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Transportation Demand Module

The NEMS Transportation Demand Module estimates energy consumption across the nine Census Divisions (see Figure 5) and over ten fuel types. Each fuel type is modeled according to fuel-specific technology attributes applicable by transportation mode. Total transportation energy consumption isthe sum of energy use in eight transport modes: light-duty vehicles (cars and light trucks), commercial light trucks (8,501-10,000 lbs gross vehicle weight), freight trucks (>10,000 lbs gross vehicle weight), freight and passenger aircraft, freight rail, freight shipping, and miscellaneous transport such as mass transit. Light-duty vehicle fuel consumption is further subdivided into personal usage and commercial fleet consumption.

Key Assumptions

Light-Duty Vehicle Assumptions

The light duty vehicle Manufacturers Technology Choice Model (MTCM) includes 63 fuel saving technologies with data specific to cars and light trucks (Tables 26 and 27) including incremental fuel efficiency improvement, incremental cost, first year of introduction, and fractional horsepower change. These assumed technology characterizations are scaled up or down to approximate the differences in each attribute for 6 Environmental Protection Administration (EPA) size classes of cars and light trucks.

The vehicle sales share module holds the share of vehicle sales by import and domestic manufacturers constant within a vehicle size class at 1999 levels based on National Highway Traffic and Safety Administration data.[32]

EPA size class sales shares are projected as a function of income per capita, fuel prices, and average predicted vehicle prices based on endogenous calculations within the MTCM[33]

The MTCM utilizes 63 new technologies for each size class and origin of manufacturer (domestic or foreign) based on the cost-effectiveness of each technology and an initial availability year. The discounted stream of fuel savings is compared to the marginal cost of each technology. The fuel economy module assumes the following:

- All fuel saving technologies have a 3-year payback period.
- The real discount rate remains steady at 15 percent.
- Corporate Average Fuel Efficiency standards remain constant at 27.5 mpg for cars and rise from a level of 20.7 mpg in 2004 to 24.0 mpg in 2011 for light trucks, and then remain constant throughout the forecast period.
- Expected future fuel prices are calculated based on an extrapolation of the growth rate between a five year moving average of fuel price 3 years and 4 years prior to the present year. This assumption is founded upon an assumed lead time of 3 to 4 years to significantly modify the vehicles offered by a manufacturer.

Table 26. Standard Technology Matrix For Cars[1]

	Fractional Fuel Efficiency Change	Incremental Cost (1990$)	Incremental Cost ($/Unit Wt.)	Incremental Weight (Lbs.)	Incremental Weight (Lbs./Unit Wt.)	Introduction Year	Fractional Horse-power Change
Unit Body Construction	4	100	0	0	-6	1980	0
Material Substitution II	3.3	0	0.4	0	-5	1990	0
Material Substitution III	6.6	0	0.6	0	-10	1998	0
Material Substitution IV	9.9	0	0.9	0	-15	2006	0
Material Substitution V	13.2	0	1.2	0	-20	2014	0
Drag Reduction II	2.3	40	0	0	0	1988	0
Drag Reduction III	4.4	85	0	0	0.2	1992	0
Drag Reduction IV	6.3	145	0	0	0.5	2002	0
Drag Reduction V	8	225	0	0	1	2010	0
Roll-Over Technology	-1.5	100	0	0	2.2	2005	0
Side Impact Technology	-1.5	100	0	0	2.2	2005	0
Adv Low Loss Torque Converter	2	25	0	0	0	1999	0
Early Torque Converter Lockup	0.5	8	0	0	0	2002	0
Aggressive Shift Logic	2	60	0	0	0	1999	0
4-Speed Automatic	4.5	285	0	10	0	1980	0
5-Speed Automatic	6.5	435	0	20	0	1995	0
6-Speed Automatic	8	570	0	30	0	2004	0
6-Speed Manual	2	100	0	20	0	1995	0
CVT	10.5	615	0	-25	0	1998	0
Automated Manual Trans	8	100	0	0	0	2006	0
Roller Cam	2	16	0	0	0	1980	0
OHC/AdvOHV-4 Cylinder	3	80	0	0	0	1980	10
OHC/AdvOHV-6 Cylinder	3	100	0	0	0	1987	10
OHC/AdvOHV-8 Cylinder	3	120	0	0	0	1986	10
4-Valve/4-Cylinder	8	205	0	10	0	1988	17
4-Valve/6-Cylinder	8	280	0	15	0	1992	17
4 Valve/8-Cylinder	8	320	0	20	0	1994	17
5 Valve/6-Cylinder	8	300	0	18	0	1998	20
VVT-4 Cylinder	2.5	45	0	10	0	1994	5
VVT-6 Cylinder	2.5	115	0	20	0	1993	5
VVT-8 Cylinder	2.5	115	0	20	0	1993	5
VVL-4 Cylinder	4	170	0	25	0	1997	10
VVL-6 Cylinder	4	260	0	40	0	2000	10
VVL-8 Cylinder	4	330	0	50	0	2000	10
Camless Valve Actuation-4cyl	7.5	450	0	35	0	2009	13
Camless Valve Actuation-6cyl	7.5	600	0	55	0	2008	13
Camless Valve Actuation-8cyl	7.5	750	0	75	0	2007	13
Cylinder Deactivation	4.5	250	0	10	0	2004	0
Turbocharging/ Supercharging	6	650	0	-100	0	1980	15
Engine Friction Reduction I	2	25	0	0	0	1992	3
Engine Friction Reduction II	3.5	63	0	0	0	2000	5
Engine Friction Reduction III	5	114	0	0	0	2008	7
Engine Friction Reduction IV	6.5	177	0	0	0	2016	9
Stoichiometric GDI/4-Cylinder	7	300	0	20	0	2006	10
Stoichiometric GDI/6-Cylinder	7	450	0	30	0	2006	10
Lean Burn GDI	5	250	0	20	0	2006	0
5W-30 Engine Oil	1	22.5	0	0	0	1998	0
5W-20 Engine Oil	2	37.5	0	0	0	2003	0
OW-20 Engine Oil	3.1	150	0	0	0	2030	0
Electric Power Steering	2	140	0	0	0	2004	0
Improved Alternator	0.3	15	0	0	0	2005	0
Improved Oil/Water Pump	0.5	10	0	0	0	2000	0
Electric Oil/Water Pump	1	50	0	0	0	2007	0
Tires II	2	30	0	-8	0	1995	0
Tires III	4	75	0	-12	0	2005	0
Tires IV	6	135	0	-16	0	2015	0
Front Wheel Drive	6	250	0	0	-6	1980	0
Four Wheel Drive Improvements	2	100	0	0	-1	2000	0
42V-Launch Assist and Regen	3	600	0	80	0	2005	-5
42V-Engine Off at Idle	4.5	800	0	45	0	2005	0
Tier 2 Emissions Technology	-1	120	0	20	0	2006	0
Increased Size/Weight	-1.7	0	0	0	2.55	2001	0
Variable Compression Ratio	4	450	0	25	0	2015	0

[1] Fractional changes refer to the percentage change from the 1990 values.
Sources: Energy and Environment Analysis, *Documentation of Technology included in the NEMS Fuel Economy Model for Passenger Cars and Light Trucks* (September, 2002). National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (Copyright 2002).

