CAMBRIDGE SYSTEMATICS

Accounting for Fuel Efficiency in Texas Fuel Tax Revenue Estimations

final

report

prepared for

Texas Department of Transportation

prepared by

Cambridge Systematics, Inc.

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Accounting for Fuel Efficiency in Texas Fuel Tax Revenue Estimations

■ Background

Technological improvements in fuel efficiency over the next several decades will have a major impact on the fuel tax revenues, which currently are the major source of transportation infrastructure financing in Texas. As the fuel efficiency of the overall motor fleet improves, overall fuel tax revenues may decline, impacting the ability of the State to maintain and operate the existing system and close the current $86 billion mobility gap.

The Texas Department of Transportation (TxDOT) has developed some "sketch-level" models to estimate the impacts of these technological improvements on future fuel tax revenues. While these existing models are useful in helping to understand the potential scope of the issue, a more detailed effort that specifically defines important assumptions is necessary to address key transportation policy questions.

Cambridge Systematics was commissioned by TxDOT to assess the assumptions of the existing Texas Motor Fleet Fuel Efficiency Model and revise the model to forecast Texas motor fleet fuel efficiency for the period of 2007 to 2031. Particular attention was paid to refining the assumptions that influence both the overall composition of the State's motor fleet and its projected fuel efficiency. This technical memorandum documents the results of a literature and data search to identify, evaluate, and revise key assumptions contained within the existing model. Subsequent sections provide recommendations and describe the results of the model with the revised assumptions.

■ Existing Texas Motor Fleet Fuel Efficiency Model

Overview

The current Texas Motor Fleet Fuel Efficiency Model is a spreadsheet whose purpose is to estimate the amount of additional state fuel tax required to fund an $86 billion highway capacity gap over the next 25 years, assuming that more fuel efficient vehicles increase their market penetration in the motor fleet. The two key parameters in the existing model are the expected amount of traffic growth and the fuel efficiency of the motor fleet. The model assesses two scenarios: 1) the Low Adoption Scenario (LAS); and 2) the High

Adoption Scenario (HAS). The main differences between the two scenarios are that LAS assumes a lower market penetration of hybrid vehicles and higher average rate of vehicle miles traveled over the next 25 years than the HAS. To determine the new capacity tax, the arithmetic mean of the two scenarios is calculated. The following provides a more detailed description of both scenarios:

- LAS assumes that:
  - New vehicles represent a constant 7 percent of the total motor fleet over the next 25 years;
  - Vehicle miles traveled increase at an annual constant rate of 4.5 percent over the next 25 years;
  - Market penetration of hybrid vehicles increases slowly, reaching 25 percent of total new vehicles in 2030;
  - Mileage per gallon (mpg) of conventional vehicles stays constant, 19.8 mpg, over the next 25 years; and
  - MPG of hybrid vehicles reaches 92 mpg in 2020 and 102 mpg in 2030.
- HAS assumes that:
  - New vehicles represent a constant 7 percent of the total motor fleet over the next 25 years;
  - Vehicle miles traveled increase at an annual constant rate of 1.5 percent over the next 25 years;
  - Market penetration of hybrid vehicles increases rapidly, reaching 75 percent of total new vehicles in 2030;
  - Mileage per gallon (mpg) of conventional vehicles stays constant, 19.8 mpg, over the next 25 years; and
  - MPG of hybrid vehicles reaches 112 mpg in 2020 and 122 mpg in 2030.

Table 1 synthesizes these assumptions.

Table 1. Low and High Adoption Scenarios Assumptions

	Low			High		
Assumption	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**
New vehicles (percent of total fleet)	7%	7%	7%	7%	7%	7%
VMT annual growth	4.5%	4.5%	4.5%	1.5%	1.5%	1.5%
Market penetration hybrids	2%	10%	25%	16%	58%	100%
MPG of hybrids	50	92	102	50	112	122
MPG of gasoline vehicles	19.8	19.8	19.8	19.8	19.8	19.8

Literature Review

To support and refine the assumptions of the existing Texas Fuel Efficiency Model, the literature revision and data collection focused on the following topics:

- Composition of current and future fuel efficient fleet;
- Current and future fuel efficiency of conventional and alternative fuel efficient vehicles (AFV);
- Motor vehicle fleet composition by type of vehicle; and
- Current and future vehicle miles traveled by type of vehicle.

Current and Future Fleet of Alternative Fuel Vehicles

A key assumption of the Texas Fuel Efficiency Model is the market penetration of alternative fuel efficient vehicles (AFV), since their faster penetration will reduce the amount of gas taxes collected.

Current Fleet

Different sources specialized in the automotive market (J. D. Power, TechCast, Volkswagen, and Bosch Corporation) were reviewed to determine current and future market shares of AFV not only for hybrid vehicles, but also for other alternative technologies. At present there exist seven alternative technologies to conventional vehicles, as reported by the Federal Highway Administration (FHWA) (see Table 2). However, data on the rate of growth of hybrid cars compared to other competing technologies (i.e., liquefied petroleum gas (LPG) and compressed natural gas (CNG)) and other sources suggest that hybrid and diesel technologies will be the main competitors to gasoline vehicles.

