Virginia's Long-Range Multimodal Transportation Plan 2007-2035

EXAMINING THE LONG-TERM VIABILITY OF THE MOTOR FUELS TAX AND POSSIBLE ALTERNATIVES

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ABBREVIATIONS AND ACRONYMS

AFV	alternative fuel vehicles
CAFE	Corporate Average Fuel Economy
CNG	compressed natural gas
DOT	department of transportation
EIA	federal Energy Information Agency
E85	85% ethanol
FHWA	Federal Highway Administration
GPS	global positioning system
HEV	hybrid electric vehicles
HTF	Highway Trust Fund
LNG	liquid natural gas
LPG	liquefied petroleum gas
LDV	light-duty vehicles
MF	mileage fee
MPG	miles per gallon
National Commission	National Surface Transportation Policy and Revenue Study Commission
ODOT	Oregon Department of Transportation
OSU	Oregon State University
the Panel	Colorado Transportation Finance and Implementation Panel
POS	point of sale
PSU	Portland State University
RUFTF	Oregon's Road User Fee Task Force
RSB	Research Synthesis Bibliography
SAFETEA-LU	Safe, Accountable, Flexible, Efficient Transportation Equity Act—A Legacy for Users
SUV	sport utility vehicle
TAC	Technical Advisory Committee
TRB	Transportation Research Board
VDOT	Virginia Department of Transportation
VMT	vehicle miles traveled
VTRC	Virginia Transportation Research Council

EXECUTIVE SUMMARY

Introduction

VTrans2035, the Commonwealth of Virginia's statewide long-range multimodal transportation plan, is being developed by Virginia's Secretary of Transportation through the five state transportation modal agencies:

- Department of Aviation
- Department of Rail and Public Transportation
- Department of Transportation (VDOT)
- Department of Motor Vehicles
- Virginia Port Authority.

This undertaking is being carried out in conjunction with the Federal Highway Administration (FHWA) and regional planning bodies across the state.

As part of this effort, staff of the Virginia Transportation Research Council (VTRC) were asked to conduct a review and analysis of the long-term viability of the motor fuels tax and possible alternatives, as described herein.

Purpose and Scope

As a part of the development of VTrans2035, VTRC staff conducted an examination of the long-term viability of the motor fuels tax and possible alternatives, including the following topics:

1. state and national studies to examine the viability of the motor fuels tax and transportation finance approaches (both short term and longer term)

2. Oregon's concept based on a fee for vehicles miles traveled (VMT) and road user fee pilot and whether Virginia should fund a similar pilot program

3. historical and expected future penetration of hybrid, electric, and other alternative fuel vehicles

4. historical and projected (through 2035) taxable gallons, fleet fuel efficiency, and tax revenues

5. potential effects of carbon taxes on surface transportation revenues

6. viability of a VMT-type tax or combination VMT/motor fuels tax.

Since the timeframe of the study did not allow original research to be conducted, the investigation was limited to a literature review of available information on these topics.

Methods

VTRC staff were assisted by staff of the VDOT Research Library in their survey of available information on these topics. The VDOT Research Library prepared a separate annotated Research Synthesis Bibliography for this effort, which is currently being finalized and is available as RSB 19 at http://rclibrary/services/rsb.asp.

In addition to using the resources and staff of the VDOT Research Library, VTRC staff used the Transportation Research Information Services (TRIS) online bibliographic database and a variety of online search tools to identify and locate technical papers and reports relevant to the six topics under study.

Results

State and National Studies Examining the Viability of the Motor Fuels Tax and Other Approaches to Transportation Finance

Five studies examining the viability of the motor fuels tax and other approaches to transportation finance were examined:

1. the 2008 study by the Colorado Transportation Finance and Implementation Panel (hereinafter Colorado Panel)

2. the 2007 study by the National Surface Transportation Policy and Revenue Study Commission (hereinafter National Commission)

3. a 15-state pooled fund study on "A New Approach to Assessing Road User Charges" reported by Forkenbrock and Kuhl (2002)

4. the University of Iowa Public Policy Center's "National Evaluation of a Mileage-Based Road User Charge" study, the follow-up to the 15-state pooled fund study, which is underway

5. the Transportation Research Board's (TRB's) Special Report 285: *The Fuel Tax and Alternatives for Transportation Finance,* which reports a study conducted by the Committee for the Study of the Long-Term Viability of Fuel Taxes of the TRB (hereinafter the Committee) (2006).

Colorado's Transportation Finance and Implementation Panel

In 2007, Colorado Governor Bill Ritter established the 32-member Blue Ribbon Colorado Transportation Finance and Implementation Panel. The Colorado Panel and its technical advisory committee (TAC) met numerous times throughout Colorado and produced *A Report to Colorado* in January 2008 (Colorado Transportation Finance and Implementation Panel, 2008). Governor Ritter also directed the panel to draft specific proposals to be considered during the 2009 legislative session

In its report (Colorado Transportation Finance and Implementation Panel, 2008), the Colorado Panel documented a $51 billion gap in the state's current funding with regard to the 2030 "cost to sustain" its infrastructure; the gap between current revenues and the state's transportation 2030 transportation vision was twice that large. The panel's preferred alternative would produce a $1.5 billion increase in annual revenue for transportation.

The Colorado Panel considered 39 revenue options, including VMT taxes. Their recommended options included the following:

- a new $100 "maintenance fee" to be added to the vehicle registration fee
- a $0.13/gallon increase in the fuels tax
- indexing of the fuels tax to inflation (alternatively, referenda on future incremental changes in the tax rate)
- a new $6/day "visitor fee" (per each day of a car rental, per each night hotel stay)
- an 0.035% increase in the sales and use tax
- a 1.7% increase in the severance (mining) tax (current tax rate is 2% to 5%) (Colorado Transportation Finance and Implementation Panel, 2008).

Among the revenue options the Colorado Panel considered but did not recommend to the governor were the following:

- VMT fees
- weight-distance taxes on heavy trucks
- local impact fees
- fines for overweight vehicles
- a "new-wheels-on-the-road" fee (for first-time vehicle registrations)
- state transportation impact fees
- real estate transfer taxes
- a sales tax on fuel purchases
- an increase in the statewide property tax (Colorado Transportation Finance and Implementation Panel, 2008).

Although the Colorado Panel did not endorse VMT fees as an immediate priority, they did endorse a pilot program of VMT fees for the state. In doing so, the panel stated that it recognized that reliance on fuel taxes might not make for sustainable funding. The panel also concluded that VMT fees had great potential for improving the efficiency of the network and spreading demand (Colorado Transportation Finance and Implementation Panel, 2008).

At the present time, however, the Colorado Panel's TAC believed collection of VMT fees "is highly problematic," citing concerns about administrative burdens, technological issues, voter skepticism, and privacy (Colorado Transportation Finance and Implementation Panel TAC, 2008a). In addition, the TAC thought that implementation of VMT taxes in Colorado without voter approval could be difficult (Colorado Transportation Finance and Implementation Panel TAC, 2008a).

National Surface Transportation Policy and Revenue Study Commission

In 2005, Congress created the National Surface Transportation Policy and Revenue Study Commission under Section 1909 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act—A Legacy for Users (SAFETEA-LU). The National Commission worked to examine not only the condition and future needs of the nation's surface transportation system but also short-term and long-term alternatives to replace or supplement the fuel tax. The National Commission expired on July 7, 2008, after completing its final report in 2007 (National Surface Transportation Policy and Revenue Study Commission, 2007).

The National Commission concluded that significant increases in surface transportation investment were essential. VMT fees were identified as a promising option for the longer term, with the caveat that a number of technological, privacy, and collection cost issues could be satisfactorily resolved. Nevertheless, the National Commission concluded that the fuels tax would continue to be a viable revenue source through at least 2025.

The National Commission believed that there was sufficient uncertainty about the adequacy of the fuels tax as a primary source of surface transportation funding after 2025 and that federal and state transportation agencies should plan on moving to an alternative revenue source. States and the federal government must begin to develop a transition strategy immediately, the National Commission concluded, because many uncertainties and complexities had yet to be resolved about alternative financing mechanisms. In identifying VMT fees as a potential preferred long-term alternative, the National Commission noted the following about such fees:

- They could be equitably applied to any fuel type.
- The rates can be adjusted in response to congestion.
- They would encourage use of more fuel efficient, cleaner vehicles.
- They can be adjusted to charge trucks based on factors contributing to infrastructure damage (i.e., different rates can be charged).

- They directly reflect amount of travel, which is a key factor affecting highway costs (National Surface Transportation Policy and Revenue Study Commission, 2007).

According to the National Commission, a number of the challenges that must be resolved before large scale implementation of VMT fees can occur are technological challenges. Reliability, flexibility, cost, security, and enforceability are all institutional requirements for the large-scale implementation of VMT fees to be feasible. Further, administrative costs to implement VMT fees represent a significant unknown (National Surface Transportation Policy and Revenue Study Commission, 2007).

In discussing the promise of VMT fees as a revenue mechanism in the longer term, the National Commission noted the encouraging results of pilot programs (most notably, in Oregon) but said that more work was necessary prior to actual VMT fee implementation. Some of this work would occur in a study by The University of Iowa Public Policy Center that will examine VMT fees at six sites in the United States (University of Iowa, 2007). The National Commission went a step further and recommended that the next surface transportation reauthorization bill require a two-phase, 5-year major national study to determine the feasibility of VMT fees, achieve agreement on system architecture, and develop specific mechanisms for a transition to a VMT tax (National Surface Transportation Policy and Revenue Study Commission, 2007).

15-State Pooled Fund Study: "A New Approach to Assessing Road User Charges"

This study was a 3-year pooled fund study led by the Minnesota Department of Transportation. The participating agencies included 15 state departments of transportation (DOTs) and the FHWA and is reported by Forkenbrock and Kuhl (2004).

The study examined the policy, privacy, institutional, and technical issues related to an alternative system of road user charges based on actual miles traveled (i.e., VMT fees). The authors contended that VMT fees are the best method for assessing road user charges but that a lengthy phase-in period (perhaps as much as 20 years) would be necessary. As VMT fees are phased in for newer vehicles, drivers of older vehicles lacking the requisite on-board equipment would continue to pay fuel taxes (the authors contended that retrofitting existing vehicles would not be feasible).

The report discussed the technological requirements for a system of VMT fees in detail. The authors concluded that a relatively simple, GPS-based, on-board computer is likely to be the most cost-effective technology. According to the authors, currently available GPS equipment and GIS files possess the required level of accuracy if VMT fees are implemented for revenue collection only (but not for congestion pricing) (Forkenbrock and Kuhl, 2002).

Components of the system envisioned by the authors would be (1) on-board vehicle equipment, (2) a data and payment collection center, and (3) communications technology to link the vehicle to the collections center. For the communications technology, the authors discussed the merits of a "smart card" in the vehicle that could be removed by its owner and put into a conveniently located reader (similar to a credit card reader). The study authors believed it would

be critical to have redundancy in the technological systems for recording VMT and the direction of travel.

The authors (Forkenbrock and Kuhl, 2002) recommended a systematic field test and demonstration involving equipping numerous vehicles to validate system technology for VMT fees, reliability, and security, and assessing user satisfaction and acceptance. Such a study was funded under SAFETEA-LU and is described next.

The University of Iowa Public Policy Center's "National Evaluation of a Mileage-Based Road User Charge" Study

The University of Iowa Public Policy Center has initiated a federally funded 4-year study to assess the appropriateness of the technology and evaluate user acceptance of a VMT charging system as a possible long-term replacement for the current gas tax. The study involves temporary installation of an on-board computer in participants' vehicles to record fees due from road use. For the study, however, no actual usage fees will be collected. The research team's objective at the end of two additional years of field testing is to have developed a fully operational system to enable a VMT tax to be implemented (The University of Iowa Public Policy Center [University of Iowa], 2007). The VMT charging system to be tested fully and refined in this study was developed in the 15-state pooled fund study reported by Forkenbrock and Kuhl (2004) described previously.

Six test sites have been identified for the study, including two in the mid-Atlantic region (Baltimore, Maryland, and the Research Triangle in North Carolina, including Durham, Raleigh, and Chapel Hill). The four other sites are San Diego, California; Austin, Texas; Boise, Idaho; and Eastern Iowa. The sample of participants at all six locations is projected to be 2,700. Monthly questionnaires for participants will allow the researchers to track participants' reactions to the VMT charges over time and to evaluate performance of the on-board equipment further (University of Iowa, 2007).

The Transportation Research Board's Special Report 285: The Fuel Tax and Alternatives for Transportation Funding

This study, conducted by the Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance of the TRB (2006), focused on identifying what recent trends imply for the future of traditional (i.e., fuel-tax based) transportation finance. Study objectives also included identifying alternatives and the criteria by which they might be evaluated and suggesting ways in which barriers to the acceptance of new approaches might be overcome.

In 2006, the Committee could not necessarily anticipate the effect of oil prices and a worldwide recession on gasoline prices and consumption in 2008. Nonetheless, they believed the risk was not so large that the current highway finance system would be unable to maintain its historical performance for the following 15 years. Overall, they thought growth in spending and capacity could continue, although not at a rate that would reduce congestion (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

In 2006, the Committee believed that fuel price increases alone would probably stimulate only a small improvement in fuel economy before 2025. They projected a reduction of perhaps 20% in average gallons of fuel consumed per light-duty vehicle mile if new regulations or large and sustained fuel price increases were to occur. The Committee thought that larger reductions in gasoline consumption could occur after 2025 if market shares for hybrid electric or fuel-cell-powered vehicles were large and/or if high fuel prices or government intervention were to affect fuel economy (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

The Committee considered two types of alternative highway financing systems: (1) an expanded network of toll roads and lanes on high-density expressways, using present tolling technology but featuring variable pricing; and (2) mileage fees (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). They believed that mileage (or VMT) fees could have a number of benefits, including (1) improved operation of the road system and reduced congestion, and (2) better targeting of investments to the most worthwhile projects.

The Committee thought that converting to a system of mileage charges would require "a sustained national effort" and doing so "would have profound impacts on every aspect of the management of transportation programs." The roles of different levels of government would change, new criteria would become important in project selection, and a greater balance between highways and transit in urban areas would be attainable (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). Any individual state or city that wished to proceed with VMT fees on its own would face "enormous difficulties" related to cost, interstate traffic, and eventual needs for coordination on a national level.

The Committee recommended maintaining and reinforcing the current transportation finance system because the United States would rely on it for at least the next 10 years. The Committee also recommended two tracks of research, one technical and the other programmatic, with the goal of providing guidance to highway agencies on how to apply and manage road use charges (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

Oregon's Mileage Fee Concept and Road User Fee Pilot

Oregon's Mileage Fee Concept

The shortcomings of fuel taxation as a revenue source for the Oregon Department of Transportation (ODOT) were apparent, widely understood, and documented in the years leading to legislative action in 2001. In 2001, the 71st Oregon Legislative Assembly mandated the creation of the Road User Fee Task Force (RUFTF) to develop an alternative for the fuel tax. The RUFTF was required to report options for an alternative to the volume fuel tax to the 72nd Oregon Legislative Assembly. It was also authorized to recommend legislation under its own sponsorship.

The Oregon concept of VMT fees satisfied the RUFTF criteria with the following characteristics:

- VMT fees applied to passenger cars only.

- Mileage data and fee collection would occur at the fuel pump.

- An on-vehicle device would identify driving zones and stored running total mileage.

- The fuel pump would communicate electronically with on-vehicle device to retrieve stored mileage total; this would transfer data to the stations' point-of-sale (POS) system.

- The POS system would apply the mileage rate and produce receipts for the customer showing fuel purchase, VMT fee paid, and gas tax refunded.

- If the vehicle was not equipped with a VMT fee device, the customer would pay the gas tax on the fuel purchase as a default charge. In other words, VMT charges were to be phased in over time as new vehicles were equipped for VMT charges in proportion to the phase-out of the fuel tax with the older fleet.

Oregon's VMT Fee Pilot Program

The Oregon VMT Fee Pilot Program was conducted over a 12-month period and featured an extensive program of public outreach and public involvement. Only mileage within Oregon was charged, and charges varied by travel zones within the state (i.e., congestion pricing was used). The full report describes some of the problems that occurred in daily VMT fee transaction of the Oregon pilot.

As designed, the pilot was revenue-neutral and had low administrative costs (since VMT fee collection was performed during the same fuel transaction as collection of the usual fuels tax would have been). The main on-board device for zone recognition and mileage tabulation was a hybrid of GPS and odometer equipment, which allowed wireless electronic transmission of travel data from the vehicle to a device on a pump at a fueling station.

ODOT's Evaluation of the VMT Tax Pilot Program

ODOT's evaluation of the results of the pilot program was positive in many, but not all, respects:

- *Customer appeal:* good
- *Ease and cost of enforcement:* good
- *Feasibility:* good
- *Coordination with current service station operations:* good
- *Start up and operating and maintenance costs:* more information needed in the future
- *Adaptability to congestion pricing:* good
- *Collection costs relative to gas tax*: favorable
- *Revenue potential:* good
- *Accuracy of technology:* satisfactory for pilot project (although mileage collection accuracy varied across devices)

- *Reliability:* needs improvement
- *Security:* needs improvement.

Overall, 91% of the participants of the pilot program indicated they were willing to continue with VMT charging if all Oregon service stations were VMT-equipped. Service station owners had more concerns about privacy protection than customers did. Station operators also had some issues with the effects of the new technology and software on existing station computers. ODOT recognized that statewide implementation would require choice in the POS system used at the station level, greater system reliability, and fuel pumps with required communication capabilities.

