ITS INSTITUTE
Intelligent Transportation Systems

From Fuel Taxes to Mileage-Based User Fees: Rationale, Technology, and Transitional Issues

Final Report

Prepared by:

David D. Coyle

Department of Applied Economics
University of Minnesota

Ferrol O. Robinson
Zhirong (Jerry) Zhao
Lee W. Munnich Jr.
Adeel Z. Lari

Humphrey School of Public Affairs
University of Minnesota

CTS 11-16

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
CTS 11-16		

4. Title and Subtitle	5. Report Date
From Fuel Taxes to Mileage-Based User Fees: Rationale, Technology, and Transitional Issues	August 2011
	6.
7. Author(s) David D. Coyle, Ferrol O. Robinson, Zhirong (Jerry) Zhao, Lee W. Munnich Jr., Adeel Z. Lari	8. Performing Organization Report No.
9. Performing Organization Name and Address Humphrey School of Public Affairs University of Minnesota 301 19th Avenue S. Minneapolis, MN 55455	10. Project/Task/Work Unit No. CTS Project #2010069 11. Contract (C) or Grant (G) No.
12. Sponsoring Organization Name and Address Intelligent Transportation Systems Institute Center for Transportation Studies University of Minnesota 200 Transportation and Safety Building 511 Washington Ave. SE Minneapolis, MN 55455	13. Type of Report and Period Covered Final Report 14. Sponsoring Agency Code

15. Supplementary Notes
http://www.its.umn.edu/Publications/ResearchReports/

16. Abstract (Limit: 250 words)

Two national commissions established by the U.S. Congress recommend replacing the current system of funding transportation based on fuel taxes with a new distance-based system of user fees. The State of Oregon has done a pilot project demonstrating a system for transitioning to mileage-based fees by paying the fees at the gas pump. The University of Iowa has conducted pilot tests around the country to determine how drivers respond to a mileage-based fee approach using GPS-based technology. The Puget Sound Regional Council has conducted a test of congestion tolling. Finally, the Minnesota Department of Transportation is testing an approach for collecting mileage-based user charges using commercially available smartphones with built-in GPS devices, in which the charge element is just one of the applications.

While there have been discussions among many transportation leaders regarding why fuel taxes are no longer a good way of funding the transportation system, there is by no means a public understanding of why this is so. The public assumes that the taxes they pay at the pump are paying for the system, and that if funding problems exist, they are due to waste and inefficiency. This examination–of the rationale, technology, and transitional issues in shifting from a financing system for surface transportation based on fuel taxes to one that is based on a mileage-based user fee (MBUF) traveled or vehicle-miles traveled (VMT) fee–sets the stage for a policy discussion on transportation-related user fees and lays the groundwork for an extensive public outreach effort.

17. Document Analysis/Descriptors	18. Availability Statement
Fuel Taxes, Mileage-based user fees, Vehicle miles of travel, Financing, Transportation policy, Taxes	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	91	

From Fuel Taxes to Mileage-Based User Fees: Rationale, Technology, and Transitional Issues

Final Report

Prepared by:

David D. Coyle

Department of Applied Economics
University of Minnesota

Ferrol O. Robinson
Zhirong (Jerry) Zhao
Lee W. Munnich Jr.
Adeel Z. Lari

Humphrey School of Public Affairs
University of Minnesota

August 2011

Published by:

Intelligent Transportation Systems Institute
Center for Transportation Studies
University of Minnesota
200 Transportation and Safety Building
511 Washington Avenue, S.E.
Minneapolis, Minnesota 55455

ACKNOWLEDGMENTS

The authors wish to acknowledge those who made this research possible. The study was funded by the Intelligent Transportation Systems (ITS) Institute, a program of the University of Minnesota's Center for Transportation Studies (CTS). Additional financial support was provided by the United States Department of Transportation Research and Innovative Technologies Administration (RITA).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

INTRODUCTION AND MOTIVATION

Two national commissions established by the U.S. Congress recommend replacing the current system of funding transportation based on fuel taxes with a new distance-based system of user fees. The State of Oregon has done a pilot project demonstrating a system for transitioning to mileage-based fees by paying the fees at the gas pump. The University of Iowa has conducted pilot tests around the country to determine how drivers respond to a mileage-based fee approach using GPS-based technology. The Puget Sound Regional Council has conducted a test of congestion tolling. Finally, the Minnesota Department of Transportation is testing an approach for collecting mileage-based user charges using commercially available smartphones with built-in GPS devices, in which the charge element is just one of the applications.

While there have been discussions among many transportation leaders regarding why fuel taxes are no longer a good way of funding the transportation system, there is by no means a public understanding of why this is so. The public assumes that the taxes they pay at the pump are paying for the system, and that if funding problems exist, they are due to waste and inefficiency. This examination–of the rationale, technology, and transitional issues in shifting from a financing system for surface transportation based on fuel taxes to one that is based on a mileage-based user fee (MBUF) traveled or vehicle-miles traveled (VMT) fee–sets the stage for a policy discussion on transportation-related user fees and lays the groundwork for an extensive public outreach effort.

SHOULD THE U.S. MOTOR FUEL TAX BE RETAINED OR REPLACED?

To properly answer whether fuel taxes should be replaced, it is important to first evaluate the fuel taxes on the basis of transportation finance principles – efficiency, equity, revenue adequacy and sustainability, environmental sustainability, and feasibility. Fuel taxes are problematic under several transportation finance principles. Table S.1 scores the fuel taxes on the various principles discussed in this paper.

Table S.1: Fuel Taxes Assessment Scorecard

Principles	Ability to Achieve Principles
Efficiency	Weak
Equity	Moderate
Revenue Adequacy and Sustainability	Moderate
Environmental Sustainability	Moderate
Feasibility	Strong

While the first section of this paper alone does not answer the question of whether the fuel tax system should be retained or replaced, the many shortcomings illustrated by our analysis suggest that transportation funding in the United States may want to move past a system of fuel taxes.

SHOULD MBUF REPLACE FUEL TAXES?

The National Surface Transportation Policy and Revenue Study Commission (2007) reviewed potential replacements for fuel taxes and concluded that MBUFs have many promising features. After examining fuel taxes against the five transportation finance principles, we next analyze MBUFs along the same principles to gain a deeper understanding of whether fuel taxes should in fact be replaced. Table S.2 illustrates that MBUFs score higher than fuel taxes on many transportation finance principles.

Table S.2: MBUF Assessment Scorecard

Principles	Ability to Achieve Principles
Efficiency	Strong
Equity	Strong
Revenue Adequacy and Sustainability	Strong
Environmental Sustainability	Moderate
Feasibility	Weak

USER FEE TECHNOLOGY AND FINANCE PRINCIPLES

To fully understand how MBUFs fare under the five principles, it is important to consider the different technology options that would be used in a MBUF system. A review of eight different technologies against the five transportation finance principles found that there are several promising options available for VMT pricing. Table S.3 below highlights the strengths and weaknesses of three of the most promising technology options.

Table S.3: Technology Options' Ability to Achieve Transportation Finance Principles

Option	Efficiency	Equity	Revenue Adequacy and Sustainability	Environmental Sustainability	Feasibility
On-board Diagnostic (OBD II) Units	Moderate	Moderate	Strong	Moderate	Strong
OBD II / Cellular	Strong	Strong	Strong	Moderate	Strong
Fine-resolution GPS	Very Strong	Very Strong	Strong	Moderate	Weak

ACTION PLAN FOR IMPLEMENTING DISTANCE-BASED USER FEES

Given MBUFs' potential and fuel tax shortcomings, and the fact that various technologies are available to allow the implementation of MBUFs, we next consider several important transitional issues and present an action plan for MBUF implementation. The action plan is presented in four parts. Rather than simply endorsing one path forward, this action plan raises several important issues related to the transition to MBUFs. The first two sections address the potential design and administration of MBUFs. Under design we discuss both the appropriate tax base and rate. Under administration we address three important questions: At what level is VMT pricing implemented, and who collects the revenue? How are revenues allocated among jurisdictions? And how best to manage the system and its costs? The third section covers important transition issues such as demonstrations, trials, and early deployment options. We conclude our action plan with a discussion of the education and outreach that is needed to bring about greater public awareness and acceptance of MBUFs.

CONCLUSION AND RECOMMENDATIONS

First and foremost, fuel taxes are not sustainable for funding surface transportation, but the MBUF would be. MBUFs have a significant advantage over fuel taxes when evaluated under efficiency, equity, and revenue adequacy and sustainability principles. Second, there are several VMT technology options available, and each has strengths and weaknesses related to the five transportation finance principles examined. Finally, we suggest a transitional structure for funding transportation. The approach that we suggest is to create a new transportation funding tax structure made up of the following three components:

- *Base Fuel Tax Component—Federal and State Level*
  Under the new transportation funding tax structure, fuel taxes would be reset to a lower base rate that would be sufficient to generate revenues for baseline transportation needs.

- *Mileage-Based Charge Component—Federal and State Level*
  The aim of this mileage-based pricing component would be to fund road and bridge reconstruction and expansion, including right-of-way acquisition. The mileage-based user charge would be set at levels that compensate for the reduction in fuel taxes to the base rate.

- *Mileage-Based Charge Component—Local Option*
  The third component aims at funding local roads. As a basic approach, the VMT charge would be a local option that would replace the patchwork of local sales taxes that are used to fund local roads.

This new transportation funding tax structure would accommodate a variety of transition options, many of which require fuel tax collection to co-exist with MBUFs over what could be a significant period of time.

The analysis in this report makes a strong case for MBUF implementation. In addition to our recommendation that MBUFs continue to be seen as an eventual replacement for fuel taxes as the primary mechanism for funding surface transportation, it is also recommended that transportation professionals and policymakers take the time to fully understand the issues presented in this examination. For MBUF implementation to move forward, it is important that policymakers understand the shortcomings of fuel taxes and how unsustainable they are in the long run. It is equally important that proponents of MBUFs understand, first, the difficult transitional issues and questions involved, and second, the education and outreach effort that will be needed if the public and policymakers are to support implementation of MBUFs.

CHAPTER 1. INTRODUCTION

Two national commissions established by the U.S. Congress recommend replacing the current system of funding transportation based on fuel taxes with a new distance-based system of user fees. The State of Oregon has done a pilot project demonstrating a system for transitioning to mileage-based fees by paying the fees at the gas pump. The University of Iowa has conducted pilot tests around the country to determine how drivers respond to a mileage-based fee approach using GPS-based technology. The Puget Sound Regional Council has conducted a test of congestion tolling. Finally, the Minnesota Department of Transportation is testing an approach for collecting mileage-based user charges using commercially available smartphones with built-in GPS devices, in which the charge element is just one of the applications.

While there have been discussions among many transportation leaders regarding why fuel taxes are no longer a good way of funding the transportation system, there is by no means a public understanding of why this is so. The public assumes that the taxes they pay at the pump are paying for the system, and that if funding problems exist, they are due to waste and inefficiency. This examination–of the rationale, technology, and transitional issues in shifting from a financing system for surface transportation based on fuel taxes to one that is based on a mileage-based user fee (MBUF) traveled or vehicle-miles traveled (VMT) fee–sets the stage for a policy discussion on transportation-related user fees and lays the groundwork for an extensive public outreach effort.

This report proceeds as follows. Chapter 2 analyzes the current fuel tax system on the basis of five transportation finance principles: efficiency, equity, revenue adequacy and sustainability, environmental sustainability, and feasibility. Chapter 3 analyzes MBUFs against the same five transportation finance principles. Chapter 4 provides an overview of eight different technology options that could be used in a MBUF system and compares them based on the five transportation finance principles. Chapter 5 provides an action plan for implementing MBUFs, and addresses several questions related to the proper design and administration of a MBUF system. Chapter 5 also addresses questions related to the transition from fuel taxes to MBUFs and highlights several education and outreach areas. Finally, chapter 6 presents the study's conclusions and recommendations.

There are several areas and facts that overlap and are repeated, particularly between chapter 2 and chapter 3. This is intentional. Our examination can be viewed as an overview of several issues related to MBUF implementation; however, we also intend for each chapter to be available as a stand-alone examination for use by researchers and policymakers concerned with a specific issue related to MBUFs. For this reason, we give the questions and issues in each section a thorough review which may result in some overlap when the report is viewed as a whole.

CHAPTER 2. SHOULD THE U.S. MOTOR FUEL TAX BE RETAINED OR REPLACED?

This examination of motor fuel taxes endeavors to answer the question, "Should the U.S. motor fuel tax be retained or replaced?" This somewhat provocative question is being asked in the context of recent reports by two national commissions charged by the U.S. Congress to examine the state of current and future funding mechanisms for funding the nation's transportation infrastructure. These reports, one by the National Surface Transportation Policy and Revenue Commission (2007), and one by the National Surface Transportation Infrastructure Commission (2009), examined motor fuel taxes as well as other taxes and fees currently being used to fund the surface transportation infrastructure. These reports point out the many historical and current shortcomings of motor fuel taxes, and recommend that more direct forms of transportation user fees (such as mileage-based user fees) be seriously considered as future alternatives to fuel taxes.

This chapter is a synthesis of previous research and analysis regarding motor fuel taxes. However, our novel approach has been to examine the attributes of motor fuel taxes in a comprehensive way, evaluating them from the perspective of five transportation finance principles, namely: efficiency, equity, revenue adequacy and sustainability, environmental sustainability, and feasibility. Under efficiency we focus on the degree to which fuel taxes send price signals that lead to efficient user behavior, investment, and land use. Under equity our discussion covers both the user-pays-and-benefits principle and the ability-to-pay principle. Under revenue adequacy and sustainability we examine whether fuel taxes are providing adequate revenue for surface transportation investments, and how sustainable they are as a revenue source going forward. Under environmental sustainability we highlight the degree to which fuel taxes adhere to the polluters pay principle and lead to more environmentally friendly outcomes. Under feasibility we consider both administrative feasibility and political feasibility. Under each of these principles we evaluate fuel taxes at their current rate. It should be noted however, some problem areas with fuel taxes could be remedied, at least in the short term, by simply raising the fuel tax rate. This chapter focuses on the U.S. Federal and state surface transportation funding mechanism that is characterized by fuel-tax based trust funds. Thus, our discussions center primarily on highway development. We do address transit funding, but only to the extent that Highway Trust Fund proceeds are partially allocated to transit.

This chapter is the first of a four-phase project that seeks to set the stage for a policy discussion on transportation-related user fees in the United States. In subsequent chapters, we will also evaluate the attributes of an alternative to motor fuel taxes, namely, mileage-based user fees, using the same principles enumerated above. In addition, we will explore the outreach and education effort with the public, stakeholders and policy-makers that will be necessary if we are to transition to a more direct user fee approach for funding the transportation system. This chapter does not directly answer the question of whether fuel taxes should be replaced or retained. However, when viewed along with subsequent chapters, we hope that insights can be gained on the relative strengths and weaknesses of fuel taxes when compared to mileage-based user fees.

Before we begin our analysis, it is important to note the distinction between the terms tax and fee. From a public finance perspective, a tax is a charge levied upon individuals and corporations for general revenue purposes. A user fee, on the other hand, is a targeted fee levied upon users of a specific government service for the use of that service. In this chapter, we examine how fuel taxes as user fees perform under transportation finance principles.

2.1 EFFICIENCY

Under the efficiency principle we evaluate fuel taxes on three different criteria: how well they lead to efficient user behavior, how well they direct transportation investment, and how well they lead to efficient land use. For a tax to encourage efficient user behavior, it should send the right price signals to drivers so that only those drivers who value the use of the road above the cost they impose will use it. As we will see, fuel taxes send weak price signals to drivers and thus lead to inefficient overuse of the highways. This is the result of users underpaying for system use, and users being unaware of what they do pay in fuel taxes. Overuse, in turn, leads to high levels of congestion, emissions, and may result in less-optimal modal use in term of efficiency. In addition to sending weak price signals, fuel taxes fail to provide proper price signals to public officials and investors and thus may direct investment away from the more economically worthwhile projects. Finally, fuel taxes have little connection to land use, and fail to discourage urban sprawl or support livability principles.

2.1.1 Overuse of transportation system

For a tax to lead to efficient use of the transportation system it must make users pay the full costs to society of their use. As stated by Small et al. (1989),

> "The best way to economize…is to apply a user charge equal to the actual cost each user imposes on society through his effect on the road's condition and on the speed that other users can travel. Such a charge, known as the marginal-cost user charge, ensures that the independent decisions by users reflect the interests of all…If road users are required to incur this entire amount themselves, they will use the highway (at that time and place) only if the value to them of doing so exceeds the amount society must pay…" (p. 9).

In our current transportation system, fuel taxes cannot be considered what Small et al. call marginal-cost user charges, since they fall short of covering the costs imposed on the system by each individual user. This underpricing leads to inefficient overuse. While the average user pays about three cents per vehicle-mile (1.9 cents per km) traveled in user fees, a driver on a congested highway imposes costs of 10 to 29 cents per vehicle- mile (6.2 to 18 cents per km) traveled (Atkinson 2009). As noted by Robinson (2008) and others, "Unpriced commodities, such as the current transportation system capacity, are viewed by users as being 'free' and lead to excessive use. In the case of roads, this unconstrained demand results in high levels of congestion and delays and an associated reduction in safety and air quality" (p. 2).

Users underpaying for system use, and the unconstrained demand that results, can lead to over-production of highway capacity. This is because the congestion that results from underpayment sends signals to public officials that highways need to be widened and expanded to accommodate peak travel demand. Furthermore, it is possible that user underpayment leads to under-investment in some instances, because insufficient fuel tax revenue is raised to complete worthwhile projects.

In addition to user underpayment, and the resulting system overuse, many users are unaware of what they pay to use the system. In its findings and recommendations, the National Surface Transportation Infrastructure Financing Commission (2009) noted that, "[S]ystem users are typically unaware of how much they pay in fuel taxes (as distinct from the price of gasoline), such that daily swings in price mask the tax component and blunt its effect on demand…" (p. 7). Surveys show that users are not aware of the amount they pay in fuel taxes. A report prepared for the Minnesota Department of Transportation (Mn/DOT) found that, in general, survey participants were unaware of what they paid in gas taxes (Fichtner et al. 2007). Participants' estimates of the current gas tax rate (the state gas tax was 20 cents (5.3 cents per L) at the time) ranged from 0.009 cents to one dollar per gallon (0.002 cents to 26.3 cents per L). If users are unaware of how much they pay in fuel taxes, they will also be unable to make the connection between what they pay and the effect their travel has on congestion, emissions, and the unbalanced ratio of auto to transit use.

2.1.1.1 Effect on roadway congestion

When drivers use a congested road, the cost they impose on society is higher than the cost when using an uncongested road. One of the main impacts of congestion on road system expenditures is the pressure it puts on road authorities to "fix" the congestion problem. The fix often takes the form of costly road capacity expansion, or sometimes costly transit capacity and service improvements, or setting up less costly, but often less effective, congestion management programs. A study by Winston et al. (2006) estimated that one dollar of government spending on highways reduced road users' congestion costs by only eleven cents. From this finding the study went on to estimate that states would have to spend nearly $350 billion annually to eliminate congestion costs. These costs, and the need for some costly road expansions, could largely be reduced if demand during peak-use periods were reduced. A second cost factor resulting from congestion is the increase in emissions (Barth et al. 2009), which impose health as well as environmental costs to society. A third factor is the increase in cost associated with each user slowing the speed of all other users on a part of the system at a particular time. This cost is expressed in terms of time lost due to delays times the value of time of different users.

Another reason why fuel taxes send weak price signals is that they are largely fixed, per-gallon taxes. As stated by the National Surface Transportation Policy and Revenue Study (2007), "Motor fuel taxes are not economically efficient because they do not vary as the cost of travel increases. They do vary with vehicle fuel efficiency, but the decline in fuel efficiency when vehicles operate in congested traffic does not reflect the full costs of travel in congested conditions" (p. 5.39). Since fuel taxes are undifferentiated by time of use or parts of the system being used, fuel taxes are unable to effectively price for congestion and avoid overuse of the system. Experience has confirmed that when pricing mechanisms are implemented to make users face the full costs of their travel, users do in fact change their behavior (Rufolo et al. 2003). In fact, in the first few months after congestion pricing was implemented in London, automobile traffic declined by about 20 percent (Litman 2004). Similar results were experienced in Stockholm (Robinson 2006).

The inability of fuel taxes to price congestion is one of the contributing factors in our nation's growing congestion problem. Annual delay per peak period traveler rose from 21 hours in 1982 to 51 hours in 2007 in the nation's 14 largest urban areas (Texas Transportation Institute 2009).

This growing rate of congestion imposes real costs to users and the economy as a whole. Using value of travel time (estimated at $15.47 per hour of person travel and $102.12 per hour of truck time) and excess fuel consumption (estimated using state average cost per gallon), the Texas Transportation Institute (2009) estimates the total cost of congestion in the nation's urban areas for 2007 at approximately $87.2 billion. In addition to individual users, businesses are also hurt by congestion. In part because of rising congestion, the logistic costs for American businesses rose to 10 percent of GDP in 2006 (National Surface Transportation Policy and Revenue Study Commission 2007).

2.1.1.2 Effect on mode shift

In part because fuel taxes are unrelated to congestion, they send poor price signals to users regarding the tradeoff between using autos and using transit. Lewis (2008) notes that it should come as no surprise that while our roadways are congested, there is little use of public transit. This is due, in part, to users not being aware of the true cost of their travel. Because the cost users pay for auto and truck use on the highway system is below the socially optimal cost, auto and truck use looks relatively inexpensive compared to transit and freight rail. If fuel taxes reflected true costs, including congestion and environmental costs, it is likely that, over time, some users would shift to transit and freight rail. As Wachs (2003a) points out, raising the gas tax sends price signals to motorists to use the transportation system more efficiently as it encourages motorists to switch to public transit to save money.

While our highway system is experiencing growing levels of congestion, our freight rail system remains relatively uncongested. In 2006, 88 percent of the freight rail corridors were operating at below practical capacity (National Surface Transportation Policy and Revenue Study Commission 2007). Thus, if fuel taxes were reformed to more accurately price highway use, the result would most likely be a more balanced use of the highway system compared to the rail system. It should be noted however, transit, like the highway system, is underpriced and thus transit costs are not fully covered either.

In addition to sending price signals that lead users to shift away from peak period travel, and auto and truck trips to shift to transit and freight rail, respectively, a properly set tax could help reduce the number of less-than-full truckload and empty trips. Once again, because fuel taxes do not price the use of the system at the full cost imposed by users, shippers have less of an incentive to reduce less-than-full truckload trips, including "empties". Robinson (2008) indicates that the introduction of heavy vehicle tolling in Germany, which priced trucks per-kilometer of use of the Autobahn, more closely reflect full direct costs since these tolls are in addition to fuel taxes. Tolling of trucks resulted in about a 20 percent reduction in the number of empty truck trips. The pricing of trucks was based on maximum rated gross vehicle weight, which meant that empty trucks were charged the same rate per kilometer as fully-loaded trucks. This gave rise to load consolidation brokers, and led to greater efficiency in truck operation.

2.1.2 Inefficient investment in transportation

Small et al. (1989) explain that, in addition to leading to a more efficient use of transportation capacity by users, an advantage of marginal-cost user charges is that, "[T]he resulting revenues provide a tangible signal to public officials as to whether additional investments to provide more or better services are likely to be worthwhile" (p. 9). Thus, by properly pricing roads to reflect the true costs of use, public officials and investors are able to get a more accurate picture of the demand for more or better service.

As indicated previously, fuel taxes do a poor job of accurately pricing the social costs of highway use and lead to inefficient overuse of the capacity. Because of this, they also fail to convey price signals to help direct investment to the most worthwhile projects. Underpayment may result in underinvestment in transportation, as fuel taxes do not raise sufficient funds for economically justifiable projects. Underpayment by users, and the resulting unconstrained demand, may also lead to over-production in some instances. As stated by Lewis (2008), "Because the absence of congestion pricing encourages peak period demand that would not otherwise arise, the need for highway investment is increased accordingly… the federal taxpayer should not be burdened by investment costs that are not economically justified" (p. 30). Thus, fuel taxes can lead not only to excessive congestion, but also to excessive highway investment. A study by Boarnet (1997), which estimated county- level production functions, found that while there was strong evidence that congestion reduction can affect county output, there was weaker evidence that street and highway capital stock increases were productive. In their findings and recommendations, the National Surface Transportation Financing Commission (2009) concluded that greater use of pricing mechanisms such as a mileage-based pricing may lead to more efficient investment and reduce the need for additional capacity that may otherwise be built, by shifting demand to off-peak hours and to other transportation modes.

