OPTION 1E
MORE EFFICIENT ON-ROAD DIESEL MEDIUM- AND HEAVY-DUTY TRUCKS

Description

This paper updates prior analysis[1] performed under legislative direction in 2001 and subsequently incorporated in the proceedings for the 2003 Integrated Energy Policy Report. The option assumes implementation of a regulatory strategy intended to achieve fuel use efficiency improvements in medium- and heavy-duty vehicles, defined as vehicles weighing greater than 14,000 pounds gross vehicle weight. Based on the staff's monitoring of research and development activity by government and industry, we find negligible change in the status, implementation, implementation rate and cost to implement efficient technologies onto heavy-duty vehicle platforms since 2003.

The aggressive scenario under this option assumes implementation of a national fuel economy standard for the heavy-duty vehicle fleet based on the U.S. Department of Energy's (DOE's) 21st Century Truck Program targets.[2] The Business-As-Usual (BAU) scenario assumes fuel economy targets that are less aggressive than the 21st Century Program targets. The less aggressive fuel economy improvement scenario is based on previous studies[3,4,5] that suggest modest efficiency gain potential for medium- and heavy-duty vehicles. These two scenarios of improved fuel economy are used to project upper and lower bound impacts on future diesel fuel demand in California.

For the BAU Scenario, on-road diesel demand is reduced by 2 percent or 0.6 percent of combined gasoline and diesel fuel demand in 2025 with no net direct benefits over the range of fuel prices and discount rates used in the analysis. The net benefit is expressed as a present value result over the period 2005 to 2025. For the Aggressive Scenario, on-road diesel demand is reduced by 42 percent or 11 percent of combined gasoline and diesel fuel demand in 2025 and with positive net direct benefits. The key components in the net direct benefit result are displayed in Tables 1-4 along with their monetary present values.

Table 1: Summary of Results for Low Fuel Price and 5 Percent Discount Rate

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
Business As Usual	0.12	0.57	(0.77)	(0.06)	0.12	0.06	(0.65)
Aggressive	2.3	11	7.5	(1.43)	1.93	1.04	9.04

Table 2: Summary of Results for Low Fuel Price and 12 Percent Discount Rate

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
Business As Usual	0.12	0.57	(0.53)	(0.02)	0.12	0.06	(0.37)
Aggressive	2.3	11	2.3	(0.56)	1.93	1.04	4.71

Table 3: Summary of Results for High Fuel Price and 5 Percent Discount Rate

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
Business As Usual	0.12	0.57	(0.69)	(0.06)	0.12	0.06	(0.49)
Aggressive	2.3	11	9.5	(1.43)	1.93	1.04	11.04

Table 4: Summary of Results for High Fuel Price and 12 Percent Discount Rate

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Highest Cumulative Benefit or Change, Present Value, 2005-2025, 5% discount rate, Billion $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
Business As Usual	0.12	0.57	(0.50)	(0.02)	0.12	0.06	(0.34)
Aggressive	2.3	11	3.1	(0.56)	1.93	1.04	5.51

Previous Studies

Assessments to determine potential vehicle and truck fuel economy improvement have been conducted since the early seventies. We rely on three of those studies to determine the potential for reducing petroleum use from heavy-duty vehicles in this option.

The U.S DOE’s Energy Information Administration (EIA) National Energy Modeling System (NEMS) projects fuel economy improvements based on truck efficiency gains of 0.4 percent per year from a 1982 baseline of 5.2 mph.[6] If this 0.4 percent annual efficiency gain is maintained and applied to the 2000 fleet average fuel economy of 6.5 miles per gallon (mpg), then the fuel economy of heavy trucks (Classes 7 and 8) will have improved to 6.76 mpg, 7.04 mpg, and 7.33 mpg by 2010, 2020, and 2025, respectively. Applying the same improvement rate to the fleet average fuel economy of 12.5 mpg for medium-duty vehicles, (Classes 3-6) could result in fuel economy levels of 13 mpg, 13.5 mpg, and 14.1 mpg by 2010, 2020, and 2025, respectively.

In another technology assessment, DeCicco cites KG Duleep’s estimate for new heavy-duty truck fuel economy improvements of 1.2 percent per year[7]. Applying this fuel economy improvement rate to the 2000 fleet average fuel economy of 6.5 mpg, would result in fuel economy values for class 7 and 8 trucks of 7.3 mpg, 8.3 mpg, and 8.7 mpg by 2010, 2020, and 2025, respectively. The corresponding numbers for medium-duty vehicles are 14.1 mpg, 15.9 mpg, and 16.8 mpg by 2010, 2020, and 2025, respectively.