According to automotive market specialists, diesel and hybrid vehicles will be the main alternative technologies, given that:

- Diesel and hybrid performance in mileage per gallon is superior to conventional, LPG, and CNG vehicles;[1]
- Diesel vehicles are becoming more environmentally friendly; ultralow sulfur diesel (ULSD) started replacing conventional diesel fuel in 2006; and
- Other types of "future" technologies such as fuel cell and biodiesel vehicles are not considered price competitive. Fuel cell vehicles might be mass produced in the next 15 years, but they will cost more that $100,000 each;[2] whereas, biodiesel is more expensive to produce than diesel.[3]

Table 2. U.S. Current Fuel Efficient Vehicles in Use
2000 to 2004

Fuel Type	2000	2001	2002	2003	2004	Average Annual Growth (2000 to 2004)
LPG	181,994	185,053	187,680	190,438	194,389	1.7%
CNG	100,750	111,851	120,839	132,988	143,742	9.3%
LNG	2,090	2,576	2,708	3,030	3,134	10.9%
M85	10,426	7,827	5,873	4,917	4,592	-18.2%
E85	87,570	100,303	120,951	133,776	146,195	13.8%
E95	4	0	0	0	0	0.0%
Electricity	11,830	17,847	33,047	45,656	55,852	49.1%
Hybrid[a]	9,367	29,654	65,615	113,140	196,293	120.9%
Total	**404,031**	**455,111**	**536,713**	**623,945**	**744,197**	**16.5%**

Source: U.S. FHWA, Highway Statistics, annual.

[a] Hybrid vehicles are not reported by the U.S. FHWA, the data correspond to the cumulative sales of hybrids in the U.S.

[1] On-road heavy-duty diesels to be more than 60 percent more fuel efficient than similarly sized spark-ignited natural gas engines (Diesel Technology Forum, 2001).

[2] Hybrid Car, interview with Honda President, December 2006, http://www.hybridblog.com.

[3] http://www.biodiesel.org.

Future Fleet

When available, forecasts for AFV focused only on diesel and hybrid technologies; therefore, no forecasts were publicly available for other technologies.

Among automotive specialists, there is no consensus on the market share that diesel and hybrid vehicles will achieve in the U.S market in the short and long term. For 2025, the range of market share forecasts for diesel vehicles varies between 20 to 50 percent of the total market, while for hybrid vehicles the range oscillates between 15 to 75 percent of the total market. Table 3 summarizes the forecasts collected from different sources.

Table 3. Forecasts of Hybrid and Diesel Market Penetration

Source	2006	2010	2012	2015	2025
Diesel					
J. D. Power	3.6%	N/A	8.0%	N/A	N/A
Volkswagen/Auto Insider (12/15/06)	N/A	N/A	N/A	15.0%	50.0%
Bosch Corporation	N/A	6.0%	N/A	15.0%	20.0%
Hybrid					
J. D. Power	1.6%	N/A	4.0%	N/A	N/A
BusinessWeek (9/5/03)	N/A	N/A	N/A	5.0%	15.0%
BusinessWeek (10/27/03)	N/A	N/A	N/A	N/A	75.0%
Exploration Production	N/A	4-7%	15.0%	N/A	N/A

Source: Cambridge Systematics, Inc., with information from J.D. Power, Auto Insider, TechCast, Bosch Corporation, and Exploration Production.

Existing and Future Fuel Efficiency for AFV and Conventional Vehicles

Given that the consensus among automotive market specialists suggest that diesel and hybrid vehicles will be the main competitors to conventional gasoline vehicles, research of existing and future fuel efficiency focused only on diesel, hybrid, and conventional vehicles.

Current Fuel Efficiency

In 2006, the EPA undertook a study, *Draft Technical Report on Fuel Economy Labeling of Motor Vehicles: Revisions to Improve Calculations of Fuel Economy*, to create more accurate estimates of fuel economy for conventional, diesel, and hybrid vehicles. The new estimates are based on a "5 cycle" formulae that is expected to reflect the fuel efficiency that consumers attain in the "real world." The proposed approach resulted in city fuel economy estimates that are between 10 to 20 percent lower than today's labels for the majority of conventional vehicles. For vehicles that achieve generally better fuel economy, such as gasoline-electric hybrid vehicles, new city estimates are about 20 to 30 percent lower than today's labels. The new highway fuel economy estimates are 5 to 15 percent lower for the majority of vehicles, including hybrids. Table 4 presents the results based on the "5 cycle" formulae.

Table 4. Current Mileage per Gallon "5 Cycle" Formulae

Vehicle	City	Highway	Average
Diesel	22.7	31.4	27.0
Hybrid	32.0	36.8	34.4
Conventional	16.2	22.4	19.3

Source: The EPA's *Draft Technical Report on Fuel Economy Labeling of Motor Vehicles: Revisions to Improve Calculations of Fuel Economy Estimates*, 2006.