2.1.3 Inefficient land use

In addition to failing to provide price signals which lead to a more efficient use of the roads and to more efficient investments, fuel taxes can lead to inefficient land use. On this criterion, fuel taxes are problematic; as Langer et al. (2008) state,

> "By undercharging vehicles for using the nation's roadways, policymakers have also reduced the per-mile cost of commuting...and distorted the development of metropolitan areas by inducing households to live in more distant, lower-density locations, thereby contributing to urban sprawl…it is likely that households' decisions regarding residential locations…have resulted in socially inefficient outcomes because they reduce economies of agglomeration" (p. 127).

Once again, the inability of fuel taxes to price roads to reflect the true costs imposed by users leads to inefficiencies. Long-distance commuters do not have to pay their full cost of travel, which is a built-in incentive to locate to more distant locations to take advantage of lower home prices and higher acreage, which in turn contributes to urban sprawl. According to the national census, from 1970 to 2000 central city density declined by approximately 35 percent (Langer et al. 2008). It should come as no surprise that during this period the ability of fuel taxes to recover the full costs was significantly eroded.

2.1.4 Summary

On efficiency grounds, fuel taxes fare poorly, based on the following findings:

- Fuel taxes do not price for the total cost to the system for each trip, which leads to inefficient overuse. Fuel taxes' inability to price for congestion exacerbates this problem and leads to excessive delays, which comes with stiff costs to users and businesses.
- Use of fuel taxes as pricing mechanisms may also contribute to an unbalanced ratio of auto and truck use versus transit and freight rail use, leaving our highways congested while use of public transit and freight rail remain, generally, below capacity.
- In addition to contributing to an inefficient use of the system, fuel taxes lead to inefficient system investments because they send poor price signals to public officials and investors: Investments are sometimes made in projects that are overused, rather than in more worthwhile projects.
- The failure of fuel taxes to accurately price the use of the system has contributed to urban sprawl because fuel taxes result in low per-mile cost of commuting and induces households to live in farther, lower-density locations.

2.2 EQUITY

In revenue analysis, the equity criterion is often assessed based on two principles: (1) a benefit-received principle (or "user-pays-and-benefits"), which is applied to user fees to examine the extent to which users pay in proportion to their amount of use and to the costs they impose on the system, and (2) the ability-to-pay principle, which relates relative revenue burden to people of different income brackets. In the US, the motor fuel tax system was originally created as a user fee, and thus we focus the majority of our analysis on the user-pays-and-benefits principle. Nonetheless, we will also consider ability-to-pay in our analysis.

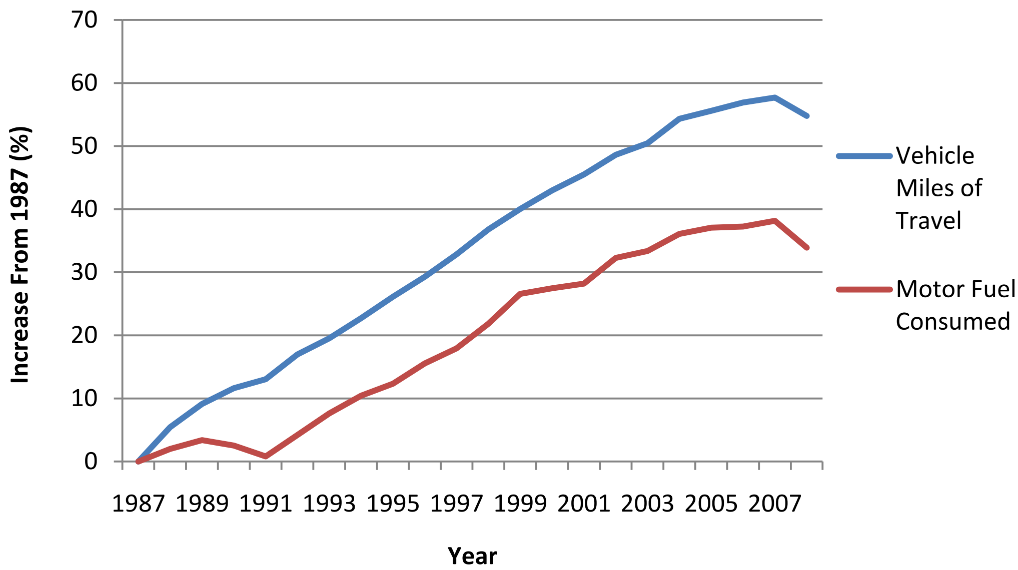
2.2.1 Motor fuel taxes as user fees

In this section, we begin our analysis with an evaluation of how closely motor fuel taxes, as user fees, adhere to the user-pays-and-benefits principle. It is important that we remind ourselves what we mean by user fees. These are fees collected from those who use a particular service, as opposed to fees collected from the public-at-large. User fees apply to activities that generally provide special benefits to identifiable recipients or beneficiaries, and fees generally vary in proportion to degree of use.

The users-pay-and-benefit principle was well understood at the state level in the 1950s when several states were dedicating their gas tax revenue for highway improvements (Patashnik 2000). The Federal Government first imposed a tax on gasoline fuel under the Revenue Act of 1932 (Federal Highway Administration 2008); however, the federal gas tax could not be considered a user fee that upheld the user-pays-and-benefits principle until the creation of the Highway Trust Fund in 1956, when gas tax revenue began to be specifically allocated for transportation (Small et al. 1989). In his book, Putting Trust in the US Budget: Federal Trust Funds and the Politics of Commitment, Patashnik (2000) states, "The Highway Trust Fund also signaled a political commitment that Congress would forgo the temptation to use highway revenues as a lucrative source of funding other programs. [In addition,] Highway tax rates would be kept no higher than necessary to meet the costs of the highway program" (p.117-118). Thus, with the inception of the Highway Trust Fund, the gas tax would satisfy the user-pays-and-benefits principle, since fees collected from users would benefit users through improvements to the highway system, and fees would be set to meet the costs imposed on the system by the users. Today, fuel taxes still function as a user fee, but, as currently applied, fuel taxes violate the user-pays-and-benefits equity principle in many ways.

2.2.1.1 Improvements in fuel efficiency

One of the most significant reasons why fuel taxes no longer uphold the user-pays-and-benefits principle has been the improvements in motor vehicle fleet fuel efficiency that have occurred since the 1970s. In 1975 the average fleet fuel economy was 13.1 miles per gallon (mpg) (5.6 km/L); by 2008 it was 20.4 mpg (8.7 km/L), a 56 percent improvement. This significant improvement has caused users on the whole to pay less per vehicle-mile traveled. The Environmental Protection Agency (EPA) estimate of 20.4 mpg (8.7 km/L) fleet average for 2008 light duty-vehicles is an eight percent increase from their estimate for model year 2004 (Environmental Protection Agency 2008). These increases in fuel efficiency are a large reason why today's overall user fee, estimated at three cents per mile (1.9 cents per km) (Atkinson 2009), is well below the six cents-per-mile (in current dollars) (3.8 cents per km) user fee of the 1960s (Morris 2006). Figure 2.1 shows that the increase in vehicle-miles traveled has outpaced the increase in motor fuel consumption. In fact, from 1987 to 2008, vehicle-miles traveled increased by approximately 55 percent, while motor fuel consumption increased by approximately 34 percent (Federal Highway Administration 2009d).



(Data from Federal Highway Administration 2009d)
Figure 2.1: Motor Fuel Consumption and Vehicle Miles of Travel

The trend of increasing fuel efficiency for the overall fleet is expected to continue as average fuel economy for new vehicles accelerates (Energy Information Administration 2009). The Energy Information Administration (2008) estimates that average fuel efficiency for all light-duty vehicles on the road will grow from 20.4 mpg (8.7 km/L) in 2008 to 28.9 mpg (12.3 km/L) by 2030. A report of the National Surface Transportation Infrastructure Financing Commission (2009) found that the current federal surface transportation funding structure, which relies heavily on motor fuel taxes, is not sustainable and is likely to erode more quickly than previously thought due, in large part, to a drive for greater fuel efficiency caused both by heightened concerns over global climate change and by an effort to reduce dependence on foreign energy sources. The commission went on to state that fuel taxes and other user fees account for less than 60 percent of total transportation system revenue (federal, state, and local), which clearly shows that users do not bear the full cost of their travel. Going forward, as fuel efficiencies increase and users pay less in fuel taxes per mile traveled, fuel taxes will account for less and less of the system cost imposed by users.

The Energy Information Administration (2009) gives the projected fuel economy of new light-duty vehicles under five different scenarios: high oil prices, high levels of technological advancement, a reference group, low oil prices, and low levels of technological advancement. Under all five scenarios, the average fuel economy of new light-duty vehicles is expected to grow to between 36 and 39 miles per gallon (15 and 17 km/L) by 2030. This level of fuel efficiency may be reached even sooner, as the current administration has set a new CAFE (Corporate Average Fuel Economy) standard of 39 miles per gallon (17 km/L) for new passenger cars and 30 miles per gallon (13 km/L) for light trucks by 2016. These increases in fuel economy will exacerbate the equity problem under the user-pays-and-benefits principle, as those with newer cars pay increasingly less in fuel taxes per mile traveled than drivers with similar, but older and less fuel-efficient vehicles, even if both types of vehicle owners travel the same distance and impose the same cost on the highway system.

2.2.1.2 Use of alternative fuel vehicles

While increasing fuel efficiencies have allowed users with more fuel efficient vehicles to pay less in taxes per vehicle mile traveled, the introduction of alternative fuel vehicles makes it possible for some users to pay very little or no fuel taxes. The Environmental Protection Agency (2008) estimates that 2.5 percent of the model year 2008 fleet will be hybrids. While plug-in hybrids and electrical vehicles still make up a small minority of all drivers, they nonetheless represent a significant violation of the user-pays-and-benefits principle since a substantial part of their propulsion is powered by electricity and thus not subject to fuel taxes. For users with vehicles powered entirely by alternative fuels, the user-pays-and-benefits principle is completely violated since these users pay no fuel taxes, even though they impose costs on the system and benefit from system improvements paid for by other users.

2.2.1.3 Not all users pay fuel taxes

The user-pays-and-benefits principle for fuel taxes is further eroded by the extent that groups of users do not pay their fair share of fuel taxes. This comes in the form of exemptions and outright evasion.

Federal law exempts users such as state government, non-profit educational organizations, and emergency vehicles from having to pay fuel taxes (National Surface Transportation Infrastructure Financing Commission 2009). Subsidies are also provided for users of gasohol (Schade et al. 2006). In terms of evasion, there are several forms including bootlegging across state lines, diluting the blend, and “daisy chains” (creating a dummy corporation and a fraudulent and complex trail of paperwork) (Denison et al. 2000a). As stated by Denison et al. (2000b), “Like all types of tax fraud, evasion of the motor fuels tax is an elusive and burgeoning threat, its methods constantly evolving and adapting to new enforcement methods" (p. 171). The National Surface Transportation Infrastructure Financing Commission (2009) notes that evasion remains a problem, even though progress has been made in recent years through legislative changes and increased enforcement. Total fuel tax evasion at the state and federal level may exceed one billion dollars annually or 3.5 percent of total federal motor fuel tax revenue.

Other studies have tried to estimate motor fuel tax evasion. The Federal Highway Administration (1992) estimated that the evasion rate for federal gas tax was between three and seven percent, and the evasion rate for federal diesel tax was between 15 and 25 percent. The Federal Highway Administration (1999) estimated that in 1994 the combined state and federal fuel tax evasion approached three billion dollars annually. In their article, *Cheating Our State Highways: Methods, Estimates and Policy Implications of Fuel Tax Evasion*, Denison et al. (2000a) state that, for Kentucky, diesel revenue would increase by eight percent and gas revenue would increase by three percent if evasion was completely eliminated in the state. Their study also suggests that increasing the gas and diesel fuel tax in the state of Kentucky by 10 cents may increase evasion by 37.5 percent. While various estimates of fuel tax evasion have been made, changes in enforcement have made estimating evasion difficult, and the Federal Highway Administration's Office of Transportation Policy Studies (2009b) now states that reliable estimates of evasion are not available. While an estimate of losses due to evasion is not currently known precisely, it can credibly be stated that significant losses do occur.

2.2.1.4 Full cost recovery of direct costs

Closely related to the user-pays-and-benefits principle is the concept that payments should be based on full cost recovery. This encompasses both direct costs, such as road construction and maintenance, and external costs, such as pollution and congestion effects. Overall, users do not bear the full costs of their travel, and fuel taxes make up less than 60 percent of total system revenue (National Surface Transportation Infrastructure Financing Commission 2009). In 2008 the Highway Trust Fund necessitated an eight-billion dollar transfer from the general fund to keep it solvent and, in the face of continuing deficits, the fund will require additional regular infusions unless structural problems faced by fuel taxes are corrected. Several studies and economists have noted that fuel taxes would need to be greatly increased to be able to meet full cost recovery, with some estimates suggesting fuel tax increases to over $1.00 (Wachs 2003a).

Taking a closer look at costs, we first turn to a discussion of direct costs. Small et al. (1989) state, "Charges associated with scarce durability, which causes road wear (that is, pavement deterioration), should reflect a vehicle's contribution to this wear" (p. 10). In other words, part of user fees should go towards recovering the costs they impose on the deterioration of the roads they use. Martin Wachs (2003a) suggests that fuel taxes fare relatively well in recovering direct costs: heavier vehicles pay more in fuel taxes because they are less fuel efficient. However, Small et al. (1989) note that, while structural damage to roads is caused mostly by trucks and buses, it is not total weight but weight per axle that is important. (It should be added, however, that total weight is relevant when assessing structural damage to bridges.) Since fuel taxes, as collected in most states, do not discriminate based on weight or number of axles, states are unable to have much precision in charging users to make up for direct costs (Small et al. 1989). Furthermore, while heavier trucks do pay more in fuel taxes than lighter trucks, the extra amount they pay normally does not make up for the sizable added amount of wear and tear they impose (National

Surface Transportation Infrastructure Financing Commission 2009). According to the Federal Highway Administration's Cost Allocation Study (2000), updated in 2000, the equity ratio (ratio of tax and fee payments by type of vehicle and highway costs imposed by those vehicles) is 0.53 for heavier single-unit trucks (over 25 000 pounds (11 340 kg)) and 0.48 for the heaviest combination trucks (over 80 000 pounds (36 287 kg)). Even for the bread-and-butter five-axle combination units (50 000 to 80 000 pounds (22 680 to 36 287 kg)) the equity ratio is 0.83 (Federal Highway Administration 2000). This means that, while it is true that heavy trucks pay higher transportation taxes and fees than light vehicles, they in turn impose substantially higher costs than are recovered through their payments. As the equity ratios for trucks show, automobiles and light trucks are actually subsidizing the cost of wear and tear imposed by heavier trucks on the transportation infrastructure, thus introducing an inequitable situation.

2.2.1.5 Full cost recovery of external costs

In addition to direct costs, vehicular traffic creates indirect or external costs such as congestion, adverse air quality and health effects, noise and greenhouse gases, among others. These costs are not borne solely by users of the highway system, but by society at large. To be equitable, and to comply with the user-pay-and-benefits principle, fuel taxes, as user fees, should also move towards full recovery of external costs. The idea of correcting externalities with taxes was first developed by English economist A.C. Pigou (1920) in his work, The Economics of Welfare.

In a report by the National Surface Transportation Policy and Revenue Study Commission (2007,) the authors state, "Without a doubt, congestion is one of the greatest threats to the integrity of the Nation's transportation system and the country's overall vitality and quality of life. Over the past decade, congestion has reached alarming levels across the United States" (p. 3-13). The external costs from congestion come in the form of economic value of time wasted, extra operating costs of driving under congested conditions, and damage to the environment and human health (Lewis 2008). While a user on a congested highway generates between $0.10 to $0.29 per mile (6.3 cents to 18.1 cents per km) traveled in costs, an average user only pays $0.03 in user fees per mile (1.9 cents per km) traveled (Atkinson 2009). As stated by Lewis (2008), "By making people aware of the full economic costs of their travel choice, the widespread application of congestion pricing would encourage roadway users to determine whether the benefits of using the road at busy times of the day are worth the full economic implications of doing so" (p. 19). Lewis goes on to explain that congestion charges are calculated to reflect the costs one driver imposes on all other drivers on the same roadway, and that estimates of these costs range from $18 to $40 per hour depending on the given road and time of travel.

Absent congestion pricing, fuel taxes fail to recover the full costs of travel because fuel taxes are unable to discriminate between users travelling on congested roads and those that do not. Furthermore, congestion costs can vary depending on the time of travel (Small et al. 1989). Since we are unable to vary fuel tax rates for users who travel at peak hours and those that travel during off peak hours, we are also unable to accurately recover costs resulting from different times of travel. As noted in a report by the National Surface Transportation Infrastructure Financing Commission (2009), fuel taxes do not come close to requiring users to bear the full costs of their travel, in part because they have no direct link to the segment of the roadway system being used nor to the time of day.

Fuel taxes are also problematic when trying to recover the external costs associated with pollution. Although vehicles that are less fuel efficient and, generally dirtier, pay more in fuel taxes per mile traveled, the extra amount they pay is usually exceeded by the cost of the extra amount of pollution they contribute (National Surface Transportation Infrastructure Financing Commission 2009).

2.2.1.6 Fuel tax revenues are used for other purposes

In concluding our analysis of how closely fuel taxes adhere to the user-pays-and-benefits principle, it is important to note that a not-insignificant portion of fuel tax revenues are used for non-highway purposes. Since 1983, a portion of the revenues collected from fuel taxes have been used to fund mass transit projects and, since 1987, a small percentage has been allocated to the Leaking Underground Storage Tank Trust Fund (Schade et al. 2006). The user-pays-and-benefits principle was further diminished from 1990 to 1997 when a portion of fuel tax revenues were used for federal budget-deficit reduction (Schade et al. 2006). Funds from the Highway Trust Fund have also been used for such things as graffiti elimination in New York, and films about state roads in Alaska (Williams 2007). Some analysts have suggested that nearly 40 percent of federal fuel tax revenues are spent on non-general road projects (Utt 2003).

2.2.2 Ability-to-pay considerations

2.2.2.1 Horizontal equity

We conclude our discussion of equity and fairness with an analysis of users' ability to pay. We will do this through the lenses of horizontal and vertical equity. Horizontal equity can be defined as, "People in equal positions should be treated equally." (Rosen 2005, p. 571) Several issues related to horizontal equity have already been touched on in prior sections. As already mentioned, some users such as emergency vehicles are exempt from the tax and others such as those who use gasohol or have more fuel efficient vehicles pay reduced rates. With the great variation in fuel efficiencies and possibilities for alternative fuel usage, the assumption that heavier vehicles that contribute more to road damage pay more in fuel taxes because they are less fuel efficient no longer holds (Rufolo et al. 2003). The inability of fuel taxes to price congestion also contributes to horizontal inequity as those travelling at peak hours impose more of a cost on the transportation system, but pay relatively the same amount as those travelling at off peak times (Rufolo et al. 2003).

Another horizontal equity issue occurs in the form of jurisdictional inequity. If individual users were to receive benefits in proportion to their user fees, it should follow that states should receive federal funds equivalent to their contributed fuel tax revenues. Throughout the years this has not been the case, and a system of donor states and beneficiary states has arisen under the fuel tax system. From the founding of the Highway Trust Fund in 1956 through fiscal year 2005, Texas has been the largest donor state, receiving 88 cents in federal transportation spending for every dollar contributed to the Highway Trust Fund. Alaska has been the largest beneficiary state, receiving $6.66 in federal spending for every dollar contributed (Williams 2007). In fiscal year 2005 Minnesota was the largest donor state, receiving 87 cents in federal spending for every dollar contributed (Williams 2007).

The Safe Accountable Flexible Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU) attempted to correct jurisdictional inequities by ensuring that states would receive at least a specified percentage of their contributions (Williams 2007). For 2009, the floor rate for federal spending has been set at 92 percent of contributions (Federal Highway Administration 2009a). While the SAFETEA-LU approach lessens the jurisdictional equity problem, it leaves room for persistent inequities as it does not ensure that a state will be compensated at 100 percent, nor does it correct for beneficiary states that receive more than 100 percent of their contributions. Jurisdictional inequity can also occur at the state level. In many places, fuel taxes penalize urban areas and benefits rural areas or the suburban fringe (Puentes et al. 2003).

2.2.2.2 Vertical equity

Fuel taxes exhibit some vertical equity issues as well. Vertical equity can be defined as, "Distributing tax burdens fairly across people with different abilities to pay." (Rosen 2005, p. 576) It is important to note that there is often a trade-off between the user-pays-and-benefits principle and vertical equity. As mentioned before, since 1983 a portion of federal fuel tax revenues have been spent on mass transit projects. Currently, 2.86 cents of the 18.4 cents federal gas tax goes to the mass transit account (Williams 2007). In 2004, highway user fees collected at all levels of government, of which fuel taxes are the main component, transferred $11 billion to transit projects, which amounted to approximately 10 percent of total user fee revenue collected at all levels of government (Schade et al. 2006). While this transfer violates the user-pays-and-benefits principle, since highway users do not necessarily benefit directly from these expenditures, using a portion of fuel taxes for mass transit helps provide mobility for disadvantaged groups, but also provides transit choices for auto owners and non-owners alike. Thus, individuals who are unable to drive or afford to drive or choose not to drive, are still granted access and mobility through mass transit that is funded in part by fuel taxes.

While fuel taxes may aid in providing mobility to disadvantaged groups, it has other vertical equity issues that negatively affect low income groups. Wachs (2003a) cites fuel taxes as being fairer to the poor than other alternatives as one of his 12 reasons for why fuel taxes should be raised. Wachs concedes that fuel taxes are moderately regressive, but then lists three ways in which fuel taxes are fairer than other approaches to funding transportation. First, only the poor who drive, and thus benefit from the roads, pay the tax, while those whose poverty precludes them from driving are not charged. Second, lower income groups are the primary beneficiaries of expenditures on transit funded by fuel taxes, since--on the whole--public transit users have lower incomes than highway users. Finally, in jurisdictions where fuel taxes are kept low, sales taxes, which are roughly as regressive as fuel taxes, are increasingly being used to fund transportation. Thus, by keeping fuel taxes dedicated for transportation, sales taxes can be kept low and sales tax revenue can be used for programs and services that aid the poor (Wachs 2003a).

In contrast, the National Surface Transportation Infrastructure Financing Commission (2009) concluded that fuel taxes were "highly regressive", and more regressive than a general sales tax. The Commission also indicates that higher income groups are more likely to shift to more fuel efficient vehicles and thus pay less in fuel taxes. Whitty et al. (2009) build off the Commission's assertion that higher income groups are more likely to buy fuel efficient vehicles and state that, as new vehicles become more fuel efficient, the stratification between what owners of old vehicles and new vehicles pay may become greater without a justification based on road use. Whitty et al. (2009) conclude that the unfairness of this situation might be a worthy reason for certain segments of society to object to fuel tax increases.

Backing the Commission's claim that fuel taxes are highly regressive are estimates found in a Tax Foundation report by Williams (2007). While Americans earning less than $40,000 pay between 0.8 and 1.6 percent of their income in gas taxes, those earning over $100,000 pay between 0.25 and 0.45 percent of theirs (Williams 2007). It is important to once again note the trade-off between the user-pays principle and the ability-to-pay principle. While fuel taxes should be increased to adhere to the user-pays principle, this increase would make fuel taxes even more burdensome to lower income groups. In his article, published by the Tax Foundation, Williams (2007) also adds, "When…serving as a true user fee, the gas tax is simply… 'regressive', only in the same way that…everything else is regressive. But when gas taxes fund 'deficit reduction,' i.e., flow into a general fund with income tax revenue and are spent on general government operations, then the income patterns of gas tax payers becomes a major concern" (p. 17). Williams concludes that lawmakers should keep in mind the regressive nature of fuel taxes when considering whether to raise fuel taxes for non-highway uses.

2.2.3 Summary

We have seen in this discussion that fuel taxes have moved away from the user-pays-and-benefits principle:

- Improvements in motor vehicle fleet fuel efficiency since the 1970s have allowed drivers to pay less in fuel taxes per vehicle mile traveled. This trend of increasing fuel efficiency for the overall fleet is expected to continue and even accelerate.
- The introduction of hybrids and alternative fuel vehicles has created an even greater disconnect between system costs and user benefits.
- Not all users pay fuel taxes as some are exempt while others evade payment.
- Fuel tax payments do not cover total direct costs associated with road construction and maintenance. This is especially true for heavy trucks.
- Fuel tax payments do not recover external costs such as congestion and pollution.
- Finally, the user-pays-and-benefits principle is violated as some fuel tax revenues have been used for non-highway purposes such as mass transit.

Fuel taxes are also problematic under the ability-to-pay principle:

- From the perspective of horizontal equity, violations of the user-pays-and-benefits principle lead to problems in which people in equal positions are treated unequally. Furthermore, as currently allocated, fuel taxes have a jurisdictional equity problem whereby some states pay more in fuel taxes than they receive in federal funding, while some receive more than they pay.
- Finally, although fuel taxes do help to promote mobility for disadvantaged groups, through public transit funding, there remain vertical equity issues that negatively affect lower income groups.

