$13,523	$0	$12,550	$24,210	$35,080	$45,186	$0.00	$0.00	$0.00	$0.00	0.00	0.00	-0.10
$14,097	$0	$13,097	$25,307	$36,659	$47,227	$0.00	$0.00	$0.00	$0.00	0.00	0.00	-0.22
$15,461	$0	$14,413	$27,813	$40,288	$51,823	$0.00	$0.00	$0.00	$0.00	0.00	0.00	-0.44
$16,786	$0	$15,607	$30,137	$43,570	$56,104	$0.00	$0.00	$0.00	$0.00	0.00	-0.16	-0.68
$17,986	$0	$16,745	$32,226	$46,670	$60,136	$0.00	$0.00	$0.00	$0.00	0.00	-0.34	-0.94
$19,135	$0	$17,692	$34,197	$49,585	$63,801	$0.00	$0.00	$0.00	$0.00	0.00	-0.55	-1.25
$20,078	$0	$18,731	$36,195	$52,328	$67,394	$0.00	$0.00	$0.00	$0.00	0.00	-0.81	-1.62
$20,222	$0	$18,853	$36,270	$52,535	$67,900	$0.00	$0.00	$0.00	$0.00	0.00	-0.91	-1.77
$20,352	$0	$18,802	$36,361	$52,948	$68,431	$0.00	$0.00	$0.00	$0.00	-0.04	-1.02	-1.94
$20,297	$0	$18,955	$36,860	$53,574	$69,177	$0.00	$0.00	$0.00	$0.00	-0.11	-1.17	-2.15
$20,461	$0	$19,328	$37,370	$54,212	$69,934	$0.00	$0.00	$0.00	$0.00	-0.21	-1.34	-2.39
$20,862	$0	$19,475	$37,654	$54,625	$70,467	$0.00	$0.00	$0.00	$0.00	-0.30	-1.51	-2.64
$21,021	$0	$19,623	$37,940	$55,039	$71,001	$0.00	$0.00	$0.00	$0.00	-0.40	-1.71	-2.93
$21,179	$0	$19,771	$38,226	$55,454	$71,537	$0.00	$0.00	$0.00	$0.00	-0.52	-1.94	-3.27
$21,338	$0	$19,919	$38,513	$55,871	$72,074	$0.00	$0.00	$0.00	$0.00	-0.66	-2.21	-3.66
$21,498	$0	$20,068	$38,801	$56,288	$72,613	$0.00	$0.00	$0.00	$0.00	-0.82	-2.53	-4.12
$21,658	$0	$20,217	$39,090	$56,707	$73,153	$0.00	$0.00	$0.00	$0.00	-1.02	-2.91	-4.67

Type 3 Continued

Cost Effectiveness FactorEnhancement B				Tech. Adoption Factor Enhancement A								
Payback Periods (years)				Payback Periods (years)								
1	2	3	4	1		2		3		4		1
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.0E+02	100.0	1.0E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	9.76E+01	97.6	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	8.50E+01	85.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	6.92E+01	69.2	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	8.99E+01	89.9	4.90E+01	49.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	7.51E+01	75.1	2.24E+01	22.4	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	4.49E+01	44.9	-3.42E+01	0.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	8.28E+01	82.8	3.44E+00	3.4	-1.18E+02	0.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	5.91E+01	59.1	-5.72E+01	0.0	-2.51E+02	0.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	2.59E+01	25.9	-1.50E+02	0.0	-4.69E+02	0.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	-2.47E+01	0.0	-3.03E+02	0.0	-8.69E+02	0.0	1.00E+02
0.00	0.00	0.00	0.00	1.00E+02	100.0	-4.82E+01	0.0	-3.84E+02	0.0	-1.11E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	9.54E+01	95.4	-7.73E+01	0.0	-4.97E+02	0.0	-1.45E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	8.78E+01	87.8	-1.22E+02	0.0	-6.60E+02	0.0	-1.95E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	7.69E+01	76.9	-1.80E+02	0.0	-8.89E+02	0.0	-2.71E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	6.52E+01	65.2	-2.53E+02	0.0	-1.20E+03	0.0	-3.84E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	5.06E+01	50.6	-3.53E+02	0.0	-1.68E+03	0.0	-5.66E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	3.17E+01	31.7	-4.96E+02	0.0	-2.42E+03	0.0	-8.83E+03	0.0	1.00E+02
0.00	0.00	0.00	0.00	6.54E+00	6.5	-7.11E+02	0.0	-3.67E+03	0.0	-1.47E+04	0.0	1.00E+02
0.00	0.00	0.00	0.00	-2.80E+01	1.0	-1.05E+03	0.0	-5.94E+03	0.0	-2.69E+04	0.0	1.00E+02
0.00	0.00	0.00	0.00	-7.78E+01	1.0	-1.63E+03	0.0	-1.05E+04	0.0	-5.51E+04	0.0	1.00E+02

Med

TYPE M: Classes 3 - 6

Enhancement B Fuel Typ	Diesel Fuel	(Enhancemant A Default Fuel Type = Diesel Fuel)
Discount Rate	8%	
Annual VMT	212500	Not including first cost of enhancement
Fuel Efficiency Escalator	1.000	

