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Transportation System Efficiency in Vermont – An Initial Evaluation

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Disclaimer

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Executive Summary

In the 2007-08 Legislative Biennium, the Vermont State Legislature passed a law directing the Vermont Agency of Transportation to examine programs, policies and trends related to efficient transportation in Vermont and report to the Legislature by December 15, 2008.

VTrans contracted with the UVM Transportation Research Center to: 1) Conduct a literature review of transportation system efficiency measures that relate to rural communities; 2) Examine transportation system efficiency trends in Vermont; and 3) Provide a list of education and policy strategies that might encourage increased transportation system efficiency.

TRC researchers followed a transportation system efficiency framework developed in the VTrans Climate Action Plan, focused on reducing the energy used in individual vehicles and through switching travelers to different travel modes. Following this framework, recommendations to increase transportation system efficiency fall into two categories: 1) Strategies to increase individual <u>vehicle efficiency</u>, such as: the adoption of the California LEV standards and incentives to consumers to buy more fuel efficient vehicles (including AFVs); and 2) Strategies to increase <u>transportation system efficiency</u>, such as programs that increase vehicle occupancy rates, (e.g. car-pooling, ride-sharing, van-pooling, park and ride lots and household, and employment-based Transportation Demand Management programs), targeted public transit investments, and increased education and outreach regarding efficient driving styles, use of non-motorized transportation modes, and efficient vehicle purchases.

<u>Report Findings:</u>

- Vermonters are buying more fuel-efficient vehicles.
- Vermonters and travelers within Vermont are driving less and purchasing less gasoline. For example, vehicle miles traveled in Vermont declined from 7712.2 million miles in 2004 to 7528.6 in 2007. Total gasoline sales increased about one percent in the six-year period between 2002 and 2007.
- State park and ride lots are fairly well distributed as potential meeting spots for commuters. But there is evidence of additional need for lots in the more urban areas of the state.
- Individual driver style/behavior can reduce gasoline consumption.
- Increasing vehicle occupancy rates may be the most effective strategy for increasing system efficiency.
- Improving transportation system efficiency by shifting travelers to fixed route transit systems should focus on commuter link routes and on intra-city systems in those areas with denser population centers.
- Significant obstacles to increasing transportation efficiency in Vermont are the states dispersed settlement patterns, automobile dependency and aging population.

1. INTRODUCTION

In the 2007-08 Legislative Biennium, the Vermont State Legislature passed a law directing the Vermont Agency of Transportation to examine programs, policies and trends related to efficient transportation in Vermont and report to the Legislature by December 15, 2008.

The Legislature requested VTrans to collaborate with the Vermont Agency of Natural Resources and the Transportation Research Center at UVM to conduct:

> "1) An analysis of the role of motor vehicles in creating and contributing to air contaminants in Vermont, and a determination of what portion of overall statewide energy consumption is due to the use of motor vehicles.
>
> 2) Recommendations regarding policy options that would encourage and reward efficient transportation, reduce the amount of greenhouse gases generated by the transportation sector, and support alternative modes of transportation.
>
> 3) Recommendations for public education regarding clean and efficient transportation.
>
> 4) Other recommendations regarding the efficient use of transportation services…"[1]

On September 2, 2008, VTrans contracted with the UVM Transportation Research Center to: 1) Conduct a literature review of transportation system efficiency measures that relate to rural communities; 2) examine transportation system efficiency trends in Vermont; and 3) provide a list of education and policy strategies that might encourage increased transportation system efficiency.

This report presents data and analysis based on the above tasks. Because of the short time frame and limited budget, TRC researchers draw primarily on available data in this Phase 1 report. This report identifies future research needs and ongoing, already funded TRC research projects that will provide additional information. Policy, education and other recommendations are discussed at the end of the report.

When this report was commissioned, Vermont gas prices were close to their all-time high of $4.09 (set in July, 2008) and had been steadily rising over the previous 12 months. In fact, gas prices in Vermont steadily increased from $1.50 in 2002 (average price) to $4.09 in July 2008. Since then prices have dropped 50 percent to below $2.00. VTrans project managers were particularly interested in any efficient transportation trends stemming from high gas prices.

The mission of the UVM Transportation Research Center is to conduct innovative interdisciplinary research, education and outreach programs that advance sustainable transportation systems. The research for this report fits directly with the Center's mission and draws on data and analyses from the Center's diverse teams of research staff, faculty and graduate students.

2. BACKGROUND

In recent years, several state agency studies, legislative reports and gubernatorial commissions have examined strategies to reduce GHG emissions, increase public transit and promote transportation system efficiency.[2] This report builds on that work.

The literature review undertaken for this analysis underscores the obstacles to increasing transportation efficiency in a rural state such as Vermont – primarily because of our dispersed settlement patterns, aging population and automobile dependency. Existing literature includes many examples of transportation efficiency strategies for urban areas with dense residential, employment and activity areas. However, there is a lack of literature and best practices regarding efficiency improvements in rural areas.

2.1 Transportation System Efficiency

Energy efficiency strategies in Vermont are often viewed through the context of the state's successful electric energy efficiency program. Electric energy efficiency is defined as delivering the same quality of electric service with less energy. For most consumers, the efficiency of the electric resource is not related to the quality of the service. They flick on the switch and power is delivered. More efficient electric systems at the state or household level deliver the same quality of service.

A similar definition of delivering the same quality of "transportation" with less energy is more difficult to apply to the transportation system. While the electricity resource is transparent to the end-user, many aspects of the transportation system are based on a complex series of individual decisions. Transportation users choose and care about the routes they drive, the vehicles they purchase and the travel modes they use. Additionally, while the efficiency program is funded through a charge on rate-payers bills and managed statewide by Efficiency Vermont, the transportation system is funded by a variety of taxes and fees levied at the state and federal level. Options to regulate this system are limited because, unlike the 24 regulated monopolies that comprise the retail electric system in Vermont, there are hundreds of thousands of individual users of Vermont's transportation system.

In this report, the definition of transportation efficiency is focused on increasing vehicle efficiency and the efficiency of different modes of travel. We suggest that policy-makers should discuss a broader definition of efficiency that examines the whole transportation system including individuals travel behavior, the effects of present land use patterns and the energy used in the construction, maintenance, and operation of the transportation system.

One useful concept is the current discussion around "access" in contrast to "mobility." Access refers to the ability of citizens to reach desired goods, services and needs. Access is the ultimate goal of transportation, (except for a few activities such as recreational biking or horseback riding). Mobility, or travel, is a means to achieve access. The primary access tool today is the individual vehicle. But access can also be provided by living closer to services that could then be accessed through walking or biking. Some goods and services might be obtained with less travel in an automobile or perhaps no travel at all. Much of our transportation system today has grown up around providing mobility through the automobile. Re-framing the discussion around access, human needs and quality of life would contribute to an understanding of how to improve transportation efficiency and increase policy options available to achieve increased efficiency.

In this broader context, the review of the literature suggests the primary challenge to increasing the efficiency of the overall system is Vermont's rural dispersed settlement patterns and long-term transportation infrastructure investments which limit alternatives and contribute to the dependence on the automobile as the primary source of mobility in Vermont.