Historical and Expected Future Market Penetration of Hybrid, Electric, and Other Alternative Fuel Vehicles

Market Share of Alternative Fuel Vehicles

The share of vehicles that run on liquid natural gas (LNG) and compressed natural gas (CNG) comprised a stable, and small, share of the total vehicle fleet as of 2005. The share of LNG vehicles might still have been growing as of 2005. The shares of vehicles that run on 85% ethanol (E85) and all-electric vehicles were still growing in 2005 (Alternative Fuels and Advanced Vehicles Data Center, 2008). Forecasts of future growth rates in alternative fuel vehicles (AFV) sales are unlikely to be reliable, given both recent sales trends and changes in fuel prices in the last 2 years.

Market Share of Hybrid Electric Vehicles

The share of hybrid electric vehicles (HEVs) in the total vehicle fleet was growing rapidly as of 2007. To predict the level at which HEVs will level off is challenging (Alternative Fuels and Advanced Vehicles Data Center, 2008). The sales of HEVs as a class were still growing at a much faster rate in 2007 than were total sales of all light-duty vehicles (LDVs). In addition, the proportion of HEVs among total new LDV sales exceeds greatly the proportion of HEVs in the existing LDV fleet. Without additional information on which to base a forecast of the market share at which HEVs will level off, it is hard to know what growth rate to expect for them over the next few years. Once again, the recent increases in the relative price of fuel make a forecast based on recent trends unreliable. The recent market situation, in which full-capacity production of HEV vehicles could not keep up with demand, is not a stable condition. Table ES-1 shows sales of HEVs by model and year through 2007.

Table ES-1. Hybrid Electric Vehicle (HEV) Sales by Model										
Vehicle	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**
Honda Insight	17	3,788	4,726	2,216	1,200	583	666	722	0	13,918
Toyota Prius		5,562	15,556	20,119	24,600	53,991	107,897	106,971	181,221	515,917
Honda Civic				13,700	21,800	25,571	25,864	31,251	32,575	150,761
Ford Escape						2,993	18,797	20,149	21,386	63,325
Honda Accord						1,061	16,826	5,598	3,405	26,890
Lexus RX400h							20,674	20,161	17,291	58,126
Toyota Highlander							17,989	31,485	22,052	71,526
Mercury Mariner							998	3,174	3,722	7,894
Lexus GS 450h								1,784	1,645	3,429
Toyota Camry								31,341	54,477	85,818
Nissan Altima									8,388	8,388
Saturn Vue									4,403	4,403
Lexus LS600hL									937	937
Saturn Aura									772	772
Total	17	9,350	20,282	36,035	47,600	84,199	209,711	252,636	352,274	997,604
Data Sources:										
Insight, 1999-2002	www.insightcentral.net/KB/sales.html (Accessed 7/18/2007)									
Prius, 2000-2002	www.toyoland.com/prius/chronology.html (Accessed 7/18/2007)									
Civic, 2002; All, 2003	www1.eere.energy.gov/vehiclesandfuels/facts/2007_fcvt_fotw462.html (Accessed 4/3/2007)									
Insight, Prius, Civic, Accord, 2004	Hybrid Vehicles Report (Dec 2005, Volume 7, Issue 6)									
Escape, 2004	www.greencarcongress.com/2005/01/us_hybrid_sales.html (Accessed 7/18/2007)									
All but RX440h & Highlander, 2005	www.electricdrive.org/index.php?tg=articles&idx=Print&topics=7&article=692 (Accessed 7/18/2007)									
RX400h, Highlander, 2005	Hybrid Vehicles Report (Feb 2007, Volume 9, Issue 1); 2006 Ford and GM data not included									
All, 2006-2007	Manufacturer-reported numbers, as posted on www.hybridcars.com/market-dashboard.html (Accessed 2/11/2008)									
Notes:										
No single source contains a complete and accurate list of sales data so multiple sources were compiled by the National Renewable Energy Laboratory.										
Year refers to calendar year, not model year.										
GMC Silverado and Sierra are not tracked because they are not full hybrids.										

Reprinted from Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: Vehicles: Alternative Fuel Vehicles and Hybrid Electric Vehicles (HEVs): HEV Sales by Model: Trend of Sales by HEV Models from 1999-2007. http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls. Accessed October 27, 2008.

Historical and Projected Taxable Gallons, Fleet Fuel Efficiency, and Tax Revenues Through 2035

A variety of forces, including technological advances and changes in the price of fuel, has influenced the kinds of vehicles that manufacturers brought to market in past years and the number of each kind of vehicle that consumers purchased (U.S. Environmental Protection Agency, 2008). The two variables that bear most heavily on taxable fuel consumption, and as a consequence on motor fuels tax revenue, are the average fuel economy of the vehicle fleet (in miles per gallon [MPG]) and the average mileage per vehicle per unit of time (VMT per vehicle per year).

Trend data presented in the full report imply a nationwide annual rate of growth of 1.341% in taxable fuel consumption and a Virginia annual rate of growth of 1.543%. The U.S. fuel consumption data presented in the report, however, show a trend of 2.305% annual growth since 2000—a markedly faster rate. Clearly, recent fuel consumption trends have been affected by changes in the price of fuel and overall economic conditions. The sensitivity of fuel efficiency and VMT to changes in fuel prices are discussed in the full report and are summarized here.

Sensitivity of Fuel Efficiency and VMT to Changes in Fuel Price

The sensitivity of fuel efficiency and the sensitivity of VMT to changes in fuel price are discussed separately here. Combined, they imply a sensitivity of fuel consumption to changes in fuel price in a range from –0.4 to –0.8 (according to a 1997 survey by Johannson and Schipper) or possibly as high as –0.92 (according to a 1999 study by Agras and Chapman), the median estimate being –0.6 or –0.7 (cited in Victoria Transport Policy Institute [VTPI], 2008). This means that a 10% increase in the price of gasoline, if it persists for a period of years, may be expected to depress fuel consumption by 6% or 7%, possibly as little as 4% or as much as 9.2%. (Although fuel prices increased by substantially more than 10% in 2008, the increases have not persisted in the short term.)

Figure ES-1 compares the projection of nationwide fuel consumption based on the trend in the nationwide fuel consumption data (2.305%) against the projection based on the difference between the trends in VMT and MPG (1.341%) over the VTrans planning horizon.

Figure ES-2 shows historical vehicle fuel efficiencies and a trend forecast based on the averages in years 2000 through 2007. The historical data show that the average fuel efficiency of the U.S. LDV fleet rose markedly during the 1970s and carried over into the 1980s as vehicles built to the lower standards of the early 1970s were gradually replaced by those built to the standards of the late 1970s. From a peak in 1989, the average fuel economy dropped off slightly, as a shift in the composition of the fleet toward vans, sport utility vehicles (SUVs), and light trucks offset the very small gains in fuel efficiency. The forecast based on the trend from 2000 to 2007 predicts for the future a small (0.419%) annual increase in average fuel efficiency.

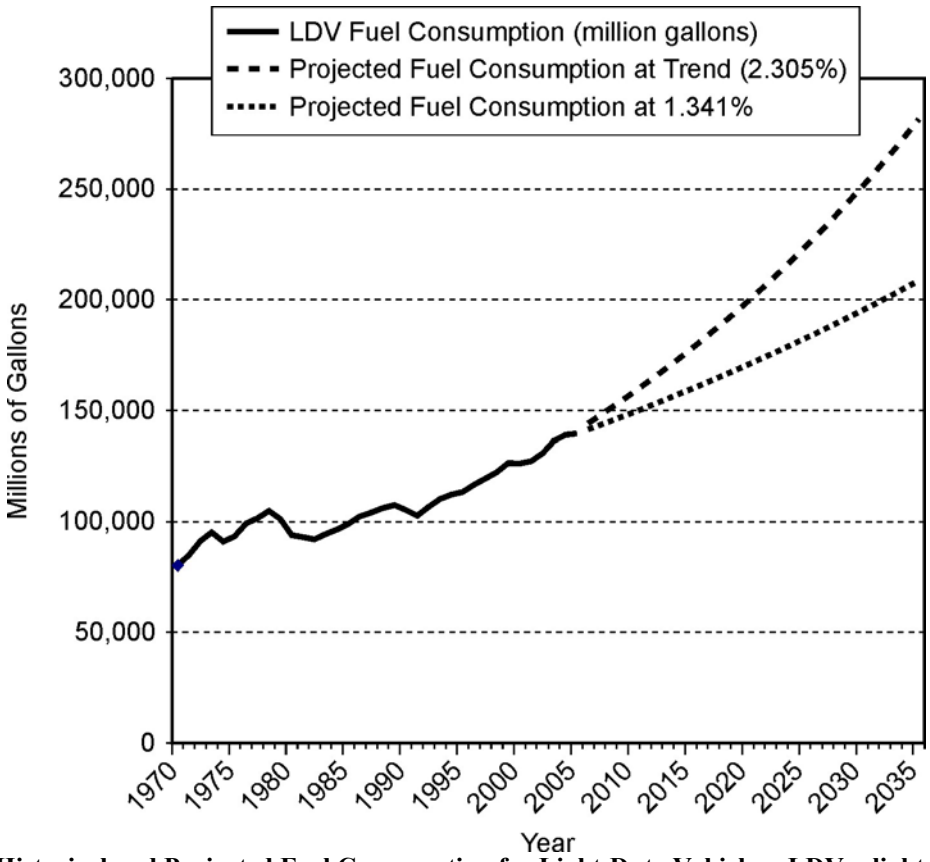

Figure ES-1. Historical and Projected Fuel Consumption for Light-Duty Vehicles. LDV = light-duty vehicle. The data source for "LDV Fuel Consumption" is Table 4 in the full report.

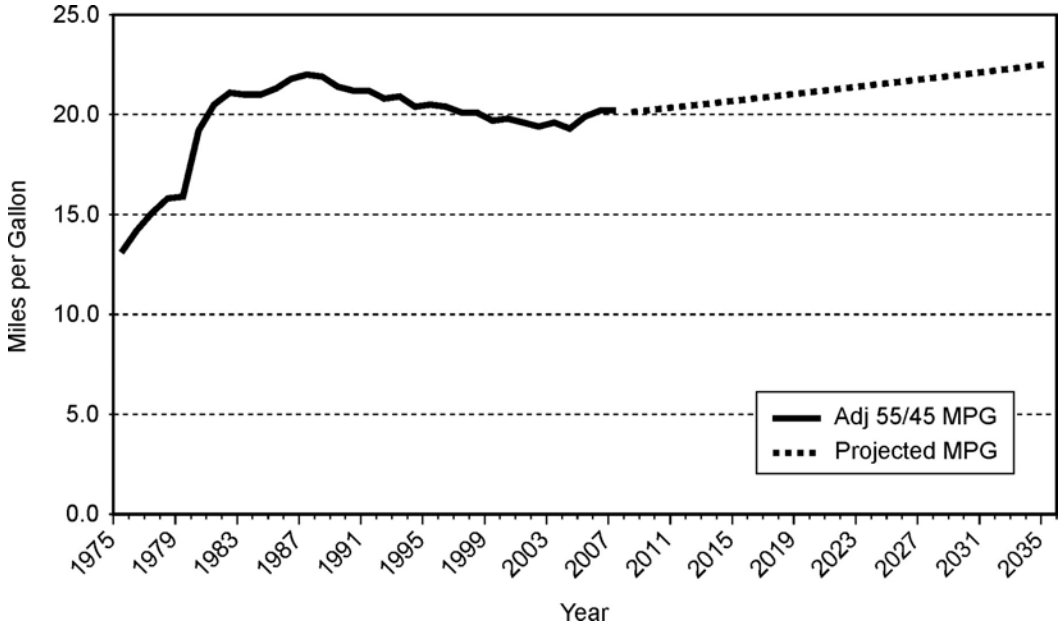

Figure ES-2. Historical Fuel Efficiencies and Trend Forecast Based on Averages in Years 2000 through 2007. "Adj 55/45 MPG" indicates (1) that EPA *adjusted* the fuel economy figures that were measured by standardized laboratory procedures to reflect real road conditions rather than laboratory conditions, and (2) that the fuel economy is a weighted average of 55% city fuel economy and 45% highway. The data source for "Adj 55/45 MPG" is Table 3 in the full report. MPG = miles per gallon.

Figure ES-3 shows the trends in U.S. population and VMT per capita. The trend forecasts of 0.99% annual growth in population and 0.77% annual growth in VMT per capita, based on the historical data from 2000 through 2005, imply 1.76% annual growth in VMT.

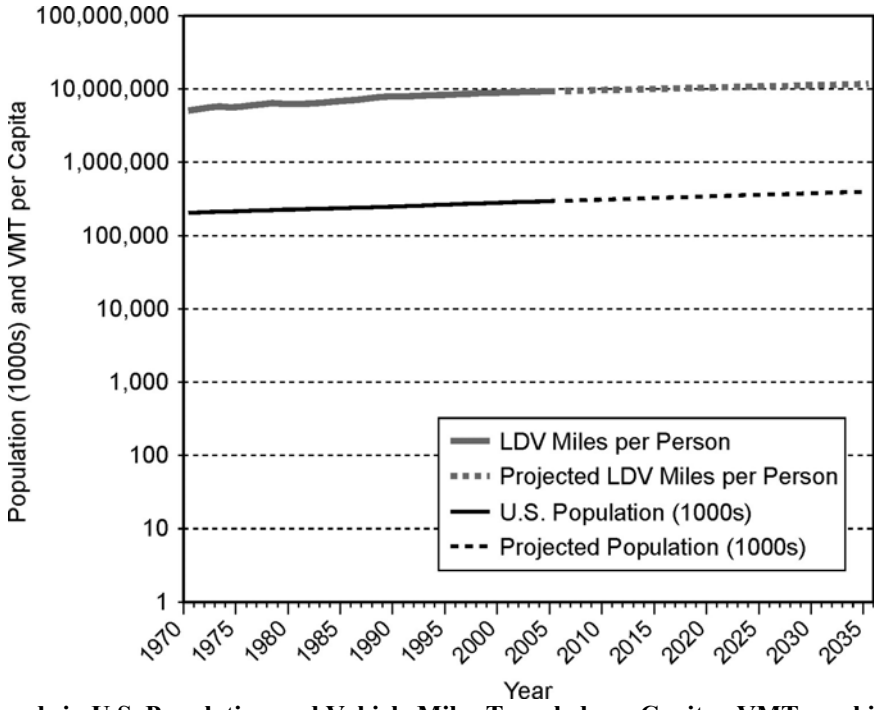

Figure ES-3. Trends in U.S. Population and Vehicle Miles Traveled per Capita. VMT = vehicle miles traveled; LDV = light-duty vehicle. The data source for "LDV Miles per Person" and "U.S. Population" is Table 4 in the full report.

Potential Effects of Carbon Emissions Reductions Policies on Transportation Revenues

An additional issue on which the National Commission was briefed was how future policy actions to reduce carbon emissions—i.e., to address global warming—could affect surface transportation revenues. National Commission staff who prepared the briefing paper on this topic thought that generally the emissions reduction policy details (as yet unknown) would determine the extent to which the HTF was affected (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b). A National Commission briefing paper summarized the effectiveness of surface transportation strategies to reduce carbon emissions (ICF International and Bill Cowart, 2007).

The National Commission staff made the following general observations:

- Fuel tax increases to lower carbon emissions could create additional revenue.
- Increases in CAFE standards to reduce carbon emissions would increase fuel efficiency and, as a consequence, reduce revenue per mile of travel.

- If other carbon-emitting sectors of the economy (e.g., electricity generation) are not also a focus of policy initiatives, policy changes in transportation will be designed to produce larger reductions.

- Enacting tailpipe standards to lower carbon emissions per mile would have similar effects as increasing CAFE standards.

- VMT fees could play a limited role in reducing carbon emissions (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

Potential Impacts of Carbon Taxes or Cap-and-Trade Policies on Transportation Revenues

The potential impacts of carbon taxes and cap-and-trade policies have been assessed by the National Commission and others. A national carbon tax would add a tax to (fossil) fuels based on the amount of carbon they contain. Fuel costs would rise as a result, and the policy goal would be to discourage consumption of conventional fuels. According to National Commission staff, all other things being equal, transportation revenues would decline. These taxes are envisioned to be economy-wide and would provide market incentives to develop or switch to renewable or lower-carbon fuels. National Commission staff also reported that the electricity generation sector (which uses coal) would likely feel the greatest effects of such a tax (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

Cap-and-trade policies have also been proposed as a means for limiting carbon emissions across multiple sectors of the economy (i.e., not only transportation). This involves setting a cap on carbon emissions and requiring that all emissions be tied to permits that would be sold. Caps could be established at different points in the fossil fuel production or consumption cycle. National Commission staff pointed out that cap-and-trade policies would raise equity issues and issues related to differing economic effects on population groups. Carbon taxes may be less problematic in this regard because carbon taxes paid could offset other taxes paid, etc. (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

National Commission staff emphasized that until the details of any policy proposal to reduce carbon emissions (carbon taxes, cap-and-trade, "feebates" for purchases of vehicles that exceed a fuel efficiency standard, etc.) were known, the impacts of the policies on revenues can be projected only in general terms.

Feasibility of a VMT Tax for Virginia

Based on the studies reviewed for this report, it appears very likely that Virginia (and many or all other states) will need to consider implementation of a VMT tax over the longer term. Although the experts' opinions vary, the National Commission concluded that the fuels tax would continue to be a viable revenue source through at least 2025. Similarly, in 2006, the Committee for the Study of the Long-Term Viability of Fuel Taxes in TRB Special Report 285 concluded that "the risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years." The current

performance of the highway finance system, however, has been affected by spikes in oil prices and an economic recession, which may not have been fully anticipated in 2006.