The American Council for an Energy-Efficient Economy’s (ACEEE‘s) “Transportation Energy Trends in 2030” report[8] assesses long-term potential for heavy-truck fuel economy improvement as 65 percent by 2030 over 1990 levels. This is equivalent to a 1.65 percent annual improvement rate over the 40 year period. The ACEEE projects heavy-truck fuel economy to improve 65 percent by 2030 compared to 1990 levels.[9] This improvement is equivalent to an average annual improvement rate of 1.65 percent over a 40-year period.

We took a simple average of these three previous estimates and the observed annual fuel economy improvement rate of 1.25 percent in the last two decades to establish a lower bound fuel economy improvement rate of 1.125 percent for this analysis. The fuel economy values generated from the 1.125 percent annual fuel economy improvement rate are used in our Scenario 1 (BAU) analysis later. The fuel economy estimates based on this approach are lower than the 21st Century Program goals.

21st Century Program Goals

The U.S. DOE’s 21st Century Truck Program is a government-industry initiative to double the 2000 fuel economy of a prototype Class 8 truck on a ton-mile/gallon basis by 2010. The Truck Program will also triple the fuel economy of a prototype representative Class 2b-6 vehicle, as well as transit buses, on a miles per gallon basis by 2010, while meeting prevailing emission standards.[10]

Applying the 21st Century Program targets to the year 2000 fuel economies on a mpg basis will produce 13 mpg for Class 7 and 8 trucks and 38.1 mpg for Class 3-6 trucks. However, due to the uncertainty in implementing the breakthrough technologies to triple the fuel economy for Class 3-6 vehicles, the analytical team lowered the fuel economy improvement target for Class 3-6 vehicles, to match the 2x multiplier for the Class 7 and 8 vehicles. Therefore, this analysis uses a fuel economy target of 25.4 mpg for Class 3-6 vehicles.

Anticipated improvements in diesel vehicle technologies are the bases for the projected efficiency gains. Technology development and commercialization prospects were determined feasible from a comprehensive assessment of potential technologies in the 21st Century Truck Program Roadmap. According to the Roadmap, fuel economy improvements are possible from a suite of technologies that include combustion improvements, vehicle weight reduction, use of hybrid and auxiliary power technologies, aerodynamic improvements, and rolling and inertia resistance improvements.

Assumptions and Methodology

The following assumptions and methodology are common to the two scenarios considered:

- The assumed fuel economy targets are achieved.
- The 21st Century Truck Program Goals are established as federal fuel economy standards for 2010 and beyond.
- All new vehicles sold comply with the assumed federal fuel economy standards.
- All new vehicles sold comply with the prevailing emission standards.
- Variable penetration rates in all vehicle classes with higher rates in some time periods.[11]
- Certain costs for achieving the fuel economy targets and the estimated petroleum displacements include the added capital costs for hybrid propulsion systems in certain vehicle classes, new electrical systems, and new materials. The costs are distributed across the vehicle classes.

Fuel Economy and Vehicles Miles Traveled

The 2005 base case year fuel economies used for the vehicle classes were determined by reviewing and taking the weighted average of miles traveled and fuel consumed data from several sources.[12,13,14,15] We estimated 12.5 mpg for vehicle Classes 3, 4, 5, and 6 and 6.5 mpg for vehicle Classes 7 and 8. (Our analyses cover Classes 3, 4, 5, 6, 7, and 8. This is a subset of the DOE's program that focuses on Classes 2b through 8.) From the same sources we also determined a fleet average vehicle miles traveled of 36,000 miles for Class 3-6 vehicles and 87,000 miles for Class 7-8 vehicles. We used 16 years as the useful life for the analysis. This is the observed useful life reported in the Gas Research Institute Study for medium- and heavy-duty vehicles.[16]

Since the initial analysis, new information has emerged that suggest the fleet average fuel economy has declined. Several industry reports[17] confirmed the projected fuel economy losses of 3.5 to 5 percent by new diesel vehicles that accompanied the introduction of emission control technologies in October 2002 and 2004. An additional fuel economy drop of 3.5 to 5 percent is anticipated as the 2007 emission standards take effect.[18] Fuel economy decreases of 1 percent to 3 percent are anticipated as new ultra-low sulfur diesel fuel is introduced in 2006.[19]

For this analysis, we adjusted the model year 2000 base fleet average fuel economy for the relevant vehicle classes on a weighted average basis by 8 percent to account for these declines. We then projected future fuel economies from the adjusted base.

