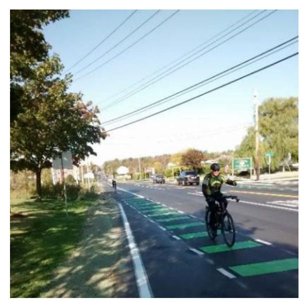
VERMONT
AGENCY OF TRANSPORTATION

Vermont Transportation Energy Profile 2021



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Disclaimer

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

Table of Contents

List of Tables

List of Figures

Executive Summary

Slightly more than one-third of the total energy consumed in Vermont is used for transportation (see Figure E-1). Transportation energy is overwhelmingly derived from fossil fuels, with over 95% coming in the form of gasoline and diesel fuel. Transportation is also the largest source of greenhouse gas (GHG) emissions in the State, accounting for 39.1% GHGs in 2017.

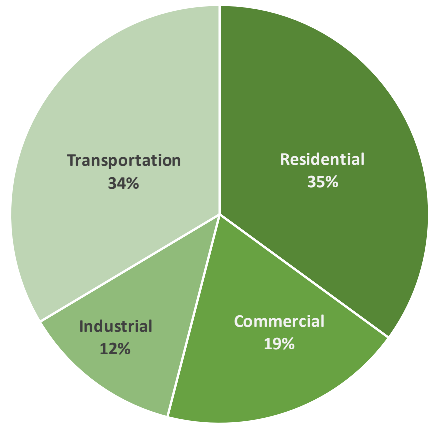


Figure E-1.Vermont Sectoral Energy Consumption, 2019 (U.S. EIA, 2021)

Consequently, the 2016 Vermont Comprehensive Energy Plan (CEP) included three goals and nine supporting objectives related to reducing transportation sector energy consumption and GHG emissions (VDPS, 2016). The 2021 Vermont Transportation Energy Profile ("the Profile") is the fifth installment of a biannual reporting series that evaluates the State's progress toward achieving these transportation sector targets.

Near-term CEP transportation targets are presented in Table E-1. In order to assess the State's progress toward achieving these targets, the recent trend in each metric was extrapolated out to the target date and compared to the CEP goal for that date.[1] When the extrapolated value did not meet the CEP target, the State's progress was assessed as lagging behind the CEP target. For example, the CEP calls for the State to reduce transportation energy use from 48.3 trillion Btu to 38.6 trillion Btu by 2025. Extrapolating from the last five years of data, however, demonstrates that if current trends continue transportation energy consumption will total 40.7 trillion Btu in 2025, and thus that energy reductions are currently lagging 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, the fact that the State is not currently on pace to achieve a particular goal or objective does not mean that the target cannot be achieved. Additionally, some (but not all) of the metrics shown reflect data collected after the spring of 2020, when the COVID-19 pandemic resulted in lockdowns and dramatic changes in travel behavior in Vermont and around the world. There is considerable uncertainty about how these changes will impact travel behavior going forward so caution should be used when interpreting recent trends.

Overall, Vermont's progress lags CEP targets across the board. Vermont's ability to achieve the CEP goals would be strengthened by rigorous data collection and policy-

[1] Current trends are calculated based on the last five years of data using a least squares, linear fitting process. This method finds the straight line which minimizes the sum of the squared residuals between the line and the empirical data points.

oriented research to inform the design of effective and equitable strategies to achieve CEP goals.

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

	2016 CEP Transportation Targets	Baseline		Most Recent		Target Value	Projected Value
		Value	Year	Value	Year		
Goals for 2025	1. Reduce energy use by 20%	48.3	2015	46.3	2019	38.6	40.7
	2. Increase the share of renewable energy to 10%	5.5%	2015	6.1%	2019	10%	7.0%
	3. Reduce GHGs emissions by 30% from 1990 levels	3.32	1990	3.43	2018	2.32	3.48
Supporting Objectives for 2025 and 2030	1. Hold VMT/capita stable	11,390	2011	11,772	2019	11,390	11,892
	2. Reduce the share of SOV commute trips by 20%	74.1%	2011	75.9%	2019	59.3%	77.2%
	3. Double the share of bicycle/ pedestrian commute trips	6.7%	2011	6.9%	2019	13.4%	6.2%
	4. Increase state park-and-rides spaces to 3,426	1,140	2011	1,734	2021	3,426	2,274
	5. Increase annual transit ridership to 8.7 million trips	4.58	2011	4.16	2020	8.70	3.87[1]
	6. Increase annual Vermont-based passenger-rail trips to 400,000	91.9k	2011	45.4k	2020	400.0k	0.0k[1]
	7. Double the rail-freight tonnage in the state	6.6	2011	6.9	2018	13.2	7.4
	8. Increase electric vehicle registrations to 10% of fleet[2]	0.0%	2011	0.70%	2020	10%	1.3%
	9. Increase renewably powered heavy duty vehicles to 10% of fleet	This objective is challenging to measure as vehicle specifications provide only limited insight into the energy sources that a vehicle uses. A heavy-duty diesel vehicle, for example, may operate using different biodiesel blends at different times depending on factors such as cost and availability. Biodiesel currently supplies just over 3% of total diesel energy used in Vermont.					

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

1. Transit and rail ridership projections include 2020 data, which was significantly affected by the COVID-19 pandemic. Projecting these values in an alternative scenario where 2020 and 2021 ridership remained at 2019 levels, yields projections of 5.2 million transit trips and 67.7k passenger rail trips in 2030.

2. Electric vehicle fleet penetration calculated as a share of all vehicles registered in Vermont, including publicly owned and heavy-duty vehicles.

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 January 2021, 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. By statute, the Department of Public Service must update the CEP by January 15 every six years.

CNG: Compressed Natural Gas – An alternative fuel currently used primarily in a small number of 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 landfills 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} expresses 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, also referred to as conventional hybrids. 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 a small number of heavy-duty fleets in Vermont. Liquefied natural gas is cooled until it reaches a liquid state to 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 landfills 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 (PHEVs), which use a combination of gasoline and electricity, and all-electric vehicles (AEVs), 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 January 2021, the Toyota Prius Prime is the most common PHEV in Vermont.

NHTS: National Household Travel Survey – A national survey conducted periodically (generally every 6 – 8 years) by the U.S. Department of Transportation. The most recent NHTS was completed in 2017. Unlike the 2009 NHTS, the 2017 NHTS sample size in Vermont was not large enough to make state-level estimates of travel behavior in Vermont. Data for New England are provided for the 2009 and 2017 NHTS for indications of trends that may be occurring in Vermont. States can purchase larger NHTS samples to facilitate transportation research and planning.

RFS: Renewable Fuel Standard – A federal 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 that include passengers. Reducing SOV trips is one strategy for reducing VMT and transportation sector energy consumption.

TDM: Transportation Demand Management – a suite of strategies to increase travelers' choices and reduce VMT. These strategies can include promoting and investing in public transit, rail, bicycle and pedestrian travel, ridesharing and carsharing, carpooling, and telecommuting. They can also include changes in land use planning to encourage the use of non-SOV transportation options and reductions in the distances that people need to travel to meet their needs.

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.

1 Introduction

The transportation sector is vital to the physical, social, and economic well-being of Vermonters, but it is also responsible for 34% of the total energy consumed in the State (U.S. EIA, 2021) and 39% of total greenhouse gas (GHG) emissions (VT ANR, 2021). The 2021 Vermont Transportation Energy Profile ("the Profile"), the fifth edition of this biannual reporting series, documents a wide range of data and trends related to transportation energy consumption and GHG emissions. The Profile is intended to inform transportation-related policy-making and to directly track the State's progress toward achieving the transportation sector goals and objectives articulated in the State's 2016 Comprehensive Energy Plan (CEP).

The 2016 CEP was a multi-agency effort led by the Vermont 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.[2] 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 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 teleworking.

Smart Land Use

- Maintain historical settlement patterns, emphasizing compact centers.

The CEP also provided nine supporting objectives for these goals. As shown in Table 1-1, these objectives relate to controlling the increase in vehicle miles traveled (VMT)—an estimate of the total on-road distance driven by all vehicles in Vermont, increasing the percentage of trips taken using lower-energy-intensity travel modes such as walking and public transit, and increasing renewable fuel usage for vehicle trips.

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

Table 1-1. 2016 CEP Supporting Transportation Objectives

Control Vehicle Miles Traveled:

1. Hold per capita VMT to 2011 levels.

Increase the Share of non-SOV Travel Modes:

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-ride 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 the Use of Electricity and Renewable Fuels:

8. Increase the number of electric vehicles registered in Vermont to 10% of the fleet by 2025.[3]
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. Overall conclusions are provided in Section 8.

1.1 Vermont in Context

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. The same set of comparison states have been used since the 2015 edition of the Profile to provide a consistent basis for comparison.

[3] Throughout the Profile, "the fleet" is assumed to refer to all on-road vehicles registered in Vermont unless specifically indicated otherwise. Thus achieving this objective would require that the number of electric vehicles registered in Vermont equal 10% of all on-road vehicle registrations by 2025.

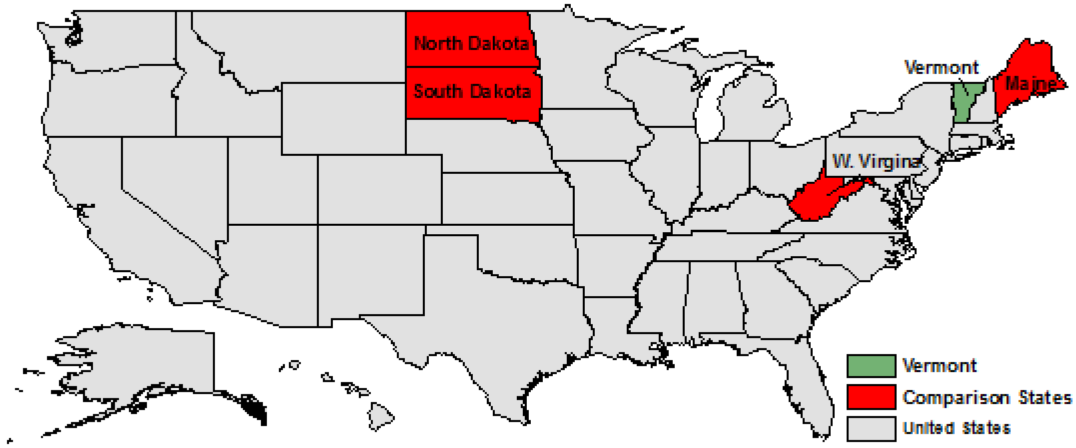


Figure 1-1. Vermont and Comparison States

1.2 COVID-19 Impacts on Travel in Vermont

In the spring of 2020, the COVID-19 pandemic resulted in lockdowns and reduced out-of-home activity in Vermont and around the world. The pandemic dramatically impacted travel behavior, with many changes persisting through the date of the publication of the 2021 Profile, and there is considerable uncertainty about how these changes will impact travel behavior going forward. The data included in the Profile come from a range of sources, some of which lag the Profile by up to three years. Since travel behaviors have historically changed relatively slowly, data that is two to three years old has generally been relatively representative of current travel behavior. Given the dramatic shifts brought about by the COVID-19 pandemic, data from 2019 is unlikely to accurately reflect travel behavior and energy use in 2020 and 2021. Whenever possible, the 2021 edition of the Profile provides early insights into some of the effects of the pandemic on travel in several key indicators.

Overall the pandemic resulted in a relatively brief period of significantly reduced motorized travel. Early data indicate that Vermont saw a substantial reduction in vehicle travel during spring and summer 2020 (Figure 2-3 and Figure 2-4) resulting in a drop in fuel sales of approximately 15% in 2020 relative to 2019 (Table 4-1), as well as a reduction in the share of fuel sold to out-of-state travelers in 2020 (Section 2.1.) Bus ridership in Vermont declined in 2020 (Table 2-11) while Amtrak ridership dropped substantially as service was suspended from March of 2020 until July of 2021 (Figure 2-15). These reductions in transit ridership reflect ridership declines seen across the US and in neighboring states (Figure 2-14). These changes likely occurred at least in part due to the substantial increase in telecommuting that occurred during the COVID-19 pandemic, as discussed in Section 2.2.1.

Bicycling and walking for recreation in Vermont may have increased during the pandemic as people sought outdoor activities and open-air social opportunities. Non-motorized travel may have also increased for those who would normally ride transit to travel relatively short distances. Although systematic data on non-motorized travel across the state is unavailable at this time, changes in bicycle and walk commute modes may be reflected in data from the US Census in a future edition of the Profile.

The extent to which pandemic-related travel trends will persist in the future is unknown. From March 2021 through June 2021 – the most recent data available –

US vehicle travel has rebounded and may be exceeding pre-pandemic levels (BTS, 2021a), as has the rate of trips made in Vermont (Figure 2-4). However, US transit ridership declines have been slower to recover (Figure 2-14) and fuel sales remain below 2019 levels (Figure 4-4).

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: 2019
- Highway Statistics Series, Federal Highway Administration (FHWA)
    - Data Collection Cycle: Annual
    - Most Recent Data Available: 2019
- National Household Travel Survey (NHTS), FHWA
    - Data Collection Cycle: Six- to eight-years
    - Most Recent Data Available: 2017
- State Energy Data System, U.S. Energy Information Administration (EIA)
    - Data Collection Cycle: Annual
    - Most Recent Data Available: 2019
- Vermont Department of Motor Vehicles (VDMV) licensing/vehicle registration
    - Data Collection Cycle: Annual
    - Most Recent Data Available: 2021
- Vermont Greenhouse Gas Emissions Inventory, Agency of Natural Resources (ANR)
    - Data Collection Cycle: Annual
    - Most Recent Data Available:2018
- Vermont Legislative Joint Fiscal Office (JFO) gasoline/diesel sales
    - Data Collection Cycle: Monthly
    - Most Recent Data Available: July 2021
- VTrans Public Transit Route Performance Reviews
    - Data Collection Cycle: Annual
    - Most Recent Data Available: State Fiscal Year (SFY) 2020

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 the 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, the Chittenden County Regional Planning Committee (CCRPC), and the University of Vermont purchased an "add-on" sample that 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 2017 NHTS. Consequently, the 2017 NHTS sample size in Vermont was not large enough to make state-level estimates of travel behavior in Vermont. Data for New England are provided for the 2009 and 2017 NHTS for indications of trends that may be occurring in Vermont. 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. In 2020, FHWA launched the Next-Generation National Household Travel Survey (NextGen NHTS) that combines a smaller traditional travel survey with passive data collection to enable more frequent data collection and dissemination. Purchasing a Vermont add-on to NextGen NHTS would improve the ability of research and policy makers to track changes in Vermont travel behavior and craft more effective policies for achieving the State's energy and GHG goals.

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 over 90% of all commute trips in the State. Despite efforts to reduce VMT, per capita VMT in Vermont is above the national average and has increased by 4% since 2014.

2.1 Vehicle Miles Traveled

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. When seeking VMT reductions, decision-makers often look to transportation demand management (TDM), which is a suite of approaches to increasing travelers' options. TDM strategies can include promoting and investing in alternatives to SOV travel, including transit, rail, bicycle and pedestrian travel, ridesharing, carsharing, carpooling, and telecommuting. TDM can also include changes to land use planning that allow people to travel shorter distances and use transit and active travel modes. Vermont has adopted several TDM strategies at local and state levels, including investing in bicycle and pedestrian infrastructure, transit service, and programs that incentivize non-SOV travel.

Reducing VMT has proven to be challenging in Vermont, as it has in other parts of the US. After climbing

VEHICLE MILES TRAVELED (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: After a low in 2014, Vermont's VMT increased to a high in 2017, followed by a period of relative stability through 2019. Vermont's per capita VMT is higher than the national and rural comparison state averages. The upward movement in VMT since 2014 likely reflects improved economic conditions and lower gas prices. These data do not yet reflect pandemic-related travel disruptions.

