ANL-05/60

FreedomCAR and Vehicle Technologies Heavy Vehicle Program FY 2006 Benefits Analysis: Methodology and Results — Final Report

prepared by
TA Engineering, Inc.
Under contract 2F-00562

Argonne National Laboratory is managed by
The University of Chicago for the U. S. Department of Energy

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November 2005

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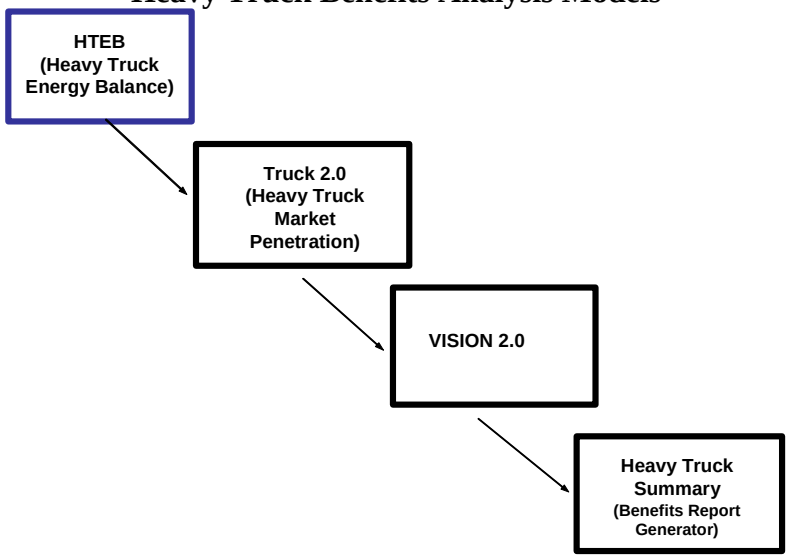
Executive Summary

An analysis of the petroleum and carbon reduction benefits associated with Heavy Vehicle technologies supported by the FreedomCAR and Vehicle Technologies (FCVT) Program has been completed for the FY 2006 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 newly- developed 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

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)	4.55	6.16	7.50	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 Miles,	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 conventional vehicles, and the incremental cost of the technology. Factors used for the FY 2006 analysis are summarized in Exhibit ES-3.

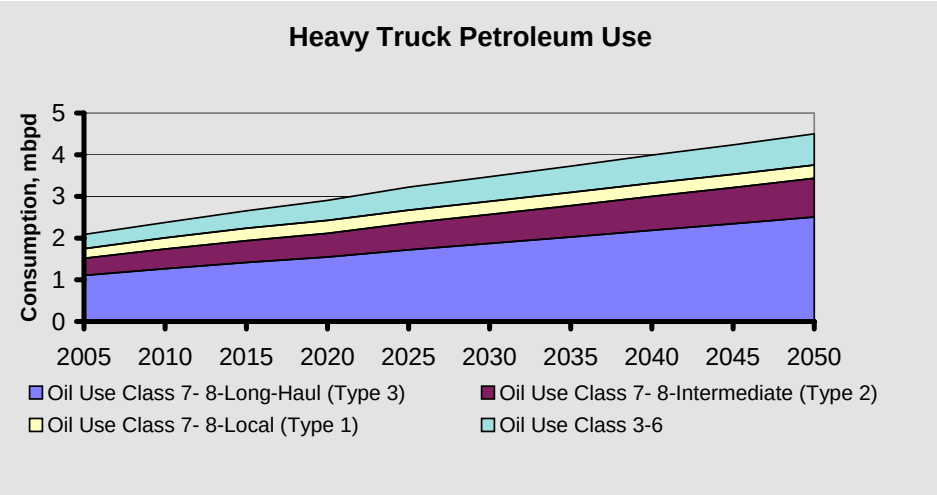
Exhibit ES-3: Fuel Economy Improvement and Cost Assumptions

	Characteristic	2010	2020	2030	2040	2050
1	Fuel Economy Class 7-8, Local, mpg Multiplier	1.26	1.46	1.46	1.46	1.46
2	Fuel Economy Class 7-8, Intermediate, mpg Multiplier	1.35	1.64	1.64	1.64	1.64
3	Fuel Economy Class 7-8, Long-Haul, mpg Multiplier	1.47	1.79	1.79	1.79	1.79
4	Fuel Economy Class 3-6-Hybrid, mpg Multiplier	1.70	1.70	1.70	1.70	1.70
5	Fuel Economy Class 3-6-Non-hybrid, mpg Multiplier	1.20	1.37	1.37	1.37	1.37
6	Class 7-8, Iincremental Cost, $	$ 35,000	$ 15,000	$ 7,500	$ 7,500	$ 7,500
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

Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Oil Use Class 7- 8-Local (Type 1)	0.235	0.269	0.297	0.305	0.312	0.317	0.319	0.320	0.319	0.317
Oil Use Class 7- 8-Intermediate (Type 2)	0.410	0.470	0.525	0.573	0.638	0.694	0.751	0.811	0.869	0.929
Oil Use Class 7- 8-Long-Haul (Type 3)	1.104	1.267	1.415	1.545	1.720	1.873	2.026	2.187	2.343	2.505
Oil Use Class 3-6	0.339	0.369	0.419	0.480	0.552	0.591	0.630	0.671	0.709	0.748
Total:	2.087	2.375	2.656	2.903	3.221	3.476	3.727	3.989	4.239	4.499

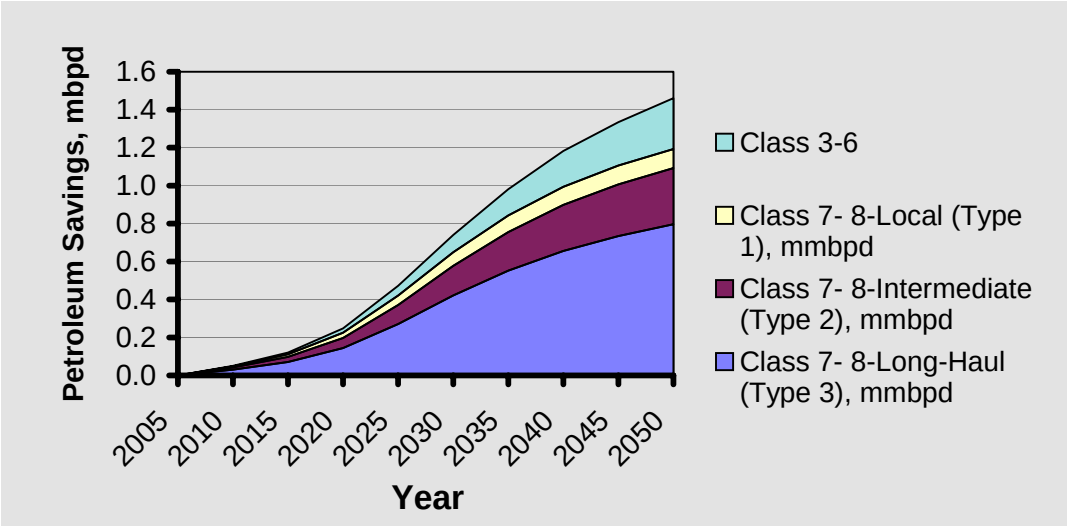


From the graph it is apparent that Heavy Vehicle energy currently is dominated by trucks in Long-Haul duty, and that this will continue throughout the analysis period. The information in Exhibit ES-4 indicates expected consumption absent the effects of the DOE program.

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	0.01	0.01	0.03	0.05	0.07	0.09	0.10	0.10	0.10
Class 7- 8-Intermediate (Type 2), mmbpd	0.00	0.01	0.03	0.05	0.10	0.16	0.20	0.24	0.27	0.30
Class 7- 8-Long-Haul (Type 3), mmbpd	0.00	0.03	0.07	0.14	0.27	0.42	0.55	0.66	0.73	0.80
Class 3-6	0.00	0.00	0.01	0.02	0.05	0.09	0.14	0.19	0.23	0.27
Totals:	0.00	0.05	0.12	0.25	0.47	0.74	0.98	1.18	1.33	1.46



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 in Intermediate Use (Class 7 and 8). It is interesting that the savings in that sector are only slightly greater than in the Class 3-6 (Medium Truck) market.

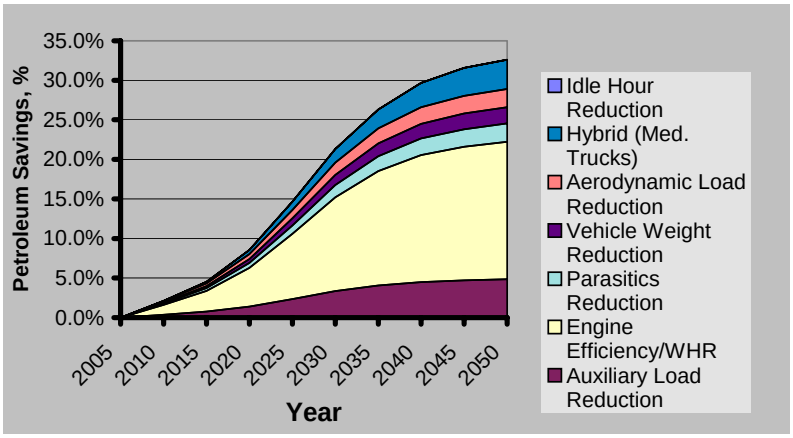
Local-use (Type 1) trucks have limited annual miles and lower speeds than the other Class 7 and 8 segments which explains the relatively low contribution to total savings from this segment.

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

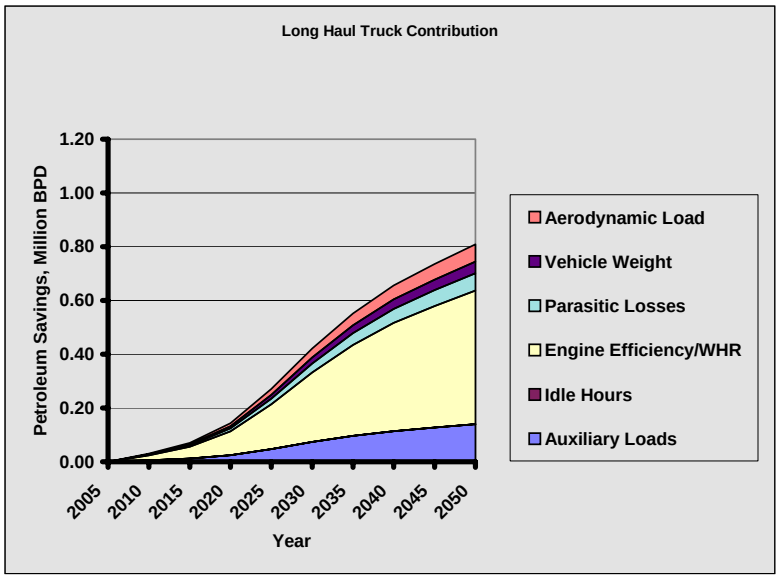
Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Load Reduction	0.0%	0.4%	0.7%	1.4%	2.3%	3.3%	4.1%	4.5%	4.7%	4.8%
Idle Hour Reduction	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Engine Efficiency/WHR	0.0%	1.3%	2.6%	4.9%	8.3%	11.9%	14.5%	16.1%	16.9%	17.4%
Parasitics Reduction	0%	0.2%	0.3%	0.6%	1.1%	1.5%	1.9%	2.1%	2.2%	2.3%
Vehicle Weight Reduction	0%	0.1%	0.3%	0.5%	0.9%	1.3%	1.6%	1.9%	2.0%	2.1%
Aerodynamic Load Reductior	0%	0.2%	0.3%	0.6%	1.1%	1.5%	1.9%	2.1%	2.2%	2.3%
Hybrid (Med. Trucks)	0%	0.1%	0.2%	0.5%	1.1%	1.7%	2.4%	3.1%	3.5%	3.7%
Totals:	0%	2%	5%	9%	15%	21%	26%	30%	32%	33%



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

	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Loads	0.00	0.01	0.01	0.03	0.05	0.07	0.10	0.11	0.13	0.14
Idle Hours	0.00	0.00000	0.00001	0.00001	0.00001	0.00002	0.00002	0.00002	0.00002	0.00002
Engine Efficiency/WHR	0.00	0.02	0.04	0.09	0.17	0.26	0.34	0.40	0.45	0.50
Parasitic Losses	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.06
Vehicle Weight	0.00	0.00	0.00	0.01	0.01	0.02	0.03	0.03	0.04	0.04
Aerodynamic Load	0.00	0.00	0.01	0.01	0.02	0.03	0.04	0.05	0.06	0.06
Total, Type 3	0.00	0.03	0.07	0.14	0.27	0.42	0.55	0.66	0.73	0.81

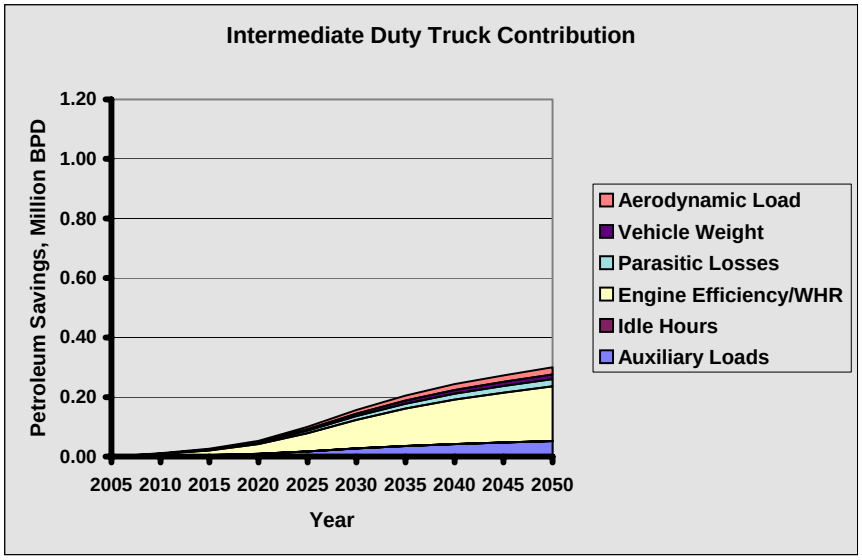


For the long-haul segment in a given year, engine efficiency represents about sixty percent (60%) of the savings opportunity. Auxiliary Load reduction by electrification is the next most significant contributing technology, but represents less than twenty percent (20%) of the expected savings. The other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

	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050
Auxiliary Loads	0.00	0.00	0.00	0.01	0.02	0.03	0.04	0.04	0.05	0.05
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	0.01	0.02	0.03	0.06	0.10	0.13	0.15	0.17	0.18
Parasitic Losses	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02
Vehicle Weight	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.02
Aerodynamic Load	0.00	0.00	0.00	0.00	0.01	0.01	0.02	0.02	0.02	0.02
Total, Type 2	0.00	0.01	0.03	0.05	0.10	0.16	0.20	0.24	0.27	0.30



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

	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	0.02	0.02	0.02
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	0.01	0.02	0.03	0.04	0.05	0.06	0.06	0.06
Parasitic Losses	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Vehicle Weight	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
Aerodynamic Load	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Total, Type 1	0.00	0.01	0.01	0.03	0.05	0.07	0.09	0.10	0.10	0.10

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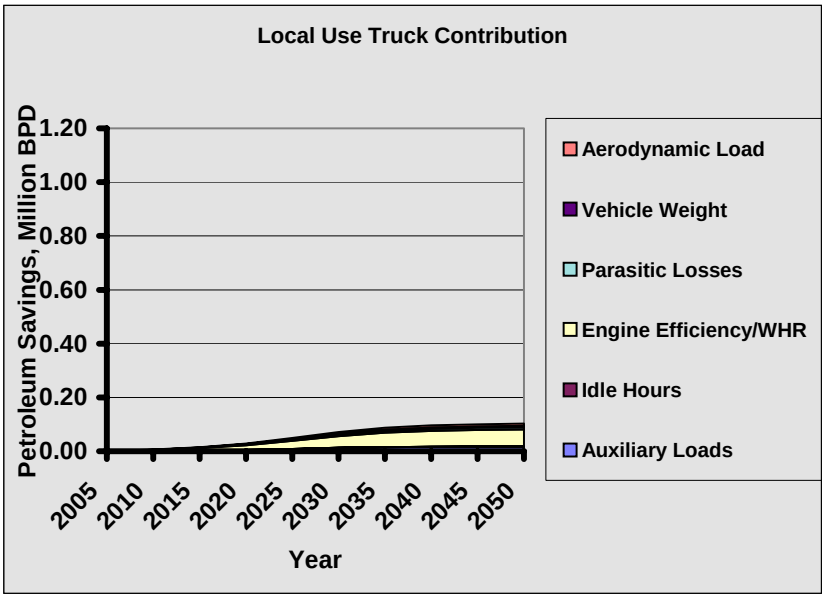