The Committee concluded that despite the advantages of a VMT tax, the transition from the current system of highway finance will require a sustained national effort, and the National Commission reached a similar conclusion (National Surface Transportation Policy and Revenue Study Commission, 2007). The challenges that must be addressed include the following:

- the remaining problems with technology required for VMT taxation
- public acceptance, including public education and outreach and overcoming concerns about privacy, security, etc.
- additional pilot programs
- a transition strategy and guidance for DOTs considering broader implementation of VMT fees.

Both the Committee and the National Commission emphasized the need for further research and testing, and as mentioned earlier, the University of Iowa Public Policy Center already has such a study underway. The Committee envisioned two research "tracks," one technical and the second programmatic, focusing on research to provide guidance to DOTs on the administration and management of mileage-based fees. The National Commission envisioned an initial VMT tax feasibility study, followed by a study to develop a plan for implementing a federal VMT tax and to coordinate it with state and/or local VMT tax implementation.

The studies reviewed for this report envisioned parallel taxation systems being necessary for a period of time (perhaps 20 years, the National Commission suggested). New cars would have needed on-board equipment for VMT fee collection; drivers of older cars would pay fuel taxes until the vehicle was retired from the fleet (National Surface Transportation Policy and Revenue Study Commission, 2007).

The Committee concluded that that the general introduction of mileage charging "would have profound effects on every aspect of the management of transportation programs." Some of the effects they identified were changed roles of federal, state, and local governments; new criteria for project selection; the availability of a new means to regulate traffic and influence congestion, air quality, etc.; and the opportunity to affect resource allocation to and use of transit and highways in urban areas (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

These recommendations for further research, planning, etc., may seem too time-consuming or deliberate for transportation executives currently facing severe revenue problems. Nonetheless, despite the success of the Oregon VMT tax pilot, system reliability, security, and technology were identified as needing improvement. Oregon's VMT tax pilot was also revenue-neutral (by design) to encourage public acceptance of VMT taxes. Revenue-neutral VMT taxes

would not solve the financial problems many state DOTs currently face. The Committee also concluded that "an individual state or city that wished to proceed with mileage charging would face enormous difficulties . . . ." (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). High fixed costs to build the first implementations, issues related to interstate traffic, and future needs for national coordination of standards or policies were among the significant difficulties identified by the Committee.

Conclusions

With regard to the six issues investigated in this study, the following conclusions may be drawn:

1. *With regard to the viability of the motor fuels tax,* although the experts' opinions vary, the National Surface Transportation Policy and Revenue Study Commission (National Commission) concluded that the fuels tax would continue to be a viable revenue source through at least 2025. Further, the Committee for the Study of the Long-Term Viability of Fuel Taxes in TRB Special Report 285 concluded that "the risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years." Of course, as mentioned previously, the present performance of the highway finance system has been affected by spikes in oil prices and an economic recession, which may not have been fully anticipated in 2006.

2. *With regard to Oregon's VMT fee pilot and whether Virginia should fund a similar pilot program,* despite the success of the Oregon pilot, system reliability, security, and technology were identified as needing improvement. The pilot was also revenue-neutral (by design) to encourage public acceptance of VMT taxes. The current VMT tax study being led by the University of Iowa Public Policy Center will provide more information on these issues and will involve a larger number of drivers at six locations in the United States. As stated in Recommendation 1 that follows, Virginia could consider being a pilot location for studies of VMT taxes.

3. *With regard to the historical and expected future penetration of hybrid, electric, and other alternative fuel vehicles (AFVs),* many of the AFV growth rates to date do not lend themselves to reliable forecasting. It is unclear where market shares for some AFVs will level off. Hybrid electric vehicle (HEV) sales, in particular, are climbing rapidly, much faster than light-duty vehicle sales overall. Conditions are unstable, however, for making a reliable forecast of the market share at which HEV sales could level off. As stated in Recommendation 3, Virginia should closely watch the trends in coming years, particularly with regard to HEV sales.

4. *With regard to historical and projected (through 2035) taxable gallons, fleet fuel efficiency, and tax revenues,* average fuel economy for the vehicle fleet and average annual VMT per vehicle are the most important determinants of fuels tax revenue (apart from the tax rate itself). Fleet fuel efficiency has changed in very small

increments since the 1980s, and the report's forecast of future fuel efficiency gains is consistent with that. The researchers projected growth in fuel consumption for the VTrans forecast period based on two alternative growth rates, which they discuss in detail. Virginia is growing more rapidly than the United States as a whole, and the report's forecast of VMT growth reflects that fact. The economic recession and the instability of oil prices, however, contribute to the researchers' recommendation that trends in fuel consumption be closely followed in the near future (Recommendation 3).

5. *With regard to the potential effects of carbon taxes on surface transportation revenues,* according to National Commission staff, all other things being equal, transportation revenues would decline. However, staff emphasized that until the details of any policy proposal to reduce carbon emissions (carbon taxes, cap-and-trade, "feebates" for purchases of vehicles that exceed a fuel efficiency standard, etc.) were known, the impacts of the policies on revenues can be projected only in very general terms.

6. *With regard to the viability of a VMT-type tax or combination VMT/motor fuels tax,* it appears very likely that Virginia (and many or all other states) will need to consider implementation of a VMT tax over the longer term. Many issues must be addressed, including remaining problems with the technology required; public acceptance, including public education and outreach and overcoming drivers' concerns about privacy, security, etc.; the need for additional pilot programs; and development of a transition strategy and guidance for DOTs considering broader implementation of VMT fees. Parallel taxation systems would be necessary for a period of time (perhaps 20 years, the National Commission suggested). High fixed costs to build the first implementations, issues related to interstate traffic, and future needs for national coordination of standards or policies are among other significant difficulties remaining to be resolved. The National Commission recommended that the next surface transportation reauthorization include funding for a 5-year major national study to address many of these questions.

Recommendations

VTRC staff were asked to offer recommendations for the short term (2020) and the longer term (2035) with regard to VMT taxes as an alternative to the fuels tax. For the short term, three recommendations can be offered:

1. *The Office of Intermodal Planning and VDOT should closely follow and when warranted participate in ongoing and future technical and programmatic research with regard to VMT taxes. Virginia could also offer to be a pilot location for yet-to-be initiated studies of VMT taxes.* Among the states, Virginia has considerable experience with tolling that could inform the design of future research studies, and it has major public-private partnerships underway that will use congestion pricing in the

Northern Virginia/Washington, D.C., region. Residents of that region are familiar with the concept and are interested in strategies that would reduce traffic congestion.

2. *The Office of Intermodal Planning and VDOT could begin to plan and develop a public information and outreach plan to inform citizens and legislators how the growing transportation revenue problem could be equitably addressed with VMT taxes and the advantages of VMT taxes vs. the current highway finance system.* An extensive program of public education and outreach was a key factor in the success of the Oregon VMT tax pilot, and it would be no less important in Virginia—there is sensitivity about tax increases and privacy, and these issues would need to be effectively addressed before VMT taxes could be implemented on even a limited basis.

3. *The Office of Intermodal Planning and VDOT should continue to follow closely trends in fuel consumption and vehicle purchases, especially purchases of HEVs.*

At the time this report was prepared, a number of these trends were rapidly changing and were not well suited for longer range forecasts of behavior. For that reason, the trends should continue to be followed closely.

Recommendations for the longer term (2035) are quite dependent on the results of studies being conducted now, or to be conducted in the short term, which would address the questions that still remain about system architecture for VMT taxes, privacy, security, coordination among different levels of government, and program management at different levels of government. The direction of any policy initiatives to reduce consumption of conventional fuels (carbon taxes or cap-and-trade policies) will also matter. In the interim, some of the trends that are difficult to forecast with any certainty may become clearer.

INTRODUCTION

VTrans2035, the Commonwealth of Virginia's statewide long-range multimodal transportation plan, is being developed by Virginia's Secretary of Transportation through the five state transportation modal agencies:

- Department of Aviation
- Department of Rail and Public Transportation
- Department of Transportation (VDOT)
- Department of Motor Vehicles
- Virginia Port Authority.

This undertaking is being carried out in conjunction with the Federal Highway Administration (FHWA) and regional planning bodies across the state.

As part of this effort, staff of the Virginia Transportation Research Council (VTRC) were asked to conduct a review and analysis of the long-term viability of the motor fuels tax and possible alternatives, as described herein.

PURPOSE AND SCOPE

As a part of the development of VTrans2035, VTRC staff conducted an examination of the long-term viability of the motor fuels tax and possible alternatives, including the following topics:

1. state and national studies to examine the viability of the motor fuels tax and transportation finance approaches (both short term and longer term)

2. Oregon's concept based on a fee for vehicles miles traveled (VMT) and road user fee pilot and whether Virginia should fund a similar pilot program

3. historical and expected future penetration of hybrid, electric, and other alternative fuel vehicles

4. historical and projected (through 2035) taxable gallons, fleet fuel efficiency, and tax revenues

5. potential effects of carbon taxes on surface transportation revenues

6. viability of a VMT-type tax or combination VMT/motor fuels tax.

Since the timeframe of the study did not allow original research to be conducted, the investigation was limited to a literature review of available information on these topics.

METHODS

VTRC staff were assisted by staff of the VDOT Research Library in their survey of available information on these topics. The VDOT Research Library prepared a separate annotated Research Synthesis Bibliography for this effort, which is currently being finalized. The RSB is available as RSB 19 at http://rclibrary/services/rsb.asp.

In addition to using the resources and staff of the VDOT Research Library, VTRC staff used the Transportation Research Information Services (TRIS) online bibliographic database and a variety of online search tools to identify and locate technical papers and reports relevant to the six topics under study. Previous projects undertaken at VTRC had included contact with staff of the federal Energy Information Agency (EIA) and staff of Virginia state government agencies who maintain data on taxable gallons of fuels sold and fuels tax revenues.

RESULTS

State and National Studies Examining the Viability of the Motor Fuels Tax and Other Approaches to Transportation Finance

Five studies examining the viability of the motor fuels tax and other approaches to transportation finance were examined:

1. the 2008 study by the Colorado Transportation Finance and Implementation Panel (hereinafter Colorado Panel)

2. the 2007 study by the National Surface Transportation Policy and Revenue Study Commission (hereinafter National Commission)

3. a 15-state pooled fund study on "A New Approach to Assessing Road User Charges" reported by Forkenbrock and Kuhl (2002)

4. the University of Iowa Public Policy Center's "National Evaluation of a Mileage-Based Road User Charge" study, the follow-up to the 15-state pooled fund study, which is underway

5. the Transportation Research Board's (TRB's) Special Report 285: *The Fuel Tax and Alternatives for Transportation Finance,* which reports a study conducted by the Committee for the Study of the Long-Term Viability of Fuel Taxes of the TRB (hereinafter the Committee) (2006).

Colorado Transportation Finance and Implementation Panel

In 2007, Colorado Governor Bill Ritter established a 32-member Blue Ribbon Colorado Transportation Finance and Implementation Panel. The Colorado Panel and its technical

advisory committee (TAC) met numerous times throughout Colorado and produced *A Report to Colorado* in January 2008 (Colorado Transportation Finance and Implementation Panel, 2008). In June 2008, Governor Ritter directed the panel to embark on a public education campaign about the state's transportation funding situation.

Governor Ritter also directed the Colorado Panel to draft specific proposals to be considered during the 2009 legislative session. Colorado's last increase in its fuels tax was in 1991 (to $0.22/gallon). Legislators have been prevented from any subsequent initiatives to increase taxes to keep pace with highway cost inflation by the state's Taxpayer Bill of Rights. As a consequence, since 1977, the state has been supplementing gas tax revenues with revenues from the General Fund during good economic periods. These transfers accounted for 0% to 28% of the balance of the Highway Users' Trust Fund, depending on the year (Colorado Transportation Finance and Implementation Panel, 2008).

In its report (Colorado Transportation Finance and Implementation Panel, 2008), the Colorado Panel documented a $51 billion gap in the state's current funding with regard to the 2030 "cost to sustain" its infrastructure; the gap between current revenues and the state's transportation 2030 transportation vision was twice that large. The panel's recommended options would produce a $1.5 billion increase in annual revenue for transportation.

The Colorado Panel considered 39 revenue options, including VMT taxes. Their recommended options included the following:

- a new $100 "maintenance fee" to be added to the vehicle registration fee
- a $0.13/gallon increase in the fuels tax
- indexing of the fuels tax to inflation (alternatively, referenda on future incremental changes in the tax rate)
- a new $6/day "visitor fee" (per each day of a car rental, per each night hotel stay)
- an 0.035% increase in the sales and use tax
- a 1.7% increase in the severance (mining) tax (current tax rate is 2% to 5%) (Colorado Transportation Finance and Implementation Panel, 2008).

Among the revenue options the Colorado Panel considered but did not recommend to the governor were the following:

- VMT fees
- weight-distance taxes on heavy trucks
- local impact fees

- fines for overweight vehicles
- a "new-wheels-on-the-road" fee (for first-time vehicle registrations)
- state transportation impact fees
- real estate transfer taxes
- a sales tax on fuel purchases
- an increase in the statewide property tax (Colorado Transportation Finance and Implementation Panel, 2008).

Although the Colorado Panel did not endorse VMT fees as an immediate priority, they did endorse a pilot program of VMT fees for the state. In doing so, the panel stated that it recognized that reliance on fuel taxes might not make for sustainable funding. The panel also concluded that VMT fees had great potential for improving the efficiency of the network and spreading demand (Colorado Transportation Finance and Implementation Panel, 2008).

Documents from the Colorado Panel's TAC meetings summarize their discussions of VMT taxes and other possible revenue options. The summary of their discussion of VMT taxes stated: "Collection [of VMT fees] is highly problematic" (Colorado Transportation Finance and Implementation Panel TAC, 2007). Other factors opposing the implementation of a VMT tax in Colorado included the administrative burden, technology, and voter skepticism regarding the "Big Brother" aspect of the tax (Colorado Transportation Finance and Implementation Panel TAC, 2008a,b). Technology issues noted by the TAC included the feasibility of retrofitting existing vehicles, whether inclusion of required technology could be mandated for new vehicles, and the potential for fraud if vehicle owners were to self-report odometer readings.

In discussing the technology issues associated with VMT taxes, the Colorado Panel's TAC highlighted retrofitting of existing vehicles as a significant problem "because applications for various makes and models are not standardized" (Colorado Transportation Finance and Implementation Panel TAC, 2008a). Self-reporting odometer readings in lieu of retrofitting the existing vehicle fleet was believed to be susceptible to fraud. Other technological issues mentioned by the Colorado Panel's TAC based on the Oregon pilot (discussed later) included the following needs:

- provision of technical assistance to fuel stations on a continuous basis (under the assumption that vehicle mileage counting devices would be read there)
- improvement in the speed of cash transactions at the fuel pump
- improvement in the accuracy of mileage data transmission at the fuel pump to 99.99% (Colorado Transportation Finance and Implementation Panel TAC, 2008a).

In addition, the Colorado Panel's TAC thought that implementation of VMT taxes in Colorado without voter approval could be difficult (Colorado Transportation Finance and Implementation Panel TAC, 2008a).

The Colorado Panel's TAC analyzed a scenario specifying full conversion from fuels taxes to a $0.01/mile VMT tax with a hypothetical beginning date of January 1, 2008. Projected 2008 revenues from the VMT tax were $506 million, compared to projected revenues of $533 million from fuels taxes. The reader should be reminded that this analysis was done before the national spike in oil prices and the drop in VMT. Over the full 2035 planning horizon, the revenue from the VMT tax was projected to be about $2 billion more, in nominal dollars, than that from the fuels tax (Colorado Transportation Finance and Implementation Panel TAC, 2008a,b).

National Surface Transportation Policy and Revenue Study Commission

In 2005, Congress created the National Surface Transportation Policy and Revenue Study Commission under Section 1909 of the Safe, Accountable, Flexible, Efficient Transportation Equity Act—A Legacy for Users (SAFETEA-LU). The National Commission was created because, as Congress declared, "it is in the national interest to preserve and enhance the surface transportation system to meet the needs of the United States for the 21st century" (National Surface Transportation Policy and Revenue Study Commission, n.d.).

The National Commission had 12 members representing federal, state, and local governments; metropolitan planning organizations; transportation-related industries; and public interest organizations. The National Commission worked to examine not only the condition and future needs of the nation's surface transportation system but also short-term and long-term alternatives to replace or supplement the fuel tax as the principal revenue source to support the Highway Trust Fund (HTF) over the next 30 years. The term of the National Commission expired July 7, 2008 (National Surface Transportation Policy and Revenue Study Commission, n.d.).

The National Commission completed its final report in 2007 (National Surface Transportation Policy and Revenue Study Commission, 2007). It offered revenue recommendations for the mid-term (2010-2015) and the longer term (after 2015). Included in the final report are numerous technical briefing papers on a wide range of topics (National Surface Transportation Policy and Revenue Study Commission, n.d.).

The National Commission concluded that significant increases in surface transportation investment were essential. VMT fees were identified as a promising option for the longer term, with the caveat that a number of technological, privacy, and collection cost issues could be satisfactorily resolved. Nevertheless, the National Commission concluded that the fuels tax would continue to be a viable revenue source through at least 2025.