2.2 State Agency Transportation Efficiency Definitions

A number of states have adopted plans to increase the efficiency of their transportation systems--often in the context of reducing transportation related greenhouse gas (GHG) emissions.[3] The primary strategy to reduce GHG emissions is to reduce petroleum use.[4] California, for example, has a three-part strategy to reduce GHG emissions: 1) increase vehicle efficiency; 2) increase the use of alternative fuels in vehicles; and 3) reduce vehicle miles traveled.[5] In 2008, VTrans adopted a three-pronged approach to increase the efficiency of the transportation system to reduce GHG emissions: [6]

1. Promote the development, availability and use of bio-fuels

2. Increase vehicle efficiency
    - The Vermont Low Emission Vehicle Program
    - Alternative fueled vehicles
    - Promote more efficient vehicle purchase behavior by consumers
    - Reduce vehicle idling

3. Increase the efficiency of the transportation system
    - Reduce personal VMT by transferring trips to public transportation, van-pools, and non-motorized modes
    - Increase occupancy rates of personal vehicles
    - Increase efficient driving (e.g. smooth acceleration and deceleration, 55mph speed on freeways)

This report examines and analyses data following the above framework. TRC researchers were directed to look particularly for trends in any of the above areas that could be reinforced with state policy, education, or outreach.

2.3 Vermont Travel Patterns

In this section we introduce research on present travel patterns and use of vehicle modes because of the critical role these patterns play in increasing the efficiency of the system. As has been documented in many studies, the relationship between transportation infrastructure investments and related land use settlement patterns has increased our dependence on the automobile as the primary means of travel.[7] This dependence creates obstacles to improving the efficiency of the system either through reducing car trips or switching travelers to other transportation modes.

In general, rural states such as Vermont are more auto dependent than more urban states. Vermont's per capita vehicle miles traveled (VMT) of 12,379 is 7th highest in the U.S. and the highest in New England.[8] Nationally about 84 percent of per capita VMT is generated by private automobile use.[9]

Travel pattern data comes from both the U.S. Census, which examines trips from home to work, known as the "journey to work," and the National Household Travel Survey (NHTS), which examines trips at the household level.

Vermonters' travel behavior is also documented in a number of surveys conducted by VTrans and other Vermont-based organizations.

2.4 Journey to Work

The U.S. Census has collected "journey to work" data on a regular basis for many decades. Comprehensive surveys at the census tract and block level are conducted every ten years, and county level surveys are conducted bi-annually. The 2000 U.S. Census examined Vermonters mode choice for trips to work as shown in Figures 1 and 2.

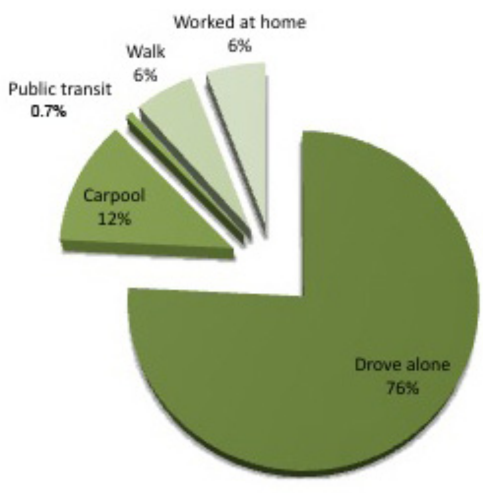

Figure 1. Mode Share of Commuters in 2000. [10]

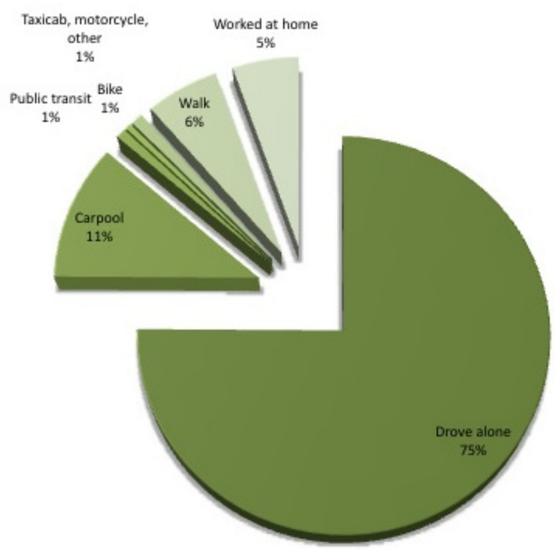

Figure 2. Mode Share of Commuters in 2006. [11]

Figure 1 indicates in 2000, 75.5 percent of total work trips were workers driving alone, 5.7 percent walking, 12 percent car-pooled and less than one percent of total trips were taken by bicycle or public transit. (The figures do not add to 100 percent because six percent worked at home). As shown in Figure 2, the 2006 American Consumer Survey conducted six years later indicates little change in these patterns. Over the five years, car-pooling decreased to about 11.2 percent, workers driving alone slightly decreased and public transit and bicycle use stayed about the same.

2.5 National Household Travel Survey

The National Household Travel Survey (NHTS) measures travel behavior at the household level, for all purposes (not just commuting).[12] In 2001, the NHTS New England data indicated approximately 86.3 percent of total trips were by automobile and 1.0 percent by public transportation.[13] Walking and bicycling comprised 9.3% of total trips. One of the travel behavior changes in the last decade that contributes to vehicle dependence is the practice of trip chaining or trip tours – no longer are most trips from home or home to work. Instead, many trips are now made from work to other places, or trips are made in sequence (example from home to daycare, to work, to store, to gym and to home)—a practice often referred to as trip chaining or trip tours. It is difficult for public transportation to serve these complex trip tours particularly when destinations and employment centers are broadly dispersed in suburban or rural areas. The NHTS indicates that for New England, in 2001, 5.9% of trips were home-based work trips, 29.7% were home-based non-work, and 64.2% were non-home based. The latter category would include the middle "legs" of trip chains or tours. Table 1 below indicates the percent of trips by each mode for each purpose.

Table 1. Percent of trips by mode and type of trip for New England in 2001.[14]

Trip Purpose	Auto	Transit	Bike/Walk
Home-based work	92.4%	3.4%	3.2%
Home-based non-work	82.6%	0.6%	12.6%
Non-home-based trips	87.5%	1.0%	8.3%

The length of trips and travel patterns vary by household type and trip purpose. It is reasonable to assume that the potential to increase transportation efficiency will differ between households and trips as well. For example, most workers cannot eliminate or shorten their work trip, but as travelers they can elect to make fewer shopping or leisure trips, or combine these discretionary trips. Survey data indicate that the first response by consumers to higher gas prices is to combine or reduce discretionary trips.[15]

Additional TRC Research: The TRC, VTrans and CCMPO purchased a survey of 1500 Vermont households as part of the NHTS 2008 dataset. This will provide a rich and comprehensive data set on the number and types of trips conducted at the household level in Vermont. TRC researchers expect to start analyzing these data in the summer of 2009.

2.6 Vermont Travel Surveys

VTrans conducts regular surveys of the travel behavior of Vermonters as part of the long-range transportation planning process. The surveys indicate travel behavior trends over time. One clear trend is the increased use and reliance on the automobile as the primary means of mobility for many Vermonters. For example, the average number of miles that Vermonters reported traveling by car each weekday increased 46 percent between 2000 (36 miles) and 2006 (over 50 miles). The number of miles driven alone increased by 34 percent; from 28 miles in 2000 to just less than 38 miles in 2006.