Table 27. Standard Technology Matrix For Light Trucks[1]

	Fractional Fuel Efficiency Change	Incremental Cost (1990$)	Incremental Cost ($/UnitWt.)	Incremental Weight (Lbs.)	Incremental Weight (Lbs./UnitWt.)	Introduction Year	Fractional Horse-power Change
Unit Body Construction	4	100	0	0	-6	1980	0
Material Substitution II	3.3	0	0.4	0	-5	1994	0
Material Substitution III	6.6	0	0.6	0	-10	2002	0
Material Substitution IV	9.9	0	0.9	0	-15	2010	0
Material Substitution V	13.2	0	1.2	0	-20	2018	0
Drag Reduction II	2.3	40	0	0	0	1992	0
Drag Reduction III	4.4	85	0	0	0.2	1998	0
Drag Reduction IV	6.3	145	0	0	0.5	2006	0
Drag Reduction V	8	225	0	0	1	2014	0
Roll-Over Technology	-1.5	100	0	0	2.2	2006	0
Side Impact Technology	-1.5	100	0	0	2.2	2006	0
Adv Low Loss Torque Converter	2	25	0	0	0	2005	0
Early Torque Converter Lockup	0.5	8	0	0	0	2006	0
Aggressive Shift Logic	2	60	0	0	0	2006	0
4-Speed Automatic	4.5	285	0	10	0	1980	0
5-Speed Automatic	6.5	435	0	20	0	1999	0
6-Speed Automatic	8	570	0	30	0	2008	0
6-Speed Manual	2	100	0	20	0	2000	0
CVT	10.5	615	0	-25	0	2008	0
Automated Manual Trans	8	100	0	0	0	2010	0
Roller Cam	2	16	0	0	0	1985	0
OHC/AdvOHV-4 Cylinder	3	80	0	0	0	1980	10
OHC/AdvOHV-6 Cylinder	3	100	0	0	0	1990	10
OHC/AdvOHV-8 Cylinder	3	120	0	0	0	1990	10
4-Valve/4-Cylinder	7	205	0	10	0	1998	17
4-Valve/6-Cylinder	7	280	0	15	0	2000	17
4 Valve/8-Cylinder	7	320	0	20	0	2000	17
5 Valve/6-Cylinder	7	300	0	18	0	2010	20
VVT-4 Cylinder	2.5	45	0	10	0	1998	5
VVT-6 Cylinder	2.5	115	0	20	0	1997	5
VVT-8 Cylinder	2.5	115	0	20	0	1997	5
VVL-4 Cylinder	4	170	0	25	0	2002	10
VVL-6 Cylinder	4	260	0	40	0	2001	10
VVL-8 Cylinder	4	330	0	50	0	2006	10
Camless Valve Actuation-4cyl	7.5	450	0	35	0	2014	13
Camless Valve Actuation-6cyl	7.5	600	0	55	0	2012	13
Camless Valve Actuation-8cyl	7.5	750	0	75	0	2011	13
Cylinder Deactivation	4.5	250	0	10	0	2004	0
Turbocharging/Supercharging	6	650	0	-100	0	1987	15
Engine Friction Reduction I	2	25	0	0	0	1992	3
Engine Friction Reduction II	3.5	63	0	0	0	2000	5
Engine Friction Reduction III	5	114	0	0	0	2010	7
Engine Friction Reduction IV	6.5	177	0	0	0	2016	9
Stoichiometric GDI/4-Cylinder	7	300	0	20	0	2008	10
Stoichiometric GDI/6-Cylinder	7	450	0	30	0	2010	10
Lean Burn GDI	5	250	0	20	0	2010	0
5W-30 Engine Oil	1	22.5	0	0	0	1998	0
5W-20 Engine Oil	2	37.5	0	0	0	2003	0
OW-20 Engine Oil	3.1	150	0	0	0	2030	0
Electric Power Steering	2	140	0	0	0	2005	0
Improved Alternator	0.3	15	0	0	0	2005	0
Improved Oil/Water Pump	0.5	10	0	0	0	2000	0
Electric Oil/Water Pump	1	50	0	0	0	2008	0
Tires II	2	30	0	-8	0	1995	0
Tires III	4	75	0	-12	0	2005	0
Tires IV	6	135	0	-16	0	2015	0
Front Wheel Drive	2	250	0	0	-3	1984	0
Four Wheel Drive Improvements	2	100	0	0	-1	2000	0
42V-Launch Assist and Regen	3	600	0	80	0	2005	-5
42V-Engine Off at Idle	4.5	800	0	45	0	2005	0
Tier 2 Emissions Technology	-1	160	0	20	0	2006	0
Increased Size/Weight	-2.5	0	0	0	3.75	2001	0
Variable Compression Ratio	4	450	0	25	0	2015	0

[1]Fractional changes refer to the percentage change from the 1990 values.

Sources: Energy and Environment Analysis, *Documentation of Technology included in the NEMS Fuel Economy Model for Passenger Cars and Light Trucks* (September, 2002). National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (Copyright 2002).

Degradation factors (Table 28) used to convert Environmental Protection Agency-rated fuel economy to actual "on the road" fuel economy are based on application of a logistic curve to the projections of three factors: increases in city/highway driving, increasing congestion levels, and rising highway speeds.[34] Baseline degradation factors are then adjusted to reflect the percentage of reformulated gasoline consumed.

Table 28. Car and Light Truck Degradation Factors

	2000	2005	2010	2015	2020	2030
Cars	79.2	79.7	80.0	80.2	80.6	81.0
Light Trucks	79.9	77.3	77.5	77.6	77.7	78.0

Source: Energy Information Administration, *Transportation Sector Model of the National Energy Modeling System, Model Documentation 2005*, DOE/EIA-M070(2006), (Washington, DC, 2006).

