The 2017 Vermont Transportation Energy Profile

September 2017

VTrans Working to Get You There
Vermont Agency of Transportation

Acknowledgements

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Executive Summary

The transportation sector is responsible for 37% of the total energy consumed in Vermont (see Figure E-1), more than any other sector in the State. The energy used by the transportation sector is derived overwhelmingly from fossil fuels, almost 75% in the form of gasoline and an additional 22% in the form of diesel. Consequently, the 2016 Vermont Comprehensive Energy Plan (CEP) included three goals and nine supporting objectives related to reducing transportation sector energy consumption and greenhouse gas emissions (VDPS, 2016). The 2017 Vermont Transportation Energy Profile ("the Profile") is the third installment of a biannual reporting series that evaluates the State's progress toward achieving these transportation sector goals and objectives (together referred to as targets).

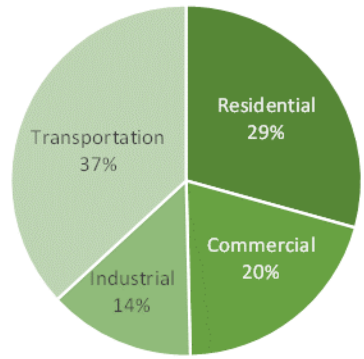

Figure E-1. Vermont Energy Consumption, 2015 (U.S. EIA, 2017)

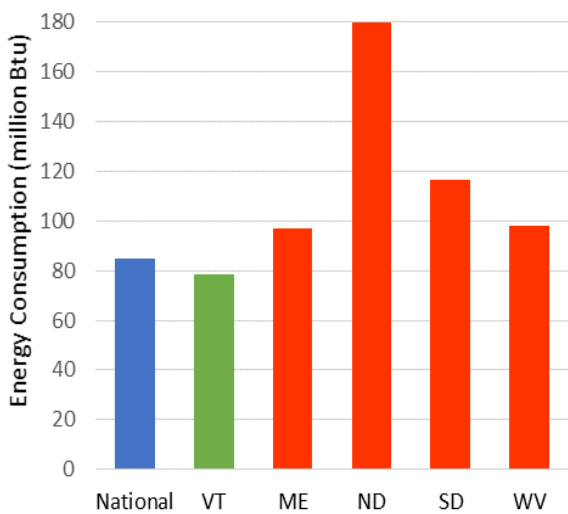

Figure E-2. Per Capita Transportation Sector Energy Consumption, 2015 (U.S. EIA 2017)

Though the industrial sector is the largest consumer of energy nationally, this is not the case in Vermont. Vermont is one of 23 U.S. states that consumes more energy for transportation than for any other sector (U.S. EIA, 2017). Nonetheless, as shown in Figure E-2, the State's per capita transportation sector energy use is below the national average, at 78.4 million Btu annually in 2015, and below levels seen in four rural comparisons states selected on the basis of similarities in population and development characteristics.

The short-term CEP transportation targets are presented in Table E-1. In order to conduct this assessment, the change in each metric is compared to the average annual rate of change required to hit the CEP target. For example, since 2011, the CEP has called for the State to add 2,284 park-and-ride parking spaces by 2030. In order to achieve this target, the State must add an average of 120 spaces per year over the 2011 to 2030 period. When the average number of new parking spaces is at or above 120 spaces per year, the State is on pace to meet the CEP target. When the average number of new parking spaces falls below this rate, the State is lagging behind the CEP target.

For many of these metrics, progress toward achieving the CEP target is likely to lag in the early years due to the necessity of upfront investments and the slow pace of behavior change. Progress may be particularly slow for metrics related to the vehicle fleet since cars and trucks typically have a long operating life. Thus cases where the State is currently lagging in achieving a particular goal or objective should not be taken to mean that the target cannot be achieved.

Table E-1 summarizes the state's progress toward achieving these 12 targets. Since goals 1 through 3 were first defined in the 2016 CEP, the annual rates of change required to meet the targets were calculated for the nine year period from 2016 through 2025. Given that data later than 2016 are not yet available, progress toward these goals cannot yet be evaluated. The supporting Objectives were set in the 2011 CEP so target rates of change are calculated for the 2011 through 2030 period. Currently, the State is moving in the right direction for several objectives, but none are moving fast enough to keep pace with the targeted rate of change.

Table E-1. Current Progress toward Achieving CEP Transportation Targets

2016 CEP Transportation Targets		Baseline		Most Recent		Average Rate of Change[1]		
		Value[3]	Year	Value	Year	Period	Target	To Date
Goals for 2025	1. Reduce energy use by 20%	49.1	2015	49.1	2015	'16-'25	-1.09[3]	N/A
	2. Increase the share of renewable energy to 10%	5.5%	2015	5.5%	2015	'16-'25	0.5%[3]	N/A
	3. Reduce GHGs emissions by 30% from 1990 levels	3.22	1990	3.67	2013	'16-'25	-0.16[3]	N/A
Supporting Objectives for 2025 and 2030	1. Hold VMT/capita stable	11,402	2011	11,680	2015	'11-'30	0	69.5
	2. Reduce the share of SOV commute trips by 20%	79.5%	2011	80.7%	2015	'11-'30	-1.1%	0.3%
	3. Increase the share of bicycle/ pedestrian commute trips to 15.6%	7.2%	2011	7.1%	2015	'11-'30	0.4%	-.03%
	4. Increase state park-and-rides spaces to 3,426	1,142	2011	1,525	2017	'11-'30	120	64
	5. Increase annual transit ridership to 8.7 million trips	4.58	2011	4.71	2016	'11-'30	0.22	0.03
	6. Increase annual Vermont-based passenger-rail trips to 400,000	91,942	2011	92,422	2016	'11-'30	16,214	96
	7. Double the rail-freight tonnage in the state	6.6	2011	7.3	2014	'11-'30	0.35	0.23
	8. Increase electric vehicle registrations to 10% of fleet	0.0%	2011	0.3%	2016	'11-'25	0.7%	0.05%
	9. Increase renewably powered heavy duty vehicles to 10% of fleet	Since diesel vehicles can run on conventional diesel and biodiesel, this objective cannot be tracked without tracking biodiesel fuel sales						

[1] Rates of change are annual averages. Target rates are calculated for the period shown and indicate the average annual rate of change required to meet the CEP target. Rates of change for Objectives 2-3 are measured as the change in percent of total commute trips. Objective 8 is measured as the change in the percent of the total vehicle fleet.

[2] Units: Goal 1 - trillion Btu; Goal 3 - MMTCO2e; Obj. 5 - millions of riders; Obj. 7 - millions of tons

[3] Preliminary target rate of change assumes 2016 value is equal to the most recent value.

Glossary of Selected Abbreviations

AEV: All-Electric Vehicle – Any vehicle powered solely by an electric motor. Also referred to as electric vehicles or battery electric vehicles, AEV is used throughout the profile to avoid confusion with plug-in hybrid electric vehicles. As of July, 2017, the Nissan Leaf is the most common AEV in Vermont.

ACS: American Community Survey – An annual survey conducted by the U.S. Census Bureau that collects demographic, economic, housing and social information, including information about commuting behavior and vehicle ownership.

CEP: Comprehensive Energy Plan – A statutorily mandated framework for implementing state energy policy produced by the Vermont Department of Public Service in conjunction with other agencies and stakeholders. The most recent CEP was adopted in 2016.

CNG: Compressed Natural Gas – An alternative fuel currently used primarily in heavy-duty fleets in Vermont. Compressed natural gas is pressurized to reduce the volume that it occupies and increase its energy density. Most natural gas is extracted from finite underground reserves that are not renewable but natural gas can also be produced renewably from organic materials including from landfill and agricultural waste. Conventional natural gas offers modest greenhouse gas benefits relative to gasoline and diesel while renewable natural gas offers greater benefits.

CO_2 and CO_{2e}: Carbon Dioxide and Carbon Dioxide Equivalent – CO_2 is a greenhouse gas. CO_2 emissions are the most significant transportation-sector contributor to climate change. CO_{2e} express the climate impacts of different greenhouse gases in terms of their climate impact relative to CO_2. It allows for the consistent comparison of different greenhouses in a manner that accounts for their differential impacts on climate change.

HEV: Hybrid Electric Vehicles – Any vehicle with both an internal combustion engine and an electric motor that *cannot* be plugged into an external source. HEVs have fuel efficiency advantages over conventional internal combustion engine vehicles.

ICEV: Internal Combustion Engine Vehicle – Any vehicle powered solely by the combustion of fuel in an engine. Also referred to as conventional vehicles, ICEVs can use a variety of liquid and gaseous fuels including gasoline, diesel, natural gas and biofuels.

GHG: Greenhouse gas – Any of several gases that contribute to climate change by trapping heat in the atmosphere. Carbon dioxide emissions from the combustion of fossil fuels are the largest contributor to climate change in the transportation sector.

LRTPS: Long Range Transportation Planning Survey – A survey commissioned by VTrans, conducted in 2016, to gather public opinion on transportation issues to inform updates to the State's Long Range Transportation Plan.

LNG: Liquefied Natural Gas – An alternative fuel currently used exclusively in heavy-duty fleets in Vermont. Liquefied natural gas is cooled until it reaches a liquid state to the volume that it occupies and increase its energy density. Most natural gas is extracted from finite underground reserves that are not renewable but natural gas can also be produced renewably from organic materials including from landfill and agricultural waste. Conventional natural gas offers modest greenhouse gas benefits relative to gasoline and diesel while renewable natural gas offers greater benefits.

LCA: Life Cycle Assessment – A technique used to evaluate the environmental impacts of a product comprehensively, including the impacts related to producing, operating, and decommissioning the product.

MPG and MPGe: Miles per Gallon and Miles per Gallon Equivalent – MPG is the measure of the distance a vehicle can travel on a gallon of fuel. MPGe is the measure of the distance a vehicle can travel using the equivalent energy that is in a gallon of gasoline. MPGe is used to compare the fuel efficiency of vehicles that use different energy sources (e.g. gasoline and electricity).

PEV: Plug-in Electric Vehicle – Any vehicle with an electric motor that plugs into an external power source to charge. This includes plug-in hybrid electric vehicles, which use a combination of gasoline and electricity, and all-electric vehicles, which use electricity exclusively.

PHEV: Plug-in Hybrid Electric Vehicle – Any vehicle with both an internal combustion engine and an electric motor that can be plugged into an external power source to charge. As of July, 2017, the Ford C-Max Energi Plug-in Hybrid is the most common PHEV in Vermont.

NHTS: National Household Travel Survey – A national survey conducted on a periodic basis (generally every 6 – 8 years) by the U.S. Department of Transportation. The survey collects a wide range of travel data. Data collection for the 2016 NHTS has been completed and is slated for release in 2018. The 2009 NHTS is the last edition of the survey for which data is available.

RFS: Renewable Fuel Standard – A regulatory mechanism that mandates sales of specific renewable fuels. The U.S. RFS was established in 2005 and updated in 2007 and mandates sales volumes for biomass-based diesel, cellulosic biofuel, advanced biofuel and total renewable fuel.

SOV: Single Occupancy Vehicle – Any vehicle occupied only by the driver. SOV trips have lower energy efficiency per passenger mile than trips which include passengers. Reducing SOV trips is one strategy for reducing transportation sector energy consumption.

VMT: Vehicle Miles Traveled – The total on-road distance driven by all vehicles within a given jurisdiction. Reducing VMT is one strategy for reducing transportation sector energy consumption.

"To measure is to know. If you cannot measure it, you cannot improve it."

—Lord Kelvin

1 Introduction

The transportation sector is vital to the physical, social, and economic well-being of Vermonters, but it is also responsible for 37% of the total energy consumed in the state, more than any other economic sector (U.S. EIA, 2017). The 2017 Vermont Transportation Energy Profile ("the Profile"), the third edition of this biannual reporting series, documents a wide range of data and trends related to transportation energy consumption and greenhouse gas (GHG) emissions. The Profile is intended to inform transportation-related policy-making generally and to directly track the State's progress toward achieving the transportation-sector goals and objectives articulated in the State's Comprehensive Energy Plan (CEP).

The 2016 CEP was a multi-agency effort led by the Public Service Department that provides a framework for achieving the State's vision of an efficient, reliable, and heavily renewable energy future. Near term goals in the 2016 CEP include reducing per capita energy consumption by 15% by 2025, meeting 25% of the state's remaining 2025 energy needs with renewable sources, and reducing GHG emissions by 40% by 2030.[1] To support these economy-wide goals, the CEP quantified three specific goals for the transportation sector:

1. Reduce total transportation energy use by 20% from 2015 levels by 2025;
2. Increase the share of renewable energy in all transportation to 10% by 2025 and 80% by 2050;
3. Reduce transportation-emitted GHGs by 30% from 1990 levels by 2025.

2016 CEP STRATEGIES FOR TRANSPORTATION

Light-Duty Vehicles

- Increase the fuel efficiency of light-duty vehicles registered in Vermont.
- Increase registrations of electric vehicles in Vermont to 10% by 2025 by promoting consumer awareness, incentivizing purchase, and deploying charging infrastructure.

Heavy-Duty Vehicles

- Increase the fuel efficiency of heavy-duty vehicles registered in Vermont.
- Increase the use of renewable fuels such as advanced liquid or gaseous biofuels.

Travel Modes

- Provide more efficient alternatives to single-occupancy vehicle trips.
- Promote transit, walking, biking, carpooling, and telework.

Smart Land Use

- Maintain historical settlement patterns, emphasizing compact centers.

The CEP also provided 9 supporting objectives for these goals. As shown in Table 1-1, these objectives relate to controlling the increase in vehicle miles traveled

[1] Per capita energy reduction goals are relative to a 2015 baseline while GHG emissions reductions goals are relative to a 1990 baseline.

(VMT)—an estimate of the total on-road distance driven by all vehicles in Vermont, increasing the percent of trips taken using lower-energy-intensity travel modes such as walking and public transit, and increasing renewable fuel usage for vehicle trips.

Table 1-1. 2016 CEP Supporting Transportation Objectives

Control Vehicle Miles Traveled: 1. Hold per capita VMT to 2011 levels.
Increase the Share of Travel Modes with Lower Energy Intensities: 2. Reduce the share of SOV commute trips by 20%. 3. Double the share of bicycle and pedestrian commute trips to 15.6%. 4. Triple the number of state park-and-rides spaces to 3,426. 5. Increase public transit ridership by 110% to 8.7 million trips annually. 6. Quadruple Vermont-based passenger-rail trips to 400,000 trips annually. 7. Double the rail-freight tonnage in the state.
Increase Renewable Fuel Usage: 8. Increase the number of electric vehicles registered in Vermont to 10% of the fleet by 2025. 9. Increase the number of heavy duty vehicles that are renewably powered to 10% by 2025.
Note: All objectives are for 2030 and relative to a 2011 baseline except where noted otherwise.

As articulated in the CEP, achieving the goals of reducing transportation energy use and GHG emissions while also increasing renewable energy use in the transportation sector will require a multifaceted approach that reduces VMT, improves fuel economy, and reduces GHG emissions per mile traveled. Currently, none of the eight objectives that can be assessed quantitatively are on pace to achieve the CEP targets. Additional policy initiatives that accelerate mode shifts and vehicle electrification may be needed to succeed in meeting the vision put forth in the 2016 CEP.

Sections 2 through 6 of the Profile provide the data needed to evaluate the CEP transportation objectives in a broader transportation context. Progress toward achieving each of the three goals and nine supporting objectives are evaluated in Section 7. Final recommendations for CEP goal revisions and additional data collection needs are provided in Section 8.

1.1 Additions to the 2017 Profile

The 2017 edition of the Profile expands on the data collection and reporting in previous Profiles in several ways. For the first time the Profile provides an estimate of the total electricity used for vehicle charging (Section 4.3). The 2017 profile also includes a new tracking of GHG emissions (Section 5) and incorporates new data sources, including the results from the VTrans Long Range Transportation Planning Survey (LRTPS) (RSG, 2016).

1.2 Vermont in Context

In order to provide context for the data outlined in this Profile, national data are provided alongside Vermont data whenever possible. In addition, since transportation demand is closely tied to development patterns, Vermont data are juxtaposed with four comparison states: Maine, North Dakota, South Dakota, and West Virginia. These four states, shown in Figure 1-1, were selected based on similarities in terms of (1) the proportion of each state that is rural versus urban, (2) residential density distribution, (3) household size distribution, (4) the distribution of the number of workers in each household, and (5) overall population. In addition, potential comparison states were limited to states that experience significant winter weather and its associated impact on travel.