Year	Baseline Fuel Efficienc MPG	Enhancement A Efficiency Improvement	Enhancement A Adjusted MPG	Enhancement B Efficiency Improvement	Enhancement B Adjusted MPG	Enhancement B Fuel Cost ($/gal-ge)	ANNUAL OPERATING COST OF ALL OPTIONS Baseline	Enhancement A	Enhancement B
1995	8.82	1.000	8.82	1.000	8.82	$0.00	$0	$0	$0
1996	8.86	1.000	8.86	1.000	8.86	$0.00	$0	$0	$0
1997	8.90	1.000	8.90	1.000	8.90	$0.00	$0	$0	$0
1998	8.90	1.000	8.90	1.000	8.90	$0.00	$0	$0	$0
1999	8.90	1.000	8.90	1.000	8.90	$0.00	$0	$0	$0
2000	8.90	1.000	8.90	1.000	8.90	$1.52	$36,394	$36,394	$36,394
2001	8.90	1.000	8.90	1.000	8.90	$1.41	$33,646	$33,646	$33,646
2002	8.90	1.000	8.90	1.000	8.90	$1.31	$31,162	$31,162	$31,162
2003	8.90	1.000	8.90	1.000	8.90	$1.32	$31,456	$31,456	$31,456
2004	8.90	1.000	8.90	1.000	8.90	$1.33	$31,750	$31,750	$31,750
2005	8.90	1.000	8.90	1.000	8.90	$1.34	$32,044	$32,044	$32,044
2006	8.90	1.000	8.90	1.000	8.90	$1.35	$32,337	$32,337	$32,337
2007	8.90	1.000	8.90	1.000	8.90	$1.37	$32,631	$32,631	$32,631
2008	8.90	1.000	8.90	1.000	8.90	$1.38	$32,925	$32,925	$32,925
2009	8.90	1.000	8.90	1.000	8.90	$1.39	$33,219	$33,219	$33,219
2010	8.90	1.000	8.90	1.000	8.90	$1.40	$33,513	$33,513	$33,513
2011	8.90	1.000	8.90	1.000	8.90	$1.40	$33,540	$33,540	$33,540
2012	8.90	1.000	8.90	1.000	8.90	$1.41	$33,566	$33,566	$33,566
2013	8.90	1.000	8.90	1.000	8.90	$1.41	$33,593	$33,593	$33,593
2014	8.90	1.000	8.90	1.000	8.90	$1.41	$33,619	$33,619	$33,619
2015	8.90	1.000	8.90	1.000	8.90	$1.41	$33,646	$33,646	$33,646
2016	8.90	1.000	8.90	1.000	8.90	$1.40	$33,540	$33,540	$33,540
2017	8.90	1.000	8.90	1.000	8.90	$1.40	$33,434	$33,434	$33,434
2018	8.90	1.000	8.90	1.000	8.90	$1.40	$33,328	$33,328	$33,328
2019	8.90	1.000	8.90	1.000	8.90	$1.39	$33,222	$33,222	$33,222
2020	8.90	1.000	8.90	1.000	8.90	$1.39	$33,116	$33,116	$33,116
2021	8.90	1.000	8.90	1.000	8.90	$1.39	$33,136	$33,136	$33,136
2022	8.90	1.000	8.90	1.000	8.90	$1.39	$33,155	$33,155	$33,155
2023	8.90	1.000	8.90	1.000	8.90	$1.39	$33,175	$33,175	$33,175
2024	8.90	1.000	8.90	1.000	8.90	$1.39	$33,195	$33,195	$33,195
2025	8.90	1.000	8.90	1.000	8.90	$1.39	$33,215	$33,215	$33,215
2026	8.90	1.000	8.90	1.000	8.90	$1.39	$33,235	$33,235	$33,235
2027	8.90	1.000	8.90	1.000	8.90	$1.39	$33,255	$33,255	$33,255
2028	8.90	1.000	8.90	1.000	8.90	$1.39	$33,275	$33,275	$33,275
2029	8.90	1.000	8.90	1.000	8.90	$1.39	$33,295	$33,295	$33,295
2030	8.90	1.000	8.90	1.000	8.90	$1.40	$33,315	$33,315	$33,315

Med Continued

INCREMENTAL COST OF ENHANCEMENT A				INCREMENTAL COST OF ENHANCEMENT B				Cost Effectiveness Factor ENHANCEMENT A				
Payback Periods (years)				Payback Periods (years)				Payback Periods (years)				Enhan B
1	2	3	4	1	2	3	4	1	2	3	4	Cost
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	0
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	5400
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	5000
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	4600
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	4200
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	3800
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	3400
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	3060
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	2720
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	2380
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	2040
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700
$0	$0	$0	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	1700

Med Continued

Cost Effectiveness FactorEnhancement B				Tech. Adoption Factor Enhancement A								Tech. Adoption Factor Enhancement B							
Payback Periods (years)				Payback Periods (years)								Payback Periods (years)							
1	2	3	4	1		2		3		4		1		2		3		4	
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.0E+02	100.0	1.0E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0
0.00	0.00	0.00	0.00	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0