Future Fuel Efficiency

There is little public information available on future fuel efficiency of conventional and alternative technologies. Information from car makers suggests that the next generation of hybrids will lean towards hybrid plug-in, which could achieve 100 mpg. However, there is no consensus on when hybrid plug-in technology will be available and how affordable it will be to consumers. Regarding diesel technology, further advances are focusing on improving its impact on the environment, rather than on improving its fuel efficiency. For conventional vehicles, new Corporate Average Fuel Economy (CAFE) standards were approved for conventional gasoline light trucks; the mandate requires that all new light truck models in 2011 achieve 24 mpg. Table 5 summarizes the findings on future fuel efficiency for hybrid plug-in vehicles and gasoline light trucks.

Table 5. Future Fuel Efficiency

Technology	MPG	Availability	Comments
Hybrid Plug-In	100+	2010	Nissan
Hybrid Plug-In	100+	2010 to 2015	Toyota
Light Truck (Gasoline)	24	2011	CAFE

Source: Cambridge Systematics, Inc., with information from CAFE and http://www.hybridcars.com.

Though there is no information publicly available on the future mpg of conventional vehicles, historical data from two sources, CAFE and the FHWA, can be used to estimate forecasts of fuel consumption of conventional vehicles. Historical data of CAFE standards provide information on the evolution of mpg standards in that last 20 years, while the FHWA data provide information on the average mileage performance of the U.S. motor fleet. According to the data on Table 6, between 1983 and 2003, mileage standards based on CAFE regulations for new vehicles suggest that mpg for passenger vehicles and light trucks improved at an annual rate of 0.3 and 0.4 percent, respectively. Data from the FHWA show that, on average, mpg for cars and light and heavy trucks increased at an annual rate of 1.4, 1.3, and 0.1 percent, respectively, between 1983 and 2003.

Table 6. Historical Mileage per Gallon

	Mileage per Gallon					Annual Change				
	CAFE		FHWA			CAFE		FHWA		
	Car	Light Truck	Car	Light Truck	Heavy Truck	Car	Light Truck	Car	Light Truck	Heavy Truck
1983	26.0	19.0	17.1	13.7	5.6					
1984	27.0	20.0	17.4	14.0	5.7	3.8%	5.3%	1.8%	2.2%	1.8%
1985	27.5	19.5	17.5	14.3	5.8	1.9%	-2.5%	0.6%	2.1%	1.8%
1986	26.0	20.0	17.4	14.6	5.8	-5.5%	2.6%	-0.6%	2.1%	0.0%
1987	26.0	20.5	18.0	14.9	5.9	0.0%	2.5%	3.4%	2.1%	1.7%
1988	26.0	20.5	18.8	15.4	6.0	0.0%	0.0%	4.4%	3.4%	1.7%
1989	26.5	20.0	18.0	16.1	6.1	1.9%	-2.4%	-4.3%	4.5%	1.7%
1990	27.5	20.2	20.3	16.1	6.0	3.8%	1.0%	12.8%	0.0%	-1.6%
1991	27.5	20.2	21.2	17.0	6.0	0.0%	0.0%	4.4%	5.6%	0.0%
1992	27.5	20.2	21.0	17.3	6.0	0.0%	0.0%	-0.9%	1.8%	0.0%
1993	27.5	20.4	20.6	17.4	6.1	0.0%	1.0%	-1.9%	0.6%	1.7%
1994	27.5	20.5	20.8	17.3	6.1	0.0%	0.5%	1.0%	-0.6%	0.0%
1995	27.5	20.6	21.1	17.3	6.1	0.0%	0.5%	1.4%	0.0%	0.0%
1996	27.5	20.7	21.2	17.2	6.2	0.0%	0.5%	0.5%	-0.6%	1.6%
1997	27.5	20.7	21.5	17.2	6.4	0.0%	0.0%	1.4%	0.0%	3.2%
1998	27.5	20.7	21.6	17.2	6.1	0.0%	0.0%	0.5%	0.0%	-4.7%
1999	27.5	20.7	21.4	17.0	6.0	0.0%	0.0%	-0.9%	-1.2%	-1.6%
2000	27.5	20.7	21.9	17.4	5.8	0.0%	0.0%	2.3%	2.4%	-3.3%
2001	27.5	20.7	22.1	17.1	5.9	0.0%	0.0%	0.9%	-2.0%	1.7%
2002	27.5	20.7	22	17.5	5.8	0.0%	0.0%	-0.5%	2.6%	-1.7%
2003	27.5	20.7	22.3	17.7	5.7	0.0%	0.0%	1.4%	1.1%	-1.7%
2004	27.5	20.7	N/A	N/A	N/A	0.0%	0.0%	N/A	N/A	N/A
2005	27.5	21	N/A	N/A	N/A	0.0%	1.4%	N/A	N/A	N/A
2006	27.5	21.6	N/A	N/A	N/A	0.0%	2.9%	N/A	N/A	N/A
2007	27.5	22.2	N/A	N/A	N/A	0.0%	2.8%	N/A	N/A	N/A
Avg. 83-03	27.1	20.3	20.2	16.4	6.0	0.3%	0.4%	1.4%	1.3%	0.1%
Std. Dev.	0.6	0.5	1.8	1.3	0.2	1.8%	1.6%	3.4%	1.9%	2.0%

Source: U.S. FHWA, *Highway Statistics*, annual.