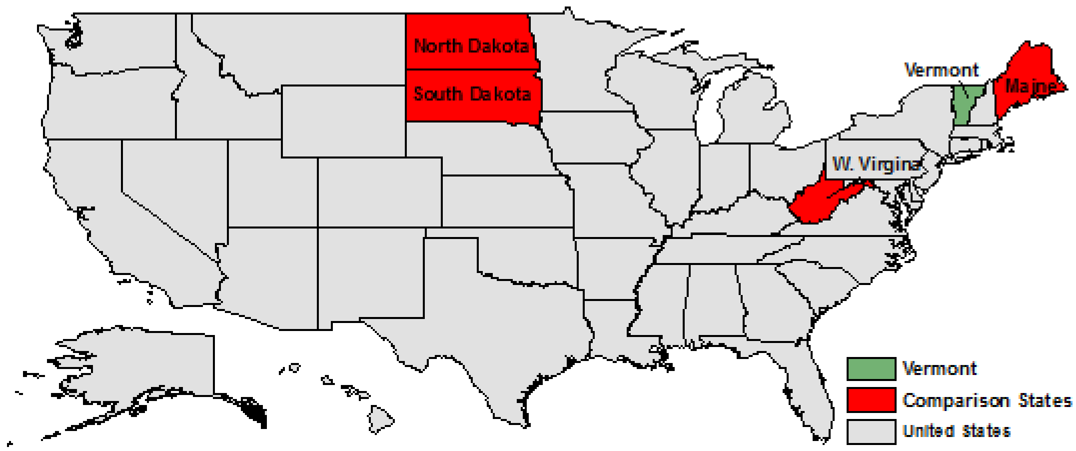

Figure 1-1. Vermont and Comparison States

1.3 Data Sets Used in the Energy Profile

This report draws on a variety of data sets to illustrate trends in Vermonters' travel behavior, vehicle fleet composition, and fuel sources that are relevant to CEP metrics and broader transportation policy-making initiatives. These data sources are expected to be available at regular intervals in the future. They include but are not limited to:

- American Community Survey (ACS), U.S. Census Bureau
  - Data Collection Cycle: Annual
  - Most Recent Data Available: 2015
- Highway Statistics Series, Federal Highway Administration
  - Data Collection Cycle: Annual
  - Most Recent Data Available: 2015
- National Household Travel Survey (NHTS)
  - Data Collection Cycle: Six- to eight-years
  - Most Recent Data Available: 2009
- State Energy Data System, U.S. Energy Information Administration (EIA)
  - Data Collection Cycle: Annual
  - Most Recent Data Available: 2015
- Vermont Department of Motor Vehicles (VDMV) licensing/vehicle registration
  - Data Collection Cycle: Annual

  - Most Recent Data Available: 2016

- Vermont Greenhouse Gas Emissions Inventory, Agency of Natural Resources
  - Data Collection Cycle: Annual
  - Most Recent Data Available :2013

- Vermont Legislative Joint Fiscal Office (JFO) gasoline/diesel sales
  - Data Collection Cycle: Monthly
  - Most Recent Data Available: 2016

- VTrans Public Transit Route Performance Reviews
  - Data Collection Cycle: Annual
  - Most Recent Data Available: SFY 2016

The NHTS is the single most comprehensive source of U.S. travel behavior data. The survey includes a travel diary, where all members of a participating household log their travel on a specified study day. The information collected in the diary includes information on travel mode (household vehicle, transit, bicycle, etc.), trip purpose, and number of travelers for each reported trip. Because of this, the NHTS can be used to calculate mode share, vehicle occupancy, travel patterns, rates of biking and walking, and many other variables. For the 2009 NHTS, VTrans, CCRPC, and the University of Vermont purchased an "add-on" which over-sampled Vermonters relative to the national population, enabling these variables to be calculated at the State level.

Due to rising costs, the State did not opt to purchase an add-on for the 2016 NHTS. Consequently, there will be limitations on the state-level variables that can be calculated when the 2016 NHTS data is made publically available (anticipated for 2018). While not required to track the 2016 CEP targets, the NHTS has provided a great deal of context for this Profile and transportation decision-makers. VTrans is exploring other options for collecting the data that may be incorporated into future editions of the Profile (Aultman-Hall and Dowds, 2017).

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2 Vermonters' Travel Behavior

Individuals' travel behaviors (where, how, and how often they travel) are a key determinant of the total energy and specific fuels consumed by the transportation sector. Travel behavior in Vermont is heavily influenced by the State's rural and village-based land-use patterns. Automobile usage is the dominant mode of travel, accounting for approximately 85% of all trips made in the State. Per capita VMT in Vermont has fallen since its peak in 2007 but remains above the national average and increased modestly in 2015.

2.1 Vehicle Miles of Travel

Total annual VMT is an estimate of the total mileage driven by all vehicles on a given road network. VMT is an important metric that is used in several capacities: in highway planning and management, to estimate fuel consumption and mobile-source emissions, to project potential gasoline tax revenues, and as a proxy for economic activity. Total VMT is influenced by how far and how frequently people drive and by vehicle occupancy rates.

After climbing steadily through the mid-2000s, VMT declined for several years at both the state and national level beginning in 2008 (see Table 2-1 and Figure 2-1). At the national level, total VMT has risen since 2011 and per capita VMT has risen since 2013. In Vermont, total and per capita VMT hit their lowest levels in 2014 and both increased in 2015. These increases in VMT have been linked to increased economic activity and lower gasoline prices (McCahill, 2017). Demographic trends and changing travel preferences, particularly among teens and young adults, may mitigate future VMT growth. Drivers age 65 and older, a growing proportion of the Vermont population, drive considerably less than drivers between the ages of 20 and 64 (FHWA 2015). In addition, teens and young adults are traveling less than their counterparts in previous generations did (Blumenberg et al., 2013). Rates of licensure, trip chaining, and the use of car sharing may also impact VMT and are discussed in Sections 2.1.1 through 2.1.3.

VEHICLE MILES OF TRAVEL (VMT)

Definition: Annual VMT is an estimate of the total miles driven by all vehicles on a road network. VMT can provide insight into transportation energy use, emissions, and economic activity.

Trends: Vermont's total and per capita VMT fell between 2007 and 2014 but increased in 2015. A similar pattern is apparent at the national level. Vermont's per capita VMT remains higher than the national and rural comparison state averages.

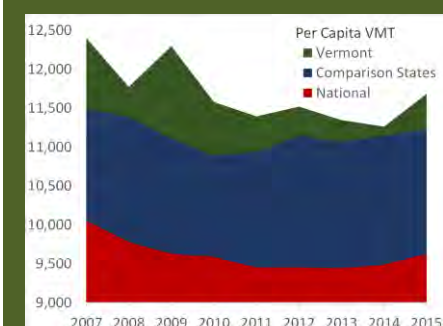

Figure 2-1. Trends in Per Capita VMT (FHWA, 2008–2016)

Driving Factors: The upward movement in VMT likely reflects improved economic conditions and lower gas prices.

In 2015, total and per capita VMT in Vermont increased by 3.5% and 3.7%, respectively. Over this same time period, at the national level, total VMT increased by 2.2% and per capita VMT by 1.5%. In the four comparison states (ME, ND, SD, and WV), total VMT increased by 1.2% while per capita VMT rose by 0.9%. Vermont's per capita VMT remained higher than the national average, and higher than the per capita VMT in every rural comparison state other than North Dakota, as shown in Figure 2-2. Overall, Vermont ranked 11th highest among all states in terms of per capita VMT in 2015, the most recent year for which national VMT data are available. As reported in the two previous editions of the Profile, Vermont ranked 10th in per capita VMT in 2011 and 2013.

Vermont's comparatively high per capita VMT is influenced by the state's rural character. Sparse development patterns result in longer distances between residences, work, school, and shopping locations, requiring longer trips to meet residents' needs. In addition, since VMT estimates are made based on traffic counts, travel by out of state drivers contributes to total VMT. Vermont has a relatively high proportion of tourism and pass-through traffic originating out of state.

Table 2-1. Total and Per Capita VMT, 2007–2015

		2007	2008	2009	2010	2011	2012	2013	2014	2015
Total VMT (billions)	Vermont	7.69	7.31	7.65	7.25	7.14	7.22	7.12	7.06	7.31
	Comparison States	52.44	52.14	51.09	50.9	51.34	52.62	52.58	53.16	53.82
	National	3,031	2,976	2,956	2,966	2,946	2,969	2,988	3,026	3,095
VMT/Capita (thousands)	Vermont	12.40	11.77	12.30	11.58	11.40	11.52	11.35	11.26	11.68
	Comparison States	11.49	11.39	11.11	10.89	10.94	11.14	11.07	11.14	11.24
	National	10.05	9.79	9.63	9.59	9.45	9.45	9.44	9.49	9.63

Source: FHWA, 2008 - 2016

Vermont's predominantly rural land use is reflected in the proportion of the State's total roadway miles in rural, 89.8%, and urban, 10.2%, areas (see Table 2-2). VMT on urban roads accounts for close to 30% of total VMT, more than 2.5 times the share of urban road miles.

Table 2-2. Vermont VMT by Road Class, 2015

	Urban / Rural	Total Roadway Miles1	% of Total	VMT (Millions)	% of Total
Interstate	Rural	259	1.8%	1219	16.7%
	Urban	62	0.4%	539	7.4%
Arterial/Major Collector	Rural	3030	21.3%	2826	38.6%
	Urban	520	3.6%	1184	16.2%
Minor Collector/Local	Rural	9503	66.7%	1155	15.8%
	Urban	880	6.2%	392	5.4%
Totals	Rural	12791	89.8%	5199	71.1%
	Urban	1462	10.3%	2115	28.9%
	Combined	14252	100.0%	7314	100.0%

Source: FHWA, 2016

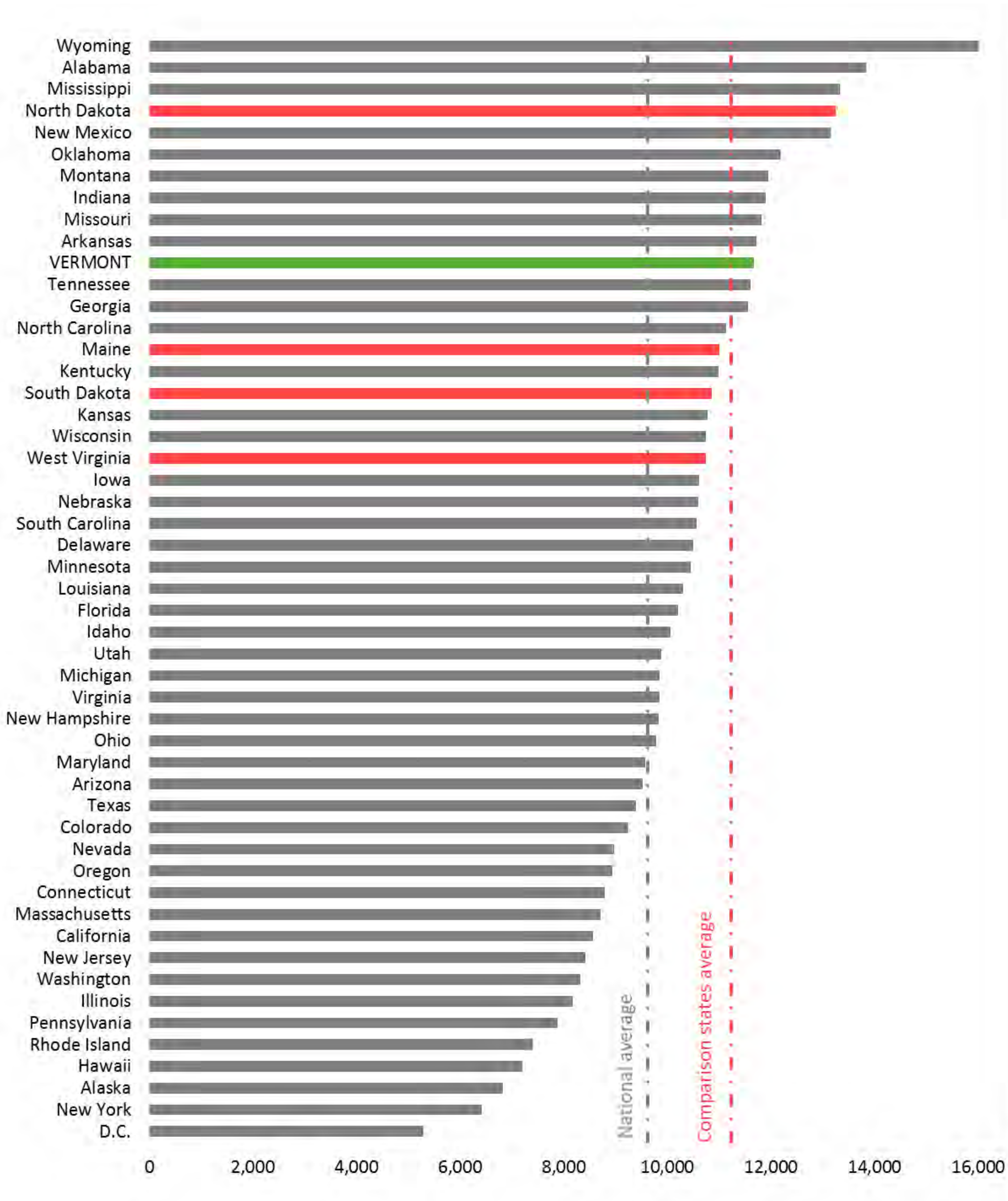

Figure 2-2. 2015 Per Capita VMT for U.S. States (FHWA, 2016; USCB, 2016)

2.1.1 Licensure

One factor that can influence VMT is the percentage of the population that is licensed to drive. The number of Vermonters with driver's licenses and learner's permits from 2008 through 2016 is shown in Table 2-3. The per capita licensure initially dropped from 2008 levels but now exceeds those levels.

Table 2-3. **Driver's Licenses** and Permits in Vermont, 2008–2016

	2008	2009	2010	2011	2012	2013	2014	2015	2016
Driver's Licenses	541,990	506,977	513,481	521,666	541,462	546,573	533,742	551,622	557,287
Learner's Permits	20,229	17,392	17,768	18,661	19,943	20,731	19,457	20,764	21,230
Licenses/ Capita	0.87	0.82	0.82	0.83	0.86	0.87	0.85	0.88	0.89

Sources: VDMV, 2017, USCB 2017

Vermont's rate of licensure per capita is higher than the national average and higher than licensure rates in any of the four rural comparison states. In part, this reflects the state's demographics, as the percentage of the population that is under 16 is lower in Vermont than in any of the comparison states.

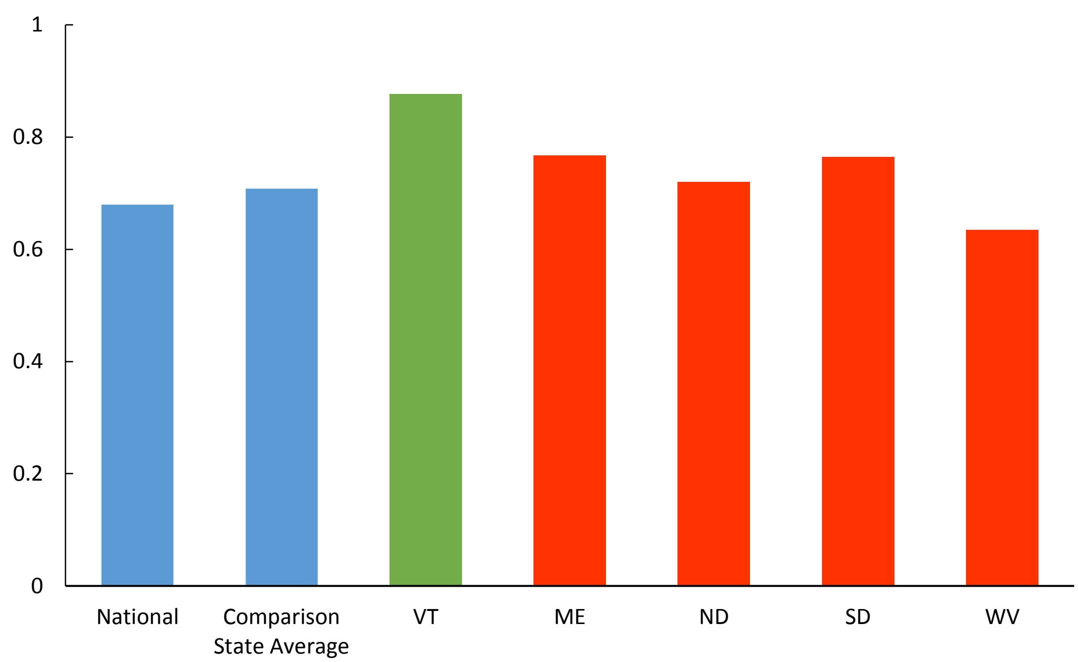

Figure 2-3. Per Capita Licensure, 2015 (FHWA, 2016; USCB, 2017)

2.1.2 Trip Chaining

Travelers' propensity for trip chaining is an additional determinant of VMT. Within the transportation field, a trip is defined as a single leg of a journey, with a discrete beginning and end. Traveling from home to work or from home to a store each constitutes a single trip. Trip chaining occurs when multiple trips are combined in a single journey. Traveling from work to the store to home is considered a single journey that chains together two trips. Trip chaining frequently results in fewer miles traveled than completing each trip independently. One method for tracking the frequency of trip chaining is to look at the percentage of trips that end at home. A reduction in the proportion of trips ending at home may indicate an increase in trip chaining. The distribution of trip destinations by Vermonters for all modes in 2009 is shown in Figure 2-4. This Profile establishes a baseline for trip chaining for use in future reports.

Figure 2-4. Distribution of Trip Purpose or Destination for Vermonters, 2009 (USDOT, 2010)

2.1.3 Car-Sharing Services

Vehicle-sharing organizations provide an alternative to personal vehicle ownership and are gaining popularity in Vermont. The net impact of car sharing on VMT is not yet known (Lovejoy et al., 2013). Researchers have alternatively suggested either that car sharing may increase VMT by giving non-car-owners access to a vehicle, or that it may decrease VMT by reducing overall car ownership rates. Several recent studies suggest that car sharing programs reduce overall car ownership rates, especially in urban areas (Martin, Shaheen, and Lidicker 2010; Clewlow 2016), and also produce a net decrease in VMT and GHG emissions (Shaheen and Cohen 2013), though the extent to which these impacts relate to self-selection among car share members has not yet been determined (Clewlow 2016).