New MPG

Year	Class 3-6				Class 7&8 Type 1				Class 7&8 Type 2				Class 7&8 Type 3				Class 7&8[1]			
	Conventional	Enhancement A	Enhancement B	New Average	Conventional	Enhancement A	Enhancement B	New Average	Conventional	Enhancement A	Enhancement B	New Average	Conventional	Enhancement A	Enhancemant B	New Average	Conventional	Enhancement A	Enhancement B	New Average
2000	8.9	8.9	8.9	8.9	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.96	5.96	5.96	5.96	5.85	5.85	5.85	5.85
2001	8.9	8.9	8.9	8.9	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.96	5.96	5.96	5.96	5.85	5.85	5.85	5.85
2002	8.9	8.9	8.9	8.9	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.96	5.96	5.96	5.96	5.85	5.85	5.85	5.85
2003	8.9	8.9	8.9	8.9	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.96	5.96	5.96	5.96	5.85	5.85	5.85	5.85
2004	8.9	8.9	8.9	8.9	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.60	5.96	6.56	5.96	5.96	5.85	6.24	5.85	5.85
2005	8.9	8.9	8.9	8.9	5.60	6.16	6.16	5.60	5.60	6.16	5.60	5.60	5.96	7.15	5.96	5.96	5.85	6.82	5.90	5.85
2006	8.9	8.9	9.4	8.9	5.60	6.33	6.61	5.60	5.60	6.33	5.60	5.60	5.96	7.33	5.96	5.96	5.85	7.00	5.93	5.85
2007	8.9	8.9	10.0	8.9	5.60	6.50	7.06	5.60	5.60	6.50	5.60	5.60	5.96	7.51	5.96	5.96	5.85	7.18	5.96	5.85
2008	8.9	8.9	10.5	8.9	5.60	6.66	7.50	5.60	5.60	6.66	5.60	5.60	5.96	7.69	5.96	5.96	5.85	7.35	5.99	5.85
2009	8.9	8.9	11.0	8.9	5.60	6.83	7.95	5.60	5.60	6.83	5.60	5.60	5.96	7.87	5.96	5.96	5.85	7.53	6.01	5.85
2010	8.9	9.8	11.6	8.9	5.60	7.00	8.40	5.60	5.60	7.00	5.60	5.60	5.96	8.04	5.96	5.96	5.85	7.70	6.03	5.85
2011	8.9	10.0	11.9	8.9	5.60	7.22	8.69	5.60	5.60	7.22	5.60	5.60	5.96	8.22	5.96	5.96	5.85	7.90	6.05	5.85
2012	8.9	10.1	12.3	8.9	5.60	7.45	8.98	5.60	5.60	7.45	5.60	5.60	5.96	8.40	5.96	5.96	5.85	8.09	6.06	5.85
2013	8.9	10.3	12.6	8.9	5.60	7.67	9.27	5.60	5.60	7.67	5.60	5.60	5.96	8.58	5.96	5.96	5.85	8.29	6.07	5.85
2014	8.9	10.5	13.0	8.9	5.60	7.90	9.56	5.60	5.60	7.90	5.60	5.60	5.96	8.76	5.96	5.97	5.85	8.48	6.08	5.86
2015	8.9	10.7	13.4	8.9	5.60	8.12	9.86	5.61	5.60	8.12	5.60	5.61	5.96	8.94	5.96	5.98	5.85	8.68	6.09	5.86
2016	8.9	10.8	13.7	8.9	5.60	8.15	9.86	5.61	5.60	8.15	5.60	5.61	5.96	9.09	5.96	6.01	5.85	8.79	6.09	5.89
2017	8.9	10.9	14.1	9.0	5.60	8.15	9.86	5.61	5.60	8.15	5.60	5.62	5.96	9.25	5.96	6.03	5.85	8.89	6.09	5.90
2018	8.9	10.9	14.4	9.0	5.60	8.15	9.86	5.63	5.60	8.15	5.60	5.62	5.96	9.40	5.96	6.06	5.85	8.99	6.09	5.93
2019	8.9	11.0	14.8	9.4	5.60	8.15	9.86	5.65	5.60	8.15	5.60	5.63	5.96	9.56	5.96	6.16	5.85	9.09	6.09	5.99
2020	8.9	11.1	15.1	9.5	5.60	8.62	9.86	5.67	5.60	8.79	5.60	5.77	5.96	9.71	5.96	6.32	5.85	9.40	6.09	6.13
2021	8.9	11.2	15.1	9.6	5.60	8.62	9.86	5.71	5.60	8.79	5.60	5.79	5.96	9.71	5.96	6.38	5.85	9.40	6.09	6.18
2022	8.9	11.3	15.1	9.8	5.60	8.62	9.86	5.76	5.60	8.79	5.60	5.86	5.96	9.71	5.96	6.50	5.85	9.40	6.09	6.28
2023	8.9	11.4	15.1	9.9	5.60	8.62	9.86	5.79	5.60	8.79	5.60	5.88	5.96	9.71	5.96	6.61	5.85	9.40	6.09	6.36
2024	8.9	11.5	15.1	9.9	5.60	8.62	9.86	5.83	5.60	8.79	5.60	5.96	5.96	9.71	5.96	6.69	5.85	9.40	6.09	6.44
2025	8.9	11.6	15.1	9.9	5.60	8.62	9.86	5.95	5.60	8.79	5.60	6.13	5.96	9.71	5.96	6.90	5.85	9.40	6.09	6.63
2026	8.9	11.7	15.1	10.0	5.60	8.62	9.86	5.98	5.60	8.79	5.60	6.16	5.96	9.71	5.96	6.94	5.85	9.40	6.09	6.67
2027	8.9	11.9	15.1	10.2	5.60	8.62	9.86	6.12	5.60	8.79	5.60	6.52	5.96	9.71	5.96	7.52	5.85	9.40	6.09	7.15
2028	8.9	12.1	15.1	10.6	5.60	8.62	9.86	6.29	5.60	8.79	5.60	6.58	5.96	9.71	5.96	7.56	5.85	9.40	6.09	7.21
2029	8.9	12.3	15.1	10.6	5.60	8.62	9.86	6.42	5.60	8.79	5.60	7.01	5.96	9.71	5.96	7.97	5.85	9.40	6.09	7.59
2030	8.9	12.5	15.1	10.9	5.60	8.62	9.86	6.61	5.60	8.79	5.60	7.09	5.96	9.71	5.96	8.05	5.85	9.40	6.09	7.69
2031	8.9	12.6	15.1	10.9	5.60	8.53	9.86	6.65	5.60	8.79	5.60	7.15	5.96	9.71	5.96	8.13	5.85	9.39	6.09	7.75
2032	8.9	12.7	15.1	10.9	5.60	8.43	9.86	6.67	5.60	8.79	5.60	7.39	5.96	9.71	5.96	8.40	5.85	9.38	6.09	7.99
2033	8.9	12.9	15.1	10.9	5.60	8.34	9.86	6.85	5.60	8.79	5.60	7.40	5.96	9.71	5.96	8.41	5.85	9.37	6.09	8.02
2034	8.9	13.0	15.1	11.0	5.60	8.24	9.86	7.04	5.60	8.79	5.60	7.45	5.96	9.71	5.96	8.48	5.85	9.36	6.09	8.10
2035	8.9	13.2	15.1	11.1	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.49	5.96	9.71	5.96	8.53	5.85	9.35	6.09	8.14
2036	8.9	13.2	15.1	11.3	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.49	5.96	9.71	5.96	8.54	5.85	9.35	6.09	8.14
2037	8.9	13.2	15.1	11.3	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.49	5.96	9.71	5.96	8.54	5.85	9.35	6.09	8.15
2038	8.9	13.2	15.1	11.3	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.50	5.96	9.71	5.96	8.55	5.85	9.35	6.09	8.16
2039	8.9	13.2	15.1	11.4	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.50	5.96	9.71	5.96	8.56	5.85	9.35	6.09	8.17
2040	8.9	13.2	15.1	11.5	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.51	5.96	9.71	5.96	8.57	5.85	9.35	6.09	8.17
2041	8.9	13.2	15.1	12.5	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.52	5.96	9.71	5.96	8.58	5.85	9.35	6.09	8.18
2042	8.9	13.2	15.1	12.5	5.60	8.15	9.86	7.04	5.60	8.79	5.60	7.53	5.96	9.71	5.96	8.59	5.85	9.35	6.09	8.19
2043	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.54	5.96	9.71	5.96	8.60	5.85	9.35	6.09	8.20
2044	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.55	5.96	9.71	5.96	8.62	5.85	9.35	6.09	8.21
2045	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.56	5.96	9.71	5.96	8.64	5.85	9.35	6.09	8.23
2046	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.57	5.96	9.71	5.96	8.67	5.85	9.35	6.09	8.25
2047	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.59	5.96	9.71	5.96	8.70	5.85	9.35	6.09	8.27
2048	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.61	5.96	9.71	5.96	8.71	5.85	9.35	6.09	8.28
2049	8.9	13.2	15.1	12.6	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.63	5.96	9.71	5.96	8.72	5.85	9.35	6.09	8.30
2050	8.9	13.2	15.1	12.7	5.60	8.15	9.86	7.05	5.60	8.79	5.60	7.65	5.96	9.71	5.96	8.73	5.85	9.35	6.09	8.31