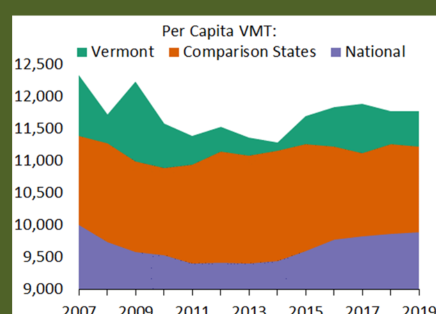


Figure 2-1. Trends in Per Capita VMT (FHWA, 2008–2020; USCB, 2021a)

Reducing VMT: Transportation demand management (TDM) is a suite of strategies that aim to reduce VMT by increasing travelers' options.

steadily through the mid-2000s, VMT declined for several years at both the state and national level beginning in 2010 (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 have been relatively stable from 2015 through 2019, peaking in 2017. Economic activity and gasoline prices can (in part) drive changes in VMT, and are discussed more in Section 2.1.1. 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 and the use of car-sharing and ride-hailing services may also impact VMT and are discussed in Sections 2.1.2 and 0. Travel from March 2020 through the present has also been affected by the COVID-19. These changes are reflected throughout this chapter where data from 2020 onward is available, and are also highlighted in Figure 2-3, Figure 2-4, and Figure 2-14.

Table 2-1. Total and Per Capita VMT, 2007–2019

Year	Total VMT (Billions)			VMT/Capita		
	Vermont	Comparison States	National[1]	Vermont	Comparison States	National[1]
2007	7.69	52.45	3,050	12,340	11,388	10,001
2008	7.31	52.14	2,996	11,715	11,267	9,731
2009	7.65	51.09	2,976	12,237	10,988	9,584
2010	7.25	50.88	2,985	11,580	10,889	9,536
2011	7.14	51.34	2,965	11,390	10,941	9,404
2012	7.22	52.62	2,987	11,525	11,150	9,409
2013	7.12	52.58	3,007	11,363	11,078	9,407
2014	7.06	53.16	3,040	11,291	11,151	9,444
2015	7.31	53.82	3,110	11,698	11,262	9,592
2016	7.38	53.62	3,189	11,837	11,219	9,768
2017	7.42	53.17	3,227	11,888	11,122	9,825
2018	7.35	53.81	3,255	11,766	11,256	9,868
2019	7.35	53.70	3,276	11,772	11,226	9,886

[1] National total includes 50 US states and Puerto Rico.
Source: FHWA, 2008 - 2020

Since 2014, total and per capita VMT in Vermont has increased by 4.1% and 4.3%, respectively. Over this same period, at the national level, total VMT increased by 7.8% and per capita VMT by 4.7%. In the four comparison states (ME, ND, SD, and WV), total VMT increased by 1.0% and per capita VMT increased by 0.7%. 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 13th highest among all states in terms of per capita VMT in 2019, the most recent year for which national VMT data are available. As reported in the four previous editions of the Profile, Vermont ranked 10th in per capita VMT in 2011 and 2013, 11th in 2015, and 13th in 2017.

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. Using non-SOV travel modes such as public transit and active travel modes can be more challenging in many rural communities. 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. An analysis by the Vermont Agency of Commerce and Community Development of credit card receipt data provided by VisaVue calculated that just over 18% of gasoline sales paid for with a Visa card in 2020 and the first half of 2021 were made by accounts tied to an out of state "home" location as determined by VisaVue (Jones, 2021), in contrast to an estimated 25% in 2018 (Jones, 2019). While these data do not include cash sales or sales with other cards, they may be indicative of the overall magnitude of traffic originating out of state. They also indicate a reduction in out-of-state traffic coming to Vermont during the pandemic.

Vermont's predominantly rural land use is reflected in the proportion of the State's total roadway miles in rural and urban areas, 89.5% and 10.5%, respectively (see Table 2-2). VMT on urban roads accounts for nearly 29% of total VMT, more than 2.5 times the share of urban road miles.

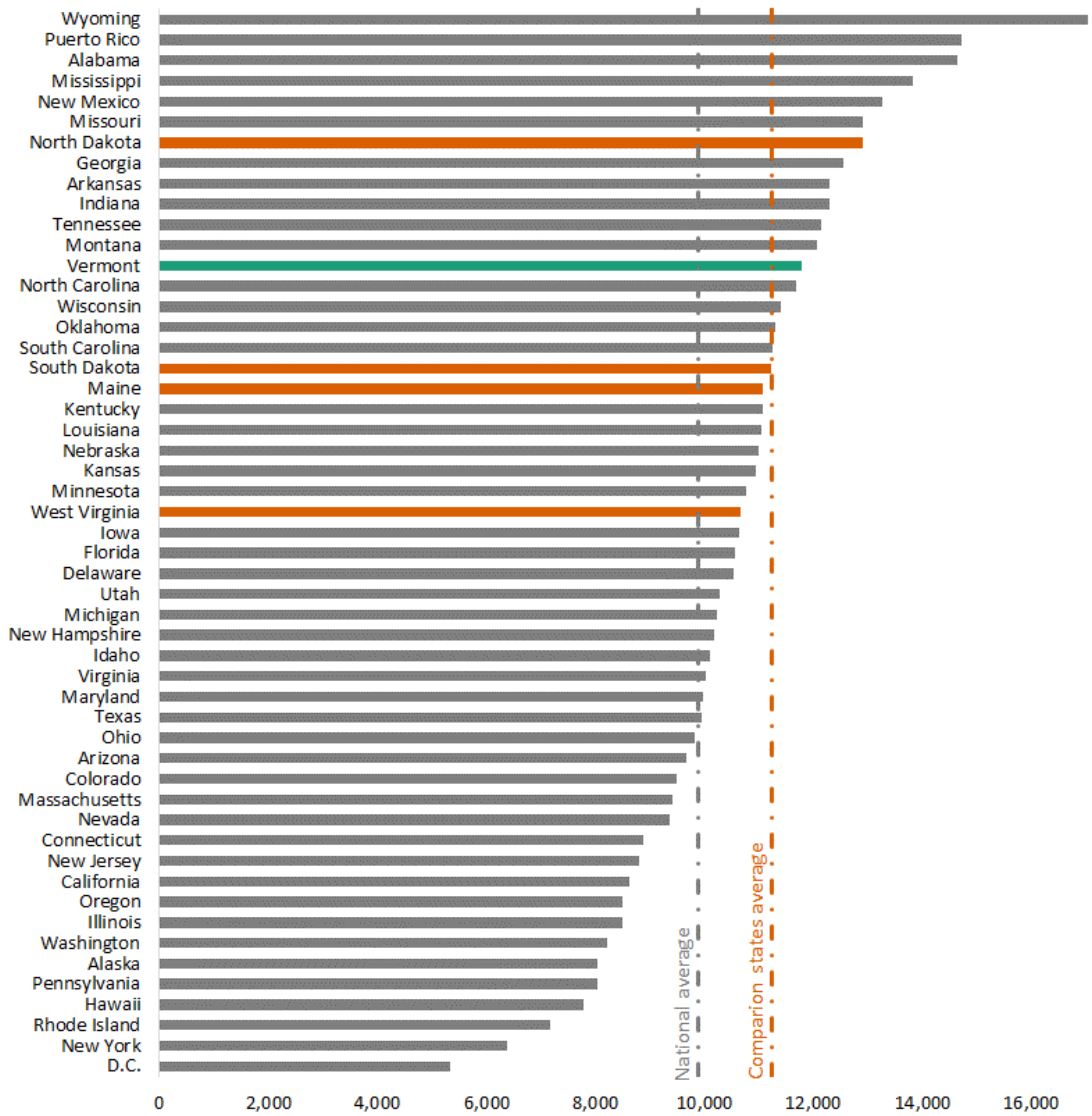


Figure 2-2. 2019 Per Capita VMT for U.S. States (FHWA, 2020; USCB, 2020a)

Table 2-2. Vermont VMT by Road Class, 2019

	Urban/ Rural	Total Roadway Miles	% of Total	VMT (Millions)	% of Total
Interstate	Rural	255.97	1.8%	1,263	17.2%
	Urban	64.31	0.5%	551	7.5%
Arterial/Major Collector	Rural	3,038	21.3%	2,880	39.2%
	Urban	538	3.8%	1,227	16.7%
Minor Collector/Local	Rural	9,457	66.4%	1,078	14.7%
	Urban	900.79	6.3%	346	4.7%
Totals	Rural	12,751	89.5%	5,221	71.1%
	Urban	1,503	10.5%	2,124	28.9%
	Combined	14,254	100.0%	7,346	100.0%

Source: FHWA, 2020

Although pandemic-related travel disruptions are not yet reflected in comprehensive federal transportation data sources, recent changes in travel have been estimated using mobile device data. Figure 2-3 presents estimated monthly VMT in Vermont from January 2020 through April 2021, relative to a January 2020 baseline. Figure 2-4 shows monthly trip-making rates for Vermont relative to average 2019 trip-making rates. Both figures show a dramatic drop in travel coinciding with COVID-19-related closures in March 2020, followed by a rebound in travel. Since these data are estimated using mobile device data, they may not capture the full extent of pandemic-related travel changes but are indicative of recent trends.

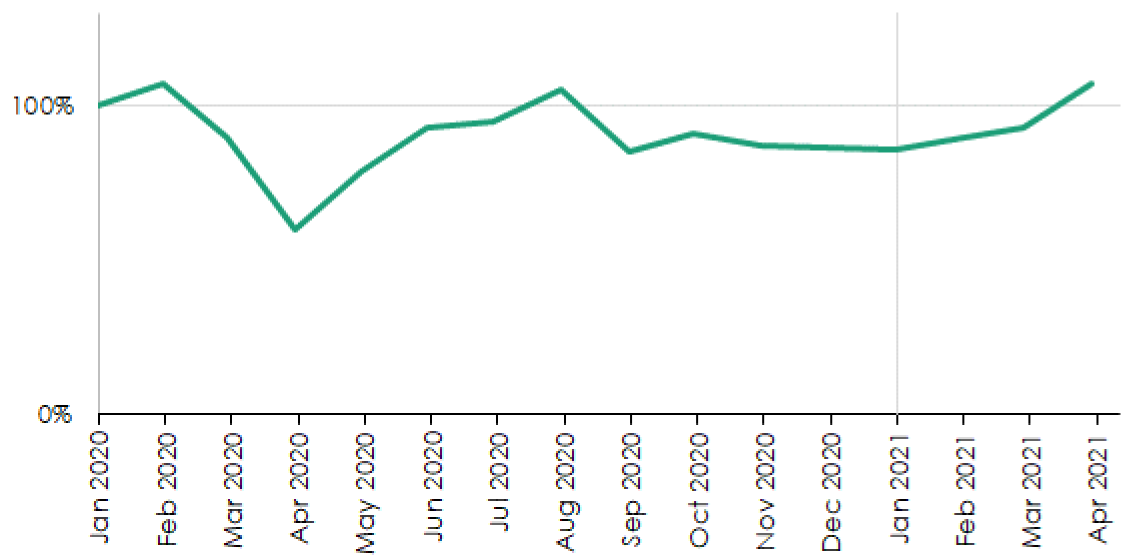


Figure 2-3. Vermont Per Capita VMT Relative to a January 2020 Baseline (based on MTI, 2020)

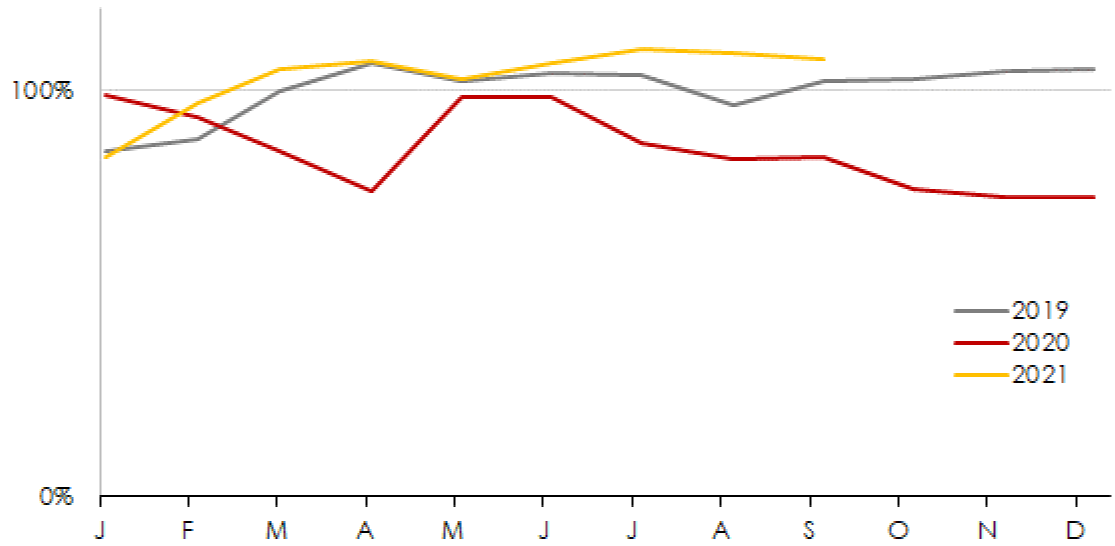


Figure 2-4. Vermont Trips Relative to 2019 Baseline (based on BTS, 2020b)

2.1.1 Economic Context

VMT is influenced by both overall economic conditions and fuel prices. Historically, VMT has tracked closely with GDP. GDP is generally assumed to drive VMT since periods of high economic activity lead to greater work-related travel and higher levels of discretionary income support more leisure travel. Although it has been suggested that policies that reduce VMT could lead to a decrease in GDP, research suggests that reducing VMT is unlikely to cause a decline in economic activity (McMullen and Eckstein, 2012). At the national level, both GDP and VMT grew at the same 3.5% annual rate from 1960 through 1997 but GDP has increased more rapidly than VMT at the national level since that period (EERE, 2018). Figure 2-5 shows changes in Vermont GDP and VMT for 2000 through 2019 relative to a 2000 baseline. As at the national level, GDP has grown faster than VMT over the last decade.

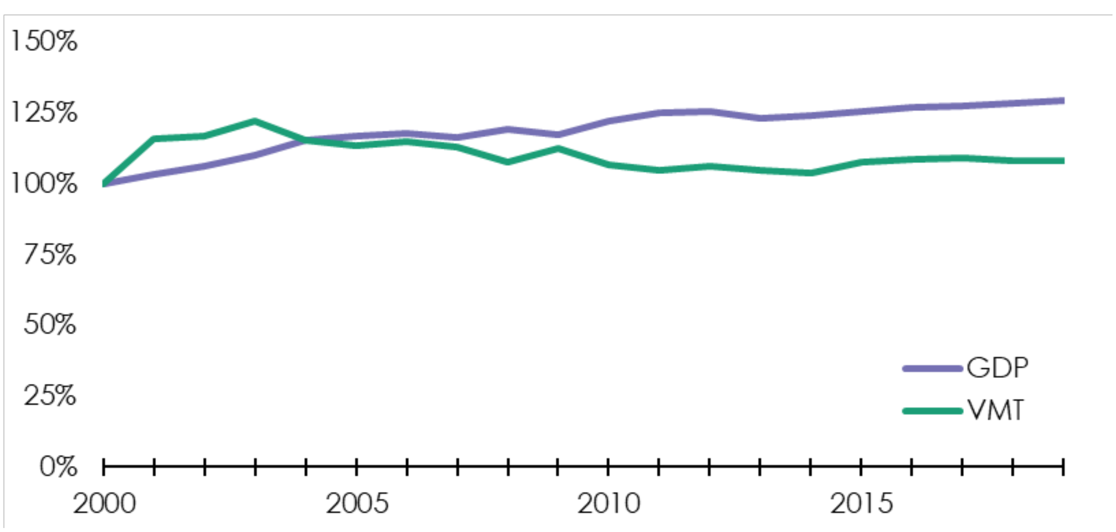


Figure 2-5. Vermont GDP and VMT relative to 2000 baseline, (U.S. BEA, 2021; FHWA, 2020).

