The Vermont Transportation Energy Profile

August 2013

VTrans Working to Get You There
Vermont Agency of Transportation

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Disclaimer

The Profile was developed and written as a collaborative project. The UVM TRC is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the UVM Transportation Research Center or the Vermont Agency of Transportation. This profile does not constitute a standard, specification, or regulation.

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If we are to achieve our goals, we must measure and evaluate our progress and adjust it on the basis of data, not just broad policy. Therefore, at least every five years, VTrans and other relevant state agencies as assigned by the Vermont Climate Cabinet in the implementation of the CEP will review data collected by the Agency and the U.S. Census Bureau to determine progress in meeting objectives. A summary report will be produced detailing progress levels in relation to targets and an explanation of whether the objectives are being met or not.

- Vermont Comprehensive Energy Plan 2011

1 Executive Summary

The Vermont Transportation Energy Profile (the Profile) is the first installment of a biannual report measuring and evaluating progress in meeting the goals outlined in the 2011 Vermont Comprehensive Energy Plan (CEP). Due to the transportation sector's almost exclusive reliance on fossil fuels and significant contributions to carbon emissions in Vermont, meeting these goals are critical to the success of the Plan. The Profile builds upon work by the University of Vermont's Transportation Research Center (TRC) to formulate metrics to assess progress towards the CEP goals. The results of this analysis can be found in Table 1-1 below.

The quantitative objectives outlined in the CEP fall into four primary categories: Vermonters' travel behavior, composition of the privately-owned vehicle fleet, transportation fuel consumption, and freight transport. For each of these categories, associated data-sets, and metrics form benchmarks to judge changes in Vermont's general transportation energy consumption. Over time, the analysis of these trends will provide policy makers with valuable insight into policy efficacy.

These metrics reveal significant trends and data points including:

- SUV and light-duty truck classes represent a significant proportion of private vehicles (40% of all modes).
- 19 public electric vehicle charging stations have been placed statewide[1].
- Total on-road annual petroleum consumption (gasoline and diesel) has declined by an average of 6.3 million gallons per year over the past 5 years to its current level of 393 million gallons.
- 88% of all trips are conducted with a personal vehicle.
- 82% of all commute trips in Vermont were completed by a single driver, 11% of trips were by carpool, 4% were by biking or walking, and less than 1% were by public transit.
- Annual transit ridership stood at 4.2 million in 2011, with an annual growth of approximately 4%.
- Vehicle registrations per licensed driver increased at an annual rate of 1.1%, while vehicles per household decreased 0.4%, revealing an ongoing demographic shift.

[1] Additional public electric vehicle charging stations are coming online monthly.

Table 1-1: CEP transportation metrics, current status and targets

Ensure that 25% of all vehicles registered in Vermont are powered by renewable sources by 2030.		
Metric	2013 Value	CEP 2030 Goal Value
Number of renewably-powered vehicles registered in Vermont, expressed as a percentage of all registered cars and trucks in Vermont	0.05%	25%
Improve the combined average fuel economy (in mpg) of the Vermont vehicle fleet to meet the national average fuel economy set by the federal combined average fuel economy (CAFÉ) standard or improve it by 5% (whichever is greater) by 2025.		
Metric	2012 Value	CEP 2025 Goal Value
Improve the combined average fuel economy (in mpg) of the Vermont vehicle fleet to meet the national average fuel economy set by the federal CAFE standards or improve it by 5% (whichever is greater) by 2025.	2009 CAFE Standard: 27.3 mpg 2012 Vermont CAFÉ: 27.6 mpg	2025 Non-Final CAFE Standard: 48.7–49.7 mpg 2012 Vermont CAFE, plus 5%: 28.9 mpg
Increase the number of medium- and heavy-duty vehicles powered by biodiesel or CNG by up to 10% by 2030.		
Metric	2011 Value	CEP 2030 Goal Value
Number of medium- and heavy-duty vehicles powered by biodiesel or CNG, expressed as a percent of total medium- and heavy-duty vehicles	Unknown[2]	10%
Keep VMT annual growth rate to 1.5% (half of the national average) for that portion controlled by the state.		
Metric	2011 Value	CEP Goal Limit
Year-over-year percent change in VMT	-1.4%	< +1.5%
Hold VMT per capita to 2011 base year values.		
Metric	2011 Value	CEP Goal Limit
Annual VMT per capita	11,399	11,399

[2] 2 As of 2011, there were 47 CNG vehicles registered in Vermont.

Reduce share of SOV commute trips by 20% by 2030.		
Metric	2011 Value	CEP 2030 Goal Value
Percent of commute trips taken in a single occupancy vehicle (SOV).	82.7%	62.7%
Increase public transit ridership by 110%, to 8.7 million annual trips by 2030.		
Metric	2011 Value	CEP 2030 Goal Value
Total number of riders on fixed-route transit buses in Vermont in one year	4.2 million riders	8.7 million riders
Double the bicycle and pedestrian share of commute trips to 15.6% by 2030.		
Metric	2010 Value	CEP 2030 Goal Value
Percent of commuting workers who travel via bicycle or walk	7.4%	15.6%
Double the carpooling-to-work share to 21.4% of commute trips by 2030.		
Metric	2010 Value	CEP 2030 Goal Value
Percentage of workers who carpool to work	11.7%	21.4%
Quadruple passenger rail trips to 400,000 Vermont-based trips by 2030.		
Metric	2012 Value	CEP 2030 Goal Value
Total yearly ridership on the Amtrak Ethan Allen and Vermonter lines	133,191 riders	400,000 riders
Double the amount of rail freight tonnage in the state from 2011 levels by 2030.		
Metric	2007 Value	CEP 2030 Goal Value
Total rail freight tonnage in Vermont in one year	2,211 million ton-miles	4,422 million ton-miles
Triple the number of state park-and-ride spaces to 3,426 by 2030.		
Metric	2012 Value	CEP 2030 Goal Value
Total parking spaces within park-and-ride lots in Vermont	Approximately 1,690 spaces	3,426 spaces

This report also provides a set of recommendations for improved data gathering, modeling, and analysis. These cover a wide range of issues including gaps in data collection, needed analysis of additional complimentary metrics, and guarantees of continuing data-collection funding.

2 Introduction

Transportation is Vermont's single greatest energy-consuming sector. In response the CEP sets transportation-energy specific goals and objectives and a set of transportation-specific strategies to reduce energy consumption and shift toward greater renewable-energy utilization. These strategies are listed in the box below.

The development of the CEP was a multi-agency planning effort led by the Public Service Department as a first-year priority of Governor Peter Shumlin's administration (VDPS, 2011). The CEP includes the broad goal of a 90% renewable energy profile by 2050 for all sectors including transportation.

Given this broad goal, the transportation portion of the CEP includes:

1. Reducing petroleum consumption in the state of Vermont through improvements to vehicle efficiency and an increase in the consumption of alternative fuels
2. Reducing energy use in the transportation sector in Vermont through more efficient and less energy intensive mobility options
3. Addressing the effects of decreasing use of fossil fuels on transportation funding
4. Measuring and evaluating progress

The Profile is in response to the fourth priority listed above and outlines current trends within Vermonters' travel behavior, privately owned vehicle fleet composition, freight transport, and transportation-fuel usage. Data relevant to these trends form the basis for derivation of metrics to track the state's progress toward the CEP targets concerning fossil fuel and renewable-energy consumption. See Table 1-1, above.

The data presented here provides an important feedback mechanism to inform decision makers and provide a quantitative basis for future transportation policies. The Profile defines relevant data-sets and metrics; presents current data and historical trends; analyzes potential data-set limitations; and evaluates progress towards the CEP objectives. Finally, it closes with recommendations for improved data gathering, modeling, and analysis.

To measure the impact of the proposed strategies, the Profile examines travel "behavior" i.e. how individuals interact with the transportation system. Relevant behavioral choices include how long, how far, where, and by what mode trips are taken. A number of tools allow for the examination of these behaviors over time setting benchmarks to evaluate future trends. Data and information related to passenger vehicle miles traveled, vehicle occupancy, trip purpose, mode choice, and emerging options such as car sharing, telecommuting, and transit supportive development reveal the travel preferences of Vermonters. In addition to behavioral metrics, The Profile examines private-vehicle fleet composition, freight movement, and fuel consumption data.

This data builds upon previous analyses completed by the UVM Transportation Research Center (Sears and Glitman, 2011; Sears and Glitman, 2010; Kenyan et. al., 2009).

The final section of the Profile contains a set of recommendations to further improve tracking of progress toward the goals and objectives of the CEP. The recommendations are compiled into five categories:

- Additional Metrics
- Future Collection and Reporting of Data
- Improved Data
- New Data
- Improved and New Modeling

CEP transportation specific strategies:

• Increasing the fuel efficiency and registrations of electrically powered vehicles in Vermont

• Supporting the deployment of a cleaner-burning and more energy-efficient truck fleet

• Providing more efficient alternatives to single-occupancy vehicles for most trips

• Making transit options available for commuter trips in developed areas

• Encouraging carpooling and car-sharing

• Providing seamless connections between intercity rail, bus, and airport services.

• Providing safe accommodation for bicycles and pedestrians on all Vermont roadways

• Focusing new development and jobs in "smart growth" locations, where land use density and the mix of uses will support shorter trips through transit, bike, and pedestrian modes

2.1 Data Sets

Several data sets pertaining to the demographics and travel behavior of Vermonters are used in the Profile to describe trends and to establish the CEP metrics. These data sources are expected to be available at regular intervals in the foreseeable future. They include, but are not limited to:

- The National Household Travel Survey (NHTS) (six- to eight-year cycle)
- The American Community Survey (annual cycle)
- The Vermont Travel Model, Base Year 2009-2010
- State of Vermont Department of Motor Vehicle driver's licensing data and vehicle registration data (annual cycle)
- Federal Highway Administration annual summaries of roadway utilization from the Highway Performance Monitoring System
- Ridership reports from Vermont's ten bus transit authorities

- Vermont Joint Fiscal Office (VJFO) annual report of gasoline and diesel revenue and gallons and monthly reports of Amtrak ridership and revenue

3 Vermonters' Travel Behavior

This section provides data to describe travel behavior and corresponding energy uses in Vermont.

3.1 Passenger Vehicle Miles of Travel

- 7.141 billion miles were traveled in Vermont in 2011
- 11.4 thousand miles were traveled in Vermont per capita
- Vermont exceeds national average VMT per capita by 20%
- Since 2008, both national and Vermont's VMT has stabilized and even decreased per capita
- Vermont's VMT per capita is decreasing at a lower rate (0.45%) compared to national reductions (0.75%)

Definition

Total Annual Vehicle Miles of Travel (VMT) is a measure of the total vehicle miles traveled in an area's transportation system. It provides a common measure of roadway use but can also be extrapolated to reveal mobile source emissions, potential gas tax revenues, and regional economic trends.

Current Data[3]

In the most recent data available, 2011, an aggregate 7.141 billion miles were traveled in Vermont. This equates to 11,399 miles traveled per capita: 20% greater distance than the national average of 9,506 miles per capita. (See Table 3-1) Due to sparse land development patterns resulting in comparatively larger distances between residences and work, school, and shopping attractions, Vermont has the 10th highest level of vehicles miles traveled per capita among the states. (See Figure 1)

Table 3-1. Vermont and U.S. Vehicle-Miles Traveled Per Capita

	2007	2008	2009	2010	2011
VMT in Vermont (billions)	7.519	7.176	7.154	7.243	7.141
VT Population	620,460	621,049	621,760	625,909	626,431
VT Per Capita VMT	12,118	11,555	11,506	11,572	11,399

[3] Yearly VMT data is released by VTrans. This, and other relevant publications, can be accessed at http://vtransplanning.vermont.gov/research/highway/publications

	2007	2008	2009	2010	2011
VMT in the U.S. (billions)	3,031	2,976	2,977	2,998	2,962
U.S. Population	301,579,895	304,374,846	307,006,550	309,330,219	311,591,917
U.S. Per Capita VMT	10,050	9,777	9,697	9,692	9,506
Sources: FHWA, 2011; USCB, 2012					

In addition, Vermont's rural geography creates disproportionate use of its transportation system. Although rural roadways comprise 90% of the total miles of public roadway in the state, they incur only 74% of its VMT. Urban roadways, on the other hand, constitute only 10% of the state's public roadways but receive a disproportionately heavy share of its VMT (26%). (See Table 3-2)

Table 3-2. VMT by Road Class, 2011

Roadway Class	Urban/Rural	Total Roadway Miles	% of Total	VMT (millions)	% of Total
Interstate	Rural	280	2.0%	1,252	17.5%
	Urban	50	0.4%	376	5.3%
Arterial/ Major Collector	Rural	3,941	27.6%	3,037	42.5%
	Urban	488	3.4%	1,069	15.0%
Minor Collector/ Local	Rural	8,602	60.2%	995	13.9%
	Urban	937	6.6%	413	5.8%
Totals		14,298	100%	7,141	100%
Source: FHWA, 2011.					

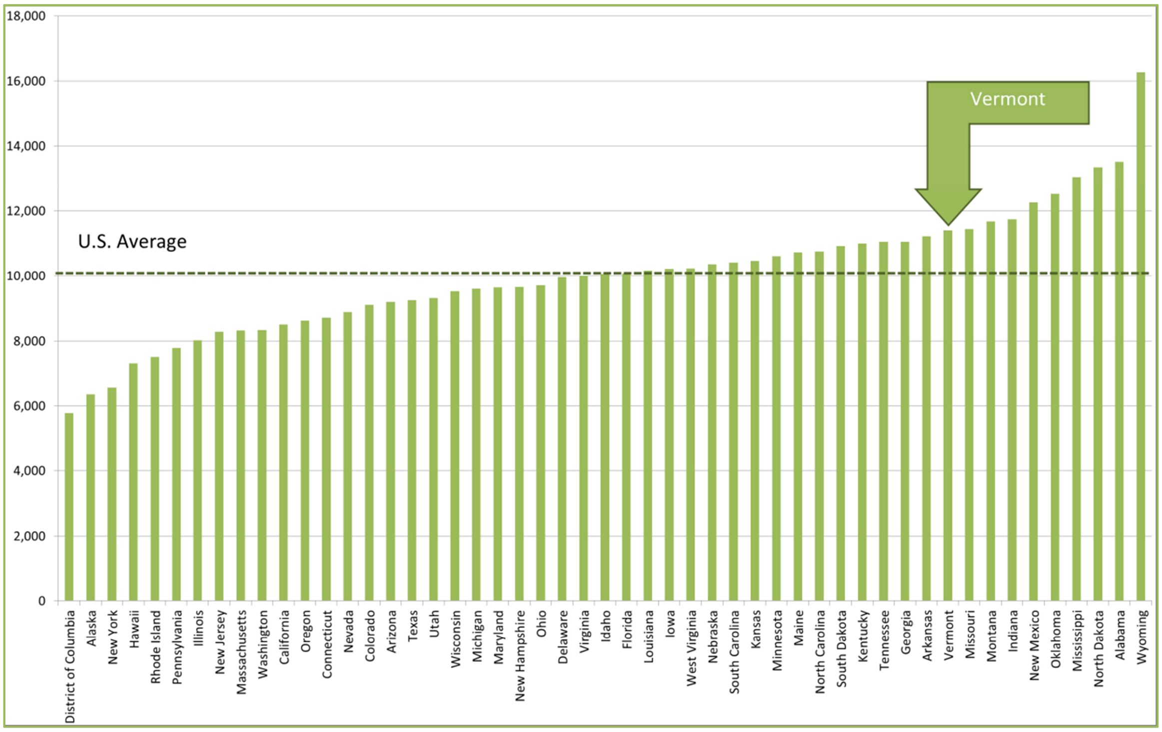

Figure 1. 2011 VMT Per Capita for U.S. States (FHWA, 2011)

Trends

While Vermont and national VMT data have shown a steady climb in per capita VMT over the past 30 years, recent increases in petroleum prices, the 2008 economic downturn and other factors have halted and even reversed this trend. (See Table 3-1) The decrease in VT (-0.45%), however, is not as great as the national decrease (-0.75%).