Year	Class 7 & 8 MPG Ratio	Class 3-6 MPG Ratio	Class 7 & 8 MPG difference	Class 3-6 MPG Difference
2000	1.00	1.00	0.00	0.00
2001	1.00	1.00	0.00	0.00
2002	1.00	1.00	0.00	0.00
2003	1.00	1.00	0.00	0.00
2004	1.00	1.00	0.00	0.00
2005	1.00	1.00	0.00	0.00
2006	1.00	1.00	0.00	0.00
2007	1.00	1.00	0.00	0.00
2008	1.00	1.00	0.00	0.00
2009	1.00	1.00	0.00	0.00
2010	1.00	1.00	0.00	0.00
2011	1.00	1.00	0.00	0.00
2012	1.00	1.00	0.00	0.00
2013	1.00	1.00	0.00	0.00
2014	1.00	1.00	0.01	0.00
2015	1.00	1.00	0.02	0.02
2016	1.01	1.00	0.04	0.04
2017	1.01	1.01	0.05	0.11
2018	1.01	1.02	0.08	0.15
2019	1.03	1.05	0.15	0.48
2020	1.05	1.07	0.29	0.60
2021	1.06	1.08	0.33	0.69
2022	1.07	1.10	0.44	0.90
2023	1.09	1.11	0.52	0.97
2024	1.10	1.11	0.60	0.98
2025	1.13	1.11	0.78	0.99
2026	1.14	1.12	0.82	1.08
2027	1.22	1.14	1.30	1.28
2028	1.23	1.19	1.36	1.67
2029	1.30	1.19	1.74	1.71
2030	1.31	1.23	1.84	2.02
2031	1.33	1.23	1.90	2.03
2032	1.37	1.23	2.14	2.02
2033	1.37	1.23	2.18	2.04
2034	1.39	1.24	2.25	2.12
2035	1.39	1.25	2.29	2.25
2036	1.39	1.27	2.30	2.38
2037	1.39	1.27	2.30	2.39
2038	1.40	1.27	2.31	2.42
2039	1.40	1.28	2.32	2.48
2040	1.40	1.30	2.32	2.64
2041	1.40	1.40	2.33	3.58
2042	1.40	1.41	2.34	3.63
2043	1.40	1.41	2.35	3.69
2044	1.40	1.41	2.36	3.68
2045	1.41	1.41	2.38	3.68
2046	1.41	1.41	2.40	3.68
2047	1.41	1.41	2.42	3.68
2048	1.42	1.41	2.44	3.69
2049	1.42	1.42	2.45	3.71
2050	1.42	1.42	2.46	3.76

Market Vehicle Penetration

Market Penetration of Enhanced Technologies, % of Vehicles Sold

	Diesel Fuel Class 7-8 Type 1		Diesel Fuel Class 7-8 Type 2		Diesel Fuel Class 7-8 Type 3		Diesel Fuel CLASS 7-8 Final		Diesel Fuel CLASS 3-6 Final	
Year	Type 1 Non-Hybrid	Type 1 Hybrid	Type 2 Non-Hybrid		Type 3 Non-Hybrid		Non-Hybrid	Hybrid	Type M Hybrid	Type M Non-Hybrid
2000	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	
2001	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2002	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2003	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2004	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2005	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2006	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2007	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2008	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2009	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2010	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2011	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2012	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2013	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
2014	0.0%	0.0%	0.1%	0.0%	0.3%	0.0%	0.2%	0.0%	0.0%	0.0%
2015	0.0%	0.1%	0.1%	0.0%	0.5%	0.0%	0.3%	0.0%	0.0%	0.2%
2016	0.0%	0.1%	0.2%	0.0%	1.3%	0.0%	0.8%	0.0%	0.0%	0.3%
2017	0.0%	0.2%	0.3%	0.0%	1.7%	0.0%	1.1%	0.0%	0.0%	0.7%
2018	0.0%	0.4%	0.6%	0.0%	2.6%	0.0%	1.7%	0.1%	0.0%	1.0%
2019	0.1%	0.7%	0.8%	0.0%	5.0%	0.0%	3.2%	0.1%	0.0%	3.1%
2020	0.3%	1.1%	4.0%	0.0%	8.6%	0.0%	6.1%	0.2%	0.0%	4.1%
2021	0.5%	1.5%	4.6%	0.0%	10.1%	0.0%	7.1%	0.3%	0.0%	4.7%
2022	0.6%	2.2%	6.5%	0.0%	13.3%	0.0%	9.5%	0.4%	0.1%	6.5%
2023	0.7%	2.5%	7.2%	0.0%	15.8%	0.0%	11.2%	0.5%	0.2%	7.3%
2024	1.1%	2.8%	9.5%	0.0%	18.3%	0.0%	13.3%	0.5%	0.5%	7.3%
2025	1.6%	4.6%	13.7%	0.0%	23.1%	0.0%	17.1%	0.8%	0.6%	7.3%
2026	2.0%	4.9%	14.6%	0.0%	24.3%	0.0%	18.1%	0.9%	0.7%	8.0%
2027	2.2%	6.8%	23.7%	0.0%	38.0%	0.0%	28.3%	1.2%	1.4%	10.7%
2028	3.5%	8.7%	25.0%	0.0%	38.9%	0.0%	29.4%	1.5%	1.6%	14.5%
2029	3.8%	10.7%	35.4%	0.0%	48.1%	0.0%	37.3%	1.9%	1.7%	15.0%
2030	5.5%	12.3%	37.8%	0.0%	50.3%	0.0%	39.5%	2.2%	2.1%	19.4%
2031	6.4%	12.4%	39.6%	0.0%	52.2%	0.0%	41.2%	2.2%	3.6%	19.2%
2032	6.6%	12.9%	45.6%	0.0%	58.6%	0.0%	46.4%	2.3%	4.1%	18.0%
2033	7.3%	16.4%	46.0%	0.0%	59.0%	0.0%	46.8%	2.9%	6.7%	17.7%
2034	8.9%	18.5%	46.9%	0.0%	60.1%	0.0%	48.0%	3.3%	11.3%	16.8%
2035	8.9%	18.8%	47.9%	0.0%	61.5%	0.0%	49.1%	3.3%	14.0%	14.7%
2036	8.9%	18.8%	48.0%	0.0%	61.7%	0.0%	49.2%	3.3%	14.2%	14.5%
2037	9.0%	18.8%	48.2%	0.0%	61.9%	0.0%	49.4%	3.3%	14.3%	14.6%
2038	9.0%	18.8%	48.3%	0.0%	62.2%	0.0%	49.6%	3.4%	14.4%	14.9%
2039	9.0%	18.8%	48.5%	0.0%	62.5%	0.0%	49.8%	3.4%	14.6%	15.5%
2040	9.0%	18.8%	48.7%	0.0%	62.7%	0.0%	50.0%	3.4%	13.3%	17.8%
2041	9.0%	18.8%	48.9%	0.0%	63.0%	0.0%	50.2%	3.4%	20.1%	30.8%
2042	9.0%	18.9%	49.2%	0.0%	63.2%	0.0%	50.4%	3.4%	23.0%	26.1%
2043	9.0%	18.9%	49.5%	0.0%	63.6%	0.0%	50.7%	3.4%	23.3%	24.3%
2044	9.1%	18.9%	50.0%	0.0%	64.0%	0.0%	51.1%	3.4%	23.5%	24.0%
2045	9.1%	18.9%	50.4%	0.0%	64.6%	0.0%	51.5%	3.4%	23.6%	23.9%
2046	9.1%	18.9%	50.7%	0.0%	65.4%	0.0%	52.1%	3.4%	23.7%	23.9%
2047	9.1%	18.9%	51.2%	0.0%	66.3%	0.0%	52.7%	3.4%	23.8%	24.0%
2048	9.1%	18.9%	51.8%	0.0%	66.6%	0.0%	53.0%	3.4%	23.9%	24.2%
2049	9.1%	18.9%	52.4%	0.0%	66.9%	0.0%	53.3%	3.4%	24.2%	24.8%
2050	9.1%	19.0%	53.1%	0.0%	67.2%	0.0%	53.7%	3.4%	0.0%	26.2%