Exhibit ES-10 is a tabular summary of the program benefits analysis results for the years 2010, 2020, 2030, 2040, and 2050. Information contained in the table includes the following:

- 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 emissions.
- 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	2010	2020	2030	2040	2050
1	Oil Use Class 7- 8-Local, mmbpd	0.269	0.305	0.317	0.320	0.317
2	Oil Use Class 7- 8-Intermediate, mmbpd	0.470	0.573	0.694	0.811	0.929
3	Oil Use Class 7- 8-Long-Haul, mmbpd	1.267	1.545	1.873	2.187	2.505
4	Total Class 7-8, mmbpd	2.006	2.424	2.884	3.313	3.732
5	Oil Use Class 3-6, mmbpd	0.369	0.480	0.591	0.671	0.748
6	Total Oil Use, mmbpd	2.375	2.903	3.476	3.984	4.481
7	Class 7- 8-Local (Type 1), mmbpd	0.006	0.028	0.071	0.096	0.101
8	Class 7- 8-Intermediate (Type 2), mmbpd	0.011	0.053	0.156	0.243	0.295
9	Class 7- 8-Long-Haul (Type 3), mmbpd	0.030	0.144	0.422	0.655	0.797
10	Total Class 7-8, mmbpd	0.048	0.225	0.649	0.992	1.187
11	Oil Reduction Class 3-6, mmbpd	0.003	0.023	0.091	0.188	0.268
12	Total Oil Reduction, mmbpd	0.050	0.248	0.740	1.181	1.455
13	Oil Reduction Class 7-8, %	2%	9%	23%	30%	32%
14	Oil Reduction Class 3-6, %	1%	5%	15%	28%	36%
15	Total Oil Reduction, %	2%	9%	21%	30%	32%
16	Total Carbon Emissions, mmtce	137.39	168.11	201.49	231.40	260.49
17	Carbon Reduction Class 7- 8-Local, mmtce	0.668	3.455	10.293	16.420	20.069
18	Carbon Reduction Class 7- 8-Intermediate, mmtce	0.870	4.318	12.866	20.525	25.087
19	Carbon Reduction Class 7- 8-Long-Haul, mmtce	1.406	6.765	20.157	32.156	39.303
20	Total Carbon Reduction Class 7-8, mmtce	2.930	14.394	42.887	68.416	83.623
21	Carbon Reduction Class 3-6, mmtce	0.003	0.023	0.091	0.188	0.255
22	Total Carbon Reduction, mmtce	2.932	14.417	42.979	68.604	83.878
23	Total Carbon Reduction, %	2%	9%	21%	30%	32%
24	Vehicle Miles Traveled Class 7-8, Local; milliions	16,791	21,595	26,395	30,462	34,464
25	Vehicle Miles Traveled Class 7-8, Intermediate; mllions	39,729	51,094	62,451	72,074	81,543
26	Vehicle Miles Traveled Class 7-8, Long-Haul; millions	133,065	171,131	209,170	241,401	273,116
27	Total Class 7-8, millions	189,585	243,820	298,016	343,937	389,122
28	Vehicle Miles Traveled Class 3-6; millions	52,547	68,692	85,087	96,451	107,633
29	Total Vehicle Miles Traveled , millions	242,132	312,512	383,103	440,388	496,755
30	Fuel Economy Class 7-8, Local, mpg	4.5	5.8	6.6	6.6	6.6
31	Fuel Economy Class 7-8, Intermediate, mpg	6.1	6.4	8.2	9.0	9.2
32	Fuel Economy Class 7-8, Long-Haul, mpg	7.4	10.4	12.2	12.7	12.9
33	Average, Class 7-8, mpg	6.7	8.7	10.4	10.9	11.0
34	Fuel Economy Class 3-6, mpg	9.0	10.5	12.3	13.7	13.7
35	Market Penetration Class 7-8, Local, % VMT	0.3%	58.0%	83.0%	83.0%	83.0%
36	Market Penetration Class 7-8 Hybrid, Local, % VMT	0.3%	35.7%	48.6%	48.6%	48.6%
37	Market Penetration Class 7-8, Intermediate, % VMT	0.0%	13.8%	65.8%	81.8%	85.5%
38	Market Penetration Class 7-8, Long Haul, % VMT	0.7%	64.7%	89.4%	94.9%	96.3%
39	Market Penetration--All Types, Class 7-8, % VMT	0.5%	53.4%	83.9%	91.1%	92.9%
40	Market Penetration Hybrid Class 3-6, % VMT	0.7%	15.3%	50.0%	71.7%	71.7%
41	Vehicle Stock Class 7-8, Local, vehicles x 1000	932	1,056	1,180	1,341	1,499
42	Vehicle Stock Class 7-8, Intermediate, Vehicles x 1000	1,181	1,338	1,495	1,699	1,899
43	Vehicle Stock Class 7-8, Long-Haul, Vehicles x 1000	3,116	3,529	3,945	4,482	5,011
44	Total Vehicle Stock Class 7-8, Vehicles X 1000	5,228	5,923	6,620	7,521	8,409
45	Vehicle Stock Class 3-6, Vehicles x 1000	52,547	68,692	85,087	96,451	107,633
46	Total Vehicle Stock Class 3-8, Vehicles X 1000	57,776	74,615	91,707	103,972	116,041

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	2010	2020	2030	2040	2050
	Consumption Breakdown, mmbpd					
1	Oil Use Class 7- 8-Local (Type 1)	0.269	0.305	0.317	0.320	0.317
2	Oil Use Class 7- 8-Intermediate (Type 2)	0.470	0.573	0.694	0.811	0.929
3	Oil Use Class 7- 8-Long-Haul (Type 3)	1.267	1.545	1.873	2.187	2.505
4	Total Class 7-8	2.006	2.424	2.884	3.313	3.732
5	Oil Use Class 3-6	0.369	0.480	0.591	0.671	0.748
6	Total Oil Use, mmbpd	2.375	2.903	3.476	3.984	4.481
7	Class 7 & 8 Savings Breakdown, mmbpd					
8	Oil Reduction Class 7- 8-Auxiliary Load Reduction	0.008	0.040	0.113	0.173	0.209
9	Idle Hour Reduction	0.000	0.000	0.000	0.000	0.000
10	Oil Reduction Class 7- 8--Engine Efficiency/WHR	0.029	0.138	0.398	0.610	0.740
11	Oil Reduction Class 7- 8--Parasitics Reduction	0.004	0.018	0.052	0.079	0.097
12	Oil Reduction Class 7- 8--Vehicle Weight Reduction	0.003	0.012	0.035	0.053	0.064
13	Oil Reduction Class 7- 8-Aerodynamic Load Reduction	0.004	0.018	0.052	0.079	0.097
14	Total Class 7-8, mmbpd	0.0479	0.225	0.649	0.992	1.200
15	Oil Reduction Class 3-6-Auxiliary Load Reduction	0.0001	0.001	0.003	0.006	0.008
16	Oil Reduction Class 3-6--Engine Efficiency/WHR	0.0004	0.004	0.014	0.030	0.040
17	Oil Reduction Class 3-6--Parasitics Reduction	0.0001	0.001	0.002	0.004	0.006
18	Oil Reduction Class 3-6--Vehicle Weight Reduction	0.0003	0.003	0.010	0.021	0.029
19	Oil Reduction Class 3-6-Aerodynamic Load Reduction	0.0001	0.001	0.002	0.004	0.006
20	Oil Reduction Class 3-6-Hybrid	0.0017	0.015	0.060	0.123	0.167
21	Oil Reduction Class 3-6, mmbpd	0.003	0.023	0.092	0.189	0.256
22	Total Oil Reduction, mmbpd	0.050	0.248	0.740	1.181	1.455
23	Oil Reduction-Auxiliary Load Reduction	0.4%	1.4%	3.3%	4.5%	4.8%
24	Idle Hour Reduction	0.0%	0.0%	0.0%	0.0%	0.0%
25	Oil Reduction--Engine Efficiency/WHR	1.3%	4.9%	11.9%	16.1%	17.4%
26	Oil Reduction--Parasitics Reduction	0.2%	0.6%	1.5%	2.1%	2.3%
27	Oil Reduction--Vehicle Weight Reduction	0.1%	0.5%	1.3%	1.9%	2.1%
28	Oil Reduction-Aerodynamic Load Reduction	0.2%	0.6%	1.5%	2.1%	2.3%
29	Oil Reduction-Hybrid	0.1%	0.5%	1.7%	3.1%	3.7%
30	Total Oil Reduction, %	2%	9%	21%	30%	32%
31	Total Carbon Emissions, Class 7-8, mmtce	118.05	143.82	169.44	194.51	218.69
32	Total Carbon Emissions, Class 3-6, mmtce	19.341	24.292	32.045	36.899	41.802
33	Total Carbon Emissions, mmtce	137.39	168.11	201.49	231.40	260.49
34	Carbon Emissions-Auxiliary Load Reduction, mmtce	0.49	2.30	6.60	10.06	12.01
35	Carbon Reduction--Engine Efficiency/WHR, mmtce	1.71	8.06	23.22	35.55	42.63
36	Carbon Reduction--Parasitics Reduction, mmtce	0.22	1.03	3.00	4.63	5.58
37	Carbon Reduction--Vehicle Weight Reduction, mmtce	0.15	0.70	2.01	3.07	3.66
38	Carbonl Reduction-Aerodynamic Load Reduction, mmtce	0.22	1.03	3.00	4.63	5.58
39	Carbon Reduction-Hybrid, mmtce	0.14	1.28	5.15	10.76	14.76
40	Total Carbon Reduction, mmtce	2.932	14.417	42.979	68.604	83.878
41	Total Carbon Reduction, %	2%	9%	21%	30%	32%

1.0 Introduction

This report describes the approach to estimating benefits and the analysis results for the Heavy Vehicle Technologies activities of the Freedom Car 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,
- Identification of 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 the activities planned for FY 06. 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. These benefits estimates, along with market penetrations and other results, are then modeled as part of the EERE-wide integrated analysis to provide final benefit estimates reported in the FY06 Budget Request.

2.0 Background

This analysis of the initial 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 requirements—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 >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 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.

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.

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.

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

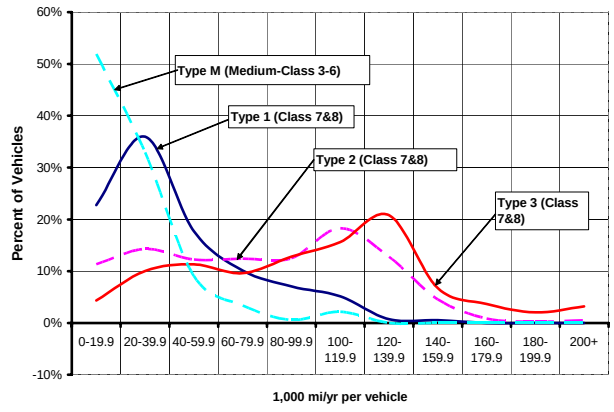


Exhibit 2:
Type 1 Vehicle Use

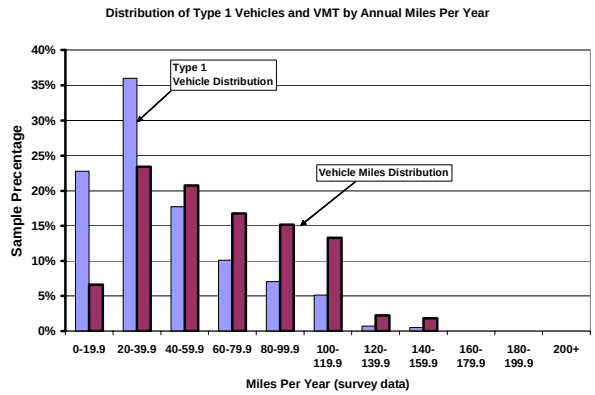
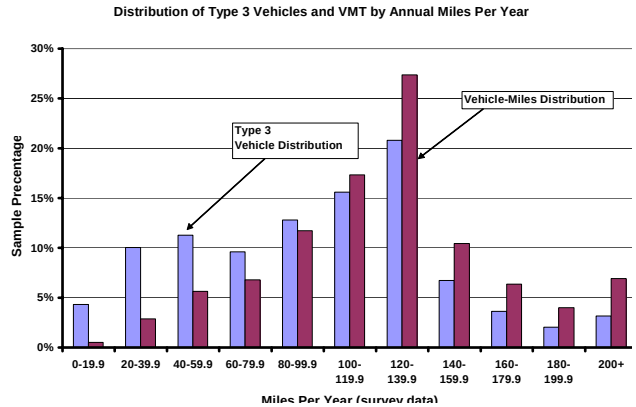


Exhibit 3:
Type 3 Vehicle Use



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.

Another key factor is regulation of emissions from Heavy Trucks by the Environmental Protection Agency. This regulation in turn is changing engine technology and diesel fuel refining. Some reduction in fuel economy with the new low-emissions engines is expected as the combustion process optimization addresses emissions reduction. These changes are expected to impose both operating and capital cost penalties on truck operators.

3.2 Market Segmentation Analysis

Heavy vehicle characteristics for the four vehicle Types are summarized in Exhibit 4. In the medium truck market segment, vehicles 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 1997 VIUS data, Type 3 heavy vehicles exhibit an average fuel economy considerably higher than Type 1 heavy vehicles (7.5 vs. 4.55 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.)

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)	4.55	6.16	7.50	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 Miles,	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

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 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. This is described in greater detail in Appendix A. The description of program goals and timelines was used as the basis for a meeting with the Program Management team in June 2004 to review the Analysis Team's preliminary characterizations and to obtain feedback.

Since the Plan does not address technology cost, input on cost projections or goals was also requested. A third principal item of discussion was how to address the cumulative or interactive effects of technologies that span the entire vehicle system.

Based on this meeting it appeared that the general characterizations of the program technologies were accurate. These characterizations were subsequently incorporated into runs of the Heavy Truck Energy Balance model (see 4.3) to develop specific estimates of fuel economy improvements associated with meeting the program goals. Lacking feedback on technology cost, a 'cost 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. Cost reductions were assumed over time as the technology matures and production levels increase.

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

Exhibit 5: TRUCK 2.0 Inputs for FY 06 Benefits Analysis

	Characteristic	2010	2020	2030	2040	2050
1	Fuel Economy Class 7-8, Local Travel (Type 1) mpg Multiplier	1.26	1.46	1.46	1.46	1.46
2	Fuel Economy Class 7-8, Intermediate Travel (Type 2) mpg Multiplier	1.35	1.64	1.64	1.64	1.64
3	Fuel Economy Class 7-8, Long Haul Travel (Type 3) mpg Multiplier	1.50	1.76	1.76	1.76	1.76
4	Fuel Economy Class 3-6-Hybrid, mpg Multiplier	1.70	1.70	1.70	1.70	1.70
5	Fuel Economy Class 3-6-Non-hybrid, mpg Multiplier	1.20	1.37	1.37	1.37	1.37
6	Class 7-8, Iincremental Cost, $	$ 35,000	$ 15,000	$ 7,500	$ 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 (developed for the 2006 analysis)
- TRUCK 2.0--Heavy Vehicle Market Penetration Model. Pages from this model are reproduced in the Appendix
- VISION 2.0, and
- Heavy Truck Summary (HVS) report generator.

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

[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 (2.0) model was developed by Margaret Singh and Anant Vyas of ANL.