Motor Fleet Composition

To obtain more accurate estimates of the impact of fuel efficient technologies on gas taxes, data on the composition of the motor fleet from the FHWA were reviewed to propose additional assumptions on Texas' motor fleet. These proposals are described in more detail in the Conclusions and Recommendations section of this memo.

As Table 7 shows, in 2006, 51 percent of Texas' motor fleet was automobiles, 49 percent trucks, while buses represented only 0.5 percent of the total.

Table 7. Texas Motor Fleet Composition

	Auto	Buses	Trucks	Total
2006	8,911,818	89,557	8,468,172	17,469,547
2005	8,735,544	86,753	8,084,417	16,906,714
2004	7,841,637	84,260	6,962,883	14,888,780
Percentage				
2006	51.0%	0.5%	48.5%	100.0%
2005	51.7%	0.5%	47.8%	100.0%
2004	52.7%	0.6%	46.8%	100.0%

Source: U.S. FHWA, *Highway Statistics*, annual.

Since disaggregated information on the composition of trucks at the state level is not available from the U.S. FHWA, to get a further disaggregation of the composition of trucks for Texas, data at the national level from the FHWA on total vehicle miles traveled by light and heavy trucks were used as a proxy to determine the share of each them. Data provided in Table 8 suggest that around 80 percent of the VMT correspond to light trucks, while light trucks accounted for 20 percent of the total VMT by trucks.

Table 8. U.S. Vehicle Miles Traveled (in Billions)

	Light Trucks	Heavy Trucks	Total Trucks
1980	291	108	399
1985	391	124	515
1990	575	146	721
1995	790	178	968
2000	923	206	1,129
2003	998	216	1,214
Percentage			
1980	73%	27%	100%
1985	76%	24%	100%
1990	80%	20%	100%
1995	82%	18%	100%
2000	82%	18%	100%
2003	82%	18%	100%

Source: U.S FHWA, *Highway Statistics*, annual.

If the shares of VMT for light and heavy trucks derived from Table 8 are applied to Texas' truck fleet, the estimates suggest that around 40 percent of its fleet would be light trucks, and close to 8 percent heavy trucks, as shown in Table 9.

Table 9. Texas' Motor Fleet Composition

	Auto	Buses	Light Trucks	Heavy Trucks	Total
2006	8,911,818	89,557	6,943,901	1,524,271	17,469,547
2005	8,735,544	86,753	6,629,222	1,455,195	16,906,714
2004	7,841,637	84,260	5,709,564	1,253,319	14,888,780
Percentage					
2006	51.0%	0.5%	39.7%	8.7%	100.0%
2005	51.7%	0.5%	39.2%	8.6%	100.0%
2004	52.7%	0.6%	38.3%	8.4%	100.0%

Source: Cambridge Systematics, Inc., with information from the U.S. FHWA.

Vehicle Miles Traveled

The number of vehicle miles traveled is another variable that affects the tax gas collected, since all things being equal, the longer the distance traveled, the more fuel is needed to travel.

To determine VMT by different types of vehicles, historical data from the U.S. FHWA on mileage traveled by cars, light trucks, and heavy trucks were collected. As Table 10 shows, at the national level, VMT annually increased by 1.4, 0.5, and 1.7 percent, respectively, between 1980 and 2003. In 2003, on average, cars traveled 12,200 miles; light trucks, 11,500 miles; and heavy trucks, 27,300 miles.

Table 10. U.S. Motor Vehicle Distance Traveled by Type of Vehicle
National Average

	Miles Traveled (1,000)			Annual Growth Rate		
	Cars	Light Trucks	Heavy Trucks	Cars	Light Trucks	Heavy Trucks
1980	8.8	10.4	18.7	–	–	–
1981	8.9	10.2	19.0	1.1%	-1.9%	1.6%
1982	9.1	10.3	19.9	2.2%	1.0%	4.7%
1983	9.1	10.5	21.1	0.0%	1.9%	6.0%
1984	9.2	11.2	22.6	1.1%	6.7%	7.1%
1985	9.4	10.5	20.6	2.2%	-6.2%	-8.8%
1986	9.5	10.8	22.1	1.1%	2.9%	7.3%
1987	9.7	11.1	23.3	2.1%	2.8%	5.4%
1988	10.0	11.5	22.5	3.1%	3.6%	-3.4%
1989	10.2	11.7	22.9	2.0%	1.7%	1.8%
1990	10.3	11.9	23.6	1.0%	1.7%	3.1%
1991	10.3	12.2	24.2	0.0%	2.5%	2.5%
1992	10.6	12.4	25.4	2.9%	1.6%	5.0%
1993	10.5	12.4	26.3	-0.9%	0.0%	3.5%
1994	10.8	12.2	25.8	2.9%	-1.6%	-1.9%
1995	11.2	12.0	26.5	3.7%	-1.6%	2.7%
1996	11.3	11.8	26.1	0.9%	-1.7%	-1.5%
1997	11.6	12.1	27.0	2.7%	2.5%	3.4%
1998	11.8	12.2	25.4	1.7%	0.8%	-5.9%
1999	11.9	12.0	26.0	0.8%	-1.6%	2.4%
2000	11.9	11.7	25.7	0.0%	-2.5%	-1.2%
2001	11.9	11.2	26.6	0.0%	-4.3%	3.5%
2002	12.2	11.4	27.1	2.5%	1.8%	1.9%
2003	12.2	11.5	27.3	0.0%	0.9%	0.7%
Avg. 80-03	10.6	11.5	24.2	1.4%	0.5%	1.7%
Std. dev.	1.1	0.7	2.7	1.2%	2.8%	4.0%

Source: U.S. Federal Highway Administration, *Highway Statistics*, annual.