The average amount of time Vermont residents spent driving was 70.4 minutes per day in 2006, also an increase over 2000. Average daily driving time was highest in the Southeast Counties at 83.1 minutes and lowest in the Burlington-Centered region (63.4 minutes). The average estimated number of miles traveled by the Vermont residents surveyed was 52.5 miles per day.[16]

The survey also asked Vermonters what actions or activities would cause them to drive their vehicle less. Thirty-seven percent of Vermont residents responded that nothing would make them drive less. The next most popular response to encourage less driving was improved public transportation (22%) and higher gas prices (17%). A 2007 survey by the Center for Rural Studies at the University of Vermont revealed that a plurality of respondents (40 percent) said they had no options other than a significant life change to reduce their driving behavior.[17] A recent national survey found that in an effort to save on gas, Americans first tend to reduce non-essential driving (26 percent) before looking to alternate forms of transportation such as carpooling (7%), walking or biking (6%), or using public transportation more often (4%).[18]

2.7 Gasoline Sales and VMT

Transportation is the second highest household expense after housing, consuming about 15 percent of the average total annual income of households in the northeast.[19] Rural households are more auto-dependent, drive greater distances on average, and spend higher proportions of their income on transportation than their urban counterparts.[20] Gasoline purchases represent a small portion of the total cost of transportation, commonly from 4-8 percent.[21] The fixed cost of the car is the largest portion of the transportation expense.

Gas prices in Vermont have been steadily increasing since 2002 (see Figure 3) reaching a peak in July, 2008 before starting to decline to today's prices.[22]

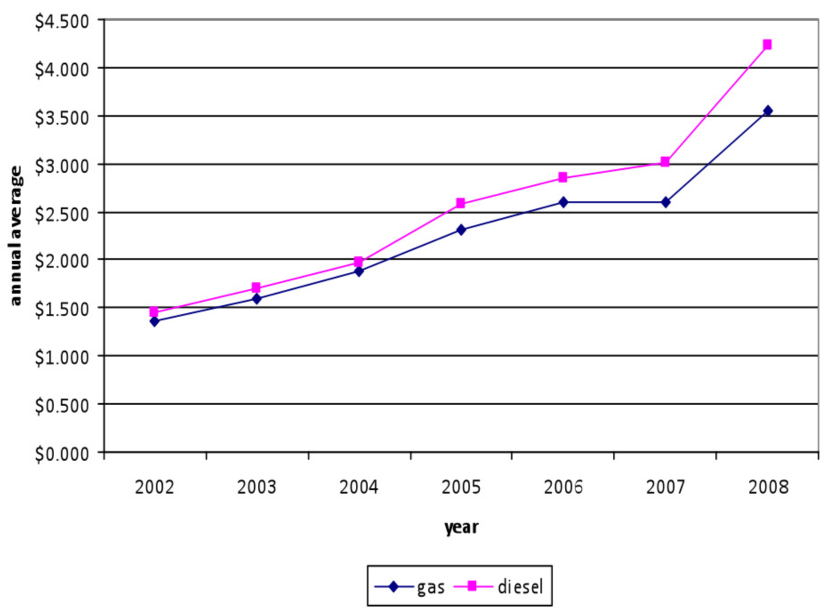

Figure 3. Average annual price for a gallon of gasoline and diesel in Vermont through July, 2008. [23]

There is evidence that Vermonters and travelers within Vermont have responded to this steady increase in prices by reducing consumption and vehicle miles traveled. Table 2 shows that for the six years between 2002 and 2007 the total number of gallons of gasoline sold in Vermont has been essentially flat.

Table 2. Gallons of gasoline sold in Vermont by calendar year.[24]

	2002	2003	2004	2005	2006	2007
Gasoline	346	357	355	361	344	348
Diesel	66.7	68.4	68.3	68.0	72.2	69.8
Bio-Diesel	N/A	0.01	0.06	0.28	1.40	N/A
Total	413	425	423	429	418	418

Similarly, the total number of vehicles miles traveled in Vermont has been declining.[26] Neither the gas sales or VMT data differentiates between Vermonters and travelers within Vermont. The VMT data is based on estimates from traffic counters, gasoline sales data is based on actual sales data.

While higher gas prices are likely contributing to flat gasoline sales and declining VMT, national research indicates that consumers are less responsive to gas price increases today than 20 years ago. Consumers are less responsive to gas prices because of growth in incomes, reduced transit options, increased vehicle efficiencies and more dispersed settlement patterns.[27] In one study, researchers found that every 10 percent increase in gas prices means about one-half of one percent decrease in consumption.[28] Similarly, a recent study by the Congressional Budget Office found that a 10 percent increase in fuel costs would reduce consumption by about 0.6 percent in the short run. Over the long term, a 10 percent increase in gas prices could lead to a 4 percent decrease in consumption. These studies indicate that fuel consumption usually drops more rapidly in response to higher gas prices than personal VMT. Drivers respond to high fuel prices by driving more efficiently, by driving the most fuel efficient vehicle in their household and by combining trips.

The Congressional Budget Office study found that on California freeways, every 50 cent increase in gas prices meant that vehicle trips declined by about 0.7 percent only when there was a rail transit substitute – which increased by a commensurate amount. In car dependent Vermont and other rural areas such options do not exist.

2.8 Aging Population

Vermont's aging population is a significant factor when evaluating the future efficiency of the transportation system. Vermont will soon pass Maine as the state with the oldest average population in the U.S.[29] Recent research indicates that the percent of the population above 65 years of age in Vermont will increase by 100 percent over the next twenty years. Generally older Vermonters live in the more rural areas of Vermont (Figure 4) and are more dependent on the automobile than those with some access to public transportation and pedestrian systems. Since most older Vermonters plan to continue to live where they are, vehicle dependence is a key factor in their ability to access services. A recent AARP study of baby boomers (those born between 1946 and 1964) found that 89 percent of those 65 and older plan to continue where they currently live.[30] National research indicates that older people use transit less.[31]

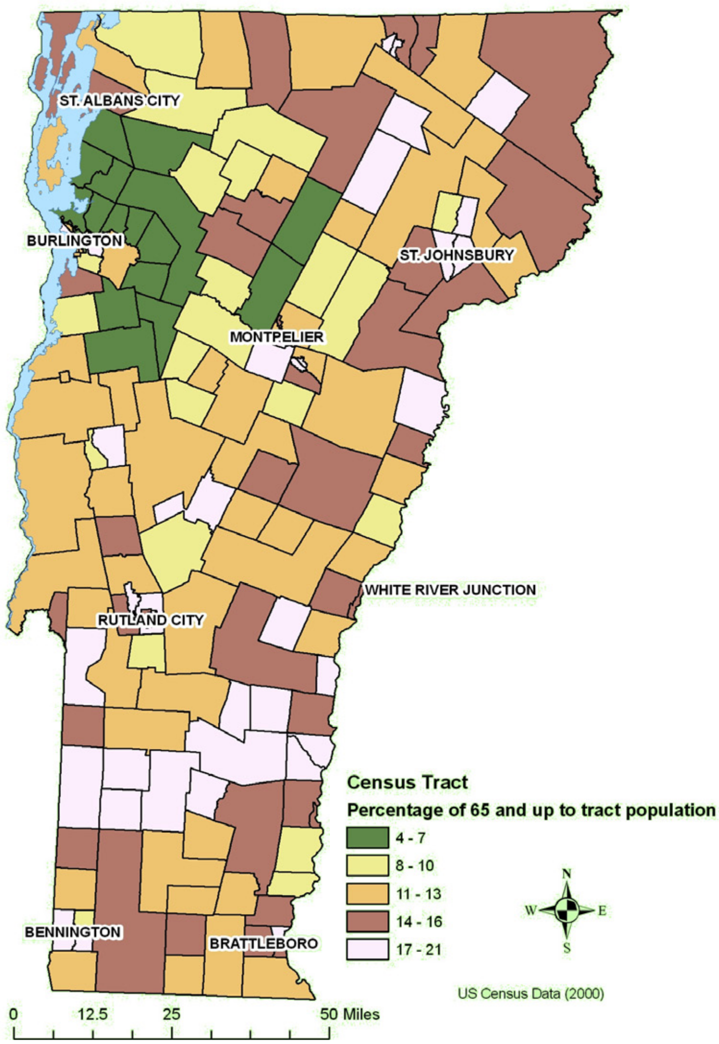

Figure 4. Percent of Vermonters older than 65 by Vermont Town. [32]

3. Vehicle Efficiency Analysis

In this section we report on measures to increase the efficiency of individual vehicles.