Two car-sharing services operate in Vermont. CarShare Vermont currently has a total of 18 vehicles at locations in Burlington, Winooski, and Montpelier (CarShareVT.org). ZipCar, a national for-profit car-sharing outfit, has a total of five vehicles located on the campuses of Middlebury College, Norwich University, and Vermont Law School (http://www.zipcar.com/cities). Person-to-person (P2P) car-sharing services, such as RelayRides, provide web-based options to search for privately owned vehicles available for hourly or daily rental.

2.2 Mode Share

VERMONT MODE SHARE

Definition: Mode share measures how people travel from location to location—that is, the proportion of trips that are made by private vehicle, public transit, active transport, or other means. Mode share is important for determining the overall energy efficiency of travel. Some modes, such as walking or taking a bus with high ridership, are considerably more energy efficient than others, notably SOV trips.

Status: The overwhelming majority of trips in Vermont, nearly 85%, are taken in passenger vehicles. However, Vermont's SOV commute rate is below that of the comparison states, reflecting higher rates of biking and walking by Vermont commuters than by commuters in ME, ND, SD, and WV. Since 2009, SOV commute mode share has increased by 1.4% and carpooling has declined by an equivalent amount. Transit, walking, and biking commute mode shares have remained relatively stable over this period.

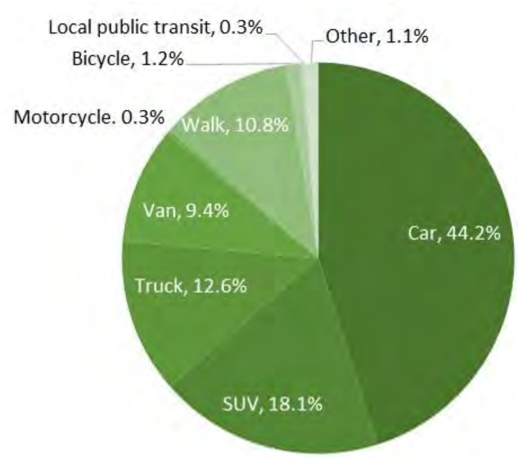

Figure 2-5. **Vermonters' Mode Share, 2009** (USDOT, 2010)

Mode share refers to the proportion of all trips taken with a specific mode (e.g. private automobile, transit, or active transportation). It is commonly measured using travel surveys such as the NHTS. As shown in Figure 2-5, motorized modes, especially personal automobiles, were the dominant mode of travel reported by Vermonters in the 2009 NHTS. According to these data, cars, SUVs, trucks, and vans accounted for nearly 85% of all Vermonters' trips. Notably, nearly half of these vehicle trips take place in larger, generally less energy-efficient vehicles—SUVs, light trucks, and vans. Further discussion of Vermont's privately owned vehicle fleet is provided in Section 3. Active transportation—walking and biking—accounted for 12% of all trips in the NHTS data set.

In addition to the NHTS, mode share data specifically for commute trips have been collected in the ACS and in the VTrans LRTPS (RSG, 2016). Mode share for commuting trips is discussed in Section 2.2.1.

2.2.1 Mode Shares for Commuter Travel

The ACS collects mode data for commute trips on an annual basis and reports these data in one-year and five-year estimates. Since single-year ACS estimates have a relatively small sample size, five-year estimates, which have a smaller margin of error, are used for comparing Vermonters' mode share with comparison states and national mode shares.[2] From 2009 through 2015, SOV commute mode share in Vermont increased from 79.3% to 80.7%. Over this same time period the carpooling mode share declined from 11.4% to 10.1% while shares for other non-SOV commute modes have remained relatively stable, as shown in Figure 2-6 and Table 2-4.

The ACS one-year estimate showed higher rates of SOV commuting, 81.9% and lower rates of carpooling, 8.7%, than the five-year estimates which may be because of the larger margin of error or which may suggest that the five-year estimates are understating a shift away from carpooling. For comparison purposes, the 2016 LRTPS reported SOV as the primary mode for 83% of commuters with only 6% of commuters carpooling/traveling as a passenger in a private vehicle. The primary commute mode shares for transit, walking, and biking were 3%, 4%, and 2%, respectively (RSG, 2016).

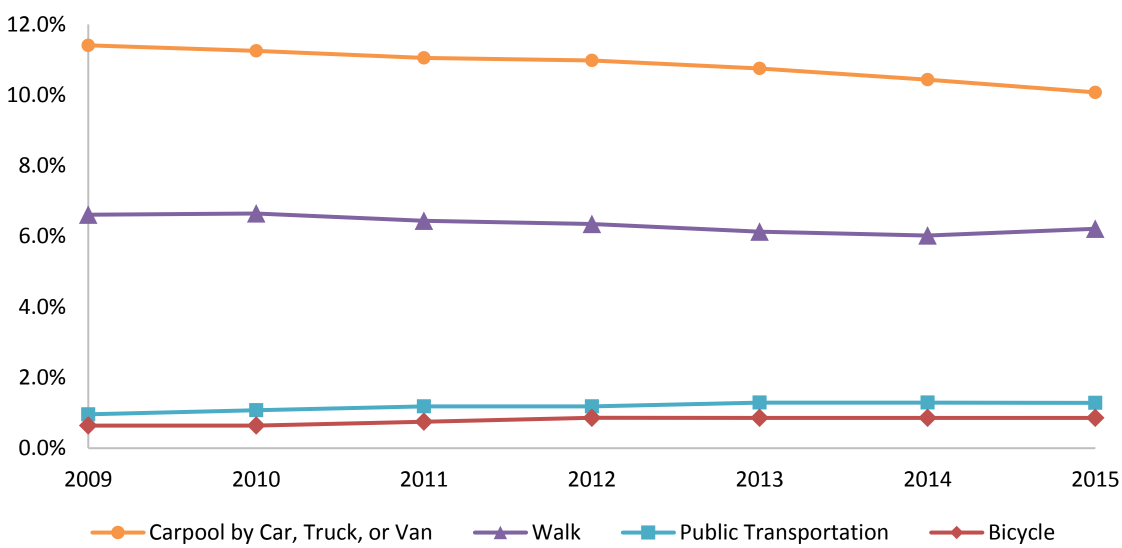

Figure 2-6. Mode Share for Non-SOV Vermont Commuters, 2009–2015 (ACS, 2011-2017)

[2] The 2015 Profile used three-year ACS estimates, but these estimates are no longer produced by the ACS.

Table 2-4. Comparison of Commuter Mode Share (%) for Vermonters, 2009 – 2015

	NHTS	ACS (5-Year Estimates)						
Commuting Modes	2009	2009	2010	2011	2012	2013	2014	2015
Drive Alone by Car/Truck/Van	82.7	79.3	79.4	79.5	79.7	80.1	80.5	80.7
Carpool by Car/Truck/Van	11.7	11.4	11.3	11.1	11.0	10.8	10.4	10.1
Public Transportation	0.6	1.0	1.1	1.2	1.2	1.3	1.3	1.3
Walk	3.1	6.6	6.6	6.4	6.4	6.1	6.0	6.2
Bicycle	0.9	0.6	0.6	0.8	0.9	0.9	0.9	0.9
Taxicab, Motorcycle, or Other	1.0	1.1	1.0	1.1	1.0	0.9	0.9	0.9

Source: ACS, 2011-2017

Using the five-year ACS estimates, the proportion of Vermonters who commuted by SOV, 80.7%, is slightly higher the national average, 79.9%, but lower than all four of the comparison states (ME, ND, SD, WV), which had SOV commute rates ranging from 82.5% to 84.9%, as shown in Figure 2-7. As would be expected given the state's rural nature, Vermonters use public transit less frequently than the national average. Vermonters carpooled at a similar rate to residents of the comparison states but commuted by walking or biking at a considerably higher rate, 7.1%, than the national average or than in any of the comparison states.

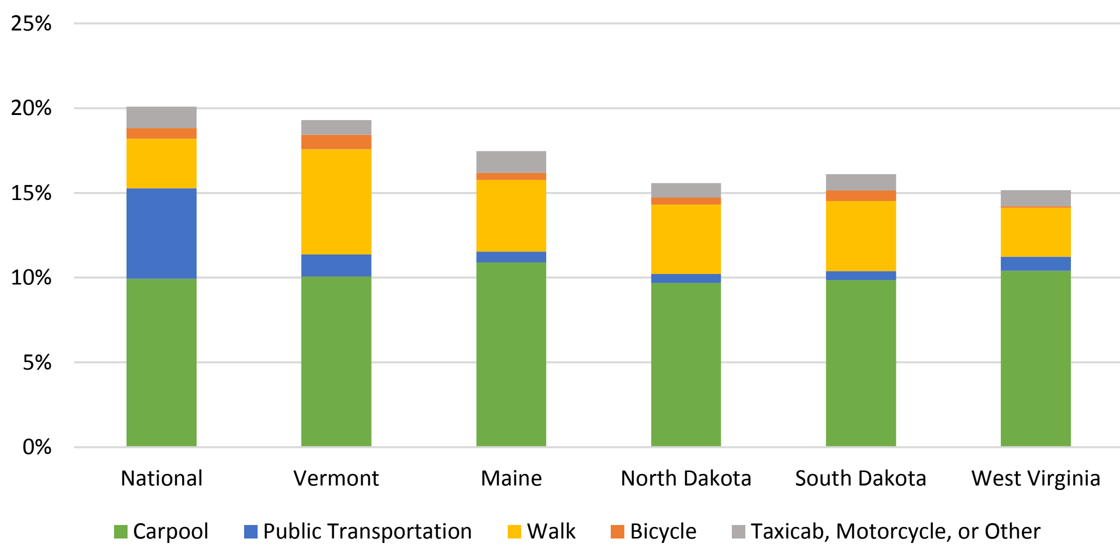

Figure 2-7. Commute Mode Share for Non-SOV Trips, 2015 (ACS, 2011-2017)

Table 2-4, Figure 2-6, and Figure 2-7 only include primary modes to work for commuters. Workers who worked from home, and therefore did not make commute trips, are not included in these numbers. Vermonters worked from home at a higher rate (6.7%) than the national average (4.4%) or than in any of the comparison states (between 2.9% and 5.6%) (ACS, 2017).

2.2.2 Energy Intensity by Mode

Shifting travel to modes with lower energy intensities is one method for reducing energy use in transportation. Energy intensity can be considered at either the vehicle level or the passenger level. Vehicle energy intensity measures how many Btus are required to move a vehicle one mile without adjusting for the number of passengers it carries. Passenger energy intensity measures the energy used to move each passenger one mile. An inverse relationship exists between occupancy and passenger energy intensity—the higher the occupancy, the lower the passenger energy intensity. For many applications, passenger energy intensity provides a more useful measure of energy efficiency than does vehicle efficiency.

Figure 2-8 shows U.S. DOE estimates of vehicle and passenger energy intensity for several commonly used motorized modes (Davis et al., 2016). In Figure 2-8, passenger energy intensity is calculated using national average occupancy rates for rail, air, transit buses, and demand-response transit. Passenger energy-intensities for cars and light-duty trucks are calculated with both one and two occupants as well as for average occupancy to illustrate the impact of increased vehicle occupancy on passenger energy intensity. After demand-response transit, which frequently uses larger vehicles and has a low average occupancy rate, SOV trips in light-duty trucks and passenger cars have the highest energy intensity of the modes shown here. Policies aimed at reducing transportation energy use in Vermont may be able to achieve this objective by promoting mode shifting and increases in average vehicle occupancy rates. Shifting vehicle trips to vehicle types with lower energy intensity will also reduce energy use and is discussed in Section 3.2.1.

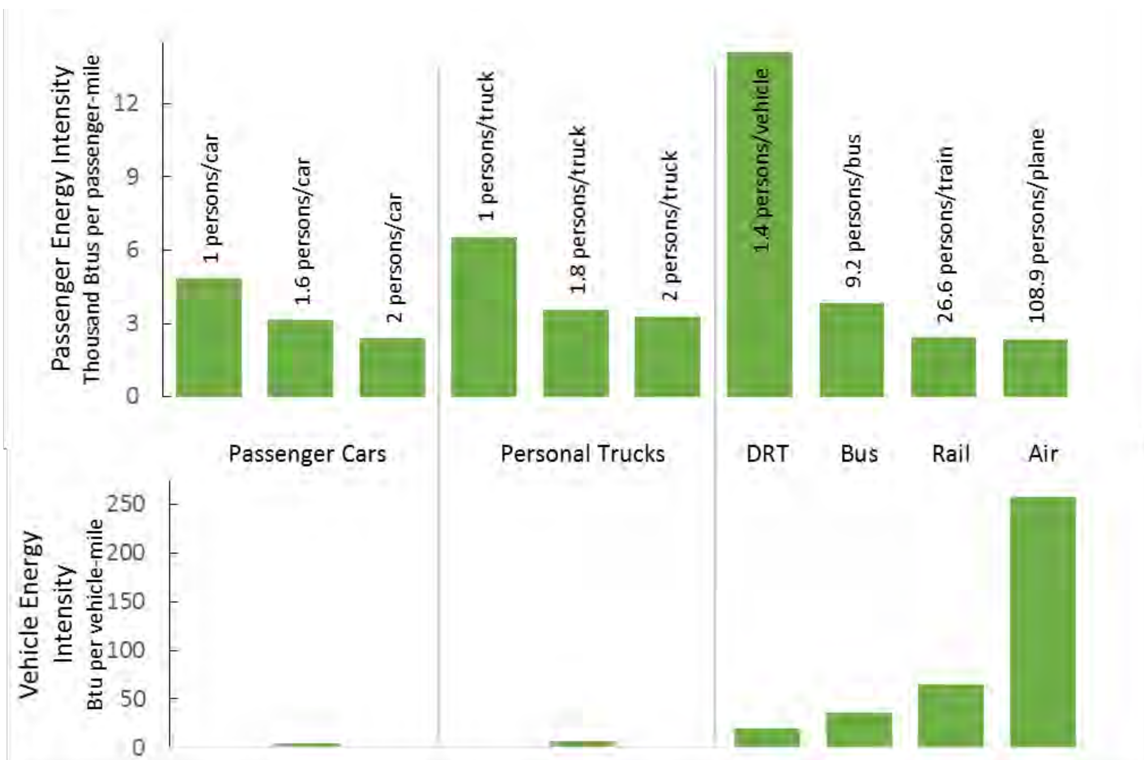

Figure 2-8. Energy Intensities of Common Transport Modes (Davis et al., 2016)

2.3 Vehicle Occupancy

VERMONT VEHICLE OCCUPANCY

Definition: Vehicle occupancy rates are a measure of the average number vehicle occupants per vehicle trip. Increasing vehicle occupancy can decrease VMT and the per passenger energy intensity of travel.

Status: Vehicle occupancy data are collected by travel surveys such as the NHTS. As of 2009, Vermonters' averaged a vehicle occupancy rate of 1.57 people per vehicle, below the national average of 1.67. The loss of carpooling commute mode share may indicate that Vermont's vehicle occupancy rate has declined since then. Trends in vehicle occupancy will be reported in future Profiles as new survey data becomes available.

New Factors: The State has undertaken several initiatives to increase carpooling, and thus vehicle occupancy rates, since 2009, including expanding park-and-ride coverage and the Go! Vermont program. Since 2012, over 1,100 new parking spaces have been added to state and municipal park-and-rides. In the same time frame, Go! Vermont has registered 5,207 commuters for carpools and vanpools. The impact of these initiatives on vehicle occupancy rates is not yet known, though evidence from the ACS suggests carpooling may be falling in spite of these efforts.

Vehicle occupancy rates measure the average number of vehicle occupants per vehicle trip. Vehicle occupancy is an important component of transportation energy intensity, as described in Section 2.2.2. Increasing vehicle occupancy decreases the per passenger energy intensity per mile traveled. Generally, increasing vehicle occupancy also results in lower total VMT.

Occupancy data are generally collected via travel surveys. The most recent survey to collect vehicle occupancy data for Vermont was the 2009 NHTS. Vehicle occupancy rates from the NHTS are summarized for Vermont, the nation, and the four comparison states in Table 2-4. Vehicle occupancy is generally lower for trips that take place entirely in-state than for trips that include travel in other states or Canada. Trips to work have the lowest occupancy rates of all trip types. Trips for meals and social or recreational purposes as well as trips to transport another individual, which by definition included multiple people per vehicle, have the highest vehicle occupancy rates (USDOT, 2010).

Table 2-5. Average Vehicle Occupancy, 2009

	Average Vehicle Occupancy
National	1.67
Vermont	1.57
Maine	1.54
North Dakota	1.70
South Dakota	1.73
West Virginia	1.41
Source: USDOT, 2010.	

2.3.1 Carpooling Incentives

According to NHTS and ACS data, carpooling rates in the U.S. have steadily declined from 20% in 1980 to its current estimated level of 10%. This 30-year decline may be attributable to a number of factors such as rising rates of vehicle ownership, declining household size, sustained low fuel prices, and an increase in suburban settlement patterns. In 2008, the state of Vermont established Go! Vermont, a carpooling initiative designed 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 participants and provide information for those seeking to share rides to work, meetings, and conferences. Results of Go! Vermont activities are summarized in Table 2-6.