For future fuel economies used to assess petroleum reduction potential based on efficient technologies, we used the lower and upper bound numbers discussed previously and summarized in Table 5.

Table 5: Summary of Fuel Economies

	2010		2020		2025	
Scenario	Class 3-6	Class 7-8	Class 3-6	Class 7-8	Class 3-6	Class 7-8
Lower Bound/Nominal Fuel Economy (mpg)	N/A	N/A	14.2	7.1	15	7.5
Upper Bound/ Aggressive Fuel Economy (mpg)	N/A	N/A	24.5	13.5	24.5	13.0

Costs

The incremental capital cost (price) of Class 7 and 8 heavy-duty vehicles with technologies to meet the assumed fuel economy target is estimated to be $7,500 by 2020. This incremental cost declines to $3,600 by 2025-2030. The decline in cost is expected to occur from scale-up in manufacturing volume and learning curve effects.

Medium-duty vehicle incremental capital cost is projected to be $5,000 by 2010, rise to $7,000 by 2020, but decline to $3,000 by 20252030. The anticipated rising trend for medium-duty vehicle incremental cost through 2020 is due to greater deployment of more expensive hybrid technologies that include fuel cell hybrids and advanced batteries. By 2025, we estimate that the incremental cost drops by more than half due to scale manufacturing, learning curve effects and a more responsive market. We generated these estimates from previous studies[20,21,22] that estimated the cost associated with fuel economy improvements in heavy-duty vehicles.

In one such study, Sachs et al identified eight efficiency improvement technology areas, potential improvement and associated costs.[23,24] An additional improvement area discussed by Sachs is related to changes in driver behavior. However, this potential improvement is not used in this analysis because fuel economy benefits based on driver behavior is not a reliable predictor of fuel demand changes. The technology areas are listed in Tables 1-4. It is anticipated that these technologies will be implemented by 2010, if the requisite investments are made for efficiency improvements. The 21st Century Truck Program relies on many of these same broad technology improvement areas.

Our cost estimates assume that some of the identified technologies, such as turbo charging have already been fully implemented, while others have been implemented partially (as an example aerodynamic improvements), and others requiring breakthroughs (such as improvements in the basic thermodynamic cycle) not yet implemented. We used a technology implementation schedule to characterize the technology implementation rate and cost. Under this schedule, technologies not yet implemented have 100 percent or full potential to improve the vehicle fuel economy. Technologies partially implemented at the 25 percent, 50 percent, or 75 percent levels have a corresponding residual potential to improve vehicle fuel economy. Based on the assumption that some technologies are already partially implemented, we employed a simplified approach to reduce DeCicco's estimated cost by the percent by which a fuel economy improvement technology has been implemented since 1992. For example, where DeCicco estimated a $100 cost for a fuel economy improvement measure that has since been implemented 50 percent onto a vehicle platform, we estimated the cost of capturing the residual improvement benefit to be $50 or half the initial cost. This adjusted cost was then expressed in 2001 dollars. Similarly, we used the full DeCicco cost, adjusted for 2001 dollars, for a technology that the 21st Century Truck Roadmap indicates still offers significant (> 75 percent to full) fuel economy improvement potential.

We converted 1992$ to year 2001$ using the Energy Commission's price inflator-deflator series of 3.0 percent for the period.[25] For the 2005 base numbers, we assumed negligible change in the cost for this analysis. We reduced the resulting numbers by 60 percent to account for economy of scale manufacturing (reduced component costs due to increased production volume)[26]. Table 6 summarizes these estimated fuel economy improvement measure costs for Class 7 and 8 trucks.