2.3 REVENUE ADEQUACY AND SUSTAINABILITY

Under the revenue adequacy and sustainability principle, fuel taxes should collect enough revenue to fund the construction, maintenance, operation and reconstruction of the transportation system. Fuel taxes should also remain a stable and adequate funding mechanism regardless of changes in external factors. In other words, fuel taxes should be self-sustaining.

2.3.1 Revenue adequacy

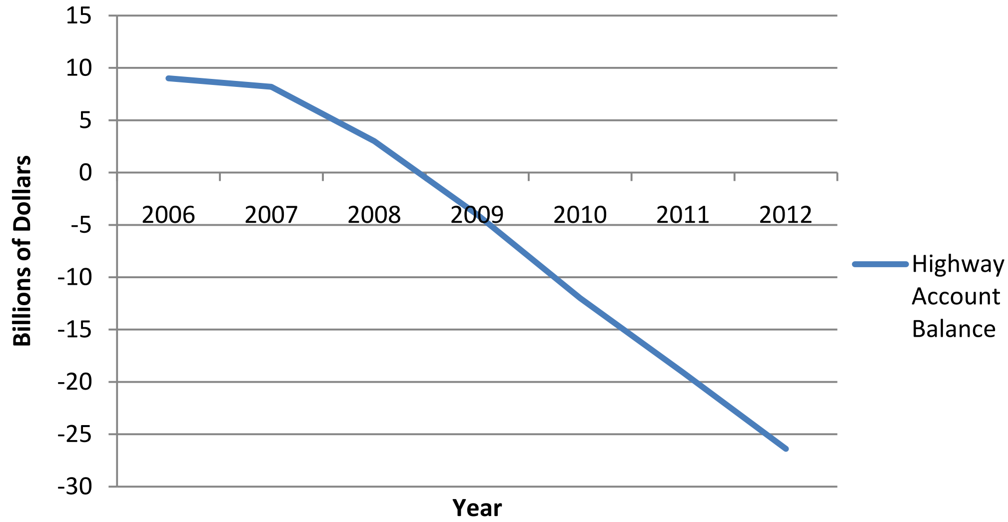
As stated in the equity and fairness section, in 2008 the Highway Trust Fund (which is primarily funded by fuel tax revenue) necessitated an eight-billion dollar transfer from the general fund to keep it solvent. In 2009, it required an additional seven billion dollars. Since 2009 it has received billions more in stimulus dollars to remain solvent. These infusions, while significant, only tell part of the story. According to the National Surface Transportation Infrastructure Financing Commission (2009),

> "Without changes to current policy, it is estimated that revenues raised by all levels of government for capital investment will total only about one-third of the roughly $200 billion necessary each year to maintain and improve the nation's highways and transit systems… At the federal level, the investment gap is of a similar magnitude, with long-term annual average Highway Trust Fund (HTF) revenues estimated to be only $32 billion compared with required investments of nearly $100 billion per year" (p. 3).

The Commission goes on to explain that the current investment gap is too great to be solved by the economic stimulus package alone. The Commission notes that a stimulus package, which includes $40 billion for highway and transit projects, would only pay for three months of the annual national funding gap to maintain and improve the system.

It should come as no surprise to many Americans that we have large gaps in financing our transportation system, despite our relatively large tax base. In 2007, there were approximately 205 million licensed drivers in the United States, which represented approximately 68 percent of the population (Federal Highway Administration 2009c). While this is a sizable tax base, current fuel tax rates are below the rate needed to raise sufficient revenue. To get an idea of the U.S.'s relatively low fuel tax rates, it is useful to compare our rates to those of other industrialized nations. While Americans currently pay on average $0.49 per gallon ($0.13 per L) in federal, state, and local fuel taxes, Canadians pay approximately $1.26 per gallon ($0.34 per L), and the Dutch pay $5.57 per gallon ($1.47 per L) (Marsh 2008).

Writing in 2007, the National Surface Transportation Policy and Revenue Study Commission (2007) noted that since 2000 balances in the Highway Account of the HTF have been declining as expenditures have exceeded revenue. Figure 2.2 illustrates the expected shortfalls in the Highway Account of the HTF in coming years, assuming no changes in revenues or program levels. One of the recommendations made by the Commission to keep the HTF solvent and to make up for the investment gap is to increase the federal fuel tax by five to eight cents per gallon (1.3 to 2.1 cents per L) per year for the next five years.



(Source: U.S. Department of the Treasury projections. Data from National Surface Transportation Policy and Revenue Study Commission 2007)
Figure 2.2: Projected Highway Account Balances

2.3.2 Revenue sustainability

Not only are fuel taxes inadequate for generating sufficient revenue, they are unsustainable in the long run. A proper user fee should ensure that revenues are self-sustaining and predictable regardless of changes in external factors. Inflation, changes in the price of fuel and in fuel efficiency, and the introduction of alternative fuels, all lead to revenue sustainability problems. The National Surface Transportation Infrastructure Financing Commission notes (2009), "The current...funding structure that relies primarily on taxes imposed on petroleum-derived vehicle fuels is not sustainable in the long term and is likely to erode more quickly than previously thought. This is due in large measure to a drive for greater fuel efficiency, alternative fuels, and new vehicle technology" (p. 7).

2.3.2.1 Effects of inflation

Fuel taxes fail to collect adequate revenue, in part, because they are not indexed to inflation. Although the federal gas tax has been raised many times since its inception, it has not kept pace with inflation. In fact, although the federal gas tax has more than doubled since 1983, its purchasing power remains at approximately 1983 levels (National Surface Transportation Policy and Revenue Study Commission 2007). This Commission suggests that since 1993 the federal gas tax rate has decreased by 40 percent when compared to the Producer Price Index for Highway and Street Construction. The National Surface Transportation Infrastructure Financing Commission (2009) estimates that since it was last raised in 1993, the federal gas tax has experienced a 33 percent loss in purchasing power.

The Policy and Revenue Commission (2007) notes that, since 1980, the Highway Trust Fund has seen substantial growth in current dollars, however, growth in constant dollars has been much more subdued. Writing in 2007, the Commission noted that since 2003 HTF revenue had fallen four percent per year in real dollars.

The corrosive effect of inflation on revenue could be eliminated by indexing fuel taxes to inflation. In its findings and conclusions, the Policy and Revenue Commission (2007) notes that a limitation of the fuel tax is that it is not currently able to react to increasing construction costs, and adds that this could be remedied by indexing it to the Consumer Price Index or a targeted measure such as the Producer Price Index for Highway and Street Construction.

2.3.2.2 Changes in fuel prices

Small et al. (1989) state, “The fuel tax has not always proven a reliable source of revenue; since 1973 receipts have fluctuated along with economic conditions and fuel prices” (p. 6). Most notably, fuel tax revenue dwindled during the 1970s in part due to the energy crisis (Patashnik 2000). While price spikes tend to cause a reduction in the amount of fuel consumed and thus fuel tax revenue raised, they also lead to a drive for more fuel efficient vehicles, thus further reducing the sustainability of fuel taxes. Some analysts have estimated that the average gallons of fuel consumed per vehicle mile by the light-duty fleet could fall by 20 percent if new regulations or large and sustained fuel price increases drive fuel economy improvements (Schade et al. 2006).

2.3.2.3 Fuel efficiency changes

The Environmental Protection Agency (2008) notes that fuel efficiencies have been improving since 2005. Several analysts expect this trend to continue and accelerate. The Energy Information Administration (2008) estimates that the average fuel efficiency for all light-duty vehicles on the road will grow from 20.4 mpg (8.7 km/L) in 2008 to 28.9 mpg (12.3 km/L) by 2030. Although this is a positive trend for the environment, it also means lower fuel tax revenues. As users consume less fuel, they pay less in fuel taxes per vehicle-mile traveled. Between 1980 and the present, VMT has grown by approximately 100 percent while fuel consumption has grown by about 50 percent (Sorensen et al. 2009). This is bad news for transportation funding: As demand for road capacity increases and as road damage grows with VMT, revenues needed to address capacity and maintenance needs continuously decline.

Schade et al. (2006) suggest that given a 15 percent reduction in the fleet average fuel consumption per mile, a 17.6 percent increase in the combined average state and federal fuel tax rate would be necessary to maintain constant revenue per vehicle mile. Thus, for the fuel taxes to be self-sustaining in the face of fuel efficiency changes, tax rates would have to be continuously altered. Sorensen et al. (2009) note that raising fuel taxes has become increasingly unpopular and states, “[T]he frequency and magnitude of the recent fuel tax increases has been grossly insufficient to maintain comparable purchasing power in terms of real revenue per mile of travel” (p. 2).

2.3.2.4 Introduction of alternative fuels

Like improving fuel efficiencies, the introduction of alternative fuels poses a substantial risk to the sustainability of fuel taxes as a funding mechanism. While increases in fuel efficiency decrease the rate users pay in fuel taxes per vehicle-mile traveled, the introduction of alternative fuels could potentially narrow the tax base as some users stop using petroleum-based fuels to power their vehicles. Sorensen et al. (2009) note, "Additionally, as alternative fuel vehicles begin to achieve market penetration, a greater share of the motoring public may be able to avoid paying motor fuel taxes by, for instance, charging an electric vehicle at home or at work" (p. 2).

2.3.3 Summary

As currently structured, fuel taxes fare poorly on revenue adequacy and sustainability grounds:

- Inflation has eroded the purchasing power of revenue collected through fuel taxes, making the current rate too low and the funding inadequate.
- Fuel taxes are inadequate and unsustainable going forward. Inflation, changes in the form of increases in the price of fuel, fuel efficiency gains, and the introduction of alternative fuels and vehicle propulsion systems conspire to reduce the tax base and the amount of fuel tax revenue collected.

2.4 ENVIRONMENTAL SUSTAINABILITY

With the advent of the current administration, environmental sustainability has been added to the national agenda when discussing the maintenance and improvement of the transportation system. On June 16, 2009, the EPA, jointly with the U.S. Department of Housing and Urban Development and the U.S. Department of Transportation, announced that one of their aims was to improve the transportation system while protecting the environment (Environmental Protection Agency 2009). Furthermore, recent reports by the National Surface Transportation Infrastructure Financing Commission (2009) and the National Surface Transportation Policy and Revenue Study Commission (2007) included protecting the environment in their review and analysis. Thus, it is important to explore the degree to which fuel taxes, as user fees support environmental sustainability.

Broadly speaking, environmental sustainability involves improving transportation system efficiency so as to reduce emissions and greenhouse gases, and maintaining and implementing policies and practices that protect and improve the environment. To achieve this goal, fuel taxes should adhere to the polluters-pay principle, whereby those responsible for producing pollution pay for the environmental damages they impose on society. By this measure, the current fuel tax approach has mixed results in reducing petroleum-based fuel consumption, greenhouse gas emissions, and local air pollutants, and in promoting the use of less polluting fuels.

2.4.1 Effect of fuel taxes on petroleum-based fuel consumption, greenhouse gas emissions, and local air pollutants

Fuel taxes have some effect in reducing petroleum-based fuel consumption and greenhouse gas emissions. One could argue that the polluters-pay principle is in effect since drivers with lower fuel efficiency vehicles do pay more in fuel taxes per vehicle mile. Also, it is possible that increases in fuel taxes may encourage some motorists to purchase more fuel efficient vehicles and tune their vehicles to get better gas mileage (Wachs 2003a). Writing in 1994, Hsing (1994) estimated the impact of the newly passed 4.3 cents per gallon (1.1 cents per L) increase in the tax on gasoline. Hsing found that the 4.3 cents per gallon (1.1 cents per L) increase was expected to reduce gasoline consumption by 2.0 percent, which amounted to 53.4 million barrels of oil per year.

While, in the short-run, fuel tax increases are likely to have marginal effects on fuel consumption, the price elasticity of fuel in the long run is much more significant (Sterner 2007). Analysts have suggested that the price elasticity for fuel in the United States in the short run is around -0.18, while in the long-run it is closer to -1.0 (Sterner et al. 1992). Sterner (2007) estimates that if, for a long period of time, the United States would have applied the tax policy of the European nations with the highest tax on fuel, U.S. gasoline consumption would have been reduced by approximately 57 percent. Furthermore, the estimated reduction in CO_2, if all OECD countries applied the highest fuel tax rates found in Europe, is estimated to be 8.5 billion tons of CO_2 over a decade (Sterner 2007).

When it comes to reducing local air pollutants, fuel taxes have less of an effect. Various emissions scrubbing technologies are able to reduce the amount of pollutants emitted and thus fuel consumption and emission of local air pollutants are not highly correlated. A system like the German tolling system is better equipped to reduce local air pollutants since it imposes higher fees on higher emitting trucks (Robinson 2008).

2.4.2 Promotion of less-polluting fuels

Fuel taxes promote less-polluting fuels insofar as they raise the price of petroleum-based fuels, thus creating an incentive to develop and use alternative fuels. The Schade et al. (2006) notes, "[S]ubsidies in the form of waivers of excise taxes have been a popular way to promote alternative energy development (e.g., the fuel tax subsidy granted to gasohol)" (p. 14). While one could argue over the degree to which gasohol is a less-polluting fuel then gasoline, the argument that fuel taxes promote the use of less-polluting fuels could be extended to other fuels. As long as there is a tax on petroleum-based fuel, there will be an incentive to develop and use other forms of fuel. However, given that fuel taxes in the United States are both historically and comparatively low in real terms, the extent to which they provide an incentive to use less-polluting fuels is also low. It should be noted that alternative fuels are not necessarily less polluting.

2.4.3 Summary

Fuel taxes shows mixed results when it comes to environmental sustainability:

- Fuel taxes weakly adhere to the polluters-pay principle, and are a blunt tool in promoting environmental sustainability.
- In looking at fuel taxes and their ability to reduce petroleum-based fuel consumption, greenhouse gas emissions, and local air pollutants, their effect in America are limited, mainly due to the current low tax rate imposed on fuel.
- Fuel taxes also provide some incentive for the use of less-polluting fuels; however, because of the low fuel tax rates in the United States, this effect is marginal.

2.5 FEASIBILITY

Under the feasibility principle we use two criteria to evaluate fuel taxes: political feasibility and administrative feasibility. Under the political feasibility criterion, a tax fares well when it ensures taxpayers' privacy and system security, and generates less political resistance. Furthermore, a tax tends to enjoy higher rates of popularity when visibility is low and tax exportation is high (Mikesell 2006). Under the administrative feasibility criterion, a tax fares well when its implementation, operation, enforcement, and compliance costs are reasonable. As we will see, fuel taxes fare reasonably well when considering both political feasibility and administrative feasibility.

2.5.1 Political feasibility

Since the fuel tax system already is already in place, we focus not on whether it is politically feasible to implement fuel taxes, but rather on the feasibility of future fuel tax increases. As described in the revenue sustainability section, because of fuel efficiency improvements and the effects of inflation, the real value of revenue collected from fuel taxes has been declining. Thus, if we want to maintain and improve the transportation system, it is important to consider whether it is politically feasible to raise fuel taxes. Small et al. (1989) note, "(D)espite the occasionally severe erosion of real revenues, states have found it politically difficult to raise gasoline taxes" (p. 6). Their assertion that the states have found it politically difficult to raise gasoline taxes can be extended to the federal level, where taxes on gasoline and diesel have not been increased since 1993, despite shortfalls in highway funding. Wachs (2003a) asks, "Why is it assumed to be a political liability to raise fuel taxes by a few pennies when fuel prices routinely change by more than that several times every year" (p. 237).

Fuel taxes initially had great public support. In discussing the popularity of state gasoline taxes in the 1930s, Williams (2007) states, "Gasoline taxes met with little public resistance and in fact became quite popular with the general public. Citizens saw the benefit principle in action, as gas taxes served mostly as user fees, generating revenue for more and better roads" (p. 4). As we documented in the equity section, however, fuel taxes have since moved away from the user-pays-and-benefits principle and, with this shift, their popularity has dwindled. The 2009 Tax Foundation/Harris Interactive poll (2009) found that at the state and local level, respondents found the gas tax to be the least fair tax when compared to state income taxes, retail sales taxes, motor vehicle taxes, local property taxes, and taxes on cigarettes, beer and wine, with only 7percent of respondents finding the gas tax "very fair". At the federal level, the only tax respondents found more unfair than the gas tax was the estate tax, with only 7percent of respondents finding the federal gas tax "very fair". It should be noted, other taxes were also not seen as "very fair", and taxes of any kind are generally unpopular.

This weakening of public opinion for fuel taxes has coincided with less political support as well. As stated by Sorensen et al. (2009), "With rising anti-tax sentiment among the populace, elected officials have become wary of this politically unpopular task, and the frequency and magnitude of the recent fuel tax increases has been grossly insufficient to maintain comparable purchasing power in terms of real revenue per mile of travel" (p. 2). As noted before, the federal tax on gasoline and diesel has not been significantly raised since 1993. Thus, it would appear that future attempts to raise fuel taxes may be politically difficult, especially if these increases do not adhere to the user-pays-and-benefits principle.

Political feasibility is typically evaluated by also looking at the tax visibility to taxpayers, the potential for tax exportation, and general political support and public opinion. In our analysis we also include driver's privacy and system security, as these issues have been raised when comparing fuel taxes with transportation funding alternatives such as distance-based fees.

2.5.1.1 Visibility to taxpayers

Broadly speaking, tax visibility can be defined as the extent to which users are aware of a tax. The popularity of a tax with the public tends to decrease as the tax becomes more visible. When the visibility of a tax is low, it may be tempting for government to increase the tax. Visibility should not be confused with transparency: the extent to which taxpayers know the actual costs they incur as a result of the tax.

The National Surface Transportation Infrastructure Financing Commission (2009) notes, "…system users are typically unaware of how much they pay in fuel taxes (as distinct from the price of gasoline), such that daily swings in price mask the tax component…" (p. 7). As mentioned before, a study prepared for Mn/DOT by Fichtner et al. (2007), found that, in general, participants were unaware of what they paid in gas tax. Thus, it would appear that fuel taxes are visible to the extent that users know that they are paying them; however, fuel taxes are not transparent and most users do not know precisely how much they pay. How this translates into the political feasibility of raising fuel taxes is somewhat unclear. It should be noted, however, that the study prepared for Mn/DOT also found that many participants were aware that the gas tax had not been raised in many years, and that comments were often made that they would be willing to pay a higher gas tax, particularly if the increased revenues were spent on roads.

2.5.1.2 Tax exportation

Tax exportation pertains to the potential for nonresidents to pay a tax. Tax exportation increases the popularity of a tax for residents, as residents are able to benefit from revenues derived from taxes paid by others. For the most part, fuel taxes in the United States do not benefit from tax exportation. While foreign tourists and shippers traveling in the United States by auto or truck do pay fuel taxes when they refuel, this is an insignificant portion of total federal fuel tax revenues. Nonetheless, in citing a January 23, 1919 article in the *Portland Oregon Journal*, Williams (2007) states, "Needless to say, state lawmakers also strongly approved of the gas tax. Also, many lawmakers saw gasoline taxes as a way to 'export' their state's tax burden to travelers from other states" (p. 4).

2.5.1.3 Driver's privacy and system security

For a user fee system to be politically feasible, the system must ensure drivers' privacy and provide system security. Ensuring drivers' privacy entails taking measures so that information collected, kept and disseminated is limited to the level needed to administer the user fee system and ensure data confidentially. Ensuring system security entails making sure the system is designed with security features to protect it from unauthorized access and improper or illegal use. Little has been written on driver's privacy and system security as it pertains to fuel taxes. This is likely because the simplicity of the fuel tax system, and the fact that fuel taxes are paid at the wholesaler level, minimizes any sort of risk to drivers' privacy or overall system's security. Fuel taxes are built into the price that drivers pay at the pump and, thus, unlike MBUFs, do not involve the need for any device being installed in vehicles or for driver data to be collected, stored, and sent to remote billing locations.

2.5.2 Administrative feasibility

Administrative feasibility includes administrative costs, such as the costs of implementation, operation, and enforcement, and compliance costs, which entail the costs associated with the public compliance with the tax policy.

2.5.2.1 Implementation, operation, and enforcement costs

Fuel taxes have relatively low implementation costs. Unlike other alternatives for funding the transportation system, fuel taxes do not involve the construction of tollbooths or developing a system for recording vehicle-miles traveled. However, charging a tax similar to fuel taxes to alternative fuel vehicles would require creation of a structure for collecting the tax (since vehicles such as electric-powered do not use fuel stations). In listing the attributes that make fuel taxes attractive sources for funding transportation, the National Surface Transportation Policy and Revenue Study Commission (2007) notes, "low administrative and compliance costs," as well as "ease of implementation."

Fuel taxes also have relatively low operation and enforcement costs. Martin Wachs (2003a) notes fuel taxes' low collection costs and the fact that they are relatively fraud proof, as one of his 12 reasons for why gasoline taxes should be raised. Wachs (2003a) states, "Governments have a responsibility to be concerned about the cost of collecting revenues and…evasion…the fuel tax is unusually efficient in this regard. Whereas traditional manual toll collection, for example, incurs costs that range from 20percent to 25percent of the revenue produced, the cost of administering the fuel tax is typically only 1percent or 2percent of the revenue" (p. 239). Others have estimated the cost to administer and enforce the federal motor fuel taxes to be as low as 0.2 percent of gross receipts (Peters et al. 2003).

If fuel taxes are to be raised, however, enforcement costs will most likely have to increase as well to counter the added incentive to evade the tax. As mentioned earlier, it has been estimated that a proposed ten cent increase in the tax on both gasoline and diesel fuels in the state of Kentucky would lead to increased fuel tax evasion by 37.5 percent (Denison et al. 2000).

2.5.2.2 Compliance cost

Finally, when evaluating the administrative feasibility of a tax we consider how difficult it is for the public to pay the tax. Unlike the federal income tax, which costs non-business tax payers on average 10.7 hours of time and 129 dollars per year in record keeping, tax planning, form-completion and submission, and other activities (Internal Revenue Service 2009), fuel taxes have very low compliance costs for the general public. As fuel taxes are collected from wholesalers and passed on to drivers when they refuel, there is no need for the general driving public to keep records of the fuel taxes they pay or complete and submit any forms documenting their payments (unless it concerns documenting work-related mileage for tax purposes).

2.5.3 Summary

On both political feasibility and administrative feasibility grounds, fuel taxes fare relatively well:

- From a political feasibility perspective, states and the federal government have had a difficult time raising fuel taxes because they consider such action a political liability.
- Because of the simplicity of the system, fuel taxes do a good job of ensuring driver privacy and system security.
- While fuel taxes are visible to a degree, and they currently have low levels of political and public support. It is possible that if they more closely adhered to the benefit principle, as they did in the early and middle decades of the 1900s, they would garner greater support.
- Fuel taxes experience low levels of tax exportation.
- On administrative grounds, fuel taxes perform well. Not only are implementation, operation, and enforcement costs relatively low, especially when compared to methods such as manual toll collection, but compliance costs are low as well.

2.6 CONCLUSIONS

As we have seen, fuel taxes are problematic under several transportation finance principles. In terms of efficiency, fuel taxes do not recover the total cost imposed on the system by drivers. This under-pricing of the road capacity leads to inefficient overuse of the system, causing excessive delays and an unbalanced ratio of auto and truck use compared to transit and freight rail. Fuel taxes also contribute to urban sprawl, and fail to direct efficient investment where it is most needed.

Fuel taxes also fare poorly on equity grounds. Due in large part to increases in fuel efficiencies and the introduction of hybrid and alternative fuel vehicles, fuel taxes have moved away from the user-pays-and-benefits principle. Through evasion or exemptions, some users pay nothing. Fuel taxes do not cover the direct costs associated with road construction and maintenance nor do they cover external costs such as congestion and pollution. Furthermore, the user-pays-and-benefits principle is not adhered to as some fuel tax revenue is used for non-highway purposes. When considering ability-to-pay, fuel taxes have both jurisdictional equity and vertical equity problems. It should be noted, however, that while lower income groups spend a greater share of their income on fuel taxes, they may also benefit more since a share of fuel tax revenues are used for public transit, which serves many low-income travelers.

As with efficiency and equity, revenue adequacy and sustainability problems persist because current fuel tax rates are low. While fuel taxes are paid by a relatively large base, the revenue collected is becoming increasingly inadequate and unsustainable. The main reasons are that fuel taxes are not indexed to inflation, and periodic increases in fuel prices, increases in fuel economy and the growth in alternative fuel vehicles, all contribute to lower fuel consumption and, with it, fuel tax revenue.

Fuel taxes fare somewhat better when considering their effect on environmental sustainability. Fuel taxes have some effect in promoting the use of less-polluting fuels. In the United States, however, fuel taxes are relatively low and are too blunt a tool for promoting environmental sustainability. If rates were higher, fuel taxes would be better equipped to reduce petroleum-based fuel consumption and may prove to be an effective tool for sustaining the environment.