The National Commission also recommended a federal container fee on freight passing through the nation's ports, increases in state fuel taxes and other fees, and flexibility for states to enact tolls for new interstate capacity. Giving states the flexibility to implement congestion

pricing on both new and existing interstate lanes in urban areas with populations of 1 million or more was another of the National Commission's recommendations (National Surface Transportation Policy and Revenue Study Commission, 2007).

Fuels Taxes As a Funding Source: Advantages and Disadvantages

In its 2007 final report, the National Commission reported that fuel taxes represent about 90% of total HTF revenues at the federal level (National Surface Transportation Policy and Revenue Study Commission, 2007). Fuel taxes are attractive because of their (1) low administrative and compliance costs, (2) ability to generate substantial amounts of revenue, (3) relative stability and predictability, and (4) ease of implementation. The limitation of fuel taxes for financing surface transportation is that they are not responsive to rising construction costs when charged on a per gallon basis—unless the tax is indexed to inflation. The National Commission noted that the fuels tax is the only major existing user fee not indexed to inflation.

A technical briefing paper prepared by National Commission staff compared fuels taxes and other potential revenues sources, highlighting the advantages noted (National Surface Transportation Policy and Revenue Study Commission Staff, 2007c). Although fuels tax evasion had been a significant problem, it was decreasing. A significant disadvantage of fuel taxes was that in many cases, flat rates fees per gallon had not been adjusted frequently enough to keep pace with growing infrastructure needs (Virginia's last increase to its flat rate fuels tax occurred in 1985, for example). In light of this problem, the National Commission recommended an increase in the federal fuels tax of $0.05 to $0.08/gallon/year for the next 5 years to address the projected investment gap (i.e., to "catch up"), after which they recommended that the fuels tax be indexed to inflation (National Surface Transportation Policy and Revenue Study Commission, 2007). Prices for some goods used in highway maintenance and construction have risen far more steeply than inflation on the whole in recent years, however. In that instance, even if taxes are indexed to inflation, buying power erodes (National Surface Transportation Policy and Revenue Study Commission, 2007).

VMT Fees As a Potential Transportation Revenue Source: Advantages

The National Commission believed there was sufficient uncertainty about the adequacy of the fuels tax as a primary source of surface transportation funding after 2025 and that federal and state transportation agencies should plan on moving to an alternative revenue source. States and federal government must begin to develop a transition strategy immediately, the National Commission concluded, because many uncertainties and complexities had yet to be resolved about alternative financing mechanisms. In identifying VMT fees as a potential preferred long-term alternative, the National Commission noted the following about such fees:

- They could be equitably applied to any fuel type.
- The rates can be adjusted in response to congestion.
- They would encourage use of more fuel efficient, cleaner vehicles.

- They can be adjusted to charge trucks based on factors contributing to infrastructure damage (i.e., different rates can be charged).

- They directly reflect amount of travel, which is a key factor affecting highway costs (National Surface Transportation Policy and Revenue Study Commission, 2007).

VMT Fee Issues That Need Resolution

Despite the promise of VMT fees as a surface transportation financing source in the longer term, the National Commission identified a number of issues that would require resolution before such fees could be implemented widely.

A number of the issues comprised technological challenges. Global positioning system (GPS) receivers, wireless communications, and on-board computers are the required technology for vehicles if VMT fees are to be collected. The National Commission noted that the scope/purpose of a VMT fee would strongly affect the type of technology used. Reliability, flexibility, cost, security, and enforceability were all institutional requirements for the large-scale implementation of VMT fees (National Surface Transportation Policy and Revenue Study Commission, 2007).

Additional technological challenges included:

- *Need for broader consensus on the architecture of a VMT fee.* To the extent possible, the National Commission recommended building on the architecture of vehicle-infrastructure integration (VII) systems currently being developed.

- *Ability to calculate mileage traveled in each taxing jurisdiction*.

- *Determination of how information would be transmitted to the tax collection agency.* In Oregon, information transmission occurred at fueling stations and used existing tax collection mechanisms (see later discussion of the Oregon VMT tax pilot in this report).

- *Identification of how technology failures would be handled.*

- *Method to ensure privacy.* With respect to privacy, the National Commission noted that detailed information on when and where people drive is not needed to implement VMT fees. The data collection technology envisioned for VMT fee administration could, however, provide valuable information and data on system use—if privacy concerns can be satisfactorily addressed (National Surface Transportation Policy and Revenue Study Commission, 2007).

- *Prevention of evasion.* VMT tax evasion differs from fuels tax evasion and is potentially more serious, the National Commission reported. GPS signals can be blocked. Equipment must be tamper resistant and have a backup (National Surface Transportation Policy and Revenue Study Commission, 2007).

The National Commission also noted that administrative costs to implement VMT fees represent a significant unknown. With VMT fees, every vehicle owner is potentially a taxpayer. With the current fuels tax collection "at the rack," by contrast, there are only 1,400 taxpayers (i.e., wholesale petroleum supply terminals). Frequent payments by individual drivers could represent a large increase in the tax collection burden for state and federal governments, although the National Commission noted that it is conceivable that a third-party collection agency might do billing (National Surface Transportation Policy and Revenue Study Commission, 2007).

National Commission staff were asked to conduct a brief "special issue analysis" on the administrative cost question, because it is a significant one. In their analysis (National Surface Transportation Policy and Revenue Study Commission Staff, 2007a), staff stated their belief that administrative costs for VMT fees would be comparable to costs for electronic toll collection (a range of $0.05 to $0.10 per transaction was noted). Staff concluded that a VMT fee would, without question, carry higher administrative costs than the fuels tax but that there was no indication such costs would be prohibitive (pointing to the number of transactions that credit card companies routinely process).

Ongoing and Future Studies of VMT Taxes

In discussing the promise of VMT fees as a revenue mechanism in the longer term, the National Commission noted the encouraging results of pilot programs (most notably, in Oregon) but said that more work was necessary prior to actual VMT fee implementation. Some of this work would occur in a study by The University of Iowa Public Policy Center, just getting underway, that will examine VMT fees at six sites in the United States (University of Iowa, 2007). The National Commission went a step further and recommended that the next surface transportation reauthorization bill require a two-phase, 5-year major national study to determine the feasibility of VMT fees, achieve agreement on system architecture, and develop specific mechanisms for a transition to a VMT tax (National Surface Transportation Policy and Revenue Study Commission, 2007).

Phase I of the study the National Commission proposed (2 years in duration) would focus on confirming the feasibility of the VMT tax. This phase of the study would concurrently examine other long-range transportation revenue options (i.e., alternatives to VMT fees). Until the feasibility of a wide-scale VMT fee is shown, the National Commission stated that it is premature to rule out the use of other taxes and fees to supplement the fuel tax (equitable ways to tax alternative fuels and registration fees were noted, for example). If VMT tax feasibility were established in Part I of the study, the National Commission thought the next step would be to agree on the architecture for implementing VMT taxes.

Phase II of the National Commission's proposed study would be 3 years in duration. The objective in this phase would be to develop a plan or timetable for implementing a federal VMT fee and coordinating it with VMT fees at the state and local levels. Phase II of the study would also include a large scale study to examine the full range of potential issues and to test alternative mechanisms for levying the fee.

If VMT fees appeared to be a suitable replacement for the current fuels tax at the end of the 5-year study, the National Commission envisioned a gradual phase-in of VMT fees. New cars would have the needed on-board equipment for VMT fee collection; the drivers of older cars would pay fuel taxes until the cars were retired from the fleet. The National Commission suggested that parallel taxation systems might be used for about 20 years (National Surface Transportation Policy and Revenue Study Commission, 2007).

15-State Pooled Fund Study: "A New Approach to Assessing Road User Charges"

This study was a 3-year pooled fund study led by the Minnesota Department of Transportation. The participating agencies included 15 state departments of transportation (DOTs) and the FHWA and is reported by Forkenbrock and Kuhl (2004).

The study examined the policy, privacy, institutional, and technical issues related to an alternative system of road user charges based on actual miles traveled (i.e., VMT fees). The authors contended that VMT fees are the best method for assessing road user charges but that a lengthy phase-in period (perhaps as much as 20 years) would be necessary. As VMT fees are phased in for newer vehicles, drivers of older vehicles lacking the requisite on-board equipment would continue to pay fuel taxes (the authors contended that retrofitting existing vehicles would not be feasible).

The report discussed technological requirements for a system of VMT fees in detail. The authors concluded that a relatively simple, GPS-based, on-board computer is likely to be the most cost-effective technology. According to the authors, currently available GPS equipment and GIS files possess the required level of accuracy if VMT fees are implemented for revenue collection only (but not for variable pricing). The authors stated that some shortcomings of current GIS files require attention but that technological limitations would not constitute a significant barrier to implementing the new approach (Forkenbrock and Kuhl, 2002).

Components of the system envisioned by the authors would be (1) on-board vehicle equipment, (2) a data and payment collection center, and (3) communications technology to link the vehicle to the collections center. For the communications technology, the authors discussed the merits of a "smart card" in the vehicle that could be removed by its owner and put into a conveniently located reader (similar to a credit card reader).

Further, initially, when the objective of the VMT fees might be revenue collection only, a number of features could help overcome concerns about privacy. A polygon data system would be used, and travel on individual roads would not be recorded. Data transmissions would be encrypted, and after the vehicle owner's payment was verified, data for a particular period of travel would be removed from the system. The authors suggested that it might be possible later on to convince the public of the advantages of more detailed data collection for a variety of purposes: travel demand analyses, differential charges for trucks based on pavement designs of roadways used, etc. The authors believed it would be critical to have redundancy in the technological systems for recording VMT and the direction of travel.

The authors (Forkenbrock and Kuhl, 2002) recommended a systematic field test and demonstration involving equipping numerous vehicles to validate system technology for VMT fees, reliability, and security, and assessing user satisfaction and acceptance. Such a study was funded under SAFETEA-LU and is described next.

The University of Iowa Public Policy Center's "National Evaluation of a Mileage-Based Road User Charge" Study

The University of Iowa Public Policy Center initiated a federally funded 4-year study to assess the appropriateness of the technology and evaluate user acceptance of a mileage-based (i.e., VMT) charging system as a possible long-term replacement for the current motor fuels tax (gas tax). The study involves temporary installation of an on-board computer in participants' vehicles to record fees due from road use. For the study, however, no actual usage fees will be collected. The research team's objective at the end of two additional years of field testing is to have developed a fully operational system to enable a VMT tax to be implemented (The University of Iowa Public Policy Center [University of Iowa], 2007).

The VMT charging system to be tested fully and refined in this study was developed in the 15-state pooled funding study reported by Forkenbrock and Kuhl (2004) described previously.

The current study will employ on-board GPS receivers for vehicles and on-board computers that contain systems for distinguishing state boundaries and, if applicable, substate areas (e.g., metropolitan areas). The vehicle's on-board computer stores the total amount of VMT fees owed to each jurisdiction. Route and time information is not collected (which addresses some privacy concerns). The computer compares the data from the GPS unit with the reading on the vehicle's odometer (the latter is practically tamper proof in modern vehicles) (University of Iowa, 2007). Cellular technology transmits data about VMT fees owed from the vehicle to a billing center. The study's investigators likened this to a major credit card billing center, and they reported that a number of payment options can be available.

The Iowa researchers have also developed technology that permits different classes of vehicles to be charged different per-mile rates, and they reported that they have developed user charge upload technology that "virtually assures" participant privacy (a frequently mentioned concern about VMT fees). They stated that the only information associated with an individual road user is the total amount of charges owed and total number of miles driven since the last data upload (University of Iowa, 2007). Information on the amount of the total charge to be distributed to each state or local jurisdiction is encrypted.

Six test sites have been identified for the study, including two in the mid-Atlantic region (Baltimore, Maryland, and the Research Triangle in North Carolina, including Durham, Raleigh, and Chapel Hill). The four other sites are San Diego, California; Austin, Texas; Boise, Idaho; and Eastern Iowa. The sample of participants at all six locations is projected to be 2,700. Monthly questionnaires for participants will allow the researchers to track participants' reactions to the VMT charges over time and to evaluate performance of the on-board equipment further (University of Iowa, 2007).

The Transportation Research Board's Special Report 285: *The Fuel Tax and Alternatives for Transportation Funding*

This study, conducted by the Committee for the Study of the Long-Term Viability of Fuel Taxes for Transportation Finance of the TRB (2006), focused on identifying what recent trends imply for the future of traditional (i.e., fuel-tax based) transportation finance. Study objectives also included identifying alternatives and the criteria by which they might be evaluated and suggesting ways in which barriers to the acceptance of new approaches might be overcome.

In 2006, the Committee could not necessarily anticipate the effect of oil prices and a worldwide recession on gasoline prices and consumption in 2008. Nonetheless, they believed the risk was not so large that the current highway finance system would be unable to maintain its historical performance for the following 15 years. Overall, they thought growth in spending and capacity could continue, although not at a rate that would reduce congestion (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

In 2006, the Committee believed that fuel price increases alone would probably stimulate only a small improvement in fuel economy before 2025. They projected a reduction of perhaps 20% in average gallons of fuel consumed per light-duty vehicle mile if new regulations or large and sustained fuel price increases were to occur. The Committee pointed out that the stock of vehicles on the road tends to turn over slowly—about 6% of the fleet per year, although high fuel prices could lead faster turnover (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). The Committee thought that larger reductions in gasoline consumption could occur after 2025 if market shares for hybrid electric or fuel-cell powered vehicles were large and/or if high fuel prices or government intervention were to affect fuel economy (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

The Committee considered two types of alternative highway financing systems: (1) an expanded network of toll roads and lanes on high-density expressways, using present tolling technology but featuring variable pricing; and (2) mileage fees (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). They believed that mileage (or VMT) fees could have a number of benefits, including (1) improved operation of the road system and reduced congestion, and (2) better targeting of investments to the most worthwhile projects.

The Committee thought that converting to a system of mileage charges would require "a sustained national effort" and doing so "would have profound impacts on every aspect of the management of transportation programs." The roles of different levels of government would change, new criteria would become important in project selection, and a greater balance between highways and transit in urban areas would be attainable (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). Any individual state or city that wished to proceed with VMT fees on its own would face "enormous difficulties" related to cost, interstate traffic, and eventual needs for coordination on a national level.

The Committee recommended maintaining and reinforcing the current transportation finance system because the United States would rely on it for at least the next 10 years. The

Committee also recommended two tracks of research, one technical and the other programmatic, with the goal of providing guidance to highway agencies on how to apply and manage road use charges (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). The programmatic research track would address gaining public acceptance, managing the transition, and learning to set fees appropriately. The technical research track would address the reliability, flexibility, cost, security, and enforceability of different designs and technologies. Gaining public acceptance, making the transition between the current highway financing system and mileage fees, and setting appropriate prices were all identified as major implementation issues. The Committee warned that inappropriate pricing can have undesirable equity effects and/or degrade system performance.

Oregon's Mileage Fee Concept and Road User Fee Pilot

Oregon's Mileage Fee Concept

Origins

The shortcomings of fuel taxation as a revenue source for the Oregon Department of Transportation (ODOT) were apparent and documented in the years leading to legislative action in 2001 (Whitty, 2007).

It was widely understood and agreed by 2001 that the fuel tax had the following shortcomings:

- permits state tax revenue erosion because of rising fleet fuel efficiency, driven partly by federal Corporate Average Fuel Economy (CAFE) standards for new vehicles
- lacks a direct connection to road use and cannot be modified to create such a connection
- becomes an increasingly regressive tax even under a stable tax rate as older, less fuel-efficient vehicles are acquired by lower-income classes and upper-income classes purchase new tax-avoiding fuel-efficient vehicles.

The Road User Fee Task Force (RUFTF) was the "public face" of Oregon's search for a replacement for the fuel tax. The following characterize the RUFTF:

- directly mandated by the 71st Oregon Legislative Assembly in 2001
- charged with developing an alternative revenue mechanism to (volume) fuel taxes
- required during the process of fulfilling its mandate to gather public comment
- entitled to make recommendations on criteria for the VMT tax pilot program

- required to report options for an alternative to the volume fuel tax to the 72nd Oregon Legislative Assembly

- authorized to recommend legislation under its own sponsorship (Whitty, 2007).

The RUFTF was composed of four current members of the Oregon State Legislature; four appointees from the telecommunications industry, highway user groups, or state or national transportation research or policy-making bodies; one elected current city official; one elected current county official; and two current members of the Oregon Transportation Commission. ODOT provided staff to the RUFTF. The term of membership was 4 years with the possibility of reappointment (with the exception that the elected officials had to be current office-holders). Legislators on the RUFTF were entitled to per diem and other expense reimbursements as authorized by the Legislative Assembly.

Although ODOT was subordinate to the RUFTF in the public eye (Whitty, 2007), ODOT played the central practical role in developing the "Oregon concept." ODOT was permitted to draw from the State Highway Fund to support RUFTF activities and pilot programs and was required to consider the recommendations of the RUFTF. ODOT was also required to make a preliminary report to the Legislative Assembly no later than September 30, 2002, on possible alternatives to motor fuels taxes. Ultimately, ODOT was required to initiate implementation of a pilot program no later than July 1, 2003.

Within these broad limits and permissions, ODOT was authorized to do the following:

- develop pilot programs and solicit volunteers to test alternatives to motor fuels taxes

- terminate pilot programs or participants at any time

- establish a fee for each pilot program payable by pilot participants that may replace any motor fuels taxes

- compensate participants in pilot programs

- solicit and accept federal and private grants and assistance (Whitty, 2007).