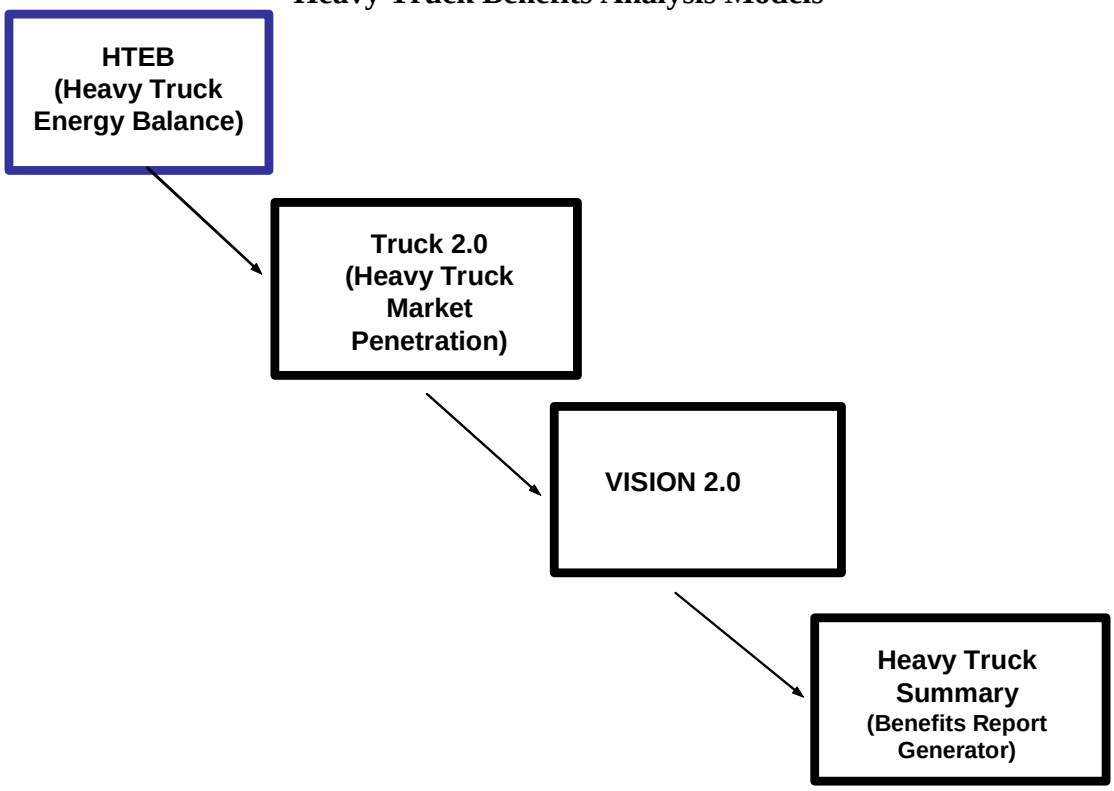
The Heavy Truck Summary Model is a report generating spreadsheet. It was initially developed by Maples, and has subsequently been modified by Analysts at the National Renewable Energy Laboratory, and TA Engineering.

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 of the vehicle. 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 Truck Energy Balance 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:

Exhibit 6:
Heavy Truck Benefits Analysis Models



- 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 (Type 1 7.5%, Types 2&3 15%)
- Engine efficiency increases of 10% and increases to 37.5% for all types. 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 are frequently over-driven 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 goals 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 8.

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**	**Program Effect**	**Notes**
Class 7-8 Type 1 Case:						
Engine Peak Power Rating			***225***	kW		*Set the engine peak power level in kW. Verify later that this engine size meets the energy needs at the peak specified cycle speed. Peak average engine load should probably not exceed about 80% of the peak engine power to account for speed variations not shown in the average values.*
Estimated Engine Average Power Rating			*107.7*	kW		
Assumed Average Truck Speed			50.0	MPH		This is the average speed of the truck while achieving the indicated fuel economy-assumed
Estimated Effective Truck Speed			61.8	MPH		**Aero power determined from lookup table**
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			50%			
Percent Full Load			48%			
Cycle Efficiency Factor			**94.1%**			Engine Efficiency Curve
Average Frictionless Cycle Efficiency:			**47.1%**		**Eng. Eff/ WHR**	Calculated average frictionless engine efficiency based on the assumed peak frictionless engine efficiency and the average cycle speed load.
Fuel Consumption Rate			**780,645**	BTU/hr		
Fuel Consumption Rate			**6.1**	gal/hr		
Non-Idle Fuel Economy			**8.24**	**MPG**		**Calculated**
Average Workday Length:			**8.00**	**hr**		
Percent of Normal Time Idling			**20%**			
Idle Fuel Consumption Rate:			**1.00**	**gal/hr**		
Internal Engine Parasitics	**Adjustment Factor**	**1.00**	**Efficiency**	**Power Consumed (kW)**	**Engine Efficency/ Waste Heat Reduction**	**Based on Gross Fuel Power Rate**
	% of Engine Full Load Capacity					
Pistons & Rings	**1.00%**			2.3		"
Connecting rod and crankshaft bearings	**1.00%**			2.3		"
Valvetrain/camshaft	**2.00%**			4.5		"
Less Total Internal Engine Parasitics				9.0		Calculated
= Gross Engine-Out Power				**98.7**		Calculated
Gross Power-Out Engine Efficiency				**43.1%**		Calculated
Engine Accessory Loads	**Adjustment Factor**	**1.00**	**Efficiency**	**Power Consumed (kW)**	**Electrification**	
	% of Engine Full Load Capacity					Based on Gross Engine-Out Power
Fuel injector pump	**1.0%**			2.3		"
Power Steering	**2.0%**			4.5		
Oil pump	**1.0%**			2.3		"
Coolant pump	**1.0%**			2.3		"
Fan	**1.0%**			2.3		"
						Based on Gross Power--Not in electrification program
Less Total Engine Aux Loads				**13.5**		Calculated
= Net Engine-Out Power				**85.2**		Calculated
Net Engine-Out Power Efficiency				**37.2%**		Calculated
Vehicle Auxiliary Loads	Average Load	**Units**	**Efficiency/ COP**	**Power Consumed (kW)**	**Electrification**	
	Adjustment Factor	**1.00**				
Alternator	**75**	**amp**	**0.8**	1.5		Capacities & efficiencies assumed, loads calculated
Air Conditioner	**1.25**	**ton**	**2**	2.2		"
Air Brake Compressor	**1.5**	**HP**	**0.5**	2.2		"
Less Total Veh. Aux. Loads				**5.9**		Calculated
= Net Available Engine Power				**79.2**		Calculated
Net Power Plant Efficiency				**34.6%**		
Drivetrain Parasitics	**Adjustment Factor**	**1.00**	**Efficiency**	**Power Consumed (kW)**		
Net Engine-Out Power Efficiency				**30.8%**		Calculated
Driving Loads (See 'Aero & Tires' Sheet)	Reduction, %			**Power Consumed (kW)**	**Aerodynamics & Weighr Reduction**	
Aerodynamic Load	**0.00%**			32.7		
Tire Rolling Resistance	**0.00%**			35.8		
Acceleration/Braking Energy	**0.00%**			11.8		Cycle energy consumed by the brakes divided by the driving cycle time
= Total Non-Hybrid Driving Loads				**80.3**		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				**11.8**		calculated
Adjusted (Hybrid) Total Driving Load				**80.33**		**calculated**
'Goal Seek' Balancing Value			**Remainder**	**-9.9**		**This value must = 0 for an energy balance to occur using Excel "goal seek" to solve for = 0**
		7.92	**mpg**	**107.7**	**kW**	

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 ($)	*Enhancement: Program Portfolio*	
		Diesel Fuel (only)	
		Gross 1st Cost ($)	Efficiency Ratio
2000	150,000	0	1.000
2005	150,000	45,000	1.500
2010	150,000	35,000	1.500
2015	150,000	25,000	1.760
2020	150,000	15,000	1.760
2025	150,000	11,000	1.760
2030	150,000	7,500	1.760
2035	150,000	7,500	1.760
2040	150,000	7,000	1.760
2045	150,000	7,000	1.760
2050	150,000	7,000	1.760

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 economic cost.

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 or fuel additive. 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.

TRUCK calculates the annual fuel savings based on the fuel economy effect of the proposed vehicle modifications, the fuel economy of the baseline vehicle, and fuel costs. All of these factors are permitted to change over time and the model currently projects costs and market penetrations. 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 B. 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 and 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 type and vehicle class. In other words, in addition to estimating the new vehicle fuel economy for the three Class 7-8 types, TRUCK estimates the average new fuel economy for Class 7-8. TRUCK similarly estimates the average fuel economy for Class 3-6 weighting hybrid and non-hybrid fuel economies. 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. Market penetrations post 2035 are extrapolated to 2050 based on trends during the 2030 to 2035 period.
11. **Detailed Inputs** - Link to **VISION** Model. This is discussed in Section 4.5. Detailed inputs 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 (= # 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 # 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 CO2 emissions from highway vehicles through 2050 (see Ref. 9). . 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 are converted into 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 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.

VISION uses only one Heavy and One Medium Truck vehicle type. It also uses NEMS rather than VIUS fuel economy data. The TRUCK model outputs are adjusted and used as inputs using the approach illustrated in Exhibit 10.

Exhibit 10:

GPRA 06 Heavy Vehicle Benefits Results for NEMS Modeling Mkt Pen Veh Mi

Revised, 12/29/04 and 2/2/05

Year	Class 7 & 8						Class 3 - 6					
	Combined Market Penetration, % VMT	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy for All New Technology Sales, mpg	Fuel Economy Multiplier only for Trucks with New Techology which Achieve the Market Penetration in Column 2	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)	Combined Market Penetration, % VMT	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy for All New Technology Sales, mpg	Fuel Economy Multiplier only for Trucks with New Techology which Achieve the Market Penetration in Column 6	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)
1	2	3	4	5	6	7	8	9	10	11	12	13
2005	0%	5.70	6.72	1.18	5.70	1.00	0%	8.67	8.90	1.03	8.67	1.00
2006	0%	5.69	6.72	1.18	5.69	1.00	0%	8.64	8.90	1.03	8.64	1.00
2007	0%	5.67	6.72	1.18	5.67	1.00	0%	8.61	8.90	1.03	8.61	1.00
2008	0%	5.66	6.72	1.19	5.66	1.00	0%	8.57	8.90	1.04	8.57	1.00
2009	0%	5.64	6.72	1.19	5.65	1.00	1%	8.54	8.91	1.04	8.54	1.00
2010	1%	5.63	6.73	1.19	5.635	**1.00**	4%	8.51	8.98	1.05	8.53	**1.00**
2011	2%	5.69	6.75	1.19	5.71	1.00	12%	8.51	9.12	1.07	8.58	1.01
2012	3%	5.75	6.78	1.18	5.78	1.00	15%	8.51	9.21	1.08	8.61	1.01
2013	5%	5.81	6.83	1.18	5.85	1.01	24%	8.52	9.46	1.11	8.73	1.02
2014	10%	5.87	6.98	1.19	5.97	1.02	24%	8.52	9.51	1.12	8.74	1.03
2015	15%	5.94	7.15	1.20	6.09	1.03	33%	8.52	9.86	1.16	8.92	1.05
2016	19%	6.00	7.29	1.22	6.21	1.04	40%	8.52	10.09	1.18	9.09	1.07
2017	27%	6.06	7.58	1.25	6.41	1.06	43%	8.52	10.21	1.20	9.18	1.08
2018	28%	6.12	7.61	1.24	6.47	1.06	48%	8.53	10.40	1.22	9.33	1.09
2019	44%	6.18	8.24	1.33	6.94	1.12	48%	8.53	10.43	1.22	9.34	1.10
2020	53%	6.24	8.66	1.39	7.33	**1.18**	50%	8.53	10.55	1.24	9.43	**1.11**
2021	57%	6.24	8.86	1.42	7.51	1.20	52%	8.53	10.73	1.26	9.54	1.12
2022	58%	6.25	8.92	1.43	7.57	1.21	52%	8.53	10.73	1.26	9.54	1.12
2023	65%	6.25	9.23	1.48	7.89	1.26	52%	8.53	10.73	1.26	9.54	1.12
2024	68%	6.25	9.39	1.50	8.08	1.29	54%	8.53	10.89	1.28	9.67	1.13
2025	69%	6.26	9.50	1.52	8.20	1.31	56%	8.53	11.02	1.29	9.77	1.15
2026	70%	6.26	9.53	1.52	8.24	1.32	56%	8.53	11.02	1.29	9.77	1.15
2027	79%	6.26	10.08	1.61	8.96	1.43	56%	8.53	11.02	1.29	9.77	1.15
2028	80%	6.26	10.11	1.61	8.99	1.44	56%	8.53	11.02	1.29	9.77	1.15
2029	83%	6.27	10.31	1.65	9.28	1.48	67%	8.53	11.68	1.37	10.41	1.22
2030	84%	6.27	10.37	1.65	9.38	**1.50**	75%	8.53	12.25	1.44	11.05	**1.30**
2031	85%	6.27	10.45	1.67	9.50	1.51	78%	8.53	12.45	1.46	11.29	1.32
2032	86%	6.28	10.54	1.68	9.64	1.54	80%	8.53	12.66	1.48	11.55	1.35
2033	87%	6.28	10.60	1.69	9.74	1.55	83%	8.53	12.89	1.51	11.86	1.39
2034	88%	6.28	10.66	1.70	9.83	1.57	86%	8.53	13.15	1.54	12.24	1.43
2035	89%	6.29	10.71	1.70	9.92	1.58	89%	8.53	13.43	1.57	12.66	1.48
2036	89%	6.29	10.75	1.71	9.99	1.59	93%	8.53	13.73	1.61	13.15	1.54
2037	90%	6.29	10.79	1.72	10.06	1.60	93%	8.53	13.73	1.61	13.15	1.54
2038	90%	6.29	10.82	1.72	10.12	1.61	93%	8.53	13.73	1.61	13.15	1.54
2039	91%	6.30	10.85	1.72	10.17	1.62	93%	8.53	13.73	1.61	13.15	1.54
2040	91%	6.30	10.88	1.73	10.22	**1.62**	93%	8.53	13.73	1.61	13.15	**1.54**
2041	91%	6.30	10.90	1.73	10.26	1.63	93%	8.53	13.73	1.61	13.15	1.54
2042	92%	6.30	10.92	1.73	10.30	1.63	93%	8.53	13.73	1.61	13.15	1.54
2043	92%	6.31	10.94	1.73	10.33	1.64	93%	8.53	13.73	1.61	13.15	1.54
2044	92%	6.31	10.95	1.74	10.35	1.64	93%	8.53	13.73	1.61	13.15	1.54
2045	92%	6.31	10.97	1.74	10.38	1.64	93%	8.53	13.73	1.61	13.15	1.54
2046	92%	6.31	10.98	1.74	10.40	1.65	93%	8.53	13.73	1.61	13.15	1.54
2047	93%	6.31	10.99	1.74	10.42	1.65	93%	8.53	13.73	1.61	13.15	1.54
2048	93%	6.32	11.00	1.74	10.43	1.65	93%	8.53	13.73	1.61	13.15	1.54
2049	93%	6.32	11.00	1.74	10.45	1.65	93%	8.53	13.73	1.61	13.15	1.54
2050	93%	6.32	11.01	1.74	10.46	**1.65**	93%	8.53	13.73	1.61	13.15	**1.54**

For Class 7- 8 vehicles, the market penetration for each Column 1 year is linked to the Truck 2.0 Model results and is shown in Column 2 in this case based on vehicle-miles. The Vision fuel economy factors are shown in Column 3. The Column 4 fuel economies are the weighted average for the 2 year and newer vehicles as calculated by the Truck model. This includes both vehicles with and without the energy conserving technology. The fuel economy multipliers in Column 5 are the ratio of the Column 4 values divided by Column 3. The harmonic average fuel economy considering the VISION base fuel economy and the new technology vehicle share 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 is shown in Exhibit 10.

4.6 Heavy Truck Summary

The **Heavy Truck Summary** report generator summarizes the first order benefits for the period covering 2000 through 2050. 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.

4.7 List of Assumptions

A list of key assumptions is contained in Exhibit 11. Additional assumptions can be seen by reviewing the Appendix B pages—especially Inputs, Fuel Prices, and Market Data pages, and by reviewing Reference 8.