Data Set Comments

In measuring total VMT in Vermont, two separate estimates were prepared for the Profile. One of the estimates is derived from the FWHA's annual summary of roadway utilization for all U.S. states, and estimates a total VMT of 7.141 billion for 2011, with a per capita rate of 11,399 (FHWA, 2011). A complementary estimate of statewide VMT, derived from the Vermont Travel Model (the Model) for 2009-2010 is significantly lower, at 6.242 billion (Sullivan and Conger, 2012). These estimates approximate travel on minor and local roads, for which little or no data exists. The gap in these estimates is most likely due to differences in these approximations. Unlike the FHWA estimate, the Model differentiates between VMT of pass-through travelers (0.124 billion) and travelers originating within the state each day (6.118 billion).

3.2 Mode Share

- Large personal vehicles (SUVs, Vans, Light Trucks) constitute 40% of all modes chosen
- In general, personal automobiles constitute 85% of all modes chosen
- Active transport (biking, walking) constitute 12% of all modes chosen.
- Measures of active transport rates varying widely due to methodological differences

Definition

Mode of transport examines the means by which people move about the state. These include single and multiple occupancy vehicles, passenger rail, airlines, bicycle, and pedestrian means.

Each mode has unique energy intensities (Btu per passenger-mile) corresponding to generalized vehicle energy efficiency. (See Table 3-3 and Figure 2)

Table 3-3. Energy Intensities of Common Transport Modes

Mode	Average or Likely Occupancy	Vehicle Energy-Intensity (Btu per vehicle-mile)	Passenger Energy-Intensity (Btu per passenger-mile)
Passenger car	1.55	5,342	3,447
Passenger car with driver only	1.00	5,342	5,342
Passenger car with one passenger	2.00	5,342	2,671
Personal light-duty truck	1.84	7,081	3,848
Motorcycle	1.16	2,881	2,484
Demand-response transit bus	0.97	15,111	15,645
Full-size transit bus (40-foot)	8.70	35,953	4,118
Transit bus at capacity (40-foot)	40.00	35,953	899
Air	101.00	276,329	2,735
Intercity rail (Amtrak)	21.80	49,453	2,271
Source: Davis et. al., 2012.			

Current Data

According to the 2009 NHTS, which measures mode share on an annual basis, Vermonters' travel for all trip purposes is dominated by use of motorized modes, with 88% of all person trips occurring by means of a privately owned passenger vehicle, public transit bus, van, commercial truck, school bus, charter/tour bus, shuttle bus, Amtrak, taxi, or airplane. Active transport modes (biking and walking) account for the remaining 12% of trips.

The personal automobile accounts for approximately 85% of all modes chosen. Large personal vehicles (SUVs, light trucks, and vans) make up a sizable 40% of all modes chosen. The reliance on personal occupancy vehicles (85% of all modes), and particularly energy inefficient SUVs, vans, and light trucks (40% of all modes) contrasts relatively low use of more energy efficient modes such as public transit buses at capacity, motorcycles, and bicycles (1.8% of all modes). See Figure 3.

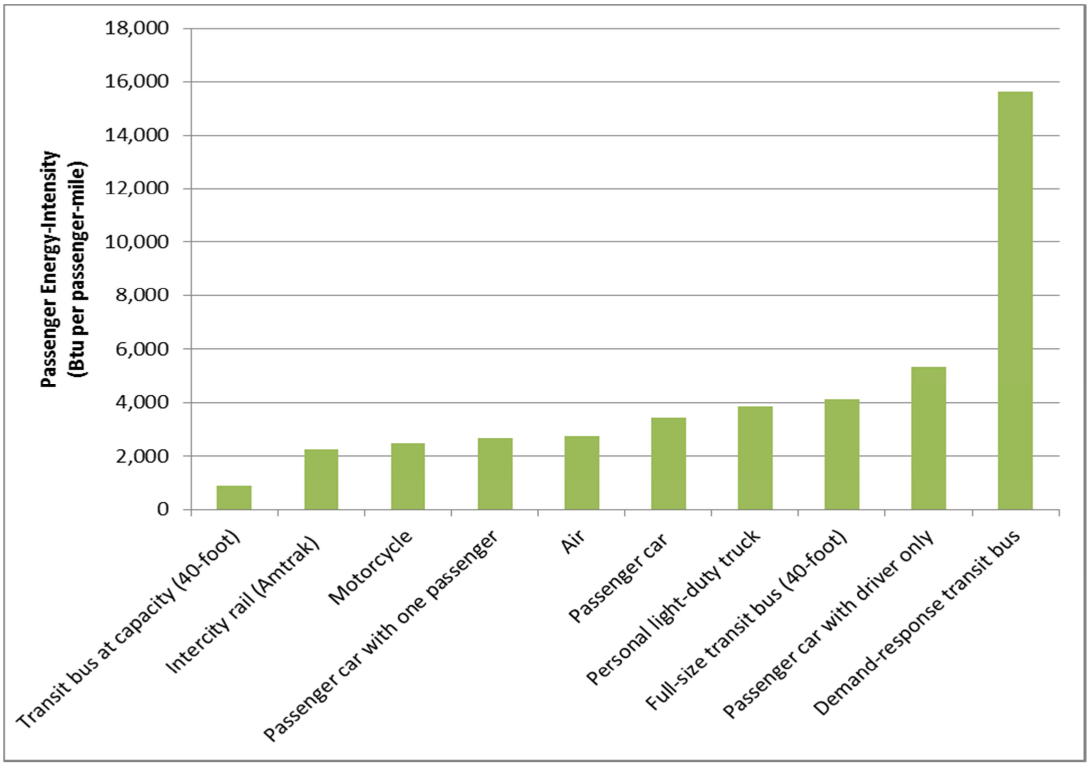

Figure 2. Energy Intensities of Common Transport Modes (Davis et. al., 2012)

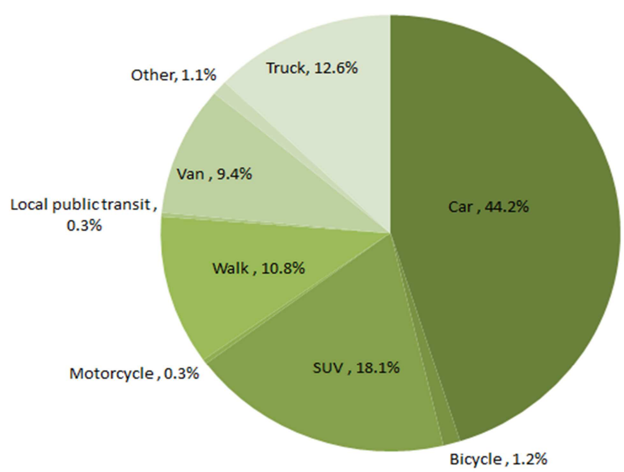

Figure 3. Mode Share for All Trip Purposes for Vermonters, 2009 (USDOT, 2010)

Active modes, such as biking and walking, make up a sizable mode share. Due to methodological differences, active-mode share estimates range from 10 to 30%. See Section 2.4.4 for an expanded discussion of the wide disparity in active mode share findings. A comparison of the results of mode share for the commuting trip is provided in Table 3-4.

Table 3-4. Comparison of Commuter Mode Share and Occupancy for Vermonters, 2009

Mode	2009 NHTS	2007-2009 ACS
Car, truck, or van; drove alone	82.7%	79.2%
Car, truck, or van; carpooled	11.7%	11.4%
Public transportation	0.6%	1.0%
Walked	3.1%	6.7%
Bicycle	0.9%	0.8%
Taxicab, motorcycle, or other	1.0%	1.1%
Sources: USDOT, 2010; ACS, 2010		

Data Set Comments

Rates of active transport revealed in other surveys in Vermont, like the New England Travel Survey (NETS), demonstrated a 30% active mode share: more than double the NHTS rate. The NETS uses a survey of limited scope and assigns different weighting values. In addition, the NETS responses, like the ACS, were designed to indicate respondent tendencies rather than actual behavior. Therefore, the elevated active mode share may be an indication that Vermonters intend to be active, but may not be finding the opportunities.

Limitations aside, surveys like the NETS which include consideration of very minor, incidental trips, such as visiting friends or walking a pet, often reveal significantly higher rates of walking and biking than do a travel diary survey such as the NHTS. Other work focused on measuring bike and pedestrian miles of travel in Vermont has reached similar conclusions (Dowds and Sullivan, 2012). An improved counting program with corresponding tracking of Bicycle and Pedestrian Miles Traveled (BPMT) statewide may better capture biking and walking behavior in Vermont.

3.3 Trip Purpose or Destination

- Vermont travelers stop at an average of 2 destinations before returning home
- Predominant trip destinations include: home (34.4%), shopping (18.4%), employment (13.7%) and entertainment (13.6%)

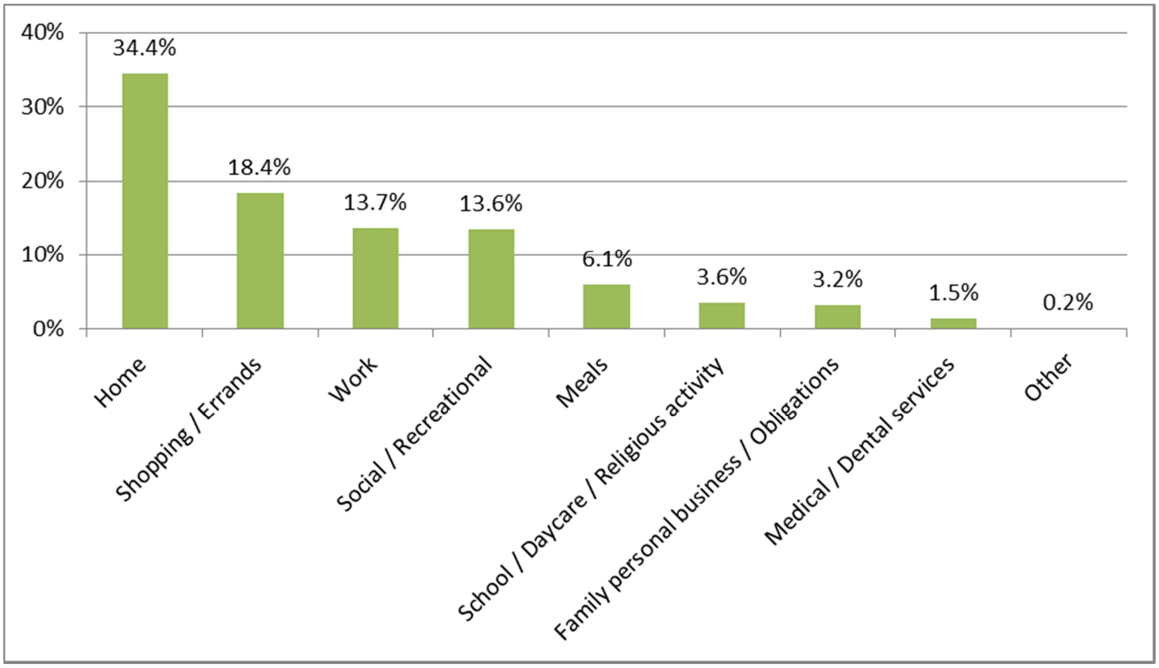

Figure 4. Distribution of Trip Purpose or Destination for Vermonters, 2009 (USDOT, 2010)

Definition

A trip is defined in the NHTS as a single leg of a journey, with a discrete beginning and end. The trip destination reveals the primary purpose of the trip. For example, work destinations reveal commuter trips while commercial destinations reveal shopping trips. An overall reduction in home destinations generally indicates a higher degree of efficiency of trip-chaining behavior, with single trips accounting for multiple purposes/tasks. Reductions in the share of home-destination trips, largely completed by passenger vehicle, may also serve as an indicator of higher occupancy rates, with multiple household members or other travelers being served by a single vehicle.

Current Data

The distribution of trip destinations by Vermonters for all modes is shown in Figure 4. Home-destined trips are the predominant trip type (34.4%), followed by shopping (18.4%), employment (13.7%), and social/recreational (13.6%). The home destined trip share indicates trip chaining with an average of approximately 2 destinations before returning home.

3.4 Vehicle Occupancy

- Trips within Vermont averaged 1.51 occupants per vehicle while those between Vermont and another state or Canada averaged 1.75 occupants per vehicle.
- Occupancy of vehicles used for work trips was significantly lower (1.16 occupants per vehicle) than the average for all trip types (1.51 occupants per vehicle)
- The 2009 Vermont carpool rate, 11.7%, was almost equal to the 12% national rate.
- Currently, there are 1,690 park-and-ride parking spaces in Vermont with an average annual growth rate of 100 spaces.

Definition

Vehicle occupancy is defined as the number of people travelling in a single vehicle typically measured for private passenger vehicles.

Current Snapshot

Mean vehicle occupancy was estimated to be significantly lower for all work trips compared with other purposes or destinations, based on the 2009 NHTS results for Vermont. Other trip purposes show higher occupancy rates, particularly those made between Vermont and other states or Canada, as seen in Table 3-5.

Table 3-5. Vehicle Occupancy by Trip Purpose for Vermonters, 2009

Trip Purpose or Destination	Trips Internal to Vermont	Trips Between Vermont and Another State or Canada
Home	1.50	N/A
Work	1.16	1.20
School/Daycare/Religious Activity	1.91	N/A
Medical/Dental Services	1.43	1.14
Shopping/Errands	1.44	1.73
Social/Recreational	1.83	2.10
Family/Personal Business or Obligations	1.62	1.92
Transport Someone	2.00	1.85
Meals	1.62	2.53
Other	1.33	2.95
All Purposes	1.51	1.75

Source: USDOT, 2010.

Carpooling Incentives

According to NHTS records, carpool rates in the U.S. have steadily declined from 20% in 1980 to its current estimated level of 12%. This 30-year decline may be attributed to a number of factors such as rising rates of vehicle ownership, declining household size, sustained low fuel prices, and increase in suburban settlement patterns.

In 2008, the state of Vermont established a carpool initiative, *Go Vermont*, to reduce single occupancy trips by encouraging higher rates of carpooling, transit use, biking, and walking. This initiative includes a website to link potential carpool and rideshare participants. To date, this program has registered over 4,643 carpool and vanpool commuters across the state. *Go Vermont* has documented considerable growth of its program over the past four years and has established its own data and tracking system (see Table 3-6).

Table 3-6. Go Vermont Program Benefits, 2008-2012

Tracking Metric	Data
Participating Businesses	229
Registered Commuters	4,578
Registered Car and Vanpools	1,156
Bike Participants	660
Total Estimated Reduction of VMT	16,466,000
Total Estimated Savings in Commuting Costs	$9,276,000
Source: McDonald, 2012.	