The vehicle miles traveled (VMT) module forecasts VMT as a function of the cost of driving per mile, and disposable personal income per capita. Coefficients were re-estimated for *AEO2007*. Based on output from the model, the fuel price elasticity rises to a maximum of -0.4 as fuel prices rise above reference case levels in each year.

Commercial Light-Duty Fleet Assumptions

With the current focus of transportation legislation on commercial fleets and their composition, the Transportation Demand Module is designed to divide commercial light-duty fleets into three types: business, government, and utility. Based on this classification, commercial light-duty fleet vehicles vary in survival rates and duration in fleet use before being sold for use as personal vehicles (Table 29). While the total number of vehicles sold to fleets can vary over time, the share of total fleet sales by fleet type is held constant at 2000 levels in the Transportation Demand Module. Of total automobile sales to fleets, 91.1 percent are used in business fleets, 6.4 percent in government fleets, and 2.4 percent in utility fleets. Of total light truck sales to fleets, 56.8 percent are used in business fleets, 12.3 percent in government fleets, and 31.0 percent in utility fleets.[35] Both the automobile and light truck shares by fleet type are held constant from 2002 through 2030. In 2003, 19.7 percent of all automobiles sold and 12.8 percent of all light trucks sold were for fleet use. The share of total automobile and light truck sales to fleet remains constant at these levels over the entire forecast period.

Table 29. The Average Length of Time Vehicles Are Kept Before they are Sold to Others
(Months)

Vehicle Type	Business	Utility	Government
Cars	35	68	81
Light Trucks	56	60	82
Medium Trucks	83	86	96
Heavy Trucks	103	132	117

Source: Oak Ridge National Laboratory, *Fleet Characteristics and Data Issues*, Stacy Davis and Lorena Truett, final report prepared for the Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting, (Oak Ridge, TN, January 2003).

Alternative-fuel shares of fleet sales by fleet type are held constant at year 2000 levels (business (4.78 percent), government (7.91 percent), utility (0.84 percent)),[36] but compared to a minimum level of sales based on legislative initiatives, such as the Energy Policy Act of 1992 and the Low Emission Vehicle Program.[37],[38] Size class sales shares of vehicles are held constant at anticipated levels (Table 30).[39] Individual sales shares of alternative-fuel fleet vehicles by technology type are assumed to remain constant for utility, government, and for business fleets[40] (Table 31).

Annual VMT per vehicle by fleet type stays constant over the forecast period based on the Oak Ridge National Laboratory fleet data.

Fleet fuel economy for both conventional and alternative-fuel vehicles is assumed to be the same as the personal new vehicle fuel economy and is subdivided into six EPA size classes for cars and light trucks.

Table 30. Commercial Fleet Size Class Shares by Fleet and Vehicle Type
(Percentage)

Fleet Type by Size Class	Automobiles	Light Trucks
Business Fleet		
Mini	0.04	3.77
Subcompact	25.32	11.91
Compact	23.18	37.87
Midsize	41.93	7.92
Large	9.45	3.58
2-seater	0.08	34.96
Government Fleet		
Minl	0.03	7.76
Subcompact	7.64	42.29
Compact	9.08	9.16
Midsize	29.03	18.86
Large	54.21	0.21
2-seater	0.01	21.72
Utility Fleet		
Mini	0.04	13.50
Subcompact	25.32	42.68
Compact	23.18	5.43
Midsize	41.93	26.14
Large	9.45	1.14
2-seater	0.08	11.11

Source: Oak Ridge National Laboratory, *Fleet Characteristics and Data Issues*, Stacy Davis and Lorena Truett, final report prepared for the Department of Energy, Energy Information Administration, Office of Integrated Analysis and Forecasting, (Oak Ridge, TN, January 2003).

Table 31. Purchases of Alternative-Fuel Vehicles by Fleet Type and Technology Type
(Percentage)

Technology	Business	Government	Utility
Ethanol	72.6	54.0	26.8
Methanol	0.0	0.0	0.0
Electric	1.1	3.0	1.1
CNG	4.6	8.5	17.3
LPG	21.7	34.5	54.7

Sources: Energy Information Administration, *Describing Current and Potential Markets for Alternative Fuel Vehicles*, DOE/EIA-0604(96), (Washington, DC, March 1996). Energy Information Administration, *Alternatives to Traditional Transportation Fuels* http://www.eia.doe.gov/cneaf/solar.renewables/alt_trans_fuel98/table14.html.

The Light Commercial Truck Model

The Light Commercial Truck Module of the NEMS Transportation Model is constructed to represent light trucks that weigh 8,501 to 10,000 pounds gross vehicle weight (Class 2B vehicles). These vehicles are assumed to be used primarily for commercial purposes.

The module implements a twenty-year stock model that estimates vehicle stocks, travel, fuel efficiency, and energy use by vintage. Historic vehicle sales and stock data, which constitute the baseline from which the forecast is made, are taken from a recent Oak Ridge National Laboratory study.[41] The distribution of vehicles by vintage, and vehicle scrappage rates is derived from R.L. Polk company registration data.[42,43] Vehicle travel by vintage was constructed using vintage distribution curves and estimates of average annual travel by vehicle.[44,45]

The growth in light commercial truck VMT is a function of industrial output for agriculture, mining, construction, trade, utilities, and personal travel. These industrial groupings were chosen for their correspondence with output measures being forecast by NEMS. The overall growth in VMT reflects a weighted average based upon the distribution to total light commercial truck VMT by sector. Forecasted fuel efficiencies are assumed to increase at the same annual growth rate as light-duty trucks (<8,500 pounds gross vehicle weight).

Consumer Vehicle Choice Assumptions

The Consumer Vehicle Choice Module (CVCM) utilizes a nested multinomial logit (NMNL) model that predicts sales shares based on relevant vehicle and fuel attributes. The nesting structure first predicts the probability of fuel choice for multi-fuel vehicles within a technology set. The second level nesting predicts penetration among similar technologies within a technology set (i.e., gasoline versus diesel hybrids). The third level choice determines market share among the different technology sets.[46] The technology sets include:

- Conventional fuel capable (gasoline, diesel, bi-fuel and flex-fuel),
- Hybrid (gasoline and diesel),
- Dedicated alternative fuel (CNG, LPG, methanol, and ethanol),
- Fuel cell (gasoline, methanol, and hydrogen), and
- Electric battery powered (lead acid, nickel-metal hydride, lithium polymer)[47]

The vehicle attributes considered in the choice algorithm include: price, maintenance cost, battery replacement cost, range, multi-fuel capability, home refueling capability, fuel economy, acceleration and luggage space. With the exception of maintenance cost, battery replacement cost, and luggage space, vehicle attributes are determined endogenously.[48] The fuel attributes used in market share estimation include availability and price. Vehicle attributes vary by six EPA size classes for cars and light trucks and fuel availability varies by Census division. The NMNL model coefficients were developed to reflect purchase decisions for cars and light trucks separately.