Finally, fuel taxes fare well when considering their political and administrative feasibility. Fuel taxes ensure driver privacy and system security and benefit from some tax exportation. While fuel taxes do have high visibility, it is likely that they would have greater support if they were closely adhered to the user-pays-and-benefits principle. In terms of implementation, operation, enforcement, and compliance costs, fuel taxes are viewed as superior to alternative funding approaches.

Table 2.1 scores fuel taxes on the various principles and sub-principles discussed in this chapter. Although a scorecard may not add much research value, we include it because it is helpful for policy communication on this issue. As mentioned in the introduction, this chapter is part of a larger effort to set the stage for a policy discussion on transportation-related user fees in the United States.

Table 2.1: Fuel Taxes Assessment Scorecard

Principles	Ability to Achieve Principles
Efficiency	**Weak**
• Transportation system overuse	Weak
• Efficient investment in transportation	Moderate
• Efficient land use	Weak
Equity	**Moderate**
• Adherence to user-pays-and-benefits principle	Moderate
• Horizontal equity	Moderate
• Vertical equity	Moderate
Revenue Adequacy and Sustainability	**Moderate**
• Revenue adequacy	Moderate
• Tax rate	Moderate
• Revenue sustainability	Weak
Environmental Sustainability	**Moderate**
• Reducing petroleum-based fuel consumption and emissions	Moderate
• Promoting less-polluting fuels	Moderate
Feasibility	**Strong**
• Public and political support	Moderate
• Implementation, operation, and enforcement costs	Strong
• Compliance costs	Strong

In this chapter, we have looked at how well fuel taxes, as user fees, perform under transportation finance principles. The research reveals that fuel taxes exhibit many shortcomings as user fees. The deficiencies of the current system speak to the possibility of replacing fuel taxes with a system that better address the five principles discussed. While this chapter alone does not answer the question of whether the fuel tax system should be retained or replaced, the analysis suggests that transportation funding in the United States may want to move past a system of fuel taxes. The National Surface Transportation Policy and Revenue Study Commission (2007), reviewed potential replacements to the fuel taxes and concluded that MBUFs have many promising features. In the next chapter we analyze MBUFs along the same principles presented in this chapter to gain a deeper understanding of whether fuel taxes should be retained or replaced.

A growing number of transportation researchers and practitioners are advocating that the United States should consider moving away from the nation's reliance on fuel taxes and move, instead, to an alternative system for funding the transportation system. Despite growing support to increase fuel taxes and eventually move towards MBUFs, these ideas are not supported by the current administration or by majority of congress. Further research should explore the potential benefits of alternative funding methods; aim to better understand the lack of support; and develop methods for framing the issue and for conducting public outreach and education.

The simplicity of the fuel tax system may be the single most important reason why there has not been more progress towards alternative funding mechanisms in the U.S. While with fuel taxes, system security and driver privacy are not an issue, alternatives such as MBUFs are seen as a potential threat to privacy. Research that explores existing and potential technologies involved with MBUFs, and the privacy and legal issues that arise, is critical. In conjunction with this research, it is important to attempt to determine the threshold at which the public feel that their privacy is protected.

CHAPTER 3. SHOULD MBUFS REPLACE FUEL TAXES?

Now that we have seen the shortcomings of the current fuel tax system, it is time to consider an alternative. This examination of MBUFs endeavors to answer the question, "Should MBUFs replace fuel taxes?" As mentioned before, two congressional commissions have recommend that more direct forms of transportation user fees (such as mileage-based user fees) be seriously considered as future alternatives to fuel taxes. Like chapter 2, this chapter is a synthesis of previous research and analysis regarding MBUFs. As in chapter 2, we evaluate MBUFs from the perspective of five transportation finance principles, namely: efficiency, equity, revenue adequacy and sustainability, environmental sustainability, and feasibility.

To allow for a side-by-side comparison with fuel taxes we have outlined this chapter with the same sections and subsections as chapter 2. Just as we did with fuel taxes in chapter 2, we include an assessment scorecard at the end of the chapter rating MBUFs on our five principles and sub-principles. These scorecards can be used by policymakers to quickly evaluate the strengths and weaknesses of the two systems.

3.1 EFFICIENCY

A fundamental reason why VMT pricing is a fair way of assessing user fees is that road damage is a function of amount of travel (VMT) and per-axle load (weight). Thus, a charge that reflects both of these factors, if set properly, should lead to either a reduction in road damage, or should generate greater levels of revenue to compensate for the damage. In this section, we will discuss how efficiency is affected when user fees are set to directly reflect use of the transportation capacity. Under the efficiency principle we consider three different criteria: how well MBUFs encourage efficient user behavior, how well they direct transportation investment to worthwhile projects, and how well they lead to efficient land use.

3.1.1 Use of transportation system

For a tax or fee to send price signals that encourage efficient use of the transportation capacity, users must be aware of the fee and the fee must cover the full societal costs imposed by the user. As described by Small et al. (1989),

> "The best way to economize…is to apply a user charge equal to the actual cost each user imposes on society through his effect on the road's conditions and on the speed that other users can travel. Such a charge, known as the marginal-cost user charge, ensures that the independent decisions by users reflect the interests of all…If road users are required to incur this entire amount themselves, they will use the highway…only if the value to them of doing so exceeds the amount society must pay…" (p. 9).

In contrast to fuel taxes, MBUFs are able to serve as what Small et al. would call a marginal-cost user charge. If MBUFs are set high enough to cover the costs users impose on the road's condition, and are variable so that they change with the type of road and time of day to capture congestion costs, then MBUFs act as marginal-cost user charges. Furthermore, if the method of payment makes users aware of what they pay in MBUFs for particular roads and times of travel, then users can better weigh their travel time decisions and their choice of mode.

3.1.1.1 Effect on roadway congestion

Roadway congestion in the United States is a serious and growing problem. A recent congressional commission noted, “Without a doubt, congestion is one of the greatest threats to the integrity of the Nation’s transportation system and the country’s overall vitality and quality of life.” (National Surface Transportation Policy and Revenue Study Commission 2007, p. 3.13) In the nation’s 14 largest urban areas, annual delay per peak period traveler rose by approximately 30 hours from 1982 to 2007 (Texas Transportation Institute 2009). For 2007, the total cost imposed by urban area congestion in the U.S. has been estimated at approximately $87.2 billion (Texas Transportation Institute 2009). Table 3.1 below illustrates the congestion costs for the nation’s 14 largest urban areas in 2007. As one can see from the table, the costs in terms of travel delay and excess fuel consumed are substantial.

Table 3.1: Costs of Congestion for Largest Urban Areas 2007

Urban Area	Travel Delay (1000 Hours)	Rank	Excess Fuel Consumed (1000 Gallons)	Rank	Congestion Cost ($ million)	Rank
Very Large Average (14 areas)	166,900		115,654		3,549	
Los Angeles-Long Beach-Santa Ana CA	485,022	1	366,969	1	10,328	1
New York-Newark NY-NJ-CT	379,328	2	238,934	2	8,180	2
Chicago IL-IN	189,201	3	129,365	3	4,207	3
Atlanta GA	135,335	6	95,936	6	2,981	4
Miami FL	145,608	4	101,727	4	2,955	5
Dallas-Fort Worth-Arlington TX	140,744	5	96,477	5	2,849	6
Washington DC-VA-MD	133,862	7	90,801	8	2,762	7
San Francisco-Oakland CA	129,393	8	94,295	7	2,675	8
Houston TX	123,915	9	88,239	9	2,482	9
Detroit MI	116,981	10	76,425	10	2,472	10
Philadelphia PA-NJ-DE-MD	112,074	11	71,262	11	2,316	11
Boston MA-NH-RI	91,052	12	60,986	13	1,996	12
Phoenix AZ	80,456	14	57,200	14	1,891	13
Seattle WA	73,636	15	50,541	15	1,591	15

(Data from Texas Transportation Institute 2009. Table reprinted with permission.)

Fuel taxes, our current method of funding the transportation system, have little or no ability to reduce congestion. On the other hand, MBUFs offer great promise in this area. Because MBUFs can be made to vary with time and location of travel, using congested roadways can be priced at levels that more closely reflect the cost of congestion. As noted by a recent congressional commission, “MBUFs, especially if applied as congestion pricing fees or weight-distance taxes can send strong pricing signals to users.” (National Surface Transportation and Revenue Study 2007, p. 5.45) Studies have shown that users do in fact respond to these price signals. Traffic declined by approximately 20 percent in the first few months after congestion pricing was implemented in London (Litman 2004) and similar results were experienced in Stockholm (Robinson 2006). A test of congestion tolling by the Puget Sound Regional Council, found that the toll could reduce vehicle use during peak periods by approximately 10 percent (Oh 2008).

While MBUFs that price for congestion are likely to lead to a more efficient use of the system, there is the possibility for some adverse effects, as noted by Whitty et al. (2009),

> “Adding a congestion pricing system…will create some undesired effects for urban areas, depending upon the congestion pricing method employed…Given a choice between a *free* facility and a tolled facility, many drivers will choose the *free* facility, even if its qualitative characteristics are not as good as those of the tolled facility. Non-tolled routes parallel to a route with a new toll may become quite congested as a direct result of the toll” (p. 32).

However, if all roads are priced, MBUFs will be lower because of the broader-tax base, thus making toll rates more affordable. In turn, since all roads are priced, diversion to “parallel” facilities will cease to be an issue. And even if only major roads are priced, the traffic management effect will be to accommodate greater volumes per hour than under congestion, thus reducing the pressure to divert.

3.1.1.2 Effect on mode shift

In addition to reducing congestion, MBUFs can lead to a greater balance between auto and other modes. If MBUFs are structured to make users pay closer to the full cost they impose on the system, drivers will be better able to compare the cost of using their automobile to that of other modes such as transit, biking, walking, and even telecommuting. Furthermore, it may be a good policy to link improvements in transit with the congestion pricing component of a MBUF system. Lee Munnich (2009) argues that all successful congestion pricing implementations have involved a transit component. If transit improvements are linked with congestion pricing, some shifts from auto travel to other modes are likely, as drivers who opt to shift to say, public transit, are more apt to do so if transit’s level of service has been significantly improved. Improving non-auto modes is also likely to help gain public and policymaker support for pricing. Singapore, which invested in rail and bus transit at the same time as they implemented congestion pricing, saw public transport’s mode share rise from 40 to 67 percent over the 30-year period from when congestion pricing was implemented (Munnich 2009). London and Stockholm, who also made significant investment in transit, also experienced significant increases in transit ridership after congestion pricing was implemented (Munnich 2009).

Since current fuel taxes underprice road use, this makes rail and other freight modes, such as waterways, comparatively expensive in relation to road transport. This may be a factor in highway/rail mode use. As mentioned earlier, U.S. highways are experiencing high and growing levels of congestion. Freight rail on the other hand, is operating below capacity. In 2006, 88percent of freight rail corridors were operating below capacity (National Surface Transportation Policy and Revenue Study Commission 2007).

MBUFs have the potential to encourage a more efficient use of the transportation system by reducing the number of less-than-full truckloads and empty truck trips. If MBUFs were to increase to reflect the actual costs imposed by users, then shippers and carriers would have a greater incentive to consolidate loads. After heavy vehicle tolling was implemented in Germany, which imposed per-kilometer charges that varied by truck weight and emission level, the number of empty trips was reduced by 20 percent (Robinson 2008). The implementation of heavy vehicle tolling in Germany gave rise to load consolidation brokers and enhanced efficiency in truck operations. It should be noted that in Germany, trucks were charged the same rate whether they were empty or fully-loaded (Robinson 2008). MBUFs should lead to greater efficiency in freight transport than the current system of fuel taxes since they have the potential to price for actual costs imposed.

3.1.2 Investment in transportation

Marginal-cost user charges, in addition to leading to efficient use of the transportation system, can also lead to more efficient investment in transportation. As noted by Small et al. (2009), "[T]he resulting revenues provide a tangible signal to public officials as to whether additional investments to provide more or better services are likely to be worthwhile" (p. 9). Thus, a MBUF that prices for actual costs imposed will convey price signals to public officials and investors as to where true demand for service improvements are occurring.

Implementing a MBUF system has the possibility of leading to additional investment in some areas and less in others. If MBUFs generate more revenue for a particular area than does the current system of fuel taxes, then worthwhile projects that previously did not have sufficient funds may be undertaken. This is more likely to happen in rural areas, where it is perceived that toll revenues would not be sufficient to cover system costs. For congested areas, MBUFs may actually decrease the need for additional improvements. As stated by Sorensen et al. (2009), "[MBUFs] could also enable our existing roads to carry far more vehicles per lane per hour during peak periods…effectively shortening the length of rush hour traffic periods and reducing the perceived need for roadway expansion" (p. 41). Making highways less congested, as opposed to just adding to capacity to relieve congestion, can lead to increased productivity for a region. An article by Boarnet (1997) found strong evidence that reducing congestion can increase county output, but weaker evidence that increasing the street and highway capital stock increases productivity.

3.1.3 Land use

MBUFs have the potential to lead to more efficient land use than fuel taxes do. Langer et al. (2008) note that the nation's fuel tax system, which undercharges vehicles for commuting, has contributed to urban sprawl. Simply defined, urban sprawl is the spreading of development away from a city's center, which requires the addition of costly infrastructure. Thus, if MBUFs can more accurately price the cost of commuting, then development pressures and decisions about where to live will be based on true costs, including transportation, and not be distorted by an artificially low cost of commuting. It should be noted, however, that development that spreads away from the city center is not necessarily an inefficient use of land. If roads are correctly priced, the spread that results may in fact be efficient.

Since MBUFs have not yet been implemented in the United States, there is much that is unknown about how they will affect land use. A general concern has been that the congestion pricing component of a MBUF will cause businesses in the affected area to lose out to businesses located in areas that do not have congestion pricing. This, in turn, can alter land use if the shift in sales causes businesses in the priced area to shrink and development in the unaffected area to expand. This concern is not supported by evidence from areas that have implemented congestion pricing: Implementation of the Orchard Electronic Road Pricing in Singapore in October 2005, affected total traffic period, but not destination traffic. Data on retail sales from 2004-2008 in the Orchard commercial area shows that they have continued to experience healthy growth (Halim 2010). In London's charge system, daily vehicular traffic reduction was about 27 percent after pricing, but transit ridership increased by 26 percent and bicycles increased 98 percent. Analysis conducted after the pricing scheme was implemented indicated that the effect on overall retail business sales was largely neutral (Robinson 2006). In Trondheim, Norway, cordon pricing was introduced in 1991 and was phased out in 2005. (By law, pricing projects in Norway have a 15-year duration limit.) Analysis conducted prior to pricing, while pricing was in effect, and after the cordon was phased out, indicates that the effect on businesses in the cordon area was negligible. This effect applied to conditions before and after cordon pricing was introduced in 1991, and before and after it was taken out in 2005, Meland et al. (2010). Ultimately, how VMT pricing affects land use is likely to be dependent on how it is implemented and structured.

3.1.4 Summary

On efficiency grounds, MBUFs have great potential:

- MBUFs can be set to price for total system costs, thus leading to a more efficient travel and less highway congestion.
- The price signals generated from MBUFs allow users to weigh the true costs of automobile vs. transit use and can lead to more efficient mode selection.
- MBUFs send price signals to public officials and investors that can lead to more efficient transportation investment.
- The effect on land use is less well understood. However, depending on the structure of a VMT system, MBUFs may reduce urban sprawl in some areas.

3.2 EQUITY

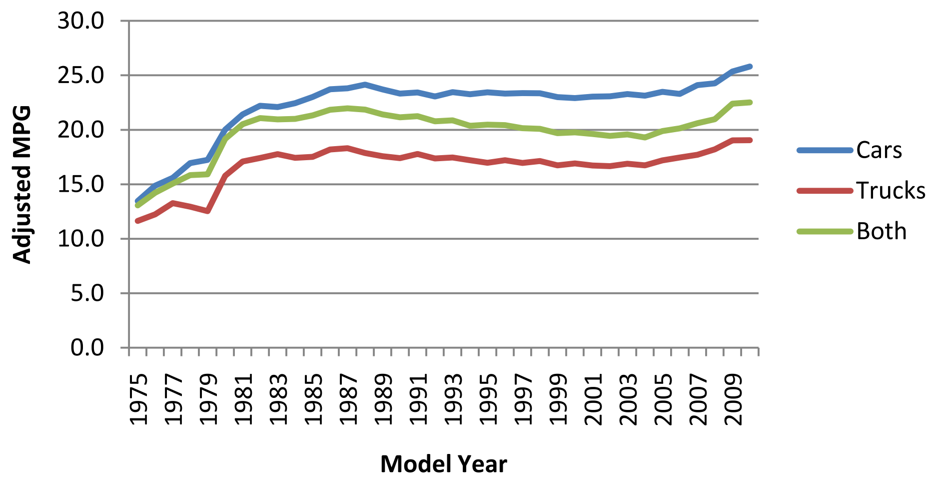
Under the equity criterion we assess MBUFs using two principles: (1) the benefit-received (or "user-pays-and-benefits") principle, and (2) the ability-to-pay principle. MBUFs fare reasonably well under both principles, especially the benefits-received principle. We focus the majority of our analysis on the benefits-received principle because transportation finance in the U.S. has historically been based on user fees. MBUFs have many features that allow them to rate well under the benefits-received principle. First, since MBUFs are based on miles traveled and not fuel used, drivers are not able to totally escape paying their fair share by driving fuel efficient or alternative fuel vehicles. Second, MBUFs can be designed with variable rates based on type of road and time of travel, and thus have ability to recover direct as well as external costs such as congestion. Like fuel taxes, MBUFs are susceptible to some users not paying either through exemptions or evasion, and to the possibility of revenues being used for non-highway purposes. Under the ability-to-pay consideration, MBUFs may have some aspects of regressivity, but other aspects of MBUFs that make them less regressive than the fuel taxes.

3.2.1 MBUFs as user fees

We begin our analysis with how MBUFs, as user fees, perform under the user-pays-and-benefits principle. User fees, as opposed to taxes collected from the public in general, are paid by users of a particular service and vary, ideally, in proportion to degree of use of the service. As documented previously (see Patashnik 2000 and Small et al. 1989), with the inception of the Highway Trust Fund, the highway network was financed with user fees that adhered to the user-pays-and-benefits principle. Because of several factors including increasing fuel efficiencies, the inability to keep pace with inflation, and the inability to vary with time or location of travel, the current fuel tax system has moved away from the user-pays-and-benefits principle. MBUFs, if implemented, have the potential to once again align the user fee system with the user-pays-and-benefits principle. As stated by Forkenbrock et al. (2002), variable road user charges could, "improve fairness, such that those who impose greater costs on the road system, on other users, or on society in general pay higher user charges" (p. 22).

3.2.1.1 Improvements in fuel efficiency and use of alternative fuel vehicles

Increases in fuel efficiency and the introduction of alternative fuel vehicles are major reasons why today's system of fuel taxes has moved away from the user-pays-and-benefits principle. For model year 1975, the adjusted fuel economy was 13.1 miles per gallon (5.6 km/L), whereas for model year 2010 the adjusted fuel economy was 22.5 miles per gallon (9.6 km/L) (EPA 2010). Furthermore, for the overall model year 2008 fleet, hybrids represented about 2.5 percent of the fleet, which was their highest level ever (EPA 2008). Figure 3.1 below documents the dramatic increase in fuel efficiencies from the 1970s to today. Although the chart depicts a gradual decline from 1987 until 2004, the overall trend, and the most recent trend beginning in 2005, is increasing fuel economies.



(Data from EPA 2010)
Figure 3.1: Adjusted MPG by Model Year

These trends in fuel economies are likely to continue in coming years. The Energy Information Administration (2009) predicts that average fuel economy of new light-duty vehicles will grow to between 36 and 39 miles per gallon (15 and 17 km/L) by 2030. Under a fuel tax system, these trends allow users with more fuel efficient vehicles to pay substantially less per-mile traveled. If MBUFs are implemented, however, increasing fuel efficiencies and the use of alternative fuel vehicles will not cause equity issues since fees are based on miles traveled and not fuel consumed.

3.2.1.2 Will all users pay MBUFs?

To adhere to the user-pays-and-benefits principle, MBUFs must ensure that fees are collected from all users. Under the current fuel tax system, some users such as state government, non-profit educational organizations, and emergency vehicles are exempt from fuel taxes. Although this does not adhere to the user-pays principle, there may be good reasons for these exemptions. A more serious threat to the user-pays principle comes in the form of evasion.

Several researchers have expressed concern over the possibility of increased evasion under a VMT system. As noted by Sorensen et al. (2009), “Additionally, moving the point of collection from a relatively small number of entities (fuel wholesalers) to a much larger number (either retail fuel stations or individual motorists) would make it more difficult to prevent tax evasion” (p. xxii). MBUFs may be collected monthly (like utility fees), unlike fuel taxes that are collected each time fuel is purchased. Whitty et al. (2009) note that frequency of collection is an important factor when considering evasion rates stating, “Infrequent payment will likely result in greater defaults, more evasion and less public acceptance…”(p. 23). Thus, it will be important for policymakers to consider evasion when thinking through different payment schemes. The technology involved with MBUFs is also an important consideration for policymakers when addressing evasion. In considering the possibility of using GPS technology, the National Surface Transportation Policy and Revenue Study Commission (2007) notes,

> "Furthermore, there are several ways a VMT fee potentially could be avoided…For instance, devices are available that can block global positioning system (GPS) signals, making that technology vulnerable to evasion unless alternative methods for calculating mileage are available when GPS signals are not being received" (p. 5.35).

To avoid this problem, a secondary method for estimating and verifying miles traveled (e.g., electronic odometer) may be required.

3.2.1.3 Full cost recovery of direct costs

For a user fee to adhere to the user-pays principle, it should work towards full cost recovery of direct costs such as road construction and maintenance. When considering direct costs, it is important to note that it is weight per axle and not total weight that matters when assessing road damage. As Small et al. (1989) state, "A 50,000-pound two-axle dump truck causes more road wear than a huge twin-trailer rig spreading 100,000 pounds over seven axles." (p. 11) Furthermore, in general, freeways are designed to withstand heavier loads than surface streets (Sorensen et al. 2009). Thus, a proper user fee must be able to price for the design of the road as well as weight per axle to equitably recover direct costs. Successful implementations of similar pricing schemes have occurred, such as Oregon's weight distance tax, which accounts for weight, number of axles, and distance traveled (Whitty et al. 2009). It is anticipated that when implementing MBUFs, rates will vary, at a minimum, by vehicle weight and by miles driven.

3.2.1.4 Full cost recovery of external costs

In addition to recovering direct costs, a user fee must also work towards cost recovery of external costs such as those associated with congestion and greenhouse gas emissions. As noted in the efficiency section, roadway congestion in the United States is a serious and growing problem which imposes significant costs on society. Our current system of fuel taxes does little to account for congestion costs. While a typical user only pays three cents per mile in highway user fees, using a congested roadway imposes costs ranging from 10 to 29 cents per mile (6.2 to 18 cents per km) (Atkinson 2009). Thus, for a VMT system to be effective at recovering the costs from congestion it must price congested roads in this range of costs. In discussing the strengths of MBUFs, the National Surface Transportation Policy and Revenue Study Commission (2007) notes their ability to incorporate congestion pricing. Regarding the inclusion of congestion pricing in a MBUF scheme, Sorensen et al. (2009) note, "The intent of this policy goal would be to raise the per-mile cost of peak hour travel in crowded corridors to capture the cost of delays imposed on others. By creating a financial incentive for drivers to shift their travel patterns where possible, this could significantly reduce traffic congestion" (p. 41). In addition to recovering the costs associated with congestion, MBUFs could be structured to recover environmental costs as well. Several studies have noted the possibility of charging different rates based on fuel efficiency.

3.2.1.5 Will VMT revenues be used for other purposes?

A final factor to consider when evaluating MBUFs under the user-pays-and-benefits principle is whether revenues will be used solely to improve the highway system or be used also for purposes unrelated to who pays the fees. To adhere to the benefits principle, those who pay user fees should be the direct beneficiaries of their payments. Thus, drivers should see their MBUFs put towards the maintenance and improvement of the highway system. Under the current system, fuel taxes are often spent on non-highway purposes. Fuel tax payments have gone to everything from budget- deficit reduction (Schade et al. 2006) to films about state roads in Alaska (Williams 2007). A percentage of fuel taxes are also dedicated to mass transit projects and to the Leaking Underground Storage Tank Trust Fund. Whether these practices would continue under a VMT system is unclear; however, it can be assumed that, like fuel taxes, a portion of MBUF revenue would go towards other purposes.