Summary of Findings

- Among automotive analysts there is consensus that hybrid and diesel vehicles will be the main competitors to gasoline vehicles. However, there is no agreement on the extent of their market penetration in the coming years. Forecasts for 2025 for hybrid vehicles oscillate between 15 to 75 percent of the new motor fleet; whereas, for diesel vehicles, forecasts fluctuate between 20 to 50 percent for the same year.

- The EPA's latest revision on fuel efficiency labels for gasoline, diesel, and hybrid vehicles suggests that its new estimates are 5 to 10 percent lower than today's labels. In addition, historical data indicate that mpg for conventional cars, light trucks, and heavy trucks have improved at an average annual rate of 1.4, 1.3, and 0.5 percent, respectively, between 1983 and 2003.

- The few data available on future mileage per gallon for hybrid vehicles suggest that hybrid plug-ins will attain 100 mpg. Though there is no consensus when the technology will be available, some car makers expect to release their first vehicles between 2010 and 2015.

- Estimates on Texas' motor fleet composition suggest that 51 percent of the motor fleet is composed of automobiles, 0.5 percent of buses, 39.7 percent of light trucks, and 8.7 percent of heavy trucks.

- Historical data at the national level on VMT by cars, light trucks, and heavy trucks reveal that VMT increase annually by 1.4, 0.5, and 1.7 percent, respectively, between 1980 and 2003. In 2003, on average, cars traveled 12,200 miles; light trucks, 11,500 miles; and heavy trucks, 27,300 miles.

Conclusions and Recommendations

The current assumptions of the model can be refined based on the revision of the literature and data collected. In particular, we propose to refine the following assumptions:

- **The number of alternative fuel efficient technologies.** The literature review indicates that diesel and hybrid vehicles will be the main competitors to gasoline vehicles; thus, diesel vehicles should be included in the model as an additional alternative to the current hybrid alternative.

- **The motor fleet composition.** The current model does not disaggregate the motor fleet among types of vehicles, but the data collected allow us to provide an estimation of Texas' motor fleet composition. The disaggregation of the fleet will offer a more accurate estimate of the average mpg efficiency of Texas' motor fleet.

- **Current mileage per gallon.** Current values of mpg for hybrid and conventional vehicles included in the model are higher than the EPA's latest estimates on fuel efficiency labels. Thus, adjustments to reflect this are undertaken in the revised model.

- **Future mileage.** Historical data on mpg suggest that in the last 20 year, all types of gasoline vehicles have improved their performance; however, the current model assumes that conventional vehicles will not improve their mpg. Adjustments to reflect future improvements on the mpg for conventional and other technologies are proposed in the revised model.

- **Future rate of growth of vehicle miles traveled.** Available data on motor distance traveled by types of vehicles allow us to estimate an average VMT annual growth for Texas' motor fleet weighted by the composition of the motor fleet. Currently, the model does not disaggregate VMT by types of vehicles; thus, in the revised model, we propose to reflect this.

The recommended adjustments to current assumptions for the Low and High Adoption Scenarios are described below.

Low Adoption Scenario

New Vehicles

- Keep the seven percent constant rate of market share of new vehicles as percentage of total fleet over the next 25 years.

Fleet Composition

To get more refined estimates of the performance of Texas' motor fleet facing new fuel efficient technologies, we propose to:

- Disaggregate motor fleet composition between cars, light trucks, and heavy trucks based on Texas' motor fleet composition estimates;

- Exclude buses from the total fleet since they represent a very small share of the motor fleet, and distribute buses' 0.5 percent share between light and heavy trucks evenly. Table 11 summarizes the proposed composition for Texas' motor fleet;

- Keep the fleet composition constant over the next 25 years; and

- Assume that heavy hybrid tucks will be available in the market in 2011 as expected by hybrid truck users' forum and their fuel performance will be 50 percent higher than today's gasoline heavy trucks.[4]

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[4] http://www.htuf.org.

Table 11. Texas' Motor Fleet Composition Proposed

Cars	Light Trucks	Heavy Trucks	Total
51.0%	40.0%	9.0%	100%

Market Penetration of AFV

Given that the data collected and the vision from automotive specialists suggest that diesel and hybrid vehicles will be the main competitors to gasoline vehicles, we recommend adding only diesel vehicles to the current hybrid alternative. Though diesel is taxable at the same rate than gasoline, since diesel vehicles are 20 to 30 percent more fuel efficient than conventional vehicles, the substitution from gasoline to diesel vehicles will decrease the gas taxes collected.