Table 2-6. Go! Vermont Program Benefits, SFY 2017

Tracking Metric	SFY 2012-2015	SFY 2016	SFY 2017
Registered Commuters	3455	943	811
Rides Posted	4224	970	837
Vanpools	19	14	11
Total Estimated Reduction of VMT	16,466,000	3,085,636	2,453,499
Estimated Commute Cost Savings	$9,276,000	$1,681,814	$1,338,524
Source: McDonald, 2017			

2.3.2 Park-and-Ride Facilities

Park-and-ride facilities provide safe, no-cost parking spaces for those who carpool or ride the bus. Currently, the state operates 30 park-and-ride sites with approximately 1,525 total spaces (see Table 2-7), while individual municipalities maintain an additional 65 sites with a total of approximately 1,293 spaces (see Table 2-8). Overall, the number of park-and-ride parking spaces has increased by 67% since 2012. In addition, park-and-ride facilities at both the state and municipal levels are considerably more likely to function as multi-modal hubs by including connections to transit and bicycle parking. Charging facilities for plug-in electric vehicles (PEVs) are also starting to be installed at park-and-rides.

Table 2-7. State Park-and-Ride Facilities in Vermont (2012 – 2017)

Number of State:	2012	2015	2017
Park-and-Rides	25	29	30
Parking Spaces (approximate)	1,140	1,380	1,525
Facilities with Bike Racks	11	20	30
Facilities with Transit Connection	3	19	21
Facilities with Paved Surface	17	24	26
Facilities Lighted	18	24	28
Facilities with PEV Charging	0	1	5
Source: Davis, 2017			

Table 2-8. Municipal Park-and-Ride Facilities in Vermont, (2012 – 2017)

Number of Municipal:	2012	2015	2017
Park-and-Rides	26	53	65
Parking Spaces (approximate)	550	1,012	1,293
Facilities with Bike Racks	2	19	22
Facilities with Transit Connection	9	20	22
Facilities with Paved Surface	20	42	52
Facilities Lighted	18	37	49
Facilities with PEV Charging	0	0	3

Source: VTrans, 2017

2.4 Active Transport

Active transportation – primarily walking and biking – has a very low energy intensity and, consequently, replacing vehicle trips with these modes can help reduce transportation energy use and GHG emissions. Of the nearly 10,800 unique trips recorded in the 2009 Vermont NHTS data set, 39% are less than two miles and 28% are less than one mile. Roughly 87% of the trips shorter than two miles were made by motor vehicle, suggesting an opportunity for increasing active transportation trips. The CEP includes an objective of increase the share of commute trips completed by walking or biking to 15.6% of all commute trips.

To better understand the role of active transportation in the State, VTrans and the University of Vermont Transportation Research Center are collaborating to create a data portal to facilitate sharing bicycle and pedestrian counts among local, regional and state agencies. Because walking and biking count data are still not collected as widely as vehicle count data, travel surveys remain the best source of biking and walking data. The 2009 NHTS and the 2016 LRTPS both provide indications of the level of biking and walking in Vermont. Because the trip frequency estimates in these surveys are not collected as part of travel diaries that also capture the total number of trips taken, they cannot be used to calculate mode share. Nonetheless, they can provide some indication of biking and walking patterns in Vermont.

The active transportation tendencies of Vermonters, as reported in the 2009 NHTS, are shown in Table 2-9. Active transportation rates in Vermont are similar to those found nationally. Approximately 14% of Vermonters in the data set had taken at least one bike trip and 75% had taken at least one walking trip within the previous week.

Table 2-9. **Vermonters' and Nationwide Biking and Walking Tendencies, 2009**

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.

The 2016 LRTPS also asked about biking and walking tendencies, as shown in Table 2-10. Similarly to the NHTS results, the LRTPS indicates most Vermonters, 81%, walk at least occasionally.

Table 2-10. Walking and Biking Frequency among Vermonters, 2016

Mode	Mode Use Frequency		
	Frequently	Infrequently	Never
Walking	45%	36%	19%
Biking	14%	31%	55%

Source: RSG, 2016.

2.5 Bus and Rail Service

Rail and bus service can each provide energy-efficient transportation options. At average occupancy rates, these modes are considerably more efficient than the state's most common commute mode, the SOV. The CEP includes goals to increase public transit and passenger rail ridership. This section describes current trends in passenger rail and transit ridership and highlights the role of private interregional bus companies and multimodal hubs in facilitating increased bus and passenger rail utilization.

2.5.1 Public Transit Ridership

As noted in the Public Transit Route Performance Reviews (KFH Group 2017), the organization of Vermont's public transit system has changed substantially in recent years. The Chittenden County Transportation Authority (CCTA) and Green Mountain Transit Agency (GMTA) merged in 2011, and the merged entity began operating as Green Mountain Transit (GMT) in 2016. In 2015, the Deer Valley Regional Transit Association assumed the assets of Connecticut River Transit and now operates as Southeast Vermont Transit (SEVT). Transit service territories are shown in Figure 2-9. The Profile reports on transit ridership for 10 transit divisions, see Table 2-11, as well as on volunteer driver services provided by the Vermont Association for the Blind and Visually Impaired (VABVI) and intercity bus routes operated by Greyhound and Vermont Translines. Greyhound and Vermont Transline data is included only for routes that receive financial assistance from VTrans.

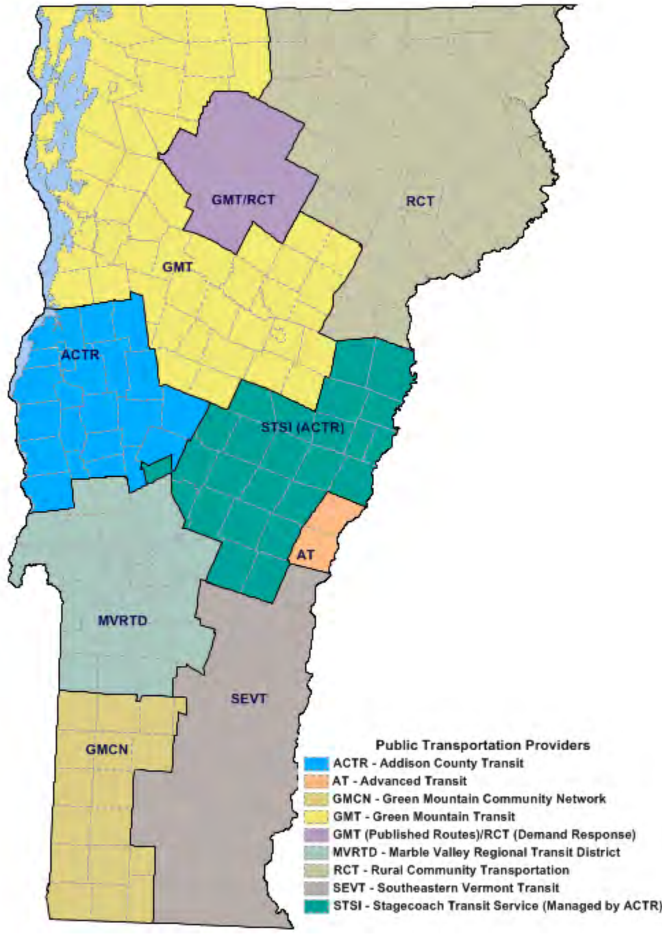

Figure 2-9. Transit Service Providers (KFH Group, 2017)

In SFY 2016, total public transit ridership was measured at 4.7 million passenger boardings, as shown in Table 2-11. Figure 2-10 shows the trend in transit ridership, across all trip types, from SFY 2012 through SFY 2016. Overall, transit ridership increased from SFY 2012 through SFY 2015 but declined by 6% in SFY 2016. This decline is primarily attributable to a drop in ridership of seasonal routes serving tourist destinations due to the poor 2015/2016 ski season (KFH Group, 2017).

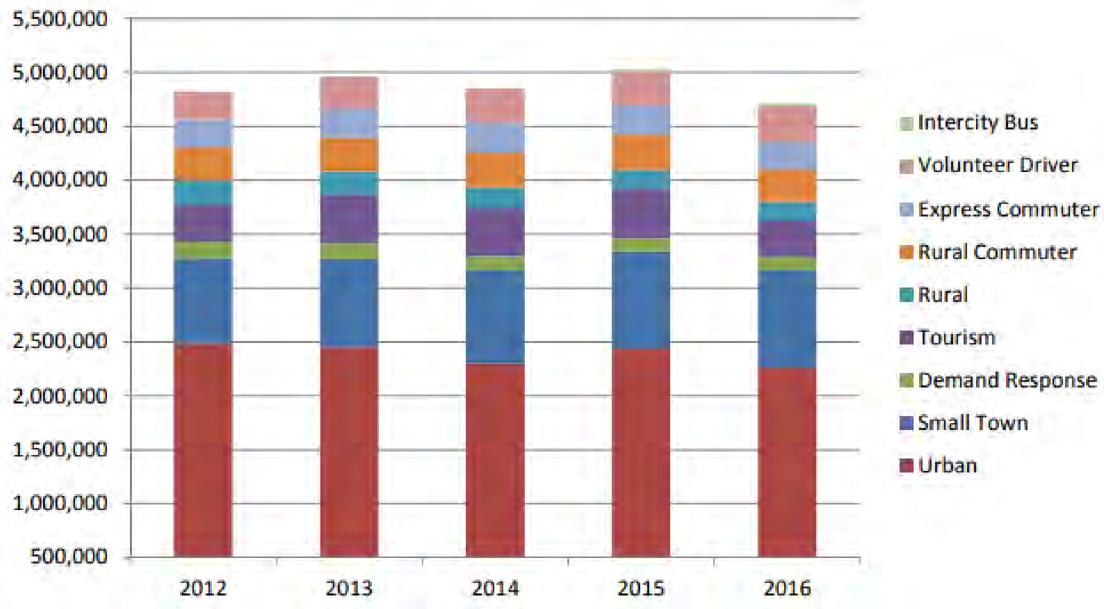

Figure 2-10. Transit Ridership FY 2012–2016 (KFH Group, 2017)

Table 2-11. Bus Ridership for Vermont Transit Authority Providers, FY 2011–16

Transit Provider	Annual Ridership (thousands)					
	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16
ACTR[1]	153.2	181.7	190.8	186.8	174.6	144.8
AT	169.8	171.8	180.6	172.6	195.9	210.7
GMCN	75.4	96.5	109.9	117.1	119.7	114.2
GMT - Rural (formerly GMTA)	419	424.2	427	418.4	417.5	381.0
GMT - Urban (formerly CCTA)	2,512.4	2,703.2	2,690.4	2,545.4	2,703.5	2,510.7
Greyhound	N/A	N/A	N/A	N/A	14.4	14.3
MVRTD	557.8	545	585.8	633.4	631.7	607.3
RCT	163	150.3	175.1	191.8	186.4	205.2
SEVT - The Current (formerly CRT)	233.6	257.3	250.2	251.6	231.9	234.5
SEVT - The MOOver (formerly DVTA)	211.2	203.1	270	271.8	281.8	218.0
STSI	77.8	83.4	75.2	60.8	59.3	56.4
VABVI	5.2	5.3	5.2	4.3	4.2	3.4
Vermont Translines	N/A	N/A	N/A	N/A	8.3	11.1
Statewide Totals	4,578	4,822	4,960	4,854	5,029	4,712

Note: ACTR ridership numbers have been updated for SFY 12 – 14 since the 2015 VTEP
Source: Pelletier 2017

2.5.2 Passenger Rail Ridership

Passenger rail service in Vermont is provided on two Amtrak lines: the Vermonter, running from St. Albans to its eventual terminus in Washington DC, and the Ethan Allen Express, running from Rutland to New York City via Albany. Passenger rail ridership is measured by tracking the number of passengers who board and disembark at rail stations in Vermont. Combined boardings and disembarkments (also called alightments) at Vermont rail stations from FY 2003 through FY 2016 are shown in Figure 2-11. Passenger rail ridership has increased steadily from FY 2005 through FY 2014 but has declined in FYs 2015 and 2016.

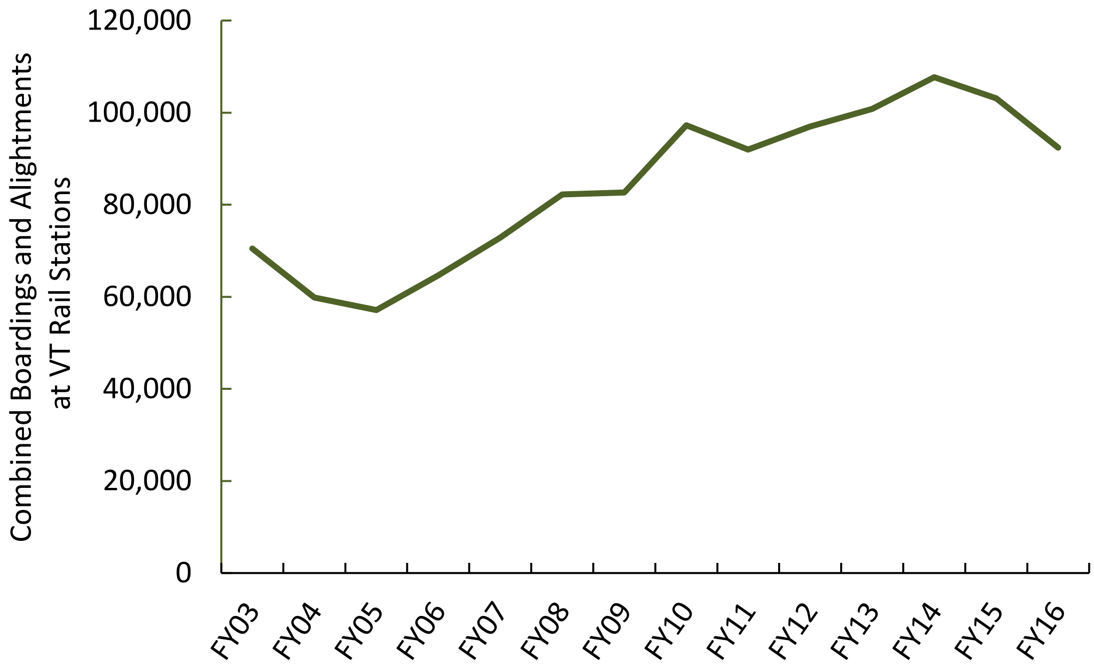

Figure 2-11. Amtrak Boardings and Alightments at Vermont Stations, FY 2003–2016 (Pappis, 2015; Amtrak, 2016 - 2017)

2.5.3 Private Interregional Bus Service

In addition to public transit services described previously, four major intercity bus carriers currently service locations in Vermont. These intercity bus carriers are Megabus, Greyhound, Yankee Trails, and Vermont Translines. With the exception of routes that receive support from VTrans, ridership data for these companies is proprietary and not included in the CEP transit metrics.

2.5.4 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. Typically, multimodality refers to the use of more than one mode in travel along a journey. From an energy-use perspective, the ability to access multiple modes along a journey increases the potential for reducing the use of the highest energy intensity modes of travel by shifting part of the trip to a less energy-intensive mode. Multimodal facilitation is an evolving priority within Vermont's transportation infrastructure.

Park-and-ride facilities are, by nature, multimodal because they facilitate shifts from automobiles to transit buses or from an SOV to a multi-passenger vehicle. As discussed previously, an increasing number of park-and-rides offer transit connections and bicycle parking, increasing their value as multimodal hubs. Co-locating bus lines at rail stops and airports is another example of the creation of multimodal hubs, providing options for the first leg of a passenger rail or airplane trip. Many CCTA buses are equipped with bike racks for their riders, allowing for the combination of biking and bus transit on a trip. Bike boardings may be a trend that can be tracked statewide if other transit providers equip their buses with bike racks.

3 Privately Owned Vehicle Fleet

The energy and specific fuel consumed per vehicle-mile traveled is a function of the vehicle used to drive that mile. The Vermont fleet of privately owned vehicles encompasses a wide variety of vehicle types utilized for a wide range of travel purposes. Vehicle purchase decisions are influenced by a variety of factors, including household demographics, employment characteristics, regional geography, and perceptions about the local climate (Bhat et al. 2009; Busse et al., 2015). Local terrain may also influence the vehicle characteristics—such as clearance and four-wheel drive—that Vermonters look for in their vehicles. This section tracks vehicle registrations to assess the overall efficiency of the Vermont vehicle fleet. Growth in sales of alternative fuel vehicles, such as electric vehicles, is also highlighted.

Analysis in this section is limited to the fleet of privately owned automobiles and trucks registered in Vermont. Privately owned vehicles are defined as all vehicles with commercial or individual registrations. Publicly owned vehicles, as well as buses, motorcycles, and off-road vehicles, are excluded from the analysis in this section. As of 2015, 9,178 publically owned vehicles, 673 privately owned buses and 31,051 privately owned motorcycles were registered in Vermont (FHWA, 2016). These vehicles accounted for 6.2% of 2015 registrations.

3.1 Vehicle Registrations

Vehicle ownership is a strong predictor of vehicle use. Table 3-1 shows the trends in driver licensing and vehicle registration at the state and national level from 2007 through 2015, the most recent year for which national data are available. Nationally, per capita vehicle ownership and vehicle ownership per licensed driver fell slightly from 2007 to 2010 – likely impacted by the 2008 economic downturn – but have increased slightly since then. Perhaps because it is more difficult to forgo a vehicle in a rural state, Vermont did not experience a comparable dip in vehicles per licensed driver. The rate remained fairly stable until 2015 when it increased by 6.7% relative to 2014.

VT PRIVATELY OWNED VEHICLE FLEET

Overview: The vehicles that Vermonters drive determines the efficiency of vehicle travel in the state as well as the fuels that are used for transportation. The Vermont vehicle fleet is composed almost entirely of gasoline- and diesel-fueled vehicles (94.4% and 5.3%, respectively), as shown in Figure 3-1. Less than 0.5% of all vehicles use other fuel types.