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	
Drag Coefficient Improvement, %	7.5%	
Engine Effiiciency Improvement, %	30	
Engine Peak Output, kW	200	
Engine Aveage 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	
Drag Coefficient Improvement, %	15.0%	
Engine Effiiciency Improvement, %	37.5%	
Engine Peak Output, kW	250	
Engine Aveage Output, kW	78	Enhanced vehicles
Weight Reduction, lb.	6000	
Type 3 Vehicles		
Vehicle Miles	30,993,527,500	
Enhanced Fuel Economy, MPG	13.6	From HTEB Model
Fuel Economy with Improvements, MPG	13.6	
Drag Coefficient Improvement, %	15.0%	
Engine Effiiciency Improvement, %	37.5%	
Engine Peak Output, kW	250	
Engine Aveage 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	12.2	
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:	37%	
Value of Savings-2 yr payback, $	7,500	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	
Fuel Economy with Improvements, MPG	12.2	
Drag Coefficient Improvement, %	15.0%	
Engine Effiiciency Improvement, %	37.5%	
Engine Peak Output, kW	125	
Engine Aveage Output, kW	20	
Weight Reduction, lb.	1600	
Gallons/veh	2,465	
Two Year Consumption	4,931	
Fuel Economy Improvement:	37%	70% for Hybrid
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 06 Results

Heavy Vehicle Technologies GPRA 06 Results

	Characteristic	2005	2010	2015	2020	2025	2030	2035	2040	2045	2050	Notes
1	Oil Use Class 7- 8-Local, mmbpd	0.235	0.269	0.297	0.305	0.312	0.317	0.319	0.320	0.319	0.317	
2	Oil Use Class 7- 8-Intermediate, mmbpd	0.410	0.470	0.525	0.573	0.638	0.694	0.751	0.811	0.869	0.929	
3	Oil Use Class 7- 8-Long-Haul, mmbpd	1.104	1.267	1.415	1.545	1.720	1.873	2.026	2.187	2.343	2.505	
4	Total Class 7-8, mmbpd	1.748	2.006	2.237	2.424	2.670	2.884	3.095	3.313	3.519	3.732	
5	Oil Use Class 3-6, mmbpd	0.339	0.369	0.419	0.480	0.552	0.591	0.630	0.671	0.709	0.748	
6	Total Oil Use, mmbpd	2.087	2.375	2.656	2.903	3.221	3.476	3.725	3.984	4.228	4.481	
7	Class 7- 8-Local (Type 1), mmbpd	0	0.006	0.015	0.028	0.049	0.071	0.087	0.096	0.100	0.101	
8	Class 7- 8-Intermediate (Type 2), mmbpd	0	0.011	0.026	0.053	0.100	0.156	0.205	0.243	0.272	0.295	
9	Class 7- 8-Long-Haul (Type 3), mmbpd	0	0.030	0.071	0.144	0.271	0.422	0.552	0.655	0.734	0.797	
10	Total Class 7-8, mmbpd	0	0.048	0.112	0.225	0.420	0.649	0.843	0.992	1.103	1.187	
11	Oil Reduction Class 3-6, mmbpd	0	0.003	0.008	0.023	0.052	0.091	0.138	0.188	0.229	0.268	
12	Total Oil Reduction, mmbpd		0.050	0.120	0.248	0.473	0.740	0.980	1.181	1.331	1.455	
13	Oil Reduction Class 7-8, %	0%	2%	5%	9%	16%	23%	27%	30%	31%	32%	
14	Oil Reduction Class 3-6, %	0%	1%	2%	5%	9%	15%	22%	28%	32%	36%	
15	Total Oil Reduction, %	0%	2%	5%	9%	15%	21%	26%	30%	31%	32%	
16	Total Carbon Emissions, mmtce	120.54	137.39	153.76	168.11	186.57	201.49	216.17	231.40	245.81	260.49	
17	Carbon Reduction Class 7- 8-Local, mmtce	0	0.668	1.669	3.455	6.567	10.293	13.627	16.420	18.520	20.069	
18	Carbon Reduction Class 7- 8-Intermediate, mmtce	0	0.870	2.086	4.318	8.209	12.866	17.033	20.525	23.150	25.087	
19	Carbon Reduction Class 7- 8-Long-Haul, mmtce	0	1.406	3.268	6.765	12.861	20.157	26.685	32.156	36.269	39.303	
20	Total Carbon Reduction Class 7-8, mmtce	0	2.930	6.954	14.394	27.364	42.887	56.777	68.416	77.168	83.623	
21	Carbon Reduction Class 3-6, mmtce	0	0.003	0.008	0.023	0.052	0.091	0.138	0.188	0.229	0.255	
22	Total Carbon Reduction, mmtce	0.495	2.932	6.962	14.417	27.417	42.979	56.915	68.604	77.397	83.878	
23	Total Carbon Reduction, %	0%	2%	5%	9%	15%	21%	26%	30%	31%	32%	
24	Vehicle Miles Traveled Class 7-8, Local; milliions	14,605	16,791	19,142	21,595	24,364	26,395	28,390	30,462	32,429	34,464	
25	Vehicle Miles Traveled Class 7-8, Intermediate; mllions	34,555	39,729	45,291	51,094	57,645	62,451	67,172	72,074	76,727	81,543	
26	Vehicle Miles Traveled Class 7-8, Long-Haul; millions	115,738	133,065	151,694	171,131	193,073	209,170	224,983	241,401	256,987	273,116	
27	Total Class 7-8, millions	164,898	189,585	216,127	243,820	275,082	298,016	320,546	343,937	366,143	389,122	
28	Vehicle Miles Traveled Class 3-6; millions	48,044	52,547	59,725	68,692	79,411	85,087	90,662	96,451	101,946	107,633	
29	Total Vehicle Miles Traveled , millions	212,942	242,132	275,852	312,512	354,493	383,103	411,208	440,388	468,089	496,755	
30	Fuel Economy Class 7-8, Local, mpg	4.5	4.5	4.7	5.8	6.6	6.6	6.6	6.6	6.6	6.6	
31	Fuel Economy Class 7-8, Intermediate, mpg	6.1	6.1	6.1	6.4	7.2	8.2	8.7	9.0	9.1	9.2	
32	Fuel Economy Class 7-8, Long-Haul, mpg	7.4	7.4	8.1	10.4	11.2	12.2	12.6	12.7	12.8	12.9	
33	Average, Class 7-8, mpg	6.7	6.7	7.2	8.7	9.5	10.4	10.7	10.9	11.0	11.0	
34	Fuel Economy Class 3-6, mpg	8.9	9.0	9.9	10.5	11.0	12.3	13.4	13.7	13.7	13.7	
35	Market Penetration Class 7-8, Local, % VMT	0.0%	0.3%	12.1%	58.0%	83.0%	83.0%	83.0%	83.0%	83.0%	83.0%	
36	Market Penetration Class 7-8 Hybrid, Local, % VMT	0.0%	0.3%	8.3%	35.7%	48.6%	48.6%	48.6%	48.6%	48.6%	48.6%	
37	Market Penetration Class 7-8, Intermediate, % VMT	0.0%	0.0%	0.9%	13.8%	39.1%	65.8%	76.7%	81.8%	84.3%	85.5%	
38	Market Penetration Class 7-8, Long Haul, % VMT	0.0%	0.7%	19.9%	64.7%	76.8%	89.4%	93.0%	94.9%	95.9%	96.3%	
39	Market Penetration--All Types, Class 7-8, % VMT	0.0%	0.5%	15.2%	53.4%	69.4%	83.9%	88.7%	91.1%	92.3%	92.9%	
40	Market Penetration Hybrid Class 3-6, % VMT	0.0%	0.7%	6.2%	15.3%	28.2%	50.0%	67.8%	71.7%	71.7%	71.7%	
41	Vehicle Stock Class 7-8, Local, vehicles x 1000	844	932	1,000	1,056	1,100	1,180	1,259	1,341	1,418	1,499	
42	Vehicle Stock Class 7-8, Intermediate, Vehicles x 1000	1,070	1,181	1,267	1,338	1,393	1,495	1,595	1,699	1,797	1,899	
43	Vehicle Stock Class 7-8, Long-Haul, Vehicles x 1000	2,823	3,116	3,343	3,529	3,676	3,945	4,208	4,482	4,742	5,011	
44	Total Vehicle Stock Class 7-8, Vehicles X 1000	4,738	5,228	5,611	5,923	6,169	6,620	7,062	7,521	7,957	8,409	
45	Vehicle Stock Class 3-6, Vehicles x 1000	48,044	52,547	59,725	68,692	79,411	85,087	90,662	96,451	101,946	107,633	
46	Total Vehicle Stock Class 3-8, Vehicles X 1000	52,782	57,776	65,335	74,615	85,581	91,707	97,724	103,972	109,903	116,041	

Exhibit 13: Heavy Vehicle Technologies GPRA 06 Results by Program Element

Heavy Vehicle Technologies GPRA 06 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)	0.235	0.269	0.297	0.305	0.312	0.317	0.319	0.320	0.319	0.317	
ii	Oil Use Class 7- 8-Intermediate (Type 2)	0.410	0.470	0.525	0.573	0.638	0.694	0.751	0.811	0.869	0.929	
iii	Oil Use Class 7- 8-Long-Haul (Type 3)	1.104	1.267	1.415	1.545	1.720	1.873	2.026	2.187	2.343	2.505	
1	Total Class 7-8	1.748	2.006	2.237	2.424	2.670	2.884	3.095	3.313	3.519	3.732	
2	Oil Use Class 3-6	0.339	0.369	0.419	0.480	0.552	0.591	0.630	0.671	0.709	0.748	
3	Total Oil Use, mmbpd	2.087	2.375	2.656	2.903	3.221	3.476	3.725	3.984	4.228	4.481	
4	Class 7 & 8 Savings Breakdown, mmbpd											
5	Oil Reduction Class 7- 8-Auxiliary Load Reduction	0	0.008	0.020	0.040	0.073	0.113	0.147	0.173	0.192	0.209	
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	0.029	0.069	0.138	0.258	0.398	0.517	0.610	0.679	0.740	
8	Oil Reduction Class 7- 8--Parasitics Reduction	0	0.004	0.009	0.018	0.033	0.052	0.067	0.079	0.089	0.097	
9	Oil Reduction Class 7- 8--Vehicle Weight Reduction	0	0.003	0.006	0.012	0.022	0.035	0.045	0.053	0.058	0.064	
10	Oil Reduction Class 7- 8-Aerodynamic Load Reduction	0	0.004	0.009	0.018	0.033	0.052	0.067	0.079	0.089	0.097	
11	Total Class 7-8, mmbpd	0	0.0479	0.112	0.225	0.420	0.649	0.842	0.992	1.102	1.200	
12	Oil Reduction Class 3-6-Auxiliary Load Reduction	0	0.0001	0.000	0.001	0.002	0.003	0.004	0.006	0.007	0.008	
13	Oil Reduction Class 3-6--Engine Efficiency/WHR	0	0.0004	0.001	0.004	0.008	0.014	0.022	0.030	0.036	0.040	
14	Oil Reduction Class 3-6--Parasitics Reduction	0	0.0001	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.006	
15	Oil Reduction Class 3-6--Vehicle Weight Reduction	0	0.0003	0.001	0.003	0.006	0.010	0.015	0.021	0.026	0.029	
16	Oil Reduction Class 3-6-Aerodynamic Load Reduction	0	0.0001	0.000	0.001	0.001	0.002	0.003	0.004	0.005	0.006	
17	Oil Reduction Class 3-6-Hybrid	0	0.0017	0.005	0.015	0.034	0.060	0.090	0.123	0.149	0.167	
18	Oil Reduction Class 3-6, mmbpd	0	0.003	0.008	0.023	0.052	0.092	0.138	0.189	0.229	0.256	
19	Total Oil Reduction, mmbpd	0.000	0.050	0.120	0.248	0.473	0.740	0.980	1.181	1.331	1.455	
24	Oil Reduction-Auxiliary Load Reduction	0.0%	0.4%	0.7%	1.4%	2.3%	3.3%	4.1%	4.5%	4.7%	4.8%	
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%	1.3%	2.6%	4.9%	8.3%	11.9%	14.5%	16.1%	16.9%	17.4%	
27	Oil Reduction--Parasitics Reduction	0.0%	0.2%	0.3%	0.6%	1.1%	1.5%	1.9%	2.1%	2.2%	2.3%	
28	Oil Reduction--Vehicle Weight Reduction	0.0%	0.1%	0.3%	0.5%	0.9%	1.3%	1.6%	1.9%	2.0%	2.1%	
29	Oil Reduction-Aerodynamic Load Reduction	0.0%	0.2%	0.3%	0.6%	1.1%	1.5%	1.9%	2.1%	2.2%	2.3%	
30	Oil Reduction-Hybrid	0.0%	0.1%	0.2%	0.5%	1.1%	1.7%	2.4%	3.1%	3.5%	3.7%	
31	Total Oil Reduction, %	0%	2%	5%	9%	15%	21%	26%	30%	31%	32%	
32	Total Carbon Emissions, Class 7-8, mmtce	60.063	118.05	132.47	143.82	158.75	169.44	181.68	194.51	206.38	218.69	
33	Total Carbon Emissions, Class 3-6, mmtce	9.878	19.341	21.290	24.292	27.823	32.045	34.483	36.899	39.420	41.802	
34	Total Carbon Emissions, mmtce	120.54	137.39	153.76	168.11	186.57	201.49	216.17	231.40	245.81	260.49	
35	Carbon Emissions-Auxiliary Load Reduction, mmtce	-	0.49	1.15	2.30	4.28	6.60	8.55	10.06	11.17	12.01	
36	Carbon Reduction--Engine Efficiency/WHR, mmtce	-	1.71	4.00	8.06	15.02	23.22	30.15	35.55	39.55	42.63	
37	Carbon Reduction--Parasitics Reduction, mmtce	-	0.22	0.51	1.03	1.94	3.00	3.91	4.63	5.16	5.58	
38	Carbon Reduction--Vehicle Weight Reduction, mmtce	-	0.15	0.35	0.70	1.31	2.01	2.61	3.07	3.41	3.66	
39	Carbonl Reduction-Aerodynamic Load Reduction, mmtce	-	0.22	0.51	1.03	1.94	3.00	3.91	4.63	5.16	5.58	
40	Carbon Reduction-Hybrid, mmtce	-	0.14	0.44	1.28	2.94	5.15	7.80	10.76	13.14	14.76	
41	Total Carbon Reduction, mmtce	0.495	2.932	6.962	14.417	27.417	42.979	56.915	68.604	77.397	83.878	
42	Total Carbon Reduction, %	0%	2%	5%	9%	15%	21%	26%	30%	31%	32%	

6.0 References

1. "FreedomCar and Vehicle Technologies R&D Plan," August 22, 2003

2. 1997 Vehicle Inventory and Use Survey, EC97TV-US U.S. Bureau of the Census, Washington, D. C., 1999.

3. 1997 Return on Investment Survey, American Trucking Association, Arlington Va., 1997.

4. "Annual Energy Outlook 2004, With Projections to 2025," Energy Information Agency, Department of Energy, Washington, D. C., Publication DOE/EIA-0383 (2005). (Website address: http://www.eia.doe.gov/bookshelf.html *(Library/Archives-Forecasting)*.

5. http://www.eere.energy.gov/office_eere/pdfs/gpra_fy04_e1.pdf

6. Personal Communication with Stacy Davis, ORNL, November 2001

7. "Heavy-Duty Truck Idling Characteristics-Results from a Nationwide Truck Survey**,"** Lutsey, Brodrick, Sperling, and Oglesby, TRB 2004 Annual Truck Meeting CD-ROM

8. "Heavy Truck Energy Balance Model User Comments Guide (Draft Final)", TA Engineering, Inc., July 15, 2005

9. Singh, M.; A. Vyas, and E. Steiner, *VISION Model: Description of Model Used to Estimate the Impact of Highway Vehicle Technologies and Fuels on Energy Use and Carbon Emissions to 2050*, ANL/ESD/04-1 (Dec. 2003).

Appendix A

APPENDIX A: Discussion of FCVT Heavy Vehicle Program Elements

This discussion is based on the Memorandum prepared by TA Engineering and used as the basis for a meeting with FCVT Program Management and Lab Analytical Support personnel on June 3, 2004. It describes the starting point for the vehicle characterizations in conjunction with the Heavy Truck Energy Balance analyses described in the report.

Heavy Vehicle Hybrid Propulsion Systems

The Advanced Heavy Hybrid Propulsion Systems (AHHPS) Program seeks to demonstrate a 60% improvement in fuel economy of trucks equipped with hybrid propulsion systems by 2007. An additional objective is to demonstrate a fuel economy improvement of up to 100% by 2008 within the most beneficial applications. The ultimate objective is to develop marketplace acceptance starting by 2010.