With public input, the RUFTF established criteria for an alternative to the fuel tax as follows:

- capable of raising equivalent levels of revenue to the fuel tax and capable of growing with inflation

- directly proportional to road use

- "visible" to the paying public

- readily enforceable (Whitty, 2007).

The RUFTF criteria also specified that alternatives should be:

- "designed to support the operation, maintenance, and preservation of the highway/road system for the state, cities and counties in all parts of the state, as the gas tax does today"

- acceptable to the public after due diligence on ODOT's part to explain the new funding mechanism (Whitty, 2007).

Features of the Oregon VMT Fees

The Oregon concept of VMT fees satisfied the RUFTF criteria with the following characteristics:

- VMT fees applied to passenger cars only.

- Mileage data and fee collection would occur at the fuel pump.

- An on-vehicle device would identify driving zones and stored running total mileage.

- The fuel pump would communicate electronically with the on-vehicle device to retrieve stored mileage total; this would transfer data to the stations' point-of-sale (POS) system.

- The POS system would apply the mileage rate and produce receipts for the customer showing fuel purchase, VMT fee paid, and gas tax refunded.

- If the vehicle was not equipped with a VMT fee device, the customer would pay the gas tax on the fuel purchase as a default charge (Whitty, 2007). In other words, VMT charges were to be phased in over time as new vehicles were equipped for VMT charges in proportion to the phase-out of the fuel tax with the older fleet.

Key Design Elements of Oregon VMT Fees and Resulting Technology Requirements

Some key design elements of the Oregon concept imposed technological requirements that ODOT identified and sought partners to solve:

- *Only mileage within Oregon should be charged; variable rates would be charged by zone of travel within Oregon (i.e., congestion pricing or charging).* The technological requirements were geolocational accuracy and the capability to turn charging "off" when driving outside Oregon.

- *The level of privacy expected by the public would be met, balanced with effective auditing capability.* The technological requirements were no storage or transmission of travel locations at any time; an on-vehicle device transmits stored data to a POS system at the fuel pump; data are limited to vehicle identification, total miles driven

in each zone since last fueling/accounting, amount of fuel purchased, and location of current fuel purchase.

- *The customer would experience transparency and user-friendliness in the fuel tax alternative while collection redundancy would be ensured for ODOT.* In other words, fuel tax assessments would continue on non-VMT-equipped vehicles and as a revenue default for VMT charging errors. The technological requirements were that VMT revenue collection occurs at the pump (same as with the gas tax); the on-vehicle display screen identifies zones of travel in real time; the driver is informed of zonal mileage fee rates at the time of fueling; the VMT-equipped-vehicle customer transaction receipt includes the mileage fee plus the cost of the fuel purchase minus the state fuel tax; a non-VMT-equipped vehicle is assessed the state fuel tax plus the cost of fuel; and an electronic accounting and communications system enables both types of payments to be made at a given service station with immediate reconciliation of the customer's account. A new electronic data acquisition system, Vehicle Miles Traveled Collected at Retail (VMTCAR), was a major component of pilot program success. This technology subtracted the state fuels tax from the price per gallon at the pump for any vehicle equipped for VMT fees (so that customers paid the appropriate amount and no more).

- *ODOT would be assured of its full revenues during phase-in of the VMT fee because of collection redundancy in the design of the phase-in.* The technological requirement is that the POS software reverts seamlessly during a fuel purchase transaction to the fuel tax when a vehicle cannot be assessed for a VMT fee (Whitty, 2007).

Other key elements of the Oregon concept warranted special emphasis in RUFTF's public outreach in order to discourage the public from favoring the old fuel tax over the VMT fee alternative:

- *Revenue neutrality.* The VMT fee rate of $0.012/mile was determined by dividing the current gas tax rate by average fleet fuel efficiency, estimated at 20 miles per gallon (MPG).

- *Low cost of administration.* VMT fee collection was performed within the same fuel transaction as the fuel tax would have been, using modified POS software.

- *Collection redundancy.* The fuel tax would continue to be paid by distributors at the point of wholesale, and fuel retailers would in turn reimburse distributors for the tax. Retailers would then assess either the fuel tax per gallon or the revenue-neutral VMT fee per mile on each vehicle when the customer purchased fuel.

- *Minimal burden on the private sector.* ODOT would not require a particular technology to handle the additional accounting functions but would develop specifications for the technology. Further, VMT fee collection equipment would be decentralized at fueling stations rather than consolidated at the level of central offices.

- *New application of existing technology.* A goal of the pilot project was to use available technology rather than to invest in research and development and incur a long delay. The main on-board device for zone recognition and mileage tabulation was a hybrid of GPS and odometer equipment that allowed wireless electronic transmission of travel data from the vehicle to a device on a pump at a fueling station (Whitty, 2007).

How the Oregon Mileage Fee Payment Process Worked at the Pump

The Oregon VMT fee process required the interaction of equipment mounted on a vehicle and equipment mounted on a fuel pump as follows:

1. A vehicle is "searched" for VMT equipment by a central reader at a fueling station when the customer parks the vehicle near an equipped fuel pump. If detection is negative, the customer is charged the fuel tax and no further action is required.

2. If detection is positive, the central reader instructs a wireless transmitter on the fuel pump to send a message to the on-vehicle device.

3. The on-vehicle device returns a message to the central reader indicating the strength of the signal from the fuel pump; greater signal strength is interpreted as closer proximity of the VMT-equipped vehicle to the fuel pump. High signal strength causes the central reader to recognize the vehicle as ready for mileage reading and fuel purchase (as opposed to other activities at a fueling station).

4. The central reader reads the mileage totals stored in the on-vehicle device; central reader software conveys the mileage total and vehicle identification number to a combined mileage fee (MF)/POS) system in the fueling station.

5. The MF system looks up the vehicle's last mileage reading (total only) by zone in a central database via high speed internet.

6. The MF system extracts fee rates by zone from the central database and applies them to the vehicle's mileage increases by zone since the vehicle's last reading; the MF system passes the mileage fee total to the POS system.

7. The POS system deducts the gas tax from the fuel cost and adds the MF to give the balance due from the customer. The customer's receipt shows these steps explicitly.

8. The central database adjusts the vehicle's record with its latest odometer reading, the current amount of fuel purchased, and the total VMT fee assessed (Whitty, 2007).

Oregon's Road User Fee Pilot

ODOT's Partners for the Pilot Program

As the sponsoring agency for the pilot project, ODOT sought the assistance of expert partners to solve the technological and administrative challenges posed by the trial of VMT fees, charged at the time of fuel purchase (with gas taxes assessed as a backup). The functions that ODOT perceived to be more than it could manage (i.e., those functions for which ODOT would need partners) were as follows:

1. *Identification of potential service station partners:* undertaken by the Oregon Petroleum Association

2. *Development of on-site and on-vehicle equipment; maintenance of mileage-by-zone database:* undertaken by Oregon State University (OSU)

3. *Documentation of driver behavior changes and participant responses to the pilot project; maintenance of participant database:* undertaken by Portland State University (PSU)

4. *Public participation with the RUFTF in a laboratory test of OSU's technology:* undertaken by the news media

5. *Conducting a "pre-pilot" test using 20 state employees (including two state legislators):* undertaken by OSU and ODOT

6. *Installation of temporary vehicle devices required for participation in pilot project:* undertaken by Car Toys (a mobile electronics retail chain)

7. *Documentation and analysis of changes in driving behavior under VMT charging via three telephone surveys of pilot participant:* undertaken by PSU

8. *Gaining access to modify fuel station POS systems and equip fuel stations with mileage readers:* undertaken by Leathers Fuels (an independent service station)

9. *Recruiting participants to test the concept from the user perspective:* undertaken by legal Oregon drivers with qualified vehicles (Whitty, 2007).

ODOT employed a screening process to find individuals it judged best suited to test the concept of VMT fees. Applicants were recruited through advertising, news releases, a website, and a telephone line. Initial telephone screening identified potential participants who were then invited to an evening meeting for sign-ups.

Volunteers received cash at the end of the pilot project to encourage completion and fuel voucher incentives after installation of vehicle equipment to provide incentivies for the meeting

of time constraints imposed by the legislation, to compensate for problems with on-vehicle devices, and to encourage attendance at training meetings.

All vehicles in a participating household that might be driven by participants were required to qualify for the pilot program in order to avoid any "leakage" of household miles traveled: 285 vehicles initially qualified to participate.

Phases of the Oregon VMT Fee Pilot Project

The Oregon VMT fee pilot project was executed in phases as follows (Whitty, 2007):

1. *Months 1-5: Control Period.* Participants purchased fuel at the two participating stations at least twice per month; VMT were recorded but gas taxes were paid; baseline driving patterns were established for each vehicle and formed the basis for endowed accounts sufficient to cover expected VMT fees for each vehicle in the test phase. Balances in endowed accounts reverted to volunteers at the end of the test phase to mimic savings from reduced driving under VMT fees.

2. *Months 6-10: Test Period.*

   — A control group (10% of participants) paid the gas tax while mileage was tracked.

   — A VMT group paid the gas tax until the midpoint of the period, then paid VMT fees from the midpoint to the conclusion of the pilot. This was a virtual transaction since the gas tax was refunded when the VMT fee was assessed, and participants paid VMT fees through personal endowed accounts established specifically for expected VMT charges, based on driving habits observed in the control period.

3. *Months 10-12: Conclusion and Wrap-up.* ODOT sponsored an informal party to thank participants and provide an opportunity for informal personal discussions between program managers and users about the user-perceived successes and failures of VMT fees.

Public Outreach and Involvement for the Oregon VMT Fee Pilot

ODOT's efforts unquestionably benefited from the support of the Oregon Legislative Assembly and numerous public champions of the VMT pilot project. But the RUFTF and ODOT diligently addressed the public's comprehension of the growing transportation revenue problem posed by fuel taxation and the avenues they wanted to explore to solve the problem. Opponents initially rallied around privacy and, ironically, environmental issues since VMT charging was perceived to penalize fuel-inefficient vehicles too little while assessing fuel-efficient vehicles fully for their highway use. Moreover, there was public misunderstanding that VMT charging would occur *in addition* to fuel taxation rather than as an alternative revenue mechanism (Whitty, 2007).

The public outreach entailed in Oregon's pilot investigation of VMT fees included all of the following (Whitty, 2007):

- creation of the RUFTF
- open meetings of the RUFTF
- public hearings across the state
- creation of a focus group
- media-friendliness with particular emphasis on correcting media and public misconceptions about privacy issues in VMT charging; the role of rate flexibility in encouraging desirable social outcomes (such as percentage of fuel-efficient cars in the existing fleet); and the environmental benefits of VMT charging versus taxing fuel, i.e., the superior economic efficiency of true highway user fees
- the RUFTF's engagement of fuel industry and public-interest stakeholders in meetings to discuss resolution of fuel tax shortcomings with a public comment period
- ODOT presentations to road-user stakeholders, transportation professionals groups, and state and local government, followed by public comment periods
- information-sharing with localities, states, and nations on request.

Problems with the Oregon VMT Fee Pilot Program

The following problems occurred in the daily transactions that represented the pilot test of VMT fees (Whitty, 2007):

- Varied radio frequency signal strength transmitted from devices at fuel pumps combined with interference sources at fuel stations caused VMT-equipped vehicle detection to fail occasionally; potentially effective solutions would violate the requirement that service station and vehicle modifications for the pilot test be temporary.
- Cellular technology could not be used for mileage data transmission because of privacy requirements and high cost; card-swiping by motorists was not considered user-friendly; common wireless communication technology used in the pilot is reliable once "vehicle-to-pump association" is established, but statewide implementation should "favor data transmission technologies that are mature and ensure a high level of interoperability across manufacturers of on-vehicle device technology."
- Motorists fueling at nonparticipating stations were refunded gas taxes at a later date directly through ODOT rather than at the pump.

- ODOT could not legally access service stations' proprietary POS systems because of resistance at the management level of corporate franchises; POS systems are often standardized within a gasoline brand and are designed for competitive advantage. Therefore, ODOT provided modified POS systems to the two independent service stations that participated in the program.

- Volunteers sometimes had unqualified vehicles; this unforeseen discovery ultimately reduced the pool of participating vehicles from 285 to 260.

- The physical distance between Portland (field test city) and OSU labs made resolution of technological glitches inconvenient; in general, a volunteer reported a problem to ODOT, ODOT relayed the problem to OSU, and OSU researchers traveled to the affected vehicle. More routine repairs were performed by volunteers, with telephone follow-up by OSU researchers.

ODOT's Evaluation of the Oregon Concept in the VMT Tax Pilot Project

Customer Appeal: Good

> The best indicator of ease and convenience of the mileage fee system to vehicle owners is when participants were asked, "If the program were changed so that participants could go to any local service station, would you have been willing to keep the equipment in your vehicle and stay with the same fee payment and refund of the gas tax?" 91% said, "Yes" (Whitty, 2007).

Ease and Cost of Enforcement: Good

- The central database of mileage fee payments and fuel purchases sorted by vehicle ID retains "targeted auditing capabilities." The legislature will ultimately decide the enforcement/privacy tradeoff between central and local data storage.

- The state receives "prepayment" of the gas tax at a distributor level; fuel station owners reimburse distributors and collect VMT charges from customers; differences between (prepaid) gas taxes and VMT charges are periodically reconciled with the state.

- A long phase-in of a mileage fee mechanism in parallel with the gas tax reduces the risk of highway user fee collection failure at the retail level.

- The incentive to tamper with VMT devices would be low if mileage fees are set at revenue-neutral rates.

Feasibility: Good

- The mileage fee was accurately calculated at the retail level.

- The mileage fee system accurately calculated transactions between station and customer; reconciliation between station and ODOT was satisfactory.

- Difficulties encountered in the pilot are not expected to carry over to statewide implementation.

Coordination With Current Service Station Operations: Good

- ODOT expects parallel revenue collection systems for approximately 20 years.
- It is not necessary to mandate unique POS system across service stations; POS specifications for proprietary software can be set instead.
- ODOT envisions weekly or monthly electronic "true-up" between service stations and ODOT using the same channels as those used to perform mileage fee calculations between stations and ODOT.
- Cash transactions were problematic outside the pilot if a customer wanted to purchase a fixed dollar amount of fuel: including VMT charges and refunding gas taxes in the same transaction would likely require more or less than the fixed dollar amount on hand.

Start-Up Costs: More Information Needed in the Future

- No additional information on start-up costs beyond 2003 estimates ($32.8 million) is available:
  - Development of prototype on-vehicle device: $209/unit
  - Manufacture of prototype on-vehicle device: $338/unit
  - Installation: $55/unit
  - Development of prototype station device: $186/unit
  - Manufacture of prototype of station device: $286/unit.
- ODOT expects statewide implementation to result in cost savings from mass production.
- Pilot costs were inflated by a midstream change in manufacturer.

Operating and Maintenance (O&M) Costs: More Information Needed in the Future

- The 2003 estimate was $1.6 million per year.
- O&M costs will rise if the database is enlarged or assigned additional functions.
- The pilot used manually managed databases; statewide implementation would use integrated electronic database systems.

Enforcement and Auditing Costs: Depends on Future Policy Choices

- Costs depends on the amount of data maintained and will be determined by the policy choice of privacy/enforcement tradeoff.

- Customer privacy is maximum, with little or no data retention in the system; there are few to no options available for enforcement activities or customer inquiries.

- The retention of too little data may lead to easy fee evasion and subsequent insufficiency of fee revenues to maintain roads, causing higher rates per mile.

- ODOT designed the pilot to (slightly) favor customer privacy relative to enforceability/customer inquiries.

Collection Costs Relative to Gas Tax: Favorable

- The bulk of the collection system remains the same; the gas tax continues to be "prepaid" by distributors, VMT charges are paid at service stations, and service stations pay difference to ODOT periodically.

- "True-up" occurred between ODOT and approximately 1,800 fuel stations; this is the electronic process that calculates the total amounts of money that the retail station and ODOT are due from the station's fuel sales to all vehicles (whether equipped for VMT fees or not).

- The pilot "true-up" process was designed for a minimal increase in the administrative burden under VMT fees.

Revenue Potential: Good

Unlike the volume fuel tax, the VMT tax

- maintains the revenue stream while vehicle fuel efficiency improves
- is not regressive with respect to income
- grows in proportion to road damage.

Accuracy of Technology: Satisfactory for Pilot Project, Although Mileage Collection Accuracy Varied Across Devices

- Devices are within ±2% on average for overall accuracy.
- There is a possible role of faulty odometers in varying collection accuracy.
- The accuracy of zone differentiation is satisfactory.

Reliability: Needs Improvement

- The vehicle-to-pump association (70%-80%) is imperfect: mileage readers at fuel stations occasionally failed to detect the pump at which the VMT-equipped vehicle was parked and charged the default gas tax.
- Variations in signal strength occurred, with occasional weak signal detection capability.
- There were no known failures of mileage reading once the initial vehicle-to-pump association was established; this was the most difficult step in the process.
- Other minor problems were batteries reported drained by on-vehicle devices with limited power management functions (resulting from hurried development and production) and unexpected device incompatibility.

Security: Needs Improvement

- On-vehicle devices (e.g., antenna) in the pilot project were accessible for tampering.
- A phase-in of VMT with revenue-neutrality relative to gas tax default payment discourages tampering.

Adaptability to Congestion Pricing: Good

Higher VMT rates by zonal differentiation and time of travel were successfully incorporated.

Cost to Drivers: Further Information Required

- The manufacturer's price differential for a VMT-equipped vehicle is unknown.
- Maintenance costs for on-board devices are unknown.
- Ease and convenience: 91% of pilot project participants were willing to continue with VMT charging if all Oregon service stations were VMT-equipped.