VMT and fuel prices tend to be inversely correlated as lower fuel prices make travel less expensive. In the short term, however, travel demand is relatively inelastic, meaning that even relatively large changes in fuel prices result in relatively small changes in VMT (U.S. EIA, 2014). Figure 2-6 shows the national average annual gasoline price in constant dollars.

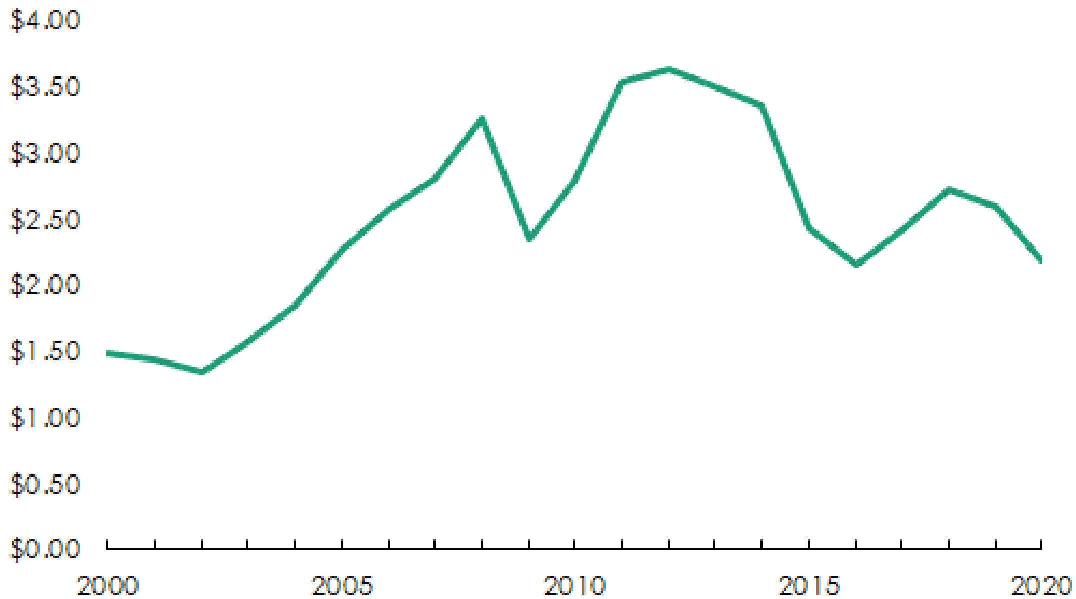


Figure 2-6. National Average Gas Price in 2021 dollars (U.S. EIA, 2021b)

2.1.2 Licensure

One factor that can influence VMT is the proportion of the population that is licensed to drive. The number of Vermonters with active driver's licenses and learner's permits from 2019 and 2020 is shown in Table 2-3.[4] Vermont's rate of licensure per capita is higher than the national average and higher than licensure rates in three of the four rural comparison states. In part, this reflects the state's demographics, as the percentage of the population that is over 16 is higher in Vermont than in all of the comparison states (FHWA, 2020).

Table 2-3. Active Driver's Licenses and Leaners Permits in Vermont, 2019 – 2020

	2019	2020
Driver's Licenses	486,763	482,015
Learner's Permits	15,030	16,194
Licenses per Capita	0.78	0.75
Sources: Fassett, 2020; UCSB 2021		

[4] The data shown include only active licenses and is limited to 2019 and 2020. Prior editions of the Profile included relied on federally reported licensure data that appears to have erroneously included expired licenses and has therefore been omitted.

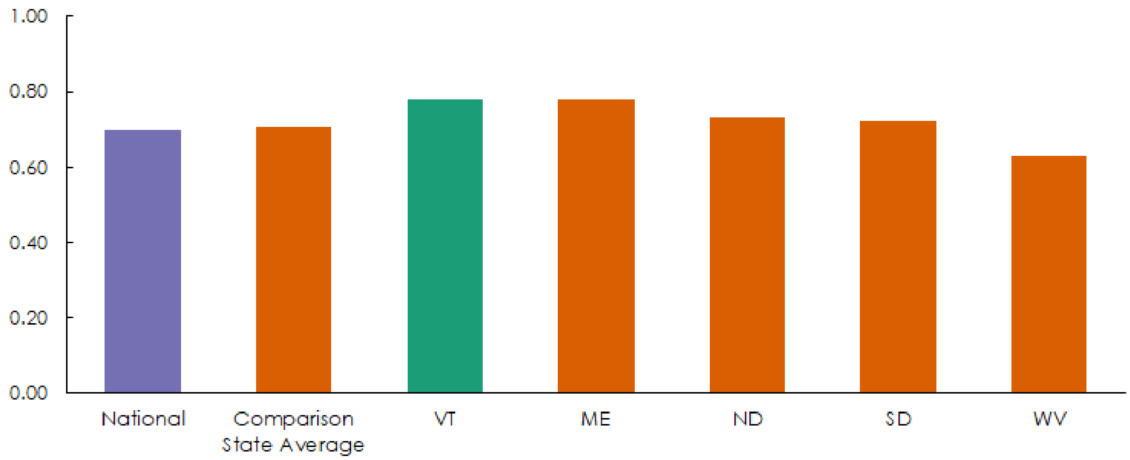


Figure 2-7. Per Capita Licensure, 2019 (FHWA, 2020, Fassett, 2020). FHWA licensure data are used for national and comparison states. Licensure data from Fassett (2020) is used for VT due to an FHWA data reporting issue.

2.1.3 Car-Sharing and Ride-Hailing Services

Vehicle-sharing organizations provide an alternative to personal vehicle ownership by allowing members to access and use vehicles on an as-needed (and usually short-term) basis. Researchers have 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 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). One car-sharing service operates in Vermont. CarShare Vermont, a local non-profit which has vehicle locations in Burlington (CarShareVT.org). ZipCar, a national for-profit car-sharing outfit, previously had locations at Middlebury College and Norwich University but they are no longer in operation. Person-to-person (P2P) car-sharing services, such as Turo, provide web-based options to search for privately owned vehicles available for hourly or daily rental. Early research on P2P car-sharing has shown a modest reduction in driving by a subset of P2P participants (Dill et. al, 2019).

Ride-hailing services allow users to arrange for rides in private vehicles through app and web-based interfaces. Ride-hailing services such as Uber and Lyft have grown rapidly in recent years and are now available in Vermont. The Vermont Ride Network (formerly Green Cab, greencabvt.com) operates throughout Vermont although the service area has been reduced during the COVID-19 pandemic. As with car-sharing, ride-hailing can reduce the need for car ownership but may also replace transit and walk/bike trips with vehicle trips. Preliminary research on the impact of ride-hailing on VMT suggests that these services are likely to contribute to an increase in VMT (Clewlow and Mishra, 2017).

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, such as SOV trips.

Status: The overwhelming majority of trips in Vermont are taken in passenger vehicles. However, Vermont's SOV commute rate is below that of comparison states, reflecting higher rates of biking and walking by Vermont commuters than by commuters in these states. From 2009 to 2019, SOV commute share has increased by 1.5% (from 74.4% to 75.9%) and carpooling has declined by 2% (from 10.7% to 8.7%). Transit, walking, and biking commute mode shares have remained relatively stable over this period. TDM strategies are often aimed at shifting travel modes for commutes and other types of travel, although this can be challenging in rural areas with limited transportation options.

Mode share refers to the proportion of all trips taken with a specific mode (e.g. automobile, transit, or active transportation). It is commonly measured using travel surveys such as the NHTS. As shown in Figure 2-8, motorized modes, (cars, SUVs, trucks, and vans), were the dominant mode of travel reported in Vermont and New England in the 2009 NHTS. According to these data motorized modes accounted for nearly 85% of all Vermonters' trips and nearly 82% of trips in New England. Nearly half of Vermont vehicle trips take place in larger, generally less energy-efficient vehicles—SUVs, light trucks, and vans. Walking and biking accounted for 13% of all Vermont trips in the 2009 NHTS data set. The share of trips taken using motorized modes dropped to 78% for New England in the 2017 NHTS but this change may in part reflect methodological changes designed to capture more stops and walking and biking trips rather than simply a change in travel behavior (McGucking and Fucci, 2018). Vermont-specific data is not available in the 2017 NHTS.

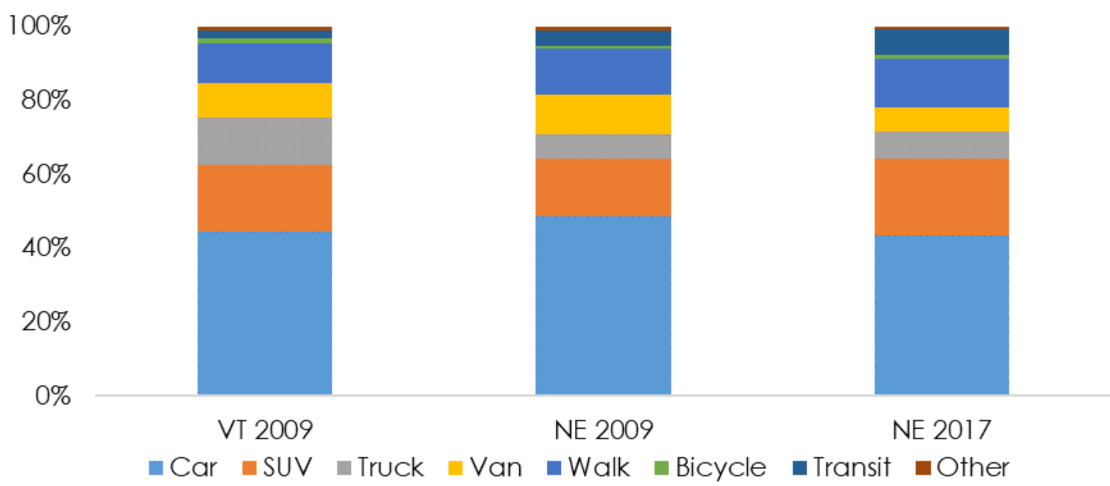


Figure 2-8. Mode Share in Vermont and New England (USDOT, 2010; USDOT, 2017)

In addition to the NHTS, mode share data for commute trips have been collected in the ACS and 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. From 2009 through 2019, SOV commute mode share in Vermont increased from 74.4% to 75.9%.[5] Over this same period, the carpooling mode share declined from 10.7% to 8.7% while shares for other non-SOV commute travel modes have remained relatively stable, as shown in Figure 2-9 and Table 2-4.

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).

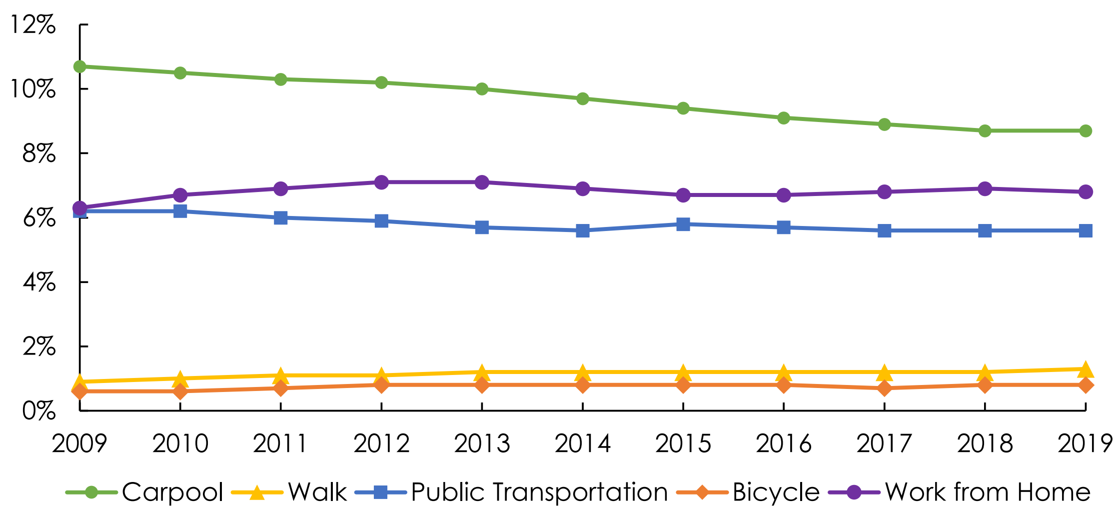


Figure 2-9. Mode Share for Non-SOV Vermont Commuters, 2009–2019 (USCB, 2021b)

[5] Attention to telecommuting has intensified during the COVID-19 pandemic. Telecommuting has the potential to reduce VMT and GHGs when telecommuters do not increase travel for other purposes. Accordingly, the 2021 Profile reports includes "work from home" in reported commute mode share. Previous editions of the Profiles reported transportation commute mode shares that excluded "work from home" commutes.

Table 2-4. Comparison of Commuter Mode Share for Vermonters, 2009 – 2019

Year	Mode Share (%)						
	Drove Alone	Carpool	Walk	Public Transport	Bicycle	Other	Work from Home
2009	74.4	10.7	0.9	6.2	0.6	1	6.3
2010	74.1	10.5	1	6.2	0.6	0.9	6.7
2011	74.1	10.3	1.1	6	0.7	1	6.9
2012	74	10.2	1.1	5.9	0.8	0.9	7.1
2013	74.5	10	1.2	5.7	0.8	0.8	7.1
2014	74.9	9.7	1.2	5.6	0.8	0.8	6.9
2015	75.3	9.4	1.2	5.8	0.8	0.8	6.7
2016	75.6	9.1	1.2	5.7	0.8	0.9	6.7
2017	75.9	8.9	1.2	5.6	0.7	0.9	6.8
2018	75.9	8.7	1.2	5.6	0.8	0.9	6.9
2019	75.9	8.7	1.3	5.6	0.8	1	6.8

Source: USCB, 2021b

Using the five-year ACS estimates, the proportion of Vermonters who commuted by SOV, 75.9%, is slightly lower than the national average, 76.3%, and also lower than all four of the comparison states, which had SOV commute rates ranging from 78.8% to 82.5%, as shown in Figure 2-10. 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, 6.4%, than the national average or than in any of the comparison states.

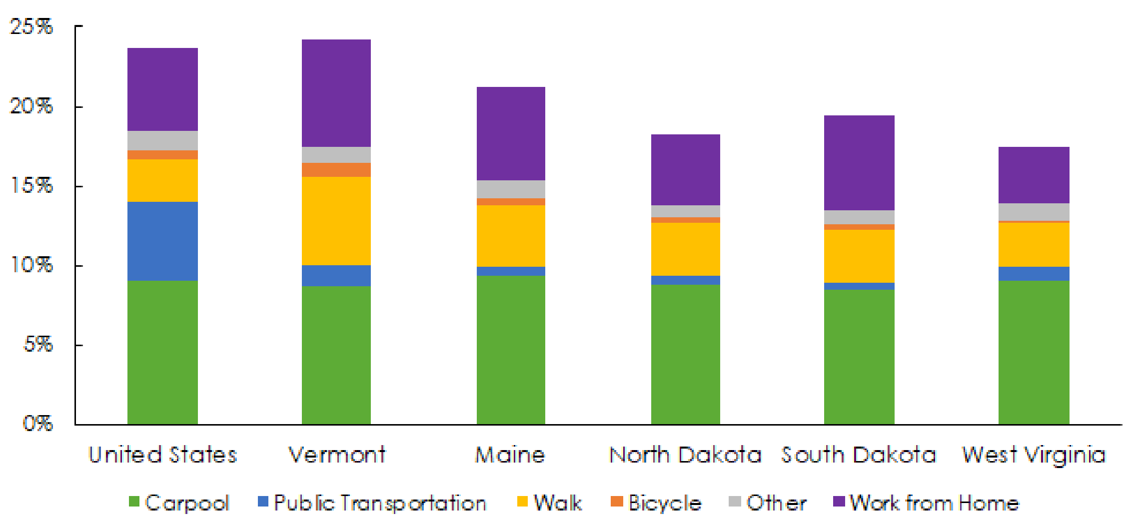


Figure 2-10. Commute Mode Share for Non-SOV Trips, 2019 (USCB, 2021b)

Table 2-4, Figure 2-9, and Figure 2-10 include primary modes to work for commuters as well as the share of workers who work from home. Vermonters worked from home at a higher rate (6.8%) than the national average (5.2%) or than in any of the comparison states (between 3.6% and 5.9%) (USCB, 2021b).