The AHHPS hybrid propulsion concepts incorporate smaller engines operating at higher average load factors and higher efficiencies supplemented with an electric motor/generator and battery system that assists the engine output during those parts of the driving cycle when more power is needed (acceleration, hill climbing, etc.). In addition, AHHPS concepts include a provision to recapture some of the vehicle kinetic energy normally consumed by the friction braking system by using generators driven by the wheels or drive system to recharge the hybrid propulsion system battery. Current regenerative systems are capable of saving approximately 30% of braking energy. Best system performance is projected to attain a 50% braking energy recovery rate.

The R&D Plan also includes “auxiliary power units” (APU’s). An APU is a separate heat engine installed on the vehicle dedicated to the support of one or more auxiliary engine and/or vehicle loads such as air conditioning, refrigeration, power steering, electrical generation, and the like. APU’s typically run at constant or near-constant speed and a high load fraction, yielding a higher marginal efficiency than powering these devices through the main propulsion unit. Note that most existing large truck refrigeration systems are already powered through an APU. In fact, truck refrigeration systems are the most common current application of APU’s. APU’s are likely to be most useful and efficient in special applications trucks (refrigeration, cement mixers, special handing systems, winches, cranes, garbage compactors, etc.)

The fuel-savings potentials of hybrid power systems and APU’s are not independent of each other. Installing an APU on a vehicle already equipped with a hybrid power system will not yield as much fuel savings as one installed on a vehicle that is not equipped with a hybrid power system. Both measures tend to increase engine efficiency by optimizing vehicle loads and timing. For purposes of this analysis, it has been assumed that APU’s will not be installed on trucks equipped with hybrid propulsion systems and that hybrid propulsion systems will not be installed on trucks that are already equipped with APU’s.

Hybrid propulsion systems are most effective when installed on vehicles that experience highly-variable driving cycles include frequent acceleration and braking, such as with multi-stop urban delivery trucks, garbage trucks, dump trucks, cement mixers, logging trucks, etc. They are less

effective in vehicles that are used predominantly in constant or near-constant power applications (such as long-haul highway driving).

As a first approximation, we have assumed the heavy vehicle hybrid propulsion option applies only to the more limited duty sector (Type 1) of Class 7 & 8 vehicles. The highest miles/year frequency category of the Type 1 trucks is 30,000 miles/yr., with average travel rate of about 40,000 miles/yr.). Hybrid technology is considered not to be cost effective for most Type 2 and Type 3 applications. This is not strictly true, in that some Type 1 vehicles are clearly driven in cycles that are not well-suited to hybrid propulsion and some Type 2 and Type 3 vehicles are clearly driven in stop and start cycles. It is understood that this is a simplifying assumption. It is expected that the proportion of Class 7 & 8 vehicles amenable to hybridization is about the same as the proportion of Type 1 vehicles (about 18% of Class 7 & 8 vehicles driving about 9% of total Class 7 & 8 vehicle-miles).

While the R&D Plan includes a targeted 60% fuel economy improvement for Class 3-8 vehicles, it is likely that the average effects on Class 7 & 8 Type 1 vehicles will be lower. We have assumed an average fuel economy improvement of 40% for this sector and type.

In addition, we initially assumed a 70% improvement for Class 3-6 vehicles, again to discount the effect for vehicles that will not be amenable to hybridization. In cases where drag improvements are mentioned in the plan but not fuel economy improvements, we have assumed a 50% effect. For example, a 10% drag reduction is projected to result in a 5% fuel economy increase.

Heavy Vehicle Parasitic Loss Reduction

The enhancements include the following elements related to heavy vehicles:

- Electrification of accessory loads demonstrated by 2004 to increase fuel economy by 8%.
- Aerodynamic drag coefficient reduction of 5% demonstrated by 2005.
- Diesel APU-12 kW demonstrated by 2008.
- Aerodynamic drag reduced by 15% by 2010 using active drag devices, tire and mirror modifications.
- Reduced cooling system size by 8% (the actual nature and the fuel economy effect of this enhancement is unclear).

In addition, the R&D Plan discusses the following elements:

- Friction and wear reduction. This appears to include both engine components and drive train components, but the discussion is unclear.
- Regenerative shock absorbers. Benefits are not quantified in the plan.
- Idle reduction. Involves the use of a larger APU system (perhaps with battery backup) to take over various vehicle accessory loads while the main propulsion system is off, but the energy-saving mechanism is unclear. Independent analysis (by others) indicates that idling hours can be reduced by 85%-95% through the use of such systems. (Ref. 6).

- Diesel reformer development. This would provide hydrogen for catalyst regeneration and direct injection systems for cold-starting aid and possibly to power an on-board fuel cell. The fuel economy effect of this measure is not evaluated in the write-up.
- Thermal management. This appears to be a new cooling system design intended to absorb the higher engine jacket heat (up to 40% higher) due to exhaust gas recirculation added for emissions control. It is claimed that new cooling systems could reduce parasitic energy losses by 10%, although the mechanisms for this improvement are not adequately defined. Nor is it clear whether or not or to what degree EGR will affect fuel economy. Based on the experience of equipping automobile engines with EGR, it is likely that EGR will substantially reduce heavy truck fuel economy, all other things being held constant.

Accessory load electrification saves energy because it replaces inefficient direct-drive engine systems with a more-efficient indirect electric drive. Many engine components (fuel pumps, power steering pumps, etc.) have loads that are relatively independent of engine or vehicle speed. These devices tend to be over-driven at normal engine speeds and the excess capacity is wasted in pressure relief devices. Therefore, the greatest benefits of accessory load electrification accrue to vehicles that travel mostly at highway speeds.

Idle Hours Limitations are included in the R&D Plan, this was analyzed separately. The TRUCK Model was modified to evaluate the benefits in a stand-alone analysis.

Heavy Truck Engine R&D

This part of the R & D program involves improvements to engine efficiency due to an increased expansion ratio, exhaust gas heat recovery, and control systems. Goals stated in the plan include:

- an increase in engine efficiency from 40% to 45% to be demonstrated by 2005, and
- a further increase to 55% to be demonstrated by 2012.

It is expected that the peak effect of this enhancement will be with engines that have higher average loading as is typical of Type 3 applications. Types 1 and 2 and Medium Vehicle benefits are discounted. In addition, the 40-45% improvement is assumed to apply to all heavy vehicles while the 45%-55% marginal improvement could be considered an optional improvement to be applied at the discretion of (and cost to) the owner.

Waste Heat Recovery

Engine exhaust heat can be captured by heat engines or thermoelectric generators and used to generate auxiliary electric power. The R&D Plan indicates a program goal of a 5% fuel economy improvement to be demonstrated in 2005 by turbo-compounding, increasing to a 10% benefit to be demonstrated by 2008. Thermoelectric systems, which generate electric directly from the exhaust heat without moving parts, are projected to demonstrate conversion efficiencies of 10% by 2005 and 15% by 2008.

The fuel economy effect will be greatest in those vehicles with the highest average engine loading, typically Type 3 vehicles. The effect is discounted slightly for Type 2 vehicles and substantially for Type 1 and Type M (Class 3-6) vehicles.

Idle Hour Limitations

Various heavy trucks undergo extensive idling periods during cargo deliveries, overnight parking of sleeper-cab trucks, and freight lot idling. It has been estimated that long-haul Class 7&8 trucks consume over 1300 gallons per year of diesel fuel during non-operations idling. Various methods have been proposed to greatly reduce such idling time. Idle Hour limitation benefit estimations required modification of the TRUCK model to utilize an idling hour distribution rather than a vehicle-miles distribution. Information contained in Reference 6 was used to complete this analysis.

Fuel Economy Improvements

While the R&D Plan discusses the potential enhancements of various technologies individually, it does not address the expected interactions between the various technologies as they are grouped together in various vehicles and end-use applications.

To estimate benefits, it is necessary to consider the conservation opportunities in the context of the TRUCK model's representation of the heavy and medium truck market. A key element of this analysis involves the estimation of fuel economy improvements on a consistent basis.

We started by characterizing the individual technologies. Six specific energy efficiency improvement categories were identified. These technologies and our assumed mechanism for market penetration are listed below:

- Accessory load electrification
- Aerodynamic drag coefficient reduction
- Engine efficiency improvements – from 40% to 55% brake thermal efficiency
- Hybrid propulsion systems
- Waste heat recovery
- Advanced parasitic load reduction

Initial assumptions of fuel economy improvement by technology and TRUCK model vehicle class and type are shown in Exhibit A-1. These fuel economy improvements are then converted to fuel consumption factors (the fraction of fuel consumed with the enhancement installed divided by the baseline fuel consumption). These are then converted back into an enhanced fuel economy value (MPG) compared to the baseline fuel economy in the TRUCK model. Finally, the fuel economy effects of a 15% average increase and a 50% increase, as discussed in R&D Plan Section 3.0-4 are shown in the exhibit. We interpreted these improvements as representative of new fleet average values, which would include vehicles with enhanced characteristics as well as those that are new and include only the effects of the technologies that we have classified as generally available in all new trucks purchased.

As discussed in Section 4.1, we presented these estimates to the program in June 2004, but developed the final estimates used in our analysis using the HTEB discussed in Section 4.3. We also corrected the baseline fuel economy shown in Exhibit A-1 for Type 3 trucks.

Exhibit A-1: Initial TRUCK Fuel Economy Improvement (FEI) Factors

Assumed TRUCK Fuel Economy Improvement (FEI) Factors Class 3-6 and 7&8 Trucks							Fuel Consumption Factors (mpg Effect of FEI Factors) Class 3-6 and 7&8 Trucks			
FCVT Improvments	**Applicable Sections of FCVT Plan**	**Type1**	**Type 2**	**Type 3**	**Medium**	**Comments**	**Type1**	**Type 2**	**Type 3**	**Type M**
Accessory load electrification	**4.2.4**	**1.03**	**1.05**	**1.08**	**1.03**	preferential for high speed travel	0.971	0.952	0.926	0.971
Aerodynamic drag coef	**4.2.4**	**1.00**	**1.02**	**1.025**	**1.02**		1.000	0.980	0.976	0.980
Engine efficiency-baseline improvement	**4.5.3**	**1.07**	**1.10**	**1.125**	**1.05**		0.935	0.909	0.889	0.952
Idle Hours Limits	4.2.4	1.00	1.00	1.00	1.00	handled in a separate custom TRUCK model	1.000	1.000	1.000	1.000
Waste Heat Recovery	4.5.4	1.05	1.08	1.10	1.00	preferential for high engine loading	0.952	0.930	0.909	1.000
Adv Parasitic Load Reduction	4.2.4	1.02	1.05	1.075	1.02	preferential for high engine loading	0.980	0.952	0.930	0.980
Engine efficiency-enhanced system	4.5.3	1.20	1.30	1.38	1.15	related to average engine load	0.833	0.769	0.727	0.870
Hybrid	4.2.2	1.40	1.00	1.00	1.70	mostly urban stop-and-go applications	0.714	1.000	1.000	0.588
							0.504	0.578	0.494	0.455
Technologies in boldface type are assumed to achieve general (across all Types) market penetration; i.e. industry adopts and incorporates in product offerings.						Overall Fuel Effect (no interactions)	1.98	1.73	2.02	2.20
						Baseline TRUCK Model fuel economy	*4.55*	*6.16*	*8.9*	*8.9*
						Enhanced Baseline MPG	**5.01**	**7.26**	**11.08**	**9.82**
						Enhanced fuel economy	9.02	10.65	18.02	19.58
						Reference: 15% effect	**5.23**	**7.08**	**10.24**	**10.24**
						Reference 50% Effect	**6.83**	**9.24**	**13.35**	**13.35**

Enhancement Costs

The R&D Plan did not address cost or market price for the proposed enhancements except in very limited examples. There are some generic cost estimates of various components, but not enough to create an estimate of installed system cost. We identified a cost goal for the technologies based on a two-year payback criteria, as determined by a heavy vehicle life-cycle cost algorithm contained in the TRUCK Model. The American Truck Associations survey results that provide the basis for the model indicated potential buyer acceptance for energy efficiency technologies with payback periods of 1 to 4 years. Since potential buyers who were willing to accept a payback of two years represented the largest segment of the responses a technology cost that would accomplish a payback of two years was selected as representative of program success.

An additional consideration for establishing priority can be the timing of commercial market availability. Time frames and performance as presented in the R&D Plan are indicated in Exhibit A-2.

Exhibit A-2: Schedule and Fuel Economy Effects per FCVT R&D Plan

Schedule and Fuel Economy Effects Per FCVT R&D Plan										
		Demonstration Year								
Enhancement	**Assumed Availability Status**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
4.2.2 Hybrid Propulsion	Optional				60%	100%				
Hybrid Power System										
Regenerative Braking										
APU (not separately evaluated)										
4.2.4 Heavy Vehicle Parasitic Loss Reduction										
accessory load electrification	All	8%								
reduce aero drag coefficient by 5%	All		2.5%							
reduce aerodynamic drag by 15%	Optional							7.5%		
12 kW diesel APU		Mentioned in both 4.4.2 and 4.2.4-is it double-counted?								
reduce engine thermal losses by 10%		mentioned as part of project, but not separately evaluated.								
reduce Idle-hours		overall effect =1.5% of surface transport energy (?)								
engine & drivetrain friction & wear reduction		mentioned as part of project, but not separately evaluated.								
regenerative shock absorbers										
predictive cruise control										
diesel reformer dev.										
4.5.3 Heavy Truck Engine R&D										
Increase engine efficiency from 40% to 45%	All		12.5%							
Increase engine efficiency to 55%	Optional									37.5%
increase engine expansion ratio		combined in above value								
exhaust heat recovery-bottoming cycle		also mentioned in 4.5.4-is this being double counted?								
improved engine controls		combined in above value								
low temperature combustion (?)										
improved turbocharger efficiency										
piston/cylinder friction reduction										
4.5.4 Waste Heat Recovery										
turbocompounding	Optional		5%			10%				
thermoelectric	Optional		10%			15%				
Overall Effect: (Page 3.0-4)		**15% improvement in new vehicle fuel economy (vehicle-mile weighted) in 2010, 50% by 2025 (assumed by R&D Plan wording, not stated specifically).**								

Appendix B

TRUCK 2.0 Model

Inputs

CLASS 7 & 8 Type 3

Year	Baseline Vehicle Cost ($)	Enhancement A-Type 3			
		Diesel Fuel (only)			
		Gross 1st Cost ($)	Subsidy = 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	45,000	0	45,000	1.000
2005	150,000	45,000	0	45,000	1.200
2006	150,000	43,000	0	43,000	1.254
2007	150,000	41,000	0	41,000	1.307
2008	150,000	39,000	0	39,000	1.361
2009	150,000	37,000	0	37,000	1.414
2010	150,000	35000	0	35,000	1.468
2011	150,000	33,000	0	33,000	1.522
2012	150,000	31,000	0	31,000	1.575
2013	150,000	29,000	0	29,000	1.629
2014	150,000	27,000	0	27,000	1.682
2015	150,000	25000	0	25,000	1.736
2016	150,000	23,000	0	23,000	1.790
2017	150,000	21,000	0	21,000	1.790
2018	150,000	19,000	0	19,000	1.790
2019	150,000	17,000	0	17,000	1.790
2020	150,000	15000	0	15,000	1.790
2021	150,000	14,200	0	14,200	1.790
2022	150,000	13,400	0	13,400	1.790
2023	150,000	12,600	0	12,600	1.790
2024	150,000	11,800	0	11,800	1.790
2025	150,000	11000	0	11,000	1.790
2026	150,000	10,300	0	10,300	1.790
2027	150,000	9,600	0	9,600	1.790
2028	150,000	8,900	0	8,900	1.790
2029	150,000	8,200	0	8,200	1.790
2030	150,000	7500	0	7,500	1.790
2031	150,000	7,500	0	7,500	1.790
2032	150,000	7,500	0	7,500	1.790
2033	150,000	7,500	0	7,500	1.790
2034	150,000	7,500	0	7,500	1.790
2035	150,000	7,500	0	7,500	1.790