3.2.2 Ability-to-pay considerations

3.2.2.1 Horizontal equity

We now turn to the ability-to-pay principle. Under this principle we consider both horizontal equity and vertical equity. Simply defined, horizontal equity is the concept that "people in equal positions should be treated equally" (Rosen 2005, p. 571). Several horizontal equity issues have already been alluded to in prior sections. For example, MBUFs, as compared to the current system of fuel taxes, have the potential to improve horizontal equity since those with fuel efficient or alternative fuel vehicles will have to pay their fair share for use of the roads. The ability of MBUFs to price for weight and congestion also allow MBUFs to improve horizontal equity as those users that impose more direct and external costs would pay higher fees. Some horizontal equity issues will most likely remain since some users will be able to escape MBUFs either through exemption or evasion.

Another horizontal equity issue is jurisdictional inequity. Williams (2007) documents how a system of donor states and beneficiary states has emerged under the current fuel tax system. Under this form of jurisdictional inequity, donor states contribute more to the Highway Trust Fund than they receive in federal transportation funding. If MBUF revenues were allocated proportionally to the jurisdictions which produced them, then the jurisdictional equity problem will be alleviated. However, there is no guarantee that shifting to a VMT system will cause Highway Trust Fund revenue to be distributed in an equitable manner. As stated by Forkenbrock et al. (2002), "[A] key requirement of a mileage-based approach to assessing road user charges is the capability to return the revenue collected to the jurisdictions in a manner consistent with where the travel actually has occurred" (p. 2). Other studies such as Oh et al. (2008) have noted the possibility of distributing revenues to the appropriate governmental authority with a MBUF system.

Finally, it is important to consider how a MBUF could affect rural drivers. Rural drivers often argue that it would be unfair to make them pay a per-mile fee since they have to drive greater distances to get to essential services, and they lack transportation alternatives. A lower rate for rural drivers may be justified because of the negligible impact rural drivers have on congestion. A study by McMullen et al. (2008) found that rural residents in Oregon would pay less under a MBUF than the current system of fuel taxes, while those in urban areas would pay slightly more. This was due in large part to rural drivers driving less fuel efficient vehicles.

3.2.2.2 Vertical equity

In concluding our discussion of the equity criterion, we examine MBUFs through their affect on vertical equity. Vertical equity entails how tax burdens are distributed among different income groups. As a national MBUF system has not yet been enacted in the U.S., it is unclear how a MBUF system would affect different income groups. Whitty et al. (2009) note, "Whether the shift to a distance-based charge will positively or negatively affect the poorer element of society depends on the rate structure adopted and the type of vehicle operated" (p. 69). Fees like sales taxes tend to be regressive for those who pay them. In other words, the poor pay a greater percentage of their income in tax than the rich. However, Whitty et al. (2009) go on to note a study by Oregon State University which reports that "a large portion of the lowest income group tends not to be affected by road taxes and fees because they do not operate motor vehicles" (p. 69-70).

There are several factors that could lessen the regressivity of a MBUF. First, how revenues generated by MBUFs are spent may affect vertical equity. If revenues are spent on public transit in poorer areas, this may work to lessen the regressivity of the system. To the extent that a MBUF may include congestion pricing, providing funding to public transit may be essential. Munnich (2009) found that all successful congestion pricing implementations have been accompanied by a significant transit investment component. Second, Oh et al. (2008) notes the possibility of introducing discounts and exemptions for lower income groups. Third, the visibility of a MBUF may cause price-sensitive individuals, such as those from lower income groups, to drive less (National Surface Transportation Infrastructure Financing Commissions 2009). Finally, after citing that low-income groups are more likely to drive less fuel efficient vehicles, Whitty et al. (2009) note, "The poorer motorist would generally pay more per mile under the fuel tax than they would under a comparable flat rate mileage charge. The gas tax therefore would be more regressive to poorer motorists than a flat rate mileage charge. Graduated, stacked, multiplied or other non-flat mileage charge rate structures will yield different outcomes" (p. 70).

3.2.3 Summary

Under the user-pays-and-benefits principle, MBUFs have great potential:

- Drivers with fuel efficient and alternative fuel vehicles would not be able to escape a MBUF since, unlike fuel taxes, the fee is, not based on fuel consumed, but on actual travel.
- Exemptions and evasion may still cause some equity issues, and it is possible that evasion would increase under a VMT system.
- By setting stacked or variable rates MBUFs have the potential to move towards full cost recovery by both direct and external costs.
- If, like fuel taxes, revenues are used for non-highway purposes this will represent a move away from the user-pays-and-benefits principle.

Under the ability-to-pay principle MBUFs have mixed results:

- Several issues touched on under the user-pays-and-benefits principle are likely to either improve horizontal equity or have no effect when compared to the current system of fuel taxes.
- Some analysts have noted the possibility of revenues being allocated to the appropriate jurisdictions; however, it is quite possible that jurisdictional equity issues will persist with MBUFs.
- Depending on the structure of a VMT system, rural and urban drivers are likely to be affected differently.
- Like fuel taxes, MBUFs are likely to be regressive. The degree of regressivity will be determined by several currently unknown factors such as the rate structure and how revenues are spent.

3.3 REVENUE ADEQUACY AND SUSTAINABILITY

Under the revenue adequacy and sustainability criterion, revenue analysis typically looks at both the tax rate and base from which a tax is collected, and how well a tax remains a stable revenue source in the face of external changes. On both adequacy and sustainability principles, MBUFs fare relatively well. MBUFs allow for a large base from which to collect revenue since they can be applied effectively to the miles driven by fuel efficient and alternative fuel vehicles. Depending on how a MBUF system is structured, some sustainability issues may persist due to inflation. Nonetheless, MBUFs should improve revenue sustainability over the current fuel tax system, since a consistent revenue stream would be generated despite changes in fuel prices and fuel efficiencies and the introduction of alternative fuel vehicles.

3.3.1 Revenue adequacy

It has been heavily documented that in 2008 the Highway Trust Fund, which is primarily funded through fuel taxes, needed an eight-billion dollar transfer from the general fund to stay solvent. In 2009, the Highway Trust Fund received an additional seven-billion dollar transfer. Since then billions more have come by way of stimulus dollars. Without significant changes in how the system is financed, the solvency of the Highway Trust Fund will continue to be an issue.

Oh et al. (2008) assert, “Given that the objective of the VMT fees is to bridge the revenue…gap of current fuel taxes, the fee rates based on the revenue needed and the vehicle-miles driven could be higher than the current fuel taxes” (p. 26). Thus, given the inadequacy of fuel taxes at current rates, for a VMT system to cover the funding shortfalls rates will most likely have to be increased. However, rates will not have to be raised as high as they would under the current fuel tax system, as a MBUF system broadens the base on which revenue is collected. While fuel taxes collect low levels of revenue per-mile of travel from highly fuel efficient vehicles and no revenue from non-petrol propelled vehicles, MBUFs have the potential to broaden the base and collecting significant revenues from both of these groups of motorists. Considering that in 2007 there were approximately 205 million licensed drivers in the U.S. (Federal Highway Administration 2009c), MBUFs have a potentially very large base from which to draw revenue.

It should be noted, that while the overall effect is a broadened base, some aspects of MBUFs may cause base reductions in some areas and at some times. If a MBUF system includes a congestion pricing component, this could lead to a base reduction as motorists shift to other modes to avoid paying the congestion charge. Singapore saw public transport's mode share grow from 40percent to 67percent in the 30 years after congestion pricing was implemented. London and Stockholm experienced similar affects after implementation (Munnich 2009).

3.3.2 Revenue sustainability

In addition to generating adequate revenue from a large base, MBUFs are expected to generate revenue streams that remain stable and predictable despite external changes. While the effects of inflation may hamper the ability of MBUFs to be a sustainable revenue source, changes in fuel prices and fuel efficiencies and the introduction of alternative fuels should not dramatically affect the stability of MBUFs as a revenue source. In its findings and conclusions, the National Surface Transportation Infrastructure Financing Commission (2009) first noted that the current system of fuel taxes is "not sustainable in the long term" before recommending MBUFs as the consensus choice for the future. The Commission noted the drive for more fuel efficient and alternative fuel vehicles as a significant factor for why fuel taxes are not sustainable going forward.

3.3.2.1 Inflation erodes the value of revenue collected

Aside from increases in fuel efficiencies, a big part of why fuel taxes are currently inadequate and unsustainable is that they are not indexed to inflation. It has been noted that since 1993 the federal gas tax rate has fallen by 40 percent when it is compared to the Producer Price Index for Highway and Street Construction (National Surface Transportation Policy and Revenue Study Commission 2007). If implemented, a MBUF system may face a similar challenge. As noted by Sorensen et al. (2009), "VMT fees would neutralize the issue of improved fuel economy…but it would still be appropriate in principle to index, or periodically increase, VMT fees to prevent the erosion of real revenue due to inflation. There is no indication that such increases would be easier to make, politically, than raising current fuel taxes" (p. 6).

3.3.2.2 Changes in fuel prices

Changes in fuel prices may have some affect on the revenue streams generated by MBUFs. Small et al. (1989) note that, since 1973, receipts from fuel taxes have fluctuated with changes in fuel prices and economic conditions. Patashnik (2000) notes that the energy crisis of the 1970s was a significant factor in dwindling fuel tax revenues during this time. If fuel price rises are dramatic enough to reduce vehicle-miles traveled, then a MBUF system, like fuel taxes, will experience lower revenues.

While changes in fuel prices may affect driving behavior, sustained elevated prices can also lead to a drive for more fuel efficient or alternative fuel vehicles. As noted by Schade et al. (2006), "After 2025, large market shares for hybrid electric and fuel cell–powered vehicles, and consequently greater reductions in gasoline consumption, are possible, if driven by government intervention or high fuel prices" (p. 180). As we will discuss below, this drive for more fuel efficient and alternative fuel vehicles, which is in part induced by higher fuel prices, will have little effect on the revenue sustainability of a MBUF system.

3.3.2.3 Fuel efficiency changes

As noted earlier by Sorensen et al. (2009), a MBUF system would "neutralize the issue of improved fuel economy" as the tax is on vehicle-miles traveled and not on fuel consumed. This is an important attribute of MBUFs as fuel efficiencies are likely to continue their recent upward trend. As documented earlier in the Equity section, the Energy Information Administration (2009) suggests that the average fuel economies for new light-duty vehicles are predicted to grow to 36 to 39 miles per gallon (15.3 to 16.6 km/L) by 2030. Just as MBUFs improve equity, they also improve revenue sustainability since increasing fuel efficiencies leave MBUF revenue largely unaffected.

3.3.2.4 Introduction of alternative fuels

When considering revenue sustainability, it is important to consider the introduction of alternative fuel vehicles. Once again, as noted in the Equity section, alternative fuel vehicles are gaining market share. For model year 2008, hybrids represented their highest market share to date, coming in at 2.5 percent of the fleet (EPA 2008). In 2003, Wachs (2003b) noted that some believe that hydrogen may become the basis of automotive power. With the emergence of the Leaf and Volt, electric vehicles and plug-in hybrids now seem more poised than hydrogen to take an early lead in the alternative fuel vehicle market. Moving to a MBUF system would inoculate transportation funding from these changes, since adequate revenue would still be collected from those drivers using alternative fuels.

3.3.3 Summary

On revenue adequacy and sustainability grounds, MBUFs fare relatively well:

- A MBUF system would broaden the tax base since drivers of fuel efficient and alternative fuel vehicles would no longer pay at a reduced rate or nothing at all. Nonetheless, rates would likely have to be increased to make up for current funding gaps.
- While inflation may hamper MBUFs ability to generate sufficient revenue, the revenue sustainability of MBUFs will be less affected by other external factors such as the price of fuel, vehicle fuel efficiencies, and the introduction of alternative fuel vehicles.

3.4 ENVIRONMENTAL SUSTAINABILITY

While not always discussed in revenue analysis, we include environmental sustainability in our analysis of MBUFs since the current administration has made clear that the environmental community should be in the discussion when addressing the transportation system. Transportation Secretary Ray LaHood explained the administration's stance on the environment and transportation stating, "We want to base our decisions on how much transit helps the environment, how much it improves development opportunities and how it makes our communities better places to live" (Green Car Congress 2010).

As mentioned in preceding sections, one of the main reasons why switching to a VMT system would improve equity, efficiency, and revenue sustainability is that fuel taxes are proving inadequate in the face of increasing fuel efficiencies and the introduction of alternative fuel vehicles. This section will discuss the effect of MBUFs on environmental sustainability in the two following areas: effect on petroleum-based fuel consumption and greenhouse gas emissions, and promotion of less-polluting fuels.

3.4.1 Effect on petroleum-based fuel consumption, greenhouse gas emissions, and local air pollutants

Since MBUFs are visible and add to the cost of driving, it is likely that they will have some effect on the consumption of petroleum-based fuels, and the emissions of greenhouse gases. However, if MBUFs are set to equivalent rates equivalent as current fuel taxes, MBUFs are likely to underperform fuel taxes in this area. It should be noted that fuel taxes in the U.S. have had a relatively insignificant effect on petroleum-based fuel consumption because of their historically low rates. However, if fuel taxes and MBUFs were set at more realistic levels, their effect on emissions could be substantial. One study found that if all OECD countries applied the highest fuel taxes applied in Europe, a reduction of 8.5 billion tons of CO_2 emissions would have resulted over a decade (Sterner 2007).

Some have argued that taxing vehicle-miles traveled rather than gallons of fuel consumed, punishes instead of rewarding drivers of more environmentally-friendly, high fuel economy and lower-emission vehicles. While it may be true that fuel taxes provide some environmental incentives, MBUFs can be structured to offer similar incentives and mitigate environmental concerns. A recent congressional report notes, “While some argue that the fuel tax rewards those who choose to drive more fuel-efficient vehicles, there are other ways to offer such rewards without reducing the highway funds needed to accommodate travel by those fuel-efficient vehicles” (National Surface Transportation Policy and Revenue Study Commission 2007, p. 5.34). First, fuel taxes would not have to be entirely scrapped with the implementation of a VMT system. A system of fuel taxes could complement a VMT system with the former aimed at environmental purposes and the latter focused on charging for the usage of the system. A second alternative would be to apply a stacked or variable rate that varies by fuel economy or emissions class. Whitty et al. (2009) note, “[P]olicymakers may apply a fuel inefficiency penalty to high fuel consuming vehicles in addition to the flat mileage charge rate” (p. 8).

Furthermore, if MBUFs contain a congestion pricing element, they may be able to reduce emissions and pollutants in some instances where fuel taxes are less effective. As noted by Whitty et al. (2009), “Vehicles driven during peak period congestion emit quantities of extra greenhouse gases beyond amounts they would emit under free flow conditions. Combining congestion pricing with varied rates based on greenhouse gas emissions may allow for creation of an effective overall strategy to reduce greenhouse gases from the passenger vehicle sector” (p. 66).

Finally, MBUFs have shown great potential in the area of reducing local air pollutants. Robinson (2008) found that a German tolling system that charged a higher rate to older, dirtier trucks led to an increase in the proportion of cleaner trucks from 50 to 64 percent. The proportion of dirtier trucks fell from 50 percent to 36 percent (Robinson 2008).

3.4.2 Promotion of less-polluting fuels

Finally, we consider the effect MBUFs will have on the promoting the use of less-polluting fuels. Similar to the effect on petroleum-based fuel consumption and greenhouse gas emissions, a simple flat-rate MBUF would have little effect on the promoting the use of less-polluting fuels as the fee is tied to road use and not the amount and type of fuel consumed. However, if MBUF rates are allowed to vary, their ability to promote use of less-polluting fuels would be greater. As noted by Ruidisch (2004), adoption of less-polluting vehicles can be promoted by charging higher rates to high polluting vehicles.

3.4.3 Summary

When evaluated on environmental sustainability grounds, MBUFs have mixed results:

- While a flat MBUF would most likely underperform the current system of fuel taxes in reducing petroleum-based fuel consumption and greenhouse gas emissions, MBUFs could be structured in such a way to create incentives for the use of fuel efficient and low emissions vehicles.
- MBUFs could also promote the adoption of less-polluting fuels if they are structured so that high polluting vehicles are charged higher rates.

3.5 FEASIBILITY

Under the feasibility criterion we evaluate the political feasibility and administrative feasibility of a MBUF system. Taxes and fees tend to be more politically feasible and enjoy greater popularity when they are less visible to taxpayers and allow for some tax exportation. And, to be politically feasible, the revenue-collection system must ensure driver privacy and system security. Under administrative feasibility, revenue-generating systems fare well when implementation, operation, enforcement, and compliance costs are low.

3.5.1 Political feasibility

Before we begin our analysis of the political feasibility of MBUFs, it is important to remember that most taxes and fees are not particularly popular. Nonetheless, not all taxes are viewed the same by taxpayers. A recent poll found that when compared to cigarette, beer and wine taxes, corporate income taxes, social security payroll taxes, estate taxes, and federal income taxes, the gas tax was the second least popular tax, with only the estate tax seen as less fair (Harris Interactive Inc./Tax Foundation 2009).

Although fuel taxes are currently not very popular, there is little indication that MBUFs would enjoy any higher rates of popularity. A recent study (Sorensen et al. 2009) looking at shifting to MBUFs noted the following:

> "In considering the public acceptability of VMT fees, the experts consulted in this project offered two salient observations. First, there is little public understanding of the current challenges in transportation finance, and in turn the motivations for a transition to VMT fees. Second, the privacy concerns associated with GPS remain a potent obstacle to the acceptance of sophisticated in-vehicle metering equipment. To bolster the prospects of

> transitioning to a VMT-fee system, concerted public education and outreach would likely be imperative" (p. xxiv).

Nonetheless, taxpayers' response may be different if given the opportunity to experience a MBUF system in operation. A recent report analyzing the Oregon MBUF pilot project noted that 91percent of participants of participants would continue paying highway user fees through MBUFs if given the option (O'Leary 2009).

The structure of any MBUF system, and how revenues will be raised, will be significant factors in determining the level of public and political support. If a MBUF system includes a congestion pricing component, it may be critical to also include extra funding for transit along with the implementation of the system to win popular support. In a recent paper, Munnich (2009) argues that successful implementations of congestion pricing schemes have included a significant investment in transit, and that the failure of congestion pricing proposals, as such as the one in New York City, may be linked to a lack of attention to transit.

Under the political feasibility principle we take a closer look at three specific criteria: visibility to taxpayers, tax exportation, and drivers' privacy and system security.

3.5.1.1 Visibility to taxpayers

Tax visibility can be broadly defined as the degree to which taxpayers are aware of a tax or fee. This should not be confused with tax transparency, which relates to the degree to which taxpayers know the actual costs they incur from a tax. As taxes become more visible, their popularity tends to decrease. Also, governments may more easily raise taxes when they are less visible. The degree of visibility of a MBUF system is dependent on how the system is implemented and designed. Whitty et al. (2009) present a discussion of the visibility issues policymakers will need to think through:

> "Many user fees are embedded within transactions and therefore hidden. Policymakers must decide whether mileage charges should be transparent to the payer or embedded within each fuel purchase like the current gas tax. If hidden, the motorist may never know the mileage charge amount. If transparent, the motorist will know the mileage charge amount either at the time of payment or while the charge tallies during travel, depending upon the technology employed within the vehicle" (p. 23).

Thus, since there are several options for the design of a MBUF system, the visibility of the system and how this level of visibility will affect political support and public opinion is largely unknown at this time. On the other hand, as discussed previously, the visibility of MBUFs is one of its key attributes since it helps drivers to be more aware of the true cost of their travel.

3.5.1.2 Tax exportation

Tax exportation enhances the popularity of a tax as it generates revenues for an area without any direct costs to area residents. A federal MBUF would benefit little or not at all from tax exportation. Depending on the set up of the system, foreign tourists and truckers may pay some in MBUFs; however, this would be a minimal amount when considering total national miles traveled and fees paid. Tax exportation may be a relevant issue when considering state MBUFs.

Whitty et al. (2009) note, “Legally, out-of-state motorists must not drive free of charge when local residents pay the charge. Policymakers must decide whether out-of-state motorists should pay under the same system as resident motorists or whether a different system could be deployed for them” (p. 23).

3.5.1.3 Driver’s privacy and system security

Finally, we consider how privacy and system security issues involved with MBUFs would affect political feasibility. As mentioned before, privacy concerns are a significant hurdle to public acceptance of MBUFs. A recent congressional report noted, “Privacy is perhaps the biggest concern with a MBUF. Many motorists fear that information on when and where they drive would be transmitted to government authorities” (National Surface Transportation Policy and Revenue Study Commission 2007, p. 5.35). Oh et al. (2008) notes that while in initial stages, pricing project users are reluctant to reveal their travel pattern information, users show less reluctance as they become more accustomed to the new technologies that are gathering their information. Oh et al. goes on to note two studies that illustrate how the privacy concern has lessened for users after implementation. In particular, Oh et al. cites a study that reported that with the SR-91 Express Lanes in Orange County, California, and the Highway 407 Toll Road in Toronto, Canada, approximately 99percent of users used a transponder system that kept travel records.

Nonetheless, despite the fact that privacy concerns have lessened for users after implementation, privacy concerns remain an important issue. Sorensen et al. (2009) note, “[T]he perception that GPS will be used to track and monitor travel remains a potent public concern despite the fact that technical approaches to the protection of privacy have already been developed and demonstrated” (p. xvi). One such privacy protection was demonstrated in the Oregon VMT project, in which intermediate travel data was purged from memory after being used for fee calculation and bill submission (Whitty 2003).

In addition to developing and demonstrating technologies that ensure drivers’ privacy, additional strategies could be utilized to help MBUFs overcome privacy concerns and gain public support. Sorensen et al. (2009) note, that in addition to public outreach and education, two factors that may assist MBUFs in overcoming privacy concerns are the ability to save money through the use of the GPS technology such as pay-as-you-drive insurance, and additional user features brought about by the technology such as navigation features. Another possible solution that has been suggested is to have a private operator as opposed to a government entity run the system (Sorensen et al. 2009).

To gain public acceptance and political support, it will also be important for the MBUF system to ensure system security. This entails employing features that protect the system from unauthorized access and illegal use. Sorensen et al. (2009) note that, through the use of firewalls and data encryption, it would be able to attain an acceptable level of security for different MBUF system designs.

3.5.2 Administrative feasibility

Administrative feasibility deals with the degree of difficulty and costs involved with implementation, operation, and enforcement as well as compliance costs.

3.5.2.1 Implementation, operation, and enforcement costs

A MBUF system is likely to experience significant implementation, operation, and enforcement costs, especially when compared to the current system of fuel taxes. Sorensen et al. (2009) note that the three most promising options for implementation of a MBUF system all have high administrative costs:

> "Though promising, the three mechanisms suggested for further consideration share several important obstacles related to cost, administrative complexity, and political acceptability…current evidence suggests that any of the three options would be more expensive - potentially much more expensive – than collecting fuel taxes…it may be necessary to develop or secure new tax collection channels; a new national agency or expanded state powers; cooperation from entities not currently involved with fuel tax collection, such as cellular providers and retail fuel stations; support from the Internal Revenue Service (IRS)…" (p. xxii-xxiii).

Moving the point of collection from a relatively small number of wholesalers to the driving public at large will also most likely come with additional enforcement costs. A recent congressional report notes evasion as a concern with MBUFs and explains the need for a back-up system for monitoring miles traveled since devices are available to block GPS signals (National Surface Transportation Policy and Revenue Study Commission 2007).

3.5.2.2 Compliance cost

Compliance costs are costs that are in addition to the direct tax or fee that taxpayers incur by complying with the tax policy. To get a better idea of the compliance cost issues involved with a MBUF, it is useful to look at the compliance costs associated with the current fuel tax system. Fuel taxes have very low compliance costs as the statutory burden is on a relatively small number of wholesalers as opposed to the general driving public.

Depending on design and fee collection method, compliance cost for MBUFs may be somewhat higher than the current system of fuel taxes. If a pay-at-the-pump method is utilized the compliance costs will be no greater than the current system of fuel taxes However, if a central billing model is used, compliance costs will be somewhat higher since motorists would have to take the time to pay their periodic MBUF bills. Whitty et al. (2009) highlight an additional compliance burden for some with the central billing method stating, "For members of the cash paying economy without access to a bank account or easy access to the Internet, regular payment of a mailed mileage charge billing adds a significant burden. While cash payers now easily pay the gas tax at the fueling station…a monthly billing requires traveling to the collection center…" (p. 42).

3.5.3 Summary

On both political feasibility and administrative feasibility grounds, MBUFs have significant hurdles that must be overcome:

- While the current system of funding transportation using fuel taxes is not very popular, there is little indication that MBUFs would be any more popular.
- It is hard to determine the visibility of a MBUF system and how that would affect public opinion and political support, because different system designs would yield different levels of visibility.
- Tax exportation is not a significant issue when analyzing a national MBUF; however, state systems may be able to benefit from tax exportation depending on how their system is designed.
- While privacy and system security remain significant obstacles to successful implementation of a national MBUF system, it is likely that this concern could be mitigated through demonstration of available technologies as well as expanded outreach and education.
- In terms of administrative feasibility, MBUFs are likely to produce higher implementation, operation, and enforcement costs than the current system of fuel taxes.
- Compliance costs may be the same or somewhat higher under a MBUF system than it is under the current system of fuel taxes, but may be significantly higher for users who are without a bank account or easy access to the internet.