Privacy Protection: Service Stations More Concerned Than Customers

- Customer bases were considered proprietary; the pilot project required sharing with ODOT.
- Privacy issues may be an obstacle to statewide implementation.
- Customers rated the transparency of the fee mechanism as "good"; there was a tight correspondence between VMT fees and road use.

Experience of Station Owners: Mixed; Some Problems Experienced

- The POS system and credit card network provider are new.
- The software crosswalk between the new POS system and the existing internal computer system for tracking daily purchases was rated by users as time-consuming and "disruptive."
- The fuel pump operation was satisfactory.
- The adoption of the technology was costlier and took more work than expected.
- The station computers froze; rebooting was time-consuming and annoying to all parties.
- Statewide implementation would require choice with regard to the POS system used at the station level; greater system reliability; and fuel pumps with required communication capabilities.
- ODOT cited user (customer) satisfaction with station functions to give a perspective on problems cited by station operators.

Historical and Expected Future Market Penetration of Hybrid Electric and Other Alternative Fuel Vehicles

A Word About Trends in Vehicles Newly Introduced to the Market

Projecting trends in the number of alternative fuel vehicles (AFVs) and hybrid electric vehicles (HEVs) is difficult. In general, one would expect the number of vehicles of any new type to exhibit an 'S' shape when plotted versus time. During the first years after its introduction, the number in service grows at an increasing rate as knowledge of the availability of the vehicle type spreads and the uses to which it is best suited are discovered. After some period, the growth of that vehicle type begins to slow down and to approach a stable equilibrium growth rate roughly proportional to that of the vehicle market as a whole. Trends in technology and trends in relative fuel prices may cause small and/or temporary deviations from this pattern, but, in general, one would not expect the number of vehicles of a well-established and well-known fuel type to exhibit a growth rate persistently higher than the rate of the vehicle market as a whole. The fact that the growth rates of HEVs and some other AFVs have not stabilized at a rate close to the growth rate of the light-duty vehicle (LDV) fleet as a whole is an indication that the demand for these vehicles is still evolving rapidly and cannot be predicted accurately.

Market Shares of Alternative Fuel Vehicles

Table 1 shows the trend in the number of AFVs in use by fuel type from 1992 through 2006 in the United States. As may be seen, the number of vehicles that run on liquified

Table 1. Alternative Fueled Vehicles in Use [1]										
Year	Liquefied Petroleum Gases (LPG)	Compressed Natural Gas (CNG)	Liquefied Natural Gas (LNG)	85% Methanol (M85)	Neat Methanol (M100)	85% Ethanol (E85)[2]	95% Ethanol (E95)	Electricity [3]	Hydrogen	Total
1992	NA	23,191	90	4,850	404	172	38	1,607	0	NA
1993	NA	32,714	299	10,263	414	441	27	1,690	0	NA
1994	NA	41,227	484	15,484	415	605	33	2,224	0	NA
1995	172,806	50,218	603	18,319	386	1,527	136	2,860	0	246,855
1996	175,585	60,144	663	20,265	172	4,536	361	3,280	0	265,006
1997	175,679	68,571	813	21,040	172	9,130	347	4,453	0	280,205
1998	177,183	78,782	1,172	19,648	200	12,788	14	5,243	0	295,030
1999	178,610	91,267	1,681	18,964	198	24,604	14	6,964	0	322,302
2000	181,994	100,750	2,090	10,426	0	87,570	4	11,830	0	394,664
2001	185,053	111,851	2,576	7,827	0	100,303	0	17,847	0	425,457
2002	187,680	120,839	2,708	5,873	0	120,951	0	33,047	0	471,098
2003	190,369	114,406	2,640	0	0	179,090	0	47,485	9	533,999
2004	182,864	118,532	2,717	0	0	211,800	0	49,536	43	565,492
2005	173,795	117,699	2,748	0	0	246,363	0	51,398	119	592,122
2006 [4]	164,846	116,131	2,798	0	0	297,099	0	53,526	159	634,559
Data Source:										
EIA's [federal Energy Information Agency's] Annual Energy Review, Table 10.4. Available at www.eia.doe.gov/emeu/aer/renew.html.										
Notes:										
[1] Vehicles in Use represent accumulated acquisitions, less retirements, as of the end of each calendar year. They do not include concept and demonstration vehicles.										
[2] Includes only those E85 vehicles believed to be using E85. Primarily fleet-operated vehicles; excludes other vehicles with E85-fueling capability. In 1997, some vehicle manufacturers began including E85-fueling capability in certain model lines of vehicles. For total number of E85 vehicles on the road, see "E85 FFVs in Use." [Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: E85 FFVs in Use. http://www.afdc.energy.gov/afdc/data/docs/ffvs_in_use.xls. Accessed October 27, 2008.]										
[3] Excludes HEVs [hybrid electric vehicles].										
[4] 2006 numbers are preliminary.										

Reprinted from Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: AFVs in Use: Trend of the Number of AFVs in Use by Fuel Type from 1992-2006. http://www.afdc.energy.gov/afdc/data/docs/afvs_in_use.xls. Accessed October 27, 2008.

petroleum gas (LPG) and compressed natural gas (CNG) comprised a stable, and small, share of the total vehicle fleet as of 2005. The share of vehicles that run on liquid natural gas (LNG) might still have been growing as of 2005. The shares of vehicles that run on 85% ethanol (E85) and all-electric vehicles were still growing in 2005 (Alternative Fuels and Advanced Vehicles Data Center, 2008).

To predict the levels at which the numbers of each type of AFV will level off is challenging. As shown in Table 1, for some experimental vehicle types, namely, those designed to burn methanol or 95% ethanol, the growth rate did not stabilize until the number of vehicles in use returned to equilibrium at zero (Alternative Fuels and Advanced Vehicles Data Center, 2008).

Figures 1 and 2 show the numbers of AFVs in use in the United States historically and a forecast based on the trend for 2000 through 2005. The historical numbers and trend forecast for total LDVs are included for reference (FHWA, various years). The markets for LPG and CNG vehicles appear to have matured by 2005 to the point where the growth rates of their numbers in use were relatively stable. On the other hand, the growth rate of E85 vehicles was so high that an extrapolation of their existing trend implies that their number will exceed the total number of

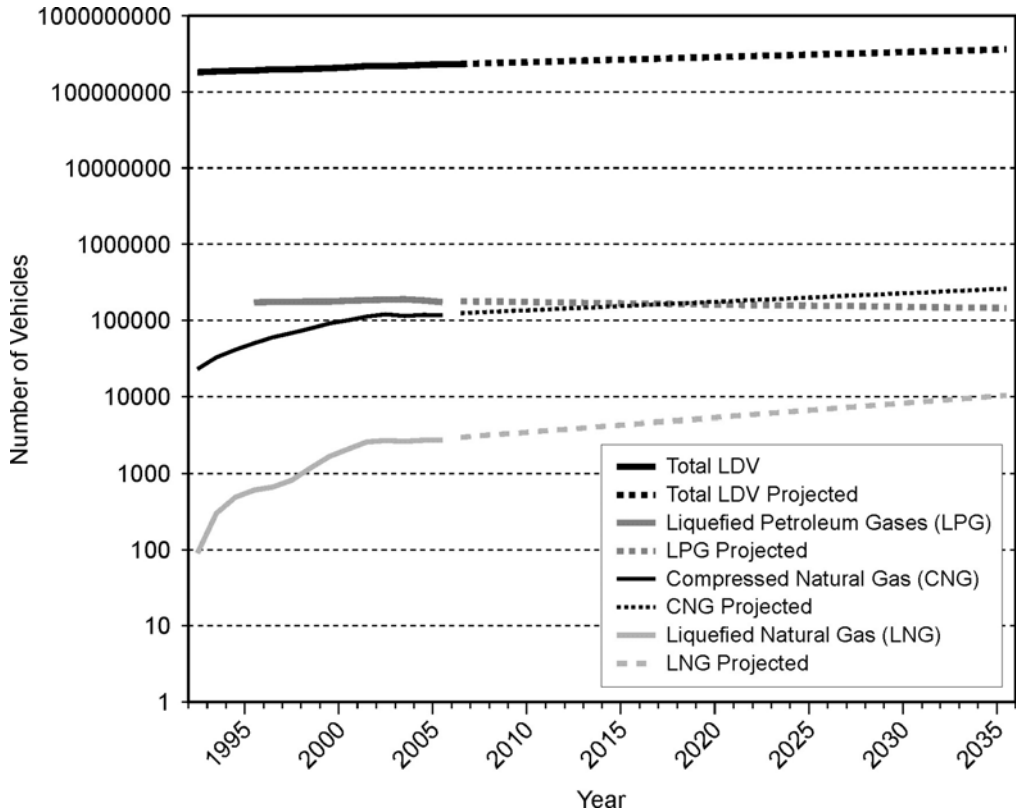

Figure 1. Projected Growth in Alternative Fuel Vehicle Fleets: Liquified and Compressed Gas Vehicles. LDV = light-duty vehicles. The data source for "Total LDV" is Federal Highway Administration, Highway Statistics (various years). The data source for "Liquified Petroleum Gases (LPG)," "Compressed Natural Gas (CNG)," and "Liquified Natural Gas (LNG)" is Table 1.

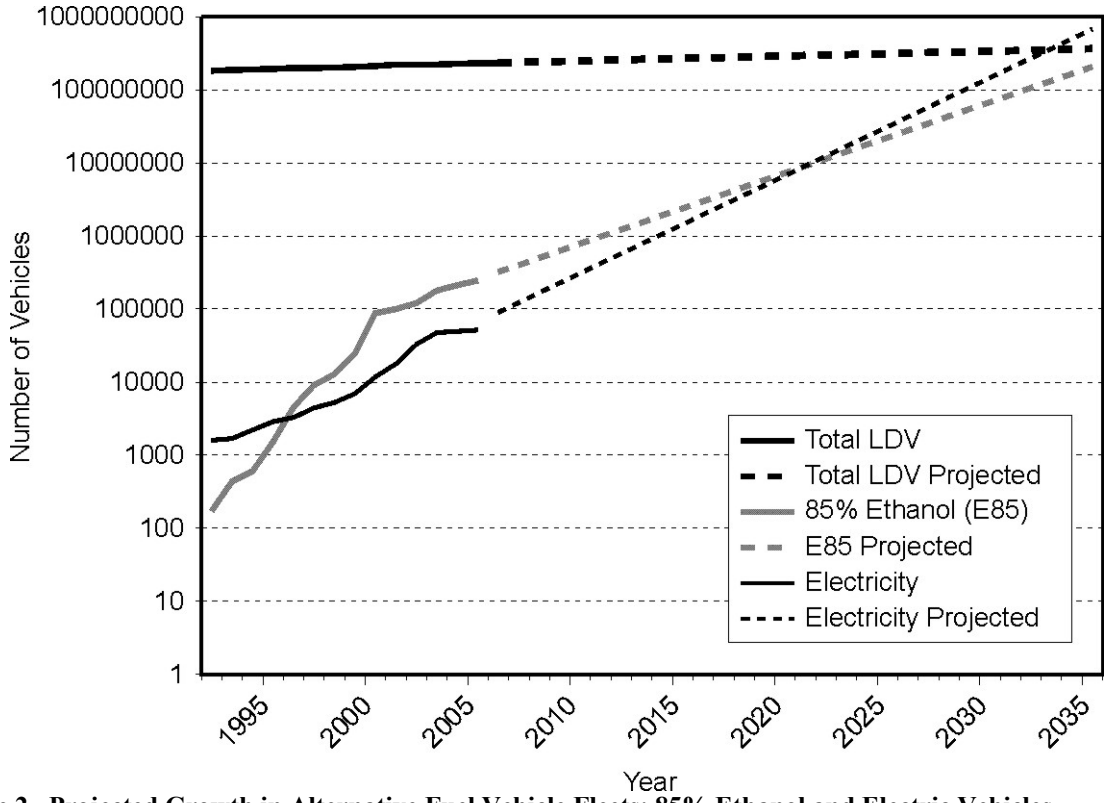

Figure 2. Projected Growth in Alternative Fuel Vehicle Fleets: 85% Ethanol and Electric Vehicles. LDV = light-duty vehicles. The data source for "Total LDV" is Federal Highway Administration, Highway Statistics (various years). The data source for "85% Ethanol (E85)" and "Electricity" is Table 1.

vehicles by 2033—a nonsensical result. A similar situation applies to the growth rate of all-electric vehicles. This means that the growth rates of E85 and all-electric vehicles were still rather higher as of 2005 than one would expect for a fuel type whose uses have been fully explored. The number of LNG vehicles may or may not have reached a stable growth rate; the pattern over the most recent years is ambiguous.

Without additional information on which to base a forecast of the market share at which E85 vehicles will level off, it is hard to know what growth rate to expect for them over the next few years. The same reasoning applies to all-electric vehicles. The significant changes in the relative price of fuel over the past 2 years make a forecast based on recent trends even less reliable.

Market Share of Hybrid Electric Vehicles

The share of HEVs in the total vehicle fleet was growing rapidly as of 2007. To predict the level at which HEVs will level off is challenging (Alternative Fuels and Advanced Vehicles Data Center, 2008).

Table 2 shows that the sales of some specific HEV models peaked before 2007. However, the sales of HEVs as a class were still growing at a much faster rate in 2007 than were total sales of all LDVs. Figure 3, which shows the historical sales data for HEVs as shown in Table 2 and for all LDVs (Alternative Fuels and Advanced Vehicles Data Center, 2008), shows

Table 2. Hybrid Electric Vehicle (HEV) Sales by Model										
Vehicle	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Total**
Honda Insight	17	3,788	4,726	2,216	1,200	583	666	722	0	13,918
Toyota Prius		5,562	15,556	20,119	24,600	53,991	107,897	106,971	181,221	515,917
Honda Civic				13,700	21,800	25,571	25,864	31,251	32,575	150,761
Ford Escape						2,993	18,797	20,149	21,386	63,325
Honda Accord						1,061	16,826	5,598	3,405	26,890
Lexus RX400h							20,674	20,161	17,291	58,126
Toyota Highlander							17,989	31,485	22,052	71,526
Mercury Mariner							998	3,174	3,722	7,894
Lexus GS 450h								1,784	1,645	3,429
Toyota Camry								31,341	54,477	85,818
Nissan Altima									8,388	8,388
Saturn Vue									4,403	4,403
Lexus LS600hL									937	937
Saturn Aura									772	772
Total	17	9,350	20,282	36,035	47,600	84,199	209,711	252,636	352,274	997,604
Data Sources:										
Insight, 1999-2002	www.insightcentral.net/KB/sales.html (Accessed 7/18/2007)									
Prius, 2000-2002	www.toyoland.com/prius/chronology.html (Accessed 7/18/2007)									
Civic, 2002; All, 2003	www1.eere.energy.gov/vehiclesandfuels/facts/2007_fcvt_fotw462.html (Accessed 4/3/2007)									
Insight, Prius, Civic, Accord, 2004	Hybrid Vehicles Report (Dec 2005, Volume 7, Issue 6)									
Escape, 2004	www.greencarcongress.com/2005/01/us_hybrid_sales.html (Accessed 7/18/2007)									
All but RX440h & Highlander, 2005	www.electricdrive.org/index.php?tg=articles&idx=Print&topics=7&article=692 (Accessed 7/18/2007)									
RX400h, Highlander, 2005	Hybrid Vehicles Report (Feb 2007, Volume 9, Issue 1); 2006 Ford and GM data not included									
All, 2006-2007	Manufacturer-reported numbers, as posted on www.hybridcars.com/market-dashboard.html (Accessed 2/11/2008)									
Notes:										
No single source contains a complete and accurate list of sales data so multiple sources were compiled by the National Renewable Energy Laboratory.										
Year refers to calendar year, not model year.										
GMC Silverado and Sierra are not tracked because they are not full hybrids.										

Reprinted from Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: Vehicles: Alternative Fuel Vehicles and Hybrid Electric Vehicles (HEVs): HEV Sales by Model: Trend of Sales by HEV Models from 1999-2007. http://www.afdc.energy.gov/afdc/data/docs/hev_sales.xls. Accessed October 27, 2008.