Table 6: Fuel Economy Improvement Potential and Estimated Cost (price increment)

		DeCicco et. al [2]	DeCicco et. al updated costs	Residual Technology Implementa -tion Factor		Adjusted Costs Lower Bound (LB) Fuel Economy	Adjusted Costs Upper Bound (UB) Fuel Economy
Fuel Economy Improvement Area	Delta Benefit %	Cost 2001$	Updated (2004$)	LB	UB	Cost 2004$	Cost 2004$
Aerodynamics - Tractor	14	$3914	$4150	0.25	0.50	$625	$1240
Aerodynamics - Trailer	5	$2610	$2768	0.25	0.75	$414	$1240
Engine control technology	16	$5220	$5535	0.25	0.50	$827	$1665
Other available engine technology	15	$2088	$2214	0.50	0.25	$657	$329
Advanced engines	10	$13048	$13836	0.25	0.50	$2078	$4135
Drive train	7	($1500)	($1500) [a]	N/A	N/A	($1500)	($1500)
Tires	8	$913	$968	0.25	0.50	$148	$290
Weight reduction	1	$3914	$4150	0.25	0.25	$625	$625

a. Not updated. Assumed reduction in drive train cost constant, and extended due to component simplification and modularization.

We assumed four fuel economies for the classes of vehicles examined. For Class 3-6 vehicles we used a nominal fuel economy of 17.5 mpg in the year 2020 for the lower bound case. We used 25.4 mpg by 2020 to represent an upper bound based on the aggressive targets of the 21st Century Truck Program. We used a nominal fuel economy of 8.5 mpg by 2020 for Class 8 trucks for our lower bound case. We used 13 mpg by 2020 to represent an upper bound based on the aggressive targets of the 21st Century Truck Program.

Costs corresponding to the fuel economy gains are estimated by projecting the technology sets most likely to be implemented in the target years as done in previous studies[27,28] and summing the associated costs. Based on our assumptions and adjustments to the cost ranges inferred from the ACEEE[29] and Oak Ridge National Laboratory[30] studies, the incremental cost to achieve the lower (7.5 mpg) and higher bound (13.0 mpg) fuel economy for a Class 8 truck, by 2020, ranges from

$3,600 to $7,500. The incremental cost to achieve these mpg figures ranges from $3,500 to $3,600 for lower bound and higher bound fuel economies by 2025 to 2030. We have not reported cost estimates for year 2010 fuel economy improvements because that date is too short a time to achieve the technology penetration levels to realize meaningful petroleum fuel use reduction impacts. We used a similar approach to estimate the incremental cost for medium-duty vehicles. These incremental costs range from $4,700 to $7,000 by 2020 and $3,000 to $6,700 by 2025 to 2030 for lower bound (14.2 mpg) and higher bound (25.4 mpg) fuel economy levels. Hybridization accounts for the higher incremental cost for the medium-duty vehicle classes for the upper bound fuel economy. These results are summarized in Table 7.

Table 7. Summary of Incremental Cost (Price) Values and Fuel Economy Estimates

Vehicle Scenario		2010		2020		2025	
		Class 3-6	Class 7-8	Class 3-6	Class 7-8	Class 3-6	Class 7-8
Lower Bound-Nominal Fuel Economy	mpg	N/A	N/A	14.2	7.1	15	7.5
	cost	N/A	N/A	$4,700	$3,600	$3,000	$3,500
Upper Bound-Aggressive Fuel Economy	mpg	N/A	N/A	25.4	13.0	25.4	13.0
	cost	N/A	N/A	$7,000	$7,500	$6,700	$3,600

A present value of costs and benefits is calculated and presented in the result section for the milestone years of 2010, 2020 and 2025 by applying a 5 and 12 percent discount factor.

Penetration Rates and Scenarios

Developing a future vehicle penetration scenario for advanced, more efficient diesel technologies is complex and challenging due to the number of factors that influence the penetrations and the overall scenario period. The process is simplified by limiting the maximum new vehicle penetration rate in any year to 7 percent, which is the historical maximum[31] of the existing vehicle population or 100 percent of the new vehicle sales, whichever is less. Additionally, the penetration period is divided into segments based on a number of clearly defined factors. A minimum penetration rate equivalent to 1 percent of the vehicle population is also assumed. This minimum rate is taken as half of the 2 percent nominal historical vehicle population growth rate reported in the 1996 World Vehicle Forecast and Strategies.[32] This rate corresponds to 14.3 percent of the new vehicle sales.

Three penetration periods between 2005 to 2025 are defined to develop an accurate penetration scenario. The three penetration periods are 2008-2010; 2011-2020; and 2021-2025. The 2005-2007 period penetrations are negligible as they are limited to prototype demonstrations and field trials. The penetration periods are defined based on regulatory milestone events, technology phase-in, maturation and availability, and alternative fuel infrastructure deployment. A more detailed description of the rationale used to formulate these penetration periods is provided below.