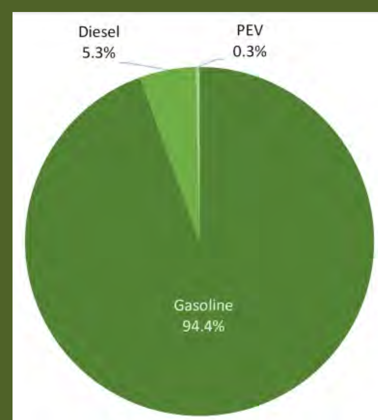

Figure 3-1. Vermont Vehicle Registrations by Fuel Type, 2017 (VDMV, 2017)

Trends in PEV Registrations: The number of plug-in electric vehicles (PEVs), such as the Chevy Volt and Nissan Leaf, increased by nearly 90% between July 2015 and July 2017. As shown in Figure 3-1, however, PEVs, are less than 0.5% of the total vehicle fleet.

Table 3-1. **Vehicle Registrations and Driver's Licenses in** Vermont and the U.S., 2007–2015

Year	Vermont			National		
	Registered Vehicles (Thousands)	Vehicles / Licensed Driver	Vehicles / Capita	Register Vehicles (Millions)	Vehicles / Licensed Driver	Vehicles / Capita
2007	555	1.04	0.89	243.1	1.18	0.81
2008	571	1.05	0.92	244.0	1.17	0.80
2009	546	1.08	0.88	242.1	1.16	0.79
2010	554	1.08	0.89	237.4	1.13	0.77
2011	564	1.07	0.90	240.8	1.14	0.77
2012	568	1.08	0.91	241.2	1.14	0.77
2013	574	1.06	0.92	243.1	1.15	0.77
2014	573	1.05	0.92	247.4	1.16	0.78
2015	614	1.12	0.98	250.5	1.15	0.79

Source: FHWA, 2008–2016

Vehicles per licensed driver and vehicles per capita in 2015 for Vermont and the four comparison states are shown in Figure 3-2. As discussed in Section 2.1.1, Vermont has a relatively high licensure rate and thus the difference in vehicles/licensed driver and vehicles/capita is relatively small. Only Maine has a lower ratio of vehicles to licensed drivers among the four comparison states.

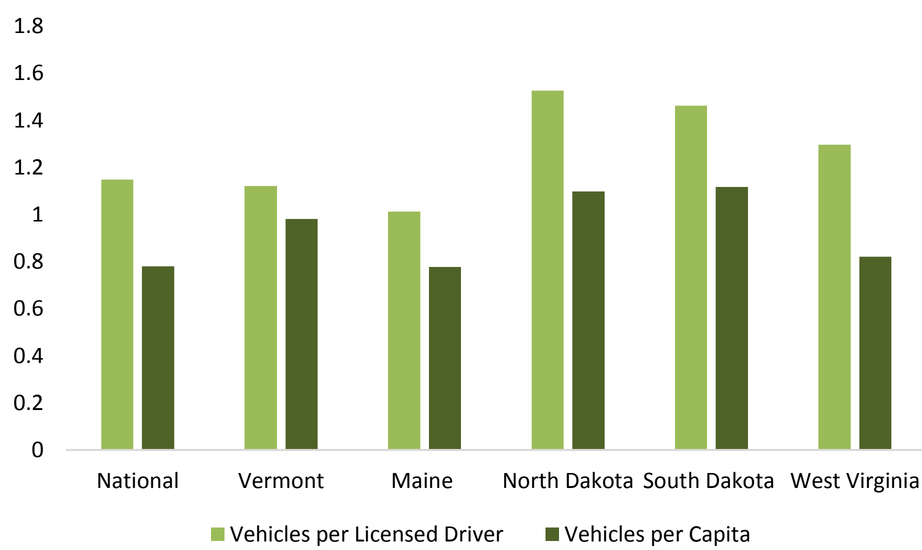

Figure 3-2. Vehicles per Capita and per Licensed Driver, 2015 (FHWA, 2016)

Note that for consistency of comparison between Vermont, national, and rural comparison state figures, all vehicle data here are taken from the FHWA's Highway Statistics, 2015 (FHWA, 2016). The Vermont vehicle numbers in Section 3.2 and 3.3

are directly from the Vermont DMV data and vary with respect to the FHWA data by as much as 4%. Vermont DMV data also show an increase in vehicles per licensed driver between 2013 and 2015, but it is slightly smaller than that shown in the FHWA data.

3.2 Vehicle Type

The vehicle fleet can be characterized by the type of fuel or propulsion system that powers it as well as by vehicle body type. As shown in Table 3-2, the Vermont fleet is dominated by conventionally powered vehicles, running on either gasoline or diesel. While gasoline internal combustion engine vehicles (ICEVs) are by far the most common vehicles registered in Vermont, gasoline-powered hybrid electric vehicles (HEVs) such as the Toyota Prius, plug-in hybrid electric vehicles (PHEVs) such as the Chevy Volt, and all-electric vehicles (AEVs) such as the Nissan Leaf have all grown in popularity. PHEVs and AEVs, collectively known as PEVs, derive some or all of their energy from electricity, helping to reduce the amount of petroleum-based fuels used for transportation. HEVs are powered entirely by gasoline but tend to have significantly better fuel efficiency than comparable ICEVs and thus also help reduce transportation energy use.

Table 3-2. Vehicles Registered in Vermont by Fuel Type, 2008–2017

Year	PEV		Propane/ CNG	Diesel	Gasoline	
	AEV	PHEV			ICEV	HEV
2008	NA	NA	75	32,140	578,881	4,656
2009	NA	NA	69	30,724	528,930	5,473
2010	NA	NA	59	25,932	524,810	5,877
2011	NA	NA	51	28,513	550,711	7,056
2012	48	140	48	38,684	541,872	7,693
2013	130	466	43	28,209	516,339	7,945
2014	197	670	43	29,879	525,199	9,242
2015	248	865	44	31,239	533,118	9,895
2016	330	1,192	43	31,213	533,021	10,676
2017[1]	381	1,387	47	30,205	532,370	10,901

[1] 2017 data through June 30th, data for all other years through December 31st.
Sources: VDMV, 2017; Drive Electric Vermont, 2017.

A breakdown of the most popular PEV models registered in Vermont and the efficiency of the vehicles measured in mile per gallon equivalent (MPGe) is provided in Table 3-3. MPGe is used to compare the energy use of PEVs to conventional gasoline vehicles. The efficiency of the most popular PHEVs in Vermont ranges from 51 – 78 MPGe. As of the 2017 model year, the lowest MPGe of the AEVs in Table 3-3 is 99.

Table 3-3. Vermont PEV Registration and MPGe by Vehicle Model

Plug-In Type	Make and Model	VT Registrations as of: July 2015	VT Registrations as of: July 2017	Combined MPGe 2015	Combined MPGe 2016	Combined MPGe 2017
AEV	Ford Focus Electric	11	19	105	105	107
AEV	Mitsubishi i-MiEV	28	26	no data	112	112
AEV	Nissan Leaf	118	173	114	114	112
AEV	Smart Fortwo Electric Drive (based on coupe model)	10	12	107	107	108
AEV	Tesla Model S (based on 60kWh model)	38	79	95	99	99
PHEV	Chevrolet Volt	138	315	62	77	77
PHEV	Ford C-Max Energi Plug-in Hybrid	204	422	51	51	54
PHEV	Ford Fusion Energi Plug-in Hybrid	115	222	51	51	57
PHEV	Toyota Prius Plug-In Hybrid	264	346	58	no data	78
	Other (including market conversions)	17	154			
	Total	943	1768			

Source: Drive Electric Vermont, 2017; U.S. DOE & U.S. EPA, 2017

Vehicle size and body type are also important determinants of fuel efficiency. Figure 3-3 shows the 20 most common vehicle makes and models registered in Vermont. Several truck makes are among the most popular vehicles.

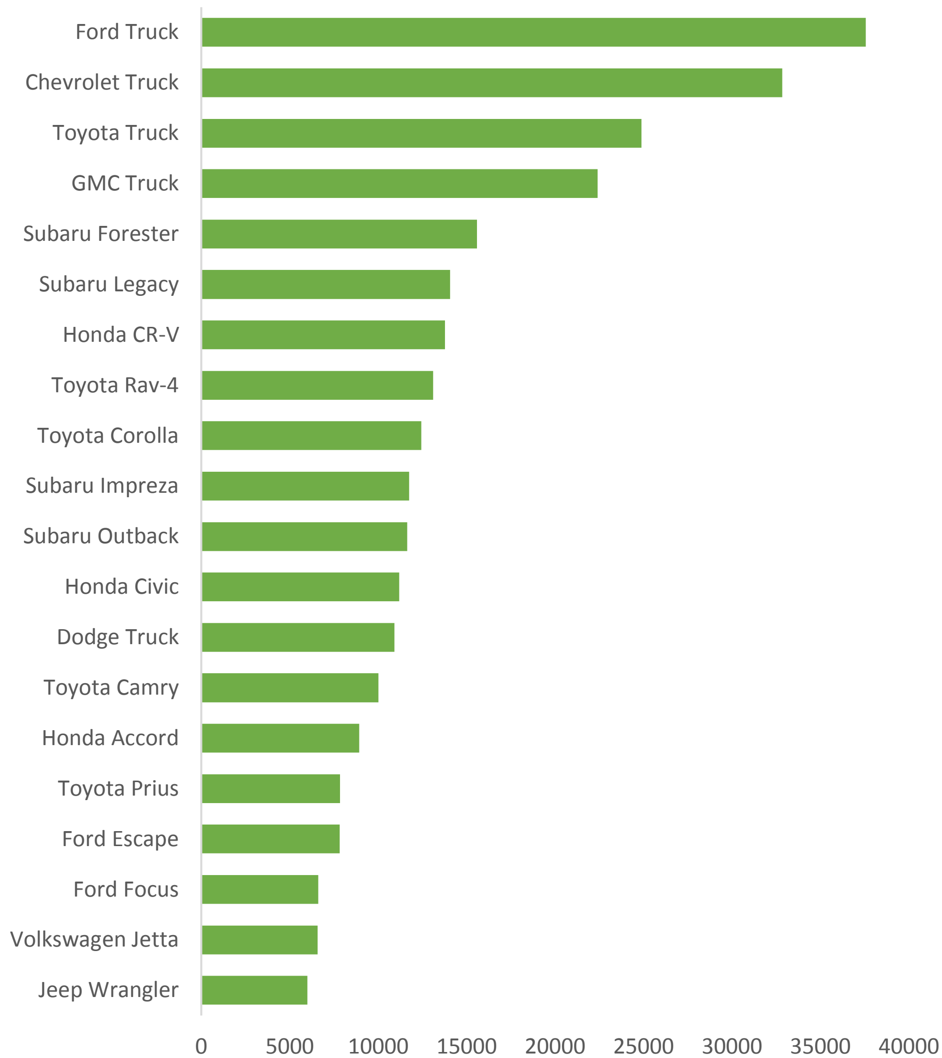

Figure 3-3. Top 20 Vehicle Models Registered in Vermont, 2017 (VDMV, 2017)

3.2.1 Life Cycle Energy and GHG Intensity by Vehicle Type

Life cycle assessments (LCAs) are used to evaluate the environmental impacts of a product comprehensively, including the impacts related to producing, operating, and decommissioning the product. Vehicle LCA for energy use and GHG emissions include the liquid fuel production (for ICEVS, HEVs, and PHEVs) and electricity generation (for PEVs) processes. Figure 3-4 shows national and Vermont specific estimates of the energy and GHG intensities of ICEVs, HEVs, PHEVs with 18 and 62 mile electric-ranges, and AEVs (Onat, Kucukvar, and Tatari 2015). For PEVs, LCA energy and GHG intensity are both influenced by the source of the electricity used to charge the vehicle. Burning fossil fuels for electricity generation results in substantial energy loss and GHG emissions when compared to most renewable electricity sources. Given the composition of electricity sources in Vermont, Onat et al. show AEVs to outperform other vehicle types on both energy use and GHG emissions (Onat, Kucukvar, and Tatari 2015).

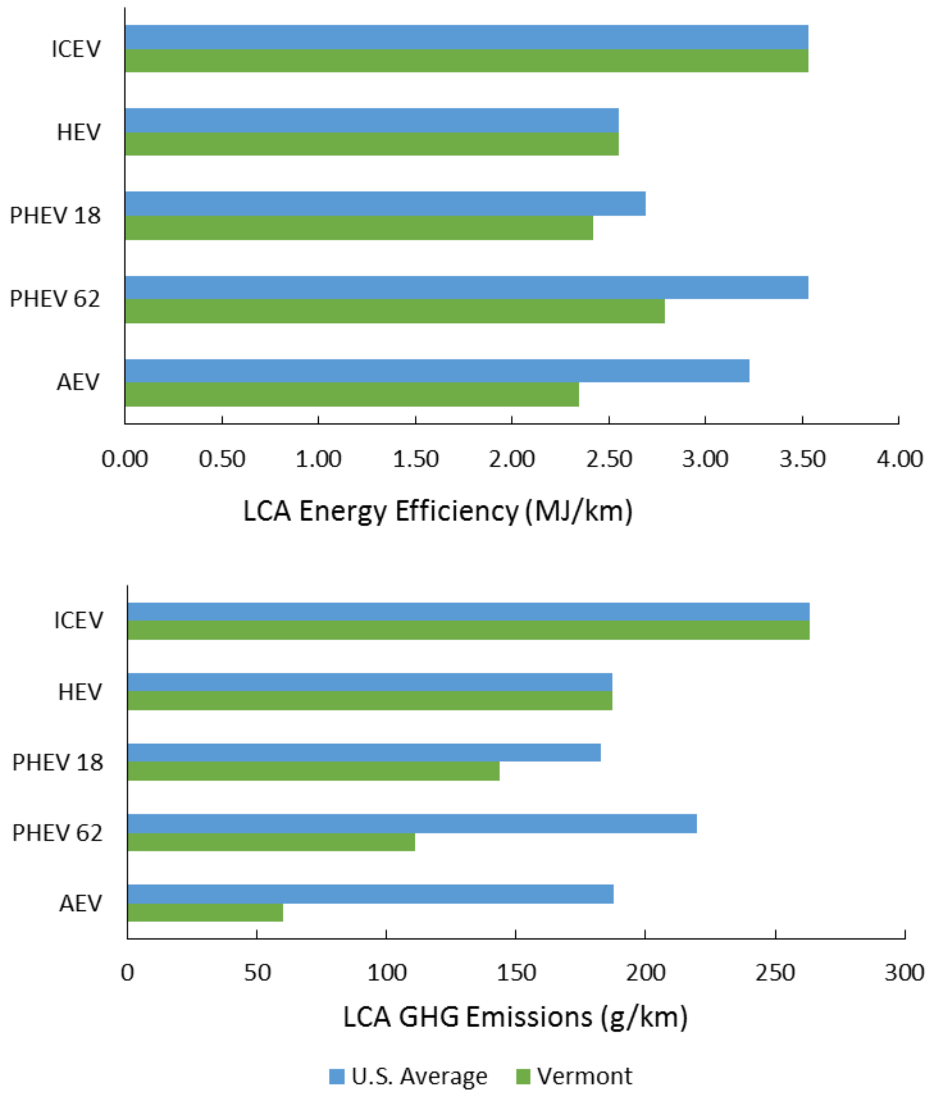

Figure 3-4. WTW Energy and GHG Intensity (Onat et al., 215)

3.3 Fleet Age

Though new vehicles with increased fuel efficiency are being introduced rapidly into the American market, the fuel-saving effect of these models is highly dependent upon the turnover rate of vehicles in the current fleet. Figure 3-5 shows the distribution of automobile and truck model years for the vehicles registered in Vermont as of June 2017. Approximately 63% of Vermont's registered vehicles were manufactured in the last ten years. A decrease in the average age of the fleet is likely to result in an improvement in the fuel economy of Vermont's privately owned vehicle fleet.

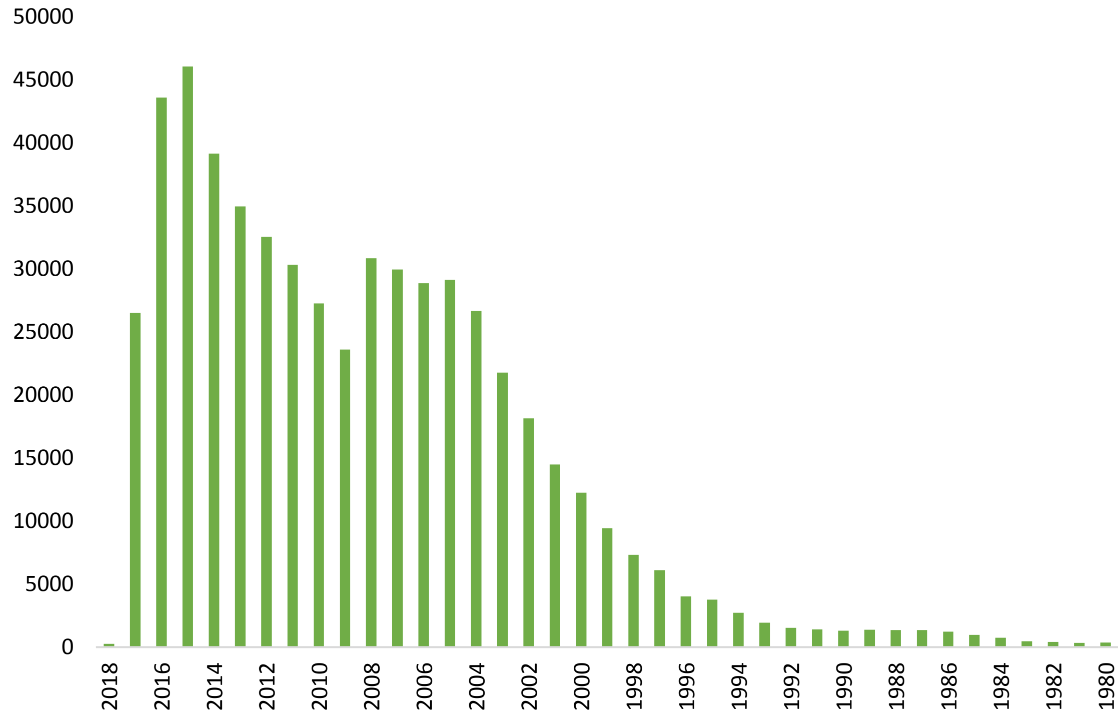

Figure 3-5. Distribution of Model Years for Vehicles in Vermont, 2017 (VDMV, 2017)

3.4 Fleet-Wide Fuel Economy

Vehicle fuel efficiency is a critical determinant of transportation energy use. Higher fuel economy vehicles can provide comparable mobility benefits with lower energy consumption than equivalent vehicles with lower fuel economy. The combined MPG of vehicles registered in Vermont has increased by an average 0.3 combined MPG per year from 2011 through the middle of 2017, as shown in Table 3-4. The values in Table 3-4 were calculated by matching DMV vehicle registration data to EPA fuel economy data available from FuelEconomy.gov. Because the DMV vehicle-make-and-model data are manually recorded in abbreviated form, matching these records to the EPA MPG data required identifying irregularities in the abbreviations used and translating these abbreviations into the complete make-and-model names in the FuelEconomy.gov data set. For instance, the Nissan Versa could be entered into the DMV database with the make defined as NISS, and model defined as VSA or VRS.