3.6 CONCLUSIONS

As we have seen, MBUFs have great promise under several transportation finance principles. In terms of efficiency, MBUFs have the ability to recover the total cost imposed on the system by drivers. This aligning of pricing with costs imposed could lead to a more efficient use of the system, reducing delays and leading to a more balanced ratio of auto and truck use compared to transit and freight rail. MBUFs may also reduce the spread of urban sprawl, and direct transportation investment where it is most needed.

MBUFs also fare well on equity grounds. Unlike fuel taxes, MBUFs would not move away from the user-pays-and-benefits principle because of increases in fuel efficiencies and the introduction of hybrid and alternative fuel vehicles. MBUFs could be structured to cover the direct costs associated with road construction and maintenance and external costs such as congestion and pollution. When considering ability-to-pay, MBUFs, like fuel taxes, would be regressive. However, to the extent that the poor drive more fuel inefficient vehicles than the rich, MBUFs may be less regressive than the current fuel tax system.

Like under efficiency and equity, MBUFs represent an improvement over fuel taxes when it comes to revenue adequacy and sustainability. While a revenue neutral MBUF would not be sufficiently high enough to cover the current inadequacies in funding transportation, and MBUFs, like fuel taxes, would suffer from inflation, MBUFs would provide more sustainable revenue streams than fuel taxes since their revenue potential would not be hurt by an increasingly fuel efficient fleet.

MBUFs fare somewhat less well under environmental sustainability since they do not directly tax the use of gasoline. However, MBUFs could fare reasonably well on environmental grounds if a higher rate was applied to dirtier or less fuel efficient vehicles.

Finally, MBUFs are problematic when considering their political and administrative feasibility. MBUFs have a major hurdle to overcome when it comes to gaining the public's trust, especially when it comes to privacy. In terms of implementation, operation, enforcement, and compliance costs, MBUFs are viewed as inferior to the current fuel tax system. Table 3.2 scores MBUFs on the various principles and sub-principles discussed in this chapter.

Table 3.2: MBUFs Assessment Scorecard

Principles	Ability to Achieve Principles
Efficiency	**Strong**
• Transportation system overuse	Strong
• Efficient investment in transportation	Strong
• Efficient land use	Strong
Equity	**Strong**
• Adherence to user-pays-and-benefits principle	Strong
• Horizontal equity	Strong
• Vertical equity	Moderate
Revenue Adequacy and Sustainability	**Strong**
• Revenue adequacy	Moderate
• Tax rate	Strong
• Revenue sustainability	Strong
Environmental Sustainability	**Moderate**
• Reducing petroleum-based fuel consumption and emissions	Moderate
• Promoting less-polluting fuels	Moderate
Feasibility	**Weak**
• Public and political support	Weak
• Implementation, operation, and enforcement costs	Weak
• Compliance costs	Weak

CHAPTER 4. USER FEE TECHNOLOGY AND FINANCE PRINCIPLES

In the first two chapters, we evaluated fuel taxes and MBUFs from the perspective of five transportation finance principles, namely: efficiency, equity, revenue adequacy and sustainability, environmental sustainability, and feasibility. What was made clear, we hope, is that the fuel tax system in the United States is not functioning the way it was intended. Fuel tax revenues are not commensurate with costs imposed or benefits received, and this has contributed to inefficient use of the system, inefficient investment in the system, and even inefficient land use and development patterns. Furthermore, the Highway Trust Fund has needed significant bailouts because of insufficient revenues, and will continue to struggle with solvency because the growth in fuel efficient vehicles has resulted in less revenue per mile driven. However, given the current problems with the current highway funding mechanism, it is fortunate that there are alternatives to fuel taxes that can overcome many of the system shortcomings. The discussion in chapter two highlighted the improvements that a MBUF system could bring in the areas of transportation efficiency, equity, and revenue sustainability.

In this chapter, we examine a number of technology options available for MBUF implementation, and discuss how each option performs under our five transportation finance principles. The technology options fall under four technology categories: current technology, on-board units, dedicated short-range communication (DSRC) and e-Vignettes, and Global Positioning System (GPS). While it is understood that policy decisions should, as a rule, drive technology, it is important to have a good understanding of the technology options available as we move towards a mileage-based funding system.

4.1 DESCRIPTION OF CURRENT DISTANCE-BASED CHARGE SYSTEMS

Germany: Robinson (2008) provides a thorough description of the German Heavy Goods Vehicle (HGV) tolling system. This system, introduced in 2005, uses a GPS-based system to charge heavy commercial vehicles based on distance traveled, number of axles and emission class. The rationale for implementing the German system was: significant infrastructure costs were being imposed by heavy trucks; a significant amount of truck-kilometers on German roads were being driven by foreign-registered vehicles that were not directly paying fuel and road taxes; many foreign trucks had a competitive advantage as they were not complying with EU emission standards; and taxes on gasoline and diesel fuels had been raised several times since 1991, and further increases were no longer a good option (Robinson 2008).

The Euro-Vignette: This is a sticker-based system that charges vehicle users based, typically, on emission level, time of travel, number of axles, and specific traffic regulations (Robinson 2008). This system was initially introduced in 1995, and is currently used in five countries: Sweden, Denmark, Belgium, The Netherlands, and Luxemburg (Eurovignette 2010). Since October 1, 2008, users have been able to register their vehicle online, thus removing the need to carry paper documentation of their enrollment in the program (Eurovignette 2010). Robinson (2008) notes the advantages of this system: ease of implementation, low risk of manipulation, need for storing only limited data, low enforcement costs, and the ability to expand to cover additional vehicles.

The Netherlands have been attempting to implement road pricing since 1988, with the primary goal of congestion reduction. Preparations were underway for the roll-out of a pricing scheme in 2010. However, the collapse of the coalition government in February of 2010 has put the program in limbo (Coyle et al. 2010). The pricing system seeks to improve road accessibility and the quality of the environment by transitioning to a system that taxes car use as opposed to car ownership. The Dutch system considered would use in-vehicle "registration units" that have GPS capabilities. Taxes would be based per-kilometer travel and would also include a rush-hour surcharge (Dutch Road Pricing Act 2010).

The Oregon Pilot Project has demonstrated what a state-level road pricing scheme could look like. The motivation for the Oregon pilot was rooted in eight principles: users should pay, local government should have control over local revenue sources, the system should have revenue sufficiency, the system should be transparent to the public, there should not be substantial burdens for taxpayers or private sector entities, the system should be enforceable, should support the entire highway and road system, and should enjoy public acceptability (Whitty 2007). The system used in the Oregon trials was a coarse-resolution GPS-based system, with a pay-at-the-pump payment method. The Oregon pilot program revealed many key findings: the concept is viable, paying at the pump works, the mileage fee can be phased in, integration with the current system can be achieved, congestion and other pricing options are viable, privacy is protected, the system would place minimal burden on business, potential for evasion is minimal, and the cost of implementation and administration is low (Whitty 2007).

We find that there has been little written in the way of peer-reviewed journal articles related to MBUF technology options for MBUF systems. That is not to say that this area has not been studied in the past. Sorensen et al. (2009) evaluated nine MBUF technology options, and found mileage metering based on fuel consumption, OBD II /cellular-based metering, and coarse-resolution GPS-based metering to be the most promising options. Whitty et al. (2009) discuss the strengths and weaknesses of several MBUF options including systems that are already operational such as the Oregon GPS-based, Pay-at-the-Pump System. Other studies focus primarily on the attributes of one specific technology option. Donath et al. (2009) focus primarily on an OBD II /cellular approach, and provide a thorough description of the technology involved. Finally, other studies focus on specific systems in existence. Robinson (2008) provides an in-depth look at HGV tolling in Germany with a discussion of system outcomes and lessons learned for potentially implementing similar systems in the United States.

4.2 DISTANCE BASED TECHNOLOGY OPTIONS

This chapter provides a unique contribution to the mounting body of work on MBUF technology by applying the five transportation finance principles developed in previous chapters to MBUF technology options. The technology options that will be evaluated are found below in Table 4.1.

Table 4.1: Technology Options

Technology	Description
Odometer Checks	Charges based on miles as recorded by a vehicle's odometer.
Fuel Consumption-based Estimates	Mileage is estimated based on fuel consumed and vehicle characteristics.
On-board Diagnostic (OBD II) Units	On-board units calculate mileage based on vehicle speed integrated over time.
OBD II / Cellular	Similar to the above method, an on-board unit calculates distance, while the cellular component roughly identifies location. This method allows for congestion pricing or other location-based pricing.
Dedicated Short-range Communications (DSRC) – Partial Road Network Only	In-vehicle devices communicate with gantries to toll a particular roadway.
e-Vignette	An electronic sticker-based tolling system.
Fine-resolution GPS	Mileage and location is calculated with the assistance of a fine-resolution in-vehicle GPS device.

The organizational structure in the following sections builds on the Sorensen et al. (2009) report and compares each technology option, side by side, against the transportation financing principles. The following description of options, except for e-Vignettes, comes from Sorensen et al. (2009).

Odometer Checks—"Self-reported odometer readings: For this option, drivers would report their current mileage each year as part of the annual registration process. The state DMV or MVA would then assess a corresponding mileage fee, which would be added to the base vehicle registration fee…The state would then pass along the mileage fee component, minus some administrative charge, to the federal government. **Annual odometer inspections:** Similar to the prior option, the key distinction here is that drivers would submit to periodic (likely annual) odometer readings at certified stations as the basis for assessing mileage fees. The odometer readings could be conducted either by a public agency, such as a state DMV or MVA, or contracted to authorized private stations."

Fuel Consumption-based Estimates—"Under this approach, fuel consumption would serve as the basis for estimating travel distance. All vehicles would be equipped with some form of automated vehicle identifier, or AVI, device (likely a radio-frequency identification, or RFID, tag embedded in the license plate or registration sticker). When a vehicle visits a gas station to purchase fuel, electronic readers installed at the pump would detect vehicle ID and use this information to determine the vehicle's fuel-economy rating (and, optionally, other characteristics such as weight or emissions class) based on the make and model. The expected mileage could then be estimated based on the number of gallons purchased. The corresponding charge could then be added to the fuel purchase price, while fuel taxes…would be subtracted."

On-board Diagnostic (OBD II) Units—"For this approach, vehicles would be equipped with an on-board unit (OBU) that serves as the mileage metering device. The OBU would be connected to the on-board diagnostics port…which provides data on vehicle speed that can be integrated over time to compute travel distance. The per-mile fee could be modified, if desired, by vehicle characteristics such as weight, fuel economy, or emissions class. Fees could be collected through the pay-at-the-pump model…or the OBU could transmit (via cellular) mileage data to a central collections agency…"

OBD II / Cellular—"The OBU would also be equipped with cellular communications, and this would make it possible to determine, with rough accuracy, the location of travel (via identification of the nearest cell phone tower or, alternately, by triangulating among multiple cell towers). This configuration would thus make it possible to vary rates by vehicle characteristics, by state or regional jurisdiction, or by smaller geographic area (e.g., area-based congestion tolls in a dense urban district). The location data would also make it possible to accurately allocate mileage fees among multiple jurisdictions. To collect fees, it would be possible to set up the pay-at-the-pump model, develop a central billing agency, or develop a debit card system under which fees would be deducted from pre-paid debit cards inserted into the OBU..."

Dedicated Short-range Communications (DSRC) – Partial Road Network Only—"With this option, all vehicles would be equipped with AVI devices featuring RFID tags. These would communicate, via dedicated short-range communication (DSRC) technology, with gantries set up along the most heavily traveled segments of the road network to support facility-based tolls--either flat tolls or tolls that vary by time and location. This approach would not support tolling across the entire road network, as it would not be practical, let alone cost effective, to install gantries on lightly traveled road segments. As such, this would likely be used to augment, rather than replace, fuel tax revenue. The two most likely options for collecting payments would be to set up a central billing agency or use pre-paid debit cards inserted into the in-vehicle equipment."

e-Vignette—Sticker-based, electronic system like the one currently in use in many European countries. Charges can include vehicle characteristics such as weight, emissions class, and time of day. Toll stickers are attached to vehicles denoting that they have paid the appropriate usage fee to travel on specific roadways.

Fine-resolution GPS—"This option is similar to the prior approach (coarse-resolution GPS), but would rely on differential GPS for sufficient accuracy (i.e., accurate within one to two meters) to determine the specific route of travel...This would enable the greatest flexibility in pricing; per-mile rates could vary by vehicle characteristics, by jurisdiction, by area within jurisdictions, by specific route or road class, and by time."

4.3 OPTIONS TO METER OR ESTIMATE TOTAL MILEAGE ONLY

Options to meter or estimate total mileage only include odometer checks, fuel-consumption based estimates, and simple OBD units.

4.3.1 Efficiency

The "self-reported odometer readings", "annual odometer inspections", "fuel consumption-based mileage estimates", and OBD units are all relatively simple systems that, while providing some improvements in the area of efficiency when compared to fuel taxes, are significantly limited when compared to other MBUF technology. As discussed in previous chapters, for a tax to lead to efficient use of the system, it must make users pay the full costs to society of their use. By charging by the mile (or estimated mile), or better yet, by factoring in vehicle characteristics such as weight and fuel economy into the per-mile charge, these options could closely approximate some of the costs associated with road use. However, because these technology approaches are unable to account for time and location of travel or road type, they cannot account for all costs imposed, especially those related to congestion.

Since these technology methods do not account for congestion costs, it is difficult to achieve efficient investment and efficient land use: the price signals sent to public officials and potential home owners distort the true costs of road travel. In fact, the odometer-based approaches may be even less effective than fuel taxes at capturing congestion costs since cars burn more fuel in congested conditions and thus are forced to purchase more fuel and pay more fuel taxes. The mileage estimate approach could potentially overcharge drivers who drive mostly congested conditions. Given that more fuel is burned in congested conditions, the mileage estimate approach will estimate a higher mileage than is actually driven. It is unclear whether this overestimate of mileage would over or under compensate for congestion costs.

4.3.2 Equity

As discussed previously, equity focuses on both the user-pays-and-benefits principle and the ability-to-pay principle. As with any MBUF system, the odometer approaches, mileage estimate approach, and OBD unit approach moves the system towards greater equity under the user-pays-and-benefits principle since increases in vehicle fuel efficiency will not allow some users to escape some of the costs their use impose. Furthermore, alternative fuel vehicles will no longer be shielded from payment when using the odometer or OBD units approaches. The mileage estimate approach, however, will fail to collect from drivers of alternative fuel vehicles that do not refuel at gas stations (e.g., electric cars).Under the ability-to-pay principle, equity may be enhanced with use of these technology approaches, insofar as the poor drive older, less fuel-efficient vehicles. On the other hand, if emissions are factored into the per-mile charge, regressivity could increase under these technology approaches.

4.3.3 Revenue adequacy and sustainability

In previous chapters, we have documented the large shortfalls in the Highway Trust Fund (HTF). How use of these technology options would affect revenue adequacy is not known since it largely depends on the level at which per-mile rates are set. Odometer, mileage estimates, and OBD unit approaches, like other MBUF systems, would have a positive effect on revenue sustainability. As documented previously, fuel taxes perform poorly under revenue sustainability due, in large part, to a shrinking tax base caused by improving vehicle fuel economy and the introduction of alternative fuels. This concern would be alleviated by these technology approaches since users would be taxed per mile traveled, not per gallon of fuel used. In fact, in the face of rising fuel economy and alternative fuels, all MBUF technologies, including these approaches, are likely to result in greater revenue if some drivers opt to increase their taxable miles. However, this revenue increase could be offset by drivers who choose to drive less to reduce their tax burden.

4.3.4 Environmental sustainability

How any MBUF technology approach affects environmental sustainability is largely dependent on whether fuel economy and emissions class are factored into the per-mile charge. If a charge is added to vehicles that are big polluters, on top of the charge for miles driven, environmental sustainability will be enhanced. However, absent fuel economy and or emission level being factored into the charge, the use of these technology options will be less effective in promoting environmental sustainability than fuel taxes.

4.3.5 Feasibility

The odometer-based system has mixed results when it comes to feasibility. Under political feasibility, an odometer system would have high visibility since drivers could monitor their odometer to estimate how much they would have to pay in MBUFs. As discussed before, however, high visibility taxes or fees often lead to low popularity. The mileage estimates approach also has mixed results. Visibility will be slightly less clear than under odometer approaches, but still more clear than under current fuel taxes. Although the mileage estimates approach will not be exact, motorists could ultimately still watch their odometers to gauge their likely amount of payment. With OBD units visibility would be largely determined by the payment option. If a central billing or debit card approach is used for payment, drivers would know exactly what they pay in mileage fees. However, using a central billing payment method would entail less privacy since monthly assessments of mileage would be required to be sent to the billing agency.

The odometer system would also be highly private and could be made secure. Since no new technology needs to be installed, users are largely left unbothered. The annual inspections approach would be somewhat less private than the self-reported system, since users must comply with periodic inspections. Privacy and system security are also enhanced under the mileage estimate approach. Although Automatic Vehicle Identification (AVI) devices would have to be attached to each vehicle, the information stored in these devices would be minimal.

Under administrative feasibility, the self-reported system would have relatively low implementation and operating costs; however, enforcement would be highly difficult and thus costly. The Sorensen et al. (2009) report notes that odometer fraud is already a non-trivial problem, and cites the difficulty of enforcement as the main drawback to the self-reporting system. The self-report system is also associated with a relatively high compliance cost since all users must themselves submit odometer readings to the Department of Motor Vehicles or similar agency.

The annual inspection system would incur significantly higher operation and enforcement costs. Sorensen et al. (2009) note that the extra operation costs needed to conduct odometer inspections would lead to a disproportionately higher per-mile fee than for fuel taxes. The report goes on to note that, while two-thirds of the states already have the infrastructure in place to conduct annual inspections, inspections of emission equipment are done infrequently. There would also be compliance costs associated with users having to make trips to comply with inspection requirements.

The mileage estimates approach would also have significant administrative costs. Whitty et al. (2009) estimated that the needed equipment at gas stations would cost approximately $15,000 per station, while producing and installing AVI devices on existing vehicles could cost as much as $50 per unit. Sorensen et al. (2009) note that the costs could be substantially lower depending on the specific deployment strategy. Furthermore, fuel efficient vehicles would have an incentive to disable their AVI device. Although drivers without a properly functioning AVI device would then have to pay fuel taxes as opposed to a charge based on estimated mileage, their total payment could be substantially lower if they operate a fuel efficient vehicle.

Simple OBD unit approaches have mixed results when it comes to administrative feasibility. While most vehicles would have to be retrofitted with technology, this would involve a simple connection to the OBD II port, which is already installed in all vehicles produced after 1996. Since users would have incentives to disconnect their units to avoid the charges, enforcement would be a significant hurdle, and could increase costs. As with the other systems, compliance costs would be increased as drivers would have to deal with periodic bills.

4.4 OPTIONS TO METER MILEAGE ON SELECTED ROADS ONLY

Descriptions of the policy options, DSRC and e-Vignettes, for this section can be found in the distance-based technology options section. The two options are somewhat similar in design; however DSRC is a more complex yet flexible system. The two systems differ from previously discussed options since DSCR and e-Vignettes have typically been thought of as options to supplement fuel taxes rather than serve as a significant replacement.

4.4.1 Efficiency

A DSRC system can provide flexibility with regard to pricing and thus has the ability to make improvements in the area of efficiency. Since charges can vary with time and location, if rates are flexible and set at an appropriate level, this can lead to more efficient driving behavior, especially on those roads that are typically congested.

Since it does not have the flexibility of DSRC or other MBUF systems, an e-Vignette system would not perform as well under efficiency considerations. Furthermore, because the tolls to travel specific roads are paid up front, this will lead to an incentive to overuse the system.

4.4.2 Equity

Equity is also improved as charges come in line with costs imposed for the tolled portions of the network. Like other MBUF systems, fuel efficiency gains and alternative vehicles will not disrupt efficiency and equity under a DSRC system. However, since DSRC systems would not be feasible for the whole road network, equity problems could continue to persist if fuel taxes are left in place.

An e-Vignette system could lead to other undesirable equity effects. As mentioned before, tolls are paid up front. Thus, those users that travel the tolled roadway often will be rewarded, while those users who buy the e-Vignette sticker but then for whatever reason fail to travel the roadway frequently will be punished.

4.4.3 Revenue adequacy and sustainability

Both DSRC and e-Vignettes would likely lead to improvements in the area of revenue adequacy and sustainability. DSRC and e-Vignettes would not solve all revenue issues since they are primarily envisioned as supplementary systems, however they would bring about a steady and predictable revenue stream for the tolled roadways.

4.4.4 Environmental sustainability

Like other MBUF systems, for environmental sustainability to be enhanced vehicle emission characteristics must be factored into charges. Since DSRC and e-Vignettes would likely not completely replace fuel taxes, the fuel tax component of the total system would aid with environmental sustainability. This could bring about greater clarity in policy debates since fuel taxes are left in place as a tool to target environmental sustainability, while DSRC or e-Vignettes focus primarily on roadway use.

4.4.5 Feasibility

Finally, both DSRC and e-Vignettes do not have some of the hurdles faced by other MBUF systems when it comes to political and administrative feasibility. Robinson (2008) notes the feasibility advantages of the e-Vignette system stating, "…[I]t can be implemented relatively easily; the risk of manipulation, theft or forgery is low; no drive or vehicle data is kept, except for license plate number, emission class and other charge-related data; enforcement technology cost is low…" (p. 12). Especially compared to the GPS options, DSRC and e-Vignettes represent very limited privacy issues. Since the entire roadway would not be tolled, and DSRC and e-Vignettes do not involve any sort of technology that would be able to pinpoint one's location, motorists should feel that their privacy is protected. DSRC would acknowledge when a motorist passes under a tolling gantry, but this would be quite a limited intrusion.

When it comes to administrative feasibility, an e-Vignette system performs relatively well. While users would have to obtain a sticker and electronically register their vehicle as part of the program, no new technology would have to be installed. Furthermore, although payment would be shifted to each individual user, payment would be very transparent and would not involve complicated bills or payment methods. The DSRC system would have some administrative hurdles since it would involve installing gantries along the tolled roadway. Furthermore, the payment method would be more complex and would most likely involve setting up a central billing agency. Nonetheless, Sorensen et al. (2009) note that the "cost of in-vehicle equipment with this option would be low" (p. 70).

4.5 OPTIONS TO METER MILEAGE BY TIME AND LOCATION

Options to meter mileage by time and location include fine-resolution GPS and OBD II / cellular units. Descriptions of both can be found in the distance-based technology options section. The main difference between these two technologies is that the fine-resolution GPS can identify the specific roadway that the user is on, while OBD II / cellular technology can only identify an area or zone of travel. Thus, the fine-resolution GPS approach has greater capabilities and flexibility for fine-grained road pricing.

4.5.1 Efficiency

Fine-resolution GPS and OBD II / cellular approaches allow for the most dynamic pricing options, and thus has the potential to improve efficiency beyond the capabilities of the other systems. GPS options allow policy makers to price specific routes of travel to account for type of road surface or level of congestion. By pricing in this way, fees pay can more accurately reflect costs imposed and thus lead to a more efficient use of the roadway. The OBD II /cellular approach leads to gains in the area of efficiency since the cellular component is able to detect different zones. With the OBD II /cellular approach, congestion pricing could be applied whenever a driver was traveled in an urban area or predetermined congested zone.

4.5.2 Equity

Similar to the arguments under the efficiency principle, because of the precision of GPS, fees charged can be matched to costs imposed and thus equity is enhanced. If benefits (improved capacity and maintenance) are tied to payments, the GPS approaches have the capability of precisely assigning revenues so that the user-pays-and-benefits principle is satisfied. The OBD II / cellular approach leads to gains in the area of equity since the system can be designed to charge drivers who travel during congested periods and thus impose congestion costs on others.

4.5.3 Revenue adequacy and sustainability

Similar to other MBUF-based systems, fine-resolution GPS and OBD II / cellular approaches lead to improvements in the area of revenue adequacy and sustainability. And since charges are based on miles traveled, improvements in fuel efficiency will not erode revenues.

4.5.4 Environmental sustainability

Similar to other approaches, if vehicle characteristics are taken into account in setting rates, environmental sustainability can be enhanced under a GPS or OBD II / cellular approach. Both technology approaches could improve environmental sustainability to the extent that congestion pricing decreases congestion and related emissions.

4.5.5 Feasibility

Where GPS options succeed in terms of efficiency and equity, they also represent significant political feasibility hurdles. Although there are reputable strategies to protect privacy, any GPS option will continue to represent a privacy concern in many motorists' minds. To a lesser degree, the OBD II / cellular unit approach will also have some privacy concerns since it is able to detect zone of travel.

The GPS and OBD II / cellular options will also have significant administrative hurdles since like other MBUF systems it involves a dramatic increase in total collection points, and involves retrofitting vehicles with new technology.