Park-and-Ride Facilities

Park-and-ride facilities provide safe and cost-free parking for those who carpool or ride the bus. Currently, the state operates 25 park-and-ride sites with approximately 1,690 total spaces, while individual municipalities maintain 26 sites with a total of approximately 490 spaces (see Table 3-7).

Table 3-7. Park-and-Ride Facilities in Vermont, 2012

	State	Municipal	Total
Number of Facilities	25	26	51
Approximate Number of Parking Spaces	1,140	550	1,690
Number of Facilities with Bike Racks	11	2	13
Number of Facilities with Transit Connection	3	9	12
Number of Facilities with Paved Surface	17	20	37
Number of Facilities Lighted	18	18	36
Source: Croft, 2012.			

Occupancy at most park-and-ride facilities is measured over a brief period annually on the basis of parking capacity utilized at the time of observation. These yearly snapshots of occupancy rates tend to be high, yet growth in demand appears inconsistent across the state, with the heaviest demand arising from the facilities proximal to Interstates 89 and 91. Overall, the number of state-maintained parking spaces at these facilities is on the rise, with average annual growth rate of 100 spaces per year.

Data Set Comments

The ACS's relatively small sample size allows for greater error than alternatives such as the NHTS. Therefore, the values from the NHTS should be the primary data source with the ACS serving to confirm general trends and tendencies. The figures for Vermonters' tendencies to use a carpool to commute to work are very similar for both sources, at close to 12%. An increase in the percentage of drivers who reported carpooling (from the ACS), or the percentage of trips made in a carpool (from the NHTS) is thought to correspond with lower fuel use. However, it appears as though the tendency-based survey format of the ACS underreports the use of SOV for the commute trip and over-reports the tendency of people to walk to work. It is possible that commuters who intend to walk to work neglect participating in carpool services, and instead end up driving alone when walking is not feasible.

These results also attest to the importance of identifying the composition of the multiple-occupant vehicle when evaluating the effect of ridesharing on decreased fuel use. Focusing on the commuter trip helps clarify the vehicle occupancy composition, but does not exclude the possibility of trips whose passengers are below the legal driving age, perhaps being dropped off at school on the driver's way to work. Therefore, the best metric of vehicle occupancy to correlate with decreased fuel use is a trip whose occupancy characteristics include at least one driver as a passenger.

Only the NHTS is able to provide this level of detail when a passenger was recorded as a driver elsewhere in the survey, presumably because he or she lives in the same surveyed household (e.g., a spouse or a child who is a driver). The rate of carpooling for the commuting trip when at least one passenger could be confirmed to be a driver is 5.2%, approximately half of the total carpooling number. The rest of the carpools consist of a passenger who is not a driver, or a passenger who is a driver but was not included in the survey because he or she is not in the same household as the driver.

3.5 Active Transport

- Active transport modes were used in 13% of trips less than 2 miles.
- 14% of Vermonters have taken at least one bike trip and 75% having taken at least one walking trip in the past week
- Vermont rates of active transport closely correspond to national averages.

Definition

Active transport modes are defined as all non-motorized forms of transportation. These modes include all forms of self-propulsion such as biking and walking.

Current Data

Of the nearly 10,800 unique active trips recorded from the Vermont 2009 NHTS data set, 39% are less than 2 miles and 28% are less than 1 mile. Of all trips of length under 2 miles, roughly 87% percent were made by motor vehicle. Active transport rates in Vermont reflect those found nationally, with approximately 14% of Vermonters having taken at least one bike trip and 75% of Vermonters having taken at least one walking trip within the previous week. See Table 3-8.

Table 3-8. Vermonters' and Nationwide Biking and Walking Tendencies

Number of Trips in the Past Week	Vermonters		Nationwide	
	Bike	Walk	Bike	Walk
0	85.4%	24.6%	87.2%	32.1%
1-2	6.9%	16.9%	8.2%	16.2%
3-5	4.2%	26.3%	4.4%	24.1%
5+	3.6%	31.6%	2.2%	26.6%
	100%	100%	100%	100%

Source: USDOT, 2010.

Data Set Comments

The NHTS data presented in Table 3-8 above are self-reported tendencies as opposed to travel diary records. Respondents tend to overestimate rates of actual biking and walking with this survey methodology. The data in Table 3-8 is intended to show Vermonter's intentions to bike and walk, an important trend to affect eventual shift in mode share towards active modes. However, given that this data is not derived from the actual travel diary section of the NHTS, it does not provide a reliable indication of mode share.

Currently, statewide data on the availability of bicycle and pedestrian infrastructure facilities is inconsistently collected.

3.6 Passenger Rail Travel

- In Fiscal Year 2012, 46,934 rail passengers boarded and 50,040 disembarked in Vermont.

Definition

Passenger rail service in Vermont consists of two lines – The Vermonter, running north-south from St. Albans to its eventual terminus in Washington D.C., and the Ethan Allen Express, running from Rutland to New York City via Albany. These Amtrak services are hosted in Vermont by New England Central Railroad (the Vermonter) and Vermont Railway (the Ethan Allen Express). The benefits of rail travel on energy use are evident from its relative passenger energy-intensity value; second only a transit bus at full capacity in efficiency (see Figure 2).

Current Data

From 2003 through 2012, total ridership on Vermont's Amtrak lines showed an upward trend. In 2012, 46,934 boardings took place in Vermont for an aggregate 40% increase from 2003 values.

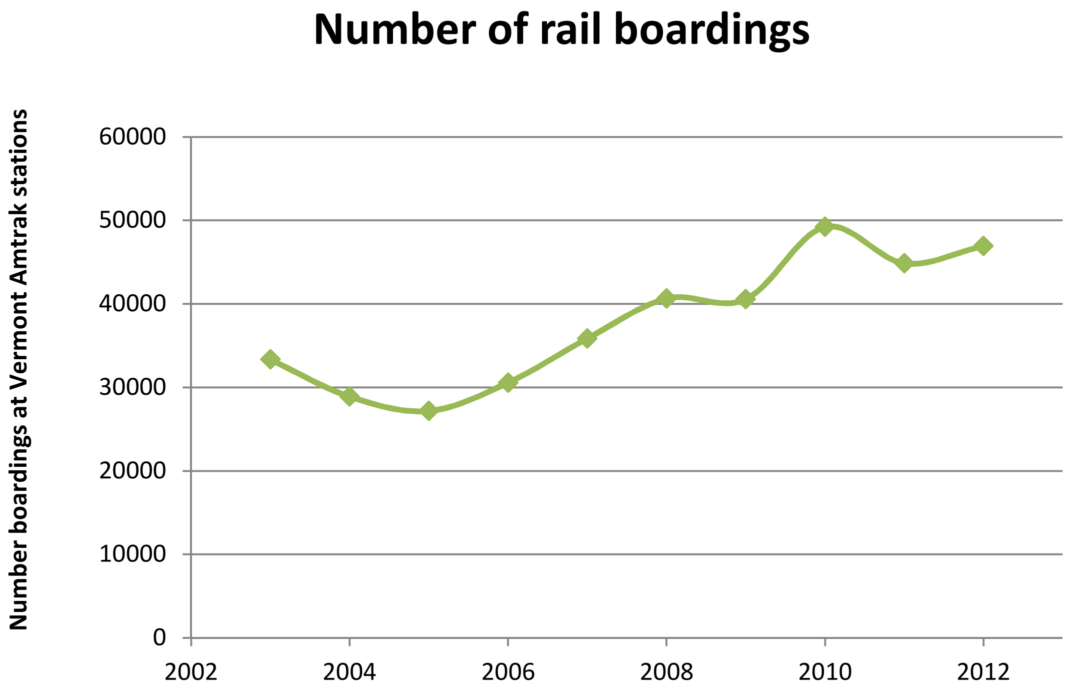

Figure 5. Amtrak annual Vermont boardings, 2003–2012 (Amtrak Annual Report, 2004-2013)

Trends

The significant increase in total Amtrak ridership between 2005 and 2011 may indicate that Vermonters are seeking alternatives to air and long-distance personal-vehicle travel. Despite disruption to service and a resulting dip in ridership aboard The Vermonter as a result of Hurricane Irene in the fall of 2011, total Amtrak ridership continues to show an upward trend. Before the drop, annual average ridership increases of approximately 9,000 were observed on both lines, and this trend appears to be continuing following the post-Irene return to normal service and ongoing track upgrades and service improvements.

Data Set Comments

Increases in rail ridership should be examined with rail occupancy and compared to long-distance private passenger vehicle occupancy rates to confirm an overall improvement in energy use.

3.7 Transit Ridership

- Transit use varies significantly throughout the state ranging from 103 trips per household on the Deerfield Valley Transit Authority service to 1.96 trips per household on the Rural Community Transit service.
- In 2011, there were 4.2 million transit service riders.
- Total statewide number of transit trips is increasing at an annual rate of 4.3%

Definition

Current statewide transit demand is measured in total boardings. Though ridership is an adequate measure of current transit utilization, unmet demand for transit remains difficult to measure and not captured by this metric.

To better understand the intensity of ridership use, a passenger-to-VMT ratio provides a relative measure of the amount of utilization within a transit authority catchment area. Transit catchment areas with higher ratios indicate greater service utilization and can point to strategies for improving utilization when coupled with estimates of demand, as in a recent study prepared by the UVM TRC for VTrans (Sullivan et. al., 2011). Because types of service provided vary considerably by authority, these passenger-to-VMT ratios serve to only illustrate the relative utilization rates of each regional transit provider, not the vehicle occupancy rates or average trip lengths.

Public bus-transit is made available to Vermonters through regional service providers throughout the state. In 2011, Chittenden County Transit Authority (CCTA) officially merged with Green Mountain Transit Agency (GMTA), which operates local and regional transit services across much of the northern half of Vermont – Washington, Lamoille, Caledonia, Grand Isle, and Franklin counties, including the Mad River Valley, Stowe, and the Montpelier Capital District. The majority of transit operations in Vermont along fixed routes can be characterized as smaller shuttle-bus services which seat no more than about 20 people, with the exception of CCTA, which provides service with traditionally-sized larger buses along a majority of its routes which seat up to about 40 people. A significant proportion of transit operation outside of the urbanized areas is provided by on-demand services, which typically serve single passenger requests, often with mobility impairments.

Current Data

In 2011, total transit ridership was measured at 4.2 million (see Table 3-9). Due to Vermont's relatively low commercial and residential densities, transit service and demand vary considerably across provider jurisdictions (see Figure 6). Annual transit trip rates by household vary from as low as 2 to as high as 103 trips per household per year. Regional transit authorities with highest rates of annual rides per household include Chittenden County (40.7), the Upper Valley (83.2), and Deerfield Valley (104) transit catchment areas (see Figure 6).

Table 3-9. Bus Ridership for Vermont Transit Authority Providers, FY 2011

Transit Provider	Counties Served	Annual Ridership	Annual Transit VMT	Passenger to VMT Ratio
Chittenden County (CCTA)	Chittenden	2,510,957	1,588,728	1.58
Marble Valley Regional Transit (MVRTD)	Rutland	505,437	751,034	0.67
Green Mountain Transit (GMTA)	Lamoille, Washington, Franklin, Grand Isle, Orange	391,644	983,013	0.40
Deer Valley (DVTA)	Windham	206,056	263,518	0.78
Connecticut River Transit (CRT)	Rutland, Windham, Windsor	169,609	503,660	0.34

Transit Provider	Counties Served	Annual Ridership	Annual Transit VMT	Passenger to VMT Ratio
Addison County Transit (ACT)	Addison	111,547	409,438	0.27
Rural Community Transit	Caledonia	76,475	177,299	0.43
Stagecoach	Orange, Windsor	75,985	541,897	0.14
Advance Transit (AT)	Windsor	72,464	100,011	0.72
Green Mountain Community Network	Bennington	48,372	301,685	0.16
Statewide Annual Totals		4,168,546	5,620,283	0.74
Source: VTrans, 2012a				

Trends

The total statewide number of transit trips is increasing at an annual rate of 4.3%. Recent expansions of transit service are most notable in Chittenden County, where three Link Express routes have been added to meet the demand of intercity commuters. In 2011, Montpelier LINK ridership rose by 21%, Middlebury LINK by 10% and the St. Albans LINK by 9%. CCTA has also recently purchased seven new low-emission Gillig-style buses which are expected to reduce particulate emissions by over 90%. CCTA is also adding new coach buses with increased seating capacity for its LINK services to meet heavy commuting demands.

Data Set Comments

As with rail ridership, the goal to increase transit ridership must be accompanied by additional measures of occupancy. Currently, only limited data exists to represent the utilization of each route within each of the transit systems described above. The best way to get this information is by obtaining estimates of vehicle occupancy by trip, where the trip is represented by a specifically served route (e.g., the Valley Floor route provided by GMTA leaving Lincoln Peak at 8:00am).

To better understand the intensity of ridership use, a passenger-to-VMT ratio provides a relative measure of the amount of utilization within a transit authority catchment area. Transit catchment areas with higher ratios indicate greater service utilization and can point to strategies for improving utilization when coupled with estimates of demand, as in a recent study prepared by the UVM TRC for VTrans (Sullivan et. al., 2011). Because types of service provided vary considerably by authority, these passenger-to-VMT ratios serve to only illustrate the relative utilization rates of each regional transit provider, not the vehicle occupancy rates or average trip lengths.[4]

[4] These vehicle occupancy estimates are critical because a private passenger vehicle with two occupants (1 driver and 1 passenger) is 50% less energy-intensive than a 40-foot transit bus at an average occupancy of about 9 passengers (see Figure 2), meaning that a private passenger vehicle can be significantly more energy-efficient than a 40-foot transit bus if the bus occupancy is below a certain level. Of course, in Vermont, many of our transit providers use buses that are smaller than the full-size, 40-foot, 40-passenger bus. Some of these

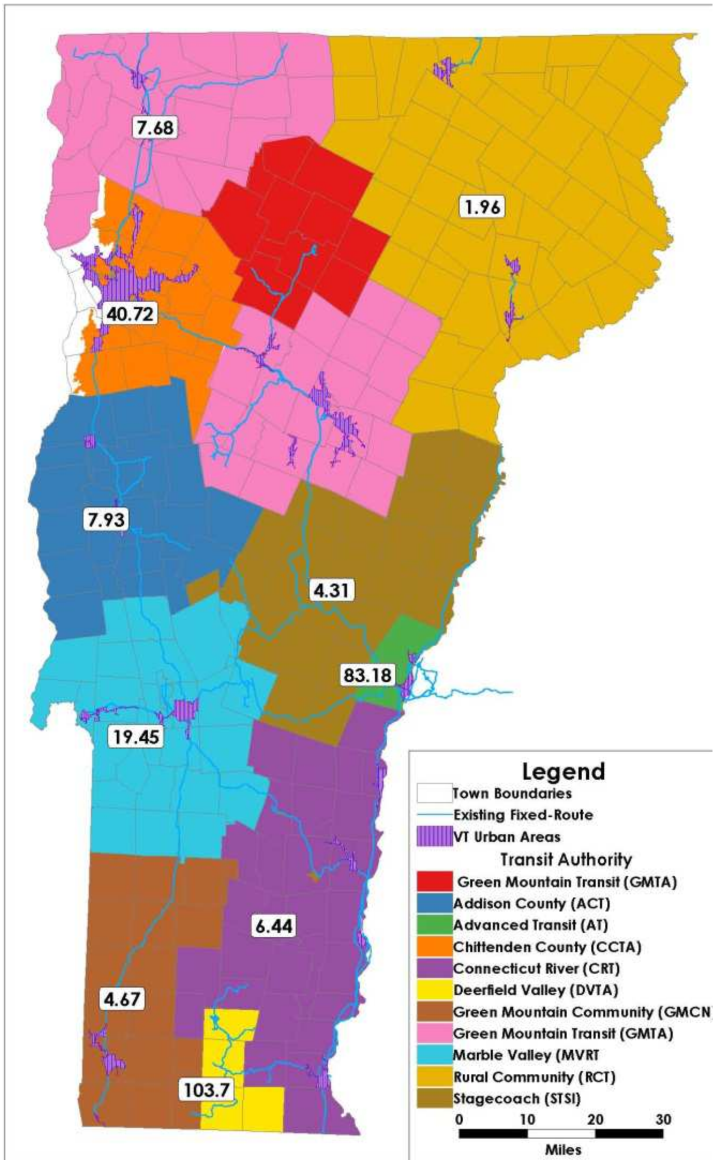

Figure 6. Vermont Service Providers, Fixed-Routes, and Annual Rides per Household, 2011 (VTrans, 2012a)

3.8 Private Interregional Bus Service

- In 2011, there were 80,000 trips (~225 daily) taken through the Megabus service.