Additionally, we propose to:

- Adjust market penetration considering both diesel and hybrid technologies using the lowest market penetration forecasts based on the different sources reviewed; and
- Interpolate data to get market penetration for unknown years.

Table 12 describes the assumptions for market penetration for the Low Adoption Scenario.

Table 12. Market Penetration
Low Adoption Scenario

	2006	2010	2025	Average Growth 2006 to 2010	Average Growth 2006 to 2030
Hybrid	1.6%	4.0%	15.0%	25.7%	9.2%
Diesel	3.6%	6.0%	20.0%	13.6%	8.4%

Current and Future MPG

To estimate current and future MPG for diesel, hybrid, and conventional vehicles, we propose to:

- Adjust current mileage per gallon for hybrid and gasoline vehicles based on the EPA's latest revision of fuel efficiency labels. For the technologies and types of vehicles, EPA does not provide estimates; information from the U.S. FHWA and from http://www.fueleconomy.org was used to determine mpg estimates.

- Use an annual average rate of improvement of mpg for hybrid, diesel, and conventional vehicles estimated based on the FHWA historical data on mpg for gasoline vehicles. This assumes that all technologies for the same type of vehicles would evolve at the same rate over the next 25 years. The exceptions are gasoline light trucks between 2006 and 2011, since in 2011, according to CAFE regulations, gasoline light trucks should achieve 24 mpg. This means that mpg of light trucks should improve at a 7.1 percent annual rate starting in 2006 to reach 24 mpg in 2011. Table 13 summarizes the assumptions for current and future mpg for different technologies.

Table 13. Current and Future Mileage per Gallon

Miles per Gallon	2006	Average MPG Annual Growth 2006 to 2011	Average MPG Annual Growth 2012 t o 2025
Cars			
Hybrid	34.4	1.4%	1.4%
Diesel	27.0	1.4%	1.4%
Gasoline	19.3	1.4%	1.4%
Light Truck			
Hybrid	30.0	1.3%	1.3%
Diesel	23.0	1.3%	1.3%
Gasoline	17.0	7.1%	1.3%
Heavy Truck			
Hybrid[a]	9.0	0.1%	0.1%
Diesel	8.1	0.1%	0.1%
Gasoline	6.0	0.1%	0.1%

Source: Cambridge Systematics, Inc. with information from EPA, Fueleconomy.org, and U.S. FHWA, *Highway Statistics*, annual.

[a] Heavy Trucks available in the market in 2011.

Future Vehicle Miles Traveled

To generate a more accurate forecast of the annual growth of VMT, we propose to:

- Use as a proxy the national average annual growth of VMT by type of vehicle, plus one standard deviation weighted by Texas' fleet composition to get an average annual growth of VMT for Texas' motor fleet. The calculations are based on the historical data of VMT from the U.S. FHWA.

- Keep the weighted average of 3.2 percent constant over the next 25 years.

Table 14 summarizes the assumptions for VMT.

Table 14. VMT Annual Growth Weighted by Fleet Composition

	Average 1983 to 2003	**Standard Deviation**	**Average + 1 Standard Deviation**
Cars	1.4%	1.2%	2.6%
Light trucks	0.5%	2.8%	3.3%
Heavy trucks	1.7%	4.0%	5.7%
Weighted Average +1 Standard Deviation by Texas' Motor Fleet Composition			3.2%

Source: Cambridge Systematics, Inc.

High Adoption Scenario

New Vehicles

- Same as low scenario.

Fleet Composition

- Same as low scenario.

Market Penetration of AFV

For the same reasons already explained in the Low Gap Scenario, we suggest including diesel as an alternative technology to the current hybrid technology.

Additionally, we propose to:

- Adjust market penetration considering both diesel and hybrid technologies using the highest market penetration forecast for hybrids, 75 percent penetration in 2025, and the lowest forecast for diesel, 20 percent market. Since hybrids a more fuel efficient than diesel vehicles it is assumed that the majority of the vehicles are highly efficient.

- Keep a 95 percent market penetration of fuel efficient vehicles constant over the last five years of the period of analysis.

- Interpolate data to get market penetration for unknown years.

Table 15 describes the assumptions for market penetration of alternative fuel vehicles for the High Adoption Scenario.

Table 15. Market Penetration
High Adoption Scenario

	2006	2010	2025	Average Growth 2006 to 2010	Average Growth 2006 to 2025	Average Growth 2025 to 2030
Hybrid	1.6%	15.0%	75%	75.0%	11.3%	0.0%
Diesel	3.6%	6.0%	25%	13.6%	8.4%	0.0%

Current and Future MPG

- Current mileage same as in the Low Gap Scenario.

For future mileage we propose to:

- Increase hybrid mpg performance for cars and light trucks at an annual rate of 19.5 percent between 2006 and 2012. This would mean that in 2012, hybrids cars will achieve 100 mpg and light truck hybrids 67 mpg. This is based on the assumption that plug-in hybrids will be available by 2012 as expected by Nissan and Toyota.

- Use the historical average rate of growth of gasoline heavy trucks to increase mpg for hybrid heavy trucks. Since hybrid heavy trucks are expected to be available in the market in 2011 and their fuel performance is expected to be 50 percent higher than conventional vehicles, gains in fuel efficiency after 2011 are assumed to improve at the historical average growth rate of gasoline heavy trucks.