Fuel Prices

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	**Transportation Energy Prices**												
2	**AEO'04**												
3	**Input Values in Yellow, values are interpolated**												
4	**Old Values from previous AEO Reports in Grey**												
5	Reference values are highlighted. All others are by linear interpolation												
6		**2002 Dollars per Million BTU**						**2002 Dollars Per Gallon-Gasoline Equivalent**					
7								(except Diesel Fuel which is in $/gal of diesel fuel)					
8	Year	Gasoline	Diesel	LPG	CNG	Electricity	Ethanol	Gasoline	Diesel	LPG	CNG	Electricity	Ethanol
9	1995												
10	1996												
11	1997												
12	1998												
13	1999												
14	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
15	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
16	2002	11.15	9.41	15.00	7.38	21.10	15.19	1.39	1.31	1.88	0.92	2.64	1.90
17	2003	11.24	9.50	15.00	7.49	20.91	15.44	1.41	1.32	1.87	0.94	2.61	1.93
18	2004	11.33	9.59	14.99	7.60	20.72	15.70	1.42	1.33	1.87	0.95	2.59	1.96
19	2005	11.42	9.68	14.99	8.26	20.53	15.95	1.43	1.34	1.87	1.03	2.57	1.99
20	2006	11.51	9.77	14.98	8.37	20.34	16.21	1.44	1.35	1.87	1.05	2.54	2.03
21	2007	11.60	9.85	14.98	8.48	20.14	16.46	1.45	1.37	1.87	1.06	2.52	2.06
22	2008	11.69	9.94	14.97	8.59	19.95	16.71	1.46	1.38	1.87	1.07	2.49	2.09
23	2009	11.78	10.03	14.97	8.70	19.76	16.97	1.47	1.39	1.87	1.09	2.47	2.12
24	2010	11.87	10.12	14.96	8.26	19.57	17.22	1.48	1.40	1.87	1.03	2.45	2.15
25	2011	11.87	10.13	15.05	8.42	19.71	17.43	1.48	1.40	1.88	1.05	2.46	2.18
26	2012	11.87	10.14	15.13	8.58	19.84	17.64	1.48	1.41	1.89	1.07	2.48	2.21
27	2013	11.87	10.14	15.22	8.75	19.98	17.86	1.48	1.41	1.90	1.09	2.50	2.23
28	2014	11.87	10.15	15.30	8.91	20.11	18.07	1.48	1.41	1.91	1.11	2.51	2.26
29	2015	11.87	10.16	15.39	9.07	20.25	18.28	1.48	1.41	1.92	1.13	2.53	2.29
30	2016	11.88	10.13	15.41	9.07	20.21	18.63	1.48	1.40	1.93	1.13	2.53	2.33
31	2017	11.88	10.10	15.44	9.07	20.16	18.98	1.49	1.40	1.93	1.13	2.52	2.37
32	2018	11.89	10.06	15.46	9.06	20.12	19.33	1.49	1.40	1.93	1.13	2.51	2.42
33	2019	11.89	10.03	15.49	9.06	20.07	19.68	1.49	1.39	1.94	1.13	2.51	2.46
34	2020	11.90	10.00	15.51	9.06	20.03	20.03	1.49	1.39	1.94	1.13	2.50	2.50
35	2021	11.93	10.01	15.57	9.07	20.01	20.01	1.49	1.39	1.95	1.13	2.50	2.50
36	2022	11.96	10.01	15.64	9.07	19.99	19.99	1.50	1.39	1.95	1.13	2.50	2.50
37	2023	12.00	10.02	15.70	9.08	19.96	19.96	1.50	1.39	1.96	1.13	2.50	2.50
38	2024	12.03	10.02	15.77	9.08	19.94	19.94	1.50	1.39	1.97	1.14	2.49	2.49
39	2025	12.06	10.03	15.83	9.09	19.92	19.92	1.51	1.39	1.98	1.14	2.49	2.49
40	2026	12.09	10.04	15.89	9.10	19.90	19.90	1.51	1.39	1.99	1.14	2.49	2.49
41	2027	12.12	10.04	15.96	9.10	19.88	19.88	1.52	1.39	1.99	1.14	2.48	2.48
42	2028	12.16	10.05	16.03	9.11	19.85	19.85	1.52	1.39	2.00	1.14	2.48	2.48
43	2029	12.19	10.05	16.09	9.11	19.83	19.83	1.52	1.39	2.01	1.14	2.48	2.48
44	2030	12.22	10.06	16.16	9.12	19.81	19.81	1.53	1.40	2.02	1.14	2.48	2.48
45	2031	12.25	10.07	16.22	9.13	19.79	19.79	1.53	1.40	2.03	1.14	2.47	2.47
46	2032	12.29	10.07	16.29	9.13	19.77	19.77	1.54	1.40	2.04	1.14	2.47	2.47
47	2033	12.32	10.08	16.36	9.14	19.75	19.75	1.54	1.40	2.04	1.14	2.47	2.47
48	2034	12.35	10.08	16.42	9.14	19.72	19.72	1.54	1.40	2.05	1.14	2.47	2.47
49	2035	12.39	10.09	16.49	9.15	19.70	19.70	1.55	1.40	2.06	1.14	2.46	2.46
50	2036	12.42	10.10	16.56	9.16	19.68	19.68	1.55	1.40	2.07	1.14	2.46	2.46
51	2037	12.45	10.10	16.63	9.16	19.66	19.66	1.56	1.40	2.08	1.15	2.46	2.46
52	2038	12.49	10.11	16.69	9.17	19.64	19.64	1.56	1.40	2.09	1.15	2.45	2.45
53	2039	12.52	10.11	16.76	9.17	19.62	19.62	1.56	1.40	2.10	1.15	2.45	2.45
54	2040	12.55	10.12	16.83	9.18	19.59	19.59	1.57	1.40	2.10	1.15	2.45	2.45
55	2041	12.59	10.13	16.90	9.19	19.57	19.57	1.57	1.40	2.11	1.15	2.45	2.45

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				1
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%	

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

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 Typ 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/y 1

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	7.40	1.000	7.40	1.000	7.40	$0.00	$0	$0	$0
1996	7.40	1.000	7.40	1.000	7.40	$0.00	$0	$0	$0
1997	7.40	1.000	7.40	1.000	7.40	$0.00	$0	$0	$0
1998	7.40	1.000	7.40	1.000	7.40	$0.00	$0	$0	$0
1999	7.40	1.000	7.40	1.000	7.40	$0.00	$0	$0	$0
2000	7.40	1.000	7.40	1.000	7.40	$1.52	$44,928	$44,928	$44,928
2001	7.40	1.000	7.40	1.000	7.40	$1.41	$41,534	$41,534	$41,534
2002	7.40	1.000	7.40	1.000	7.40	$1.31	$38,468	$38,468	$38,468
2003	7.40	1.000	7.40	1.000	7.40	$1.32	$38,831	$38,831	$38,831
2004	7.40	1.000	7.40	1.000	7.40	$1.33	$39,194	$39,194	$39,194
2005	7.40	1.200	8.88	1.000	7.40	$1.34	$39,557	$32,964	$39,557
2006	7.40	1.254	9.28	1.000	7.40	$1.35	$39,920	$31,844	$39,920
2007	7.40	1.307	9.67	1.000	7.40	$1.37	$40,283	$30,816	$40,283
2008	7.40	1.361	10.07	1.000	7.40	$1.38	$40,645	$29,869	$40,645
2009	7.40	1.414	10.47	1.000	7.40	$1.39	$41,008	$28,993	$41,008
2010	7.40	1.468	10.86	1.000	7.40	$1.40	$41,371	$28,182	$41,371
2011	7.40	1.522	11.26	1.000	7.40	$1.40	$41,404	$27,211	$41,404
2012	7.40	1.575	11.66	1.000	7.40	$1.41	$41,436	$26,305	$41,436
2013	7.40	1.629	12.05	1.000	7.40	$1.41	$41,469	$25,460	$41,469
2014	7.40	1.682	12.45	1.000	7.40	$1.41	$41,502	$24,668	$41,502
2015	7.40	1.736	12.85	1.000	7.40	$1.41	$41,534	$23,925	$41,534
2016	7.40	1.790	13.25	1.000	7.40	$1.40	$41,404	$23,131	$41,404
2017	7.40	1.790	13.25	1.000	7.40	$1.40	$41,273	$23,057	$41,273
2018	7.40	1.790	13.25	1.000	7.40	$1.40	$41,142	$22,984	$41,142
2019	7.40	1.790	13.25	1.000	7.40	$1.39	$41,011	$22,911	$41,011
2020	7.40	1.790	13.25	1.000	7.40	$1.39	$40,880	$22,838	$40,880
2021	7.40	1.790	13.25	1.000	7.40	$1.39	$40,905	$22,852	$40,905
2022	7.40	1.790	13.25	1.000	7.40	$1.39	$40,929	$22,866	$40,929
2023	7.40	1.790	13.25	1.000	7.40	$1.39	$40,954	$22,879	$40,954
2024	7.40	1.790	13.25	1.000	7.40	$1.39	$40,979	$22,893	$40,979
2025	7.40	1.790	13.25	1.000	7.40	$1.39	$41,003	$22,907	$41,003
2026	7.40	1.790	13.25	1.000	7.40	$1.39	$41,028	$22,920	$41,028
2027	7.40	1.790	13.25	1.000	7.40	$1.39	$41,052	$22,934	$41,052
2028	7.40	1.790	13.25	1.000	7.40	$1.39	$41,077	$22,948	$41,077
2029	7.40	1.790	13.25	1.000	7.40	$1.39	$41,101	$22,962	$41,101
2030	7.40	1.790	13.25	1.000	7.40	$1.40	$41,126	$22,975	$41,126

Type 3 Continued

ANNUAL DOLLAR SAVINGS OF ENHANCEMENTS		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
Enhancement A	Enhancement B	1	2	3	4	1	2	3	4	1	2	3	4	Cost
$0	$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	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$0	$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	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$0	$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	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$0	$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	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$0	$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	$0	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$6,593	$0	$7,512	$15,704	$24,379	$33,376	$0.00	$0.00	$0.00	$0.00	0.00	0.00000	0.00	0.00	$0
$8,076	$0	$7,581	$14,696	$21,373	$27,640	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$9,467	$0	$8,885	$17,225	$25,051	$32,337	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$10,777	$0	$10,114	$19,606	$28,443	$36,669	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	0.00	$0
$12,015	$0	$11,275	$21,773	$31,545	$40,643	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	-0.10	$0
$13,189	$0	$12,279	$23,710	$34,352	$44,259	$0.00	$0.00	$0.00	$0.00	0.00	0.00	0.00	-0.26	$0
$14,193	$0	$13,213	$25,514	$36,966	$47,628	$0.00	$0.00	$0.00	$0.00	0.00	0.00	-0.12	-0.44	$0
$15,131	$0	$14,086	$27,200	$39,409	$50,730	$0.00	$0.00	$0.00	$0.00	0.00	0.00	-0.27	-0.64	$0
$16,009	$0	$14,904	$28,779	$41,646	$53,577	$0.00	$0.00	$0.00	$0.00	0.00	0.00	-0.44	-0.85	$0
$16,834	$0	$15,671	$30,204	$43,679	$56,175	$0.00	$0.00	$0.00	$0.00	0.00	-0.12	-0.62	-1.08	$0
$17,609	$0	$16,329	$31,471	$45,511	$58,531	$0.00	$0.00	$0.00	$0.00	0.00	-0.26	-0.82	-1.34	$0
$18,273	$0	$16,945	$32,657	$47,227	$60,737	$0.00	$0.00	$0.00	$0.00	0.00	-0.42	-1.05	-1.64	$0
$18,215	$0	$16,891	$32,553	$47,077	$60,595	$0.00	$0.00	$0.00	$0.00	0.00	-0.55	-1.24	-1.89	$0
$18,158	$0	$16,837	$32,450	$46,982	$60,508	$0.00	$0.00	$0.00	$0.00	0.00	-0.71	-1.47	-2.18	$0
$18,100	$0	$16,783	$32,405	$46,946	$60,480	$0.00	$0.00	$0.00	$0.00	0.00	-0.91	-1.76	-2.56	$0
$18,042	$0	$16,794	$32,425	$46,974	$60,517	$0.00	$0.00	$0.00	$0.00	-0.12	-1.16	-2.13	-3.03	$0
$18,053	$0	$16,804	$32,444	$47,002	$60,553	$0.00	$0.00	$0.00	$0.00	-0.18	-1.28	-2.31	-3.26	$0
$18,064	$0	$16,814	$32,464	$47,030	$60,589	$0.00	$0.00	$0.00	$0.00	-0.25	-1.42	-2.51	-3.52	$0
$18,075	$0	$16,824	$32,483	$47,059	$60,625	$0.00	$0.00	$0.00	$0.00	-0.34	-1.58	-2.73	-3.81	$0
$18,085	$0	$16,834	$32,503	$47,087	$60,662	$0.00	$0.00	$0.00	$0.00	-0.43	-1.75	-2.99	-4.14	$0
$18,096	$0	$16,844	$32,522	$47,115	$60,698	$0.00	$0.00	$0.00	$0.00	-0.53	-1.96	-3.28	-4.52	$0
$18,107	$0	$16,854	$32,541	$47,143	$60,734	$0.00	$0.00	$0.00	$0.00	-0.64	-2.16	-3.58	-4.90	$0
$18,118	$0	$16,864	$32,561	$47,171	$60,771	$0.00	$0.00	$0.00	$0.00	-0.76	-2.39	-3.91	-5.33	$0
$18,129	$0	$16,874	$32,580	$47,200	$60,807	$0.00	$0.00	$0.00	$0.00	-0.90	-2.66	-4.30	-5.83	$0
$18,140	$0	$16,884	$32,600	$47,228	$60,844	$0.00	$0.00	$0.00	$0.00	-1.06	-2.98	-4.76	-6.42	$0
$18,151	$0	$16,894	$32,620	$47,256	$60,880	$0.00	$0.00	$0.00	$0.00	-1.25	-3.35	-5.30	-7.12	$0

Type 3 Continued

Cost Effectiveness Factor Enhancement 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	8.97E+01	89.7	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	6.97E+01	69.7	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	8.72E+01	87.2	4.42E+01	44.2	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	6.88E+01	68.8	1.10E+01	11.0	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	4.53E+01	45.3	-3.34E+01	0.0	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	8.74E+01	87.4	1.45E+01	14.5	-9.46E+01	0.0	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	7.05E+01	70.5	-2.72E+01	0.0	-1.82E+02	0.0	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	4.78E+01	47.8	-8.67E+01	0.0	-3.16E+02	0.0	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	2.66E+01	26.6	-1.46E+02	0.0	-4.59E+02	0.0	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	-2.97E+00	0.0	-2.36E+02	0.0	-6.89E+02	0.0	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	-4.75E+01	0.0	-3.82E+02	0.0	-1.09E+03	0.0	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	8.73E+01	87.3	-1.20E+02	0.0	-6.43E+02	0.0	-1.88E+03	0.0	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	7.99E+01	79.9	-1.61E+02	0.0	-8.07E+02	0.0	-2.42E+03	0.0	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	7.10E+01	71.0	-2.15E+02	0.0	-1.03E+03	0.0	-3.18E+03	0.0	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	6.02E+01	60.2	-2.85E+02	0.0	-1.34E+03	0.0	-4.32E+03	0.0	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	4.68E+01	46.8	-3.78E+02	0.0	-1.79E+03	0.0	-6.09E+03	0.0	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	2.99E+01	29.9	-5.07E+02	0.0	-2.47E+03	0.0	-8.97E+03	0.0	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	1.11E+01	11.1	-6.67E+02	0.0	-3.38E+03	0.0	-1.32E+04	0.0	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	-1.31E+01	1.0	-8.93E+02	0.0	-4.81E+03	0.0	-2.04E+04	0.0	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	-4.50E+01	1.0	-1.23E+03	0.0	-7.19E+03	0.0	-3.39E+04	0.0	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	-8.84E+01	1.0	-1.76E+03	0.0	-1.15E+04	0.0	-6.12E+04	0.0	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	-1.50E+02	1.0	-2.65E+03	0.0	-1.99E+04	0.0	-1.23E+05	0.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0	1.00E+02	100.0