Early data indicate that during the COVID-19 pandemic teleworking increased substantially. From August 2020 through March 2021, the share of adult Vermonters living in a household with at least one telecommuter was approximately 40%, compared to about 9% of adults in 2019 (BTS 2021c). While telework has led to short-term reductions in commute VMT, the long-term persistence of this shift is unknown, as is the potential for increases in non-commute trips among Vermont telecommuters.

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 much energy is 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 2-11 shows U.S. Department of Energy (DOE) estimates of vehicle and passenger energy intensity for several commonly used motorized modes as of 2018 (Davis and Boundy, 2021). In Figure 2-11, 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 has a lower average occupancy rate than other transit services, bus trips have the next highest energy intensity of the modes shown here, followed by single-occupancy cars and light-duty trucks. Policies aimed at reducing transportation energy use in Vermont may be able to achieve this objective by promoting mode shifts to non-auto travel and high vehicle occupancy modes such as carpools and transit vehicles with high occupancy. Shifting vehicle trips to vehicle types with lower energy intensity and vehicles that use cleaner fuels will also reduce energy use and greenhouse gas emissions.

Demand response transit and fixed-route transit provide critical connections to essential destinations for many Vermonters. However, nationally these services on average are more energy-intensive than traveling alone in a car. In other words, depending on the occupancy and energy intensity of a given transit service, it may not be a lower GHG emitting option when compared with personal vehicle travel. In Vermont, the energy intensity of transit is likely to be on the high end because of the State's rural context. In 2019, transit occupancy rates for Green Mountain Transit (GMT), the only Vermont transit agency for which data are available, were below the national average[6], indicating that the energy intensity of GMT transit service may be higher than the US average if GMT vehicles are of comparable

[6] In 2019, GMT transit vehicle occupancy rates were 58%, 49%, and 14% below the national average, for commuter buses, motor buses, and demand response transit, respectively. Occupancy rates are estimated based on Federal Transit Administration data for passenger miles traveled and vehicle revenue miles for US transit operators (FTA, 2021).

efficiency. Occupancy rates vary by route, time, day of the week, and season. Depending on the context, adding service can either increase occupancy by attracting new riders or decrease occupancy by adding vehicles and trips without a proportionate increase in ridership. It may be desirable to maintain or increase service on low occupancy routes to support mobility goals. Shifting transit to cleaner fuels and "right-sizing" vehicles for less-traveled routes can also improve the energy intensity of transit services.

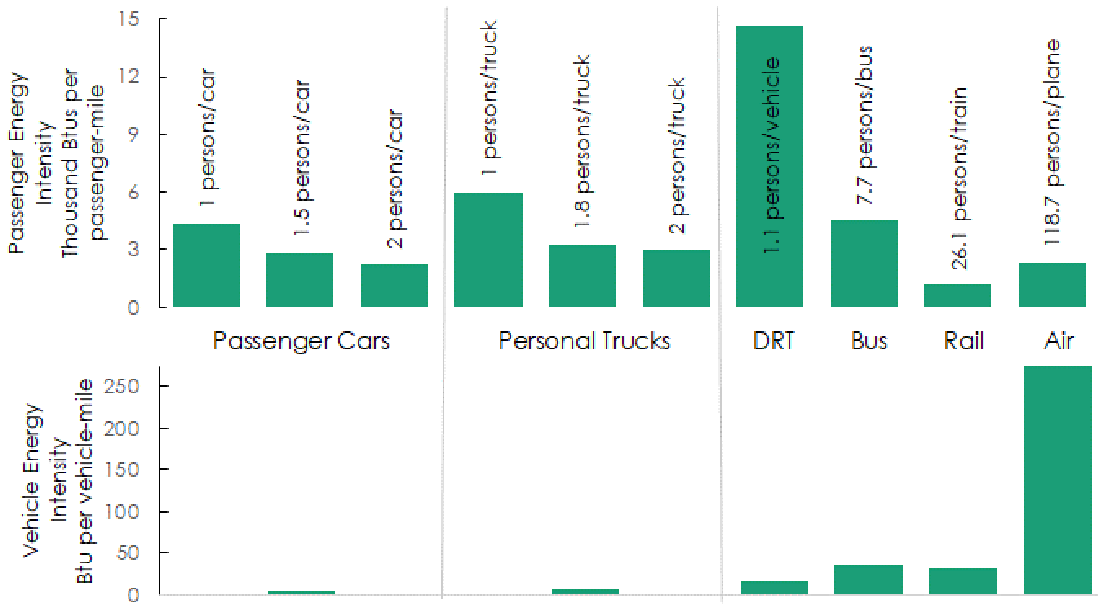


Figure 2-11. Energy Intensities of Common Transport Modes in 2018 (Davis and Boundy, 2021)

Figure 2-12 shows the trend in average energy intensity per vehicle mile for cars and trucks from 2000 through 2018. Improving vehicle efficiency has led to a 23% drop in per-mile energy intensity for cars and a 14% drop for light trucks. Reductions in energy consumption achieved through improved vehicle efficiency can be partially eroded by a "rebound" effect, whereby a reduction in drivers' fuel costs leads to increases in travel, the purchase of larger vehicles, or the purchase of other goods and services that have energy consumption implications.

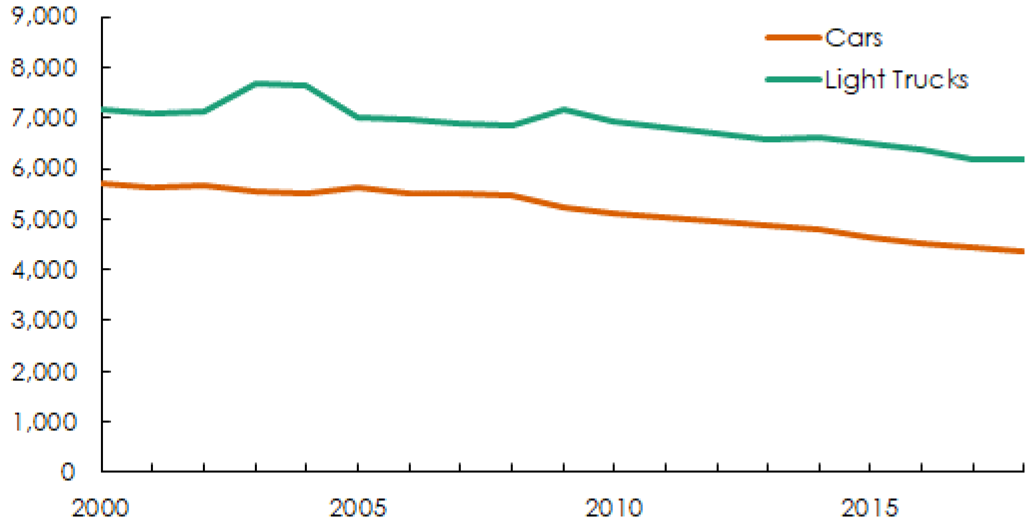


Figure 2-12. Energy Intensity Trends 2000 – 2018 (Btu/vehicle-mile) (Davis and Boundy, 2021)

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 is a TDM strategy and it 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 1.58 people per vehicle, below the national average of 1.68. Regional data from the 2017 indicate a small uptick in vehicle occupancy in New England but the loss of carpooling commute mode share may indicate that Vermont's vehicle occupancy rate has declined since then.

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 2009 and 2017 NHTS for New England and the nation are summarized in Table 2-5 and show relatively little change. 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 and 2017

	Average Vehicle Occupancy	
	2009	2017
Vermont	1.58	N/A
New England	1.58	1.61
National	1.68	1.65

Source: USDOT, 2010; USDOT, 2018

2.3.1 Carpooling Incentives

According to ACS data, carpooling rates in Vermont have steadily declined from 2009 through 2019. This 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 and phone application 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. Note that the service provider and the method for tracking registered commuters with Go! Vermont Program changed in FY2018/2019, so 2019 data are not directly comparable to the data from prior years. In addition, the carpool matching service was temporarily unavailable from the end of SFY 2018 through early 2019. SFY2020 and SFY 2021 data reflect pandemic-related travel disruptions, including a decrease in commuting and efforts to avoid close contact with other passengers.

Table 2-6. Go! Vermont Program Benefits

Tracking Metric	SFY 2012-2015	SFY 2016	SFY 2017	SFY 2018	SFY 2019	SFY 2020	SFY 2021
Registered Commuters	3455	943	811	4389	5885	6924	7649
Rides Posted	4224	970	837	385	--	--	--
Carpool participants	--	--	--	--	90	104	62
Vanpools	19	14	11	12	14	11	6
VMT reduction (1000 miles)							
Carpools	--	320	275	139	125	289	137
Vanpools	--	2,766	2,178	864	772	604	247
Total	16,466	3,086	2,453	1,003	897	893	384
Estimated Cost Savings ($1000)							
Carpools	--	174	152	76	70	167	79
Vanpools	--	1,507	1,187	470	434	349	140
Total	9,276	1,682	1,339	546	505	516	219

Source: Currier, 2021: Kunze, 2021: GSA, 2021

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 31 park-and-ride sites with approximately 1,734 total spaces (see Table 2-7), while individual municipalities maintain an additional 72 sites with a total of approximately 1,470 spaces (see Table 2-8). Overall, the number of park-and-ride parking spaces has increased by almost 90% since 2012. In addition, park-and-ride facilities at both the state and municipal levels are considerably more likely to include connections to transit and bicycle parking.

Table 2-7. State Park-and-Ride Facilities in Vermont, 2012 – 2021

Number of State:	2012	2015	2017	2019	2021
Park-and-Rides	25	29	30	31	31
Parking Spaces (approximate)	1140	1,380	1,525	1,639	1,734
Facilities with Bike Racks	11	20	22	23	24
Facilities with Transit Connection	3	19	21	21	21
Facilities with Paved Surface	17	24	26	27	29
Facilities Lighted	18	24	28	26	26
Source: VTrans, 2021					

Table 2-8. Municipal Park-and-Ride Facilities in Vermont, 2012 – 2021

Number of Municipal:	2012	2015	2017	2019	2021
Park-and-Rides	26	53	65	69	72
Parking Spaces (approximate)	550	1,012	1,293	1,362	1,470
Facilities with Bike Racks	2	19	22	25	26
Facilities with Transit Connection	9	20	22	25	28
Facilities with Paved Surface	20	42	52	53	56
Facilities Lighted	18	37	49	51	54
Source: VTrans 2021					

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 with a motor vehicle, suggesting an opportunity for increasing active transportation trips. The CEP includes an objective of increasing the share of commute trips completed by walking or biking to 15.6% of all commute trips.

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. Similar to the NHTS results, the LRTPS indicates that 81% of Vermonters 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

2.4.1 Bike Rental and Lending

Several services provide bikes to Vermont visitors and residents seeking to travel by bike or try different types of bicycles. Bike rentals are available at many locations, including many bike shops. In addition, the Greenride Bikeshare (http://greenridebikeshare.com/) allows users to rent and operate e-bikes in Burlington and parts of South Burlington and Winooski. Local Motion's e-bike lending program (https://www.localmotion.org/ebikes) allows Vermonters to try e-bikes and e-cargo bikes and operates at fixed and traveling locations around the state.

2.5 Bus and Rail Service

The CEP includes goals to increase public transit and passenger rail ridership. Rail and bus services can each provide transportation options for travelers without access to a vehicle. These options can be relatively energy-efficient when they involve high-efficiency vehicles and crucially when operating with high occupancy rates. As shown in Figure 2-11, with typical occupancy rates and efficiencies, bus efficiency is similar or slightly worse when compared with the state's most common commute mode, the SOV. 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 for 2017 and 2019 (KFH Group, 2017; KFH Group, 2019), 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). In 2017, ACTR and STSI merged operations under the name Tri-Valley Transit. Transit service territories are shown in Figure 2-13.

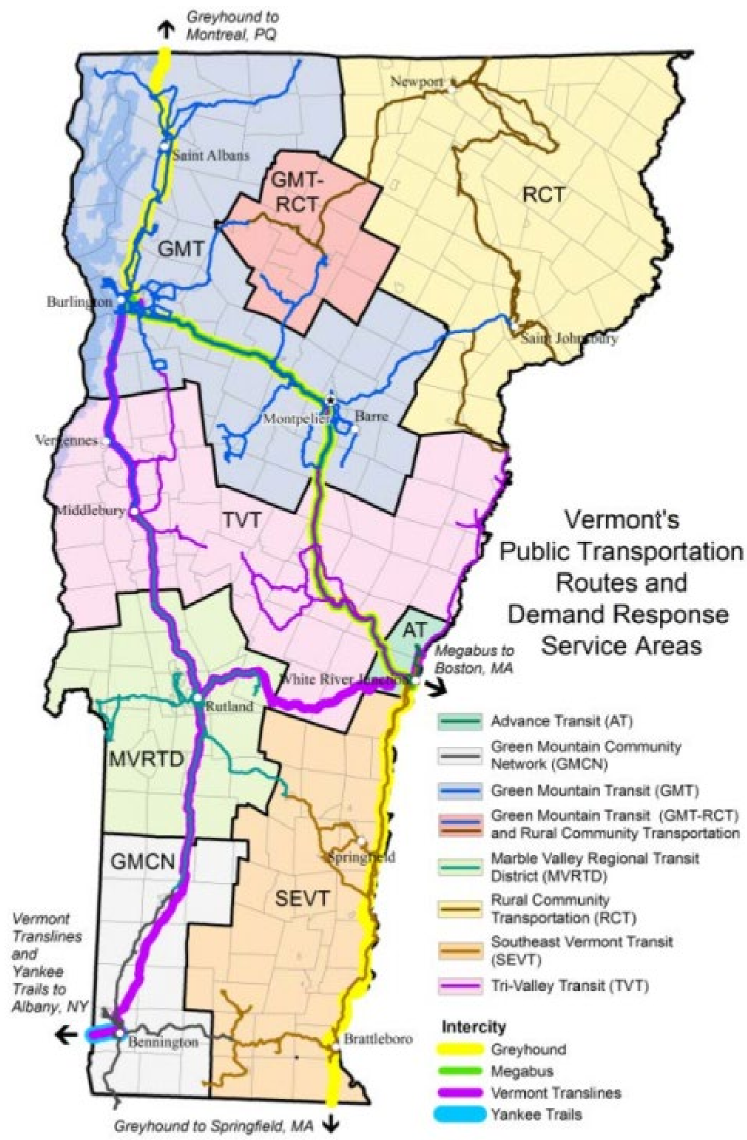


Figure 2-13. Transit Service Providers (KFH Group, 2019)

In recent years, VTrans has partnered with transit operators to pilot innovative demand response transit programs, including the Rides to Wellness program to connect people to health care destinations, the Recovery and Job Access Rides to connect people struggling with substance use disorders with treatment and jobs, and MyRide, which provides flexible, on-demand service to the general public in the Montpelier area. In 2019, Vermont also launched statewide coverage in the Transit app, which provides users with real-time information about transit services for all transit providers in the state (VTrans 2020).

The Profile reports on transit ridership for 8 transit divisions (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.

As shown in Table 2-11 in SFY 2019, total public transit ridership was measured at 5.1 million passenger boardings. This was followed by a decline to 4.2 million passenger boardings in 2020. Much of this decline in ridership can likely be attributed to the COVID-19 pandemic, which resulted in fewer trips out of the home as well as recommendations to avoid crowded public spaces. Reduced transit ridership was observed across the US during this time. Figure 2-14 shows the precipitous drop in transit ridership observed among Transit App users across the US and in Massachusetts, the only New England region for which data are available.