Where applicable, CVCM fuel efficient technology attributes are calculated relative to conventional gasoline miles per gallon. It is assumed that many fuel efficiency improvements in conventional vehicles will be transferred to alternative-fuel vehicles. Specific individual alternative-fuel technological improvements are also dependent upon the CVCM technology type, cost, research and development, and availability over time. Make and model availability estimates are assumed according to a logistic curve based on the initial technology introduction date and current offerings. Coefficients summarizing consumer valuation of vehicle attributes were derived from assumed economic valuation compared to vehicle price elasticities. Initial CVCM vehicle stocks are set according to EIA surveys.[49] A fuel switching algorithm based on the relative fuel prices for alternative fuels compared to gasoline is used to determine the percentage of total VMT represented by alternative fuels in bi-fuel and flex-fuel alcohol vehicles.

Freight Truck Assumptions

The freight truck module estimates vehicle stocks, travel, fuel efficiency, and energy use of three size classes: light medium (Class 3), heavy medium (Classes 4 –6), and heavy (Classes 7-8). Within the size classes, the stock model structure is designed to cover twenty vehicle vintages and estimate energy use by four fuel types: diesel, gasoline, LPG, and CNG. Fuel consumption estimates are reported regionally (by Census Division) according to the distillate fuel shares from the *State Energy Data Report*. [50] The technology input data specific to the different types of trucks including the year of introduction, incremental fuel efficiency improvement, and capital cost of introducing the new technologies, is shown in Table 32.

Table 32. Standard Technology Matrix for Freight Trucks

	Medium Light Trucks			Medium Heavy Trucks			Heavy Trucks		
Technology Type	Introd-uction Year	Capital Cost	Incr. Fuel Econ. Improve-ment	Introd-uction Year	Capital Cost	Incr. Fuel Econ. Improve-ment	Introd-uction Year	Capital Cost	Incr. Fuel Econ. Improve-ment
Areo dynamic I: Cab top deflector, sloping hood and cab side flares	2002	600.00	0.025	N/A	750.00	0.025	N/A	750.00	0.020
Closing/covering of gap between tractor and trailer, aero dynamic bumper, underside air baffles, wheel well covers	N/A	N/A	0.000	2004	800.00	0.040	2005	1500.00	0.025
Trailer leading and trailing edge curvatures	N/A	N/A	0.000	2005	400.00	0.010	2005	500.00	0.013
Aero Dynamics IV: pneumatic blowing	N/A	N/A	0.000	N/A	N/A	0.000	2010	2500.00	0.050
Tires I: radials	0	40.00	0.020	N/A	N/A	0.000	2010	2500.00	0.050
Tires II: low rolling resistance	2004	180.00	0.025	2005	280.00	0.025	2005	550.00	0.030
Tires III: super singles	N/A	N/A	0.000	N/A	N/A	0.000	2008	700.00	0.020
Tires IV: reduced rolling resistance from pneumatic blowing	N/A	N/A	0.000	N/A	N/A	0.000	2015	500.00	0.012
Transmission: lock-up, electronic controls, reduced friction	2005	750.00	0.020	2005	900.00	0.020	2005	1000.00	0.020
Diesel Engine I: turbocharged, direct injection with better thermal management	2003	700.00	0.050	2004	1000.00	0.080	N/A	N/A	0.000
Diesel Engine II: integrated starter/alternator with idle off and limited regenerative breaking	2005	1500.00	0.050	2005	1200.00	0.050	N/A	N/A	0.000
Diesel Engine III: improved engine iwth lower friction, better injectors, and efficient combustion	2012	2000.00	0.100	2008	2000.00	0.080	N/A	300.00	0.000
Diesel Engine IV: hybrid electric powertrain	2010	6000.00	0.400	2010	8000.00	0.400	N/A	N/A	0.000
Diesel Engine V: internal friction reduction - improved lubricants and bearings	N/A	N/A	0.000	N/A	N/A	0.000	2005	N/A	0.020
Diesel Engine VI: increased peak cylinder pressure	N/A		0.000	N/A	N/A	0.000	2006	N/A	0.040
Diesel Engine VII: improved injectors and more efficient combustion	N/A	N/A	0.000	N/A	N/A	0.000	2007	N/A	0.060

Table 32. Standard Technology Matrix for Freight Trucks (cont.)

Technology Type	Medium Light Trucks			Medium Heavy Trucks			Heavy Trucks		
	Introd-uction Year	Capital Cost	Incr. Fuel Econ. Improve-ment	Introd-uction Year	Capital Cost	Incr. Fuel Econ. Improve-ment	Introd-uction Year	Capital Cost	Incr. Fuel Econ. Improve-ment
Gasoline Engine I: electronic fuel injection, DOHC, multiple values	2003	700.00	0.050	2003	1000.00	0.050	N/A	N/A	0.000
Gasoline Engine II: integrated starter/alternator with idle off and limited regenerative breaking	2005	1000.00	0.050	2005	1200.00	0.080	N/A	N/A	0.000
Gasoline Engine III: direct injection (GDI)	2008	700.00	0.120	2008	1000.00	0.120	N/A	N/A	0.000
Gasoline Engine IV; hybrid electric powertrain	2010	6000.00	0.450	2010	8000.00	0.450	N/A	N/A	0.000
Weight Reduction I: high strength lightweight materials	2010	1300.00	0.050	2007	2000.00	0.050	2005	2000.00	0.100
Diesel Emission-NO_x I: exhaust recirculation, timing retard, selective catalytic reduction	2002	250.00	-0.040	2003	400.00	-0.040	2003	500.00	-0.040
Diesel Emissions-NO_x II: nitrogen enriched combustion air	2003	500.00	-0.005	2003	700.00	-0.005	2003	750.00	-0.005
Diesel Emissions-NO_x III: non-thermal plasma catalyst	2007	1000.00	-0.015	2006	1200.00	-0.015	2007	1250.00	-0.015
Diesel Emissions-NO_x IV: NO_x absorber system	2007	1500.00	-0.030	2006	2000.00	-0.030	2007	2500.00	-0.030
Diesel Emission-PM I: oxidation catalyst	2002	150.00	-0.005	2002	200.00	-0.005	2002	250.00	-0.005
Diesel Emission-PM II: catalytic particulate filter	2006	1000.00	-0.015	2006	1250.00	-0.025	2006	1500.00	-0.015
Diesel Emission-HC/CO I: oxidation catalyst	2002	150.00	-0.005	2002	200.00	-0.005	2002	250.00	-0.005
Diesl Emission-HC/CO II: closed crankcase system	2005	50.00	0.000	2005	65.00	0.000	2005	75.00	0.000
Gasoline Emission-PM I: Improved oxidation catalyst	2005	250.00	0.000	2005	350.00	-0.003	N/A	N/A	0.000
Gasoline Emission-NO_x I: EGR/spark retard	2002	25.00	-0.003	2002	25.00	-0.015	N/A	N/A	0.000
Gasoline Emission-NO_x II: oxygen sensors	2003	75.00	-0.015	2003	75.00	0.000	N/A	N/A	0.000
Gasoline Emission-NO_x III: secondary air/closed loop system	2008	50.00	0.000	2008	50.00	0.000	N/A	N/A	0.000