Market Vehicle-Miles Penetration

Market Penetration of Enhancements A and B (In Fraction of Vehicle-Miles)

	Diesel Fuel Class 7-8 Type 1				Diesel Fuel Class 7-8 Type 2		Diesel Fuel Class 7-8 Type 3		Diesel Fuel CLASS 7-8 Final		Diesel Fuel CLASS 3-6 Final	
Year	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B
2000	0.0%	0.0%			0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2001	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2002	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2003	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2004	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2005	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2006	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2007	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2008	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2009	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2010	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2011	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
2012	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%	0.0%
2013	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.2%	0.0%	0.1%	0.0%	0.0%	0.0%
2014	0.0%	0.1%	0.0%	0.1%	0.2%	0.0%	0.6%	0.0%	0.5%	0.0%	0.0%	0.1%
2015	0.0%	0.2%	0.0%	0.2%	0.3%	0.0%	1.0%	0.0%	0.8%	0.0%	0.0%	0.8%
2016	0.0%	0.3%	0.0%	0.3%	0.6%	0.0%	2.5%	0.0%	1.9%	0.0%	0.0%	1.2%
2017	0.0%	0.5%	0.0%	0.5%	0.9%	0.0%	3.2%	0.0%	2.5%	0.0%	0.0%	3.2%
2018	0.1%	1.0%	0.1%	1.0%	1.4%	0.0%	4.7%	0.0%	3.6%	0.1%	0.0%	4.3%
2019	0.2%	1.7%	0.2%	1.7%	1.8%	0.0%	8.6%	0.0%	6.5%	0.2%	0.0%	12.9%
2020	0.7%	2.4%	0.7%	2.4%	7.9%	0.0%	14.7%	0.0%	12.0%	0.2%	0.0%	15.4%
2021	1.4%	3.4%	1.4%	3.4%	8.9%	0.0%	16.9%	0.0%	13.9%	0.3%	0.0%	17.4%
2022	1.5%	5.1%	1.5%	5.1%	12.1%	0.0%	21.5%	0.0%	17.7%	0.5%	0.1%	22.3%
2023	1.9%	6.2%	1.9%	6.2%	13.1%	0.0%	25.4%	0.0%	20.7%	0.6%	0.5%	23.6%
2024	2.9%	6.9%	2.9%	6.9%	16.7%	0.0%	28.4%	0.0%	23.7%	0.6%	1.0%	23.5%
2025	4.2%	10.2%	2.9%	10.2%	23.9%	0.0%	35.2%	0.0%	30.0%	0.9%	2.2%	23.1%
2026	5.2%	10.5%	2.9%	10.2%	25.2%	0.0%	36.7%	0.0%	31.3%	0.9%	2.3%	24.9%
2027	5.4%	15.2%	2.9%	10.2%	39.0%	0.0%	53.7%	0.0%	46.1%	0.9%	2.8%	28.7%
2028	8.1%	19.0%	2.9%	10.2%	40.9%	0.0%	54.9%	0.0%	47.4%	0.9%	5.8%	34.6%
2029	8.8%	22.4%	2.9%	10.2%	55.5%	0.0%	65.2%	0.0%	57.7%	0.9%	6.6%	34.8%
2030	12.8%	24.9%	2.9%	10.2%	57.8%	0.0%	67.3%	0.0%	59.6%	0.9%	6.9%	40.2%
2031	14.4%	25.1%	2.9%	10.2%	59.8%	0.0%	69.0%	0.0%	61.2%	0.9%	7.7%	39.6%
2032	14.7%	25.8%	2.9%	10.2%	66.6%	0.0%	75.1%	0.0%	66.9%	0.9%	11.9%	36.2%
2033	15.7%	30.4%	2.9%	10.2%	67.1%	0.0%	75.5%	0.0%	67.3%	0.9%	12.9%	35.6%
2034	19.1%	33.3%	2.9%	10.2%	68.4%	0.0%	77.0%	0.0%	68.6%	0.9%	17.1%	33.6%
2035	19.1%	33.5%	2.9%	10.2%	69.4%	0.0%	78.0%	0.0%	69.5%	0.9%	24.7%	29.5%
2036	19.1%	33.5%	2.9%	10.2%	69.5%	0.0%	78.1%	0.0%	69.7%	0.9%	27.9%	29.3%
2037	19.1%	33.5%	2.9%	10.2%	69.6%	0.0%	78.3%	0.0%	69.8%	0.9%	28.4%	29.1%
2038	19.1%	33.5%	2.9%	10.2%	69.7%	0.0%	78.5%	0.0%	69.9%	0.9%	28.5%	29.5%
2039	19.1%	33.6%	2.9%	10.2%	69.9%	0.0%	78.7%	0.0%	70.1%	0.9%	28.7%	30.2%
2040	19.1%	33.6%	2.9%	10.2%	70.0%	0.0%	78.8%	0.0%	70.3%	0.9%	28.9%	32.8%
2041	19.1%	33.6%	2.9%	10.2%	70.2%	0.0%	79.0%	0.0%	70.4%	0.9%	27.5%	48.1%
2042	19.1%	33.6%	2.9%	10.2%	70.5%	0.0%	79.2%	0.0%	70.6%	0.9%	35.3%	42.6%
2043	19.2%	33.6%	2.9%	10.2%	70.8%	0.0%	79.5%	0.0%	70.9%	0.9%	38.3%	41.0%
2044	19.2%	33.6%	2.9%	10.2%	71.1%	0.0%	79.8%	0.0%	71.2%	0.9%	39.1%	40.3%
2045	19.2%	33.7%	2.9%	10.2%	71.4%	0.0%	80.2%	0.0%	71.5%	0.9%	39.4%	40.0%
2046	19.2%	33.7%	2.9%	10.2%	71.7%	0.0%	80.8%	0.0%	72.0%	0.9%	39.4%	40.0%
2047	19.2%	33.7%	2.9%	10.2%	72.2%	0.0%	81.4%	0.0%	72.5%	0.9%	39.5%	40.0%
2048	19.3%	33.7%	2.9%	10.2%	72.7%	0.0%	81.7%	0.0%	72.8%	0.9%	39.6%	40.0%
2049	19.3%	33.7%	2.9%	10.2%	73.2%	0.0%	81.9%	0.0%	73.1%	0.9%	39.6%	40.2%
2050	19.3%	33.8%	2.9%	10.2%	73.9%	0.0%	82.2%	0.0%	73.4%	0.9%	39.8%	40.8%