Definition

In addition to public transit services, three major privately-owned intercity bus carriers currently service locations in Vermont. The newest provider, Megabus, began its Vermont service in 2011 and currently operates daily service from Burlington to five destinations across the Northeast, without any passenger facilities. Yankee Trails

smaller buses can be more than twice as efficient as the typical 40-foot bus. The estimates of energy-intensity provided in this profile do not represent the full spectrum of bus fuel efficiencies in Vermont public transit fleet. Therefore, a blanket increase of annual transit ridership may not represent an improvement in Vermont's energy usage for transportation. Complementary estimates of vehicle occupancy of the transit routes are required before the benefits of a transit service can be assessed, along with a comprehensive record of the fuel efficiencies of all the public transit buses in Vermont.

operates a single Bennington – Albany route, and Greyhound operates out of four Vermont locations (Burlington, Brattleboro, Montpelier, and White River Junction) with service throughout the Northeast.

Current Data

In its first year of operation in Vermont, Megabus ridership topped 80,000 passengers, or 225 daily passenger trips (Alyich, 2012). In 2011, ridership for the Yankee Trails' Bennington – Albany service totaled 297 passengers annually (Keens, 2013). No data was available for Greyhound services.

3.9 Multimodal Connections

Though often overlooked and difficult to measure, an additional indicator of reduced reliance upon personal vehicles is the expansion of mobility options provided through multimodal hubs.

Park-and-ride facilities are by nature multimodal because they facilitate shifts from automobiles to transit buses or from a SOV to a multi-passenger vehicle.

Greyhound recently relocated their Burlington, Vermont terminal from Pine Street to the Burlington Airport to assist bus-air connections.

Many CCTA buses are equipped with bike racks for their riders, allowing for the combination of biking and bus transit on a trip. In 2011, a total of 33,685 bike boardings occurred across all CCTA routes, indicating a small but significant bike-transit connection (CCTA, 2011).

3.10 Car Sharing Services

Definition

Vehicle sharing organizations provide an alternative to personal vehicle ownership and are gaining popularity in Vermont. CarShare Vermont, a non-profit launched in 2008, currently offers 10 vehicles for hourly or daily use. Current operations are limited to the Burlington metropolitan area. ZipCar, a national for-profit car sharing outfit, has a total of six vehicles located in Middlebury, Poultney and Royalton, Vermont, towns with college populations. Most recently, the creation of a peer-to-peer (P2P) car sharing service, RelayRides, provides a web-based option to search for privately owned vehicles available for hourly or daily rental, though no information is available on member usage.

Current Data

CarShare Vermont currently has a total of 750 member drivers, or approximately 75 members per vehicle (VanDyke, 2012). On average, CarShare's 10 vehicles are operated 5.5 hours each day of the week, compared with the U.S. mean driving duration of 55 minutes (USDOT, 2010). Data for other services was unavailable.

Data Set Comments

Current measurement of car sharing vehicle utilization is limited by the proprietary nature of each organization's data.

3.11 Transit-Supportive Development

- There are 51.4 square miles of transit-supportive urban areas throughout Vermont.

Definition

Smart growth strategies are often used to relate transit use to land use, advocating the focusing of new development and jobs where density and the mix of uses will support shorter trips through transit, bike, and pedestrian modes. A useful metric for the extent of transit-supportive, high-density development in Vermont will focus on transit-supportive zones (TSZs) within the state (Belz et. al., 2010). A finer-grained measure of smart growth and transit supportive development can be calculated by selecting only those portions of TSZs that also lie within Census urban areas (UAs).

Current Data

There are currently 51.4 square miles of transit-supportive UAs overlapping TSZs. Figure 7 below shows the extent of the UA around Middlebury, Vermont, as an example, with the transit supportive UAs highlighted.

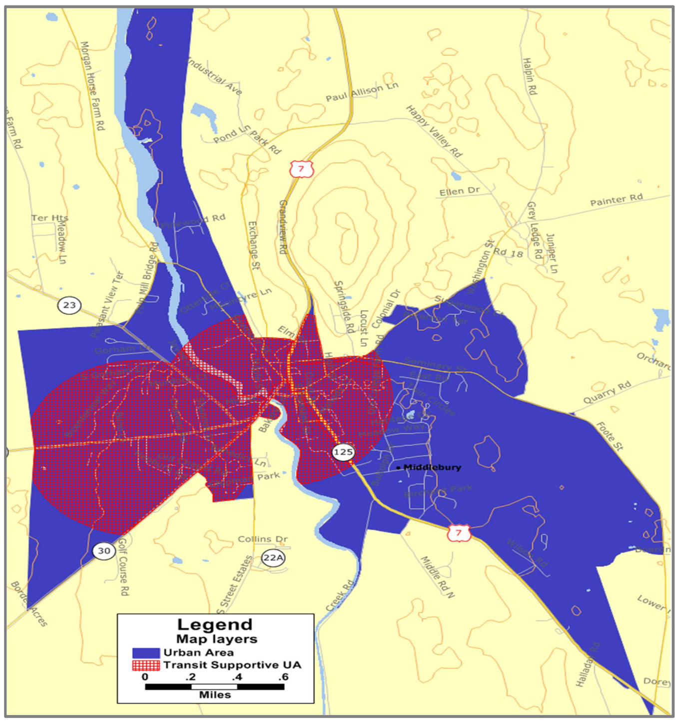

Figure 7. Transit-Supportive Urban Area in Middlebury, VT (USCB, 2012; Sullivan et. al., 2011)

4 Privately Owned Vehicle Fleet

The Vermont fleet of privately owned vehicles encompasses a wide variety of vehicle types utilized for a wide range of travel purposes. In this section, registrations of vehicle type to assess the overall statewide efficiency of the fleet are tracked, as well as the share of vehicles powered renewably. While it is difficult to accurately gauge the energy impact of these vehicles without some measure of their usage, these fleet snapshots establish basic trends in vehicle choice.

4.1 Trends in Driver Licensing and Vehicle Registration

- There were approximately 565,000 cars and trucks registered in Vermont in 2011.
- The state's public fleet represents 0.31% of this total with 1,743 vehicles.

- Total vehicle registrations have not increased significantly over the 2007- 2011 period.
- There was a decline in applications for Driver's Licenses (-1%) and Learner's Permits (-2.9%) over this same period.
- The number of vehicles registered per licensed driver is increasing at an annual rate of 1.1%, however vehicle registrations per capita is decreasing at 0.2%.
- Vermont's household-level vehicle ownership is declining (-0.4%) nearly as fast as the national average (-1.0%).

Current Data

In 2011, there were a total of 565,232 cars and trucks registered in Vermont, not including publicly owned vehicles, of which the state's public fleet of 1,743 vehicles comprises 0.31% of the total. Although Vermont's per capita vehicle ownership is higher than the national average, it's per driver vehicle ownership is lower.

Table 4-1. Vehicle Registrations and Driver's Licenses in Vermont, 2007-2011

	2007	2008	2009	2010	2011	Average % Change
Vehicle Registrations[1]	554,917	570,901	546,245	555,005	565,232	0.1%
Driver's Licenses	534,495	541,990	506,977	513,481	521,666	-1.0%
Learner's Permits	20,190	20,229	17,392	17,768	18,661	-2.9%
Vehicles per Licensed Driver[2]	1.04	1.05	1.08	1.08	1.08	1.1%
Registered Vehicles per Capita	0.89	0.92	0.88	0.89	0.90	-0.2%
Estimated Number of Households	317,837	319,901	321,429	322,907	324,389	0.5%
Vehicle Registrations per Household	1.75	1.78	1.70	1.72	1.74	-0.4%

Notes:

1. Does not include publicly owned fleet vehicles.

2. Holders of learner's permits are not considered licensed drivers in this ratio.

Sources: FHWA, 2011; USCB, 2012

Trends

While the number of total vehicle registrations in Vermont has remained relatively steady over the past five years (average growth rate of 0.1% per year), a 6% dip in the number of licensed drivers occurred in 2009, possibly as a result of the 2008 recession. Also noticeable was the 12% drop in learner's permits in the same year, indicating a sharp reversal of the previous increase in licensing rates among younger Vermonters. Since then, levels of driver licensing are showing a recovery to earlier levels, but the overall rate of change over the five-year period is still negative (-1.0%).

The number of vehicle registrations per capita in Vermont is exhibiting a slow but steady decline (-0.2%), even as the number of vehicles per driver increases (+1.1%). This inconsistency may indicate demographic changes within Vermont's population. However, an even more significant decline is revealed in the vehicle registrations per household, a trend that mirrors a national pattern of lower vehicle ownership. Table 4-2 provides equivalent nationwide data.

Table 4-2. Vehicle Registrations and Driver's Licenses in the U.S., 2007-2010

	2007	2008	2009	2010	2011	Average % Change
Vehicle Registrations (millions)[1]	243.1	244.0	242.1	237.8	241.1	-0.4%
Driver's Licenses (millions)	205.7	208.3	209.6	210.1	211.8	0.7%
Vehicles per Licensed Driver[2]	1.18	1.17	1.16	1.13	1.14	-0.4%
U.S. Population (millions)	301.6	304.4	307.0	309.3	311.6	0.8%
Registered Vehicles per Capita	0.81	0.80	0.79	0.77	0.77	-1.2%
Estimated Number of Households (millions)	129.1	130.5	131.3	131.8	132.3	0.6%
Vehicle Registrations per Household	1.88	1.87	1.84	1.80	1.82	-1.0%

Notes:

1. Does not include publicly owned fleet vehicles.

2. Holders of learner's permits are not considered licensed drivers in this ratio.

Sources: FHWA, 2011; USCB, 2012

Vermont's population has a lower rate of growth (0.3%) than the nation (0.8%). Likewise, Vermont's household-level vehicle ownership is declining (-0.4%) at a lower rate than the national average (-1.0%).Unlike population, the number of households is increasing at the national rate.

4.2 Vehicle Type

- Large vehicles (SUVs, vans, light-trucks) represent 40% of new vehicle purchases.
- Four of the five top selling models were trucks.

Definition

Characterization of Vermont's privately owned vehicle fleet is typically based upon body type but can also be refined by engine size or fuel type. Although the fleet is dominated by conventionally powered internal combustion engine (ICE) vehicles, electric vehicles (EVs) which can be powered by renewable energy are now available in the Vermont marketplace. There are two primary categories of EVs: all-electric vehicles (AEVs) which are powered solely by electric energy stored in the battery and plug-in hybrid electric vehicles (PHEVs) which can be powered by a combination of battery power and gasoline or diesel fuel. The EV data contained in this report excludes electric powered low-speed neighborhood vehicles, electric motorcycles, and traditional hybrid electric vehicles (HEVs) which receive all of their energy through gasoline or diesel fuel.

Current Data

Recent purchasing data reveals continuing preference for relatively large vehicles such as SUVs and vans in greater proportion (40%) than economy class (35%) or mid- to full-size sedans (24%) (Sears and Glitman, 2011). Figure 8below shows the 20 most common vehicle make and models registered in Vermont. Notably, four of the top five models were trucks.

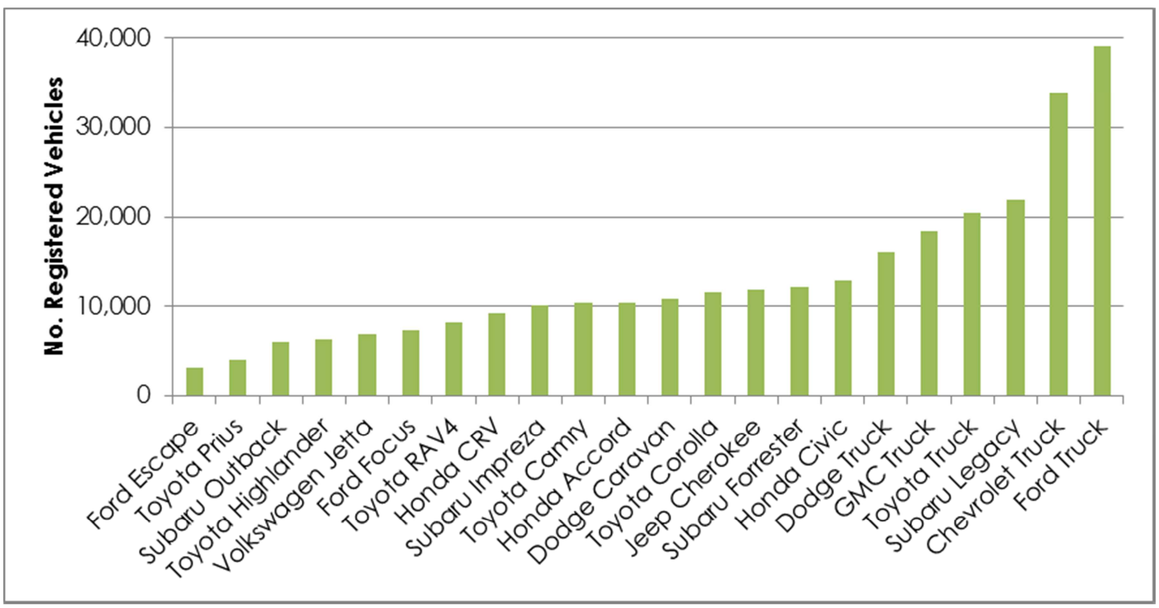

Figure 8. Top 20 Vehicle Models Registered in Vermont, 2012 (VDMV, 2012)

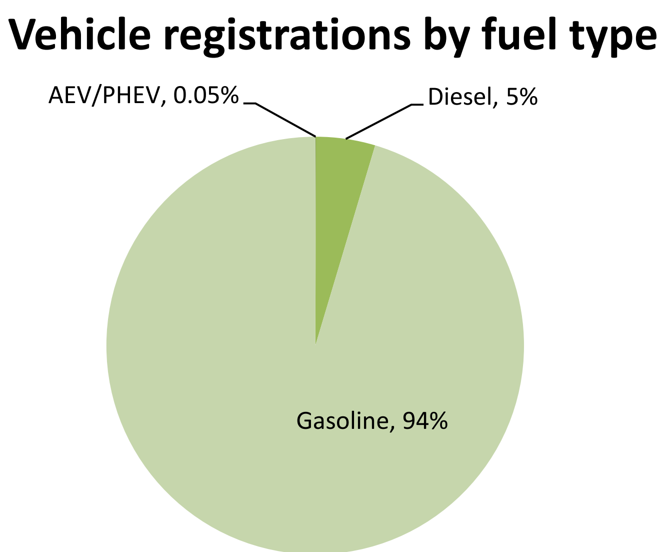

Figure 9. Passenger Vehicle Purchases by Fuel Type, 2012 and Newer (VT DMV, 2013)

Table 4-3 provides a more detailed breakdown of vehicles registered in Vermont by fuel type for the past five years.