Table 2-11. Bus Ridership for Vermont Transit Authority Providers, FY 2011–20

Transit Provider	Annual Ridership (thousands)									
	FY 11	FY 12	FY 13	FY 14	FY 15	FY 16	FY 17	FY 18	FY 19[1]	FY 20[1]
AT	170	172	181	173	196	211	209	213	215	183
GMCN	75	97	110	117	120	114	98	104	215	161
GMT - Rural	419	424	427	418	418	381	369	388	442	408
GMT - Urban	2512	2703	2690	2545	2703	2511	2282	2272	2461	1978
Greyhound	N/A	N/A	N/A	N/A	14.4	14.3	16.5	14.3	11.4	7.7
MVRTD	558	545	586	633	632	607	648	687	750	612
RCT	163	150	175	192	186	205	263	210	263	195
SEVT	445	460	520	523	514	453	515	514	455	368
TVT	231	265	266	247	234	201	272	319	285	224
VABVI	5.2	5.3	5.2	4.3	4.2	3.4	3.7	4.8	4.5	3.0
Vermont Translines	N/A	N/A	N/A	N/A	8.3	11.1	12.3	16.3	19.6	14.9
Statewide Totals	4,578	4,822	4,961	4,854	5,029	4,712	4,687	4,742	5,121	4,155

[1] Data from FY19 onward includes demand-response services such as Medicaid NEMT and ADA.
Source: Bradshaw, 2021

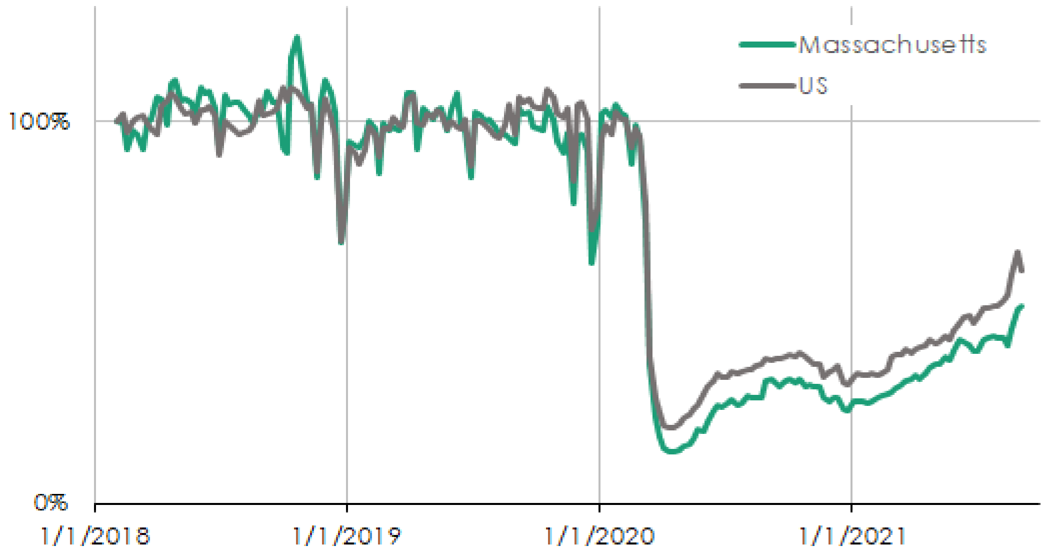


Figure 2-14. Transit App User Ridership Relative to Feb. 2018 (APTA and Transit App, 2021)

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 2020 are shown in Figure 2-15. Passenger rail ridership increased steadily from FY 2005 through FY 2014 but declined in FYs 2015 and 2016 and remained relatively stable in FYs 2017 through FY 2019. As expected, ridership declined during FY 2020 due to lower demand and service cuts during the COVID-19 pandemic.

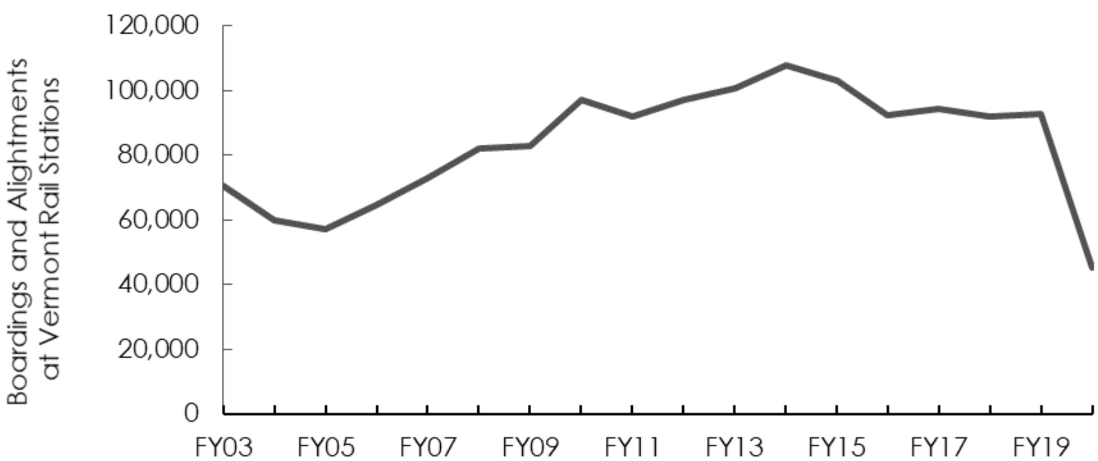


Figure 2-15. Amtrak Boardings and Alightments in Vermont, FY 2003–2020 (Pappis, 2021)

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. Except for routes that receive support from VTrans shown above, 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 GMT buses are equipped with bike racks for their riders, allowing for the combination of biking and bus transit on a trip.

3 Vermont 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 vehicle fleet encompasses a wide variety of vehicle types used 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 all-wheel drive—that Vermonters look for in their vehicles. This section tracks private vehicle registrations to assess the overall efficiency of the Vermont vehicle fleet. Growth in sales of alternative fuel vehicles, such as AEVs and PEVs, is also highlighted.

Vehicles can be classified based on several different characteristics, including weight, primary use, and fuel type. The precise classification of specific vehicles can vary by agency and jurisdiction. The FHWA's Federal Highway Statics series divides on-road vehicles into motorcycles, automobiles, buses, and trucks. For the purpose of regulating mobile source emissions, the EPA divides on-road vehicles into motorcycles, light-duty vehicles with a gross vehicle weight rating (GVWR) under 8,500 pounds, and heavy-duty vehicles with a GVWR over 8,500 pounds (U.S. EPA, 2019) Light-duty vehicles can be further classified as either passenger cars (sedans, coupes, and station wagons) or light trucks (a category that includes most pickup trucks, minivans, and sport-utility vehicles), but a growing number of crossover utility vehicles (CUV) do not align well with these categories. CUVs such as the Toyota RAV4 and Ford Escape are categorized as light trucks by the Bureau of Economic Analysis but, depending on their specific features, may be counted as passenger cars by the EPA (U.S. EIA, 2017). The EPA's heavy-duty vehicle classification includes large pick-ups, commercial trucks, and buses.

Except where specifically noted otherwise, analysis in the Profile is focused on privately owned automobiles and trucks (including heavy-duty trucks), as classified by the FHWA, with

VT PRIVATELY OWNED VEHICLE FLEET

Overview: The vehicles that Vermonters drive determine 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 (93.7% and 5.5%, respectively), as shown in Figure 3-1. Less than 1% of all vehicles use other fuel types.

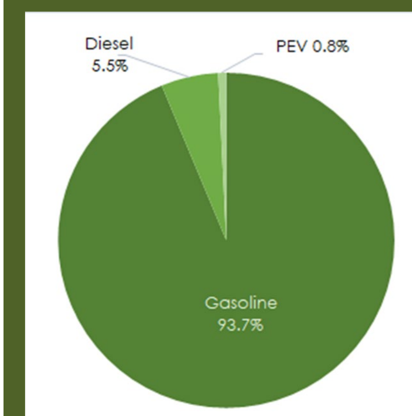


Figure 3-1. Vermont Private Vehicle Registrations by Fuel Type, 2020 (VDMV, 2021)

Trends in PEV Registrations: The number of all electric vehicles and plug-in hybrid electric vehicles increased by 29% and 8% respectively between December 2019 and December 2020. As shown in Figure 3-1, however, PEVs, are still less than 1% of private vehicle registrations.

current registrations in Vermont. Privately owned vehicles are defined as all vehicles with commercial or individual registrations. Publicly owned vehicles, as well as motorcycles and off-road vehicles, are excluded from analyses of registered vehicles. As of 2019, 12,054 publicly owned vehicles and 30,404 privately owned motorcycles were registered in Vermont (FHWA, 2020). These vehicles accounted for 6.8% of 2019 registrations.

3.1 Vehicle Registrations

Vehicle ownership is a strong predictor of vehicle use. Table 3-1 shows the trends in vehicle registration at the state and national level from 2007 through 2019, the most recent year for which national data are available. Nationally, per capita vehicle ownership fell slightly from 2007 to 2010 – likely impacted by the 2008 economic downturn. Vehicle ownership has slowly rebounded since then and appears to be relatively stable in recent years.

Table 3-1. Vehicle Registrations in Vermont and the U.S., 2007–2019

	Vermont		National	
	Registered Vehicles (thousands)	**Vehicles per Capita**	**Registered Vehicles (millions)**	**Vehicles per Capita**
2007	555	0.89	243.1	0.81
2008	571	0.92	244	0.80
2009	546	0.88	242.1	0.79
2010	554	0.89	237.4	0.77
2011	564	0.9	240.8	0.77
2012	568	0.91	241.2	0.77
2013	574	0.92	243.1	0.77
2014	573	0.92	247.4	0.78
2015	614	0.98	250.5	0.78
2016	572	0.92	255.4	0.79
2017	578	0.93	259.1	0.80
2018	576	0.92	260.2	0.80
2019	578	0.93	263.3	0.80

Source: FHWA, 2008–2020.

The number of vehicles per capita in 2019 for Vermont and the four comparison states are shown in Figure 3-2. Vermont's vehicles per capita is higher than for two comparison states (Maine and West Virginia) and lower than two states (North and South Dakota). In previous versions of the Profile, Table 3-1 and Figure 3-2 also showed vehicles per licensed driver, however due to concerns about the accuracy of the licensure data identified in the 2019 and 2020 FHWA data these figures are not included in the 2021 Profile.

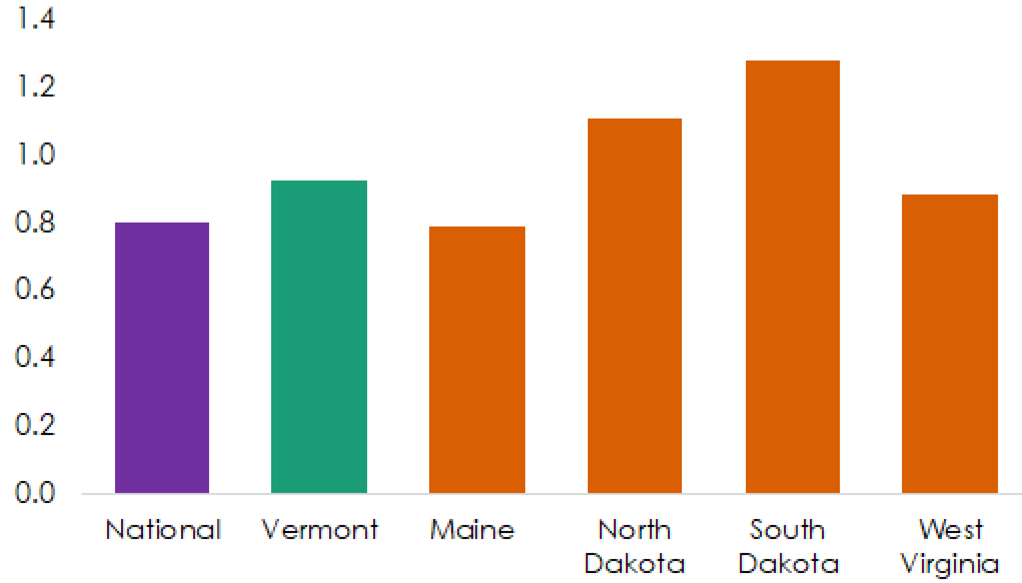


Figure 3-2. Vehicles per Capita, 2019 (FHWA, 2020)

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, 2019 (FHWA, 2020). The Vermont vehicle numbers in Section 3.2 and 3.3 are directly from the Vermont DMV data and differed from the FHWA data by less than 1% for 2019.

3.2 Vehicle Types

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 plug-in electric vehicles (PEVs), derive some or all of their energy from electricity, helping to reduce the amount of petroleum-based fuels used for transportation. The number of PEVs registered in Vermont, as well as their share of the total vehicle registrations, has increased every year from 2011 through 2020. 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. Private Vehicles Registered in Vermont by Fuel Type, 2008–2020

Fuel Type	PEV[1]		Propane / CNG	Diesel	Gasoline	
	AEV	PHEV			ICEV	Gas: 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	695	1,632	40	30,597	548,417	11,556
2018	1,010	1,975	37	30,699	546,340	12,027
2019	1,600	2,116	37	30,961	533,196	12,219
2020	2,063	2,297	37	30,941	515,236	12,341

[1] PEV data includes public as well as private vehicle registrations.
Data for all years is through December 31st.
Sources: VDMV, 2021; Drive Electric Vermont, 2021.

A breakdown of the most popular PEV models currently registered in Vermont and the efficiency of the vehicles measured in mile per gallon equivalent (MPGe) is provided in Table 3-3. Note that the MPGe, which is used to compare the energy use of PEVs to conventional gasoline vehicles, varies with model features such as battery capacity. The values shown are an average of the available vehicles of each make and model and should be seen as illustrative, not definitive. The MPGe values shown for PHEVs represent driving in “charge depleting mode,” when the battery is the primary energy source. MPGe values are considerably lower when the battery is substantially depleted and gasoline is the primary energy source. The efficiency of the most popular PHEVs in Vermont ranges from 88 – 133 MPGe for model years 2015 – 2021. As of the 2021 model year, the lowest MPGe of the AEVs in Table 3-3 is 96.

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

Type	Make and Model	Vermont Registration through Dec. 2020	MPGe for Model Year:			
			2015	2017	2019	2021
AEV	Nissan Leaf	611	114	112	108	108
AEV	Chevrolet Bolt	292	N/A	119	119	118
AEV	Tesla Model 3	289	N/A	126	125	130
AEV	Tesla Model S	129	95	100	103	107
AEV	Tesla Model X	74	N/A	90	88	96
PHEV	Toyota Prius Prime	402	N/A	133	133	133
PHEV	Chevrolet Volt	377	98	106	106	N/A
PHEV	Ford CMax Energi	368	88	95	N/A	N/A
PHEV	Toyota Prius Plug-in	282	95	N/A	N/A	N/A
PHEV	Ford Fusion Energi	213	88	97	103	N/A

Source: Drive Electric Vermont, 2021; US DOE & EPA, 2021

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 through the end of June 2021. Several trucks are among the most popular vehicles.