Approximately 85% of the registered vehicles in the reported time period (2011-2017) could be matched to MPG data. The remaining 15% of the vehicle fleet could not be matched either because the vehicles were not in the FuelEconomy.gov data set, which is only available for vehicle model years after 1984 and does not include medium- and heavy-duty trucks, or because of anomalous make-and-model abbreviations. Since older and heavier vehicles are less well represented in the matched data set, the actual fuel economy of the Vermont fleet is likely lower than the values shown here.

Table 3-4. EPA Fuel Economy for Vehicles Registered in Vermont, 2011–2017

Year	Registered Vehicles	MPG Match Rate	Average City MPG	Average Highway MPG	Combined MPG	
					Average	Std Dev
2011	586,422	85.00%	18.1	24.2	20.3	5.7
2012	578,415	85.60%	18.4	24.5	20.7	6.1
2013	552,665	85.80%	18.7	24.8	20.9	6.5
2014	564,591	86.40%	19.1	25.3	21.4	7.1
2015	589,608	85.44%	19.5	25.6	21.8	7.3
2016	591,864	85.64%	19.8	25.9	22.1	7.5
2017[1]	596,783	85.52%	20.0	26.1	22.2	7.6

[1] As of June 2017, all other values as of yearend.
Source: VDMV, 2017.

In addition, the realized fuel economy for Vermont drivers depends on the distance that each vehicle is driven. If lower-MPG vehicles are driven over longer distances than more fuel-efficient vehicles, fuel consumption is higher than if more fuel-efficient vehicles are driven preferentially. The 2009 NHTS suggests that highly fuel-efficient vehicles may be driven less than vehicles with lower fuel efficiency. For example, HEVs are driven only about 5,000 miles per year as compared with the statewide average of 10,275 miles per vehicle per year (USDOT, 2010).

One method for estimating the realized fuel economy in Vermont is dividing the annual VMT by the annual fuel sales in the state. Table 3-5 shows the MPG values that result from this approach.

Table 3-5. Realized MPG (VMT/Fuel Sales)

Year	Average MPG[1]
2011	18.3
2012	18.8
2013	18.7
2014	18.7
2015	18.9

[1] Annual VMT divided by combined annual gas and diesel sales.
Source: FHWA, 2016; VT JFO, 2017

4 Transportation Energy Consumption

The transportation sector continues to be the largest consumer of energy among all sectors in Vermont as shown in Figure 4-1. In 2015, 49 trillion Btus of energy were consumed for transportation purposes (U.S. EIA, 2017). Vermont is one of 23 U.S. states that consumes more energy in the transportation sector than in any other sector (U.S. EIA, 2017).

Nonetheless, Vermont's per capita transportation sector energy use is below the national average, at 78.4 million Btu annually in 2015. Per capita transportation-sector energy consumption in all four of the rural comparison states is above the national average, as shown in Figure 4-2.

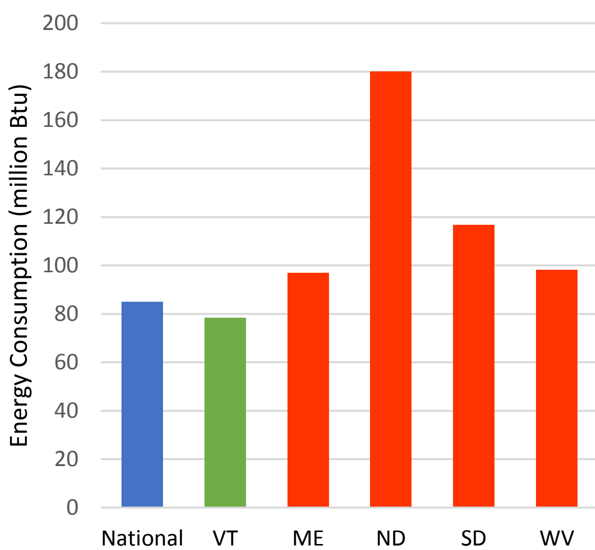

Figure 4-2. 2015 Per Capita Transportation Sector Energy Consumption (U.S. EIA, 2017)

Petroleum-based fuels accounted for well over 90% of the total energy used by the Vermont transportation sector in 2015. Including blended ethanol and biodiesel, gasoline and diesel accounted for 74.4% and 21.9% percent of Vermont's total transportation energy usage, respectively, while jet fuel accounted for an additional 3.1% (U.S. EIA, 2017). Nationally, ethanol and biodiesel account for approximately 5% of total transportation

VT TRANSPORTION FUEL CONSUMPTION

Overview: The transportation sector is responsible for 37% of total fuel consumption in Vermont, as shown in Figure 4-1. More than 90% of all of the energy used for transportation in Vermont is derived from petroleum fuels.

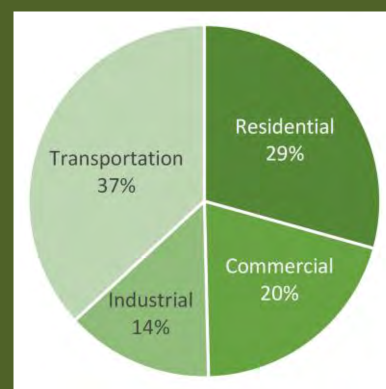

Figure 4-1. Vermont Sectoral Energy Consumption, 2015 (U.S. EIA, 2017)

Status of Alternative Fuel Sales: With the exception of ethanol, sales of alternative fuels are not well documented at the state level.

Growth in the number of PEV registrations and public PEV charging stations (up by more than 120% since the 2015 Profile) indicate a growing role for electricity as a transportation fuel.

Vermont Gas sales data show CNG use for transportation increased rapidly from 2010 to 2012 but has been relatively stable since then.

energy use (U.S. EIA, 2017b). It is likely that these fuels make up a slightly larger percentage of total energy use in Vermont since the state uses a comparatively low share of aviation fuel. The variety of fuels consumed, their shares of total transportation energy use, and historic consumption levels are presented in Section 4.1. Fuel use is a direct function of the types of vehicles operated and their levels of utilization.

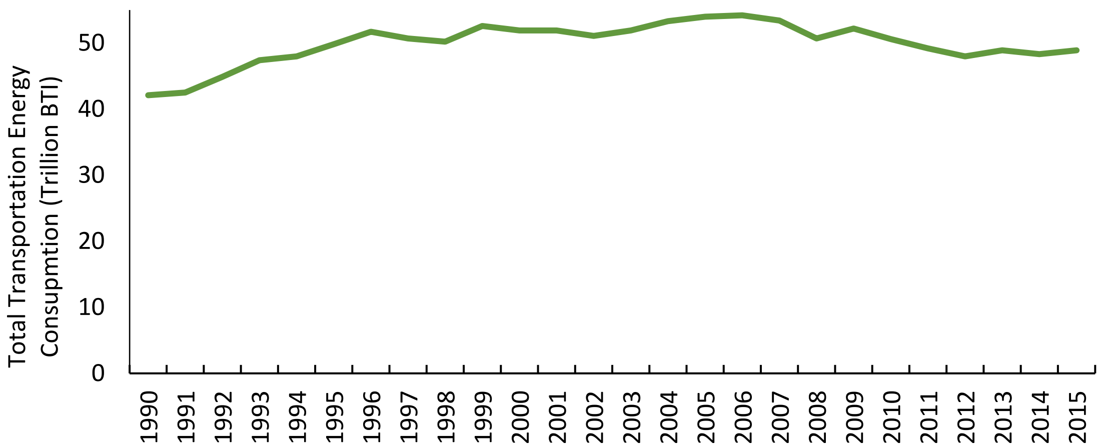

Figure 4-3. Total Vermont Transportation Energy Consumption, 1990 - 2015 (U.S. EIA, 2017)

4.1 Petroleum-Based Fuel Sales

As shown in Table 4-1, gasoline is the predominant petroleum-based fuel used for ground transportation in Vermont. Diesel constitutes an additional 16 – 18 % of ground transportation fuel sales, while compressed natural gas (CNG) represents a small fraction of the fuel mix. Mirroring VMT, gasoline sales fell steadily from 2011 through late 2014, as illustrated in Table 4-1 and Figure 4-4 before increasing in 2015 and 2016. Gasoline and diesel sales in Table 4-1 and Figure 4-4 include ethanol and biodiesel sold in blended form, as discussed in Section 0. CNG sales are discussed in more detail in Section 4.4. Sales of aviation fuels and natural gas for pipeline operations are not considered in this Profile.

Table 4-1. Fuels Sales for Ground Transportation in Vermont, 2011–2016

	2011	2012	2013	2014	2015	2016
Gasoline	328.3	320.1	318.1	309.4	319.8	315.7
Diesel	62.0	63.6	62.6	68.6	67.9	64.1
CNG	0.054	0.104	0.143	0.146	0.143	0.133

Note: Gasoline and diesel sales included blended ethanol and biodiesel and are reported in millions of gallons. CNG sales are report in millions of gallons of gasoline equivalent.
Sources: VT JFO 2017, Vermont Gas 2017

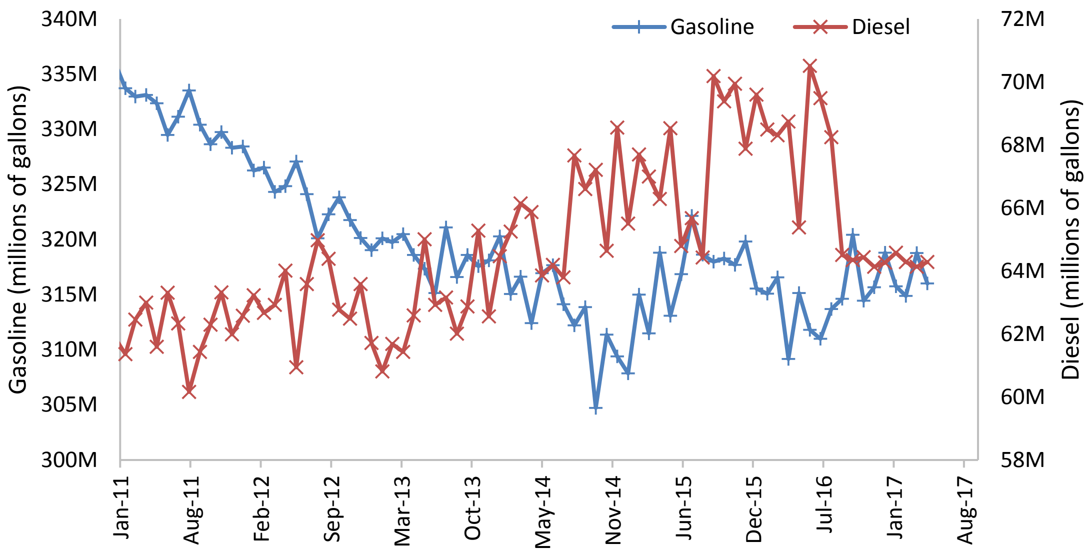

Figure 4-4. VT Gasoline and Diesel Sales, Rolling 12-Mo. Total, 2011 – 2017 (VT JFO, 2017)

4.2 Biofuels

The two primary transportation biofuels are ethanol and biodiesel. Commercially, ethanol is produced from sugars in organic materials such as corn and sugar cane. Research on the use of cellulosic feedstocks is on-going, but they are not yet widely commercialized. Biodiesel is chemically processed from either raw feedstocks (e.g. soybeans and rapeseed) or waste vegetable oil.

Ethanol sales are tracked at the federal level in order to ensure compliance with the National Renewable Fuel Standard (RFS) that was passed in 2007. It is sold primarily in blended gasolines. In 2015, approximately 28.7 million gallons of ethanol were consumed in Vermont (U.S. EIA, 2017) which is equal to just under 9% of "at the pump" gasoline sales.

Biodiesel production, though not state level biodiesel sales, is also tracked at the national level. Nationally, biodiesel accounted for approximately 3.3% of the volume of diesel fuel consumed by the transportation sector (U.S. EIA 2017b). As with ethanol, biodiesel is consumed predominantly in blended form. If the ratio of biodiesel to total diesel sold in Vermont matches that reported at the national level, this would equate to 2.2 million gallons of biodiesel sales in the state.

On an energy basis, 28.7 million gallons of ethanol and 2.2 million gallons of biodiesel provide 2.7 trillion Btus. This represents 5.5% of the total energy consumed by the transportation sector. As noted in the CEP, the environmental benefits of biofuels vary with fuel type, feedstock, and production methods (VDPS 2016). There are several social and environmental uncertainties associated with corn ethanol that are noted in the CEP. Nonetheless, as a result of federal policies promoting ethanol, ethanol currently accounts for nearly 90% of the biofuel energy consumed in the State.

4.3 Electricity

As discussed in Section 3, PEV registration has increased rapidly in recent years, though the absolute number of PEVs in the Vermont fleet remains small. PEVs can be charged at home outlets or at public charging stations. As of July 2017 there are a total of 156 public electric charging stations in Vermont, an increase of 86 charging stations since 2015. Of these stations, 11 are Level 1, 129 are Level 2, and 23 are DC Fast Charging.

There are currently no reporting requirements for either home-based or public charging, so directly tracking the total electricity used for vehicle charging is not possible. Electricity consumption can be estimated based on the number of registered PEVs, however, as shown in Table 4-2. Several assumptions must be made to make these calculations, including the distance that PEVs drive and their electric drive efficiency. For the Table 4-2, PEVs are assumed to be driven at the average VMT per vehicle for the state of Vermont. Average electric drive efficiency is calculated based on DOE estimates for electric drive efficiency for the vehicles listed in Table 3-3, weighted by number of vehicles registered in Vermont. PHEVs are assumed to travel 55% of the time on electric power (AFDC 2017). Based on these assumptions, total electricity demand can be estimated at 3.8 million kWhs for 2016. This equates to almost 13 billion Btus or approximately 0.03% of the direct transportation energy use in the state. Some fraction of this energy comes from renewable sources but it does not yet contribute significantly toward the CEP goal of increased renewable energy use.

Table 4-2. Estimated PEV Electricity Consumption in Vermont for 2016

EV Type	Register Vehicles (Dec 2016)	Average Annual Miles Driven	Average Miles Driven On Electricity	Average Electric Drive Efficiency (kWh/mi.)	Total Electricity Use (kWhs)
AEV	330	11,905	100%	0.313	1,228,688
PHEV	1,192	11,905	55%	0.329	2,567,290
				Total	3,795,978

The availability of public charging infrastructure is an important component of PEV adoption as access to charging away from the home increases the effective range of PEVs and reduces range anxiety. To illustrate the current levels of charging at publically accessible charging stations, Green Mountain Power and ChargePoint have voluntarily provided charging data through the Vermont Clean Cities Coalition. Detailed use data at several GMP locations are highlighted in Table 4-3 for the period of October 2016 – July 2017. (The start of the data collection period coincides with a switchover from Lite-On to SemaConnect charging stations.) Aggregate data for all GMP stations on the EVgo network, representing 92 ports, are provided in Table 4-4. Aggregate charging data for all 72 ChargePoint charging stations, representing 139 ports, are provided in Table 4-5. ChargePoint continues to provide the single largest network of public charging station in Vermont.

Table 4-3. Sample of Electricity Demand at Vermont PEV Charging Stations

	EV Station Location	Charge Events	Ports	Total Energy Usage (kwh)	Total Charge Time (hrs)	Mean Charge (kWh)	Mean Charge Time (Min)
Level 2 Charging	St. Michaels College, Winooski	115	1	191	235	1.7	120
	Healthy Living, S. Burlington	337	2	1,976	213	5.9	38
	City Hall, Montpelier	222	1	1,441	222	6.5	60
	VSECU, Montpelier	344	2	3,550	761	10.3	133
DC Fast	VSECU, Montpelier	279	1	2,256	126	8.1	27

Note: All level 2 charging data are for the period of Oct. 2016 – Jul. 2017. DC Fast charging data are for calendar 2016.
Sources: GMP, 2017.