- Use the historical average rate of growth of conventional vehicles to increase mpg for diesel and gasoline vehicles.

Table 16 synthesizes the assumptions for mpg.

Table 16. Current and Future Mileage per Gallon

Miles per Gallon	2006	Average MPG Annual Growth 2006 to 2012	Average MPG Annual Growth 2013 to 2025
Cars			
Hybrid	34.4	19.5	1.4%
Diesel	27.0	1.4%	1.4%
Gasoline	19.3	1.4%	1.4%
Light Truck			
Hybrid	30.0	19.5%	1.3%
Diesel	23.0	1.3%	1.3%
Gasoline	17.0	7.1%	1.3%
Heavy Truck			
Hybrid[a]	9.0	0.1%	0.1%
Diesel	8.1	0.1%	0.1%
Gasoline	6.0	0.1%	0.1%

Source: Cambridge Systematics, Inc. with information from EPA, Fueleconomy.org, and U.S. FHWA, *Highway Statistics*, annual.

[a] Heavy trucks available in the market in 2011.

Future Vehicle Miles Traveled

Similarly to the Low Gap Scenario, we propose to:

- Use as a proxy the national average annual growth rate of VMT by type of vehicle weighted by Texas' fleet composition to get an average annual growth rate of VMT for Texas' motor fleet. The calculations are based on the historical data of VMT from the U.S. FHWA.
- Assume a constant annual average growth rate of 1.1 percent of VMT for Texas' motor fleet over the next 25 years.

Table 17 presents VMT assumptions for the High Adoption Scenario.

Table 17. VMT Annual Growth Weighted by Fleet Composition

	Cars	Light Trucks	Heavy Trucks
Average 1983 to 2003	1.4%	0.5%	1.7%
Weighted average	1.1%		

Scenario Testing

In order to provide a range of confidence on the results, particularly on the estimated tax needed to fund the gap of $86 billion Mobility Gap, given that data are not sufficient to undertake a formal risk analysis, an alternative methodology to the current arithmetic average of the Low and High Adoption Scenarios was developed.

The alternative methodology consisted on conducting a sensitivity test on the Low and High Adoption Scenarios revised with the proposed changes in the assumptions and identifying the most sensitive variables. The most sensitive variables were then included in the creation of alternative scenarios using their Lowest, Average, and Highest values associated with probabilities of 25, 50, and 75 percent, respectively. This approach allows us to approximate the most sensitive variables to a normal distribution, and develop scenarios associated with probabilities of occurrence. For the rest of the variables the value of the average between the Low and High Scenarios was estimated and kept constant for all alternative scenarios.

The sensitivity tests suggested that Market Penetration and Mileage per Gallon were the most sensitive variables, and since each variable is associated with three possible values (Low, Average, and High), a total of nine permutations of scenarios were developed. Table 18 summarizes the nine scenarios with their respective probabilities.

Table 18. Alternative Scenarios

Scenario	Probability	Cumulative Probability
Low Market Penetration and Low MPG	6.25%	6.25%
Low Market Penetration and High MPG	6.25%	12.50%
Low Market Penetration and Average MPG	12.50%	25.00%
Average Market Penetration and Low MPG	12.50%	37.50%
Average Market Penetration and High MPG	12.50%	50.00%
Average Market Penetration and Average MPG	25.00%	75.00%
High Market Penetration and Low MPG	6.25%	81.25%
High Market Penetration and High MPG	6.25%	87.50%
High Market Penetration and Average MPG	12.50%	100.00%

Source: Cambridge Systematics, Inc.

The lowest and highest values for Market Penetration and Mileage Per Gallon were taken from the Low and High Adoption Scenarios, respectively, and their average value was estimated by the arithmetic mean of the Low and High Gap Scenarios. For the rest of the variables the arithmetic mean of the Low and High Gap Scenarios was estimated and kept constant for all the alternative scenarios.

The results from the alternative scenarios suggest that with a 75 percent probability, the tax needed to fund the Mobility Gap is within a range of $1.33 and $1.79, and the average expected value is $1.53.

Comparing the lowest and highest Tax estimate of the revised model with the previous model, the results of the revised model, based on the nine alternative scenarios, are 66 percent higher for the low scenario ($1.26 versus $0.76) and equal to the high scenario ($2.14 versus $2.14).