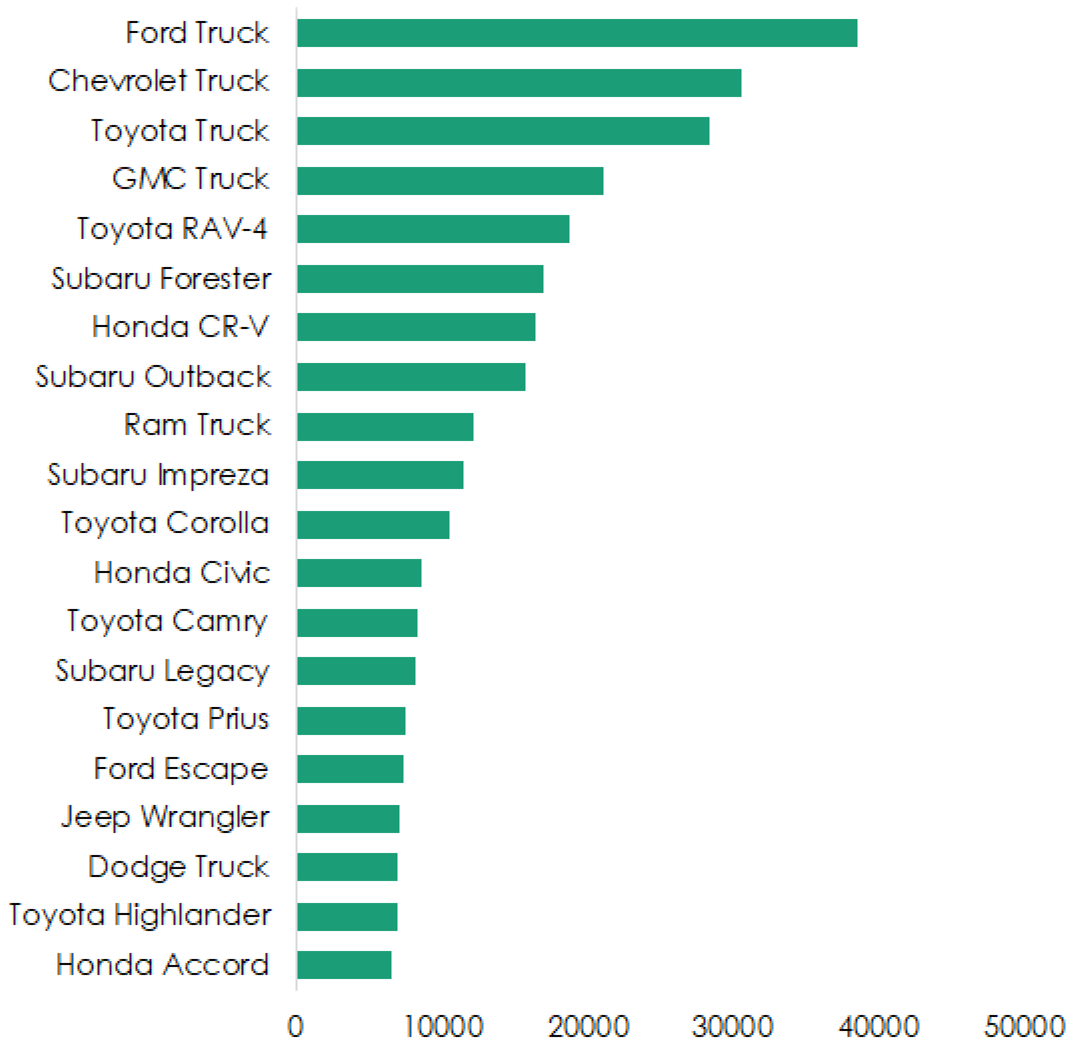


Figure 3-3. Top 20 Vehicle Models Registered in Vermont, end of June 2021 (VDMV, 2020)

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 liquid fuel production (for ICEVS, HEVs, and PHEVs) and electricity generation processes (for PEVs). 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. Given the composition of electricity sources in Vermont, Onat et al. show AEVs outperform other vehicle types on both energy use and GHG emissions (Onat, Kucukvar, and Tatari 2015).

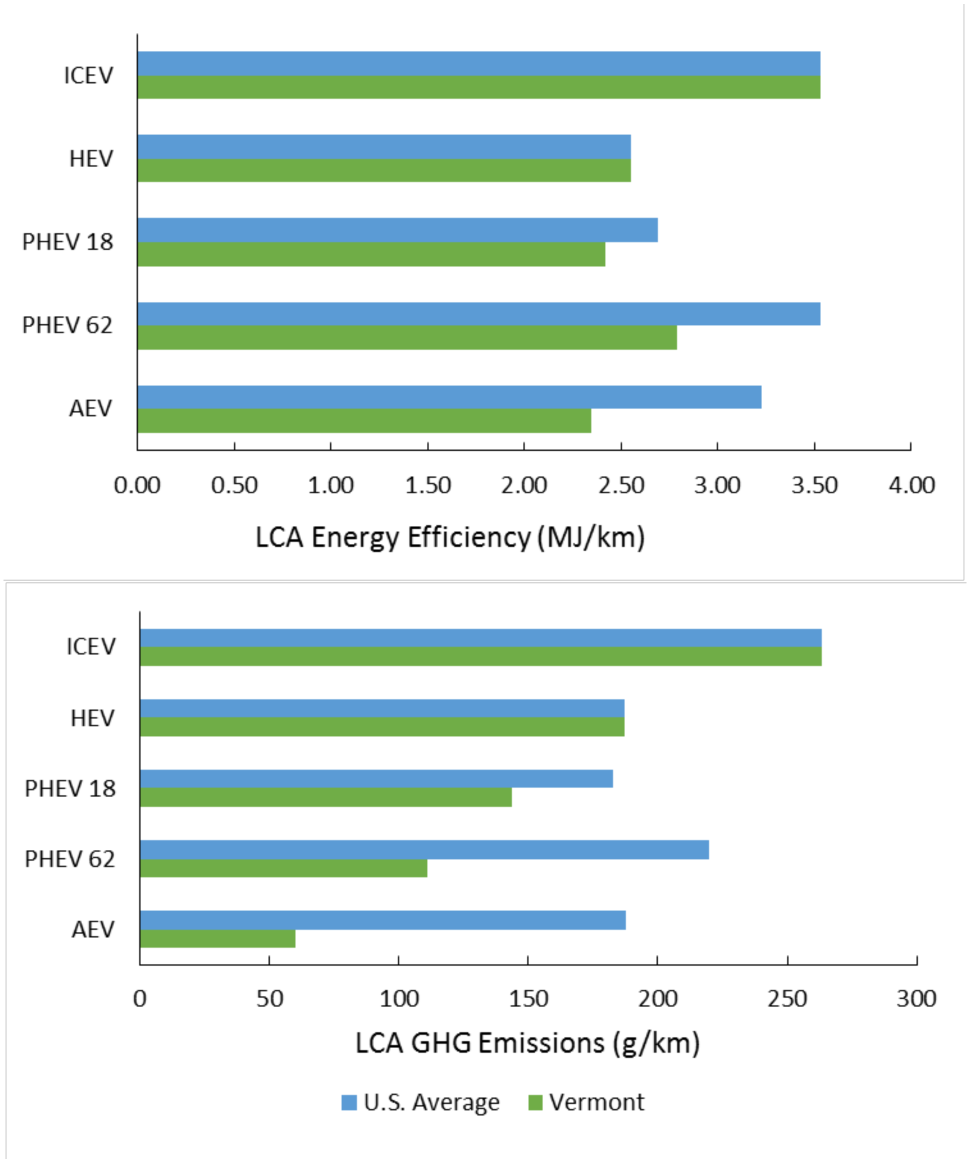


Figure 3-4. LCA Energy and GHG Intensity (Onat et al., 2015)

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 all private automobiles and trucks registered in Vermont through the end of June 2021. Approximately 70% of Vermont's registered vehicles are model year 2010 or newer and 62% are model year 2012 or newer. 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.

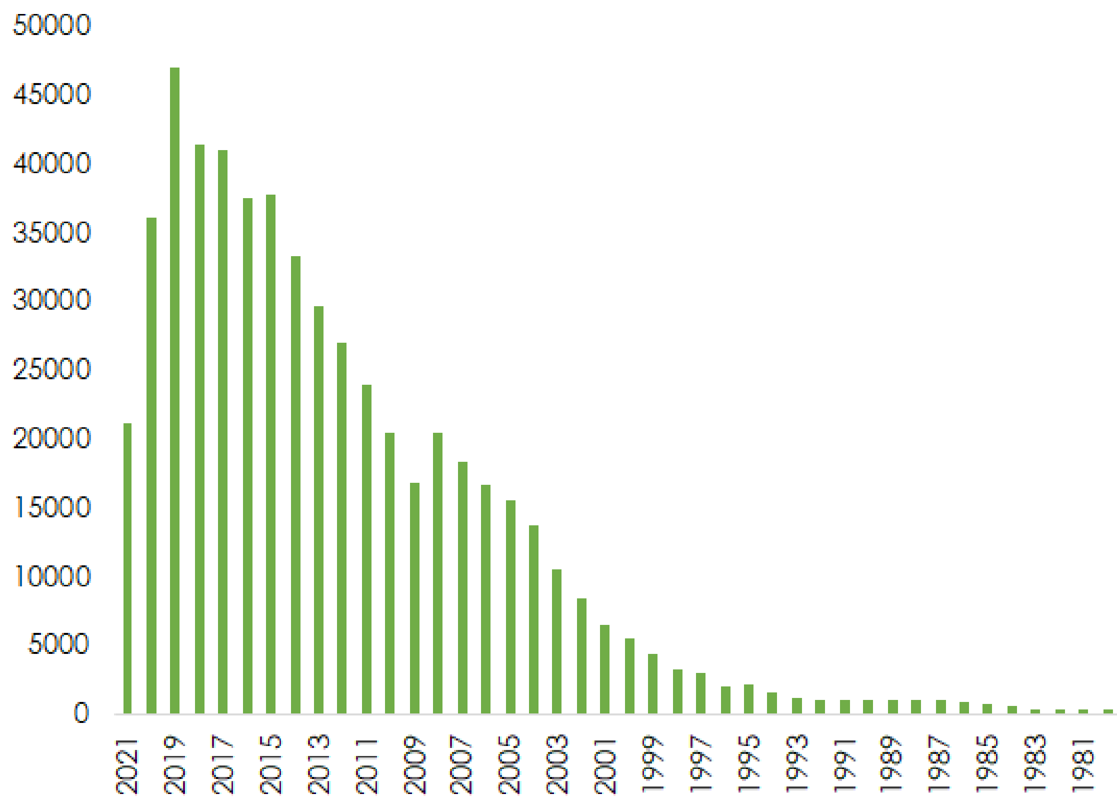


Figure 3-5. Distribution of Model Years for Vehicles in Vermont, end of June 2021 (VDMV, 2021)

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 of 0.3 combined MPG per year from 2011 through 2020, 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. For years 2011 to 2018, vehicle-make, model, and model year data from the DMV were matched directly to EPA fuel economy data. Beginning with 2019 and 2020 data shown in the 2021 Profile, Vehicle Identification Numbers (VINs) recorded by the DMV were decoded using the FHWA VIN database (NHTSA 2021). Vehicle information encoded in the VIN was subsequently matched to the EPA data. This process allowed for a more specific match with the EPA fuel economy data accounting for additional vehicle features such as transmission type. This process avoided some irregularities in the DMV make and model data, but the updated matching process still requires rectifying differences between the information in the VIN and EPA fuel economy data. To better account for the impacts of vehicle electrification, the 2021 Energy Profile also reports MPGe instead of MPG. To estimate the magnitude of the difference between the two estimation methods, both methods were used to estimate the fuel economy of the 2017 and 2018 fleets, yielding differences of less than 1%.

Approximately 85% to 87% of the registered vehicles in the reported period (2011-2021) could be matched to fuel economy data. The remaining 13% to 15% of the privately-owned vehicle fleet could not be matched to the FuelEconomy.gov data set, which does not include model year before 1984 or include medium- and heavy-duty trucks. Anomalous VIN records or relatively infrequent differences between VIN data and EPA fuel economy records also precluded matches in a small number of cases. 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, although this bias may be smaller in more recent years as older vehicles leave the fleet.

Table 3-4. EPA Fuel Economy for Vehicles Registered in Vermont, 2011–2021

Year	Registered Vehicles	Vehicles with MPG / MPGe Estimates	Average City MPG / MPGe	Average Highway MPG / MPGe	Combined MPG / MPGe	
					Average	Std Dev
2011[1]	586,422	85.00%	18.1	24.2	20.3	5.7
2012[1]	578,415	85.60%	18.4	24.5	20.7	6.1
2013[1]	552,665	85.80%	18.7	24.8	20.9	6.5
2014[1]	564,591	86.40%	19.1	25.3	21.4	7.1
2015[1]	589,608	85.44%	19.5	25.6	21.8	7.3
2016[1]	591,864	85.64%	19.8	25.9	22.1	7.5
2017[1]	593,076	86.93%	20.1	26.2	22.4	7.7
2018[1]	592,237	86.68%	20.4	26.4	22.6	7.8
2019[2]	580,284	87.04%	20.7	27.0	23.0	7.8
2020[2]	563,027	86.98%	20.9	27.2	23.3	8.1
2021[2,3]	569,933	86.54%	21.1	27.3	23.4	8.3

Source: VDMV, 2021.

[1] MPG estimated by matching DMV make, model, and year to EPA fuel economy data.
[2] MPGe estimated by matching DMV VIN to FHWA VIN records, which are then matched to make, model, year, transmission, and fuel(s) in EPA fuel economy data.
[3] As of the end of June 2021, all other values are as of yearend.

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.

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. This approach provides a lower estimate of MPG but also shows an overall trend toward greater fuel efficiency, although 2018 and 2019 exhibit modest decreases in realized MPG when compared with 2016 and 2017.

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
2016	19.4
2017	19.5
2018	19.2
2019	19.3

[1] Annual VMT divided by combined annual gas and diesel sales.
Source: FHWA, 2020; VT JFO, 2021

4 Transportation Energy Consumption

Energy consumption in the residential sector outpaced consumption in the transportation sector in 2018 and 2019, marking the first time this century that the transportation sector was not the largest consumer of energy in Vermont. As shown in Figure 4-1, transportation energy consumption accounted for 34% of the state's total energy consumption in 2019, down from 36% in 2017. The drop in the share of energy consumption in the transportation sector reflects both a gradual decrease in transportation energy consumption beginning in 2006 and a concurrent increase in residential energy consumption during the same period Figure 4-3). In 2019 46.3 trillion Btu of energy were consumed for transportation purposes in Vermont (U.S. EIA, 2021).

Consistent with previous years, Vermont's per capita transportation energy use in 2019, 74.2 million Btu, was below the national average of 82.8 million Btu. In contrast, per capita transportation energy consumption in three of the four rural comparison states is above the national average (Figure 4-2).[7] Vermont's relatively low energy use reflects lower per capita consumption of aviation fuels and diesel, pointing to relatively low air travel and heavy-duty vehicle activity.

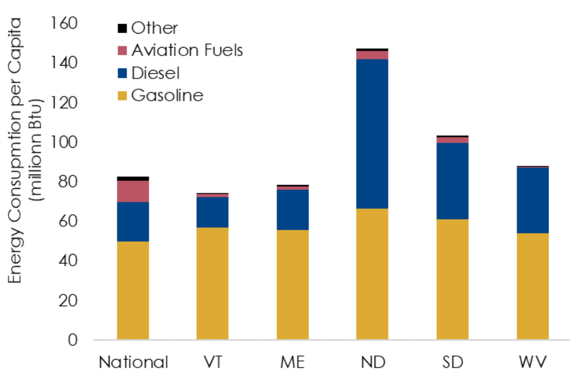


Figure 4-2. 2019 Per Capita Transportation Sector Energy Consumption (U.S. EIA, 2021)

VT TRANSPORTATION ENERGY CONSUMPTION

Overview: The transportation sector is responsible for 34% of total energy consumption in Vermont (Figure 4-1). More than 95% of the energy used for transportation in Vermont is derived from petroleum fuels.

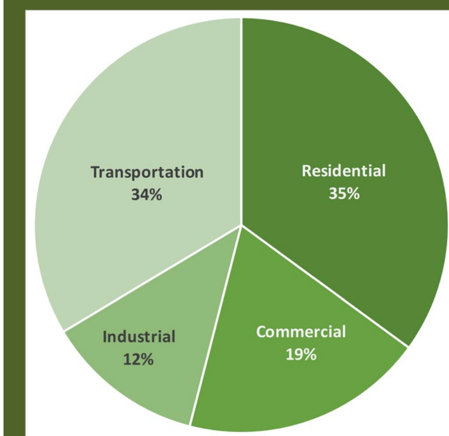


Figure 4-1. Vermont Sectoral Energy Consumption, 2019 (U.S. EIA, 2021)

Status of Alternative Fuel Sales: Increases in the number of PEV registrations and public PEV charging stations indicate a growing role for electricity as a transportation fuel in Vermont although electricity currently provides only 0.1% of total transportation energy. Between 2015 and 2019, ethanol and biodiesel use remained relatively stable, accounting for approximately 6% of transportation energy use.

[7] Excludes natural gas consumption used primarily for pipeline operations.