Table 4-3. Vehicles Registered in Vermont by Fuel Type, 2007-2012

Fuel Type	2007	2008	2009	2010	2011	2012
AEV & PHEV	NA	NA	NA	NA	NA	81
Propane/CNG	93	75	69	59	40	47
Diesel	31,648	32,140	30,724	25,932	25,515	28,738
Gasoline	583,568	578,881	528,930	524,810	526,723	541,848
Source: VT DMV, 2012						

Trends

A recent increase in registrations of new diesel-powered passenger vehicles is evident in Table 4-3, exclusively consisting of popular European makes such as Volkswagen, Audi, and Mercedes Benz.

4.3 Fleet Age and Popular Models

- 96% of all vehicles registered were manufactured after 1980
- Median year of manufacture is 2005
- 19% of all registered vehicles are 2010 or newer

Definition

Fleet age and model type are aggregate data sets revealing the distribution of registered car ages and model types.

Current Data

A snapshot of current vehicle registrations, provided in Figure 10shows the distribution of model year (MY) for both autos and trucks. Note that some 2013 MY vehicles were available for sale in 2012, so they are shown as well.

96 percent of all Vermont's registered vehicles were manufactured after 1980, with a median model year for all vehicles of 2005. Approximately 19% of Vermont's currently registered autos and 16% of trucks are MY 2010 or newer.

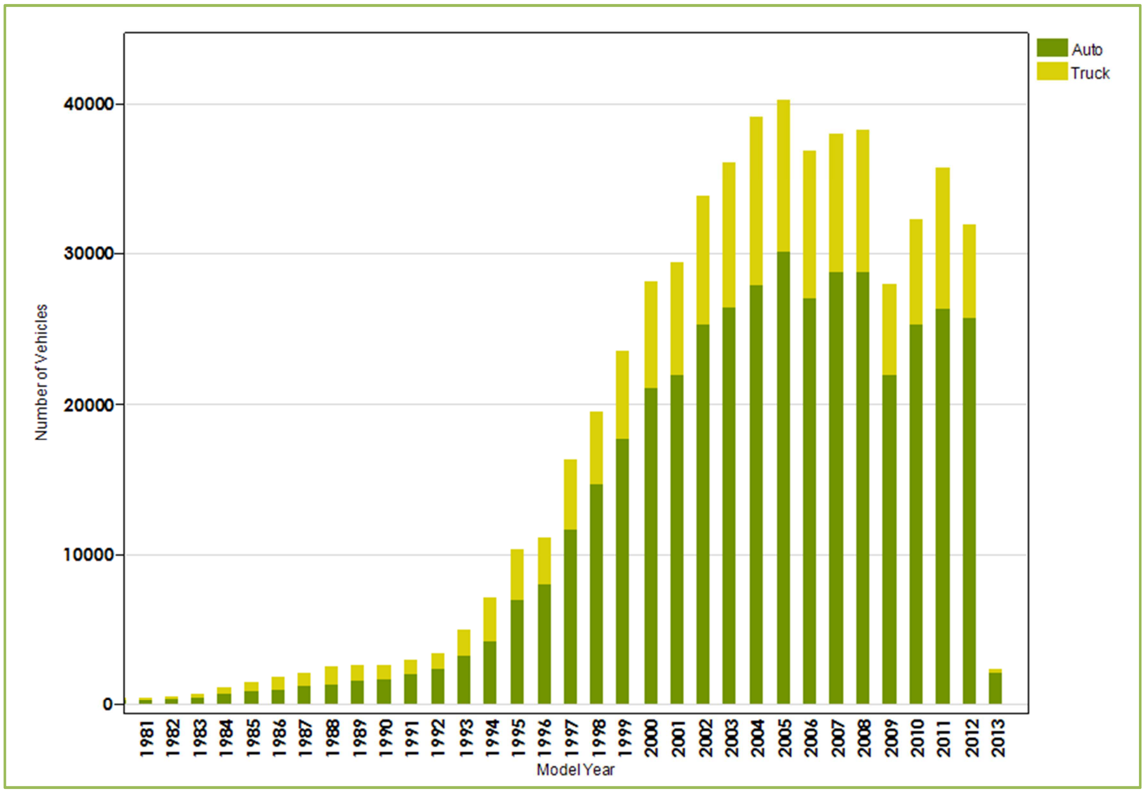

Figure 10. Distribution of Model-Year for Vehicles in Vermont, 2012 (VDMV, 2012)

Data Set Comments

An improvement in the fuel economy of Vermont's privately owned vehicle fleet is likely to result from a decrease in the average age of the fleet. Instead of calculating the average age of the fleet, it would be more effective to compare the distribution of vehicle ages, as shown in Figure 10, from one year to the next. A "newer" fleet will correspond with a distribution that features a sharper curve with a higher peak that is further to the right.

4.4 Legislative Action Pertaining to Vehicle Efficiency

The Corporate Average Fuel Economy (CAFE) standards issued in 2011 require an increase to 54.5 mpg for cars and light duty trucks by 2025 (USDOT, 2011). These new standards—to be phased in over a period of 14 years—place a greater burden on passenger cars compared with light-duty trucks. Passenger cars will be required to achieve annual improvements of 5%, while light trucks will only be held to 3.5% annual improvements (NHTSA and USEPA, 2011). CAFE standards do not directly incentivize purchase of fuel-efficient vehicles, but rather make it more expensive for automakers to build less efficient vehicles by introducing penalties. Despite these shortcomings, maintaining or increasing replacement rates of the Vermont fleet can potentially result in significant annual reductions of petroleum fuel consumption.

In addition Vermont adopted California's Low-Emission Vehicle (LEV) standards, Zero Emission Vehicle (ZEV) standards and Greenhouse Gas (GHG) standards first in 1996, and in 2003 and 2005, respectively. Since then, Vermont has amended its LEV, ZEV and GHG regulations a number of times to maintain consistency with California's standards. Vermont's adoption of these California standards results in significant reductions of air pollutants (including greenhouse gases) from motor vehicles, and corresponding environmental, public health and vehicle efficiency benefits.

4.5 Fleet-Wide Fuel Economy

- Estimates of fleet-wide fuel economy vary greatly from approximately 27 mpg to 18 mpg.

Definition

The fuel economy of Vermont's vehicle fleet.

Current Data

Estimates of fleet-wide average fuel economy, derived from 2009 NHTS vehicle data, fall between 27 and 28 miles per gallon, using the EPA mpg estimates for the vehicles in the Vermont sample (USDOT, 2010). However, using the usage-weighted variable derived by the Energy Information Administration (USEIA, 2011) for the vehicle in the NHTS, the Vermont and national fleet-wide average fuel economies were 22.8 mpg and 21.6 mpg, respectively. These values correspond better with the fleet-wide economy found by dividing total vehicle-miles of travel in Vermont with total fuel sold, 18.2 mpg. This finding indicates that the actual use-based fuel economy of the privately owned vehicle fleet in Vermont lags significantly below the simple average EPA sticker values of its registered vehicles.

Data Set Comments

Vehicle fuel efficiency is a critical factor in reducing fuel consumption statewide. Assessing the privately owned fleet efficiency relates to the energy intensity of its vehicles, which is a challenging metric to derive due to a lack of information regarding actual usage and occupancy during that usage by each registered vehicle.

Inconsistencies in the Vermont vehicle-registration data prevent accurate measurement of fleet-wide average fuel economy or use-based fuel efficiency.

EPA test values are derived in conditions that are more favorable to fuel economy than those found in Vermont. Other researchers have claimed that EPA test values under-represent fuel consumption rates found in most real world driving conditions.

Vehicle fuel economy is inversely proportional to a vehicle's fuel consumption. To improve the mathematical understanding of fuel economy, a preferred metric expresses a unit volume of fuel per unit distance—in Europe, for example, expressed as liters per 100 kilometers (L/100km). This reciprocal expression allows for more direct comparison of changes in values, with measurable goals of reducing fuel use reflected in a reduction, not increase, in the fuel efficiency measure.

4.6 Renewably Fueled Vehicles

- As of July, 2013, there are 286 plug-in passenger electric vehicles (EVs) registered in Vermont.

- From July, 2012 to July, 2013, total registrations of EVs increased by 325%, however, EVs make up very small percentage of the total vehicle fleet (0.05%).

Definition

Renewably fueled vehicles are those which are able to derive their power from renewable sources such as biofuel and non-carbon derived electricity.

Current Data

Data concerning renewably powered vehicles is of particular interest due to the CEP's goal of increasing renewably powered vehicles to 25% of the vehicle fleet by 2030. As of July 2013, 286 passenger EVs were registered in Vermont (VEIC, 2013).

Table 4-4. July 2013 AEV and PHEV Registrations by Vehicle Model in Vermont, (VEIC, 2013)

Make and Model	Number registered statewide
Chevrolet Volt(PHEV)	61
Toyota Prius Plug-in (PHEV)	133
Tesla Roadster & Model S (PHEV)	14
Nissan Leaf (AEV)	35
Mitsubishi iMiEV (AEV)	13
Ford C-MAX Energi (PHEV)	5
Ford Fusion Energi (PHEV)	2
Ford Focus Electric (AEV)	1
Smart Electric Drive (AEV)	1
Other (e.g. after market conversions)	26
Total	291

Due to the relatively recent emergence of EVs on the market, there is limited historical data from which to draw trends. From July 2012 to July 2013, EV registrations increased from 81 to 291 for a 259% increase in the total number of EVs. This trend will likely continue into the near future as more models are introduced to Vermont, EV charging stations become more prominent, and EV ownership moves beyond the innovator stage of adoption.

Data Set Comments

To account for the multitude of new electric vehicle models being introduced to the market, vehicles should be classified by fuel type in addition to body type. The introduction of these alternatively fueled vehicles requires an expansion of the previous classification by body type, to include fuel type. This would enable more effective tracking of HEV, PHEV, AEV and flex-fuel vehicles in Vermont.

There is no current method to identify a vehicle as biodiesel powered, or flex-fuel capable (able to use gasoline blends with up to 85% ethanol) within the DMV registration records. Even though many, if not all, diesel models are capable of utilizing biodiesel, their registry does not indicate or suggest the use of biodiesel; additionally, many manufacturer's warrantees may be voided with the use of blends with higher proportions of biodiesel.

The clarifications above underscore the problematic nature of quantifying the share of renewably powered vehicles on Vermont's roadways. A strict interpretation of the current data might suggest that almost none of Vermont's vehicles are being powered renewably.

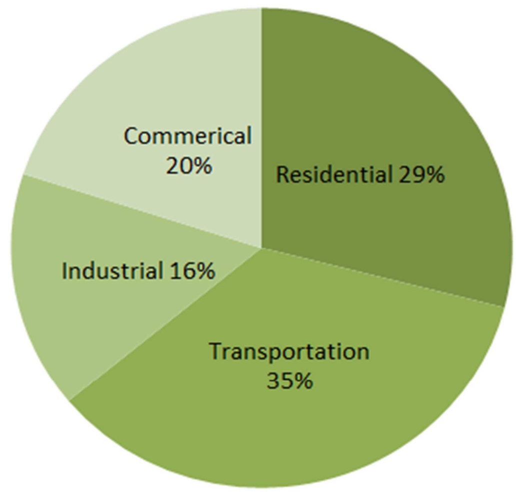

Figure 11: Energy Consumption in Vermont, 2010 (USEIA, 2012)

5 Transportation Fuel Consumption

The variety of fuels consumed, their relative share for transportation use, and the historic consumption statewide are presented in the section below. While fuel use is a direct function of the types of vehicles operated and their levels of utilization, the baseline consumption for the purposes of measuring future trends is examined here.

4.7 Energy Consumption in Vermont

The transportation sector continues to lead in energy consumption in Vermont (see Figure 11). This results in Vermont ranking 7th nationally in percentage of transportation sector consumption. On a per capita basis however, the state ranks a more moderate 20th.

4.8 Petroleum-Based Fuel Use

- Over the past 5 years, total on-road transport fuel decreased 6.3 million gallons per year

As shown in Table 5-5, fuel for transportation in Vermont is nearly exclusively derived from fossil fuels.

Table 5-5. Liquid Fuel Sales in Vermont, 2005-2011

	2005	2006	2007	2008	2009	2010	2011
Gasoline (gallons x 10^6)	361	344	348	337	337	332	329.7
Diesel (gallons x 10^6)	68	72	70	64	59	60.5	63.3
Biodiesel (gallons x 10^6)	0.054	0.364	0.378	0.392	--	--	--

	2005	2006	2007	2008	2009	2010	2011
CNG (GGE x 10^6)	--	--	0.008	0.020	0.027	0.033	0.068

Notes:

GGE – gallons of gasoline equivalent

Gallons of biodiesel are corrected to account for use in blended form

Sources: VLJFO, 2012; Vermont Gas, 2012; White, 2009

Over the past 5 years, a decreasing trend (6.3 million gallons per year) in total on-road transport fuel use has been observed (See Table 5-1), likely driven in part by increases in fuel efficiency of the Vermont passenger fleet, as well as the economic recession beginning in 2008.

Figure 13. Monthly Petroleum Fuel Sales for Transportation in Vermont, Rolling 12-Month Total, 2007-2012 (VLJFO, 2012)

4.9 Biofuel Consumption

- Biodiesel consumption for transportation was estimated at approximately 76,000 gallons, or 0.02% of the total transportation fuel portfolio.
- In 2010, 35.7 million gallons of Ethanol were consumed through blended gasoline purchases in Vermont

Definition

The emergence in recent years of alternative, non-fossil fuels has garnered attention for potential use in the transportation sector. The two primary transportation biofuels consist of Ethanol, derived from organic materials such as corn and cellulosic feedstock, and biodiesel, which is either chemically processed from raw feedstock or directly harvested from waste vegetable oil.

Current Data

Biodiesel sales in Vermont are predominantly sourced for the home heating fuel market, with an estimated 20% of sales being utilized for transportation. Consumption for transportation, last reported in 2008, was estimated at approximately 76,000 gallons, or 0.02% of the total transportation fuel portfolio (White, 2009). [5]

In 2010, 35.7 million gallons of Ethanol were consumed through blended gasoline purchases in Vermont (USDOE, 2010).[6]

Data Set Comments

Sources of feedstock and waste oil for use in Vermont are not centrally documented and remain extremely variable. Because of these issues, biofuel estimates remain unreliable.