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	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 Payback Periods (years)				Tech. Adoption Factor Enhancement A Payback Periods (years)								Tech. Adoption Factor Enhancement B 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]					Year	Class 7 & 8 MPG Ratio	Class 3-6 MPG Ratio	Class 7 & 8 MPG difference
	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	8.90	8.90	8.90	8.90	4.50	4.50	4.50	4.50	6.10	6.10	6.10	6.10	7.40	7.40	7.40	7.40	6.72	6.72	6.72	6.72		2000	1.00	1.00	0.00
2001	8.90	8.90	8.90	8.90	4.50	4.50	4.50	4.50	6.10	6.10	6.10	6.10	7.40	7.40	7.40	7.40	6.72	6.72	6.72	6.72		2001	1.00	1.00	0.00
2002	8.90	8.90	8.90	8.90	4.50	4.50	4.50	4.50	6.10	6.10	6.10	6.10	7.40	7.40	7.40	7.40	6.72	6.72	6.72	6.72		2002	1.00	1.00	0.00
2003	8.90	8.90	8.90	8.90	4.50	4.50	4.50	4.50	6.10	6.10	6.10	6.10	7.40	7.40	7.40	7.40	6.72	6.72	6.72	6.72		2003	1.00	1.00	0.00
2004	8.90	8.90	8.90	8.90	4.50	4.50	4.50	4.50	6.10	6.10	6.10	6.10	7.40	7.40	7.40	7.40	6.72	6.72	6.72	6.72		2004	1.00	1.00	0.00
2005	8.90	8.90	9.08	8.90	4.50	4.95	4.95	4.50	6.10	6.71	6.10	6.10	7.40	8.88	7.40	7.40	6.72	7.80	6.80	6.72		2005	1.00	1.00	0.00
2006	8.90	10.15	9.39	8.90	4.50	5.09	5.31	4.50	6.10	7.01	6.10	6.10	7.40	9.28	7.40	7.40	6.72	8.13	6.85	6.72		2006	1.00	1.00	0.00
2007	8.90	11.39	9.70	8.90	4.50	5.24	5.67	4.50	6.10	7.31	6.10	6.10	7.40	9.67	7.40	7.40	6.72	8.47	6.91	6.72		2007	1.00	1.00	0.00
2008	8.90	12.64	10.01	8.90	4.50	5.38	6.03	4.50	6.10	7.61	6.10	6.10	7.40	10.07	7.40	7.40	6.72	8.80	6.95	6.72		2008	1.00	1.00	0.00
2009	8.90	13.88	10.32	8.91	4.50	5.53	6.39	4.50	6.10	7.91	6.10	6.10	7.40	10.47	7.40	7.41	6.72	9.13	6.99	6.72		2009	1.00	1.00	0.01
2010	8.90	15.13	10.64	8.98	4.50	5.67	6.75	4.50	6.10	8.21	6.10	6.10	7.40	10.86	7.40	7.42	6.72	9.46	7.03	6.73		2010	1.00	1.01	0.01
2011	8.90	15.13	10.95	9.12	4.50	5.82	6.98	4.52	6.10	8.51	6.10	6.10	7.40	11.26	7.40	7.46	6.72	9.79	7.05	6.75		2011	1.01	1.02	0.04
2012	8.90	15.13	11.26	9.21	4.50	5.96	7.22	4.53	6.10	8.82	6.10	6.10	7.40	11.66	7.40	7.49	6.72	10.12	7.07	6.78		2012	1.01	1.03	0.06
2013	8.90	15.13	11.57	9.46	4.50	6.11	7.45	4.56	6.10	9.12	6.10	6.10	7.40	12.05	7.40	7.58	6.72	10.45	7.09	6.83		2013	1.02	1.06	0.12
2014	8.90	15.13	11.88	9.51	4.50	6.26	7.69	4.64	6.10	9.42	6.10	6.11	7.40	12.45	7.40	7.80	6.72	10.78	7.11	6.98		2014	1.04	1.07	0.26
2015	8.90	15.13	12.19	9.86	4.50	6.40	7.92	4.72	6.10	9.72	6.10	6.12	7.40	12.85	7.40	8.08	6.72	11.11	7.12	7.15		2015	1.06	1.11	0.43
2016	8.90	15.13	12.19	10.09	4.50	6.55	7.92	4.81	6.10	10.02	6.10	6.14	7.40	13.25	7.40	8.30	6.72	11.44	7.12	7.29		2016	1.09	1.13	0.58
2017	8.90	15.13	12.19	10.21	4.50	6.55	7.92	5.07	6.10	10.02	6.10	6.21	7.40	13.25	7.40	8.69	6.72	11.44	7.12	7.58		2017	1.13	1.15	0.86
2018	8.90	15.13	12.19	10.40	4.50	6.55	7.92	5.15	6.10	10.02	6.10	6.25	7.40	13.25	7.40	8.69	6.72	11.44	7.12	7.61		2018	1.13	1.17	0.89
2019	8.90	15.13	12.19	10.43	4.50	6.55	7.92	5.61	6.10	10.02	6.10	6.37	7.40	13.25	7.40	9.65	6.72	11.44	7.12	8.24		2019	1.23	1.17	1.52
2020	8.90	15.13	12.19	10.55	4.50	6.55	7.92	5.80	6.10	10.02	6.10	6.45	7.40	13.25	7.40	10.36	6.72	11.44	7.12	8.66		2020	1.29	1.19	1.94
2021	8.90	15.13	12.19	10.73	4.50	6.55	7.92	6.43	6.10	10.02	6.10	6.56	7.40	13.25	7.40	10.44	6.72	11.44	7.12	8.86		2021	1.32	1.21	2.14
2022	8.90	15.13	12.19	10.73	4.50	6.55	7.92	6.44	6.10	10.02	6.10	6.70	7.40	13.25	7.40	10.47	6.72	11.44	7.12	8.92		2022	1.33	1.21	2.21
2023	8.90	15.13	12.19	10.73	4.50	6.55	7.92	6.44	6.10	10.02	6.10	6.72	7.40	13.25	7.40	11.07	6.72	11.44	7.12	9.23		2023	1.37	1.21	2.51
2024	8.90	15.13	12.19	10.89	4.50	6.55	7.92	6.55	6.10	10.02	6.10	7.10	7.40	13.25	7.40	11.07	6.72	11.44	7.12	9.39		2024	1.40	1.22	2.68
2025	8.90	15.13	12.19	11.02	4.50	6.55	7.92	6.59	6.10	10.02	6.10	7.20	7.40	13.25	7.40	11.19	6.72	11.44	7.12	9.50		2025	1.41	1.24	2.78
2026	8.90	15.13	12.19	11.02	4.50	6.55	7.92	6.59	6.10	10.02	6.10	7.23	7.40	13.25	7.40	11.23	6.72	11.44	7.12	9.53		2026	1.42	1.24	2.81
2027	8.90	15.13	12.19	11.02	4.50	6.55	7.92	6.59	6.10	10.02	6.10	7.75	7.40	13.25	7.40	11.96	6.72	11.44	7.12	10.08		2027	1.50	1.24	3.37
2028	8.90	15.13	12.19	11.02	4.50	6.55	7.92	6.59	6.10	10.02	6.10	7.83	7.40	13.25	7.40	11.96	6.72	11.44	7.12	10.11		2028	1.51	1.24	3.39
2029	8.90	15.13	12.19	11.68	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.20	7.40	13.25	7.40	12.10	6.72	11.44	7.12	10.31		2029	1.53	1.31	3.59
2030	8.90	15.13	12.19	12.25	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.21	7.40	13.25	7.40	12.22	6.72	11.44	7.12	10.37		2030	1.54	1.38	3.66
2031	8.90	15.13	12.19	12.45	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.34	7.40	13.25	7.40	12.29	6.72	11.44	7.12	10.45		2031	1.56	1.40	3.73
2032	8.90	15.13	12.19	12.66	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.48	7.40	13.25	7.40	12.37	6.72	11.44	7.12	10.54		2032	1.57	1.42	3.82
2033	8.90	15.13	12.19	12.89	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.55	7.40	13.25	7.40	12.44	6.72	11.44	7.12	10.60		2033	1.58	1.45	3.88
2034	8.90	15.13	12.19	13.15	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.63	7.40	13.25	7.40	12.50	6.72	11.44	7.12	10.66		2034	1.59	1.48	3.94
2035	8.90	15.13	12.19	13.43	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.71	7.40	13.25	7.40	12.56	6.72	11.44	7.12	10.71		2035	1.59	1.51	3.99
2036	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.77	7.40	13.25	7.40	12.60	6.72	11.44	7.12	10.75		2036	1.60	1.54	4.03
2037	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.83	7.40	13.25	7.40	12.64	6.72	11.44	7.12	10.79		2037	1.61	1.54	4.07
2038	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.88	7.40	13.25	7.40	12.68	6.72	11.44	7.12	10.82		2038	1.61	1.54	4.11
2039	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.93	7.40	13.25	7.40	12.71	6.72	11.44	7.12	10.85		2039	1.62	1.54	4.14
2040	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	8.97	7.40	13.25	7.40	12.74	6.72	11.44	7.12	10.88		2040	1.62	1.54	4.16
2041	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.00	7.40	13.25	7.40	12.76	6.72	11.44	7.12	10.90		2041	1.62	1.54	4.19
2042	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.03	7.40	13.25	7.40	12.78	6.72	11.44	7.12	10.92		2042	1.63	1.54	4.20
2043	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.06	7.40	13.25	7.40	12.80	6.72	11.44	7.12	10.94		2043	1.63	1.54	4.22
2044	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.08	7.40	13.25	7.40	12.81	6.72	11.44	7.12	10.95		2044	1.63	1.54	4.24
2045	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.10	7.40	13.25	7.40	12.83	6.72	11.44	7.12	10.97		2045	1.63	1.54	4.25
2046	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.12	7.40	13.25	7.40	12.84	6.72	11.44	7.12	10.98		2046	1.63	1.54	4.26
2047	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.13	7.40	13.25	7.40	12.85	6.72	11.44	7.12	10.99		2047	1.64	1.54	4.27
2048	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.14	7.40	13.25	7.40	12.86	6.72	11.44	7.12	11.00		2048	1.64	1.54	4.28
2049	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.16	7.40	13.25	7.40	12.87	6.72	11.44	7.12	11.00		2049	1.64	1.54	4.29
2050	8.90	15.13	12.19	13.73	4.50	6.55	7.92	6.59	6.10	10.02	6.10	9.17	7.40	13.25	7.40	12.87	6.72	11.44	7.12	11.01		2050	1.64	1.54	4.29

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	
	Type1A	Type1B	Type2A	Type2B	Type3A	Type3B				
Year	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Efficiency	Hybrid (Type 1 Only)	Hybrid	Efficiency
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%	0.2%	0.0%	0.1%	0.0%	0.0%	0.2%
2010	0.0%	0.1%	0.0%	0.0%	0.3%	0.0%	0.2%	0.0%	0.2%	0.8%
2011	0.0%	0.5%	0.0%	0.0%	1.1%	0.0%	0.6%	0.1%	0.1%	2.8%
2012	0.1%	0.8%	0.0%	0.0%	1.8%	0.0%	1.1%	0.1%	0.3%	3.4%
2013	0.2%	1.2%	0.1%	0.0%	3.7%	0.0%	2.2%	0.2%	0.5%	6.8%
2014	0.6%	2.3%	0.2%	0.0%	7.3%	0.0%	4.5%	0.4%	0.5%	6.8%
2015	1.5%	3.4%	0.3%	0.0%	12.2%	0.0%	7.6%	0.6%	1.5%	10.4%
2016	2.2%	4.9%	0.7%	0.0%	15.2%	0.0%	9.6%	0.9%	1.7%	13.7%
2017	4.2%	8.1%	2.0%	0.0%	21.8%	0.0%	14.2%	1.4%	1.9%	16.4%
2018	4.4%	9.7%	2.9%	0.0%	21.8%	0.0%	14.4%	1.7%	3.2%	17.9%
2019	7.5%	15.1%	5.7%	0.0%	37.2%	0.0%	24.8%	2.7%	3.7%	17.5%
2020	9.8%	18.0%	7.7%	0.0%	47.4%	0.0%	31.7%	3.2%	5.8%	17.0%
2021	14.6%	24.3%	10.5%	0.0%	49.0%	0.0%	34.2%	4.3%	9.1%	14.7%
2022	14.6%	24.5%	13.2%	0.0%	49.2%	0.0%	34.9%	4.4%	9.1%	14.7%
2023	14.6%	24.5%	13.4%	0.0%	58.4%	0.0%	40.4%	4.4%	9.1%	14.7%
2024	16.3%	24.9%	21.8%	0.0%	58.4%	0.0%	42.6%	4.4%	11.7%	14.3%
2025	23.7%	25.3%	23.7%	0.0%	59.5%	0.0%	45.0%	4.5%	13.9%	13.9%
2026	23.8%	34.1%	24.4%	0.0%	60.4%	0.0%	45.8%	6.1%	13.9%	13.9%
2027	23.8%	39.7%	34.8%	0.0%	70.6%	0.0%	54.2%	7.1%	13.9%	13.9%
2028	24.6%	39.7%	36.8%	0.0%	70.6%	0.0%	54.8%	7.1%	13.9%	13.9%
2029	33.4%	45.3%	44.9%	0.0%	72.1%	0.0%	59.1%	8.1%	24.1%	13.7%
2030	39.0%	46.9%	45.1%	0.0%	73.8%	0.0%	61.1%	8.4%	32.3%	13.5%
2031	42.8%	48.7%	47.7%	0.0%	74.6%	0.0%	62.9%	8.7%	36.9%	13.4%
2032	47.4%	51.0%	50.5%	0.0%	75.6%	0.0%	64.9%	9.1%	42.6%	13.3%
2033	47.6%	52.4%	51.8%	0.0%	76.5%	0.0%	65.8%	9.3%	49.8%	13.1%
2034	46.2%	53.8%	53.5%	0.0%	77.1%	0.0%	66.3%	9.6%	56.2%	13.0%
2035	44.9%	55.1%	55.0%	0.0%	77.8%	0.0%	66.8%	9.8%	62.2%	12.9%
2036	43.9%	56.1%	56.1%	0.0%	78.3%	0.0%	67.2%	10.0%	68.6%	12.8%
2037	43.0%	57.0%	57.2%	0.0%	78.8%	0.0%	67.5%	10.2%	75.1%	12.6%
2038	42.2%	57.8%	58.1%	0.0%	79.2%	0.0%	67.8%	10.3%	81.4%	12.5%
2039	41.5%	58.5%	58.8%	0.0%	79.6%	0.0%	68.1%	10.4%	87.6%	12.4%
2040	40.9%	59.1%	59.5%	0.0%	79.9%	0.0%	68.3%	10.5%	87.6%	12.4%
2041	40.4%	59.6%	60.1%	0.0%	80.1%	0.0%	68.5%	10.6%	87.6%	12.4%
2042	39.9%	60.1%	60.6%	0.0%	80.4%	0.0%	68.7%	10.7%	87.6%	12.4%
2043	39.5%	60.5%	61.1%	0.0%	80.6%	0.0%	68.9%	10.8%	87.6%	12.4%
2044	39.2%	60.8%	61.5%	0.0%	80.7%	0.0%	69.0%	10.8%	87.6%	12.4%
2045	38.9%	61.1%	61.8%	0.0%	80.9%	0.0%	69.1%	10.9%	87.6%	12.4%
2046	38.6%	61.4%	62.1%	0.0%	81.0%	0.0%	69.2%	10.9%	87.6%	12.4%
2047	38.4%	61.6%	62.4%	0.0%	81.2%	0.0%	69.3%	11.0%	87.6%	12.4%
2048	38.2%	61.8%	62.6%	0.0%	81.3%	0.0%	69.4%	11.0%	87.6%	12.4%
2049	38.1%	61.9%	62.8%	0.0%	81.3%	0.0%	69.4%	11.0%	87.6%	12.4%
2050	37.9%	62.1%	62.9%	0.0%	81.4%	0.0%	69.5%	11.1%	87.6%	12.4%