Petroleum-based fuels accounted for over 95% of the total energy used by the Vermont transportation sector in 2019. Gasoline, including blended ethanol, accounted for 76.7% percent of Vermont's total transportation energy usage, while diesel and blended biodiesel accounted for 20.7%, and jet fuel accounted for an additional 2.2% (U.S. EIA, 2021).

As shown in Figure 4-3, total transportation energy consumption peaked in Vermont in 2006 and gradually declined through 2011. Energy consumption was relatively stable between 2012 and 2017 before declining to 44.5 and 46.3 trillion Btu in 2018 and 2019 respectively (US EIA, 2021). It should be noted that fuel sales in Vermont, (as documented in Section 4.1 below) did not show a comparable decline in 2018 and 2019, and the divergence between these data sources should be monitored going forward. As discussed below in 2020, gasoline and diesel sales declined significantly coinciding with significant shifts in travel behavior brought about by the COVID-19 pandemic, corresponding to an approximately 15% drop in energy use relative to 2019.

Figure 4-3. Transportation and Residential Energy Use in Vermont, 1990 - 2019 (U.S. EIA, 2021)

Sections 4.1 through 4.4 present information on the use of gasoline and diesel, biofuels, electricity, and natural gas for ground transportation. Sales of aviation fuels and natural gas for pipeline operations are not included in this section of the Profile. Tracking and reporting requirements differ for each of these fuel types at the state level. Registrations of alternative fuel vehicles can be used to understand the magnitude of current energy consumption for alternative fuel types.

The fuels that are used for transportation purposes vary considerably in GHG intensity and thus fuel shifting can be an important strategy for GHG emissions reductions. For additional context about these potential GHG reductions, life-cycle GHG intensity estimates certified by the California Air Resource Board (CARB) are provided for each fuel type. The GHG intensity of each fuel provides a way to assess the technical potential for GHG reductions by switching from gasoline or diesel to alternative fuels. Since the degree of fuel switching that can occur is limited by the number of alternative fuel vehicles on the road, projected changes in the composition of the light-duty vehicle fleet, as estimated by the U.S. Energy

Information Agency (EIA), are also reported. The EIA's projections depend on assumptions about relative fuel and vehicle costs as well as about consumer acceptance and thus should not be considered definitive.

The CARB certifies life-cycle GHG intensity values for different fuels and fuel production methods as part of that State's low-carbon fuel standard (LCFS) regulation. These GHG intensity values, reported in grams of CO_{2e} per megajoule (MJ), measure the total GHG emissions related to energy production, distribution, and use for different fuel types, feedstocks, and production methods and account for the impacts of land use change from biofuel production. Because they are specific to feedstocks and production methods (referred to as "fuel pathways") there can be a wide range of GHG intensities for a specific fuel type. Ethanol produced using corn kernels as a feedstock, for example, has a much higher GHG intensity than cellulosic ethanol produced from wheat straw or corn stover.

4.1 Gasoline and Diesel

Gasoline remains the predominant fuel used for ground transportation in Vermont. Diesel constitutes 16–19% of ground transportation fuel sales. Gasoline sales were relatively stable from 2015 through March 2020, while diesel sales fluctuated moderately during this period (Table 4-1 and Figure 4-4). As shown in Figure 4-4, pandemic-related changes in travel patterns resulted in a dramatic reduction in fuels sales beginning in March of 2020. Both gasoline and diesel sales rebounded since their lowest levels but as of July 2021, monthly gasoline and diesel sales remain approximately 10% below July 2019 levels. Gasoline and diesel sales in Table 4-1 and Figure 4-4 include ethanol and biodiesel sold in blended form.

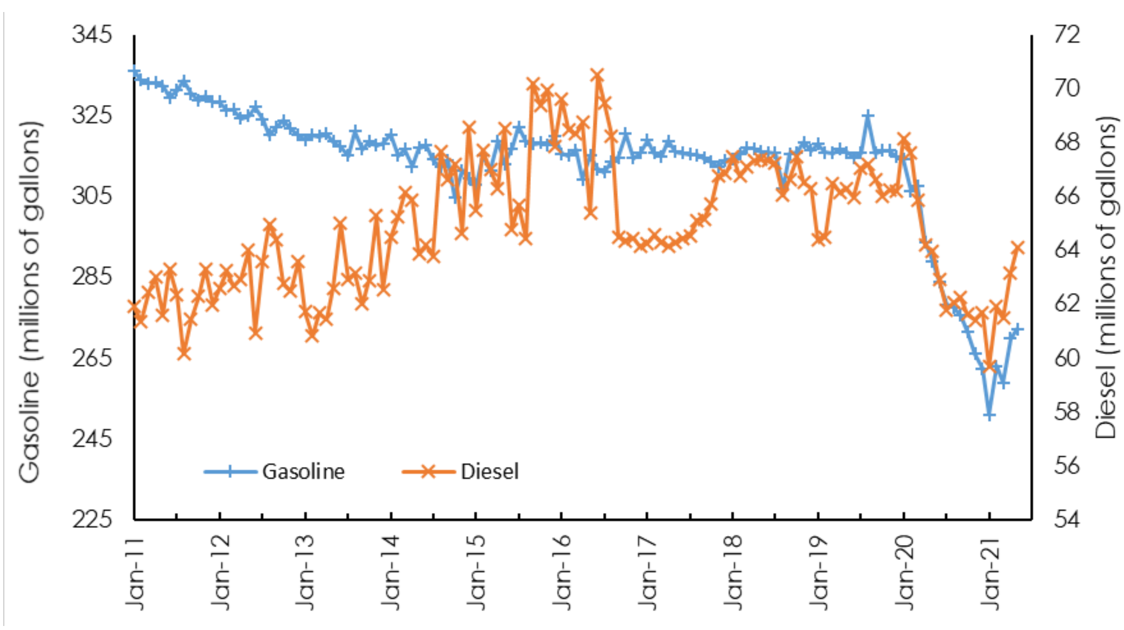


Figure 4-4. Gasoline and Diesel Sales 12-month Rolling Total 2011 – 2021 (VT JFO, 2021)

Table 4-1. Gasoline and Diesel Sales in Vermont, 2011–2020

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Gas	328.3	320.1	318.1	309.4	319.8	315.7	314.0	316.3	314.7	262.4
Diesel	62.0	63.6	62.6	68.6	67.9	64.1	64.1	66.3	66.2	61.7

Note: Sales, in millions of gallons, include blended ethanol and biodiesel.
Source: VT JFO, 2021

The CARB GHG intensity values for gasoline and diesel are 100.8 and 100.5 g CO_{2e}/MJ respectively. At the national level, the EIA projects that between 2020 and 2030 the share of gasoline and diesel ICEVs and HEVs will increase slightly from 91.3% to 91.5% of the total light duty vehicle stock. The growth in the share of gasoline and diesel vehicles reflects a projected increase in the stock of HEVs as well as a declining stock of ethanol flex fuel vehicles (U.S. EIA, 2021c).

4.2 Biofuels

The two primary transportation biofuels are conventional ethanol and biodiesel. Conventional ethanol is produced from starches in organic materials such as corn and sugar cane. Biodiesel is produced via transesterification from either raw feedstock (e.g. soybeans or rapeseed) or waste vegetable oil. Conventional ethanol and biodiesel account for over 95% of national biofuel production. Advanced biofuels, including cellulosic ethanol and renewable diesel (which is distinct from biodiesel and meets the same fuel specifications as conventional diesel), account for 4.4% of biofuel production (Moriarty et al., 2020).

Beginning in 2020, the U.S. EIA State Energy Data System has provided state-specific estimates for both ethanol and biodiesel consumption. In 2019, the transportation sector in Vermont consumed 29.2 million gallons of ethanol and 2.2 million gallons of biodiesel (U.S. EIA, 2021). On an energy basis, 29.2 million gallons of ethanol and 2.2 million gallons of biodiesel provide 2.7 trillion Btu of energy, which represents 5.9% of the total energy consumed by the transportation sector in Vermont. 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.

Both ethanol and biodiesel are predominantly sold in blended form. Ethanol is most commonly sold as E10, comprised of 10% ethanol and 90% gasoline by volume. E10 is compatible with all gasoline vehicles. E15 is approved for all vehicles model year 2001 and newer but its availability is much more limited. Only flex fuel vehicles are capable of burning E85 and other high concentration blends. The immediate potential for growth in ethanol sales is low because gasoline sales are already dominated by E10, meaning there are limited opportunities for increasing the share of ethanol sold in blended form, a phenomenon often referred to as the blend wall (Moriarty et al., 2020). Between 2020 and 2030, the EIA projects the stock of flex fuel ethanol vehicles in the US will decline from 8% of the light duty vehicle stock to 6.7% of the stock (U.S. EIA, 2021c).

Biodiesel is sold primarily as B5, which contains up to 5% biodiesel by volume, and B20, which contains up to 20% biodiesel by volume. B5 is compatible with all diesel vehicles and is not required to be labeled at the pump. Vehicle compatibility with

B20 varies by manufacture and vehicle. Currently, 80% of vehicle manufactures approve the use of B20 in at least some on-road vehicles (AFDC, 2017a). In 2019, biodiesel comprised approximately 3% of at-the-pump diesel sales. Biodiesel in blends B20 and higher is currently only publicly available at two locations in Vermont (AFDC, 2021). Nationally, biodiesel production is heavily influenced by the Renewable Fuel Standard (RFS) and a biodiesel tax credit (Moriarty, 2020). As shown in Figure 4-5, Vermont's ethanol and biodiesel consumption patterns are broadly similar to those seen nationally, reflecting the significant role of federal policy in biofuels production.

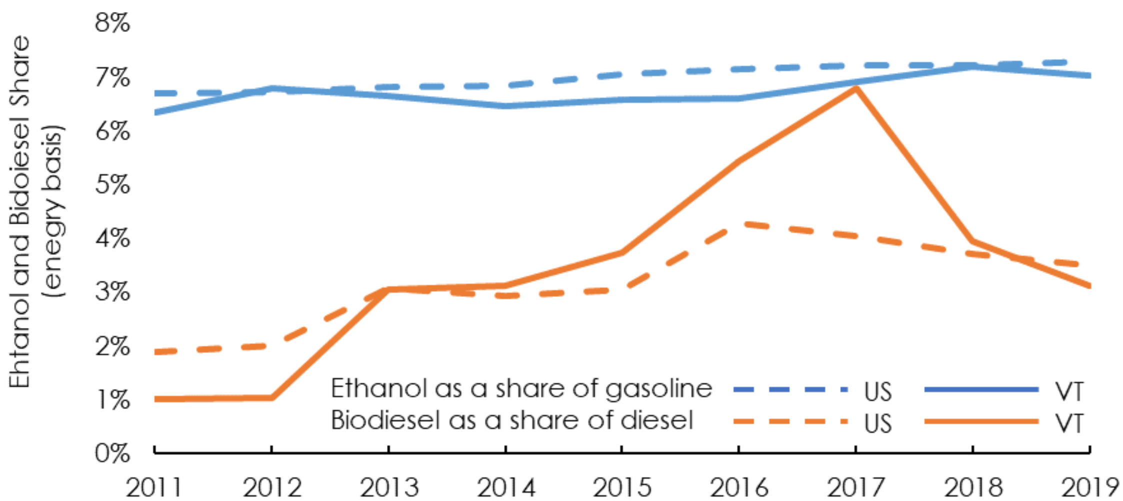


Figure 4-5. Ethanol as a Share of Gasoline and Biodiesel as a Share of Diesel, 2011-2019 (U.S. EIA, 2021)

The default 2020 carbon intensities for ethanol and biodiesel are 68.57 and 30.87 grams CO2e/MJ respectively (CARB 2021). This represents a GHG savings of approximately 32% for ethanol relative to gasoline and 70% for biodiesel relative to diesel. Although some biodiesel and ethanol fuels that are produced from plant residues and waste products have GHG intensities that are 85% to 90% lower than gasoline, these fuels are not currently produced and sold in large volumes.

4.3 Electricity

As discussed in Section 3, PEV registrations have 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 public charging stations. As of September 2021, there were a total of 309 publicly accessible electric charging stations in Vermont, an increase of 84 charging stations since August 2019. Table 4-2 shows the total number of charging stations and plugs by charger and connection type.

Table 4-2. Publicly Accessible Charging Stations in Vermont, 2021

	Charger Type			Connectors			
	Level 1	Level 2	DC Fast	J1772	CHAdeMO	SAE CCS	Tesla
Stations	15	272	32	253	24	20	49
Outlets	71	688	74	528	30	26	198

Source: AFDC, 2021

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 4-3. These calculations are based on several assumptions, including the distance that PEVs drive and their electric drive efficiency. For Table 4-3, PEVs are assumed to be driven at the average VMT per vehicle for the state of Vermont. Electric Drive Efficiency Values are taken from Argonne National Laboratory (Gohlke and Zhou, 2021). PHEVs are assumed to travel 55% of the time on electric power (AFDC, 2017b). Based on these assumptions, 2020 total electricity demand is estimated at over 13 million kWh. This equates to 46.7 billion Btu or approximately 0.1% of the direct transportation energy use in the state.

Table 4-3. Estimated PEV Electricity Consumption in Vermont for 2020

EV Type	Number of Registered Vehicles (December 2020)	Annual Miles Driven	Miles Driven on Electricity	Average Electric Drive Efficiency (kWh/mi)	Total Electricity Use (kWh)
AEV	2063	12,724	100%	0.306	8,032,389
PHEV	2297	12,724	55%	0.352	5,658,358
				Total	13,690,747

Adjusted for the efficiency of PEVs, CARB-certified GHG intensity values for electricity range from 0 grams CO_2e/MJ for carbon-free electricity sources to 81 grams CO_2e/MJ for the average grid electricity in California. Between 2020 and 2030 the EIA projects the share of PEVs to increase from 0.6% of the US light-duty vehicle stock to 1.8% of the light duty vehicle stock (U.S. EIA, 2021c). Growth in the PEV vehicles stock in Vermont would have to significantly exceed these projections in order to meet the target of 10% fleet electrification specified in the CEP.

4.4 Compressed and Liquefied Natural Gas

Natural gas can be used as a transportation fuel in either compressed or liquefied form. Compressed natural gas (CNG) is pressurized to increase its energy density and is used in light-, medium-, and heavy-duty vehicles. Liquefied Natural Gas (LNG) is super-cooled to increase its energy density. LNG has a higher energy density than CNG, providing a greater range than CNG for an equivalent volume of fuel. LNG has higher production costs than CNG and requires dedicated distribution infrastructure and is generally used in medium- and heavy-duty vehicles.

The CNG fleet currently consists of four commercial fleets, made up primarily of heavy-duty vehicles. 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.

Table 4-4. Vermont CNG Fleet

Fleet Operator	CNG Vehicles
University of Vermont	9 heavy-duty transit vehicles
City of Burlington	3 heavy-duty refuse vehicles
Casella Waste Systems	11 heavy-duty refuse vehicles
Vermont Gas Systems	1 automobile 6 service vans

Although lower tailpipe emissions and lower fuel costs make CNG an attractive alternative to petroleum, the limited geographic availability of natural gas supplies and fueling infrastructure inhibit the 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 onboard fuel storage systems.

CARB-certified GHG intensity values for conventional CNG range from 78 to 94 grams CO2e/MJ. Conventional LNG ranges from 86 to 91 grams CO2e/MJ. CNG and LNG derived from the anaerobic decomposition of organic matter (such as animal manure, food scraps, and landfill materials) are frequently referred to as renewable natural gas (RNG). RNG has a significantly lower GHG intensity than conventional CNG or LNG. Four RNG pathways that use manure and food waste for feedstocks have negative GHG intensity scores in the CARB rating system. Other CARB-certified GHG intensity values for RNG (in both compressed and liquified form) range from 0 to 81 grams CO2e/MJ. Between 2020 and 2030, the EIA projects the market share for light-duty natural gas vehicles to decline from 0.04% of the US light duty vehicle stock to 0.03% of the stock (U.S. EIA, 2021) reflecting the very limited availability of light duty natural gas vehicles. Changes in the heavy-duty vehicle stock are not projected by the EIA and this is the vehicle segment that is likely to see growth in CNG and LNG vehicle uptake.