4.10 Electricity Consumption

Definition

In recent years, the maturation of electric vehicle technology has brought new EVs to Vermont. Most EV owners do the majority of their charging at home, but more public charging stations are coming online to support increased use of EVs for longer distance travel.

Current Data

Currently, there are 19 level-2 public charging stations located in Vermont. Detailed use data is available at several locations with more advanced charging equipment. A sampling of data for three of these EV charging locations is presented in Table 5-6.

Table 5-6. Sample of Electrical Demand at Vermont Level 2 EV Charging Stations

EV Station Location	Number of Charging Events	Total Energy Consumption	Total Charging Time	Mean Charge Usage	Mean Charge Time
St. Michaels College, Winooski (11/21/2011-9/24/2012)	113	422 kWh	210 hrs	3.7 kWh	1 hr, 51 min
Healthy Living, South Burlington (10/20/2011 – 9/22/2012)	92	173 kWh	62 hrs	1.9 kWh	40 min

[5] This quantity includes the biodiesel portion of mixed fuel blends. Ethanol, mixed in conventional gasoline (E-85 for example, which contains 85% Ethanol) has been available nationally since 1982.

[6] The National Renewable Fuel Standard (RFS), passed in 2007, requires 36 billion gallons of Ethanol be mixed into the gasoline supply by 2022 (US Congress, 2007). The requirements for blending of Ethanol are being phased in over a period of 15 years, yet passage of the RFS has in effect made pure gasoline largely unavailable.

EV Station Location	Number of Charging Events	Total Energy Consumption	Total Charging Time	Mean Charge Usage	Mean Charge Time
City Hall, Montpelier (2/9/2012-9/24/2012)	198	743 kWh	375 hrs	3.8 kWh	1hr, 54 min
Source: Roberts, 2012.					

In this brief glimpse of actual electrical demand from EV charging, differences in charging events appear dictated by the location of the facility. The St. Michaels and Montpelier locations are both likely work trip generators, which result in longer, more energy consuming charges. The one commercial location, the large natural food store Healthy Living, demonstrates charging of shorter duration. This finding indicates a possible difference in demand for charging based upon the trip purpose type.

Data Set Comments

Data regarding the number and use of home-charging stations is not currently collected.

4.11 Compressed Natural Gas

- Growth of CNG for transport fuel is significant, with an average annual increase of 70%

Definition

Production of natural gas and interest in utilization as a transportation fuel is on the rise. Although reduced tailpipe emission factors and lower fuel costs make CNG an attractive alternative to petroleum, limited geographic availability of natural gas supplies and fueling infrastructure inhibit statewide adoption of CNG. Additional obstacles include the initial cost of the vehicle technology, reduced fuel economy (compared to gasoline) and additional space requirements for on-board fuel storage systems.

Current Data

Only a handful of vehicles registered in Vermont are currently fueled by CNG, consisting of five commercial fleets, made up primarily of heavy-duty vehicles and five Honda Civics (the only current CNG passenger vehicle registered in Vermont), served by four CNG filling stations, all located in Chittenden County. In 2011, these five fleets consumed 7,820,000 cubic feet of CNG or an estimated 68,536 GGE.

Trends

Growth of CNG for transport fuel is significant, with an average annual increase of 70%, as seen in Figure 12 below.

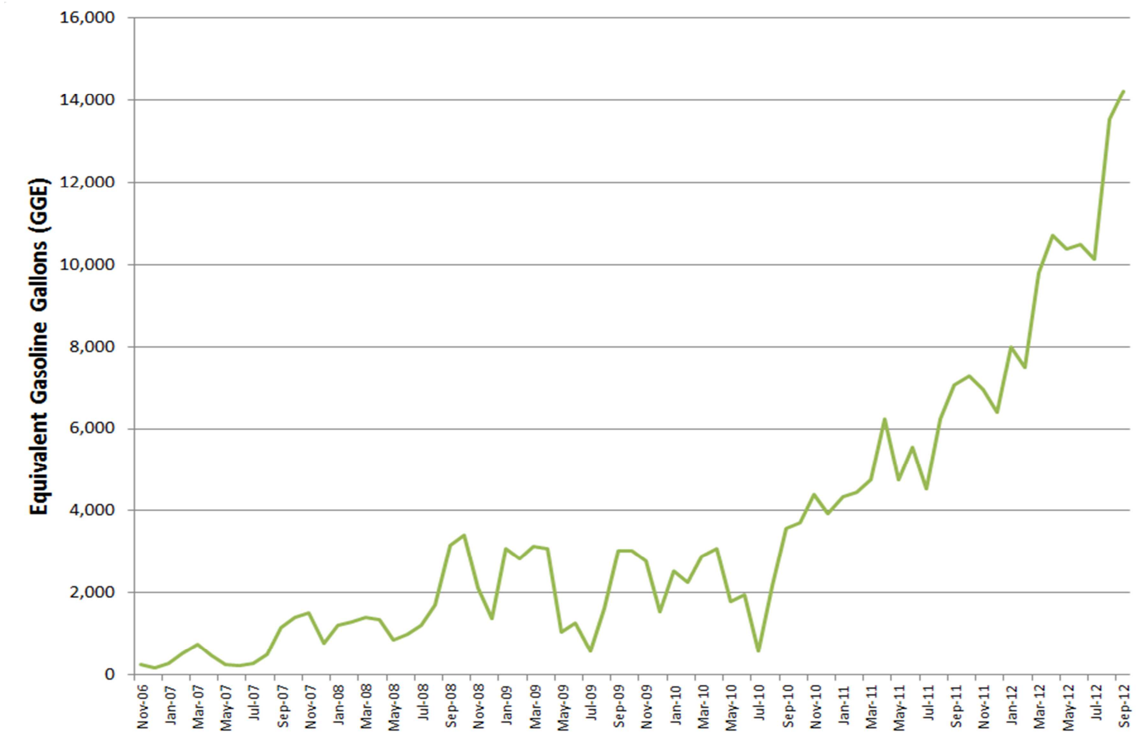

Figure 12. Monthly Compressed Natural Gas Consumption for Transportation in Vermont, 2006-2012 (Vermont Gas, 2012)

5 Freight Transport

The transport of commodities and goods to, from, and within Vermont is an essential component of the state economy. The freight network consists of the state highway system, eleven rail lines, airports and pipelines. Pipeline as a mode of freight conveyance is not considered in this report.

When considering the energy requirements of the freight transport sector in Vermont and nationwide, it is important to understand the challenge of measuring and collecting data which most accurately summarizes the sector. Given the "passivity" of freight—that is, a commodity or good cannot be surveyed for its preference or behavior—and the proprietary nature of the movement of goods, the quality of freight flow estimation varies considerably depending upon mode choice and type of commodity. Metrics presented here are highly aggregate in nature, and provide but a coarse snapshot of freight demand in Vermont.

Rail freight transport is commonly viewed as providing a more efficient means of delivering goods than trucking. Hauling goods using rail compared to single-unit and combination trucks is, on average, 64% less energy-intensive per mile of vehicle travel (13.7 and 21.4 kBtu per vehicle per mile, comparatively) (Davis et. al., 2012).

5.1 Vermont Rail Freight Infrastructure

Current Data

Of the state rail network's 569 total miles of rail bed in existence in 2006, only 3 miles are categorized as Class I, with the remaining mileage categorized as Class II and III. A map of the current rail system is shown in **Error! Reference source not found.**. The Green Mountain Railroad (VTR), Vermont Railway, WCR-Connecticut River Line and the Washington County Railroad are all owned by the state of Vermont, whereas the rest of the railroads in Vermont are privately owned. Twin State Railroad is currently inactive.

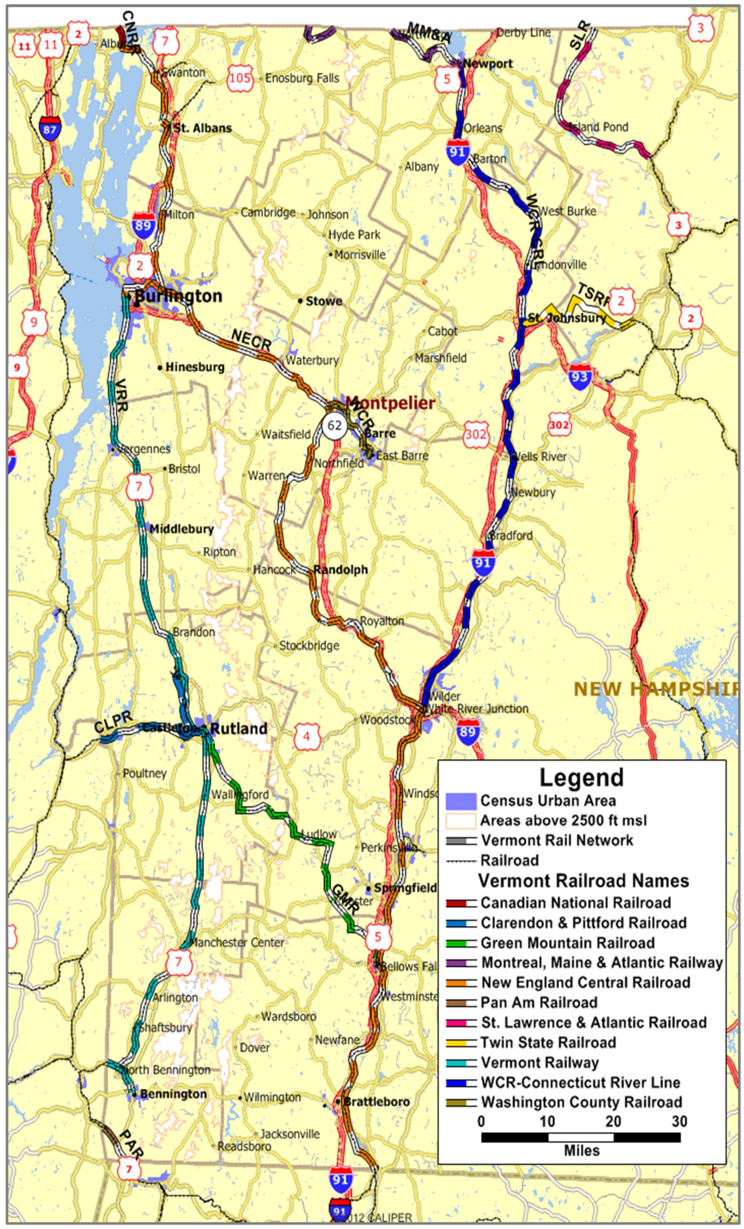

Figure 13: Vermont's Rail Network (VTrans, 2012b)

Trends

Federal and state efforts to improve the rail corridors has recently resulted in over $80 million of upgrades to 190 miles of track between St. Albans and Vernon, Vermont, involving heavier welded rail, bridge upgrades and new ties. These upgrades now enable faster running speeds (up from 59 to 79 mph) in signaled territory, as well as heavier freight cars.

5.2 Commodity Flows

- Trucking accounts for 79% of commodity transport followed by rail at 18% and air at 2%.
- Trucking accounts for 97% of intra-state commodity transport

Definition

While estimates of actual fuel consumption of Vermont's freight movement are not easily measured, currently FHWA generates estimates of commodity flows through its publicly accessible Freight Analysis Framework (FAF3), updated every five years and currently in its third incarnation. This web-based tool provides estimates of commodity flow measured in total dollar value, tons, and ton-miles transported on an annual basis (ORNL, 2011).

Current Data

Vermont's dominant freight transport mode, on a ton-mile basis, is via truck (79% in 2007), with the remainder of commodity flow supplied by rail (18%) and air modes (2%) (VTrans, 2012b). Freight mode share varies more significantly by type of movement, with intra-state flow (in ton-miles) nearly exclusively reliant upon truck (97%), while inter-state rail flow overall holds a more significant share (20%). Total rail freight movement in 2007 stands at 2.21 billion ton-miles. Table 6-1 provides a more detailed breakdown of the 2007 freight movements by mode in Vermont.

Table 6-1. Total Freight Movement in Vermont by Mode, 2007

Freight Mode	Within Vermont	Leave Vermont	Enter Vermont	All Movements
Truck	1,015	3,293	3,126	7,435
Rail	27	1,487	696	2,211
Water	0	7	22	29
Air (include truck-air)	0	2	3	5
Multiple modes and mail	0	86	113	199
All Modes	1,043	4,876	3,960	9,879

Note: All values are in millions of ton-miles.

Source: VTrans, 2012b

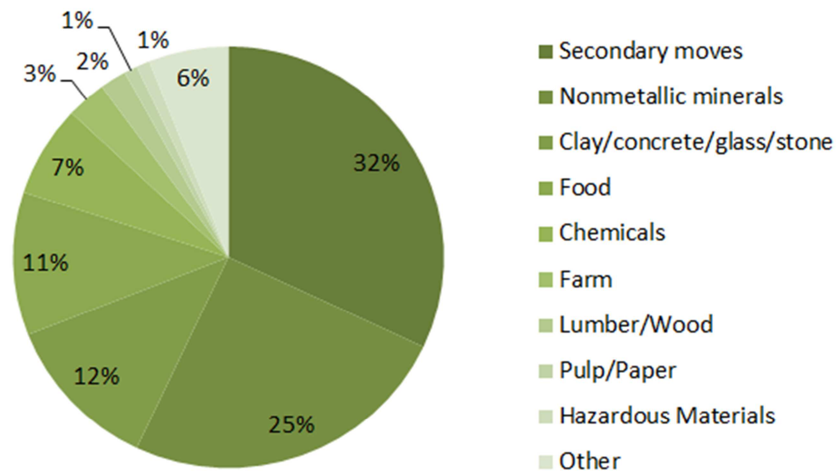

Figure 14. Top Freight Commodities in Vermont by Weight, All Modes, 2007 (VTrans, 2012b)

Freight movement (in total tonnage) by commodity type into, out of, and within Vermont in 2007 is shown in Figure 14.

The top five commodities—made up of secondary movements, non-metallic minerals, concrete/sand/stone, food and chemicals, in order of share—make up 86% of total shipments. The two top commodities—secondary moves and non-metallic minerals, constituting 55% of total tonnage—impact Vermont's transportation network quite differently. Secondary traffic is more broadly distributed across the state and typically via truck, while traffic associated with the production of non-metallic minerals is concentrated along specific corridors and production centers, and tends to be more multimodal (VTrans, 2012b).

Table 5-2. Total Freight Movement in Vermont by Mode, 2007 (Note: All values are in millions of ton-miles. Source: VTrans, 2012b)

Freight Mode	Within Vermont	Leave Vermont	Enter Vermont	All Movements
Truck	1,015	3,293	3,126	7,435
Rail	27	1,487	696	2,211
Water	0	7	22	29
Air (include truck-air)	0	2	3	5
Multiple modes and mail	0	86	113	199
All Modes	1,043	4,876	3,960	9,879

Trends

Freight movement by rail is estimated to only increase in share roughly 1% over that time period given current infrastructural conditions. A recent forecast, performed for the Vermont Freight Plan (VTrans, 2012b), predicted an increase in freight tonnage over all modes from 48 million tons in 2007 to 70 million tons in 2035 (see Figure 15) thus indicating the dominant future mode to be trucking.