Detailed Inputs Market Vehicle-Miles Penetration

Run Macro

1. Select Enhancement B Fuel Type

Diesel Fuel

2. Enter Discount Rate

7.5%

3. Enter Baseline Fuel Efficiency Escalation Factor

1.000

4. Run Macro

TYPE 1: Multi-stop or Step Van; Beverage; Utility; Winch or Crane; Wrecker; Pole, Logging, Pipe; Service; Garbage; Dump; Cement Mixer; Yard Tractor and Other

Macro last run on: 11/16/2004 15:59 Macro last run on: 11/16/2004 15:59

TYPE 2: Platform with devices; Low-boy platform; Basic platform; Livestock; Automobile Transport; Oilfield; Grain; Tank truck for liquids or gases; Tank truck for dry bulk

Macro last run on: 11/16/2004 15:58 Macro last run on: 11/16/2004 15:58

TYPE 3: Insulated; Non-refrigerated; Insulated Refrigerated; Drop Frame, Open Top, Basic Enclosed Pipe; Service; Garbage; Dump; Cement Mixer; Yard Tractor and Other

Macro last run on: 3/24/2005 10:06 Macro last run on: 3/24/2005 10:06

TYPE MEDIUM (Classes 3-6):

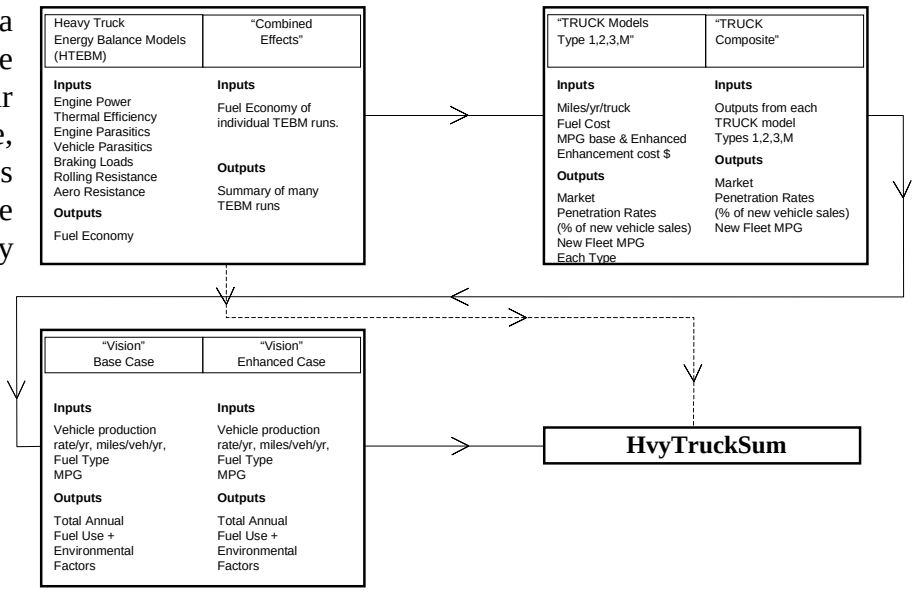
Macro last run on: 12/28/2004 12:43 Macro last run on: 12/28/2004 12:43

Appendix B

B.1 Heavy Truck Energy Use Models: Workbooks, Inputs and Outputs

Specific workbooks used in the modeling system are listed below. Exhibit B-1 provides a detailed view of the relationships among the four principal models. In practice, calendar dates indicating times of use are added to the file names for specific Energy Benefits analysis exercises, but these are omitted in this discussion.