Superimposed onto the penetration period determinants are two key factors that interact to define the likely penetration scenarios for the analysis: Cost to meet the emission standards and consumer hesitation due to uncertainty about reliability, durability, and expected performance in the early years.

Cost to Meet Emission Standards

Based on published industry information and analysis of costs (see notes to Table 2) to comply with emission standards by the U.S. Environmental Protection Agency[33], the supporting analysis finds that advanced diesel vehicles are likely to cost $15,000 to $30,000 more than diesel vehicles manufactured before October 2002. These costs presented in Table 2 include emission control components and systems, as well as related vehicle engineering costs to accommodate the new emission control components. The emission control cost is an additional incremental above the vehicle cost of $3,600 to $7,000 to achieve improved fuel economy. These higher incremental costs are assumed to influence consumer purchase decisions and therefore modulate advanced vehicle penetrations.

Consumer Hesitation

Historically, consumers hesitate to embrace a new technology until its reliability, durability, and performance expectations are proven. This is even more so for heavy-duty diesel vehicles that are employed in mission-driven applications. This market reality is expected to constrain the penetration of the advanced technology diesel vehicles for up to three years after their initial introduction.

The following penetration scenarios are likely to emerge as a result of the factors discussed above.

1. For the 2005-2007 period, sales of advanced new diesels are negligible, limited to prototypes, field trials and demonstrations. This penetration period is negligible for purposes of this analysis.

2. In the 2008-2010 period, we assumed the minimum penetration rate of 1 percent of the vehicle population in each year of the analysis period or 14.3 percent of the new vehicle sales. During this period, consumers are

likely to prefer buying 2.0 gm oxides of nitrogen (NOx) per brake-horsepower-hr natural gas (NG) and diesel products, now in the market for 5 years, versus the higher priced and less proven 0.2 gm NOx engines entering the market. As a consequence, sales of 0.2 gm NOx NG and diesel vehicles decline sharply due to product performance uncertainties and customer purchase hesitations.

3. In the 2011-2020 period, we assumed a penetration rate equal to the average of the maximum and minimum penetration rates or 57.1 percent of new vehicle sales. During this period, vehicle sales are driven by fleets replacing aging 4.0gm and 2.5gm NOx engines.

4. In the 2021-2025 period, we assume that penetration rates peak to about 100 percent of the new vehicle sales as more fleets purchase newer vehicles to replace aging vehicles and to take advantage of the potential fuel savings from the more efficient advanced vehicles.

The vehicle penetrations in the three penetration periods account for the composite populations in the milestone years for the analysis. Table 8 presents the penetration rates used in the analysis.

Table 8: Interactive Penetration Rates for Advanced Heavy-Duty Diesel as a Fraction of New Vehicle Sales

Period	Class 3-6	Class 7 & 8
2005-2007	Negligible	Negligible
2008-2010	14.3%	14.3%
2011-2020	57%	57%
2021-2025	100%	100%

Scenario 1 (BAU/Nominal Fuel Economy Improvement)

The first scenario is a lower bound scenario. The penetration rates for Scenario 1 are varied according to the schedule in Table 8 as a fraction of new vehicle sales. Moderate fuel economy improvements compared to 2000 levels are also derived (5 percent for Classes 3 through 6 and 20 percent for Classes 7 and 8 by 2025 over year 2000 levels) As previously described, the composite fuel economy improvement is based on the average between the observed historical fuel economy improvement rate for heavy-duty vehicles and model projections from studies performed by the ACEEE and the EIA's NEMS model.

Based on the penetration rate assumptions, we estimate the number of new vehicles using more efficient diesel technologies, and entering service, over the scenario period. The corresponding annual number of new vehicles using the more efficient diesel technologies in California are 1,000 per year in 2005-2010, 6,300 per year in 2011-2020 and 11,000 per year in 2021-2025.

Scenario 2 (Aggressive Fuel Economy Improvement)

The second scenario is an upper bound scenario. The penetration rates for Scenario 2 are displayed in Table 8 as a percent of annual new vehicle sales. Aggressive fuel economy improvements compared to the 2000 levels are also derived (100 percent for Classes 3 through 6 and 100 percent for Classes 7 and 8 by 2025).

Under the assumptions made in this analysis, we expect the population of more fuel efficient heavy-duty vehicles in California to comprise 5.9 percent and up to 15.3 percent of the heavy-duty vehicle population 2010, 13.2 percent and up to 30 percent of the heavy-duty vehicle population in 2020 and 15.3 and up to 49.4 percent of the heavy-duty vehicle population in 2025 under the Business-As-Usual and Aggressive scenarios, respectively.