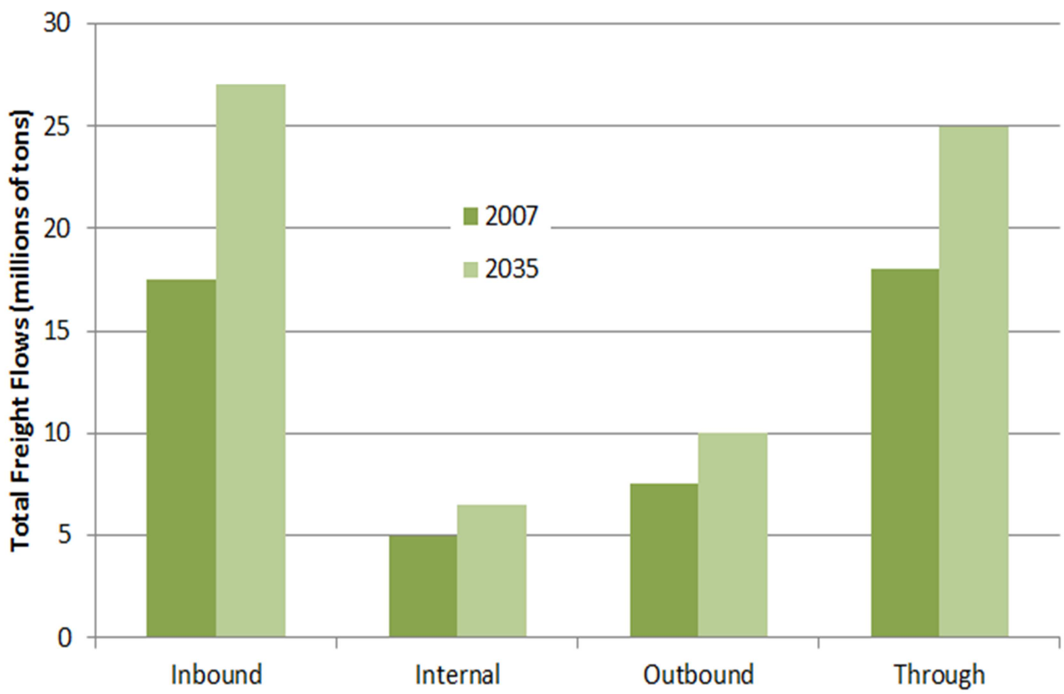

Figure 15. Freight Flow Forecast for Vermont (VTrans, 2012b)

Data Set Comments

Though viewed as the most readily accessible data source for freight movement into, out of, and through Vermont, the FAF3 is limited to aggregate statewide volumes and does not differentiate between highway and rail volume.

6 Tracking Progress for the CEP

The second part of the Profile provides a baseline of information and metrics to assess Vermont's progress toward the required changes needed to meet CEP transportation goals #1 and #2and to a lesser extent, progress toward goals described in Section 9.7.4 of the CEP, which relate more specifically to land use. This section is followed by a final section dedicated to a series of recommendations for additional metrics, future data needs, and improved modeling to increase the efficacy of the metrics chosen to track progress on the CEP.

Objective A – Renewably Powered Vehicles

Increase the share of renewably powered vehicles to 25% of the total fleet by 2030

Metric	Data Source	2013 Value	CEP 2030 Goal Value
Number of renewably-powered vehicles registered in Vermont, expressed as a percentage of all registered cars and trucks	Vermont Department of Motor Vehicles vehicle registration data	0.05%	25%

The Plug-in EV market is rapidly expanding with multiple new models being introduced on a yearly basis. As this metric evolves and new sources of electricity become available statewide, it will be important to track the primary source of electricity used to power EVs in order to ensure that they meet the definition of "renewably-powered".

Improvements to the acquisition and quality control of the vehicle-registration data from the DMV will increase the accuracy of this metric. Data for new vehicle registrations should include the primary fuel type for the vehicle, which would allow for greater classification of fuel types, to potentially include biodiesel and flex-fuel categories within this metric, as both can be argued to be renewable. Alternatively, surveying diesel-fueled, EV, and HEV vehicle operators statewide—for both passenger and heavy-duty vehicles—would allow the identification of vehicles that fit this metric because (1) they are primarily using biodiesel, or (2) they are primarily charged with electricity from a renewable source.

Objective B – Improved Fuel Economy

Improve the combined average fuel economy (in mpg) of the Vermont vehicle fleet to meet the national average fuel economy set by the federal CAFE standards, or improve it by 5%, whichever is greater, by 2025.

Metric	Data Source	2012 Value	CEP 2025 Goal Value
Improve the combined average fuel economy (in mpg) of the Vermont vehicle fleet to meet the national average fuel economy set by the federal CAFE standards, or improve it by 5%, whichever is greater, by 2025	The National Household Travel Survey, Vermont Sample	27.6 mpg	2009 CAFE Standard: 27.3 mpg (USDOT, 2011) 2025 Non-Final CAFE Standard: 48.7–49.7 mpg (NHTSA and USEPA, 2011) Vermont Combined Average Fuel Economy, plus 5%: 28.9 mpg

The fuel economy of Vermont's vehicles for 2010 exceeded the CAFE Standard that was set in 2009 for the Model Year 2011 by 1.1%.

However, the federal CAFE Standard and the Vermont fleet-wide average are not comparable metrics of fuel economy, as the Vermont average includes all makes and models currently operating in the state whereas the CAFE Standard typically only includes new vehicles sold in a single model year. In addition, a comparison of generalized fleet-wide fuel economy implicitly assumes that all vehicles are driven a similar number of miles annually in identical roadway, weather, and traffic conditions. Within the NHTS, the Energy Information Administration (EIA) has developed and implemented a fuel efficiency metric for each vehicle in the Vermont and national sample, which allows for a more accurate, comprehensive comparison of fuel efficiency. From the 2009 NHTS, the Vermont and national fleet-wide average fuel efficiencies were 22.8 mpg and 21.6 mpg, respectively. These values also correspond better with the fleet-wide efficiency found by dividing total vehicle-miles of travel in Vermont with total fuel sold, resulting in18.2 mpg. Further analysis of the trends in these values in future NHTSs can be used to ensure that Vermont continues to exceed the national average by its current lead of 5.8% or more, or improves its average by another 5%, to 24.0 mpg by 2025.

Improved collection, acquisition, and quality control of DMV vehicle-registration data can greatly improve the accuracy and effectiveness of a fleetwide fuel efficiency metric. Using the actual make and model of each vehicle in Vermont, linked to its likely fuel economy (by make, model, year, and age) and its use (in miles) in the current year will result in a comprehensive estimate of statewide fleet fuel efficiency. Some of the required data is already collected through the yearly state-inspection, but is not compiled into a centralized database at this time.

Objective C – Medium and Heavy Duty biodiesel or CNG Vehicles

Increase the number of medium- and heavy-duty vehicles powered by biodiesel or CNG by up to 10% by 2030.

Metric	Data Source	2011 Value	CEP 2030 Goal Value
Number of medium- and heavy-duty vehicles powered by biodiesel or CNG, expressed as a percentage of total medium- and heavy-duty vehicles	Vermont Department of Motor Vehicles vehicle registration data	Unknown[7]	10% over 2011 value

The baseline value for this metric does not include vehicles powered by biodiesel, as current data sources do not provide the primary fuel type used for registered diesel vehicles in Vermont. The number of registered CNG or propane vehicles in Vermont has been small and erratic in the past five years, and may not constitute useful baseline or goal values for this metric. In order to include diesel vehicles that are powered by biodiesel, a new data source will be required which provides this information. Improvements to the data collection acquisition and quality control of the vehicle-registration data from the DMV would increase the usefulness of this metric. Medium- and heavy-duty service vehicles represent the class with the highest proportion of diesel powertrains. Current reporting from DMV includes the class of vehicle registered, but the coding of this class parameter is inconsistent and subject to error. Improved coding of the vehicle class to more accurately identify diesel vehicles is imperative. Identification of CNG vehicles has been less problematic, but as their numbers increase, improved vehicle class acquisition will be necessary.

Enhancement of the DMV intake data for new vehicle registrations should include the primary fuel type for the vehicle, which would allow for greater classification of the fuel types, to include biodiesel vehicles within this metric. Alternatively, surveying diesel-fueled vehicle operators statewide—both passenger and heavy-duty vehicle operators/owners—would allow the identification of vehicles that fit into this metric because they are primarily using biodiesel.

[7] As of 2011, there were 47 CNG vehicles registered in Vermont.

Objective D – VMT Growth Rate

Keep VMT annual growth rate to 1.5% (half of the national average) for that portion controlled by the state.

Metric	Data Source	2011 Value	CEP Goal Limit
Year-over-year percent change in VMT	Annual Average Daily Traffic (AADT) Records, VTrans Highway Research Section	-1.4%	< +1.5%

Between 2010 and 2011, annual VMT decreased in Vermont by 1.4%. However, the annual VMT value used in this metric includes all VMT incurred within Vermont's borders, some of which will not be effected by Vermont policies to decrease VMT. Therefore, it will be necessary to use a refined estimate of VMT incurred solely by Vermonters to quantify Vermont's progress toward this metric. The current estimate from the Base Year 2010 Vermont Travel Model for statewide VMT incurred by Vermonters only is 6.118 billion. A new estimate of this value will be possible after the completion of the next Model update in 2016. At that time, the increase (or decrease) in VMT of Vermonters can be annualized to account for the six years elapsed.

Alternatively, a modified annual estimate of VMT can be made, which excludes a representative portion of the AADTs on Vermont roadways to account for pass-through travel, based on the results of the 2009 NHTS. This procedure, although less accurate, will allow for an annual rate of change to be calculated, which includes only VMT incurred by Vermonters, assuming that our travel behaviors will not change dramatically between 2010 and 2016.

Objective E – VMT per Capita

Hold VMT per capita to 2011 base year values.

Metric	Data Source	2011 Value	CEP Goal Limit
Annual VMT per capita	Annual Average Daily Traffic (AADT) Records, VTrans Highway Research Section	11,399	11,399

The annual VMT value used in this metric includes all VMT incurred within Vermont's borders, some of which cannot be attributed to Vermonters and may not be effected by Vermont policies to decrease VMT. Therefore, it will be necessary to use a refined estimate of VMT incurred solely by Vermonters to quantify Vermont's progress toward this metric, and to make the metric more indicative of the travel behavior of Vermonters only. The current estimate for statewide VMT incurred by Vermonters per capita is 9,778. A new estimate of this value will be possible after the completion of the next Model update in 2016.

Due to the changing demographics of Vermont's population, an estimate of VMT per capita may not effectively represent statewide efforts to reduce VMT. If Vermonters are becoming drivers faster than the population is growing (hypothetically, the opposite has been true in the past five years), a relatively stable level of VMT per capita may be masking more efficient behavior by Vermont drivers. Therefore, a more effective metric for VMT reducing behavior is the annual level of VMT per Vermont driver. This metric relates terms consistently, since it is the drivers in Vermont who are incurring the VMT, not the non-drivers. The 2010 level of annual VMT per driver is 12,873.

VMT per driver can also be broken down further in order to track the effects of specific policies on passenger car drivers and commercial truck drivers in Vermont. When the VMT per driver value of 12,873 is further refined, it reveals that Vermont passenger vehicle drivers are incurring an average of 10,275 vehicle-miles per year, whereas Vermont commercial truck drivers are incurring an average of 36,479 vehicle-miles per year. Commercial truck VMT may be more difficult to reduce, as much of it is nondiscretionary, incurred during the conduct of business and freight travel.

Objective F – Reduce Single Occupancy Vehicle trips

Reduce share of SOV commute trips by 20% by 2030.

Metric	Data Source	2011 Value	CEP 2030 Goal Value
Percent of commute trips taken in a single occupancy vehicle (SOV).	National Household Travel Survey, Vermont Sample American Community Survey, Vermont Sample	82.7%	62.7%

The 2010 value shown above is the metric taken from the 2009 NHTS for the Vermont respondents. The comparable value from the 2007–2009 ACS is 79.2%. The NHTS value was used preferentially because there were many more respondents to the NHTS than there were to the ACS, even when the ACS respondents were aggregated over the three years from 2007 to 2009. In addition, the NHTS format is a travel diary whereas the ACS estimate comes from a tendency-based survey question, asking the respondent how they most frequently tend to travel to work. A side-by-side comparison of the NHTS and ACS results for commuting mode share indicates that the ACS may be underreporting the use of SOV due to a parallel over-reporting of the tendency for people to walk to work (6.7% in the ACS vs. 3.1% for the NHTS). Therefore, the NHTS-based metric appears to be more accurate, representing the actual SOV mode share revealed by travel diary responses in the entire year of 2009.

A limitation in the use of a metric that focuses solely on commuting trips is the decreasing share of total travel this purpose occupies. The 2009 NHTS demonstrated that only about 11% of all person trips and 15% of all vehicle trips in the state are commuting trips. To connect vehicle occupancy more effectively with the goals of the CEP, a reduction of SOV travel for all trip purposes would be a more comprehensive metric.

Objective G – Public Transit Ridership

Increase public transit ridership by 110%, to 8.7 million annual trips by 2030.

Metric	Data Source	2011 Value	CEP 2030 Goal Value
Total number of riders on fixed-route transit buses in Vermont in one year	VTrans Public Transit Section and CCTA provider-reported ridership counts	4.2 million riders	8.7 million riders

Increasing transit use is an effective way to meet the goals of the CEP if its leads to vehicle energy-intensity levels that are an improvement over a SOV. An increase in ridership is likely to lead to reductions in energy use for transportation, but requires an accompanying a decrease in the energy intensity of bus transit statewide to ensure progress toward the goals in CEP. To measure the energy intensity of a transit bus, the length of the transit trip and the average occupancy of the vehicle are needed, along with the vehicle make, model, and year. In Vermont, fixed-route transit buses vary greatly in size and fuel economy, so the effectiveness of transit in helping to reduce energy use depends greatly on the vehicle.

There are many variables that contribute to increased transit use, some that focus on increasing supply and others that focus on increasing demand. On the demand side, transit-supportive development seeks to focus development into denser growth zones to primarily foster better walking access to bus stops and secondarily foster shorter trips in general. As described previously, Vermont has 51.4 square miles of transit-supportive urban areas (TSUAs) in the state.

Incorporating a bus-transit sub-module into the Vermont Travel Model is an effective step toward building knowledge about ridership on specific routes in the transit network. The sub-module would allow for the quantification of average occupancies and trip lengths on specific fixed routes. This data, when combined with information on specific bus types used by the providers, would reveal the average transit-bus energy intensity and total transit-passenger miles of travel.

Additional data needed for the development of a bus transit sub-module would include a coordinated rider survey administered to all of the transit providers in the state connecting specific riders with origins and destinations, followed by a formal estimation of transit-trip distribution between all origins and destinations statewide.

Objective H – Bicycle and Pedestrian Commute Trips

Double the bicycle and pedestrian share of commute trips to 15.6% by 2030.