3.1 The Vermont Low Emission Vehicle Program

The Governor's Commission on Climate Change reported that adopting the California Low Emission Vehicle (LEV) program would increase vehicle efficiency in Vermont and reduce GHG emissions. The impact on Vermont of the California LEV program has been carefully examined by the Vermont Agency of Natural Resources and in other state reports.[33] Adopting the California standards will reduce GHG emissions from the state vehicle fleet by 30 percent by 2016 because of concurrent increases in fleet efficiency.[34]

3.2 Alternative Fueled Vehicles

Switching vehicle fuels can increase vehicle efficiency and reduce petroleum use and associated GHG emissions. Internal combustion gasoline engines are notoriously inefficient; only 20% of the energy in gasoline powers the wheels, whereas an electric motor is about 75% percent efficient.[35] Fuel-cycle analysis, which includes transmission line losses between power generation and electric drive, shows electric vehicles to be more energy efficient than gasoline vehicles.[36]

The Governor's Commission on Climate Change and the Vermont Department of Public Service have named plug-in hybrid electrics (PHEVs) as a core transportation efficiency strategy in two recent reports.[37] TRC researchers found that the state's electric grid could handle 200,000 PHEVs if electric utilities had control over the charging algorithms to ensure night-only charging.[38]

Although policy-makers and consumers may find AFVs a desirable product for Vermont, the availability of the vehicles is highly dependent on the automobile industry. Currently there are no commercially available PHEVs, and limited numbers of compressed natural gas (CNG) vehicles available, for example. Private conversion of hybrids to plug-in hybrids would be cost prohibitive for most Vermont households. Less than 10 vehicles that run on electricity, natural gas or propane were purchased in the last four years in Vermont.[39]

Additional TRC Research: Research on the efficiency gains of PHEVs and the impacts of those vehicles on the electric system and end-user costs is the subject of a second round of studies at the TRC. Future TRC research is evaluating how travel distances vary spatially throughout the state and how that might affect the market penetration of PHEVs and other AFVs.

3.3 Efficient Vehicle Purchase Behavior

TRC researchers examined Vermonters vehicle purchase behavior for a 4 and ½ year period between January, 2004 and June, 2008. Consumers are purchasing more efficient vehicles as a percent of total vehicles sold in each year. The data also indicates a sharp decline in the total number of new and used vehicles sold in Vermont. Table 3 indicates the total number of new and used vehicle sales in Vermont since 2004. (Note that 2008 sales are based on doubling the sales data of the first six months.)

Table 3. Total new and used vehicle sales in Vermont annually 2004-2008.[40]

	New	Used	Total Sold
2004	39,578	108,646	148,224
2005	36,433	91,671	128,104
2006	35,107	68,689	103,796
2007	35,184	71,161	106,345
2008	27,124	54,248	81,372
Total Sales	**173,426**	**394,415**	**567,841**

TRC researchers examined vehicle sales data containing information on new and used vehicles sold in Vermont by segment type, make, model, fuel type, and registration type (e.g. retail, fleet, or manufacturer/dealer). In order to link the data to fuel efficiency measurements, the researchers analyzed the data based on the segment type which groups together vehicle models based on their functionality, (e.g. basic economy, mini-sport utility, sport utility, full-size pick-up, prestige luxury). Because a segment contains many vehicle types, researchers used the MPG of the most highly purchased vehicle model in that segment to represent the average miles per gallon (MPG) for all vehicles under each segment type. MPG information for the selected vehicle models were then collected from www.fueleconomy.org. Segment types were categorized into four groups:

- Low Efficiency -- Fuel economy <15 MPG
- Medium Efficiency – Fuel economy <20 MPG but > 15
- Above Medium Efficiency – Fuel economy <25 MPG but >20
- High Efficiency – Fuel economy >=25 MPG.

Assuming retail purchase decisions might be more likely affected by vehicle fuel economy then fleet or dealer purchase decisions, only "retail" purchase records were chosen for analysis. New and used vehicles were analyzed separately because of the possible purchasing behavior differences between new and used vehicle buyers. Sales of both new and used vehicles declined during this time period (Table 3).

<u>**New Vehicle Sales:**</u> Approximately 173,426 new vehicles were purchased during the time period. Figure 4 shows a per year decline in the percent of the least efficient vehicles purchased (MPG<15

and MPG 15-20). The data also indicates an increase in the percentage of vehicles purchased with fuel economy greater than 25 MPG. Results for 2008 continue these trends more sharply, but data is only available for the first six months of 2008. The rapid decrease in gas prices over the last four months may reverse these trends.[41] Recent legislation that requires dealers to include fuel economy information on vehicles for sale may also influence purchase behavior.

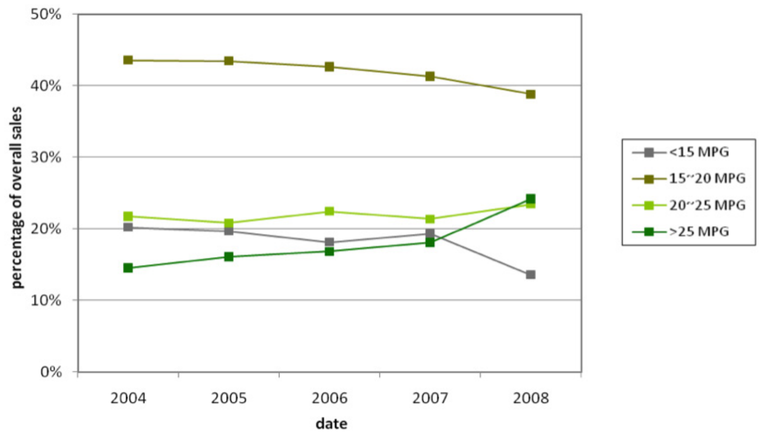

Figure 5. Vehicle efficiency trends of new car sales in Vermont.[42]

<u>Used Vehicle Sales:</u> About 394,415 used vehicles were purchased between 2004 and 2008. Used vehicles tend to be older and have lower fuel economy, so the High Efficiency segment (>25 MPG) was not evaluated in this analysis. Figure 6 indicates the Above Medium Efficiency (20-25 mpg) segment saw an increase in sales, while sales of the lowest efficiency vehicles (>15 MPG) remained relatively flat. The biggest decline came in the Medium Efficiency category (15-20 MPG) where sales declined from about 65 percent of total used vehicle sales to 55 percent.[43] Research indicates that completely changing the efficiency of vehicle fleets can take 10-12 years. Although there is evidence here of purchase behavior that favors more efficient vehicles, the portion of these vehicles to the total Vermont fleet is unknown.

<u>Additional TRC Research</u>: TRC researchers will analyze vehicle purchase data for the second six months of 2008 as part of the Vermont Clean Cities Coalition routine program work.