Results

The impact on California's diesel and gasoline demand from using more efficient technologies in medium- and heavy-duty vehicles is discussed below and summarized in Tables 9 and 10. Net-Direct benefits to the state are characterized by Direct-Non-Environmental Benefits, Change in Government Revenue Due to Reduced Fuel Taxes, Direct Environmental Net Benefits and the External Cost of Petroleum Dependency.

BAU Scenario

For the BAU Scenario, more efficient diesel technologies for heavy trucks reduce California's on-road diesel demand by 0.1 billion gallons or about less than one percent of the state's on-road gasoline and diesel demand in 2025.

Under this scenario, a 5 percent discount rate and low diesel fuel price of $1.82 per gallon, consumers are estimated to lose $0.77 billion in 2025. There is a loss in government revenue of $0.062 billion. The corresponding outcomes under this scenario, a 5 percent discount rate and high diesel fuel price of $2.18 per gallon, are estimated to be $0.7 billion in 2025. There is a loss in government revenue of $0.02 billion.

Under this scenario, a 12 percent discount rate and low diesel fuel price of $1.82 per gallon, consumers are estimated to lose $0.53 billion in 2025. The corresponding outcomes under this scenario, a 12 percent discount rate and high diesel fuel price of $2.18 per gallon is estimated to be a loss to consumers of $0.7 billion. There is a $0.02 billion loss in government revenue.

Aggressive Scenario

For the Aggressive Scenario, more efficient diesel technologies for heavy trucks reduce California’s on-road diesel demand by 2.3 billion gallons or about 11 percent of the state’s on-road gasoline and diesel demand in 2025.

Under this scenario, a 5 percent discount rate and low diesel fuel price of $1.82 per gallon, consumers are estimated to save $7.5 billion in 2025. The corresponding outcomes under this scenario, a 5 percent discount rate and high diesel fuel price of $2.18 per gallon are estimated to be $9.5 billion in 2025. There is a loss in government revenue of $1.4 billion for both.

Under this scenario, a 12 percent discount rate and high diesel fuel price of $1.82 per gallon, consumers are estimated to save $2.3 billion in 2025. The corresponding outcomes under this scenario, a 12 percent discount rate and high diesel fuel price of $2.18 per gallon are estimated to be $3.1 billion in 2025. There is a $0.56 billion loss in government revenue.

Table 9. Petroleum Reduction and Benefits for Medium and Heavy-Duty Diesel Vehicles

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Cost and Benefits, Present Value, 2005-2025, 5% discount rate, Billions $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
Business As Usual, Low Petroleum Fuel Price ($1.82 per gallon diesel)	0.1	0.57	(0.77)	(0.06)	0.12	0.06	(0.37)
Aggressive, Highest Petroleum Fuel Price ($2.18 per gallon diesel)	2.3	11	9.5	(1.43)	1.93	1.04	8.96

Table 10. Petroleum Reduction and Benefits for Medium and Heavy-Duty Vehicles

Alternative Fuel Option or Scenario	Displacement in 2025, billion gallon gasoline equivalent	Reduction from Base Case Demand, percent	Costs and Benefits Present Value, 2005-2025, 12% discount rate, Billions $2005				
			A	B	C	D	A+B+C+D
			Direct Non-Environmental Benefit	Change in Government Revenue	Direct Environmental Net Benefit	External Cost of Petroleum Dependency	Direct Net Benefit
Business As Usual, Low Petroleum Fuel Price ($1.82 per gallon diesel)	0.1	0.57	(0.53)	(0.02)	0.12	0.06	(0.37)
Aggressive, Highest Petroleum Fuel Price ($2.18 per gallon diesel)	2.3	11	3.1	(0.56)	1.93	1.04	5.51

Key Drivers and Uncertainties

- Assuming that a fuel economy standard will be established to accelerate the market penetration of more fuel efficient heavy-duty vehicles and spur industry to achieve the assumed fuel economies.
- Vehicle class distribution does not change.
- Changing material and manufacturing costs associated with achieving higher fuel economy
- No change in vehicle miles traveled (affects demand reduction and incremental operating costs)
- Fleet turnover rate in the years 2015-2025 as vehicle fleet ages and replacement justified by lower operating cost from more fuel-efficient vehicles.
- Diesel fuel price volatility.
- Manufacturers’ capacity to produce 0.2 gm NOx engines.