Exhibit B-1: Heavy Truck Energy Modeling System Details



1. Heavy Truck Energy Balance Model (HTEBM)-Version 2.0
   - Energy Balance Workbook-Baseline Model
   - Energy Balance Workbook-Technology Model(s) (copied from the Baseline Model) (mention surrogates for cycles.)
   - Combined –Effects (used to allocate fuel savings among several technologies).
2. TRUCK (Market Penetration) Models
   - TRUCK-2 Type 1 (projects market penetration of Class 7&8, Type 1 heavy trucks to 2050).
   - TRUCK-2 Type 2 (projects market penetration of Class 7&8, Type 2 heavy trucks to 2050).
   - TRUCK-2 Type 3 (projects market penetration of Class 7&8, Type 3 heavy trucks to 2050).
   - TRUCK-2 Type M (projects market penetration of Classes 3-6 Type heavy trucks to 2050).
   - TRUCK-2 Composite (combines all Type 1, 2, 3, M results to obtain summary market penetrations and fleet average fuel economies).
3. VISION MODELS
   - VISION 2005 AEO ICE MPG Base Case (projects energy use of baseline truck fleet to 2050).
   - VISION GPRA0 7Veh.Mi-1 (projects energy use of improved truck fleet to 2050).

4. HvyTrkSum-GPRA-V1 mkt pen veh mi (calculates energy and carbon savings-total heavy truck fleet, classes 3-8, to 2050).

All workbooks should be copied into the same hard drive subdirectory and all should be loaded so that all of the links are active during the data entry and calculation process.

B.1.1 HTEBM (Heavy Truck Energy Balance Model) Version 2.0

The Heavy Truck Energy Balance Model is based on a simplified calculation of average road loads experienced by typical heavy trucks. The model is a method to match baseline vehicles with actual road-load fuel economy results and then to estimate the variations in fuel economy that will occur when various engine and vehicle operational characteristics are changed. Therefore, it is important that actual, simulation-based, or program goals for road-load vehicle fuel economy values be available.

Fuel savings are caused by a combination of technologies-load reducing technologies and engine efficiency-increasing technologies. Each technology under consideration and each analysis year requires a separate run of HTEBM. Since each run includes both input assumptions and results, they need to be maintained for adequate support and documentation.

Engine/Vehicle improvements that lead to reduced fuel use can be categorized under the following headings.

- Increased engine cycle efficiency
    - Increase compression ratio
    - Reduced engine thermal losses
- Reduced engine internal friction loads
    - Air-Breathing Losses
    - Pistons & Piston Rings
    - Rod and crankshaft bearings
    - Valve train/camshaft
- Reduced engine accessory loads
    - Fuel Injector
    - Power Steering
    - Oil Pump
    - Coolant Pump
    - Engine fan
- Reduced drive-train parasitic loads
    - Transmission
    - Driveshaft
    - Axle/Transaxle
    - Differential

- Axle & Wheel bearings
- Brake Drag

- Reduced vehicle auxiliary system loads
  - Alternator
  - Air Conditioner
  - Air Brake Compressor
- Reduced road-loads
  - Aerodynamic loads
  - Rolling resistance loads
  - Braking loads.

For the Government Performance and Review Analysis (GPRA), vehicle characteristics to support fuel economy goals at 10-year increments are developed (2010, 2020, 2030, 2040, and 2050).

- **"Combined Effects" Workbook**

The results of the multiple runs of HTEBM are collected in this summary workbook. This is shown as Exhibit B-2. Whereas HTEBM permits only one set of conditions per-run, "Combined Effects" can store any number of HTEBM results.

The Combined Effects Submodel is used to allocate the fuel savings among the several technologies included in the Truck Technology option. This is done by assuming that the percentage of fuel savings attributable to each separate technology will be proportional to the relative fuel economy improvement of each separate technology, taken separately.

Currently, "Combined Effects" includes four individual heavy vehicle technologies (accessory loads reduction, engine efficiency increase, vehicle weight reduction, and aerodynamic drag reduction). These can be varied to other technologies or Technology Program definitions by the user, if desired.

B.1.2 TRUCK 2.0 Market Penetration Models

The fuel-saving technologies under analysis are characterized in TRUCK models for types 1,2, and 3 in terms of the projected fuel economy improvement ratio (new fuel economy divided by the baseline fuel economy), the installed cost of the improvement ($ per vehicle), and the cost of the fuel type being used. Market penetration occurs for technologies that meet payback values of 4 years or less. TRUCK 2.0 can be set to assume the following heavy truck fuels: diesel fuel, gasoline, liquefied propane gas (LPG), ethanol, compressed natural gas (CNG), or electricity (battery storage).

The output from the TRUCK 2.0 Models for each truck Type is a projection of market penetration rates (percent of new vehicle sales) by class and type over the future time from current through year 2050 (or shorter if modeled for a shorter time period). The absolute number of trucks projected to be equipped with the new technology is calculated in the VISION model (see below).

Exhibit B-2: Combined Effects Workbook

2010

	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %
	Type 1			Type 2			Type 3			Medium		
Baseline	5.61	0.0%		5.6	0.0%		5.90	0.0%		8.9	0.0%	0.0%
Auxiliary Loads Electrification	5.99	6.7%	34.9%	5.98	6.8%	34.5%	6.44	9.2%	39.9%	9.6	7.7%	41.3%
Engine Efficiency, WHR	6.13	9.3%	48.3%	6.14	9.6%	48.3%	6.49	10.0%	43.2%	9.7	8.5%	45.8%
Vehicle Weight Reduction	5.77	2.8%	14.4%	5.73	2.4%	12.0%	6.00	1.7%	7.2%	9.1	1.9%	10.1%
Aerodynamic Load Reduction	5.64	0.5%	2.5%	5.66	1.0%	5.2%	6.03	2.2%	9.6%	8.9	0.5%	2.7%
Sum of Individual Benefits	--	19.3%	100.0%	--	19.8%	100.0%	--	23.1%	100.0%	--	18.6%	100.0%
Combined Effects	6.76	120.5%		6.78	121.1%		7.37	124.9%		10.65	119.6%	45.87%
Hybrid	7.854	0.4								12.5664	141.2%	54.13%
										Medium	260.8%	100.0%
Corrected MPGS & Ratios	6.757619	1.2045667		6.7807993	1.210857		7.3688688	1.2489608		10.648006	1.1964052	