Metric	Data Source	2010 Value	CEP 2030 Goal Value
Percent of commuting workers who travel via bicycle or walk	National Household Travel Survey, Vermont Sample American Community Survey, Vermont Sample	7.4%	15.6%

The 2010 value shown above is the metric taken from the 2007–2009 ACS for the Vermont respondents. This value was calculated from a later data set than the one on which the

CEP goal value was based. The comparable value from the 2009 NHTS, however, is 4.0%. This discrepancy is troubling, as the goal value of the metric requires that the ACS be used, but the ACS value seems to be overestimating the tendency for Vermonters to walk to work, as described previously. The NHTS value should be used preferentially because there were many more respondents to the NHTS than there were to the ACS, even when the ACS respondents were aggregated over the three years from 2007 to 2009. In addition, the NHTS format is a travel diary whereas the ACS estimate comes from a tendency-based survey question, asking the respondent how they most frequently tend to travel to work.

A limitation in the use of a metric that focuses solely on commuting trips is the decreasing share of total travel this purpose occupies. The 2009 NHTS demonstrated that only about 11% of all person-trips in the state are commuting trips. To connect active travel behavior more effectively with the goals of the CEP, an increase in active travel for all trip purposes would be a more comprehensive metric. The most effective way to measure total active travel behavior statewide is to develop a model of total biking and walking miles of travel. The implementation of a total biking and walking miles of travel model would require a formalized, structured program of cyclist and pedestrian counts throughout the state, particularly for counties other than Chittenden, which already has a fairly comprehensive model.

Objective I – Carpooling commute trips

Double the carpooling-to-work share to 21.4% of commute trips by 2030.

Metric	Data Source	2010 Value	CEP 2030 Goal Value
Percentage of workers who carpool to work	National Household Travel Survey, Vermont Sample American Community Survey, Vermont Sample	11.7%	21.4%

The 2010 value shown above is the metric taken from the 2009 NHTS for the Vermont respondents. The comparable value from the 2007–2009 ACS is 11.4%. Both of these values were calculated from a later data set than the one on which the CEP goal value was based. The NHTS value was used preferentially because there were many more respondents to the NHTS than there were to the ACS, even when the ACS respondents were aggregated over the three years from 2007 to 2009.

A limitation in the use of a metric that focuses solely on commuting trips is the decreasing share of total travel this purpose occupies. The 2009 NHTS demonstrated that only about 11% of all person-trips and 15% of all vehicle-trips in the state are commuting trips. Given its low share of total travel, it is possible that a decrease in carpooling for commuting travel might be masking an increase in overall vehicle occupancy for all travel purposes. To better satisfy the intent of the CEP goals, vehicle occupancy for all trip purposes would be a more comprehensive metric. Overall vehicle occupancy rates from the 2009 NHTS for Vermonters were 1.51 persons per vehicle for trips within Vermont, and 1.75 persons per vehicle for trips to or from points outside the state.

Objective J – Passenger Rail

Quadruple passenger rail trips to 400,000 Vermont-based trips by 2030.

Metric	Data Source	2012 Value	CEP 2030 Goal Value
Total yearly ridership on the Amtrak Ethan Allen and Vermonter lines	Vermont Amtrak ridership and revenue - 12 month rolling total	133,191 riders	400,000 riders

Amtrak use is an effective way to measure progress against the goals of the CEP if it leads to lower miles of travel by privately owned passenger vehicles. Using the Vermont Travel Model, a direct comparison of the vehicle-miles of travel incurred on long-distance trips that mirror the Amtrak lines in Vermont can be calculated. Using this direct comparison, the displacement of privately owned vehicle miles traveled by rail ridership can be identified and tracked.

Objective K – Freight Rail

Double the amount of rail freight tonnage in the state from 2011 levels by 2030.

Metric	Data Source	2007 Value	CEP 2030 Goal Value
Total rail freight tonnage in Vermont in one year	The Freight Analysis Framework of the FHWA, which includes data primarily from the 2007 Commodity Flow Survey	2,211 million ton-miles	4,422 million ton-miles

Freight mode share is normally tracked in ton-miles, so modifying the metric from tonnage to ton-miles is recommended. The 2007 ton-miles of rail freight, measured in the FAF3, are provided. The Commodity Flow Survey is being updated in 2012, but it is not clear when the data from the 2012 survey will become available, or when it will be incorporated into an update of the Freight Analysis Framework. Therefore, it is unlikely that a 2011 level for rail freight tonnage will be obtainable, and it is not clear when the 2012 level will be obtainable. Therefore, the goal value is assumed to be double the 2007 level, as opposed to the 2011 value.

Increasing rail freight is an effective way to measure progress against the goals of the CEP if it displaces commercial truck freight, due to the improved energy-intensity of freight railcars. Therefore, the most comprehensive metric for improved energy-intensity of freight movements in Vermont would also include a corresponding reduction in commercial heavy-truck freight.

Objective L – Park-and-Ride spaces

Triple the number of state park-and-ride spaces to 3,426 by 2030.

Metric	Data Source	2012 Value	CEP 2030 Goal Value
Total parking spaces within park-and-ride lots in Vermont	VTrans Local Transportation Facilities Section	Approximately 1,690 spaces	3,426 spaces

The number of parking spaces available at park-and-ride lots can be an effective measure of progress toward the goals in the CEP, as park-and-ride utilization is associated with higher personal vehicle occupancy (by fostering carpooling), increased transit use (by fostering multimodal transit trips), and increased active travel behavior (by fostering multimodal walking and biking trips). However, the total number of parking spaces at park-and-ride lots across the state is not tracked specifically, partially because the specific number of spaces evolves rapidly but also because the lots are maintained by different entities. In order to effectively track progress on this metric, it will be imperative to improve the tracking of the specific number of parking spaces available at each lot, and require municipalities to report changes in the number of spaces available in lots they maintain. Tracking capacity at informal or private park-and-ride lots may also be useful as a measure of vehicle occupancy in Vermont.

7 Recommendations for Metrics, Data, and Modeling

Section 8 contains recommendations in addition to those described in Section 7 in order for the state agencies to further and improve the tracking of progress toward the goals and objectives of the CEP. The recommendations have been collated from throughout the document and compiled according to the following categories:

- Additional Metrics
- Future collection and Reporting of Data
- Improved Data
- New Data
- Improved Modeling

7.1 Additional Metrics

Within the NHTS, the Energy Information Administration (EIA) has developed and implemented a fuel economy metric—described as “In-Use” MPG (MPG_{I-U})—for each vehicle in the Vermont and national sample, which allows for a more accurate, comprehensive comparison of fleet-wide fuel economy (EIA, 2011). The EIA’s “In-Use” MPG is imputed in two steps. First, the commonly reported EPA “Composite” MPG of each vehicle sampled in the NHTS is adjusted based upon on-road, real world testing to yield an “On-Road” MPG. This “On-Road” MPG is further adjusted to reflect differences in vehicle performance based upon seasonal differences and annual miles driven to yield the “In-Use” MPG. This adjustment assumes that vehicles with a higher annual VMT are used for a higher proportion of longer trips, with fewer stops and higher speeds, than lower annual VMT vehicles. It is recommended here that In-Use MPG be used in computing the fleet-wide fuel economy, as it more accurately reflects the fuel economy experienced by Vermont drivers during their normal driving in Vermont.

The total VMT metric for Vermont can be better understood by separating VMT incurred solely by Vermonters within the state, as potential policies for reduction of VMT will undoubtedly be targeted primarily at Vermonters. It is recommended that refinement of the VMT per capita metric include VMT per Vermont driver, which can be further broken down by commercial drivers (CDL licenses) and non-commercial drivers to track the effects of policies intended to specifically affect the behavior of passenger car drivers separately from commercial truck drivers in Vermont.

To connect vehicle occupancy more effectively with the goals of the CEP, it is recommended to track all SOV trips, and vehicle occupancy for all trip purposes. Although commuting trips tend to be lowest in average occupancy, marginal benefits might be maximized by incentivizing increased occupancy for other purposes, including those that are already fairly high, like shopping.

An increase in ridership of bus transit is likely to lead to reductions in energy use for transportation, but a decrease in the energy-intensity of bus transit statewide is the best way to ensure progress toward the goals in CEP. It is recommended to track the energy-intensity of transit services on a Btu per passenger-mile basis, using actual fuel records reported directly by Vermont's transit authority.

A metric that accounts for the density of new development, the facilitation of mixed-use development, and transit use will be needed to track progress against the strategy related to transit-supportive development in the CEP. Total area of TSUAs would be an ideal metric to track for these indicators.

To connect active travel behavior more effectively with the goals of the CEP, it is recommended to track biking and walking modes for all trip purposes, not solely for commuting.

Freight mode share is normally tracked in ton-miles, so modifying the metric from tonnage to ton-miles is recommended.

The growth of Internet retail is gaining a foothold in Vermont and nationwide. Online shopping has become increasingly popular over the past decade, with e-commerce growing from $72 billion in 2002 to $256 billion in 2011 (Kril, 2012). Though this growth may include induced consumer demand, a proportion of shopping trips are averted by delivery of goods through the existing freight and mail service. A new metric is required to determine the overall effect of internet shopping on VMT.

To provide a better measure of the utility of park-and-ride facilities, it is recommended to measure and track the occupancy of spaces at each of the sites, preferably on a consistent and seasonal basis.

7.2 Future Collection and Reporting of Data

Future collection and reporting of the primary data sources used for the selected metrics is imperative for continued monitoring of the state's progress toward the goals and objectives of the CEP. The following data sources must continue to be available at their current level:

- The National Household Travel Survey (NHTS) (next scheduled for 2016), with a supplemental add-on similar to the one conducted for Vermont in 2009
- Statewide Coverage of Annual Average Daily Traffic counts
- The Population Estimates Program of the U.S. Census Bureau
- The Vermont Travel Model, Base Year 2010 (next scheduled update for 2016)
- State of Vermont Department of Motor Vehicle driver's licensing data and vehicle registration data (annual cycle)
- Ridership reports from Vermont's 10 bus-transit authorities
- The Commodity Flow Survey (next scheduled for 2012)
- Federal Highway Administration annual summaries of roadway utilization from the Highway Performance Monitoring System
- Vermont Joint Fiscal Office (VJFO) annual report of gasoline and diesel revenue and gallons and monthly reports of Amtrak ridership and revenue

7.3 Improved Data

Improvements to the acquisition and quality control of the vehicle-registration data from the DMV are needed to improve the fidelity of several metrics used in this study. Current reporting from DMV includes the class of vehicle registered, but the coding of this class parameter has been inconsistent. Improved coding of the vehicle class to more accurately identify diesel vehicles and CNG vehicles is imperative.

In order to effectively track progress on the parking spaces available at park-and-ride lots, it is imperative to improve the tracking of the specific number of parking spaces available at each lot, and to require municipalities to report changes in the number of spaces available in the lots they maintain. The best place to collect this data is within the shapefile that is currently provided through VCGI.

7.4 New Data

DMV data for new vehicle registrations should include the primary fuel type for the vehicle, which would allow for greater classification of vehicles, to potentially include biodiesel and flex-fuel categories because both can be argued to be renewable. Alternatively, surveying diesel-fueled vehicle and EV operators statewide—both passenger and heavy-duty vehicle operators—would allow the identification of vehicles that are primarily using biodiesel or are primarily charged with electricity from a renewable source. Furthermore, identifying the amount and primary source of electricity used to power EVs and PHEVs will be necessary to determine whether they meet the definition of "renewably powered". This data may have to be derived through communication with electric utilities for the geocoded locations of EV owners.

To measure the energy-intensity of a transit bus, the length of the transit trip and the average occupancy of the vehicle are needed, along with the vehicle make, model, and year. Some of this data could come through a coordinated rider survey administered to all of the transit providers in the state, connecting specific riders with routes, origins, and destinations.

An improved understanding of bicycle and pedestrian miles traveled (BPMT) in Vermont would require a formalized, structured program of cyclist and pedestrian counts throughout the state, particularly for counties other than Chittenden, which already has a fairly comprehensive program.

A better understanding of the displacement effects of passenger rail travel in Vermont can be gained through a rider survey of passengers on the Ethan Allen and the Vermonter lines. The focus of the survey would be the relationship between Amtrak use and private passenger vehicle use by riders of Amtrak, including the factors that influence their decisions to use passenger rail.

To measure utilization of park-and-ride lots in Vermont, it is necessary to track their use more specifically for carpooling or multimodal travel. Tracking use of park-and-ride lots statewide would involve week-long observations focused on the peak periods of use but including all seven days of the week, repeated three to four times per year. These observation periods can be supplemented with user intercept surveys that are focused on connecting the use of facility with specific origins, destinations, and modes.

7.5 Improved Modeling

A model that connects the actual make and model of each vehicle in Vermont from the DMV registration data to its fuel economy (by make, model, year, and age) and its use (in miles) in the current year, will improve upon the EIA estimate of statewide fleet fuel efficiency. Current use of the vehicle may be obtainable through vehicle inspection records, which commonly note the odometer reading on the inspected vehicle.

A modified annual estimate of VMT per driver can be made which excludes a representative portion (about 2%) of the FHWA-based value to account for pass-through travel, based on the results of the 2009 NHTS.

Incorporating a bus-transit sub-module into the Vermont Travel Model would allow us to quantify average occupancies and trip lengths for specific fixed routes, which could then be linked to specific vehicles from the providers, leading to new metrics of average transit-bus energy-intensity in Vermont and total transit-passenger miles of travel in Vermont.

An effective statewide program and bike and pedestrian counts could be used to develop a model of total biking and walking miles of travel in Vermont.

The displacement of privately owned vehicle miles of travel with Amtrak rail ridership can be identified and tracked with a corridor-based analysis implemented with the Vermont Travel Model.

Commercial truck freight can be tracked in the Vermont Travel Model if an augmented freight sub-module is incorporated into the Model. The augmented freight sub-module would allow freight movements by truck to be tracked along specific corridors also served by freight rail, so the corridor-specific mode shares can be assessed and tracked.

8 Acronyms and Abbreviations

'The Model'	Vermont Travel Model
'The Profile'	The Vermont Transportation Energy Profile
ACS	American Community Survey
AEV	All – electric vehicle
BPMT	bicycle and pedestrian miles traveled
Btu	British thermal unit
CAFÉ	Corporate Average Fuel Economy
CARS	Community Assistance to Recycle and Save Act
CCRPC	Chittenden County Regional Planning Commission
CEP	Vermont Comprehensive Energy Plan
CNG	compressed natural gas
DMV	Department of Motor Vehicles
EIA	Energy Information Administration
EPA	Environmental Protection Agency
EV	plug-in electric vehicle
FHWA	Federal Highway Administration
GGE	gallons of gasoline equivalent
GMTA	Green Mountain Transit Agency
HEV	hybrid electric vehicle
ICE	internal combustion engine
LEV	low-emission vehicle
MPG	miles per gallon
MPG_{I-U}	'in-use' miles per gallon

MY	vehicle model year
NHTS	National Household Transportation Survey
P2P	peer-to-peer car sharing service
PHEV	plug-in hybrid electric vehicle
SOV	single occupancy vehicle
TRC	University of Vermont Transportation Research Center
TSZ	transit supportive zone
UA	census urban area
USCB	United States Census Bureau
USDOT	United States Department of Transportation
USEIA	United Sates Energy Information Association
VCGI	Vermont Center for Geographic Information
VT DMV	Vermont Department of Motor Vehicles
VDPS	Vermont Department of Public Service
VEIC	Vermont Energy Investment Corporation
VLJFO	Vermont Legislative Joint Fiscal Office
VMT	vehicle miles traveled
VTEP	Vermont Transportation Energy Profile
VTrans	Vermont Agency of Transportation
ZEV	zero-emission vehicle

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