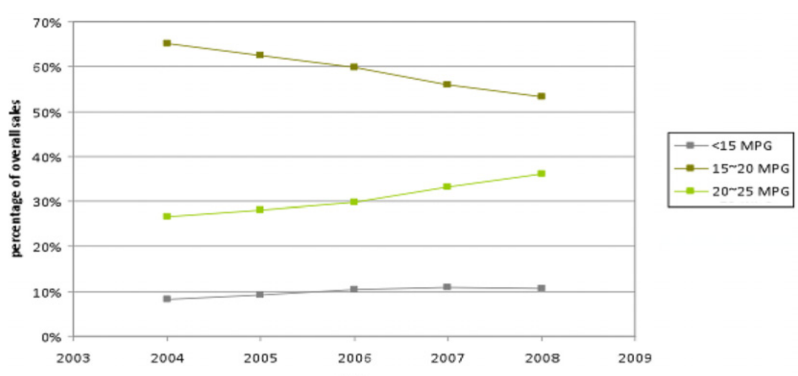

Figure 6. Vehicle efficiency trends of used car sales in Vermont.[45]

As an example of the type of efficiency gains that are possible, the Vermont electric utility Green Mountain Power was able to increase the efficiency of their 105 vehicle fleet by 25 percent in the last three years. The company used a combination of vehicle purchase and behavior modification strategies to achieve these gains.[46]

3.4 Vehicle Ownership Levels

Another factor in transportation efficiency that TRC researchers identified in the literature and attempted to apply to the Vermont analysis is the correlation between the level of vehicle ownership and per capita VMT.[47] Research indicates a strong correlation between the number of household vehicles and VMT. TRC researchers reviewed statewide vehicle registrations and vehicle sales. The purchase of new and used vehicles has been declining in Vermont over the past four years (Table 3) but vehicle ownership rates remain high (Figure 7). While overall vehicle sales have declined the level number of vehicle registrations suggests total vehicle ownership has remained constant.

This has several ramifications for vehicle efficiency. Vermonters may be holding onto their vehicles longer which can lead to a decrease in overall fleet efficiency because older vehicles tend to be less fuel efficient.[48] There is no indication that higher gas prices are reducing vehicle ownership rates which could then lead to more use of other transportation modes.

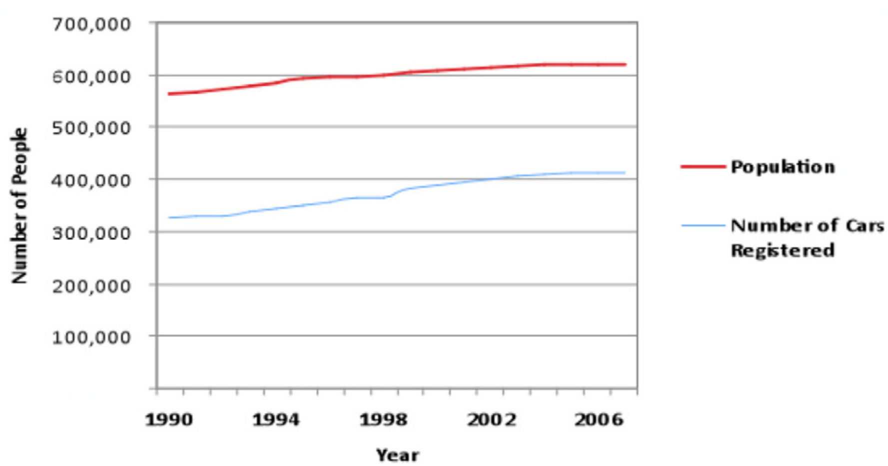

Figure 7. Number of Vermonters compared with number of cars registered in Vermont.[49]

Research indicates that car-sharing organizations such as the newly launched CarShare Vermont, can reduce vehicle ownership rates and vehicle miles traveled while still providing vehicle-based mobility options for Vermonters.[50]

4. Transportation System Efficiency Analysis

In this section, we examine strategies to increase the efficiency of the overall system by increasing vehicle occupancy rates, reducing travel distances, and switching travelers from the automobile to other modes. Figure 8 indicates the overall energy efficiency of different transportation modes. As discussed earlier, single occupancy vehicle trips are the primary mode of travel by most Vermonters. Transferring some of the trips to other modes or increasing vehicle occupancy rates can increase transportation efficiency. Not all trips are the same and different strategies are needed to address different types of trips. For example, research indicates the home to work trip may be easier to shift to alternative modes than other trips (see Table 1). However, this can also depend on the density of the employment center travelers are commuting to.[51] In addition, different households with different demographic mixes may also require different strategies. Tourism travel is also a factor in Vermont; ski resorts and other tourism-dependent businesses are looking at mode shift strategies for travelers to and within Vermont.

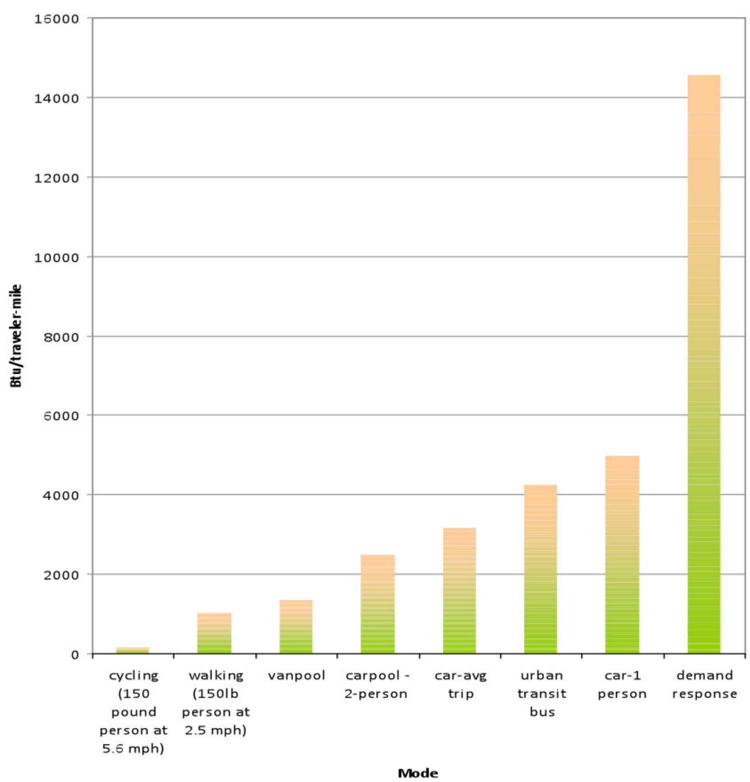

Figure 8. Energy intensity of different transportation modes based on the average BTU per passenger mile.[52]

4.1 Public Transit

Public transportation is often cited as a key strategy by Vermont policy-makers to reduce auto dependence and GHG related emissions.[54] As a percent of total trips in Vermont, public transit is a small but growing number. Public transit policies, funding, the number of providers, and inter-city and intra-city trends have been the subject of a number of recent reports.[55] The Legislature in the 2007-2008 biennium also required an assessment of various organizational structures for the state's 13 transit providers. TRC Researchers examined public transit ridership trends in the context of increasing gas prices and transit-serviceable areas in Vermont.

4.2 Transit Ridership Trends

Total public transit ridership in Vermont increased between FY 2006 and FY 2008. VTrans divides public transit routes into seven categories, urban, small town, rural, commuter, tourism, demand response for the general public, and demand response for the elderly and disabled public. Table 4 indicates that ridership is increasing in four of the seven categories, specifically in the urban, commuter, rural and small town systems.

Table 4. Transit ridership in Vermont.[56]

Route Type	One-way Rides FY06	One-way Rides FY07	One-way Rides FY08	% Change FY06 - FY07	% Change FY07- FY08
Commuter	592,824	648,409	658,877	9%	2%
D.R. General	45,787	37,586	36,650	-18%	-2%
D.R. E&D	129,251	132,274	113,988	2%	-14%
Rural	158,690	152,268	168,089	-4%	10%
Small Town	250,923	288,726	304,998	15%	6%
Tourism	447,583	441,044	418,861	-1%	-5%
Urban	1,642,553	1,707,862	1,847,597	4%	8%

The researchers found that ridership tends to increase slightly as gas prices increase, and that ridership tends to decrease as gas prices decrease. Fluctuations in gas prices account for about half of the changes in ridership on small town and urban routes. However, gas prices account for less than a quarter of the changes in transit ridership for most route types. These data suggest that other factors are cumulatively more important in determining ridership on commuter, rural, and tourism routes than are gas prices. Based on our review of the literature related to small rural transit systems, these factors include the availability, frequency and cost of transit, vehicle ownership levels, and income and demographic factors.