Whitty et al. (2009), in describing the Oregon system that utilized coarse resolution GPS as opposed to fine-resolution and a pay-at-the-pump approach, noted, “This model embeds mileage charge payments into an existing payment system for fuel purchases. As a result, the system can minimize operational costs because of seamless integration of mileage charge payments into the existing gas tax collection system” (p. 46). In regards to enforceability, the authors go on to note, “Additional auditing costs should only be slightly higher than the gas tax. The system can assure enforcement of mileage charge payments because access to fuel can be conditioned upon payment of the charge” (p. 46-47).

Since users would have incentives to disconnect their OBD II / cellular units to avoid the charge, enforcement would be a significant hurdle, and could increase costs. Donath et al. (2009) provide several solutions to the enforcement problem with the cellular approach, including tamper-proof seals, random automated checks, checks against fuel usage, and using law enforcement personnel during traffic stops.

4.6 CONCLUSIONS

This chapter considered seven technology options for MBUF implementation. As we have seen, each option presents different strengthens and weaknesses under our five transportation funding principles. Table 4.2 below scores each of the seven options under their ability to achieve our policy principles.

Table 4.2: Technology Options’ Ability to Achieve Transportation Finance Principles

Option	Efficiency	Equity	Revenue Adequacy and Sustainability	Environmental Sustainability	Feasibility
Odometer Checks	Moderate	Moderate	Strong	Moderate	Strong
Fuel Consumption-based Estimates	Moderate	Moderate	Strong	Moderate	Strong
On-board Diagnostic (OBD II) Units	Moderate	Moderate	Strong	Moderate	Strong
OBD II / Cellular	Strong	Strong	Strong	Moderate	Strong
Dedicated Short-range Communications (DSRC) – Partial Road Network Only	Moderate	Moderate	Weak	Moderate	Strong
e-Vignette	Moderate	Moderate	Weak	Moderate	Strong
Fine-resolution GPS	Very Strong	Very Strong	Strong	Moderate	Weak

Given our principles and the current state of technology, different conclusions can be reached about which technology option would be the most suitable mechanism for collecting transportation user fees. While a DSRC or e-Vignette approach would not encompass all roadways and thus would not be able to completely replace the need for fuel taxes, they may still be appealing to some policymakers because of their feasibility and ease of implementation. Policy makers who wish to find a replacement to fuel taxes, but who are less concerned with system flexibility, may prefer odometer checks, fuel consumption-based estimates, or OBD II units. Still others may opt for an OBD II / cellular, or fine-resolution GPS approach because of the efficiency and equity gains encompassed with these options.

Changes in technology and the political climate, as well as the design and administration of the system, will affect both the administrative and political feasibility of all of the options presented in this chapter. Furthermore, the myriad of transition issues will have to be navigated before any of the options could be effectively implemented. Our next chapter will discuss the design and administration of a MBUF, as well as important transition issues.

CHAPTER 5. ACTION PLAN FOR IMPLEMENTING DISTANCE-BASED USER FEES

We have examined how fuel taxes and MBUFs fare under transportation finance principles and have explored potential technology options for implementing MBUFs. In this fourth chapter we present an action plan for planning and implementation. The action plan is presented in four parts. The first two sections address the potential design and administration of MBUFs. Under design we discuss both the appropriate tax base and rate. Under administration we address three important questions: At what level is MBUF pricing implemented, and who collects the revenue? How are revenues allocated among jurisdictions? And, How best to manage the system and its costs? The third section covers important transition issues such as demonstrations and trials, and early deployment options. Finally, we conclude our action plan with a discussion of the education and outreach that is needed to bring about greater public awareness and acceptance of MBUFs.

5.1 DESIGN

5.1.1 Tax base

The first step in designing a MBUF system is determining the tax base. That is, what exactly should be taxed? A MBUF base could potentially include all vehicle-miles traveled. However, there may be reasons for not following this approach. Decisions that need to be made include, among others, the kinds of vehicles charged, type and location of roadways charged, and exceptions and exemptions that apply.

What kinds of vehicles should be covered under a MBUF system? Currently, several types of vehicles are exempt from paying fuel taxes, and there may be good reasons to continue some of these exemptions under a MBUF system. Emergency vehicles, state governments, and non-profit educational organizations are exempt from paying federal fuel taxes (National Surface Transportation Infrastructure Financing Commission 2009). Some in the trucking industry have argued that the trucking industry should be exempt from a MBUF, and continue to pay their fair share through fuel taxes. Bob Pitcher of the American Trucking Association expressed the trucking industry's position in a presentation to the 2010 Symposium on Mileage-Based User Fees (Coyle et al. 2010). As noted in the Symposium's proceedings:

> "First, motor carriers are likely to oppose a VMT fee on heavy trucks…The trucking industry has always supported a user fee system and a fair vehicle registration system that is based on weight, but not a weight-distance tax. A VMT on trucks will be rightly viewed as a weight-distance tax and opposed by trucking. More than 20 states have repealed weight-distance taxes with only four states still having them in existence today. Weight-distance taxes are cumbersome, expensive, unfair, and open to evasion. The same problems undermining gasoline taxes are not present in the trucking industry as there is no satisfactory alternative to diesel fuel for heavy trucks, so there is less need to look at VMT for the trucking industry" (p. 20).

While Pitcher may be right that the trucking industry does not pose some of the problems that undermine the gas tax such as auto use of alternative fuels, fuel tax revenue decreases are not immune from future improvements in truck-fleet fuel efficiencies. Although heavy-duty vehicles have not seen their fuel efficiencies increase since the 1970s, as experienced by light-duty trucks and cars, the EPA and National Highway Traffic Safety Administration adopted new fuel efficiency standards for heavy-duty trucks, in the order of 37 mpg (15.7 km/L) by 2016 (EPA 2010). As the fuel efficiency of heavy-duty trucks increases, the trucking industry will pay less and less in fuel taxes per mile traveled. In addition, road and bridge wear-and-tear is directly related to vehicle weight, and heavy trucks are substantial contributors. In this respect, the argument can be made that a MBUF is a more direct and fairer user-fee system, which the industry seems to support. Thus, on efficiency, equity, and revenue sustainability grounds, there is good reason to include heavy-duty vehicles in addition to light-duty trucks and cars in the tax base of a MBUF.

A second consideration is whether to cover all vehicles regardless of fuel type. While our analysis in past chapters has shown that efficiency, equity, and revenue sustainability would be enhanced by converting all vehicles from a fuel tax to a MBUF system, some have suggested that MBUFs be implemented only for vehicles that are not currently paying fuel taxes (i.e., electric vehicles). An exploratory study by the Texas Transportation Institute discussed at the 2010 Symposium on MBUFs concluded from focus group meetings that the public thought that electric vehicles should be targeted first (Coyle et al. 2010). While there is good cause to move all vehicles to a VMT system, it may prove more politically feasible to begin with electric vehicles. As noted by Ferrol Robinson at the 2010 Symposium on Mileage-Based User Fees, electric vehicles may represent the “lowest hanging fruit” since they currently do not pay any fuel taxes (Coyle et al. 2010). Furthermore, a bill has been introduced in Oregon to tax electric vehicle owners by the mile.

One concern about the above limited approach to implementing distance-based charges is the complexity and cost of a system that focuses on such a small number of vehicles. This approach may prove to be impractical and infeasible because it lacks economies of scale.

In addition to deciding what types of vehicles should be included in a MBUF system base, it is important to consider what types of roads should be included. Should the base be system-wide, limited to highways, or only in specific local areas? As discussed in the previous chapter, Dedicated Short-range Communications (DSRC) and e-Vignette options are able to only cover some roadways. These options could be applied to the most congested roadways to reduce congestion and raise revenue, while fuel taxes are left in place to raise the bulk of transportation revenue. While these approaches have some appeal, and reducing congestion is important, other options like GPS-based approaches or OBD II / cellular would be able not only to price for congestion but to cover the entire road network. Given the growing inadequacies of the fuel tax system, it would be prudent to develop a system that is able to cover all roads, while leaving the fuel tax option open to be replaced by MBUFs over time.

5.1.2 Tax rate

The second critical component in the design of a MBUF is the tax rate. Whitty et al. (2009) give careful consideration to the potential tax rate for a MBUF system but note that, “The ultimate structure will result from a legislative body considering various public policies and blending them to accomplish several goals” (p. 8). These goals could range from reducing congestion to encouraging environmental sustainability. Whitty et al. (2009) go on to describe three potential rate structures for a MBUF:

> "*A flat rate*. At the simplest level, a basic mileage charging rate can be flat but a flat rate is not a fundamental characteristic of per-mile charges. Policymakers can establish a rate structure as something other than flat, stack other rates on top of a flat rate or apply a multiplier to a flat base rate, among other possibilities.
>
> *A stacked rate*. An alternative to the flat rate involves stacking another rate on top of the flat rate to allow rate variability. For example, policymakers may apply a fuel inefficiency penalty to high fuel consuming vehicles in addition to the flat mileage charge rate. The structure could be built on top of a flat basic rate charged the more fuel-efficient vehicles.
>
> *A multiplied rate for externalities*. A second structural variation would rate each vehicle for its impact on external environmental factors. Those vehicles with the least impact could be assigned a multiplier of 1.0 and those with the greatest impact a multiplier of perhaps 6.0. When the rates for each zone are applied for mileage charge payment, a motorist's multiplier would be applied against the base rate for that zone to determine payment. Vehicles with greater impact on external factors would pay more and those with less impact would pay less" (p. 8).

As discussed in previous chapters, the external costs associated with congestion are substantial. For 2007, congestion costs for U.S. urban areas were estimated at $87.2 billion (Texas Transportation Institute 2009). Thus, given these significant costs, using a "multiplier" or applying a rate that varies with congestion would make sense when designing a MBUF system's rate structure. Furthermore, given the U.S. Department of Transportation's stated aim of improving transportation while protecting the environment (Environmental Protection Agency 2009), applying a "stacked rate" for dirtier and less efficient vehicles should also be strongly considered, especially if the MBUF system is designed to replace fuel taxes.

A final consideration when discussing the tax rate and tax base is level of revenue to be raised. Should a MBUF system be revenue neutral and raise the same amount as that raised under the fuel tax system? Should it raise enough revenue to address the projected shortfalls in the Highway Trust Fund and gaps in our national infrastructure funding needs? Or should it raise some other amount? The 2010 Symposium on Mileage-Based User Fees (Coyle et al. 2010) generated much discussion regarding the proper amount of revenue to be raised through a MBUF system. Although opinions varied, a commonly-held view was that, given the recurring shortfalls in transportation funding, it is prudent that MBUFs should be designed to raise more money than would be raised under the current fuel tax system.

5.2 ADMINISTRATION

This section considers three specific questions regarding how a MBUF system would be administered. First, at what level should MBUF pricing be implemented and who collects the revenue? Second, how should the revenue be allocated and for what use? Under this question, we consider how revenue could be allocated by jurisdiction, and whether revenue should be dedicated to local funds, the Highway Trust Fund, and/or the general fund. Finally, this section concludes with an investigation of how best to manage the system and its costs.

5.2.1 At what level is MBUF pricing implemented and who collects the revenue?

This has become an important topic as policymakers and practitioners debate MBUF pricing. Whitty et al. (2009) outlined several issues related to State vs. National implementation and concluded that, "The national interest calls for a single system that individual states can access and upon which states can build policies" (p. 114). The bullets below highlight the drawbacks from state-by-state implementation, and the advantages of national implementation, as noted by Whitty et al. (2009).

- "Interoperability may become unachievable as states choose different collection methodologies, technologies and policy goals.
- Single state implementation would require the cooperation of motor vehicle manufacturers…an isolated state would likely face tremendous resistance in imposing equipment standards on vehicle manufacturers.
- Implementation by an individual state or group of states would require special systems, potentially cumbersome, for charging out-of-state vehicles.
- For states wanting to allow congestion pricing, environmental charging or local-option charges, charging out-of-state vehicles becomes exceedingly cumbersome and impractical when considering legal requirements.
- Though heavily reliant upon gas tax revenues, most states have substantial additional revenue sources contributing to state highway funds. Since about 90 percent of the Federal Highway Trust Fund consists of fuel tax revenue, the Federal government has the most at stake in finding an implementing a suitable gas tax alternative as soon as possible.
- Further, a federal mileage charge may be more difficult to impose if the states adopt widely differing collection systems. A national collection system, on the other hand, can be designed to accommodate state applications" (p. 114).

While having national support appears critical to the successful implementation of MBUF pricing, Sorensen et al. (2009) note that some potential MBUF pricing mechanisms "would likely require significant support from the states" (p. 27). Sorensen et al. (2009) go on, "For example, to levy VMT fees based on odometer readings, states might be called upon to perform odometer inspections and collect VMT charges on behalf of the federal government" (p. 27). To gain greater insights into state issues and attitudes in regard to VMT pricing, the research team involved in the Sorensen et al. (2009) study obtained input from officials from eight states: Texas, Minnesota, South Carolina, Vermont, Oregon, California, Virginia, and New York. The bullets below document themes that emerged from the interviews with state officials with regard to their attitude towards MBUFs (p. 36-37).

- "VMT fees are seen as highly desirable, even inevitable, due to declines in fuel tax revenues.
- State DOTs have been following the Oregon pilot program with interest.
- States are waiting for the federal government to take the lead.
- States vary in their assessments of the necessary characteristics of a VMT fee system.
- A VMT fee should be mandatory, and co-exist with a gasoline tax.
- Appropriate technologies already exist.
- Self-reporting of odometer readings or other data is probably not a good idea.

- Alternative fueled vehicles are not a major issue now, but eventually they will be."

Several themes also emerged with regard to barriers to MBUF pricing implementation and potential solutions (p. 37-38):

- "Privacy and legislative issues are the main barriers.
- Privacy concerns might be addressed by third-party management of the collected data.
- Payment options may influence support.
- Public education will be needed to develop support."

Keeping in mind both Whitty et al. (2009) and Sorensen et al.'s (2009) analyses, it would seem that for MBUF pricing to be successfully implemented it must receive both state and federal support. Furthermore, it may be critical to have overall federal support while allowing states to tailor pricing for their state to match political and legislative hurdles, revenue needs, and other policy goals. For example, Sorensen et al. (2009) noted that while one state considered the ability to allow for congestion pricing essential, another state did not see congestion pricing as essential, but saw border issues as critical. Finally, policymakers will have to determine if it is more politically feasible for revenues to be directly collected by government, or whether a private company should collect the revenue on the government's behalf. Certain segments of the population that are weary of having their driving behavior recorded by the government may prefer a private company collecting data and revenue, while other segments may prefer the government to directly collect data and revenue.

5.2.2 How should revenue be allocated and for what use?

While economists do not reach a conclusion on whether road pricing revenue should be dedicated for transportation or be allowed to go into the general fund, a growing number of transportation researchers and economists believe that MBUF revenue should be dedicated for transportation improvements (Lindsey 2006). At the 2010 Symposium on Mileage-Based User Fees, Adrian Moore of the Reason Foundation and National Surface Transportation Infrastructure Financing Commission, discussed a set of issues as part of a panel on transition issues. The proceedings from the symposium (Coyle et al. 2010) note that on the issue of the use of revenue, Moore noted,

> "Is it going to be a user fee or will it be a mileage-based tax that goes into a general bundle of spending? Doing this (allocating to general fund) would be myopic. The fuel tax is a second-best user fee. Mileage-based user fees are a first–best. It would be imprudent to shift it to a tax. Spending the money ties into the public trust issue, because people want to know what the money is going to be spent on" (p. 34).

The views expressed by Moore with respect to where revenues should go are not uncommon in the MBUF pricing community, however, given the current fiscal situation, it would not be out of the realm of possibility for revenue to go to the general fund or be used for deficit reduction, as a portion of the gas tax was used for from 1990 to 1997. Nonetheless, for MBUF pricing to have public acceptance and be politically feasible it may be necessary to dedicate revenue to transportation improvements. As stated by Lindsey (2006), "A growing proportion (and perhaps now a majority) seems to favour earmarking revenues in some way. However, it may be that they support earmarking only reluctantly as a necessary concession for road pricing to move forward"

(p. 341). Munnich (2009) has argued that successful implementations of congestion pricing have always been bundled with transit improvements, and that failed attempts at introducing congestion pricing are linked to inadequate attention to transit in the implementation proposals. To gain political and public approval, it may be necessary to dedicate revenue from MBUF pricing to the transportation system, with a portion going to transit.

Even if MBUF revenue is dedicated for transportation purposes, allocation questions remain. Primarily, how will revenue be allocated between different jurisdictions? It has been heavily documented that the current system of fuel taxes has set up a system of donor states and beneficiary states. If a federal MBUF was implemented, whether this system of donor and beneficiary states would persist is largely dependent on whether careful attention is given to this matter. However, given the precision of the technology involved with MBUF pricing, it may be worthwhile to consider rectifying the donor/beneficiary system. As noted by Whitty et al. (2009),

> "With a national system able to identify the particular states in which travel occurred, allocation of mileage charge revenues among states has the potential to directly relate to travel within each state. As a result, the donor/donee revenue allocation struggle may reemerge with new evidence to support the various arguments. In this context, researchers should study the potential impact of geographically identified mileage charges upon revenue allocations among states as compared to the existing allocation formula" (p. 88).

Finally, it may be appealing for states to piggyback off of a federal MBUF pricing system. Motorists would then pay fees to both federal and state or local coffers with revenue being allocated according to federal, state, or local formulas. Given the precision of the tools that would be used to track mileage (i.e. fine-resolution GPS), MBUF revenue could be precisely allocated to the state or even roadway in which the VMT took place. As noted by Whitty et al. (2009), "If system technology could identify specific facilities for travel, the mileage charge revenue allocations could become even more granular. Under this scenario, the system might generate precise VMT data for specific federal-aid facilities with the potential for facility-based revenue allocations" (p. 88).

5.2.3 How best to manage the system and costs?

At the 2010 Symposium on Mileage-Based User Fees, the Chief Economist at the U.S. Department of Transportation, Jack Wells, gave a presentation regarding the administrative costs of MBUF pricing. Wells explained that administrative costs vary with different MBUF pricing systems and mechanisms as well as with what revenue is being generated (Coyle et al. 2010). Before getting to Wells' comments, it is important to note the distinction between a thick OBU and thin OBU. As described by Grush et al. (2008), "'[T]hin' systems, which means that location data are forwarded from the car to a data center where charges are calculated and billed using those data, and 'thick' ones which means everything is handled inside the vehicle including payment…" (p. 3). Wells discussed a U.S. Department of Transportation sponsored study that found the following with regard to administrative costs (Coyle et al., 2010):

- "Fuel tax costs…are generally about 1 percent of revenues.
- In a national user-based charge system video and AVI would generally be impractical. However, in a limited deployment administrative costs would run at about 26-51percent

of revenues if readers are used every 2 miles, 3-5percent if used every 20 miles, and 1-2percent of revenues if readers are used every 50 miles.

- Thick OBUs run about $650 and are more complex to update on a regular basis but have fewer privacy concerns. Thin OBUs cost less, about $195 per unit, but have more privacy concerns and higher data transmission costs. However, they are easier to update in terms of mapping software.
- Transaction costs are very low with GPS, running about 0.07percent of revenues. Capital costs would be about 1-4percent of revenues. Total costs of the system, if including the costs of OBUs, would be 7.9percent of revenues for a thin OBU configuration and 33.2percent of revenues for a thick OBU" (p. 33).

Wells concluded that GPS is the only feasible technology for a nation-wide MBUF pricing system and that, "administrative costs are feasible if a thin OBU configuration is used" (Coyle et al. 2010, p. 33). Wells went on to note that the costs from a GPS, thin OBU configuration are still higher than the cost to administer fuel taxes, and thus collection costs from a MBUF "could only be justified if significant benefits other than just collecting revenue…are realized" (Coyle et al. 2010, p. 33). Thus, based on Chief Economist Wells' remarks, it would appear that the best path forward in regard to costs is some form of a GPS, thin OBU approach. While this may be the best approach now, as technology changes and costs are thereby altered, another approach may prove to be superior.

There are several ways to manage or limit costs. Some of these cost limiting schemes include:

- Setting a threshold for enforcement and compliance based on an analysis of cost-effectiveness.
- Establishing a level of administrative/maintenance/operations costs as a percent of revenues, and making that threshold percent a requirement of the project.
- Reducing redundancies except where needed for safety, reliability and other critical requirements.
- Capitalizing on in-vehicle devices ability to provide added services.
- Fostering competition in the marketplace with interoperable devices.

5.3 TRANSITION ISSUES

While MBUFs perform well under the principles of efficiency, equity and revenue adequacy and sustainability, they face considerable hurdles in the area of feasibility. To gain greater public support for implementation of MBUFs, it is mandatory to address transition issues. This section gives attention to two transition approaches to reach full implementation: system trials and early and optional deployment options. A subsequent section deals with public education and outreach needs, which are also essential to the successful implementation of MBUFs.

5.3.1 System trials and in-place systems

For the most part, transportation professionals agree that, for MBUF pricing to be successfully implemented, there needs to be full trials to demonstrate the capabilities of the MBUFs approach. Recognizing this, the NCHRP recently released a study led by the RAND Corporation entitled, *System Trials to Demonstrate Mileage-Based Road Use Charges* (Sorensen et al. 2010), which highlights a number of issues to be considered when crafting and implementing MBUF trials. The study carefully examined several factors including: oversight, management, and conduct of the trials; organizing, funding, and coordinating them; size, duration, and cost of the trials; metering and pricing policies; technical and institutional issues; implementation and phase-in issues; user acceptance; and detailed strategies for implementing the trials. As noted by the study,

> "While the trials envisioned in this study would require considerable investment, they would also play a critical role in helping to prepare for the potential implementation of VMT fees by states or at the federal level within the next five to ten years. The prospect of designing, implementing, and transitioning to a system of VMT fees poses numerous technical, institutional, and political challenges and there are many remaining uncertainties. The trials described in this study are explicitly intended to reduce or resolve such uncertainties in order to inform the policy debate and prepare for the possibility of subsequent implementation" (p. xxxiii).

While the NCHRP report provides guidance, and will be useful in designing future trials, several successful trials of MBUFs, and one full implementation, have already occurred. Documented below are some of the experiences with demonstrations, trials, and implementation systems, both domestic and abroad. Results and conclusions were obtained from the National Surface Transportation Infrastructure Financing Commission's report (2009), unless noted otherwise.

Oregon VMT Pricing Pilot Project (trial): The concept is viable; paying at the pump works; the mileage fee can be phased in; integration with current systems can be achieved; congestion and other pricing options are viable; privacy can be protected; the burden on business is minimal; there is minimal evasion potential Implementation and administration costs are manageable.

University of Iowa Public Policy Center (trial): People switched their perspective on MBUF after participating in the study; participants generally preferred audit ability over privacy; during implementation folks will need to be given the opportunity to change their preferences after initial enrollment (MBUF 2010).

Puget Sound Regional Council (trial): Region-wide variable pricing in the form of optimal tolls on all freeways and arterial streets would result in significant travel time and vehicle operating cost savings for all income classes; pricing could generate enough revenue to finance all identified regional transportation needs over the life the current Metropolitan Transportation Plan.

Germany Heavy-Vehicle Tolling (system in place):

- **Outcomes**: A national GPS based system for trucks can be successfully implemented on a large scale; after a few years the number of environmentally-dirtier trucks had declined by 50 percent, and the number of trucks traveling empty declined by 20 percent; revenues collected met targets initially and have since exceeded estimates; total costs have declined from 25-30 percent of revenues, initially, to 15-20 percent.
- **Lessons Learned**: A clear and strong rationale is needed to create support among affected stakeholders for any proposed pricing scheme; a clear statement of objectives, subscribed to by stakeholders, interest groups and political parties, is key to securing broad support

and necessary for guiding system development and measuring outcomes, ensuring adherence to principles that secure pre-implementation agreements; a realistic implementation schedule has to consider the magnitude and complexity of the system as well as the time required to develop and integrate complex technologies; the impact of system requirements and specifications on system implementation and operation costs need to be considered early in the process, and adequate trade-offs need to be made at that time; concerns about privacy have to be addressed (Robinson 2008).

The Netherlands (developing system): Pricing has been attempted six times since 1988. The current attempt is currently in limbo due to the political situation in the Netherlands. Societal support is key driver, Keep it simple and stupid-this way all users can understand the system, Think backwards: exploitation, expand, test, build, develop and incorporate corresponding stakeholders during all steps in project development, Keep to basic principles: paying for use, revenue neutrality and allocating revenues to infrastructure, Focus on clear message as to why the system is necessary (Coyle et al. 2010).