Table 32. Standard Technology Matrix for Freight Trucks (cont.)

	Medium Light Trucks			Medium Heavy Trucks			Heavy Trucks		
Technology Type	Introduction Year	Capital Cost	Incr. Fuel Econ. Improvement	Introduction Year	Capital Cost	Incr. Fuel Econ. Improvement	Introduction Year	Capital Cost	Incr. Fuel Econ. Improvement
Gasoline Emission-HC/CO I: oxygen sensors	2003	75.00	0.000	2003	75.00	0.000	N/A	N/A	0.000
Gasoline Emission-HC/CO II: evap. canister w/improved vaccum, materials, and connectors	2003	50.00	0.000	2003	50.00	0.000	N/A	N/A	0.000
Gasoline Emission-HC/CO III: oxidation catalyst	2005	250.00	-0.003	2005	350.00	-0.003	N/A	N/A	0.000

1. Payback period is same for the three modes.

The freight module uses projections of dollars of industrial output to estimate growth in freight truck travel. The industrial output is converted to an equivalent measure of volume output using freight adjustment coefficients. [51],[52] These freight adjustment coefficients vary by North American Industrial Classification System (NAICS) code with the deviation diminishing gradually over time toward parity. Freight truck load-factors (ton-miles per truck) by NAICS code are constants formulated from historical data. [53]

Fuel economy of new freight trucks is dependent on the market penetration of various emission control technologies and advanced technology components.[54] For the advanced technology components, market penetration is determined as a function of technology type, cost effectiveness, and introduction year. Cost effectiveness is calculated as a function of fuel price, vehicle travel, fuel economy improvement, and incremental capital cost. Emissions control equipment is assumed to enter the market to meet regulated emission standards.

Heavy truck freight travel is estimated by class size and fuel type based on matching projected freight travel demand (measured by industrial output) to the travel supplied by the current fleet. Travel by vintage and size class is then adjusted so that total travel meets total demand. Initial heavy vehicle travel, by vintage and size class, is derived using Vehicle Inventory and Use Survey (VIUS) data. [55]

Initial freight truck stocks by vintage are obtained from R. L. Polk Co. and are distributed by fuel type using VIUS data. [56] Vehicle scrappage rates are also estimated using R. L. Polk Co. data. [57]

Freight and Transit Rail Assumptions

The freight rail module uses the industrial output by NAICS code measured in real 1987 dollars and converts these dollars into an adjusted volume equivalent. Coal production from the NEMS Coal Market Module is used to adjust coal rail travel. Freight rail adjustment coefficients (used to convert dollars to volume equivalents) are based on historical data and remain constant. [58],[59] Initial freight rail efficiencies are based on the freight model from Argonne National Laboratory. [60] The distribution of rail fuel consumption by fuel type is also based on historical data and remains constant. [61] Regional freight rail consumption estimates are distributed according to the *State Energy Data Report 1999*. [62]

Domestic and International Shipping Assumptions

As done in the previous sub-module, the domestic freight shipping module uses the industrial output by NAICS code measured in real 1987 dollars and converts these dollars into an adjusted volume equivalent.

The freight adjustment coefficients (used to convert dollars to volume equivalents) are based on historical data. Domestic shipping efficiencies are based on the model developed by Argonne National Laboratory. The energy consumption in the international shipping module is a function of the total level of imports and exports. The distribution of domestic and international shipping fuel consumption by fuel type is based on historical data and remains constant throughout the forecast. [63] Regional domestic shipping consumption estimates are distributed according to the residual oil regional shares in the *State Energy Data Report*. [64]

Air Travel Demand Assumptions

The air travel demand module calculates the domestic and international ticket prices for travel as a function of fuel cost. The ticket price is constrained to be no lower than the current lowest cost per mile provider, adjusted by load factor. Domestic and international revenue passenger miles are based on historic data,[65] per capita income, and ticket price. The revenue ton miles of air freight are based on merchandise exports, gross domestic product, and fuel cost.[66]

Airport capacity constraints based on the *FAA's Airport Capacity Benchmark Report 2004* are incorporated into the air travel demand module using airport capacity measures.[67] Airport capacity is defined by the maximum number of flights per hour airports can routinely handle, the amount of time airports operate at optimal capacity, and passenger load factors. Capacity is expected to increase over time due to planned infrastructure improvements. If the projected demand in air travel exceeds the capacity constraint, demand is reduced to match the constraint.

Aircraft Stock/Efficiency Assumptions

The aircraft stock and efficiency module consists of a stock model of wide body, narrow body, and regional jets by vintage. Total aircraft supply for a given year is based on the initial supply of aircraft for model year 2003, new passenger sales, and the survival rate by vintage (Table 33).[68] New passenger sales are a function of revenue passenger miles and gross domestic product.

Older planes, wide and narrow body planes over 25 years of age are placed as cargo jets according to a cargo percentage varying from 50 percent of 25 year old planes to 100 percent of those aircraft 30 years and older. The available seat-miles per plane, which measure the carrying capacity of the airplanes by aircraft type, vary over time, with wide bodies remaining constant and narrow bodies increasing.[69] The difference between the seat-miles demanded and the available seat-miles represents potential newly purchased aircraft. If demand is less than supply, then passenger aircraft is parked, starting with twenty nine year old aircraft, at a pre-defined rate. Aircraft continues to be parked until equilibrium is reached. If supply is less than demand planes that have been temporarily stored, or parked, are brought back into service.