2020

	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %
	Type 1			Type 2			Type 3			Medium		
Baseline	5.61	0.0%		5.6	0.0%		5.90	0.0%	0.0%	8.9	0.0%	0.0%
Auxiliary Loads Electrification	5.99	6.7%	14.6%	5.98	6.8%	14.3%	6.44	9.2%	17.8%	9.6	7.7%	18.2%
Engine Efficiency, WHR	7.55	34.5%	74.7%	7.59	35.6%	74.3%	8.04	36.3%	69.8%	11.6	30.7%	73.1%
Vehicle Weight Reduction	5.83	3.9%	8.5%	5.79	3.4%	7.0%	6.03	2.2%	4.3%	9.1	2.6%	6.3%
Aerodynamic Load Reduction	5.67	1.0%	2.2%	5.72	2.1%	4.4%	6.15	4.2%	8.1%	9.0	1.0%	2.4%
Sum of Individual Benefits	--	46.2%	100.0%	--	47.9%	100.0%	--	52.0%	100.0%	--	42.1%	100.0%
Combined Effects	8.45	150.7%		8.56	152.9%		9.36	158.6%		12.99	146.0%	47.49%
Hybrid	8.976	0.6								14.3616	161.4%	52.51%
										Medium	307.3%	100.0%

2030

	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %
	Type 1			Type 2			Type 3			Medium		
Baseline	5.61	0.0%		5.6	0.0%		5.90	0.0%		8.9	0.0%	
Auxiliary Loads Electrification	5.99	6.7%	14.0%	5.98	6.8%	13.7%	6.44	9.2%	16.9%	9.6	7.7%	17.9%
Engine Efficiency, WHR	7.55	34.5%	72.0%	7.59	35.6%	71.1%	8.04	36.3%	66.5%	11.6	30.7%	71.7%
Vehicle Weight Reduction	5.90	5.1%	10.7%	5.85	4.4%	8.8%	6.06	2.8%	5.1%	9.2	3.4%	8.0%
Aerodynamic Load Reduction	5.70	1.6%	3.2%	5.78	3.2%	6.4%	6.27	6.3%	11.5%	9.0	1.0%	2.4%
Sum of Individual Benefits	--	47.9%	103.8%	--	50.0%	104.4%	--	54.6%	105.0%	--	42.9%	
Combined Effects	8.60	153.3%		8.74	156.0%		9.60	162.7%		13.16	147.8%	47.81%
Hybrid	8.976	0.6								14.3616	161.4%	52.19%
										Medium	309.2%	100.0%

2040

	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %
	Type 1			Type 2			Type 3			Medium		
Baseline	5.61	0.0%		5.6	0.0%		5.90	0.0%		8.9	0.0%	
Auxiliary Loads Electrification	5.99	6.7%	13.8%	5.98	6.8%	13.5%	6.44	9.2%	16.8%	9.6	7.7%	17.5%
Engine Efficiency, WHR	7.55	34.5%	71.1%	7.59	35.6%	70.4%	8.04	36.3%	66.1%	11.6	30.7%	70.3%
Vehicle Weight Reduction	5.93	5.8%	11.9%	5.87	4.9%	9.7%	6.08	3.1%	5.6%	9.2	3.8%	8.7%
Aerodynamic Load Reduction	5.70	1.6%	3.2%	5.78	3.2%	6.3%	6.27	6.3%	11.4%	9.0	1.5%	3.5%
Sum of Individual Benefits	--	48.5%	100.0%	--	50.5%	100.0%	--	54.9%	100.0%	--	43.8%	100.0%
Combined Effects	8.65	154.2%		8.78	156.8%		9.62	163.1%		13.21	148.4%	47.90%
Hybrid	8.976	0.6								14.3616	161.4%	52.10%
										Medium	309.7%	100.0%

2050

	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %	Fuel Economy, mpg	Single Technol. Benefit, %	Contribution Based on Single Technol. Benefit., %
	Type 1			Type 2			Type 3			Medium		
Baseline	5.61	0.0%		5.6	0.0%		5.90	0.0%		8.9	0.0%	
Auxiliary Loads Electrification	5.99	6.7%	13.8%	5.98	6.8%	13.5%	6.44	9.2%	16.8%	9.6	7.7%	17.5%
Engine Efficiency, WHR	7.55	34.5%	71.1%	7.59	35.6%	70.4%	8.04	36.3%	66.1%	11.6	30.7%	70.3%
Vehicle Weight Reduction	5.93	5.8%	11.9%	5.87	4.9%	9.7%	6.08	3.1%	5.6%	9.2	3.8%	8.7%
Aerodynamic Load Reduction	5.70	1.6%	3.2%	5.78	3.2%	6.3%	6.27	6.3%	11.4%	9.0	1.5%	3.5%
Sum of Individual Benefits	--	48.5%	100.0%	--	50.5%	100.0%	--	54.9%	100.0%	--	43.8%	100.0%
Combined Effects	8.65	154.2%		8.78	156.8%		9.62	163.1%		13.21	148.4%	47.90%
Hybrid	8.976	0.6								14.3616	161.4%	52.10%
										Medium	309.7%	100.0%

- **“TRUCK Composite” Submodel**

This model collects the market penetration data from the four TRUCK models. It was created as a separate workbook since the TRUCK models are all driven by macros and with distinct inputs. The market penetration and fuel economy results for each of the truck Types are linked to this workbook.

B.1.3 VISION Models

- **VISION Base Case Model**

The VISION models accept average new fleet MPG values for Class 3-6 and Class 7 & 8 vehicles and calculates the amount of fuel used each year as these vehicles mature, age and eventually wear out within the operating fleet. Calculations are made for the years 2000 to 2050.

- **VISION Enhanced Case Model**

This version of VISION calculates the fleet energy use assuming that the proposed technologies (fuel savings technologies) are introduced into the new vehicle fleet as calculated by the TRUCK models. Fuel economy and market penetration results from the TRUCK models are consolidated into a single value (for each year to 2050) for Class 7 and 8, and a single value for Classes 3 through 6, using VMT data to weight the fuel economies of each truck Type.

B.1.4 Heavy Truck Summary Submodel (HvyVehSum)

Key inputs and results of the Truck Model analysis are summarized in the HvyTrkSum workbook. The format used here is intended to meet the needs and requirements of the FutureCar and Vehicle Technologies program, as well as the Planning and Evaluation Office.

HvyTrkSum results form the basis of the GPRA and related reports generated annually presenting the benefits of the Heavy Truck program elements.

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