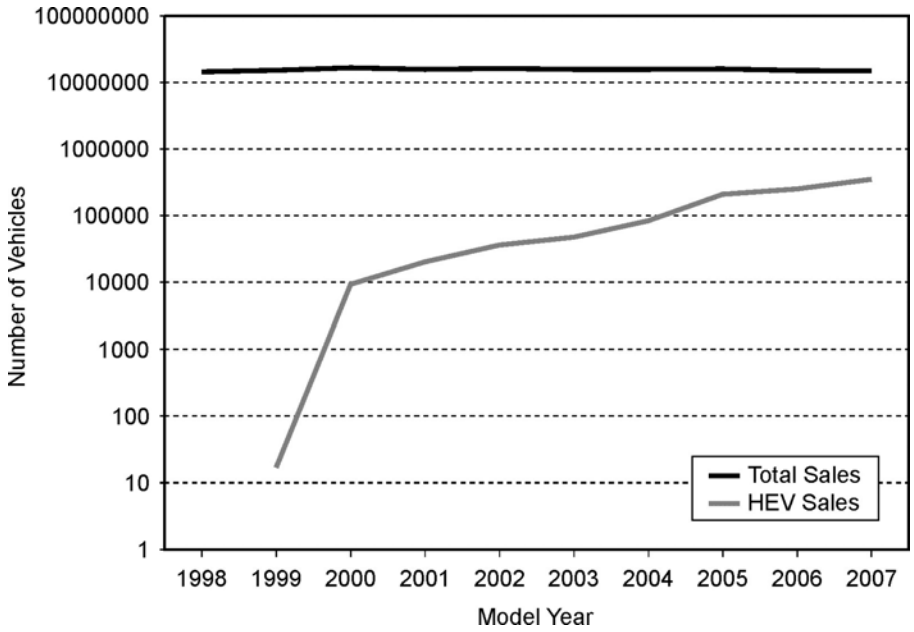

Figure 3. Total New Light-Duty Vehicle Sales and Hybrid Electric Vehicle Sales. HEV = hybrid electric vehicle. The data source for "Total Sales" is Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: Light Duty Vehicles Sold in the U.S. http://www.afdc.energy.gov/afdc/data/vehicles.html. Accessed October 27, 2008. The data source for "HEV Sales" is Table 2.

that sales of HEVs have grown faster than total sales of LDVs. The proportion of HEVs among total new LDV sales exceeds greatly the proportion of HEVs in the existing LDV fleet. This means that the market share of HEVs in use is climbing rapidly. The data on HEV sales lead therefore to a conclusion similar to the conclusion regarding AFVs: without additional information on which to base a forecast of the market share at which HEVs will level off, it is hard to know what growth rate to expect for them over the next few years. Once again, the recent increases in the relative price of fuel make a forecast based on recent trends unreliable. The recent market situation, in which full-capacity production of HEVs could not keep up with demand, is not a stable condition.

Historical and Projected Taxable Gallons, Fleet Fuel Efficiency, and Tax Revenues Through 2035

A variety of forces, including technological advances and changes in the price of fuel, has influenced the kinds of vehicles that manufacturers brought to market in past years and the number of each kind of vehicle that consumers purchased (U.S. Environmental Protection Agency, 2008).

The trend forecasts reported here do not incorporate an explicit assumption about the proportion of HEVs and AFVs into the LDV fleet. They are, however, all based on trends since 2000. Therefore, the forecasts are based on trends only in the period since HEVs were introduced to the market and only in the period since gasoline prices began their most recent rise from approximately $1 in 1999 to $3 or more in early 2008.

Taxable Fuel Consumption and Tax Revenues

The two variables that bear most heavily on taxable fuel consumption, and, as a consequence, on motor fuels tax revenue, are the average fuel economy of the vehicle fleet (in MPG) and the average mileage per vehicle per unit of time (VMT per vehicle per year).

Table 3 shows historical statistics of fuel efficiency in the U.S. LDV fleet. Table 4 shows historical statistics of LDV fuel consumption and VMT (Alternative Fuels and Advanced Vehicles Data Center, 2008). The recent (i.e., since 2000) national trends are 0.419% annual growth in average MPG and 1.760% annual growth in VMT. Because population growth in Virginia is faster than the U.S. average, as described later in this report, the appropriate VMT trend for Virginia is posited to be 1.962%. As the growth rate of fuel consumption equals the growth rate of VMT minus the growth rate of average MPG, these trends imply a nationwide annual rate of growth of 1.341% in taxable fuel consumption and a Virginia annual rate of growth of 1.543%. The U.S. fuel consumption data in Table 4, however, show a trend of 2.305% annual growth since 2000—a markedly faster rate. Figure 4 compares the projection of nationwide fuel consumption based on the trend in the nationwide fuel consumption data (2.305%) against the projection based on the difference between the trends in VMT and MPG (1.341%).

On the assumption that the motor fuels tax rates will remain unchanged (and that compliance remains unchanged, and so forth), the rate of growth of fuel tax revenue will match the rate of growth of taxable fuel consumption. Were the motor fuels tax rates to be altered, tax revenue would be altered correspondingly.

Sensitivity of Fuel Efficiency and VMT to Changes in Fuel Price

The sensitivity of fuel efficiency and the sensitivity of VMT to changes in fuel price are discussed separately here. Combined, they imply a sensitivity of fuel consumption to changes in fuel price in a range from –0.4 to –0.8 (according to a 1997 survey by Johannson and Schipper) or possibly as high as –0.92 (according to a 1999 study by Agras and Chapman), the median estimate being –0.6 or –0.7 (cited in Victoria Transport Policy Institute [VTPI], 2008). This means that a 10% increase in the price of gasoline, if it persists for a period of years, may be expected to depress fuel consumption by 6% or 7%, possibly as little as 4% or as much as 9.2%.

Sensitivity of Fuel Efficiency

Figure 5 shows historical average fuel efficiencies and a trend forecast based on the averages of fuel efficiencies for 2000 through 2007. The historical data show that the average fuel efficiency of the U.S. LDV fleet rose markedly during the 1970s. This reflects a direct market response to the oil price shocks of the 1970s, and it may reflect in part compliance with the CAFE standards issued by the federal government. The change carried over into the 1980s as vehicles built to the lower standards of the early 1970s were gradually replaced by those built to the standards of the late 1970s. From a peak in 1989, the average fuel economy dropped off

Table 3. Efficiency, Power, and Composition of the U.S. Light Duty Fleet				
Model Year	**Adj 55/45 mpg**	**Avg. Peak Horsepower**	**% Car Sales**	**% Truck Sales**
1975	13.1	137	80.6%	19.4%
1976	14.2	135	78.8%	21.2%
1977	15.1	136	80.0%	20.0%
1978	15.8	129	77.3%	22.7%
1979	15.9	124	77.8%	22.2%
1980	19.2	104	83.5%	16.5%
1981	20.5	102	82.7%	17.3%
1982	21.1	103	80.3%	19.7%
1983	21.0	107	77.7%	22.3%
1984	21.0	109	76.1%	23.9%
1985	21.3	114	74.6%	25.4%
1986	21.8	114	71.7%	28.3%
1987	22.0	118	72.2%	27.8%
1988	21.9	123	70.2%	29.8%
1989	21.4	129	69.3%	30.7%
1990	21.2	135	69.8%	30.2%
1991	21.2	138	67.8%	32.2%
1992	20.8	145	66.6%	33.4%
1993	20.9	147	64.0%	36.0%
1994	20.4	152	59.6%	40.4%
1995	20.5	158	62.0%	38.0%
1996	20.4	164	60.0%	40.0%
1997	20.1	169	57.6%	42.4%
1998	20.1	171	55.1%	44.9%
1999	19.7	179	55.1%	44.9%
2000	19.8	181	55.1%	44.9%
2001	19.6	187	53.9%	46.1%
2002	19.4	195	51.5%	48.5%
2003	19.6	199	50.4%	49.6%
2004	19.3	211	48.0%	52.0%
2005	19.9	209	50.5%	49.5%
2006	20.2	212	53.9%	46.1%
2007	20.2	223	51.0%	49.0%
Data Source:				
Heavenrich (2007). Light-Duty Automotive Technology and Fuel Economy Trends: 1975 through 2007. Tables 1 and 2. U.S. EPA: Washington DC. www.epa.gov/otaq/fetrends.htm				
Notes:				
Motorcycles are not reflected as part of the light-duty fleet.				
Light Duty Trucks include vans and sport utility vehicles (SUVs).				
EPA adjusted the fuel economy figures to reflect real road conditions rather than lab conditions.				
Adj 55/45 MPG indicates (1) that EPA *adjusted* the fuel economy figures that were measured by standardized laboratory procedures to reflect real road conditions rather than laboratory conditions, and (2) that the fuel economy is a weighted average of 55% city fuel economy and 45% highway.				

Reprinted from Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: Vehicles: Efficiency and Fleet: Trends: Efficiency, Power, and Composition of U.S. Light-Duty Vehicles: Trend of Horsepower, Fuel Efficiency, and Fleet Composition by Weight Categories of U.S. Light-Duty Vehicles from 1975-2008. http://www.afdc.energy.gov/afdc/data/docs/ldv_efficiency_power_fleet_composition.xls. Accessed October 27, 2008.

Table 4. U.S. Light-Duty Fuel Consumption and Vehicle Miles Traveled					
Model Year	**LDV Fuel Consumption (million gallons)**	**U.S. Light Duty Vehicle-Miles (millions)**	**U.S. Population**	**LDV Fuel Consumption per Person**	**LDV Miles per Person**
1970	80,193	1,042,965	205,052,174	391	5,086
1971	84,903	1,107,807	207,660,677	409	5,335
1972	91,174	1,182,318	209,896,021	434	5,633
1973	95,165	1,228,008	211,908,788	449	5,795
1974	90,995	1,195,453	213,853,928	425	5,590
1975	93,333	1,240,279	215,973,199	432	5,743
1976	99,245	1,310,052	218,035,164	455	6,008
1977	101,570	1,366,183	220,239,425	461	6,203
1978	104,958	1,433,080	222,584,545	472	6,438
1979	101,206	1,414,182	225,055,487	450	6,284
1980	93,982	1,412,745	227,224,681	414	6,217
1981	93,023	1,440,365	229,465,714	405	6,277
1982	92,016	1,477,764	231,664,458	397	6,379
1983	94,442	1,531,457	233,791,994	404	6,551
1984	96,443	1,593,833	235,824,902	409	6,759
1985	99,063	1,646,845	237,923,795	416	6,922
1986	102,436	1,703,480	240,132,887	427	7,094
1987	104,096	1,782,358	242,288,918	430	7,356
1988	106,199	1,882,502	244,498,982	434	7,699
1989	107,391	1,948,067	246,819,230	435	7,893
1990	105,370	1,992,394	249,622,814	422	7,982
1991	102,718	2,016,757	252,980,941	406	7,972
1992	106,556	2,087,989	256,514,224	415	8,140
1993	110,097	2,130,365	259,918,588	424	8,196
1994	112,191	2,180,963	263,125,821	426	8,289
1995	113,424	2,238,278	266,278,393	426	8,406
1996	116,773	2,296,314	269,394,284	433	8,524
1997	119,482	2,363,376	272,646,925	438	8,668
1998	122,363	2,428,135	275,854,104	444	8,802
1999	126,354	2,480,706	279,040,168	453	8,890
2000	126,213	2,533,815	282,192,162	447	8,979
2001	127,273	2,581,178	285,102,075	446	9,054
2002	130,882	2,634,060	287,941,220	455	9,148
2003	136,404	2,665,750	290,788,976	469	9,167
2004	139,021	2,737,176	293,655,404	473	9,321
2005	139,504	2,760,325	296,550,088	470	9,308
Data Sources:					
Population: U.S. Census: http://www.census.gov/popest/states/NST-ann-est.html and www.census.gov/popest/archives/2000s/vintage_2001/CO-EST2001-12/CO-EST2001-12-00.html					
Petroleum Consumption: Bureau of Transportation Statistics (BTS) (2006). National Transportation Statistics 2006, Table 4-05. Available at www.bts.gov/publications/national_transportation_statistics/.					
Vehicle Miles Traveled: Bureau of Transportation Statistics (BTS) (2006). National Transportation Statistics 2006, Table 1-32. Available at www.bts.gov/publications/national_transportation_statistics/.					
Notes: Figures include motorcycles in the light-duty fleet.					

Reprinted from Alternative Fuels and Advanced Vehicles Data Center, U.S. Department of Energy, Data, Analysis & Trends: Vehicles: Efficiency and Fleet: Trends: U.S. Light-Duty Fuel Consumption and Vehicle-Miles Traveled (VMT): Trend of Per Capita VMT and Fuel Use in U.S. Light-Duty Vehicles from 1970-2005. http://www.afdc.energy.gov/afdc/data/docs/ldv_efficiency_power_fleet_composition.xls. Accessed October 27, 2008.

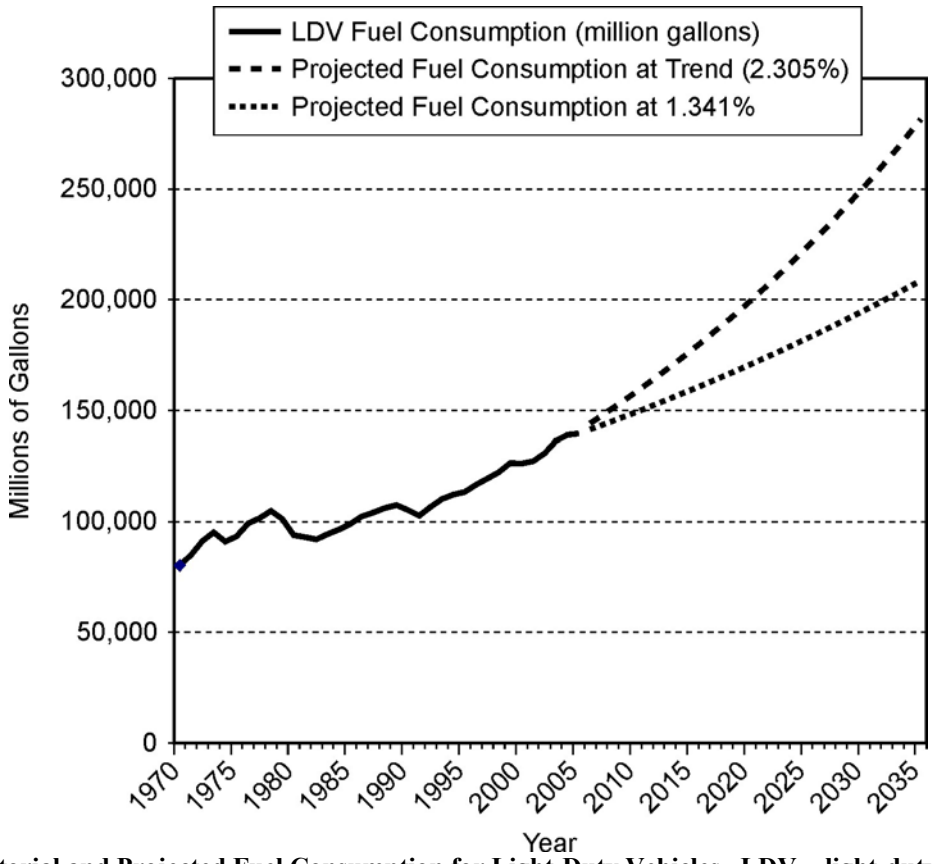

Figure 4. Historial and Projected Fuel Consumption for Light-Duty Vehicles. LDV = light-duty vehicle. The data source for "LDV Fuel Consumption" is Table 4.

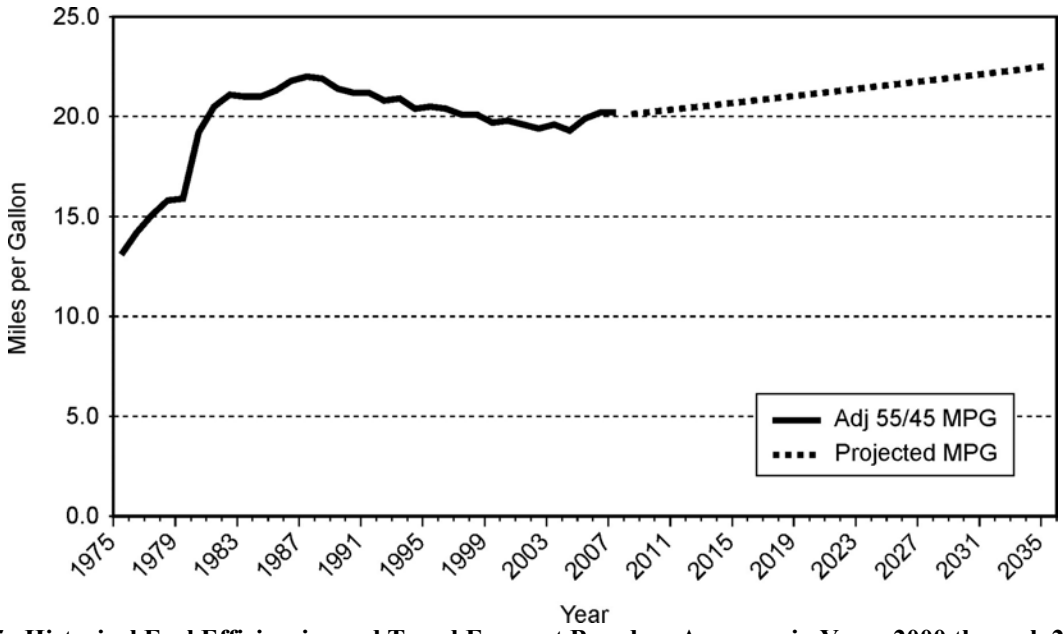

Figure 5. Historical Fuel Efficiencies and Trend Forecast Based on Averages in Years 2000 through 2007. "Adj 55/45 MPG" indicates (1) that EPA *adjusted* the fuel economy figures that were measured by standardized laboratory procedures to reflect real road conditions rather than laboratory conditions, and (2) that the fuel economy is a weighted average of 55% city fuel economy and 45% highway. The data source for "Adj 55/45 MPG" is Table 3. MPG = miles per gallon.

slightly, as a shift in the composition of the fleet toward vans, sport utility vehicles (SUVs), and light trucks offset the very small gains in fuel efficiency. The forecast based on the trend from 2000 to 2007 predicts a small (0.419%) annual increase in average fuel efficiency.