Technological availability, economic viability, and efficiency characteristics of new aircraft are based on the technologies listed in the Oak Ridge National Laboratory Air Transport Energy Use Model (Table 34)[70] Fuel efficiency of new aircraft acquisitions represents, at a minimum, a 5-percent improvement over the stock efficiency of surviving airplanes.[71] Maximum growth rates of fuel efficiency for new aircraft are based on a future technology improvement list consisting of an estimate of the introduction year, jet fuel price, and an estimate of the proposed marginal fuel efficiency improvement. Regional shares of all types of aircraft fuel use are assumed to be constant and are consistent with the *State Energy Data Report* estimate of regional jet fuel shares.[72]

Legislation

The Energy Policy Act of 2005

The Energy Policy Act of 2005 provides tax credits for the purchase of vehicles that have a lean burn engine or employ a hybrid or fuel cell propulsion system. The amount of the credit received for a vehicle is based the vehicle's inertia weight, improvement in city tested fuel economy relative to an equivalent 2002 base year value, emissions classification, and type of propulsion system. The tax credit is also sales limited by manufacturer for vehicles with lean burn engines or hybrid propulsion systems. After December 31, 2005, the first calendar quarter a manufacturer's sales of lean burn or hybrid vehicles reaches 60,000 units, the phase out period begins. Reduction of credits begins in the second calendar quarter following the initial quarter the sales maximum was reached. For that quarter and the following quarter, the applicable tax credit will be reduced by 50 percent. For the subsequent third and fourth calendar quarters, the applicable tax credit is reduced to 25 percent of the original value. These tax credits are included in the AEO2007.

Table 33. 2005 Passenger and Cargo Aircraft Supply and Survival Rate

		Age of Aircraft (years)				
Aircraft Type	New	1-10	11-20	21-30	>30	Total
Passenger						
Narrow Body	120	1,588	1,521	544	324	4,097
Wide Body	3	316	263	159	39	780
Regional Jets	191	1,713	84	7	12	2,007
Cargo						
Narrow Body	0	28	57	173	373	631
Wide Body	7	137	165	222	70	601
Survival Curve (fraction)	New	5	10	20	30	
Narrow Body	1.0000	0.9998	0.9992	0.9911	0.9256	
Wide Body	1.0000	0.9980	0.9954	0.9754	0.8892	
Regional Jets	1.0000	0.9967	0.9942	0.9816	0.9447	

Source: Jet Information Services, 2005 World Jet Inventory, data tables (2005).

Table 34. Future New Aircraft Technology Improvement List

Proposed Technology	Introduction Year	Jet Fuel Price Necessary For Cost-Effectiveness (2003 dollars per gallon)	Seat-Miles per Gallon Gain Over 1990 (percent)
Engines			
Ultra-high Bypass	2008	$0.70	10
Propfan	2000	$1.72	23
Thermodynamics	2010	$1.55	20
Aerodynamics			
Hybrid Laminar Flow	2020	$1.93	15
Advanced Aerodynamics	2000	$2.15	18
Other			
Weight Reducing Materials	2000	-	15

Source: Greene, D.L., *Energy Efficiency Improvement Potential of Commercial Aircraft to 2010*, ORNL-6622, 6/1990., and from data tables in the Air Transportation Energy Use Model (ATEM), Oak Ridge National Laboratory.

Energy Policy Act of 1992 (EPACT)

Fleet alternative-fuel vehicle sales necessary to meet the EPACT regulations are derived based on the mandates as they currently stand and the Commercial Fleet Vehicle Module calculations. Total projected AFV sales are divided into fleets by government, business, and fuel providers (Table 35). Business fleet EPACT mandates are not included in the projections for AFV sales pending a decision on a proposed rulemaking.

Table 35. EPACT Legislative Mandates for AFV Purchases by Fleet Type and Year
(Percent)

Year	Municipal & Business	Federal	State	Fuel Providers	Electric Utilities
1996	-	25	-	-	-
1997	-	33	10	30	-
1998	-	50	15	50	30
1999	-	75	25	70	50
2000	-	75	50	90	70
2001	-	75	75	90	90
2002	20	75	75	90	90
2003	40	75	75	90	90
2004	60	75	75	90	90
2005	70	75	75	70	90

Source: EIA, *Alternatives to Traditional Transportation Fuels 1994*, DOE/EIA-0585(94), (Washington, D.C, February 1996).

Because the commercial fleet model operates on three fleet type representations (business, government, and utility), the federal and state mandates are weighted by fleet vehicle stocks to create a composite mandate for both. The same combining methodology is used to create a composite mandate for electric utilities and fuel providers based on fleet vehicle stocks.[73] Fleet vehicle stocks by car and light truck are disaggregated to include only fleets of 50 or more (in accordance with EPACT) by using a fleet size distribution function based on The Fleet Factbook and the Truck and Inventory Use Survey.[74],[75] To account for the EPACT regulations which stipulate that "covered" fleets (which refer to fleets bound by the EPACT mandates) include only fleets in the metropolitan statistical areas (MSA's) of 250,000 population or greater, 90 percent of the business and utility fleets are included and 63 percent are included for government fleets.[76] EPACT covered fleets only include those fleets that can be centrally fueled, which is assumed to be 50 percent of the fleets for all fleet types, and only fleets of 50 or more that had 20 vehicles or more in those MSA's of 250,000 or greater population. It is assumed that 90 percent of all fleets are within this category except for business fleets, which are assumed to be 75 percent.[77]

Low Emission Vehicle Program (LEVP)

The LEVP was originally passed into legislation in 1990 in the State of California. It began as the implementation of a voluntary opt-in pilot program under the purview of Clean Air Act Amendments of 1990 (CAAA90), which included a provision that other States could opt in to the California program to achieve lower emissions levels than would otherwise be achieved through CAAA90. Connecticut, Maine, Massachusetts, New Jersey, New York, Rhode Island, Vermont, Oregon, and Washington have elected to adopt the California LEVP.