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	Hybrid Enhancement B	Enhancement A	Hybrid Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Enhancement A	Enhancement B	Hybrid 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%	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%	0.1%	0.0%	0.1%	0.0%	0.0%	0.4%	0.0%	0.3%	0.0%	0.0%	0.8%
2010	0.0%	0.3%	0.0%	0.3%	0.0%	0.0%	0.7%	0.0%	0.5%	0.0%	0.7%	3.4%
2011	0.1%	1.4%	0.1%	1.4%	0.0%	0.0%	2.2%	0.0%	1.5%	0.1%	0.5%	11.8%
2012	0.2%	1.7%	0.2%	1.7%	0.1%	0.0%	3.5%	0.0%	2.5%	0.2%	1.5%	13.1%
2013	0.5%	2.7%	0.5%	2.7%	0.2%	0.0%	6.2%	0.0%	4.4%	0.2%	2.0%	22.1%
2014	1.7%	5.9%	1.7%	5.9%	0.6%	0.0%	12.8%	0.0%	9.2%	0.5%	2.0%	22.1%
2015	3.8%	8.3%	3.8%	8.3%	0.9%	0.0%	19.9%	0.0%	14.5%	0.7%	6.2%	26.7%
2016	5.9%	10.7%	5.9%	10.7%	1.7%	0.0%	24.6%	0.0%	18.1%	0.9%	6.9%	33.0%
2017	10.1%	18.9%	10.1%	18.9%	4.5%	0.0%	33.7%	0.0%	25.5%	1.7%	7.4%	36.1%
2018	10.7%	21.5%	10.7%	21.5%	6.2%	0.0%	33.7%	0.0%	25.9%	1.9%	11.1%	36.5%
2019	18.9%	32.2%	18.9%	32.2%	10.7%	0.0%	52.9%	0.0%	41.0%	2.8%	12.1%	35.8%
2020	22.3%	35.7%	22.3%	35.7%	13.8%	0.0%	64.7%	0.0%	50.3%	3.2%	15.3%	34.5%
2021	32.2%	46.2%	32.2%	46.2%	18.0%	0.0%	66.0%	0.0%	53.0%	4.1%	22.0%	29.7%
2022	32.2%	46.4%	32.2%	46.4%	23.0%	0.0%	66.4%	0.0%	54.3%	4.1%	22.0%	29.7%
2023	32.2%	46.4%	32.2%	46.4%	23.4%	0.0%	75.1%	0.0%	60.5%	4.1%	22.0%	29.7%
2024	34.4%	47.5%	34.4%	47.5%	36.2%	0.0%	75.1%	0.0%	63.3%	4.2%	25.3%	29.1%
2025	46.2%	48.6%	34.4%	48.6%	39.1%	0.0%	76.8%	0.0%	65.1%	4.3%	28.2%	28.2%
2026	46.4%	57.7%	34.4%	48.6%	40.0%	0.0%	77.2%	0.0%	65.7%	4.3%	28.2%	28.2%
2027	46.4%	65.4%	34.4%	48.6%	54.6%	0.0%	86.3%	0.0%	75.1%	4.3%	28.2%	28.2%
2028	48.6%	65.4%	34.4%	48.6%	56.4%	0.0%	86.3%	0.0%	75.5%	4.3%	28.2%	28.2%
2029	57.7%	69.0%	34.4%	48.6%	65.5%	0.0%	88.0%	0.0%	78.5%	4.3%	40.3%	26.7%
2030	65.4%	71.7%	34.4%	48.6%	65.8%	0.0%	89.4%	0.0%	79.6%	4.3%	50.0%	25.1%
2031	70.1%	73.3%	34.4%	48.6%	68.6%	0.0%	90.1%	0.0%	80.7%	4.3%	53.5%	24.1%
2032	75.5%	75.3%	34.4%	48.6%	71.7%	0.0%	91.1%	0.0%	82.0%	4.3%	56.6%	23.6%
2033	79.9%	76.9%	34.4%	48.6%	73.2%	0.0%	91.8%	0.0%	82.9%	4.3%	60.1%	23.0%
2034	83.5%	78.2%	34.4%	48.6%	75.1%	0.0%	92.5%	0.0%	83.7%	4.3%	63.9%	22.3%
2035	86.9%	79.4%	34.4%	48.6%	76.7%	0.0%	93.0%	0.0%	84.4%	4.3%	67.8%	21.6%
2036	89.8%	80.4%	34.4%	48.6%	77.9%	0.0%	93.5%	0.0%	85.0%	4.3%	71.7%	21.0%
2037	92.2%	81.3%	34.4%	48.6%	79.1%	0.0%	94.0%	0.0%	85.6%	4.3%	71.7%	21.0%
2038	94.4%	82.1%	34.4%	48.6%	80.1%	0.0%	94.3%	0.0%	86.0%	4.3%	71.7%	21.0%
2039	96.3%	82.8%	34.4%	48.6%	81.0%	0.0%	94.7%	0.0%	86.5%	4.3%	71.7%	21.0%
2040	97.9%	83.3%	34.4%	48.6%	81.8%	0.0%	94.9%	0.0%	86.8%	4.3%	71.7%	21.0%
2041	99.3%	83.9%	34.4%	48.6%	82.4%	0.0%	95.2%	0.0%	87.1%	4.3%	71.7%	21.0%
2042	100.6%	84.3%	34.4%	48.6%	83.0%	0.0%	95.4%	0.0%	87.4%	4.3%	71.7%	21.0%
2043	101.6%	84.7%	34.4%	48.6%	83.5%	0.0%	95.6%	0.0%	87.6%	4.3%	71.7%	21.0%
2044	102.6%	85.0%	34.4%	48.6%	83.9%	0.0%	95.7%	0.0%	87.8%	4.3%	71.7%	21.0%
2045	103.4%	85.3%	34.4%	48.6%	84.3%	0.0%	95.9%	0.0%	88.0%	4.3%	71.7%	21.0%
2046	104.1%	85.6%	34.4%	48.6%	84.6%	0.0%	96.0%	0.0%	88.2%	4.3%	71.7%	21.0%
2047	104.7%	85.8%	34.4%	48.6%	84.9%	0.0%	96.1%	0.0%	88.3%	4.3%	71.7%	21.0%
2048	105.2%	86.0%	34.4%	48.6%	85.1%	0.0%	96.2%	0.0%	88.4%	4.3%	71.7%	21.0%
2049	105.7%	86.1%	34.4%	48.6%	85.4%	0.0%	96.3%	0.0%	88.5%	4.3%	71.7%	21.0%
2050	106.1%	86.3%	34.4%	48.6%	85.5%	0.0%	96.3%	0.0%	88.6%	4.3%	71.7%	21.0%

Detailed Inputs—Vehicles Sold

GPRA 06 Heavy Vehicle Benefits Results for NEMS Modeling

Revised, 12/29/04 and 2/2/05

Percent Vehicle Sales

	Class 7 - 8				Class 3 - 6			
Year	Combined Market Penetration Sales	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy for All New Technology Sales, mpg	Fuel Economy Multiplier only for trucks with new techology which achieve the market penetration shown in Column 2	Combined Market Penetration Sales	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy for All New Technology Sales, mpg	Fuel Economy Multiplier only for trucks with new techology which achieve the market penetration shown in Column 6
1	2	3	4	5	6	7	8	9
2005	0%	5.70	9.96	1.75	0%	8.67	11.50	1.33
2006	0%	5.69	9.96	1.75	0%	8.64	11.50	1.33
2007	0%	5.67	9.96	1.76	0%	8.61	11.50	1.34
2008	0%	5.66	9.96	1.76	0%	8.57	11.51	1.34
2009	0%	5.64	9.96	1.76	0%	8.54	11.51	1.35
2010	0%	5.63	9.96	1.77	1%	8.51	11.51	1.35
2011	1%	5.69	10.02	1.76	3%	8.51	11.54	1.36
2012	1%	5.75	10.09	1.75	4%	8.51	11.56	1.36
2013	3%	5.81	10.15	1.75	7%	8.52	11.59	1.36
2014	5%	5.87	10.22	1.74	7%	8.52	11.61	1.36
2015	8%	5.94	10.28	1.73	12%	8.52	11.64	1.37
2016	11%	6.00	10.36	1.73	15%	8.52	11.68	1.37
2017	16%	6.06	10.43	1.72	18%	8.52	11.72	1.38
2018	16%	6.12	10.51	1.72	21%	8.53	11.76	1.38
2019	28%	6.18	10.58	1.71	21%	8.53	11.80	1.38
2020	35%	6.24	10.66	1.71	23%	8.53	11.85	1.39
2021	38%	6.24	10.67	1.71	24%	8.53	11.91	1.40
2022	39%	6.25	10.68	1.71	24%	8.53	11.97	1.40
2023	44%	6.25	10.68	1.71	24%	8.53	12.03	1.41
2024	47%	6.25	10.69	1.71	26%	8.53	12.09	1.42
2025	50%	6.26	10.70	1.71	28%	8.53	12.15	1.42
2026	51%	6.26	10.70	1.71	28%	8.53	12.26	1.44
2027	59%	6.26	10.71	1.71	28%	8.53	12.37	1.45
2028	62%	6.26	10.71	1.71	28%	8.53	12.48	1.46
2029	66%	6.27	10.72	1.71	29%	8.53	12.59	1.48
2030	69%	6.27	10.72	1.71	29%	8.53	12.70	1.49
2031	72%	6.27	10.72	1.71	30%	8.53	12.68	1.49
2032	74%	6.28	10.72	1.71	30%	8.53	12.65	1.48
2033	75%	6.28	10.73	1.71	31%	8.53	12.63	1.48
2034	76%	6.28	10.73	1.71	32%	8.53	12.60	1.48
2035	77%	6.29	10.73	1.71	33%	8.53	12.58	1.47
2036	78%	6.29	10.73	1.71	33%	8.53	12.55	1.47
2037	78%	6.29	10.73	1.71	34%	8.53	12.53	1.47
2038	79%	6.29	10.74	1.71	35%	8.53	12.50	1.47
2039	79%	6.30	10.74	1.71	36%	8.53	12.48	1.46
2040	80%	6.30	10.74	1.70	37%	8.53	12.45	1.46
2041	80%	6.30	10.74	1.70	39%	8.53	12.45	1.46
2042	80%	6.30	10.74	1.70	40%	8.53	12.45	1.46
2043	81%	6.31	10.74	1.70	41%	8.53	12.45	1.46
2044	81%	6.31	10.74	1.70	43%	8.53	12.45	1.46
2045	81%	6.31	10.75	1.70	45%	8.53	12.45	1.46
2046	81%	6.31	10.75	1.70	47%	8.53	12.45	1.46
2047	81%	6.31	10.75	1.70	49%	8.53	12.45	1.46
2048	82%	6.32	10.75	1.70	51%	8.53	12.45	1.46
2049	82%	6.32	10.75	1.70	54%	8.53	12.45	1.46
2050	82%	6.32	10.75	1.70	56%	8.53	12.45	1.46

Detailed Inputs-Vehicle Miles

GPRA 06 Heavy Vehicle Benefits Results for NEMS Modeling Mkt Pen Veh Mi

Revised, 12/29/04 and 2/2/05

Year	Class 7 & 8						Class 3 - 6					
	Combined Market Penetration, % VMT	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy for All New Technology Sales, mpg	Fuel Economy Multiplier only for Trucks with New Techology which Achieve the Market Penetration in Column 2	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)	Combined Market Penetration, % VMT	Base MPG (VISION) in gasoline equivalent gallons	Fuel Economy for All New Technology Sales, mpg	Fuel Economy Multiplier only for Trucks with New Techology which Achieve the Market Penetration in Column 6	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)
1	2	3	4	5	6	7	8	9	10	11	12	13
2005	0%	5.70	6.72	1.18	5.70	1.00	0%	8.67	8.90	1.03	8.67	1.00
2006	0%	5.69	6.72	1.18	5.69	1.00	0%	8.64	8.90	1.03	8.64	1.00
2007	0%	5.67	6.72	1.18	5.67	1.00	0%	8.61	8.90	1.03	8.61	1.00
2008	0%	5.66	6.72	1.19	5.66	1.00	0%	8.57	8.90	1.04	8.57	1.00
2009	0%	5.64	6.72	1.19	5.65	1.00	1%	8.54	8.91	1.04	8.54	1.00
2010	1%	5.63	6.73	1.19	5.635	**1.00**	4%	8.51	8.98	1.05	8.53	**1.00**
2011	2%	5.69	6.75	1.19	5.71	1.00	12%	8.51	9.12	1.07	8.58	1.01
2012	3%	5.75	6.78	1.18	5.78	1.00	15%	8.51	9.21	1.08	8.61	1.01
2013	5%	5.81	6.83	1.18	5.85	1.01	24%	8.52	9.46	1.11	8.73	1.02
2014	10%	5.87	6.98	1.19	5.97	1.02	24%	8.52	9.51	1.12	8.74	1.03
2015	15%	5.94	7.15	1.20	6.09	1.03	33%	8.52	9.86	1.16	8.92	1.05
2016	19%	6.00	7.29	1.22	6.21	1.04	40%	8.52	10.09	1.18	9.09	1.07
2017	27%	6.06	7.58	1.25	6.41	1.06	43%	8.52	10.21	1.20	9.18	1.08
2018	28%	6.12	7.61	1.24	6.47	1.06	48%	8.53	10.40	1.22	9.33	1.09
2019	44%	6.18	8.24	1.33	6.94	1.12	48%	8.53	10.43	1.22	9.34	1.10
2020	53%	6.24	8.66	1.39	7.33	**1.18**	50%	8.53	10.55	1.24	9.43	**1.11**
2021	57%	6.24	8.86	1.42	7.51	1.20	52%	8.53	10.73	1.26	9.54	1.12
2022	58%	6.25	8.92	1.43	7.57	1.21	52%	8.53	10.73	1.26	9.54	1.12
2023	65%	6.25	9.23	1.48	7.89	1.26	52%	8.53	10.73	1.26	9.54	1.12
2024	68%	6.25	9.39	1.50	8.08	1.29	54%	8.53	10.89	1.28	9.67	1.13
2025	69%	6.26	9.50	1.52	8.20	1.31	56%	8.53	11.02	1.29	9.77	1.15
2026	70%	6.26	9.53	1.52	8.24	1.32	56%	8.53	11.02	1.29	9.77	1.15
2027	79%	6.26	10.08	1.61	8.96	1.43	56%	8.53	11.02	1.29	9.77	1.15
2028	80%	6.26	10.11	1.61	8.99	1.44	56%	8.53	11.02	1.29	9.77	1.15
2029	83%	6.27	10.31	1.65	9.28	1.48	67%	8.53	11.68	1.37	10.41	1.22
2030	84%	6.27	10.37	1.65	9.38	**1.50**	75%	8.53	12.25	1.44	11.05	**1.30**
2031	85%	6.27	10.45	1.67	9.50	1.51	78%	8.53	12.45	1.46	11.29	1.32
2032	86%	6.28	10.54	1.68	9.64	1.54	80%	8.53	12.66	1.48	11.55	1.35
2033	87%	6.28	10.60	1.69	9.74	1.55	83%	8.53	12.89	1.51	11.86	1.39
2034	88%	6.28	10.66	1.70	9.83	1.57	86%	8.53	13.15	1.54	12.24	1.43
2035	89%	6.29	10.71	1.70	9.92	1.58	89%	8.53	13.43	1.57	12.66	1.48
2036	89%	6.29	10.75	1.71	9.99	1.59	93%	8.53	13.73	1.61	13.15	1.54
2037	90%	6.29	10.79	1.72	10.06	1.60	93%	8.53	13.73	1.61	13.15	1.54
2038	90%	6.29	10.82	1.72	10.12	1.61	93%	8.53	13.73	1.61	13.15	1.54
2039	91%	6.30	10.85	1.72	10.17	1.62	93%	8.53	13.73	1.61	13.15	1.54
2040	91%	6.30	10.88	1.73	10.22	**1.62**	93%	8.53	13.73	1.61	13.15	**1.54**
2041	91%	6.30	10.90	1.73	10.26	1.63	93%	8.53	13.73	1.61	13.15	1.54
2042	92%	6.30	10.92	1.73	10.30	1.63	93%	8.53	13.73	1.61	13.15	1.54
2043	92%	6.31	10.94	1.73	10.33	1.64	93%	8.53	13.73	1.61	13.15	1.54
2044	92%	6.31	10.95	1.74	10.35	1.64	93%	8.53	13.73	1.61	13.15	1.54
2045	92%	6.31	10.97	1.74	10.38	1.64	93%	8.53	13.73	1.61	13.15	1.54
2046	92%	6.31	10.98	1.74	10.40	1.65	93%	8.53	13.73	1.61	13.15	1.54
2047	93%	6.31	10.99	1.74	10.42	1.65	93%	8.53	13.73	1.61	13.15	1.54
2048	93%	6.32	11.00	1.74	10.43	1.65	93%	8.53	13.73	1.61	13.15	1.54
2049	93%	6.32	11.00	1.74	10.45	1.65	93%	8.53	13.73	1.61	13.15	1.54
2050	93%	6.32	11.01	1.74	10.46	**1.65**	93%	8.53	13.73	1.61	13.15	**1.54**

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