Table 4-4. Aggregate electricity demand at GMP EVgo PEV charging stations in VT

Charging Station Type	Charging Episodes	Total Energy Usage (kWh)	Mean Charge (kWh)	Mean Charge Time (Min)
Level 2 (10/16-7/17)	3,168	25,943	8.19	148.8
DC Fast (2016)	920	8671	9.43	24.6

Source: GMP, 2017.

Table 4-5. Aggregate electricity demand at ChargePoint PEV charging stations in VT

Charging Station Type	Charging Episodes	Total Energy Usage (kWh)	Mean Charge (kWh)	Mean Charge Time (Min)
Level 1	190	578	3.06	1,219
Level 2	15,192	107,131	7.05	123
DC Fast	1,342	7,986	5.95	25

Source: ChargePoint, 2017.

4.4 Compressed and Liquefied Natural Gas

Utilization of natural gas as a transportation fuel is on the rise as can be seen in the monthly CNG sales shown in Figure 4-5. Overall CNG sales in 2016 totaled 169,575 gasoline-gallon equivalents. Growth in sales of CNG for transportation fuel increased dramatically between late 2010 and 2012 but has been comparatively stable since then. Liquefied Natural Gas (LNG) was introduced into the state fleet in 2015. LNG provides similar power as diesel, and because it has more energy per gallon, LNG enables vehicles to travel further on a tank than CNG.

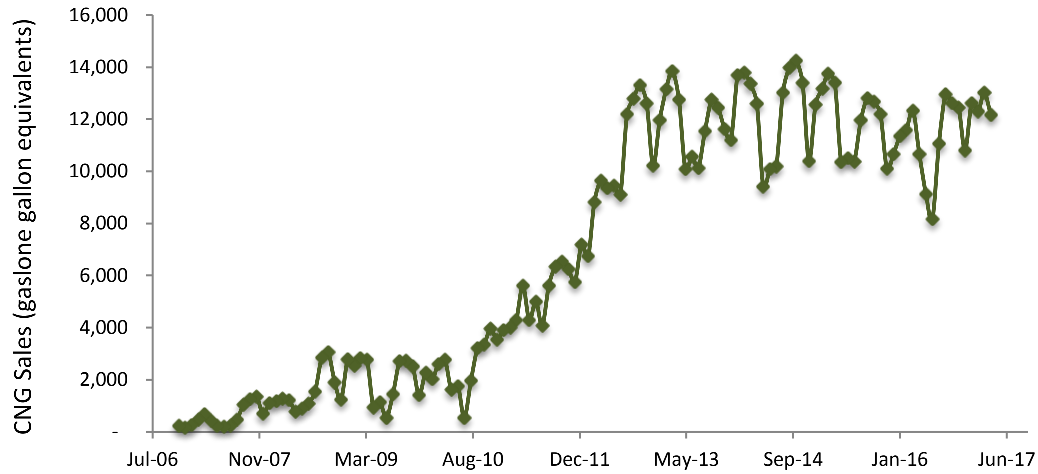

Figure 4-5. Monthly CNG for Transportation in Vermont, 2006–2017 (Vermont Gas, 2017)

The CNG fleet currently consists of five commercial fleets, made up primarily of heavy-duty vehicles and Honda Civics, the only factory-built passenger vehicle to run on CNG in the United States. The production of these vehicles ended in 2015. These fleets are served by four CNG filling stations, only one of which is public and all of which are located in Chittenden County. Omya is the only Vermont fleet utilizing LNG. Omya exclusively uses this fuel in their heavy-duty fleet operations.

Table 4-6. Vermont CNG Fleet

Fleet Operator	CNG Vehicles
University of Vermont	9 40-Ft. Buses
City of Burlington	3 Recycling Trucks 3 Honda Civics
Casella Waste Systems	9 Waste Trucks
Vermont Gas Systems	3 Honda Civics 6 Service Vans

Although lower tailpipe emissions 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, lower fuel economy relative to gasoline, and additional space requirements for on-board fuel storage systems.

5 Greenhouse Gas Emissions

Greenhouse Gas Emissions

Emissions Goals: The 2016 CEP calls for a 30% reduction in transportation sector GHGs relative to 1990 levels by 2025.

Drivers of Transportations Emissions: Three primary factors influence transportation sector GHG emissions: VMT, vehicle energy efficiency, and vehicle fuel type. Reducing VMT, increasing vehicle energy efficiency, and switching to low-carbon fuels (e.g. electricity generated by renewable sources) will all help to reduce GHG emissions.

Historical Trend: Transportation GHG emissions closely follow trends in VMT, peaking in the mid-2000s and declining from 2008 through 2011 and remaining relatively stable since then. As of 2013, transportation GHG emissions were between 11% (U.S. EPA, 2016a) and 14% (VT ANR, 2017) above 1990 levels.

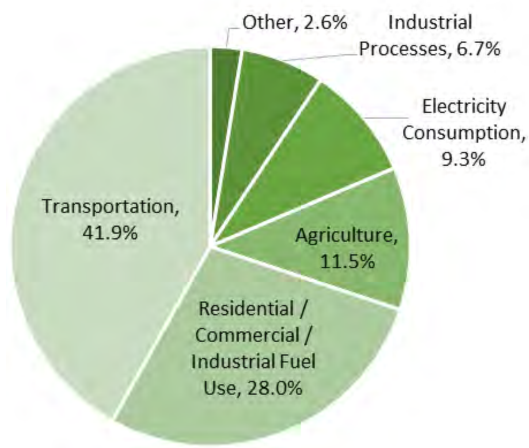

Figure 5-1. Vermont GHG Emissions by Sector, 2013 (VT ANR, 2017)

The transportation sector is the largest single source of GHG emissions in the state of Vermont as shown in Figure 5-1. These emission are largely the result of burning fossil fuels though a smaller portion are from biofuel combustion and PEV charging, as discussed in Sections 4.2 and 4.3. Three different transportation sector GHG emissions estimates are reported here.

The first emissions estimate is from the Vermont Greenhouse Gas Emissions Inventory produced by the Agency of Natural Resources (VT ANR, 2017). For the Inventory, transportation emissions are calculated using outputs from the EPA's Motor Vehicle Emissions Simulator, also known as MOVES. This "bottom up" approach simulates the GHG emissions, including methane and nitrous oxide, for vehicles registered in Vermont. MOVES accounts for a wide variety of factors that influence emissions including vehicle fuel and body type, vehicle age, vehicle speeds, and road types and is calibrated with both fuels sales and VMT data. MOVES is considered the state-of-the-art for mobile source emissions (U.S. EPA, 2016b). The transportation sector GHG emissions reported in the most recent edition of the state's GHG inventory are shown in Table 5-1.

The GHG estimate from ANR is supplemented by two "top down" emissions estimates that calculate GHG emissions based on fuels sales data. The U.S. EPA (U.S. EPA, 2016a) calculates CO_2 emissions by sector at the state level based on EIA fuel sales data. These emissions estimates are shown in Figure 5-2. Finally, GHG emissions estimates were calculated based on gasoline and diesel fuel sales data collected by the VT JFO and on the electricity demand estimates made in Section 4.3. This estimate breaks down emissions from ethanol and biodiesel separately using the sales volumes reported in Section 4.2 since these emissions come from biogenic sources. As noted previously and in the CEP, the net impact of biofuels atmospheric CO_2 is uncertain. Using the average GHG intensity of the New England grid, electricity related emissions were less than 1,500 metric tons for 2015 and thus are not visible on the figure. Both of these methods only calculate CO_2 emissions and do not include the impact of methane and nitrous oxide, which vary depending on vehicle technology and are approximately 1% of transportation emissions (U.S. EPA, 2016c).

All three GHG calculations show a similar trend – increasing emissions from 1990, a peak in emissions in the mid-2000s, followed by a period of slowly declining emissions. Emissions show an increase in 2015 and 2016 in Figure 5-3. This trend mirrors the pattern seen in the state's VMT and the Vermont Greenhouse Gas Emissions Inventory projects a similar emissions uptick (VT ANR, 2017).

Table 5-1 Transportation Sector GHG Emissions (MMTCO_2e)

Emissions Source	Year					
	1990	2000	2005	2011	2012	2013
On-road Gasoline	2.64	3.20	3.29	2.75	2.70	2.73
On-road Diesel	0.41	0.66	0.69	0.65	0.63	0.62
Jet Fuel & Aviation Gasoline	0.08	0.07	0.17	0.10	0.10	0.10
Rail/Ship/Boats/Other Non-road	0.09	0.06	0.05	0.18	0.22	0.22
Total	3.22	3.99	4.20	3.68	3.65	3.67

Source: VT ANR, 2017

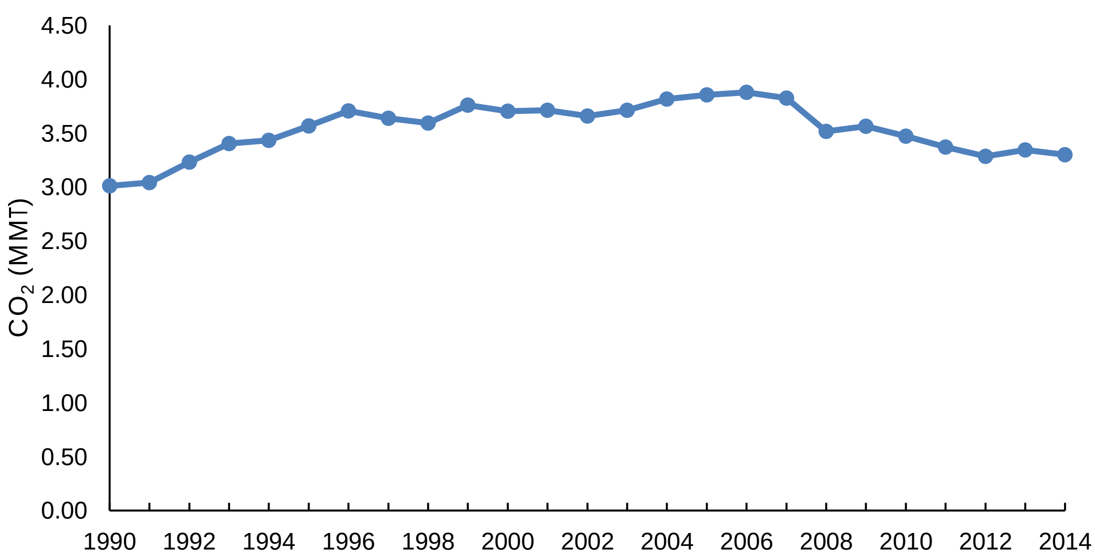

Figure 5-2. CO_2 Emissions: Transportation Sector Fossil Fuel Consumption (U.S. EPA, 2016a)

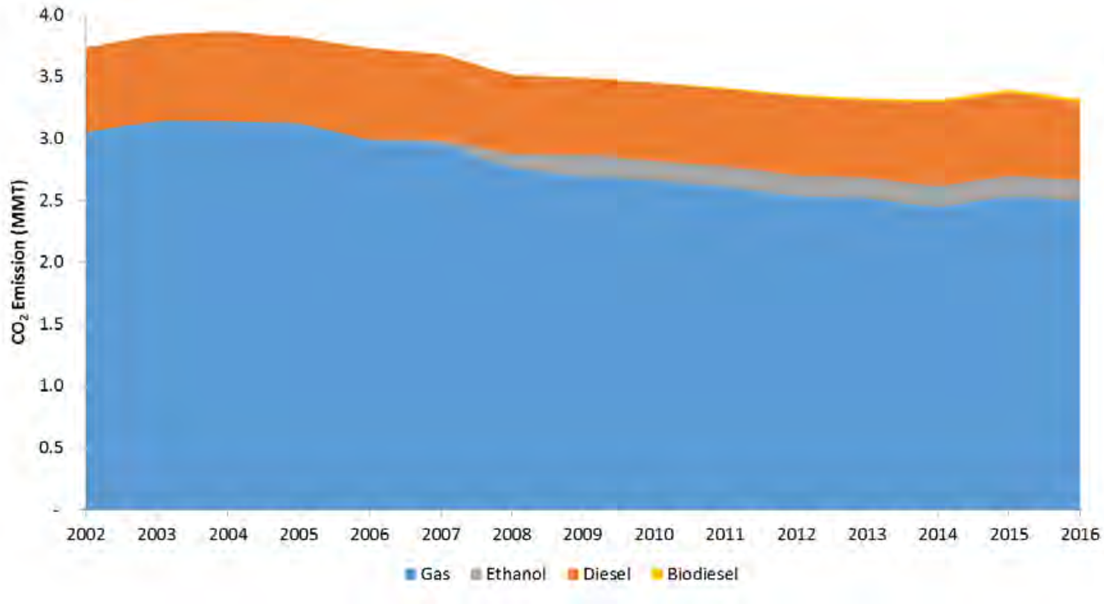

Figure 5-3. Vermont CO_2 Emissions from Gasoline and Diesel Sales

6 Freight Transport

Transporting goods and commodities to, from, within, and through Vermont is an essential component of the state economy and relies on the State's freight network. This network consists of the highway system, rail lines, airports, and pipelines. On average, the energy intensity of rail, 320 Btu per ton-mile, is less than a quarter of the energy intensity of truck transport, 1,390 Btu per ton-mile, (Grenzeback et al., 2013), though the specific energy intensity of each mode depends on a number of factors including utilization levels and the commodity being transported. For this reason, the CEP calls for doubling rail freight tonnage (Objective 7 in Table 1-1). As of 2014, rail was estimated to carry 7.3 million tons of freight in Vermont (ORNL, 2017; STB, 2017), an increase of 700,000 tons since 2011.

Collecting freight data is challenging given the proprietary nature of the movement of goods, and the quality of freight flow estimates varies considerably depending upon mode choice and type of commodity. The Freight Analysis Framework (FAF), produced by the Oak Ridge National Laboratory, is a primary source of freight information for Vermont and many other states. At the state level, FAF estimates freight movements that originate within, end within, or travel entirely within each state but does not provide estimates of pass-through freight traffic at this level (ORNL, 2017). The Surface Transportation Board's Carload Waybill Sample (STB, 2017) is the primary data source for pass-through tonnage for rail. The Carload Waybill Sample includes both public use data and a more detailed confidential sample that is considered the best source of rail data.

The freight data presented here are drawn from Version 4 of the FAF for 2014 and the 2014 public use waybill (ORNL, 2017; STB, 2017). The confidential waybill was used to estimate 2011 rail-freight tonnage in the Vermont State Rail Plan (VTrans, 2015) and reported in the 2015 Profile. The confidential waybill sample was not available for this version of the Profile and therefore rail tonnage is estimated based on the growth in rail transport in the FAF and the public waybill sample. Pipeline freight conveyance is not considered in the Profile.

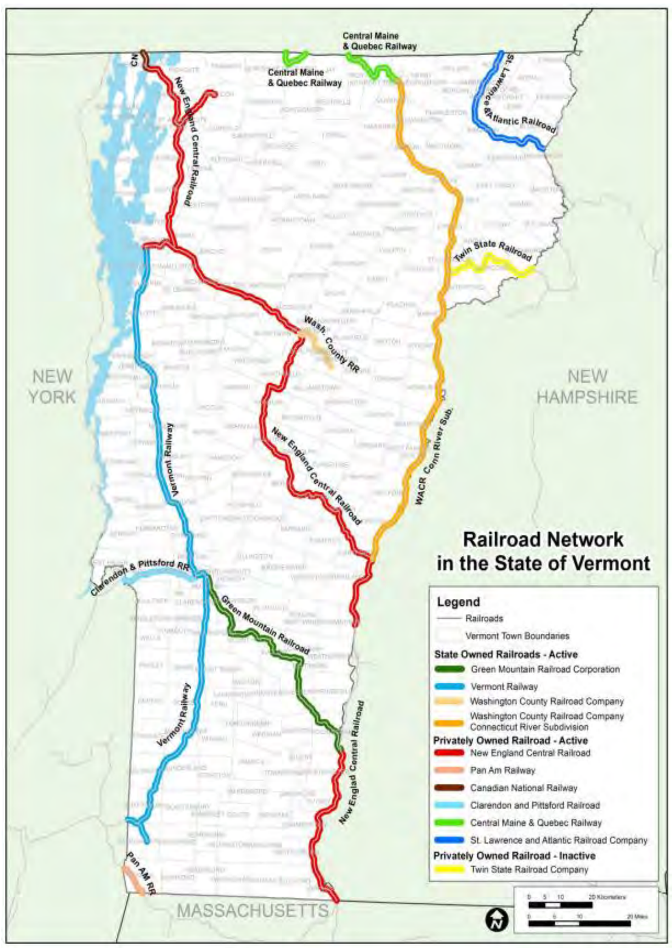

Figure 6-1. Vermont's **Rail Network (VTrans, 2015)**

6.1 Vermont Rail Freight Infrastructure

The state rail network consists of 578 total miles of rail bed, all of which is available for freight service and which is serviced by short line and regional railroads (VTrans, 2015). A map of the current rail system is shown in Figure 6-1.

6.2 Modal Flows

As of 2014, transport of 43 million tons of freight originated and/or terminated in Vermont. This volume includes inbound and outbound freight movements as well as all freight movements internal to the State. Freight that passed through Vermont and neither originated nor terminated in the State is not included in this number.

Trucking was the dominant mode of transport for freight originating or terminating in Vermont, accounting for 90% of the total freight tonnage transported. Rail accounted for 8% of all freight tonnage. Rails' share of outbound freight transport (23%) was considerably higher than its share of transport within the State or inbound (both under 4%). A complete modal breakdown of all freight movements in 2014 in thousands of tons is shown in Table 6-1.