The LEVP is an emissions-based policy, setting sales mandates for 6 categories of low-emission vehicles: low-emission vehicles (LEVs), ultra-low-emission vehicles (ULEVs), super-ultra low emission vehicles (SULEVs), partial zero-emission vehicles (PZEVs), advanced technology partial zero emission vehicles (AT-PZEVs), and zero-emission vehicles (ZEVs). The LEVP requires that in 2005 10 percent of a manufacturer's sales are ZEVs or equivalent ZEV earned credits, increasing to 11 percent in 2009, 12 percent in 2012, 14 percent in 2015, and 16 percent in 2018 where it remains constant thereafter. In August 2004, CARB enacted further amendments to the LEVP that place a greater emphasis on emissions reductions from PZEVs and AT-PZEVs and requires that manufacturers produce a minimum number of fuel cell and electric vehicles. In addition, manufacturers are allowed to adopt alternative compliance requirements for ZEV sales that are based on cumulative fuel cell vehicle sales targets for vehicles sold in all States participating in California's LEVP. Under the alternative compliance requirements, ZEV credits can also be earned by selling battery electric vehicles. Currently, all manufacturers have opted to adhere to the alternative compliance requirements. The mandate still includes phase-in multipliers for pure ZEVs and allows 20 percent of the sales requirement to be met with AT-PZEVs and 60 percent of the requirement to be met with PZEVs. AT-PZEVs and PZEVs are allowed 0.2 credits per vehicle. EIA assumes that credit allowances for PZEVs will be met with conventional vehicle technology, hybrid vehicles will be sold to meet the AT-PZEV allowances, and that hydrogen fuel cell vehicles will be sold to meet the pure ZEV requirements under the alternative compliance path.

The vehicle sales module compares the legislatively mandated sales to the results from the consumer driven sales shares. If the consumer driven sales shares are less than the legislatively mandated sales requirements, then the legislative requirements serve as a minimum constraint for the hybrid, electric, and fuel cell vehicle sales.

High Technology and 2006 Technology Cases

In the *high technology case*, the conventional fuel saving technology characteristics came from a study by the American Council for an Energy Efficient Economy.[78] Tables 36 and 37 summarize the High Technology matrix for cars and light trucks. High technology case assumptions for heavy trucks reflect the optimistic values, with respect to efficiency improvement, for advanced engine and emission control technologies as reported by ANL.[79]

The *2006 technology case* assumes that new fuel efficiency technologies are held constant at 2006 levels over the forecast. As a result, the energy use in the transportation sector was 5.8 percent higher (2.31 quadrillion Btu) than in the reference case by 2030. Both cases were run with only the transportation demand module rather than as a fully integrated NEMS run. Consequently, no potential macroeconomic feedback on travel demand, or fuel economy was captured.

Table 36. High Technology Matrix For Cars

	Fractional Fuel Efficiency Change	Incremental Cost (1990$)	Incremental Cost ($/Unit Wt.)	Incremental Weight (Lbs.)	Incremental Weight (Lbs./Unit Wt.)	Introduction Year	Fractional Horse-power Change
Unit Body Construction	4	100	0	0	-6	1980	0
Material Substitution II	3.3	0	0.4	0	-5	1990	0
Material Substitution III	6.6	0	0.5	0	-10	1998	0
Material Substitution IV	9.9	0	0.5	0	-15	2006	0
Material Substitution V	13.2	0	1.1	0	-20	2014	0
Drag Reduction II	1.6	0	0	0	0	1988	0
Drag Reduction III	3.2	0	0	0	0.2	1992	0
Drag Reduction IV	6.3	145	0	0	0.5	2002	0
Drag Reduction V	8	225	0	0	1	2010	0
Roll-Over Technology	-1.5	100	0	0	2.2	2005	0
Side Impact Technology	-1.5	100	0	0	2.2	2005	0
Adv Low Loss Torque Converter	2	25	0	0	0	1999	0
Early Torque Converter Lockup	1	8	0	0	0	2002	0
Aggressive Shift Logic	3.5	65	0	0	0	1999	0
4-Speed Automatic	4.5	285	0	10	0	1980	0
5-Speed Automatic	8	410	0	20	0	1995	0
6-Speed Automatic	9.5	495	0	30	0	2004	0
6-Speed Manual	2	80	0	20	0	1995	0
CVT	11.5	365	0	-25	0	1998	0
Automated Manual Trans	8	100	0	0	0	2006	0
Roller Cam	2	16	0	0	0	1980	0
OHC/AdvOHV-4 Cylinder	3	60	0	0	0	1980	10
OHC/AdvOHV-6 Cylinder	3	80	0	0	0	1987	10
OHC/AdvOHV-8 Cylinder	3	100	0	0	0	1986	10
4-Valve/4-Cylinder	8.8	185	0	10	0	1988	17
4-Valve/6-Cylinder	8.8	260	0	15	0	1992	17
4 Valve/8-Cylinder	8.8	320	0	20	0	1994	17
5 Valve/6-Cylinder	9	300	0	18	0	1998	20
VVT-4 Cylinder	2.5	30	0	10	0	1994	5
VVT-6 Cylinder	2.5	90	0	20	0	1993	5
VVT-8 Cylinder	2.5	90	0	20	0	1993	5
VVL-4 Cylinder	7.5	150	0	25	0	1997	10
VVL-6 Cylinder	7.5	205	0	40	0	2000	10
VVL-8 Cylinder	7.5	290	0	50	0	2000	10
Camless Valve Actuation-4cyl	12	450	0	35	0	2009	13
Camless Valve Actuation-6cyl	12	600	0	55	0	2008	13
Camless Valve Actuation-8cyl	12	750	0	75	0	2007	13
Cylinder Deactivation	9	250	0	10	0	2004	0
Turbocharging/ Supercharging	5	475	0	-100	0	1980	15
Engine Friction Reduction I	2	25	0	0	0	1992	3
Engine Friction Reduction II	3.5	63	0	0	0	2000	5
Engine Friction Reduction III	5	114	0	0	0	2008	7
Engine Friction Reduction IV	6.5	177	0	0	0	2016	9
Stoichiometric GDI/4-Cylinder	7	300	0	20	0	2006	10
Stoichiometric GDI/6-Cylinder	7	450	0	30	0	2006	10
Lean Burn GDI	6	250	0	20	0	2006	0
5W-30 Engine Oil	1	10.5	0	0	0	1998	0
5W-20 Engine Oil	2	20	0	0	0	2003	0
OW-20 Engine Oil	3.1	80	0	0	0	2030	0
Electric Power Steering	2	50	0	0	0	2004	0
Improved Alternator	0.3	15	0	0	0	2005	0
Improved Oil/Water Pump	0.5	10	0	0	0	2000	0
Electric Oil/Water Pump	1	50	0	0	0	2007	0
Tires II	1.5	15	0	-8	0	1995	0
Tires III	3	35	0	-12	0	2005	0
Tires IV	6	90	0	-16	0	2015	0
Front Wheel Drive	6	250	0	0	-6	1980	0
Four Wheel Drive Improvements	2	100	0	0	-1	2000	0
42V-Launch Assist and Regen	5	400	0	80	0	2005	-5
42V-Engine Off at Idle	6	500	0	45	0	2005	0
Tier 2 Emissions Technology	-1	120	0	20	0	2006	0
Increased Size/Weight	-1.7	0	0	0	2.55	2001	0
Variable Compression Ratio	4	350	0	25	0	2015	0

Source: Energy and Environmental Analysis, *Documentation of Technology included in the NEMS Fuel Economy Model for Passenger Cars and Light Trucks* (September, 2002). National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (Copyright 2002).