Endnotes:

[1] California Energy Commission, *Reducing California's Petroleum Dependence, August 2003, 600-03-005F.*

[2] Technology Roadmap for the 21st Century Truck Program, U.S. Department of Energy, December 2000.

[3] DeCicco, John M., Ledbetter, Marc, Mengelber, Ulrike, Sachs, Harvey M. "Heavy Truck Fuel Economy: A Review of Technologies and the Potential for Improvement" American Council for an Energy Efficient Economy, January 1992.

[4] "Scenarios for U.S. Carbon Reductions: Potential Impacts of Energy Efficient and Low Carbon Technologies by 2010 and Beyond" Oak Ridge National Laboratory, May 2000.

[5] DeCicco, John M. "Transportation Energy Issues through 2030". American Council for an Energy Efficient Economy, December 1997.

[6] Ibid.

[7] Ibid.

[8] Ibid.

[9] Ibid.

[10] Technology Roadmap for the 21st Century Truck Program, U.S. Department of Energy, December 2000.

[11] As used in this analysis, vehicle penetration rate means a percentage of new vehicles entering the existing fleet population. For this scenario, 100 percent of new vehicles sold meet the fuel economy standards. It is estimated that new vehicle sales are fewer than 10 percent of the existing population in any given year. The penetration rate is varied during the analysis period. It is lower (1 to 2 percent) in some years due to smaller production runs and slower adoption of the technology in certain vehicle classes, and market maturation or saturation. It is higher (5-7 percent) in some years, due to the rapid turnover of the vehicle population assumed to occur in the years 2015-2025 from aging and the availability of more efficient vehicles. The penetration rate is moderate (3-4 percent) in other years as the market matures and demand stabilizes. A composite vehicle class distribution is used in estimating the vehicle penetrations.

[12] "Lower Your Cost of Ownership" Arrow Truck Sales, Inc., March 2002.

[13] "1997 Truck Inventory Use Survey", U.S. Census Bureau, U.S. Department of Commerce.

[14] "Profile and Segmentation of Medium and Heavy Vehicle Purchase Patterns and Current and Projected Populations", MacKay & Company, February 1995.

[15] California Motor Vehicle Stock, Travel and Fuel Forecast, California Department of Transportation, November 2001.

[16] "Profile and Segmentation of Medium and Heavy Vehicle Purchase Patterns and Current and Projected Populations", MacKay & Company, February 1995.

[17] Ibid.

[18] p12, Light & Medium Truck, April 2005.

[19] p42, Light and Medium Truck, April 2005.

[20] DeCicco, John M., Ledbetter, Marc, Mengelber, Ulrike, Sachs, Harvey M. "Heavy Truck Fuel Economy: A Review of Technologies and the Potential for Improvement" American Council for an Energy Efficient Economy, January 1992.

[21] "Scenarios for U.S. Carbon Reductions: Potential Impacts of Energy Efficient and Low Carbon Technologies by 2010 and Beyond" Oak Ridge National Laboratory, May 2000.

[22] DeCicco, John M. "Transportation Energy Issues through 2030", American Council for an Energy Efficient Economy, December 1997.

[23] Ibid.

[24] DeCicco, John M., Ledbetter, Marc, Mengelber, Ulrike, Sachs, Harvey M. "Heavy Truck Fuel Economy: A Review of Technologies and the Potential for Improvement" American Council for an Energy Efficient Economy, January 1992.

[25] California Energy Commission, Reducing California's Petroleum Dependence, August 2003, Pub. No. 600-03-005F.
http://www.energy.ca.gov/fuels/petroleum_dependence/documents/index.html

[26] An, Feng, Stodolsky, Frank, Vyas, Anant, and Cuenca, Roy, Eberhardt, James J., "Scenario Analysis of Hybrid Class 3-7 Heavy Vehicles", SAE Paper 2000-01-0989.

[27] DeCicco, John M., Ledbetter, Marc, Mengelber, Ulrike, Sachs, Harvey M. "Heavy Truck Fuel Economy: A Review of Technologies and the Potential for Improvement" American Council for an Energy Efficient Economy, January 1992.

[28] DeCicco, John M., Greene, David L., "Engineering-Economic Analysis of Automotive Fuel Potential in the United States". Oak Ridge National Laboratory, February 2000.

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