The Euro-Vignette: This is a sticker-based system that charges vehicle users based, typically, on emission level, time of travel, number of axles, and specific traffic regulations (Robinson 2008). This system was initially introduced in 1995, and is currently used in five countries: Sweden, Denmark, Belgium, The Netherlands, and Luxemburg (Eurovignette 2010). Since October 1, 2008, users have been able to register their vehicle online, thus removing the need to carry paper documentation of their enrollment in the program (Eurovignette 2010). Robinson (2008) notes the advantages of this system: ease of implementation, low risk of manipulation, need for storing only limited data, low enforcement costs, and the ability to expand to cover additional vehicles.

Despite these experiences, Whitty, who was heavily involved with the Oregon Pilot, makes several suggestions for future state-run, but-federally funded and directed pilot programs (Whitty et al. 2009). Whitty's suggestions and their purposes are documented below.

- **Technology refinement of closed-system pay-at-the-pump model**: Completion of system design and technology refinement for the pay-at-the-pump model.
- **Central billing pilot program**: Test the central billing model under which an on-vehicle device generates mileage data by location then wirelessly sends that data to a collection center for billing by mail or e-mail to the vehicle owner's residence.
- **Open system pilot program for the integrated approach**: Test an integration of the central billing approach and the pay-at-the-pump model using an open system for technology applications that allows flexibility in applying technologies for mileage data generation, data transfer, data management and payment.
- **Electronic toll road integration pilot program**: Test integration of an electronic mileage charging system with modern all-electronic toll road systems that currently use central collection methodology.
- **VMT estimate pilot program**: Test the potential for adoption of an interim system that estimates mileage at the fuel pump using an inexpensive AVI device.
- **Electronic weight-distance tax pilot program for heavy trucks**: Test a separate electronic charging system for heavy trucks that accounts for factors beyond mileage, including distributed weight and configuration.

- **Multi-state contiguous broad scale pilot program**: After research allows reading some core conclusions, the national government should sponsor a broad scale pilot program that includes several contiguous states.

5.3.2 Early deployment options

As noted by Sorensen et al. (2009), “An assumption common to earlier VMT-fee concepts (Forkenbrock and Kuhl 2002, Whitty 2003) is that retrofitting vehicles with the required metering equipment would prove to be an extremely costly and cumbersome undertaking” (p. 93). Sorensen et al. (2009) and other researchers have given thought to ways to smooth the transition by encouraging motorists to “opt-in” and obtain the necessary technology to allow MBUF pricing. Sorensen et al. (2009) identify three factors that could be used as incentives for drivers to “opt-in”: greater convenience, lower costs, and access to desirable functionality.

In terms of convenience, Sorensen et al. (2009) note that in-vehicle equipment could allow for automated payment and alleviate the need for owners to submit to an annual odometer inspection. Under lower costs, Sorensen et al. (2009) first cite a Minnesota project which aims to encourage voluntary adoption through a reduced per-mile fee, Sorensen et al. (2009) then state about the concept:

> “Applying this concept to the mechanisms under consideration here, all conventionally-fueled vehicles might be equipped with a simple AVI device by 2015 to meter estimated mileage based on fuel consumption, with a moderately high per-mile charge. Vehicle owners willing to voluntarily adopt an OBU, however, would qualify for lower rates for rural or off-peak mileage, though they perhaps might also be required to pay higher rates for peak-hour travel in congested periods. The potential to reduce fees should encourage at least some drivers to adopt the equipment sooner rather than later. Another option would be to raise fuel taxes during the transition period such that adopting VMT fees would be cheaper than continuing to pay fuel taxes” (p. 94).

In terms of providing access to desirable functionalities , Sorensen et al. (2009) note that OBUs could offer additional features (e.g., in-vehicle navigation) as incentives for motorists to obtain them. A desirable functionality that could encourage users to opt-in is pay-as-you-drive insurance. Prior to the 2010 Symposium on Mileage-Based User Fees, a workshop was held on integrating pay-as-you-drive (PAYD) insurance and mileage-based road user charges. The workshop brought together representatives from the insurance industry and researchers involved with mileage-based fees to gauge the interest of insurance companies in partnering on mileage-based user fee projects. The workshop revealed (Humphrey Institute 2010) that, “[T]he interest level in partnering on future pilots was very high if the insurance companies would be offered the freedom to design the projects to meet their own needs.” (p. 1) These needs being data that would provide insights on driving behavior that could be used to help formulate PAYD policy structures (Humphrey Institute 2010).

5.3.3 Transitional issues and adoption scenario

At the 2010 MBUF Symposium (Coyle et al. 2010) Robinson noted several important transitional issues that need to be thought through by policymakers:

- “What vehicles and vehicle classes will be charged? (Electric vehicles may represent the ‘lowest hanging fruit’ due to the fact that they are currently not paying anything.)
- What roads and jurisdictions will be priced?
- What will be the geographic coverage (urbanized areas, statewide, nationwide, etc…)?
- Will participation be voluntary or mandatory? Will incentives be offered if voluntary?
- What taxes and fees will be replaced/supplemented be the road user charge?
- How will the mileage charge rate be structured (flat, variable)?
- What is the basis for the rate structure (revenue neutrality, recover costs, etc.)
- What technology will be used? Will available in-vehicle technology be used or will after market devices be utilized?” (p. 36-37).

As indicated previously, some have argued for a gradual introduction of MBUFs, which would require that fuel taxes remain in place for some applications over a period of time, while MBUF coverage would gradually be expanded over the same period of time. An often-cited example is to initially implement MBUFs for electric or other alternative vehicle-propulsion systems that are de facto exempt from fuel tax payments.

One possible adoption scenario is the creation of a new transportation funding tax structure that could be made up of the following three components:

- *Base Fuel Tax Component—Federal and State Level*
  Under the new transportation funding tax structure, fuel taxes would be reset to a lower base rate that would be sufficient to generate revenues for baseline transportation needs. Base fuel taxes would be designated for road and bridge maintenance and operation, and would include user and system safety and enforcement. The aim would be to ensure that ongoing funds are available to preserve the system and to protect the significant investment in federal and state infrastructure.

  Base fuel taxes would maintain their highly desirable built-in incentive for using fuel-efficient, alternative-fuel and lighter vehicles, all of which use less fuel per mile and, therefore, would pay less in fuel taxes. In other words, base fuel taxes would continue to help achieve national and state policy objectives related to reducing energy consumption and tailpipe emissions.

- *Mileage-Based Charge Component—Federal and State Level*
  The aim of this mileage-based pricing component would be to fund road and bridge reconstruction and expansion, including right-of-way acquisition. The mileage-based user charge would be set at levels that compensate for the reduction in fuel taxes to the base rate. Because these charges would be set on a per-mile basis, the approach would complement the state and federal objectives that fuel taxes support. It is likely, however, that MBUFs would have a greater impact in reducing vehicle-miles, encouraging greater use of alternatives modes of transportation, and reducing cost externalities such as congestion and crashes.

- *Mileage-Based Charge Component—Local Option*

The third component aims at funding local roads. As a basic approach, the MBUF would be a local option that would replace the patchwork of local sales taxes that fund local roads. This MBUF approach would give local governments the ability to undertake their own transportation initiatives without using the sales taxes currently used. User-fee charges such as MBUFs are paid only by those that choose to use the local road system. This third component could be implemented as a local voter option rather than being applied to all units of government equally and uniformly.

As described above, this new transportation funding tax structure would accommodate a variety of transition options, many of which require fuel tax collection to co-exist with MBUFs over what could be a significant period of time. We envision continued use of fuel taxes while a MBUF system is introduced. There will likely need to be period of co-existence with MBUFs and fuel taxes. Our three-prong system provides a scenario for this co-existence. While in the short-term there will be a continued need for fuel taxes, MBUFs may one day be able to replace the need for fuel taxes.

5.4 EDUCATION AND OUTREACH

Whitty et al. (2009) has proposed a three-step plan to gaining public acceptance of MBUF pricing. The first two steps are, “Ensure the public understands the problem the mileage fee system is designed to address” and “Ensure the design of the mileage fee collection system takes into account public sensibilities” (p. 11). Thus, for MBUF pricing to gain public acceptance and be successfully implemented, it is crucial that there be additional education and outreach.

Much work needs to be done to accomplish Whitty et al.’s (2009) first step. Sorensen et al. (2009) note that one of the observations that came out the interviews the team conducted with experts was that, “there is little public understanding of the current challenges in transportation finance, and in turn the motivations for a transition to VMT fees” (p. 98). At the 2010 Symposium on Mileage-Based User Fees, Ken Buckeye from the Minnesota Department of Transportation discussed a public opinion study and stated, “Surveys found that few Minnesota drivers were concerned about current levels of funding for transportation…Only 41percent of respondents had heard of the concept of a mileage-based user fee” (Coyle et al. 2010, p. 23).

While it is important to gauge public sensibilities so that Whitty and colleagues’ (2009) second step can be accomplished, it may be possible, through public education, outreach and system design features, to address public concerns. At the 2010 Symposium on Mileage-Based Fees, Loveland (Coyle et al. 2010) outlined approaches to mitigate various concerns that have been raised by the public over MBUFs. The issues and the responses to mitigate them are highlighted below.

VMT fees as a backdoor tax increase concern: Make it a revenue- neutral approach; find a tax-foe champion to stand up and say he is fine with VMT fees

Environmental concerns: Have a variable rate; find an environmental champion to help promote VMT fees

Lack of choice concern: Conduct pilots on an opt-in basis and early adopters should be rewarded so others envy them

"Devil you don't know" concern: Continually spotlight the urgent crisis associated with the gas tax; answer questions no matter how silly it may seem; there needs to be a technical component involved in the discussions and you shouldn't be out there talking about VMT fees until you have a sound technical base and robust technical team

Technology might crash concern: Conduct pilots; immediately fix any technical problems

"Big Brother" concern: Conduct pilots on an opt-in basis; privacy champions should be involved in design and evaluation; have a third-party audit

Complexity concern: Keep the system design simple and linear; communications should be kept simple (the more people can understand it in 15 seconds, the better. The harder it is for people to understand it, the less they are going to like it.)

5.5 CONCLUSIONS

This chapter has provided a map for the road ahead in the ongoing discussion about MBUFs. We have brought up issues related to the design and administration of mileage-based fees, looked at several transition issues, and examined the role of continued education and outreach. While there remain significant political hurdles to the implementation of MBUFs, this chapter has raised issues that should assist policy makers in their implementation attempts.

CHAPTER 6. CONCLUSION AND RECOMMENDATIONS

While there are several issues related to MBUFs that need further exploration, we hope this report has illuminated several important issues. First and foremost, fuel taxes are not sustainable for funding surface transportation, which the MBUF would be. After reviewing chapters 2 and 3 it should become clear to readers that MBUFs have a significant advantage over fuel taxes when evaluated under efficiency, equity, and revenue adequacy and sustainability principles, but fuel taxes outperform MBUFs under the feasibility principle. This means that much work is still needed to ensure that system costs, the main element of administrative feasibility, be kept at acceptable levels.

Second, there are several MBUF technology options available, and each has strengths and weaknesses related to the five transportation finance principles examined. While we do not recommend a specific MBUF technology option, our review of the options against the five principles will give those who are preparing for trials and MBUF implementation the opportunity to identify and further explore technology options that have the capabilities they desire.

Finally, because MBUFs have been recommended by two congressional commissions and many others, and show great promise as indicated in the analysis, we have outlined an action plan for MBUF implementation. This action plan raises many salient questions and issues related to MBUF implementation as well as transitioning from fuel taxes to a MBUF system.

The focus of our report has been to present issues so that readers and policymakers can come to their own conclusions regarding MBUF implementation. However, we do we do suggest a transitional structure for funding transportation. The approach that we suggest is to create a new transportation funding tax structure made up of the following three components:

- *Base Fuel Tax Component—Federal and State Level*
  Under the new transportation funding tax structure, fuel taxes would be reset to a lower base rate that would be sufficient to generate revenues for baseline transportation needs. Base fuel taxes would be designated for road and bridge maintenance and operation, and would include user and system safety and enforcement. The aim would be to ensure that ongoing funds are available to preserve the system and to protect the significant investment in federal and state infrastructure.

  Base fuel taxes would maintain their highly desirable built-in incentive for using fuel-efficient, alternative-fuel and lighter vehicles, all of which use less fuel per mile and, therefore, would pay less in fuel taxes. In other words, base fuel taxes would continue to help achieve national and state policy objectives related to reducing energy consumption and tailpipe emissions.

- *Mileage-Based Charge Component—Federal and State Level*
  The aim of this mileage-based pricing component would be to fund road and bridge reconstruction and expansion, including right-of-way acquisition. The mileage-based user charge would be set at levels that compensate for the reduction in fuel taxes to the base rate. Because these charges would be set on a per-mile basis, the approach would complement the state and federal objectives that fuel taxes support. It is likely, however,

that MBUFs would have a greater impact in reducing vehicle-miles, encouraging greater use of alternatives modes of transportation, and reducing cost externalities such as congestion and crashes.

- *Mileage-Based Charge Component—Local Option*
  The third component aims at funding local roads. As a basic approach, the MBUFs would be a local option that would replace the patchwork of local sales taxes that are used to fund local roads. This MBUF approach would give local governments the ability to undertake their own transportation initiatives without using the sales taxes currently used. User-fee charges such as MBUFs are paid only by those that choose to use the local road system. This third component could be implemented as a local voter option rather than being applied to all units of government equally and uniformly.

This new transportation funding tax structure would accommodate a variety of transition options, many of which require fuel tax collection to co-exist with MBUFs over what could be a significant period of time.

The analysis in this report makes a strong case for MBUF implementation. In addition to our recommendation that MBUFs continue to be seen as eventually replacing fuel taxes as the primary mechanism for funding surface transportation, it is also recommended that transportation professionals and policymakers take the time to fully understand the issues presented in this examination. For MBUF implementation to move forward, it is important that policymakers understand the shortcomings of fuel taxes and how unsustainable they are in the long run. It is equally important that proponents of MBUFs understand, first, the difficult transitional issues and questions involved, and second, the education and outreach effort that will be needed if the public and policymakers are to support implementation of MBUFs.

REFERENCES

Atkinson, R, 2009, *Paying our way: funding highways and transit in the future* [Online] viewed 24 May 2010, <http://www.ncsl.org/documents/transportation/P3RAtkinson09.pdf>.

Barth, M & Boriboonsomsin, K, 2009, "Traffic congestion and greenhouse gases", *Access*, vol. 35, pp. 2-9.

Boarnet, MG, 1997, "Infrastructure services and the productivity of public capital: the case of streets and highways", *National Tax Journal*, vol. 50, no. 1, pp. 39-57.

Coyle, D & Baker, R, 2010, *Proceedings 2010 symposium on mileage-based user fees: moving forward*, 2010 Symposium on Mileage-Based User Fees: Moving Forward, Texas Transportation Institute, College Station, TX.

Denison, DV, Eger, RJ, & Hackbart, MM, 2000a, "Cheating our state highways: methods, estimates and policy implications of fuel tax evasion", *Transportation Quarterly*, vol. 54, no. 2, pp. 47-58.

Denison, DV & Eger, RJ, 2000b, "Tax evasion from a policy perspective: the case of the motor fuels tax", *Public administration review*, vol. 60, no. 2, pp. 163-172.

Donath, M, Gorjestani, A, Shankwitz, C, Hoglund, R, Arpin, E, Cheng, P, Menon, A, & Newstrom B, 2009, *Technology enabling near-term nationwide implementation of distance based road user fees*, Intelligent Transportation Systems Institute, University of Minnesota, Minneapolis, MN.

Energy Information Administration, 2009, *Annual energy outlook 2009 with projections to 2030*, U.S. Department of Energy, Washington, D.C.

Energy Information Administration, 2008, *Annual energy outlook 2009 early release*, U.S. Department of Energy, Washington, D.C.

Environmental Protection Agency, 2009, *HUD-DOT-EPA interagency partnership for sustainable communities*. Environmental Protection Agency, [Online] viewed 18 November 2009 <http://www.epa.gov/dced/2009-0616-epahuddot.htm>.

Environmental Protection Agency, 2008, *Light-duty automotive technology and fuel economy trends: 1975 through 2008*, Environmental Protection Agency, Washington, D.C.

Environmental Protection Agency, 2010, *Light-duty automotive technology, carbon dioxide emissions, and fuel economy trends: 1975 through 2010*, Environmental Protection Agency, Washington, D.C.

Eurovignette, 2011, Euovignette website [Online] viewed 25 May 2011 <https://www.eurovignettes.eu/portal/>.

Federal Highway Administration, 1992, *The joint federal/state motor fuel tax compliance project*, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration, 1999, *Motor fuel tax evasion summary 1998*, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration, 2000, *Addendum to the 1997 federal highway cost allocation study*, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration, 2008, *Highway history*, U.S. Department of Transportation, [Online] viewed 11 January 2010 <http://www.fhwa.dot.gov/infrastructure/gastax.cfm>.

Federal Highway Administration, 2009a, *Fact sheets on highway provisions*, U.S. Department of Transportation, [Online] viewed 11 January 2010 <http://www.fhwa.dot.gov/safetealu/factsheets/equitybonus.htm>.

Federal Highway Administration, 2009b, *Fuel tax evasion*, U.S. Department of Transportation, [Online] viewed 11 January 2010 <http://www.fhwa.dot.gov/policy/otps/fueltax.htm>.

Federal Highway Administration, 2009c, *Licensed drivers, vehicle registrations, and resident population*, U.S. Department of Transportation, Washington, D.C.

Federal Highway Administration, 2009d, *Vehicle registrations, fuel consumption, and vehicle miles of travel as indices*, U.S. Department of Transportation, [Online] viewed 11 January 2010 <http://www.fhwa.dot.gov/policyinformation/statistics/2007/mvfvm.cfm>.

Fichtner, R & Riggleman, N, 2007, *Mileage-based user fee public opinion study: summary report phase I (qualitative)*, Minnesota Department of Transportation, St. Paul, MN.

Forkenbrock DJ & Kuhl, JG, 2002, *A new approach to assessing road user charges*, Public Policy Center, University of Iowa, Iowa City, IA.

Green Car Congress, 2010, *Obama administration proposes major public transportation policy shift to include economic development and environmental benefits as funding criteria for major transit projects*, [Online] viewed 17 January 2010 <http://www.greencarcongress.com/2010/01/lahood-20100114.html>.

Grush, B & Roth, G, 2008, "Paying for roads in the 21st century with TDP pricing", 88th Annual Meeting of the Transportation Research Board, Washington, D.C., Conference CD Paper No. 09-0222.

Harris Interactive, Inc./Tax Foundation, 2009, *Topline results for tax foundation's 2009 survey of U.S. attitudes on taxes, government spending and wealth*, Harris Interactive Inc., New York.

Halim, H, 2010, "Managing Traffic on Singapore Roads: A Demand Management Approach", Land Transport Authority, Singapore.

Hsing, Y, 1994, “Estimating the impact of the higher fuel tax on US gasoline consumption and policy implications”, *Applied Economics Letters*, vol. 1, no. 1, pp. 4-7.

Humphrey Institute of Public Affairs, 2010, *Workshop on integrating PAYD insurance and mileage-based road user fees Humphrey Institute of Public Affairs*, University of Minnesota, Minneapolis, MN.

Internal Revenue Service, 2009, *1040 forms and instructions 2009*, Internal Revenue Service, Washington, D.C.

Langer, A & Winston, C, 2008, “Toward a comprehensive assessment of road pricing accounting for land use”, *Brookings-Wharton Papers on Urban Affairs*, no. 9, pp. 127-167.

Lewis, D, 2008, “America's traffic congestion problem: toward a framework for national reform”, *The Brookings Institution*, Washington, D.C.

Lindsey, R, 2006, “Do economists reach a conclusion on road pricing? The intellectual history of an idea”, *Econ Journal Watch*, vol. 3, no. 2, pp. 292-379.

Litman, T, 2004, *London congestion pricing: implications for other cities*, Victoria Transport Policy Institute, Victoria, British Columbia, Canada.

Marsh, B, 2008, “Savoring bargains at the American pump”, *The New York Times*, 29 June.

McMullen, B, Nakahara, K, Biswas, S, Zhang, L, & Valluri, D, 2008, *Techniques for assessing the socio-economic effects of vehicle mileage fees*, Oregon Department of Transportation, Salem, OR.

Meland, S, Tretvik T, & Welde, M, 2010, *The effects of removing the Trondheim toll cordon*, Norwegian Public Roads Administration.

Mikesell, J, 2006, *Fiscal administration*, 7th edition, Wadsworth Publishing.

The Minister of Transport, Public Works and Water Management, 2010, *Dutch Road Pricing Act*, Netherlands.

Morris, JR, 2006, *The fuel tax and alternatives for transportation funding infrastructure*, Banff, Alberta, Canada.

Munnich, L, 2009, “Enhancing livability and sustainability by linking congestion pricing with transit”, 89th Annual Meeting of the Transportation Research Board, Washington, D.C., Conference CD, Paper No. 10-2492.

National Surface Transportation Infrastructure Financing Commission, 2009, *Paying our way: a new framework for transportation finance*, Washington, D.C.

National Surface Transportation Policy and Revenue Study Commission, 2007, *Transportation for tomorrow*, Washington, D.C.

Oh, J & Sinha, K, 2008, *Alternative to fuel tax: a state level perspective*, Purdue University, West Lafayette, IN, FHWA/IN/JTRP-2007/2.

O'Leary, A, 2009, *Examining the long-term viability of the motor fuels tax and possible alternatives*, Virginia Department of Transportation, Richmond, VA.

Patashnik, EM, 2000, *Putting trust in the U.S. budget: federal trust funds and the politics of commitment*, Cambridge University Press, New York.

Peters, JR & Kramer, JK, 2003, "The inefficiency of toll collection as a means of taxation: evidence from the garden state parkway", *Transportation Quarterly*, vol. 57, no. 3, pp. 17-31.

Pigou, AC, 1920, *The economics of welfare*, Macmillan and co., limited, London.

Puentes, R & Prince R, 2003, *Fueling transportation finance: a primer on the gas tax*, Brookings Institution, Washington, D.C.

Robinson, F, 2008, *Heavy vehicle tolling in Germany*, University of Minnesota, Minneapolis, MN.

Robinson, F, 2006, *Pricing experience in northern Europe: lessons learned and applicability to Minnesota and the United States*, University of Minnesota, Minneapolis, Minnesota.

Rosen, HS, 2005, *Public finance*, 7th edition, McGraw-Hill Irwin, New York.

Rufolo, AM & Bertini, RL, 2003, "Designing alternatives to state motor fuel taxes", *Transportation Quarterly*, vol. 57, no. 1, pp. 33.

Ruidisch, P, 2004, *The German Truck Charge*, European Conference of Ministers of Transport, International Conference on Managing Transport Demand Through User Charges: Experience to Date, London, U.K.

Schade, J & Schlag, B, 2006, *The fuel tax and alternatives for transportation funding*, Transportation Research Board, Washington, D.C.

Small, K, Winston, C, & Evans, C, 1989, *Road work: a new highway pricing and investment policy*, Brookings Institution, Washington, D.C.

Sorensen, P, Ecola, L, Wachs, M, Donath, M, Munnich, L, & Serian, B, 2009, *Implementable strategies for shifting to direct usage-based charges for transportation funding*, National Cooperative Highway Research Program, Transportation Research Board.

Sorensen, P, Wachs, M, & Ecola, L, 2010, *System trials to demonstrate mileage-based road use charges*, National Cooperative Highway Research Program, Transportation Research Board.

Sterner, T, 2007, "Fuel taxes: an important instrument for climate policy", *Energy Policy*, vol. 35, no. 6, pp. 3194-3202.

Sterner, T, Dahl, C, & Franzén, M, 1992, "Gasoline tax policy, carbon emissions and the global environment", *Journal of Transport Economics and Policy*, vol. 26, no. 2, pp. 109-119.

Texas Transportation Institute, 2009, *2009 Urban mobility report*, Texas Transportation Institute, College Station, TX.

Utt, R, 2003, *Reauthorization of TEA-21: a primer on reforming the federal highway and transit programs*, The Heritage Foundation, Washington, D.C.

Wachs, M, 2003a, "A dozen reasons for raising gasoline taxes", *Public Works Management and Policy*, vol. 7, no. 4, pp. 235-242.

Wachs, M, 2003b, *Improving equity and efficiency in transportation finance*, The Brookings Institution, Washington, D.C.

Whitty, J, 2007, *Oregon's mileage fee concept and road user fee pilot program*, Oregon Department of Transportation, Salem, OR.

Whitty, JM & Svadlenak, JR, 2009, *Discerning the pathway to implementation of a national mileage-based charging system*, The National Academics, Washington, D.C.

Whitty, J, 2003, *Report to the 72nd Oregon legislative assembly*, Oregon Department of Transportation, Salem, OR.

Williams, J, 2007, *Paying at the pump: gasoline taxes in America*, Tax Foundation, Washington, D.C.

Winston, C & Langer, A, 2006, "The effect of government highway spending on road users' congestion costs", *Journal of Urban Economics*, vol. 60, no. 3, pp. 463-483.