Table 37. High Technology Matrix For Light Trucks

	Fractional Fuel Efficiency Change	Incremental Cost (1990$)	Incremental Cost ($/Unit Wt.)	Incremenal Weight (Lbs.)	Incremental Weight (Lbs./Unit Wt.)	Introduction Year	Fractional Horse-power Change
Unit Body Construction	4	100	0	0	-6	1980	0
Material Substitution II	3.3	0	0.4	0	-5	1994	0
Material Substitution III	6.6	0	0.5	0	-10	2002	0
Material Substitution IV	9.9	0	0.5	0	-15	2010	0
Material Substitution V	13.2	0	1.1	0	-20	2018	0
Drag Reduction II	1.6	0	0	0	0	1992	0
Drag Reduction III	3.2	0	0	0	0.2	1998	0
Drag Reduction IV	6.3	145	0	0	0.5	2006	0
Drag Reduction V	8	225	0	0	1	2014	0
Roll-Over Technology	-1.5	100	0	0	2.2	2006	0
Side Impact Technology	-1.5	100	0	0	2.2	2006	0
Adv Low Loss Torque Converter	2	25	0	0	0	2005	0
Early Torque Converter Lockup	1	8	0	0	0	2006	0
Aggressive Shift Logic	3.5	65	0	0	0	2006	0
4-Speed Automatic	4.5	285	0	10	0	1980	0
5-Speed Automatic	8	410	0	20	0	1999	0
6-Speed Automatic	9.5	495	0	30	0	2008	0
6-Speed Manual	2	80	0	20	0	2000	0
CVT	11.5	365	0	-25	0	2008	0
Automated Manual Trans	8	100	0	0	0	2010	0
Roller Cam	2	16	0	0	0	1985	0
OHC/AdvOHV-4 Cylinder	3	60	0	0	0	1980	10
OHC/AdvOHV-6 Cylinder	3	80	0	0	0	1990	10
OHC/AdvOHV-8 Cylinder	3	100	0	0	0	1990	10
4-Valve/4-Cylinder	8.8	185	0	10	0	1998	17
4-Valve/6-Cylinder	8.8	260	0	15	0	2000	17
4 Valve/8-Cylinder	8.8	320	0	20	0	2000	17
5 Valve/6-Cylinder	9	300	0	18	0	2010	20
VVT-4 Cylinder	2.5	30	0	10	0	1998	5
VVT-6 Cylinder	2.5	90	0	20	0	1997	5
VVT-8 Cylinder	2.5	90	0	20	0	1997	5
VVL-4 Cylinder	7.5	150	0	25	0	2002	10
VVL-6 Cylinder	7.5	205	0	40	0	2001	10
VVL-8 Cylinder	7.5	290	0	50	0	2006	10
Camless Valve Actuation-4cyl	12	450	0	35	0	2014	13
Camless Valve Actuation-6cyl	12	600	0	55	0	2012	13
Camless Valve Actuation-8cyl	12	750	0	75	0	2011	13
Cylinder Deactivation	9	250	0	10	0	2004	0
Turbocharging/Supercharging	5	475	0	-100	0	1987	15
Engine Friction Reduction I	2	25	0	0	0	1992	3
Engine Friction Reduction II	3.5	63	0	0	0	2000	5
Engine Friction Reduction III	5	114	0	0	0	2010	7
Engine Friction Reduction IV	6.5	177	0	0	0	2016	9
Stoichiometric GDI/4-Cylinder	7	300	0	20	0	2008	10
Stoichiometric GDI/6-Cylinder	7	450	0	30	0	2010	10
Lean Burn GDI	6	250	0	20	0	2010	0
5W-30 Engine Oil	1	10.5	0	0	0	1998	0
5W-20 Engine Oil	2	20	0	0	0	2003	0
OW-20 Engine Oil	3.1	80	0	0	0	2030	0
Electric Power Steering	2	50	0	0	0	2005	0
Improved Alternator	0.3	15	0	0	0	2005	0
Improved Oil/Water Pump	0.5	10	0	0	0	2000	0
Electric Oil/Water Pump	1	50	0	0	0	2008	0
Tires II	1.5	15	0	-8	0	1995	0
Tires III	3	35	0	-12	0	2005	0
Tires IV	6	90	0	-16	0	2015	0
Front Wheel Drive	6	250	0	0	-3	1984	0
Four Wheel Drive Improvements	2	100	0	0	-1	2000	0
42V-Launch Assist and Regen	5	400	0	80	0	2005	-5
42V-Engine Off at Idle	6	500	0	45	0	2005	0
Tier 2 EmissionsTechnology	-1	160	0	20	0	2006	0
Increased Size/Weight	-1.7	0	0	0	3.75	2001	0
Variable Compression Ratio	4	350	0	25	0	2015	0

Source: Energy and Enviromental Analysis, *Documentation of Technology included in the NEMS Fuel Economy Model for Passenger Cars and Light Trucks* (September, 2002). National Research Council, *Effectiveness and Impact of Corporate Average Fuel Economy (CAFE) Standards* (Copyright 2002).

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[74] Bobbit, The Fleet Fact Book, (Redondo Beach, California, 1995).

[75] U.S. Department of Commerce, Bureau of Census, 1992 Truck Inventory and Use Survey, Microdata File on CD, (Washington, DC, 1995).

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[77] Ibid.

[78] Energy and Environmental Analysis, Inc., “Documentation of Technologies Included in the NEMS Fuel Economy Model for Passenger Cars and Light Trucks,” Prepared for the Energy Information Administration, (Arlington, VA, September 30, 2002).

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