Ridership is growing most rapidly on commuter routes and on intra-city routes in more densely populated areas. For example, ridership on CCTA's link express routes connecting St. Albans, Montpelier, and Middlebury with stops in Chittenden County has grown about 100 percent between FY 07 and FY 09.[57]

4.3 Public Transit in Rural Vermont

Public transit can increase the efficiency of the transportation system by providing mobility and accessibility options that reduce personal automobile VMT. However, efficient transit service using larger transit vehicles is challenging in Vermont's sparsely settled landscape. If large, less efficient transit vehicles are transporting few passengers, transit can decrease transportation system efficiency. Many of the existing system boundaries and service areas of Vermont's transit agencies are based on historic, Medicaid, or local area needs rather than current employment, shopping and residential development. These systems provide necessary transportation to transit-dependent citizens and have not necessarily been able to maximize efficiency by maximizing transit vehicle occupancy. Indeed, policy-makers and transit agencies face conflicting goals because providing service that maximizes ridership and overall efficiency may leave out those who most need public transportation services. This report focuses on transportation system efficiency, but clearly any evaluation of public transit should take into account these multiple goals, including, for example, how public transportation could encourage increases in density that would then lead to greater system efficiency.

VTrans is presently examining the efficiencies associated with current provider organizational structures, including a consolidation of providers.[58] In this analysis, TRC researchers examined the density of Vermont settlement areas to establish the most transit serviceable areas. These areas or hubs would then be connected in what is being termed an "optimal" network of routes.

Residential and employment densities are two primary factors affecting the viability of implementing transit that saves energy over private automobiles. As residential densities increase, so does the potential ridership in the immediate areas of transit facilities. Similarly, high employment, service, and recreation facility densities generate more potential trip destinations. High residential densities alone have little effect on transit usage if there is a lack of destinations for the transit riders.[59] Locations with high employment densities such as commercial businesses, restaurants and medical services have significantly higher daily trip generation rates than that of a typical household.

Using mapped household building locations from the Vermont E911 database, densities were derived in the mapping Geographic Information System ArcGIS from single-family household units (SFU) and "equivalent" household units for multi-family structures based on U.S. Census Bureau data for the New England County Metropolitan Area. This offers an advantage over town-based densities because averaging population over the whole area of a town may miss its central and more dense hub area. This research can be used to highlight the areas within a town that may be dense enough to support transit.

Sites considered as "destinations," including commercial, industrial, education, government, health care and public gathering locations were also incorporated. Labor statistics from the Vermont Department of Labor were used to identify the average employment rate by town (done by dividing the number of employees per destination type by the number of destination types within a given town). Trip generation rates[60] were then determined for each destination type for the AM and PM peak hour, which were used to determine an equivalent household unit for each location (a relation of the number of trips generated by the destination type in relation to the average number of trips generated by a single-family household). This was then applied as a destination weight factor to the E911 destination locations.

Transit-supportive residential density threshold for a local bus service (one bus per hour) has been estimated by the Institute of Transportation Engineers to be four to five dwelling units per acre and seven dwelling units per acre for intermediate bus service (one bus every 30 minutes).[61] The results are shown in Figures 9 and 10 below. These figures indicate that there are limited places in Vermont that have the residential-equivalent densities to support fixed route transit systems if energy efficiency is the goal. [62]

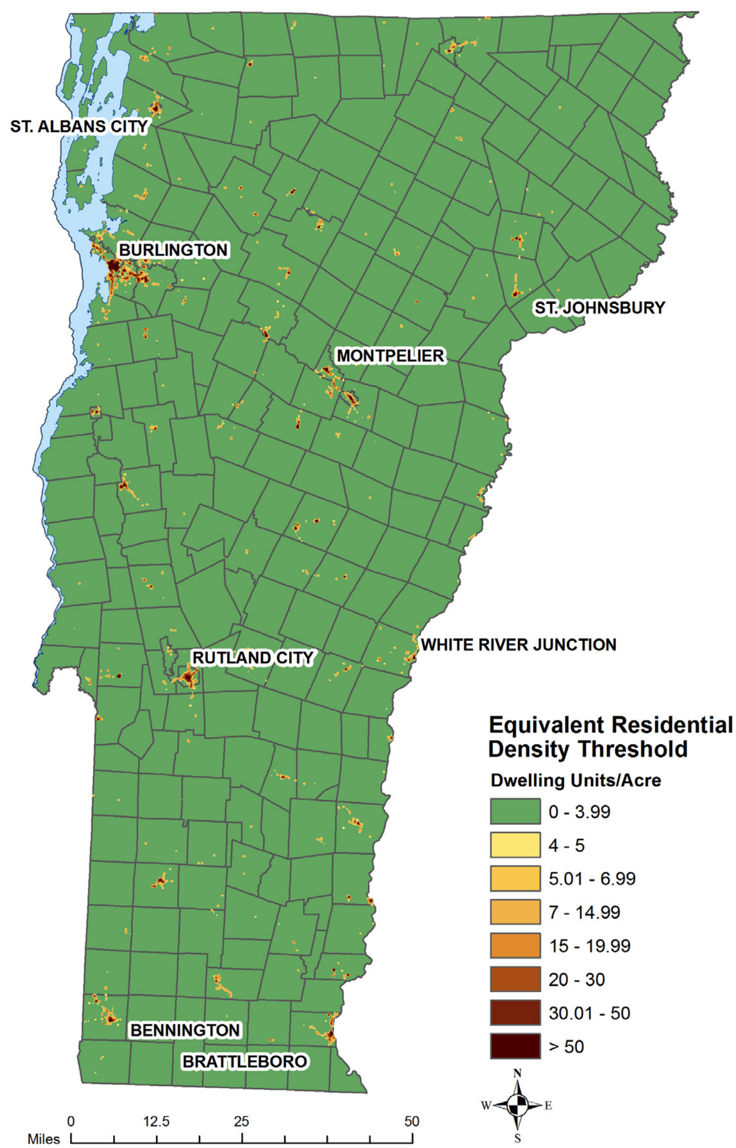

Figure 9. Densities that indicate transit viability in Vermont.

Residential and commercial densities (expressed as equivalent dwelling units) that will support energy-efficient transit service.[63]

Based on our preliminary research, improving transportation system efficiency by shifting travelers to fixed route transit system should be focused on extending commuter link routes that connect destination centers, including connecting Vermont's population centers and on intra-city systems in those areas with denser population centers. For the Chittenden County area this focus can also include shifting travelers to existing transit service. Vermonters must contend with achieving better transportation system efficiency without the ability to offer viable fixed route transit service in most areas. Importantly though, there are other social goals that make continuing public transit service essential regardless of the energy efficiency of the mode.

Additional TRC Research: TRC researchers are building on this research to begin developing an "optimal transit system" that would connect the transit viable zones and also provide service within zones.

TRC researchers are also conducting an analysis in two Maine towns to understand the impact transit oriented design (TOD) may have on reduced VMT and GHG emissions in rural areas.