A 1997 survey by Johannson and Schipper (cited in VTPI, 2008) found that estimates of the *long-run* sensitivity of fuel efficiency to changes in fuel price fall in a range from 0.35 to 0.45: that is, a 10% increase in the price of gas, if it persists over a period of years, will spur a 3.5% to 4.5% increase in average MPG. A 1999 study by Agras and Chapman (cited in VTPI, 2008) produced a long-run estimate of 0.60 (VTPI, 2008). Because vehicles are durable assets, and because motorists take time to adjust their behavioral patterns, the *short-run* sensitivity to changes in fuel prices is smaller (it is estimated to be on the order of 0.12), but for the purposes of a 30-year forecast, the short run can be ignored. European countries have a highway infrastructure broadly similar to that in the United States and they drive vehicles generally similar to those in the United States, despite the fact that gasoline prices gross of tax are in many of these countries at least twice the prices in the United States. This casual observation gives reason to suppose that gasoline prices in the United States could at least double without producing revolutionary changes in the choice of automotive technology.

The 1997 survey by Johannson and Schipper (cited in VTPI, 2008) found that estimates of the long-run sensitivity of fuel efficiency to changes in income fall in a range from 0.0 to 0.6—that is, an increase in a motorist's income tends to spur an increase in MPG—but the modal estimate is much closer to 0 than to 0.6. The same survey found that estimates of the long-run sensitivity of fuel efficiency to changes in population density fall in a range from 0.1 to 0.3; that is, motorists who live in more densely settled areas tend to drive more fuel-efficient cars than those who do not, with a 10% difference in population density corresponding to a 1% to 3% difference in MPG (VTPI, 2008).

Sensitivity of VMT, VMT per Capita, and VMT per Vehicle

Figure 6 shows the trends in U.S. population and VMT per capita. The trend forecasts of 0.99% annual growth in population and 0.77% annual growth in VMT per capita, based on the historical data from 2000 through 2005, imply a 1.76% annual growth in VMT.

In their 1997 survey, Johannson and Schipper (cited in VTPI, 2008) found that estimates of the long-run sensitivity of mean driving distance per car per year to changes in the price of fuel fall in a range from –0.05 to –0.35; that is, a 10% increase in the price of gas, if it persists over a period years, will spur a 0.5% to 3.5% decrease in average VMT per vehicle. The 1999 study by Agras and Chapman (cited in VTPI, 2008) produced a long-run estimate of –0.32. A 2000 study by Glaister and Graham (cited in VTPI, 2008) produced an estimate of –0.3.

The 1997 survey found the sensitivity of mean driving distance to changes in income to be about the same as the sensitivity to changes in the price of fuel, an increase in income leading to an increase in VMT per vehicle. The 1997 survey also found that estimates of the long-run sensitivity of mean driving distance to changes in population density fall in a range from 0.0 to –0.75, the median estimate being –0.4. This implies that a 10% increase in population density, if it persists, leads to a 4% decrease in mileage per car.

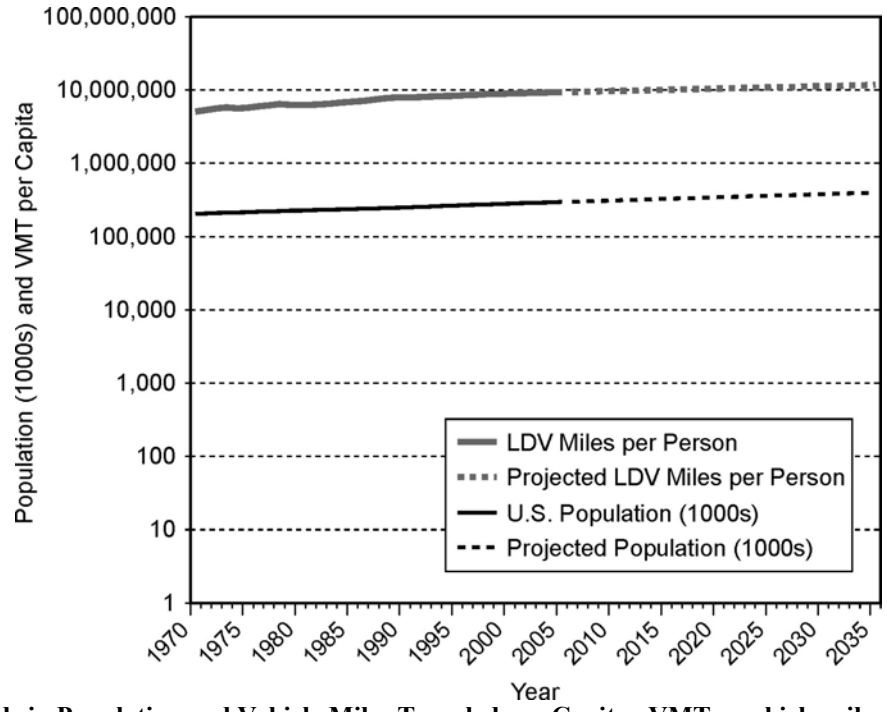

Figure 6. Trends in Population and Vehicle Miles Traveled per Capita. VMT = vehicle miles traveled; LDV = light-duty vehicle. The data source for "LDV Miles per Person" and "U.S. Population" is Table 4.

Since 2000, Virginia's population has grown at a rate higher than that of the U.S. population: 1.267% (Weldon Cooper Center, 2008) versus 0.99% (Weldon Cooper Center, 2003), respectively. One may suppose, using the argument in the previous paragraph, that VMT in Virginia will, therefore, grow at a rate 0.1662% higher than VMT in the United States (1.0 – 0.4)(1.267% – 0.990%). By this line of reasoning, the trend forecast that implies an annual rate of growth of 1.760% for VMT in the United States implies an annual growth rate of 1.926% for VMT in Virginia.

Potential Effects of Carbon Emissions Reductions Policies on Transportation Revenues

An additional issue on which the National Commission was briefed was how future policy actions to reduce carbon emissions—i.e., to address global warming—could affect surface transportation revenues. National Commission staff who prepared the briefing paper on this topic throught that generally the emissions reduction policy details (as yet unknown) would determine the extent to which the HTF was affected (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b). A National Commission briefing paper summarized the effectiveness of surface transportation strategies to reduce carbon emissions (ICF International and Bill Cowart, 2007).

The National Commission staff made the following general observations:

- Fuel tax increases to lower carbon emissions could create additional revenue.

- Increases in CAFE standards to reduce carbon emissions would increase fuel efficiency and, as a consequence, reduce revenue per mile of travel. (Indeed, the effects of higher fuel efficiency on revenues are one of reasons VMT taxes are being considered now.)

- If other carbon-emitting sectors of the economy (e.g., electricity generation) are not also a focus of policy initiatives, policy changes in transportation will be designed to produce larger reductions.

- Enacting tailpipe standards to lower carbon emissions per mile would have similar effects as increasing CAFE standards.

- VMT fees could play a limited role in reducing carbon emissions (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

Potential Impacts of Carbon Taxes or Cap-and-Trade Policies on Transportation Revenues

The potential impacts of carbon taxes and cap-and-trade policies have been assessed by the National Commission and others. A national carbon tax would add a tax to (fossil) fuels based on the amount of carbon they contain. Fuel costs would rise as a result, and the policy goal would be to discourage consumption of conventional fuels. According to National Commision staff, all other things being equal, transportation revenues would decline. These taxes are envisioned to be economy-wide and would provide market incentives to develop or switch to renewable or lower-carbon fuels. National Commission staff also reported that the electricity generation sector (which uses coal) would likely feel the greatest effects of such a tax (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

Litman (2008) described the carbon tax enacted by the Canadian province of British Columbia in July 2008. Gradual increases in the tax between now and 2012 are planned. Litman argued that carbon taxes of this kind have greater effectiveness and scope than other emissions reduction strategies. According to Litman, they do more than increase vehicle fuel efficiency—they increase the overall efficiency of the transportation system in a number of ways. Further, increasing vehicle efficiency without increasing fuel costs is conducive to "rebound effects" and increased, not decreased, VMT.

Cap-and-trade policies have also been proposed as a means for limiting carbon emissions across multiple sectors of the economy (i.e., not only transportation). This involves setting a cap on carbon emissions and requiring that all emissions be tied to permits that would be sold. Caps could be established at different points in the fossil fuel production or consumption cycle. National Commission staff pointed out that cap-and-trade policies would raise equity issues and issues related to differing economic effects on population groups. According to National Commission staff, carbon taxes may be less problematic in this regard because carbon taxes paid could offset other taxes paid, etc. (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

Congress has already considered a carbon cap-and-trade proposal (McCain-Lieberman's Climate Stewardship bill of 2003). National Commission staff cited an EIA analysis of that bill which predicted:

- steady declines in gasoline consumption
- associated declines in HTF revenues
- the majority of carbon emissions reductions coming from reductions in coal use for electricity generation (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

If VMT taxes were implemented and reduced driving, greater use of transit, and/or the purchase of more fuel-efficient vehicles occurred as a result, this could have beneficial effects on emissions reductions (especially if the VMT taxes were combined with congestion pricing). If a portion of the VMT tax revenue were allocated to the federal (or state) Transportation Trust Fund(s), effects on revenues could be positive (National Surface Transportation Policy and Revenue Study Commission Staff, 2007b).

National Commission staff emphasized that until the details of any policy proposal to reduce carbon emissions (carbon taxes, cap-and-trade, "feebates" for purchases of vehicles that exceed a fuel efficiency standard, etc.) were known, the impacts of the policies on revenues can be projected only in general terms.

Feasibility of a VMT Tax for Virginia

Based on the studies reviewed for this report, it appears very likely that Virginia (and many or all other states) will need to consider implementation of a VMT tax over the longer term. Although the experts' opinions vary, the National Commission concluded that the fuels tax would continue to be a viable revenue source through at least 2025. Similarly, in 2006, the Committee for the Study of the Long-Term Viability of Fuel Taxes in TRB Special Report 285 concluded that "the risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years." Of course, as mentioned previously, the present performance of the highway finance system has been affected by spikes in oil prices and an economic recession, which may not have been fully anticipated in 2006.

The Committee concluded that despite the advantages of a VMT tax, the transition from the current system of highway finance will require a sustained national effort, and the National Commission reached a similar conclusion (National Surface Transportation Policy and Revenue Study Commission, 2007). The challenges that must be addressed include the following:

- the remaining problems with technology required for VMT taxation

- public acceptance, including public education and outreach and overcoming concerns about privacy, security, etc.

- additional pilot programs

- a transition strategy and guidance for DOTs considering broader implementation of VMT fees.

Both the Committee and the National Commission emphasized the need for further research and testing, and as mentioned earlier, the University of Iowa Public Policy Center already has such a study underway. The Committee envisioned two research "tracks," one technical and the second programmatic, focusing on research to provide guidance to DOTs on the administration and management of mileage-based fees. The National Commission envisioned an initial VMT tax feasibility study, followed by a study to develop a plan for implementing a federal VMT tax and to coordinate it with state and/or local VMT tax implementation.

The studies reviewed for this report envisioned parallel taxation systems being necessary for a period of time (perhaps 20 years, the National Commission suggested). New cars would have needed on-board equipment for VMT fee collection; drivers of older cars would pay fuel taxes until the vehicle was retired from the fleet (National Surface Transportation Policy and Revenue Study Commission, 2007).

The Committee concluded that that the general introduction of mileage charging "would have profound effects on every aspect of the management of transportation programs." Some of the effects they identified were changed roles of federal, state, and local governments; new criteria for project selection; the availability of a new means to regulate traffic and influence congestion, air quality, etc.; and the opportunity to affect resource allocation to and use of transit and highways in urban areas (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). Further, the opportunity that mileage charging would present is large, but there are risks that the potential benefits could be diminished through poor management (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006).

These recommendations for further research, planning, etc., may seem too time-consuming or deliberate for transportation executives currently facing severe revenue problems. Nonetheless, despite the success of the Oregon VMT tax pilot, system reliability, security, and technology were identified as needing improvement. Oregon's VMT tax pilot was also revenue-neutral (by design) to encourage public acceptance of VMT taxes. Revenue neutral VMT taxes would not solve the financial problems many state DOTs currently face. The Committee also concluded that "an individual state or city that wished to proceed with mileage charging would face enormous difficulties . . . ." (Committee for the Study of the Long-Term Viability of Fuel Taxes, 2006). High fixed costs to build the first implementations, issues related to interstate traffic, and future needs for national coordination of standards or policies were among the significant difficulties identified by the Committee.

CONCLUSIONS

With regard to the six issues investigated in this study, the following conclusions may be drawn:

1. *With regard to the viability of the motor fuels tax,* although the experts' opinions vary, the National Surface Transportation Policy and Revenue Study Commission (National Commission) concluded that the fuels tax would continue to be a viable revenue source through at least 2025. Further, the Committee for the Study of the Long-Term Viability of Fuel Taxes in TRB Special Report 285 concluded that "the risk is not great that the challenges evident today will prevent the highway finance system from maintaining its historical performance over the next 15 years." Of course, as mentioned previously, the present performance of the highway finance system has been affected by spikes in oil prices and an economic recession, which may not have been fully anticipated in 2006.

2. *With regard to Oregon's VMT fee pilot and whether Virginia should fund a similar pilot program,* despite the success of the Oregon pilot, system reliability, security, and technology were identified as needing improvement. The pilot was also revenue-neutral (by design) to encourage public acceptance of VMT taxes. The current VMT tax study being led by the University of Iowa Public Policy Center will provide more information on these issues and will involve a larger number of drivers at six locations in the United States. As stated in Recommendation 1 that follows, Virginia could consider being a pilot location for studies of VMT taxes.

3. *With regard to the historical and expected future penetration of hybrid, electric, and other alternative fuel vehicles (AFVs),* many of the AFV growth rates to date do not lend themselves to reliable forecasting. It is unclear where market shares for some AFVs will level off. Hybrid electric vehicle (HEV) sales, in particular, are climbing rapidly, much faster than light-duty vehicle sales overall. Conditions are unstable, however, for making a reliable forecast of the market share at which HEV sales could level off. As stated in Recommendation 3, Virginia should closely watch the trends in coming years, particularly with regard to HEV sales.

4. *With regard to historical and projected (through 2035) taxable gallons, fleet fuel efficiency, and tax revenues,* average fuel economy for the vehicle fleet and average annual VMT per vehicle are the most important determinants of fuels tax revenue (apart from the tax rate itself). Fleet fuel efficiency has changed in very small increments since the 1980s, and the report's forecast of future fuel efficiency gains is consistent with that. The researchers projected growth in fuel consumption for the VTrans forecast period based on two alternative growth rates, which they discuss in detail. Virginia is growing more rapidly than the United States as a whole, and the report's forecast of VMT growth reflects that fact. The economic recession and the instability of oil prices, however, contribute to the researchers' recommendation that trends in fuel consumption be closely followed in the near future (Recommendation 3).

5. *With regard to the potential effects of carbon taxes on surface transportation revenues,* according to National Commission staff, all other things being equal, transportation revenues would decline. However, staff emphasized that until the details of any policy proposal to reduce carbon emissions (carbon taxes, cap-and-trade, "feebates" for purchases of vehicles that exceed a fuel efficiency standard, etc.) were known, the impacts of the policies on revenues can be projected only in very general terms.

6. *With regard to the viability of a VMT-type tax or combination VMT/motor fuels tax,* it appears very likely that Virginia (and many or all other states) will need to consider implementation of a VMT tax over the longer term. Many issues must be addressed, including remaining problems with the technology required; public acceptance, including public education and outreach and overcoming drivers' concerns about privacy, security, etc.; the need for additional pilot programs; and development of a transition strategy and guidance for DOTs considering broader implementation of VMT fees. Parallel taxation systems would be necessary for a period of time (perhaps 20 years, the National Commission suggested). High fixed costs to build the first implementations, issues related to interstate traffic, and future needs for national coordination of standards or policies are among other significant difficulties remaining to be resolved. The National Commission recommended that the next surface transportation reauthorization include funding for a 5-year major national study to address many of these questions.

RECOMMENDATIONS

VTRC staff were asked to offer recommendations for the short term (2020) and the longer term (2035) with regard to VMT taxes as an alternative to the fuels tax. For the short term, three recommendations can be offered:

1. *The Office of Intermodal Planning and VDOT should closely follow and when warranted participate in ongoing and future technical and programmatic research with regard to VMT taxes. Virginia could also offer to be a pilot location for yet-to-be initiated studies of VMT taxes.* Among the states, Virginia has considerable experience with tolling that could inform the design of future research studies, and it has major public-private partnerships underway that will use congestion pricing in the Northern Virginia/Washington, D.C., region. Residents of that region are familiar with the concept and are interested in strategies that would reduce traffic congestion.

2. *The Office of Intermodal Planning and VDOT could begin to plan and develop a public information and outreach plan to inform citizens and legislators how the growing transportation revenue problem could be equitably addressed with VMT taxes and the advantages of VMT taxes vs. the current highway finance system.* An extensive program of public education and outreach was a key factor in the success of the Oregon VMT tax pilot, and it would be no less important in Virginia—there is

sensitivity about tax increases and privacy, and these issues would need to be effectively addressed before VMT taxes could be implemented on even a limited basis.

3. *The Office of Intermodal Planning and VDOT should continue to follow closely trends in fuel consumption and vehicle purchases, especially purchases of HEVs.*

At the time this report was prepared, a number of these trends were rapidly changing and were not well suited for longer range forecasts of behavior. For that reason, the trends should continue to be followed closely.

Recommendations for the longer term (2035) are quite dependent on the results of studies being conducted now, or to be conducted in the short term, that would address the remaining questions about system architecture for VMT taxes, privacy, security, coordination among different levels of government, and program management at different levels of government. The direction of any policy initiatives to reduce consumption of conventional fuels (carbon taxes or cap-and-trade policies) will also matter. In the interim, some of the trends that are difficult to forecast with any certainty may become clearer.

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