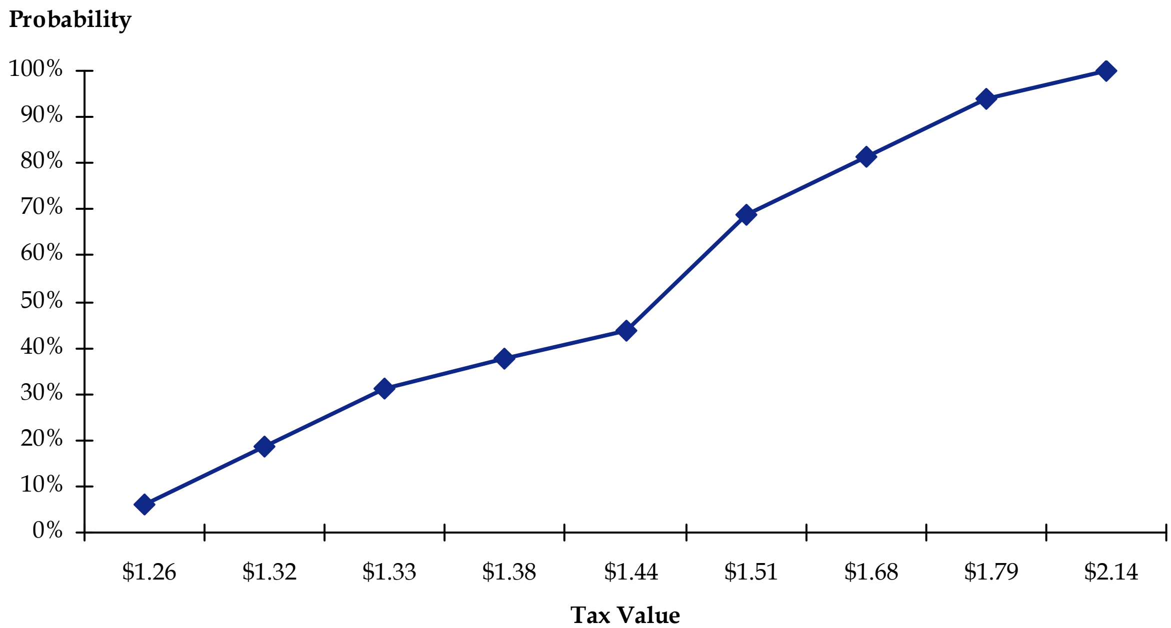
Table 19. Alternative Scenarios Results

Market Penetration of Alternative Technologies	MPG Improvement for All Technologies	Average Tax Value	Probability	Cumulative Probability
Low	Low	$1.26	6.25%	6.25%
Medium	Low	$1.32	12.50%	18.75%
Low	Medium	$1.33	12.50%	31.25%
High	Low	$1.38	6.25%	37.50%
Low	High	$1.44	6.25%	43.75%
Medium	Medium	$1.51	25.00%	68.75%
High	Medium	$1.68	12.50%	81.25%
Medium	High	$1.79	12.50%	93.75%
High	High	$2.14	6.25%	100.00%

Source: Cambridge Systematics, Inc.

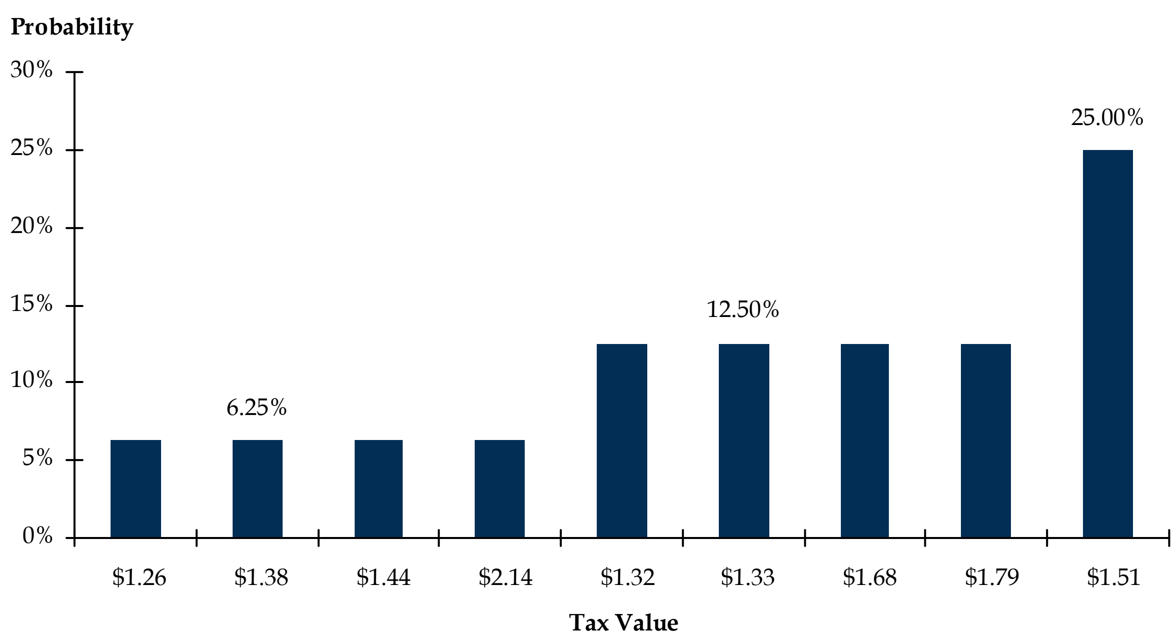
Figure 1 provides a graphic representation of the estimated tax and its cumulative probability; Figure 2 shows the individual probability of each scenario.

Figure 1. Cumulative Probability of Alternative Scenarios



Source: Cambridge Systematics, Inc.

Figure 2. Individual Probability of Alternative Scenarios



Source: Cambridge Systematics, Inc.