4.4 Vehicle Occupancy Rates

Increasing vehicle occupancy rates can immediately double, triple or quadruple the efficiency of the vehicle. Vehicle occupancy rates can be increased through car-pooling and ride-share programs. Nationally, there has been a slight increase in vehicle occupancy rates from 1.48 persons per vehicle in 1995 to 1.51 in 2001. In Vermont, data indicates that 75 percent of work trips are single drivers and 85 percent of total trips are also single occupancy vehicles (see Figure 1 and Table 1).

In this section we discuss three state programs that have received increased funding in the last few years: the states' Ride Share program, Van Pool program, and Park and Ride program. These three programs are all components of the GoVermont strategy.[64]

4.5 Ride-Share

As discussed earlier, national research indicates journey to work trips are worth targeting for efficiency improvements because they have more clearly defined origins and destinations than other types of trips. Although declining as a share of all trips, journey to work trips still comprise about 20 percent of total trips.[65]

The VTrans Ride Share program manages a database of riders who phone in to a state hotline number. The program seeks to match riders and drivers across the state. VTrans has recently re-directed $250,000 towards improving the technical capabilities of this system and integrating it with similar systems in Maine and New Hampshire. Future successful expansion of this program may depend on how well it addresses barriers Vermonters face to carpooling, which have not been systematically studied. Research elsewhere has suggested that barriers to carpooling include such concerns as lack of flexibility, fears regarding being matched with strangers and an unwillingness to interact with or rely on others.[66]

Calls to the Ride Share hotline increased from about one a day in September 2007 to between two to seven by September, 2008.[67] TRC researchers geocoded the stated origin and destinations of the 2,813 riders in the Ride Share database using the ArcGIS program. This information is useful to identify common ride share and travel routes for future public transit routes, additional park and ride lots or other travel efficiency support services. Researchers matched 2,744 pickup locations (Origins) and 2,278 drop off locations (Destinations). Figure 11 displays the origin points and destination points per town. The bullets represent the state's existing 27 park and ride lots. A visual examination of the data indicates that park and ride lots are fairly well distributed as potential meeting spots for travelers. However, the distribution and physical capacity of the lots in more populated areas presents obstacles for public transit buses attempting to meet travelers. For example, CCTA has had to enter into five contracts to lease private land to support commuter link transit services in Franklin, Chittenden and Addison counties.[68] (Note that the database does not indicate actual carpoolers, only calls to the Ride Share hotline.)

Figure 10. Ride share origins and destinations from the state ride share data base.[69]

<u>Additional TRC Research:</u> TRC researchers are creating route corridor maps that illustrate which roadways connects multiple origins and destinations to provide further information for future transit service, car-pool programs, or park and ride lots.

In a related study, researchers are conducting a social capital analysis with Vermont focus groups to examine the relationship of social networks to travel behavior. Another possible study would survey Ride Share callers to identify how many are actually carpooling.

4.6 Park and Ride Lots

VTrans estimates that 70 percent of park and ride lot use is commuter related and that the price of gas increases the use of the lots. Occupancy rates at the 27 state park and ride lots is gathered annually. In addition to the state funded lots, there are a number of VTrans funded municipal lots as well as voluntary, ad-hoc locations at churches and shopping centers and other places.[70] Table 5 indicates that occupancy rates at the state-owned park and ride lots vary by region, but the almost 1,000 spaces are only 65% occupied.[71] Occupancy rates have increased between 2006 and 2007. Rates for 2008 are expected to be available at the end of November.

Table 5. Occupancy rates at state park and ride lots.[72]

Region	Weighted Average of Regions		Total Available Spaces
	2006	2007	
Burlington-centered	66%	71%	223
Central	54%	69%	361
Northern Tier	50%	49%	103
Southeast	86%	85%	124
Southwest	7%	10%	80

4.7 Vanpooling

VTrans has recently reconfigured the state van-pool program. There are currently 15 employer-employee based car-pools set to initiate the program shortly.[73] The program is fully subscribed and VTrans managers believe there is additional demand. No data is available yet on the number of riders or the shift of those riders from single occupancy vehicles. VTrans believes the program is cost-effective in areas not currently served by transit. For example, 100 vanpools costing $60,000 can carry five times the number of passengers as one commuter bus costing $240,000.[74]

4.8 Employer-based Transportation Demand Management Programs

Research indicates that employer-based approaches to reducing vehicle use can reduce individual car trips. One recent best practices study in the U.S. found that:

- employers providing only information saw no reduction in SOV travel;
- supplying alternatives such as vanpool reduced SOV trips by 9%;
- supplying financial incentives reduced SOV trips of 16%; and
- providing both financial incentives and services (e.g. rideshare matching) reduced SOV trips by 25%.

In Vermont, the Way to Go Week has been an effective means to introduce drivers to alternative modes. In 2008, 2,738 Vermonters registered to save fuel during the week-long event. This represented an increase of almost 1,000 participants over 2007.[75]

There are a number of Vermont employers offering incentives to reduce single person occupancy vehicle trips. Further research is needed on the success of these programs. These range from work at home days (Burton Snowboards) to funding a public bus for work commuters (NRG Systems).[76] These partnerships with the private sector may grow in importance in the future.

4.9 Household-based Travel Demand Management (TDM)

In U.S. urban and suburban settings, household-level approaches have reduced SOV trips from 13 to 34 percent among participating households (2 to 13 percent among the full population targeted by initial outreach). TRC researchers found limited examples of TDM at the household level applied in rural areas in the U.S. In rural areas abroad, household-based approaches have reduced SOV trips from 2 to 6 percent.

Household-based TDM approaches focus on individualized outreach. Commonly, surveys identify potential participants, information provided is tailored to individual needs, and post-surveys track mode shifts over time. Programs in King County, Washington, Portland, Oregon, New Jersey, Australia, Germany, and England have used the neighborhood-level approach to targeting outreach, in order to build a culture of change.[77]

4.10 Walking and Biking

The most efficient transportation modes are walking and biking. Switching from motorized vehicles' to either of these modes eliminates direct petroleum consumption and also reduces parking management demand for both public and private sector entities. However, these modes can represent time efficiency challenges depending on the location of origins and destinations. Furthermore, both actual and perceived traffic safety problems prevent some individuals from using these modes for themselves or their children. There has also been a nation-wide failure to provide adequate biking and pedestrian infrastructure such as sidewalks, bike lanes, shoulders, etc.[78] Critics point out that bicyclists and walkers do not contribute to the funding of surface transportation systems as they do not pay fuel tax. This argument is becoming less persuasive in recent years as more people recognize bikers and walkers help overall system efficiency, increase mobility for car-users, reduce demand for parking spaces and as the adequacy of the present funding system deteriorates.

One additional potential obstacle to increased walking and biking in Vermont is the state's weather patterns. TRC researchers examined pedestrian data from a pedestrian counter located in downtown Montpelier. Researchers found that precipitation reduced pedestrian volume by 13%. The months of January through April, which TRC researchers connected to snow on the ground or the perception of poor weather, reduced pedestrian volume by 16%. Overall, weather could account for 30% of the variability of the volume, indicating that most walking is not affected by the weather. This data indicates that weather alone is not the leading contributor to low walking levels in Vermont. Other North American cities such as Madison, Wisconsin and Ottawa, Ontario have winter weather and much higher levels of biking and walking.

Additional TRC Research: Researchers are conducting further studies on the obstacles presented by weather and seasonality to walking and biking. Together with the New England Transportation Institute (NETI) and the CRS, a large survey of rural households will be conducted throughout 2009 to determine how season and weather impacts travel patterns, feelings of isolation, and quality of life.