Table 6-1. Freight Movement in Vermont by Mode, 2014

Mode	Intrastate	Inbound	Outbound	Total
Truck	19,577	11,625	7,640	38,842
Rail	674	547	2,379	3,600
Multiple Modes/Mail	186	255	246	688
Air	0	9	8	17
Other	5	9	72	86
Total	20,442	12,446	10,345	43,233

Note: All values in thousands of tons.
Source: ORNL, 2017

Total 2014 rail tonnage is estimated in Table 6-2. This estimate is derived by applying annual growth rates from the FAF and public waybill sample to 2011 baseline values developed from the confidential waybill sample for the 2015 Vermont State Rail Plan. Overall pass-through rail tonnage was assumed to increase at a rate equal to that shown in public waybill sample from 2011 to 2014, approximately 3.3% on an annual basis. Rail traffic originating and/or terminating in Vermont was assumed to increase by 2.2% per year based on the 2012 to 2014 increase FAF4 from 2012 to 2014. Based on these calculations overall 2014 rail tonnage is estimated at 7.3 million tons (ORNL, 2017; STB, 2017). This total represents an increase of 10% from the 2011 total. Note that the tonnage for intrastate, inbound, and out bound rail freight differs between Table 6-1 and Table 6-2 due to alternative estimates in FAF4 and the confidential waybill sample reported in the Vermont State Rail Plan, which are considered a more reliable estimate at the state level.

Table 6-2. Vermont Rail-Tonnage 2011 and 2014

	2011 Rail Tonnage	Annual Growth Rate	Estimated 2014 Rail Tonnage
Pass-through Tonnage	4.6 million	3.3%	5.1 million
Intrastate, Inbound & Outbound Tonnage	2.1 million	2.2%	2.2 million
Total	6.6 million		7.3 million

Note: 2011 components do not sum to total due to independent rounding
Source: VTrans, 2015; ORNL, 2017; STB, 2017

6.3 Future Freight Enhancements

Vermont's reliance upon trucking reflects an overall national trend as well as a lack of intermodal terminals to facilitate shipments of containers and trailers on flat car rolling stock. Standardized containers that can be exchanged between rail cars and flatbed trucks allow for a greater proportion of freight travel to be captured by non-highway modes. Currently, there are no intermodal facilities for making these types of container transfers along Vermont's relatively underutilized rail network, despite a significant proportion of Vermont's employment centers being located proximate to rail facilities. There are at least five transfer load facilities, but these only facilitate the transfer of bulk material or smaller shipment transfers from rail to truck, not container transfers (VTrans, 2015). Enhancement of Vermont's rail system—including "286" track upgrades to allow for heavier car loads and faster running speeds, removal of obstructions that limit access to double-stacked container cars, and development of intermodal facilities—will make rail more competitive with trucking and facilitate a shift to lower energy-intensity freight modes.

7 Progress toward 2016 CEP Transportation Targets

The 2016 CEP sets out three short-term transportation goals and nine supporting objectives with target dates in 2025 and 2030. The State's progress toward reaching each of these targets is assessed here. Since the three overarching goals were established in 2016 and most of the data used in this Profile are only available through 2015 (see Section 1.3), the State's progress toward these goals since their implementation cannot be measured in this Profile. Discussions of the trends leading up to 2016 are therefore provided for these three goals. The State's initial progress towards achieving these goals will be quantified in the next edition of the Profile.

In order to conduct this assessment, the change in each metric is compared to the average annual rate of change required to hit the CEP target. For example, the CEP calls for the state to add 2,284 park-and-ride parking spaces by 2030. In order to achieve this objective, the state must add an average of 120 spaces per year from 2011 through 2030. When the average number of new parking spaces is at or above 120 spaces per year, the state is on pace to meet the CEP target. When the average number of new parking spaces falls below this rate, the state is lagging behind the CEP target.

For many of these metrics, progress toward achieving the CEP objective is likely to lag in the early years due to the need for upfront investments and the slow pace of behavioral change. Metrics related to the vehicle fleet may be particularly slow to make progress given the long active life of cars and trucks. Thus cases where the state is currently lagging in achieving a particular objective should not be taken to mean that the objective cannot be achieved.

7.1 Goal 1: Reduce Total Transportation Energy Use

Goal: Reduce total transportation energy use by 20% from 2015 levels by 2025.

- Goal Set: 2016 CEP
- Period of Implementation: 2016 - 2025

Current Status: Data from 2016 and 2017 required for initial assessment.

- Transportation energy consumption totaled 49.1 trillion Btus in 2015 (the most recent year for which data are available) and will have to be reduced to 39.1 trillion Btus by 2025 to achieve this goal.
- Achieving this goal will require an average annual reduction in energy use of 1.09 trillion Btus from 2016 to 2025, assuming that 2016 energy use was equal to that in 2015.

Recent Trends: Since 1990, the State has not experienced more than three consecutive years with declining transportation energy use. Annual transportation energy use in Vermont peaked in 2007 and reached its lowest level in the 2000s in 2012 but has increased slightly since then.

Outlook: Realizing sustained reductions in energy use of close to one trillion Btus per year will require a combination of reducing VMT and reducing the energy used per mile traveled by switching to more efficient vehicles such as HEVs and PEVs. If VMT is held constant, fuel efficiency per mile traveled will have to increase by 25% to achieve this goal.

Data Sources: Sectoral energy consumption is tracked at the state level by the U.S. EIA as part of the State Energy Data System (SEDS).

7.2 Goal 2: Increase Renewable Energy Use in Transportation

Goal: Increase the share of renewable energy in all transportation to 10% by 2025.

- Goal Set: 2016 CEP
- Period of Implementation: 2016 - 2025

Current Status: Data from 2016 and 2017 required for initial assessment.

- Renewable energy in the form of ethanol and biodiesel account for 5.5% of the total transportation energy use in Vermont in 2015 (the most recent year for which data are available). Renewable electricity also contributes to the renewable energy used in the transportation sector but its contribution is currently less than 0.1%.
- Achieving this goal will require an average annual increase in renewable energy use of 0.5% of total transportation energy use from 2016 to 2025 assuming that renewable energy use in 2016 was equal to that in 2015.

Recent Trends: Consumption of blended ethanol has been essentially stable since 2011. Consumption of blended biodiesel has increased slightly in that time frame. Use of renewable electricity has also increased but remains a very small part of the transportation fuel portfolio.

Outlook: There is relatively little potential for growth in blended ethanol sales in the near future. Ethanol currently constitutes close to 10% of the at-the-pump gasoline sales in Vermont and the CEP does not support the promotion of E-85 infrastructure because of environmental concerns about ethanol production. Therefore, significant growth in biodiesel and especially renewable electricity use will be needed to achieve this goal.

Data Sources: Ethanol use is tracked at the state level by the U.S. EIA as part of the State Energy Data System (SEDS). Biodiesel use is tracked at the national level by the U.S. EIA as part of the Monthly Energy Review series. Electricity for vehicle charging is not tracked directly but can be estimated based on PEV registration data from the Vermont DMV.

7.3 Goal 3: Reduce Transportation GHG Emissions

Goal: Reduce transportation-emitted GHGs by 30% from 1990 levels by 2025.

- Goal Set: 2016 CEP
- Period of Implementation: 2016 - 2025

Current Status: Data from 2016 and 2017 required for initial assessment.

- As of 2013, transportation GHG emissions equaled 3.67 million metric tons CO_{2e}, 14% higher than baseline 1990 levels. Annual GHG emissions will have to be reduced to 2.58 million metric tons CO_{2e} by 2025 to achieve this goal.
- Achieving this goal will require an average annual decrease in GHG emissions of 0.16 million metric tons CO_{2e} per year from 2016 to 2025 (assuming that 2015 GHG emissions equal those in 2013).

Recent Trends: From 2011 through 2013 (the most recent years for which data are available) GHG emissions have varied by less than 0.05 million metric tons CO_{2e}. GHG emissions are closely tied to VMT, which has increased since 2013.

Outlook: Reducing GHG emission will require a combination of reducing VMT and reducing the GHG intensity per mile traveled by switching to vehicles with lower LCA GHG profiles such as HEVs and PEVs.

Data Sources: The Vermont Greenhouse Gas Inventory produced by the Agency of Natural Resources.

7.4 Objective 1: Per Capita VMT

Objective: Hold VMT per capita to 2011 base year value of 11,402.

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 11,402 VMT per capita
- 2015 Value: 11,680 VMT per capita

Achieving the CEP target will require stable per capita VMT from 2011 through 2030. Per capita VMT increased modestly from 2011 to 2015.

Data Sources: VMT collected by VTrans as part of the Highway Performance Monitoring System; USCB population estimates.

7.5 Objective 2: Reduce SOV Commute Trips

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

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 79.2%
- 2015 Value: 80.7%

Achieving the CEP target will require an average decrease in SOV commute share of 1.1% per year from 2011 through 2030. SOV commute share increased from 2011 through 2015.

Data Sources: American Community Survey.

7.6 Objective 3: Increase Bike/Ped Commute Trips

Objective: Double the share of bicycle/pedestrian commute trips to 15.6% by 2030.

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 7.6%
- 2015 Value: 7.1%

Achieving the CEP target will require an average increase in bicycle/pedestrian commute share of 0.4% per year from 2011 through 2030. Bicycle/pedestrian commute share fell by 0.5% between 2011 and 2015.

Data Sources: American Community Survey.

7.7 Objective 4: Increase State Park-and-Ride Spaces

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

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 1,142 spaces
- 2017 Value: 1,525 spaces

Achieving this target will require an average annual increase of 120 spaces per year. From 2011 to 2017 state park-and-ride space increased by an average of 64 spaces per year.

Data Source: VTrans Municipal Assistance Bureau.

7.8 Objective 5: Increase Transit Trips

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

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 4.58 million rides
- 2016 Value: 4.71 million rides

Achieving the CEP target will require an average annual increase of 238,500 riders per year. From FY 2011 to FY 2016, transit ridership increased by an average of approximately 26,000 riders per year.

Data Source: VTrans Public Transit Route Performance Reviews.

7.9 Objective 6: Increase Passenger Rail Trips

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

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 91,942 boardings and alightments.
- 2016 Value: 92,422 boardings and alightments.

Achieving the CEP target will require an average annual increase of 6,000 boardings and alightments per year. In FY 2016, 92,422 boardings and alightments took place at Vermont rail stations, representing an average increase of only 96 per year since FY 2011.

Note: Passenger rail ridership is measured as the *combined* boardings and alightments at Vermont Amtrak stations. This is consistent with the CEP objective but counts trips that begin and end at Vermont stations twice, so should not be equated with the *number* of rail trips in Vermont.

Data Source: VTrans.

7.10 Objective 7: Increase Rail-Based Freight

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

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Current Status: Progress lagging target.

- 2011 Baseline: 6.6 million tons.
- 2014 Value: 7.3 million tons.

Achieving the CEP target will require an average annual increase of 0.35 million tons per year from 2011 through 2030. Between 2011 and 2014 rail freight tonnage is estimated to have increased by 0.23 million tons per year.

Data Source: ORNL, 2017; STB, 2017.

7.11 Objective 8: Increase Registration of Electric Vehicles

Objective: Increase the number of electric vehicles registered in Vermont to 10% of the fleet by 2025.

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2025

Status: Progress lagging target

- 2011 Baseline: PEVs constituted 0.0% of Vermont vehicle fleet
- 2016 Value: PEVs constituted 0.3% of Vermont vehicle fleet

Achieving the CEP target will require an average annual increase average annual increase in PEV registrations of 0.7% of the vehicle fleet from 2011 through 2025. Between December 2011 and December 2016, PEVs registrations increased by an average of 0.05% of the Vermont vehicle fleet per year.

7.12 Objective 9: Increase Renewable Fuel Use in Heavy-Duty Fleets

Objective: Increase the number of heavy duty vehicles that are renewably powered to 10% by 2025.

- Objective Set: 2011 CEP
- Period of Implementation: 2011 - 2030

Status: Additional data required to evaluate this objective.

This objective is challenging to measure since a diesel vehicle can drive on 100% biodiesel, 100% conventional diesel, or a mixture of the two. Therefore, it is infeasible to track this metric without tracking biodiesel sales. Electrification of the bus and truck fleet may also help achieve this goal and could be tracked in future Profiles.

8 Recommendations for Metrics, Data, and Modeling

This section contains a set of recommendations for the State that will improve its ability to track progress toward the CEP targets. These recommendations have been compiled according to the following categories:

- Expanding/improving data collection for existing metrics.
- Recommended additional metrics.
- New data needed.
- Improved and new modeling needed.

In addition, future editions of the CEP may benefit from revisions to some transportation targets. For the renewable energy objective, the desired role of ethanol should be clarified. Ethanol is the largest single source of renewable energy in the transportation sector in Vermont but there are numerous concerns about the environmental impact of ethanol produced using corn. Ethanol made from cellulose (e.g. corn stover, wood chips, and miscanthus) and algae may have a better environmental profile but production of these fuels has not yet been widely commercialized. Switching to a single target dates for both the transportation goals and all of the transportation objectives would also improve the clarity of these targets.

8.1 Expanding/Improving Data Collection for Existing Metrics

- Expanding objectives 3–5 to consider mode share for all trip types, as opposed to the mode share for commute trips only, would increase the impact of shifting from SOV to carpool or active transportation trips. Tracking mode share across all trips would require regular collection of state-level mode data from a comprehensive travel survey.

- Improvements in 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 each vehicle that is registered, but the coding of this class parameter and other variables has been inconsistent. Improved coding of the vehicle class to more accurately identify diesel, CNG, and electric vehicles would result in more accurate data for the Profile.

8.2 Additional Metrics Recommended

- **In-Use MPG**: Tracking *In-Use MPG*, as opposed to *EPA sticker MPG*, would provide a more accurate measure of fleet-wide fuel economy. The Energy Information Administration (EIA) has developed and implemented an In-Use MPG estimate for vehicle fleets in the NHTS (U.S. EIA, 2011). In-Use MPG is imputed in two steps. First, the commonly reported EPA *Composite MPG* of each vehicle is adjusted based upon on-road testing to yield an *On-Road MPG*. The 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.

The adjustment process 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.

- **Transit Energy-Intensity**: Tracking the energy intensity of transit services on a Btu-per-passenger-mile basis using actual use data from Vermont's transit authorities is recommended to provide a clearer picture of transit's contribution to reducing transportation energy use.
- **Park-and-Ride Space Utilization**: Measuring and tracking the occupancy of spaces at each park-and-ride is recommended to provide a better measure of the utility of park-and-ride facilities.
- **New Development Density**: Tracking the density of new development will be necessary to track progress against the strategy related to transit-supportive development in the CEP. Measuring the total area of transit-supportive zones (see Belz et. al., 2010) that fall within Census urban areas would be one method of tracking the impact of new development of density.

8.3 New Data Needed

- In order 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 these 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.
- 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.
- In order to effectively track progress on park-and-ride utilization, it is necessary to improve the tracking of the specific number of parking spaces available at each lot. 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.

8.4 Improved Modeling Needed

- A model that connects the actual make and model of each vehicle in Vermont from the DMV registration data with its use (in miles) in the current year will improve upon the current estimate of statewide fleet fuel efficiency that does not account for the annual mileage of each vehicle. 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 quantification of 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 energy intensity for transit buses 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 traveled in Vermont.
- The displacement of privately owned vehicle miles of travel by 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.

9 Conclusions

The 2016 CEP sets forth an energy vision that requires rapid changes in transportation energy use patterns relative to trends in the recent past. This includes reducing total transportation energy use by 20% from 2015 levels and reducing GHG emissions by 30% from 1990 levels by 2025. Achieving this ambitious vision will require a combination of reducing VMT and reducing the energy used – and GHGs emitted – per mile traveled. Reducing VMT can be achieved by increasing vehicle occupancy and by shifting passenger vehicle trips to rail, transit, walking, and biking trips. Reducing energy use per mile traveled can be achieved by increasing the fuel economy of the vehicle fleet. Increasing vehicle electrification is one important avenue for improving fuel economy and reducing GHG intensity per mile traveled. PEVs offer significant energy and GHG savings relative to ICEV vehicles and are available in an increasing range of vehicle body types, electric ranges, and price points. The CEP provides targets related to many of these strategies. To date, however, the State is lagging behind the rate of change required to achieve each of the targets evaluated in this Profile.

Current progress toward the CEP targets suggests that additional policy initiatives may be needed. As laid out in the CEP, a variety of policy tools are available to accelerate progress toward these targets. These tools include strategic investments in needed infrastructure (e.g. supporting the deployment of PEV charging facilities and road infrastructure that supports safe walking and biking), public outreach/information sharing (e.g. the *GoVermont* program, partnerships with *Drive Electric Vermont*, the Vermont *Clean Cities Coalition,* and other groups), regulatory mechanisms (e.g. development standards that support smart growth), and market mechanisms (e.g. PEV purchase rebates). Given the rapid changes envisioned in the CEP, policy changes that would promote behavior change in the near-term may be highly desirable.

Two areas of additional research may be helpful in this process. The first area of research is to evaluate the efficacy of each of the nine supporting objectives toward achieving the three overarching transportation goals (e.g. what are the relative impacts of increasing transit ridership and increasing PEV registration on total energy use?). The second area of research is to determine what policy levers can be used to achieve these objectives most effectively (e.g. are vehicle pricing incentives or improved charging infrastructure more effective at increasing PEV sales?). Greater understanding of these issues can support more effective strategies for achieving CEP targets.

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