4.11 Efficient Driving

Research indicates that vehicle drivers respond to higher gas prices by combining and reducing automobile trips when possible and by increasing their efficient driving behavior. There are two interrelated factors, driving style and vehicle operation that could be the target for policies and education to improve transportation efficiency. Speed and idling have been the focus of most efforts in this area. Figure 12 illustrates the fuel use and CO2 emissions tabulated by TRC researchers using CMEM data from lab-based experiments in California.[79] In this case emissions and fuel use are highest at lower average speeds. This is due to the stops, accelerations and idling that occur at low speeds. Efforts to increase efficiency at low speeds would involve operational changes to reduce stops in the network as well as education to encourage drivers to make more gentle accelerations. However, some stops and starts will always be necessary in the system. Lowering speed limits would also result in reductions in fuel use and carbon emissions per mile.

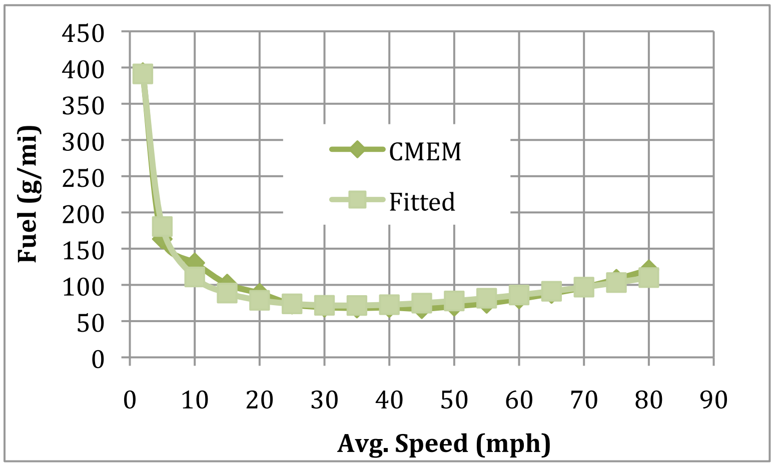

Figure 11. Gasoline consumption as a factor of speed.[80]

There are a number of educational initiatives underway aimed at educating consumers about the relationship between their driving behavior and efficiency. For example, the Alliance of Automobile Manufacturers launched their EcoDriving campaign in partnership with the Governors of California and Colorado to provide information on driving and maintenance habits that can increase fuel economy. Their comprehensive tips include everything from route planning, air conditioning use, replacing air filters, and checking tire pressure based on ambient temperatures. The Drive 55 campaign, an NGO effort based in California, focuses on the fuel savings available to any consumer by driving 55 mph on freeways.[81]

In Maine, researchers found that educating consumers about buying more efficient vehicles could increase efficient vehicle purchase behavior.[82]

Additional TRC Research: This is a core area of research at the TRC and there are a number of related research projects underway. In one project, researchers are identifying if providing on-board simultaneous information about gasoline consumption will change behavior. In another project, researchers are collecting second-by-second tailpipe emissions and gasoline consumption of hybrid and non-hybrid vehicles in Vermont's hilly terrain and cold weather.

5. Public Policy and Education Strategies

In this review, we provide a preliminary listing of possible public policy and education strategies, many of which require additional research to understand their impacts and possible effectiveness. We follow the two-part framework: 1) strategies to improve vehicle efficiency; and 2) strategies to increase transportation system efficiency. This list is based on the literature review, previous state reports, TRC brainstorming sessions and analysis. In addition, we have focused on strategies most appropriate for rural areas.

Improving Vehicle Efficiency

Vehicle Efficiency (Policy)

- Adoption of the California LEV standards
- Incentives to consumers to buy more efficient vehicles
- Employer TDM-based programs, such as parking policies, vanpools, tax breaks or grants for workplace travel planning

Vehicle Efficiency (Education)

- Educate consumers about the life-cycle costs of purchasing low efficient vehicles
- A consumer marketing campaign promoting the purchase of more efficient vehicles[83]
- Including efficient driving questions on state drivers education testing exams[84]

Improving Transportation System Efficiency

Transportation System Efficiency (Policy)

- Incentives to promote car-pooling and ride-sharing
- Expand state van-pool program
- Increase investment in state and municipal park and ride program
- Household and employment based TDM programs)
- Increased investment in public transit in transit-serviceable intra-city routes and inter-city routes
- Carsharing – tax break to car purchases for carshare programs
- Bicycle and pedestrian – investment in facilities, reduced speed on non-arterial roadways, grants for bicycle parking and other commuter facilities
- Smart growth – brownfield development incentives
- Telecommuting
- More efficient transit buses
- Create a Transportation Efficiency Utility that will provide research-based solutions and one stop shop for transportation energy planning advice to municipalities/regions/town energy committees
- Expand GoVermont program to include households, and include case studies on website
- Support taking the Way to Go initiative statewide
- Installation of roundabouts in locations where traffic volumes would result in increased efficiency
- Increase tourism-related transit such as foliage buses
- Remove 4-way stops signs to reduce emissions

- No- motorized commuting benefit, connecting reducing parking costs with travel mode
- Increasing occupancy rates on transit buses and park and ride lots
- Optimize traffic signal timings on arterial corridors
- Explore podcars and other non-traditional forms of vehicles and transport – example
- Mobility for children to stop “drop off” trips
- Utilize traffic signal off peak flashing operation
- Reverse (stop) job sprawl for low income workers
- Turn the street lights off at night or install motion sensor street lights
- Encourage franchising of neighborhood trash/recycling pick up by waste haulers

Transportation System Efficiency (Education)

- Increased education and outreach regarding efficient driving styles, for example through school programs, PSAs, partnering with workplaces and non-profits
- Increased strategic marketing of GoVermont services
- Expansion of GoVermont to include household-based TDM
- Extend bicycle season through better equipment, clothing and safer practices

6. Conclusions and Future Research

6.1 Conclusions

Vermont faces significant obstacles to improving transportation system efficiency. The literature on rural transportation efficiency, combined with Vermonters current travel behavior and rural land settlement patterns suggest that State initiatives to increase overall transportation system efficiency will require bold and innovative steps.

Changing land use settlement patterns will have the single largest long-term impact on improving the efficiency of the overall transportation system. As mentioned in the introduction, if access is the goal, not mobility or miles of travel, then the most efficient system will have people living closer to the services and destinations they wish to access -- therefore meeting their needs with fewer (or shorter) trips.

This report has focused on steps to increase the efficiency of the existing transportation system based on current land use and settlement patterns. In this context, our findings can be summarized as follows:

Vehicle Efficiency

- Increase the efficiency of existing motorized vehicles, (e.g. the adoption of the California LEV standards, incentives to consumers to buy more efficient vehicles and AFVs).

Transportation System Efficiency

- Increase vehicle occupancy rates, (e.g. car-pooling, ride-sharing, van-pooling, park and ride lots and household and employment based TDM programs).
- Targeted public transit investments in locations with transit viable intra-city routes and inter-city routes.
- Increased education and outreach regarding efficient driving styles and the impact of travel choices.

6.2 Future Research

Research in all of these areas needs to continue to enable policy-makers to choose options to provide the most energy efficient options while maintaining Vermonters access to goods and services and ensuring our quality of life. Some future research areas include:

- The development of an optimal transit network/system to coordinate and improve connections between Vermont's public transit providers.
- Vermont specific research on the relationships between driving style behavior, climate, hilly terrains and fuel usage.

- The impacts and potential of large fleets of AFVs including PHEVs in Vermont.
- Assessing the potential for transit-oriented development and infill potential in Vermont towns and villages to create denser and more transit serviceable areas.
- Increased biking and pedestrian travel behavior and the obstacles to extending that behavior into the winter
- Examination of social networks related to travel that may provide access and mobility to older Vermonters and increase vehicle occupancy rates, carpooling and ride-sharing, for example.

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