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 (including through TDM), increasing vehicle energy efficiency, and switching to low-carbon fuels (e.g., electricity generated by renewable sources) all help to reduce GHG emissions.

Historical Trend: Analysis of fuel sales data by VT ANR suggests that transportation sector GHG emissions have been falling gradually since 2004 but remain 3.3% higher than the

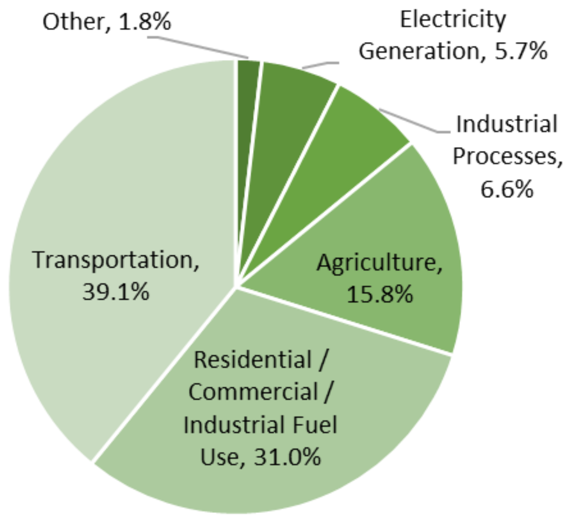


Figure 5-1. Vermont GHG Emissions by Sector, 2017 (VT ANR, 2021)

The transportation sector remains the largest single source of GHG emissions in the state of Vermont as shown in Figure 5-1. These emissions are largely the result of burning fossil fuels with smaller contributions from biofuel combustion and PEV charging, as discussed in Sections 4.2 and 4.3. Transportation-sector GHG emissions since 1990 are shown in Figure 5-2.

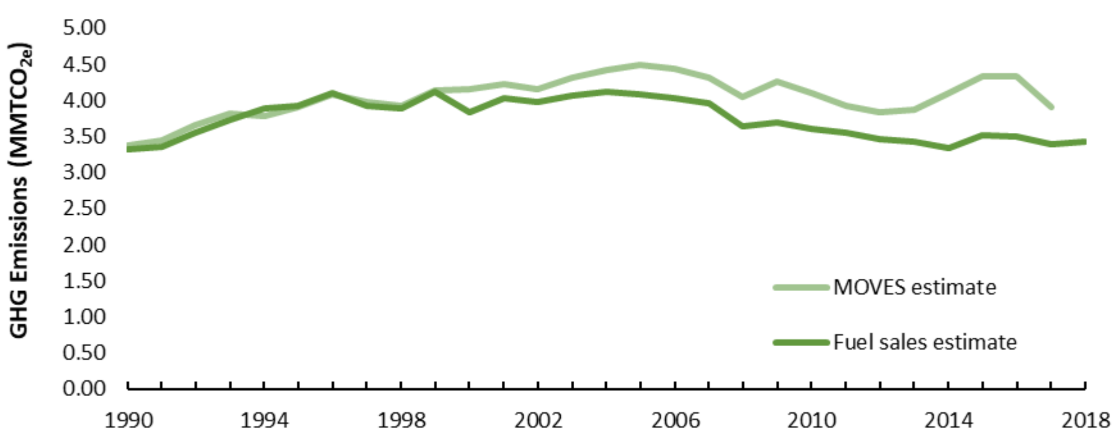


Figure 5-2. Transportation Sector GHG Emissions 1990-2018 (VT ANR 2021)

Figure 5-2 shows GHG emissions estimates calculated using the EPA's Motor Vehicle Emissions Simulator, also known as MOVES, as well as a fuel sales-based estimates calculated using the EPA's State Inventory Tool. The Agency of Natural Resources (ANR) changed calculation methodologies in 2021 because of a growing divergence between the results of these two methods (VT ANR, 2021). MOVES simulates GHG emissions, including methane and nitrous oxide, for vehicles registered in Vermont, accounting 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 fuel sales and VMT data. It provides more granular outputs than a fuels sales-based approach but, as noted in the 2019 edition of the Profile, this method showed significantly higher GHG emissions than estimates based on fuel sales data in recent years. As described in the 1990-2017 Inventory (VT ANR, 2021), the cause of this divergence is not clear, but the MOVES method relies on modeling inputs and assumptions that include significant uncertainties. Ultimately ANR opted to use fuel sales data and the EPA's State Inventory Tool to calculate GHG emissions going forward. The fuel sales-based methodology indicates that GHG emissions peaked in 2004 and have gradually decreased since that time.

As a complement to the ANR estimate, CO_2 emissions through 2020 were estimated based on fuel sales data collected by the VT JFO and on the electricity demand estimates made in Section 4.3. This estimate, shown in Figure 5-3, also includes emissions from ethanol and biodiesel sold in blended form, which are not included in the ANR calculations, based on the sales volumes reported in Section 4.2. As noted previously and in the CEP, the net impact of biofuels on atmospheric GHGs is uncertain, so this portion of the estimates should be interpreted with caution. Using the average GHG intensity of the New England grid, electricity-related emissions were less than 2,000 metric tons for 2020 and thus are not visible on the figure. Additionally, note that this method only calculates CO_2 emissions and does 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, 2016b).

The impacts of pandemic-related travel changes on 2020 GHG emissions are readily apparent in Figure 5-3 as 2020 emissions are 15% below 2019 levels. As with other pandemic-related impacts, there is a great deal of uncertainty about how quickly and to what extent GHG emissions will rebound to pre-pandemic levels. Maintaining some behavior changes seen during the pandemic, such as increased telework, may lower emissions if they are not accompanied by increases in travel to non-work locations, while other trends, such as a reduction in transit use, could increase GHG emissions if transit riders switch to less efficient travel modes.

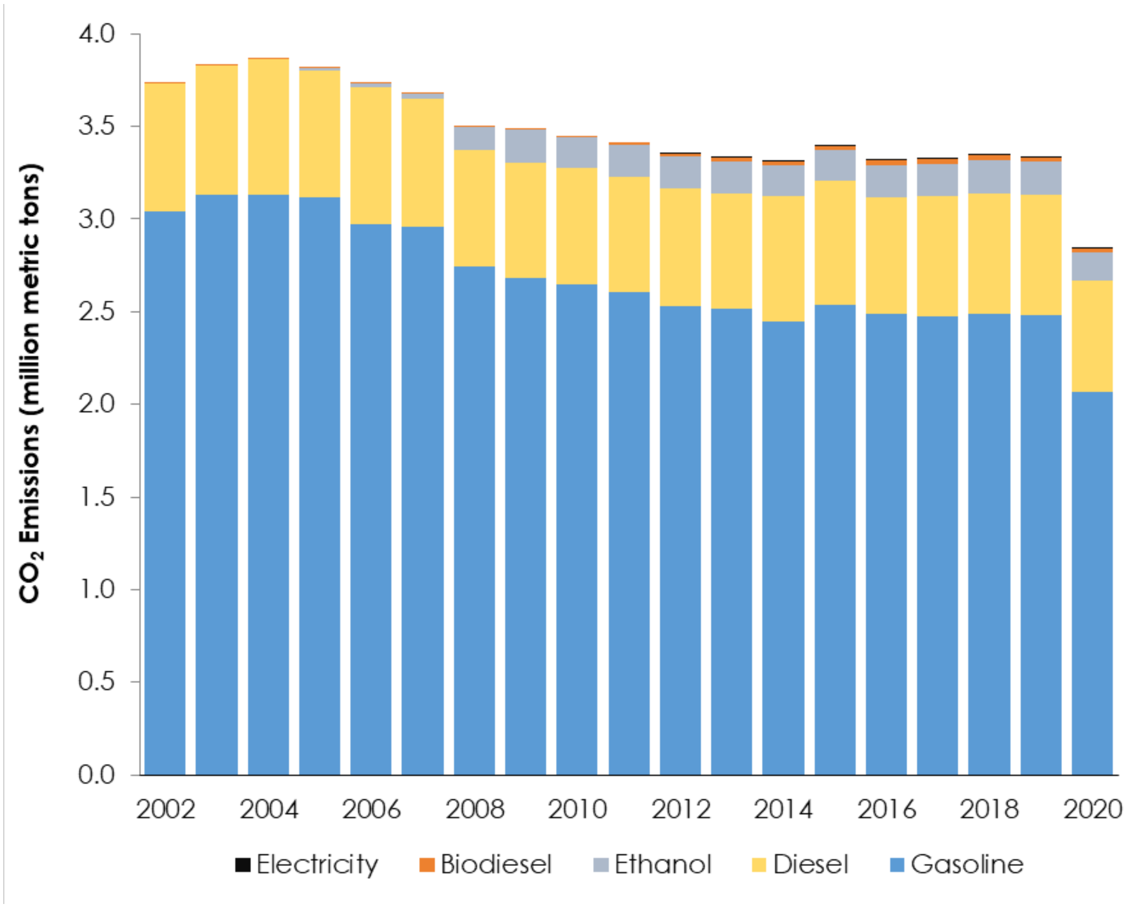


Figure 5-3. Vermont CO_2 Emissions from Ground Transportation, 2002-2020

6 Freight Transport

Transporting goods and commodities to, from, within, and through Vermont is an essential underpinning of the state economy. The state's freight network consists of the highway system, rail lines, airports, and pipelines. At 320 Btu per ton-mile, the average energy intensity of rail is less than a quarter of the energy intensity of truck transport at 1,390 Btu per ton-mile (Grenzeback et al., 2013), though the specific energy intensity of each mode depends on several factors including utilization levels and the commodity being transported. For this reason, the CEP calls for doubling rail freight tonnage relative to 2011 levels (Objective 7 in Table 1-1). As of 2018, rail was estimated to carry 6.9 million tons of freight in Vermont, an increase of 300,000 tons since 2011 (Cambrige Systematics et al., 2021).

Collecting freight data is challenging given the proprietary nature of the movement of goods, and the quality of freight flow estimates vary considerably depending upon mode choice and type of commodity. The Freight Analysis Framework (FAF), produced by Oak Ridge National Laboratory (ORNL), is a primary source of freight information for US states and is created based on the Commodity Flow Survey which was most recently conducted in 2017. At the state level, the FAF estimates freight movements that originate within, end within, or travel entirely within each state, however, the FAF does not provide estimates of pass-through freight traffic at the state level (ORNL, 2021).

As noted in the "Commodity Flow and Economic Futures" report produced for the 2021 update to the Vermont Freight Plan, the Surface Transportation Board's (STB) Carload Waybill Sample is considered the best source of rail freight data and was used in place of FAF estimates for that report.

Consequently, the rail freight data presented in Section 6.1 draws on the Commodity Flow & Economic Futures report while Section 6.2 draws on FAF5.1 which was released after the completion of that report.

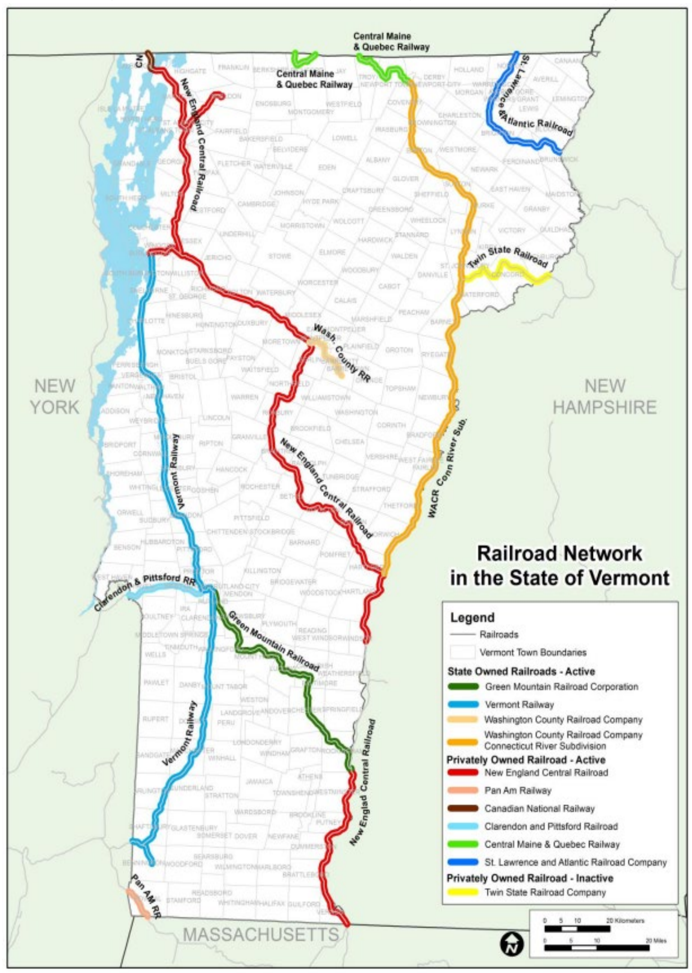


Figure 6-1. Vermont's Rail Network (VTrans, 2021)

6.1 Vermont Rail Freight

The state rail network consists of 578 total miles of rail bed, all of which are available for freight service, and which are serviced by short line and regional railroads (VTrans, 2015). A map of the current rail system is shown in Figure 6-1. The Vermont rail system is not currently experiencing any significant congestion issues (Cambridge Systematics, 2021). Freight rail tonnage increased modestly from 2011 to 2018 as shown in Table 6-1.

Table 6-1. Vermont Rail-Tonnage 2011 and 2018

	2011 Rail Tonnage	2018 Rail Tonnage
Pass-through Tonnage	4.6 million	4.0
Intrastate, Inbound & Outbound Tonnage	2.1 million	2.9
Total	6.6 million	6.9

Note: 2011 components do not sum to total due to independent rounding

Source: VTrans, 2015; Cambridge Systematics 2021

6.2 Other Modal Flows

According to the most recent FAF5 data release, transport of 36 million tons of freight originated and/or terminated in Vermont in 2017 (ORNL 2021). This volume includes inbound and outbound freight movements as well as all freight movements internal to Vermont but excludes freight that passed through Vermont that neither originated nor terminated in Vermont. Trucking was the dominant mode of transport for freight originating or terminating in Vermont, accounting for 84% of the total freight tonnage transported. Rail accounted for 6% of all freight tonnage. A complete modal breakdown of all freight movements in 2017 in thousands of tons is shown in Table 6-2.

Table 6-2. Freight Movement in Vermont by Mode, 2017

Mode	Intrastate	Outbound	Inbound	Total
Truck	13,342	8,982	7,927	30,250
Rail	532	1,195	403	2,130
Multiple Modes/Mail	6	2,958	498	3,462
Air	0	3	6	9
Other	1	12	180	193
Total	13,880	13,150	9,013	36,043

Note: All values in thousands of tons.

Source: ORNL, 2021

Note that the tonnage for intrastate, inbound, and outbound rail freight differs between Table 6-1 and Table 6-2 due to alternative estimates in FAF5 and the STB Waybill reported in the Commodity Flow and Economic Futures report and that the STB Waybill is considered a more reliable estimate at the state level.

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. In order to conduct this assessment, the recent trend in each metric was extrapolated out to the target date and compared to the CEP goal for that date.[8] When the extrapolated value did not meet the CEP target, the State's progress was assessed as lagging behind the CEP target. For example, the CEP calls for the State to reduce transportation energy use from 48.3 trillion Btu to 38.6 trillion Btu by 2025. Extrapolating from the last five years of data, however, demonstrates that if current trends continue transportation energy consumption will total 40.7 trillion Btu in 2025, and thus that energy reductions are currently lagging the CEP target.

Two figures are provided to illustrate the evaluation of each metric. The first shows the historical data for that metric and the linear path needed to achieve the associated CEP target over the full implementation period – from the date the target was first established through the target date. The second figure includes the extrapolated linear trend based on the last five years of data and an updated path needed to achieve the CEP target from the date of the most recently available data through the target date. When the State is lagging in achieving these targets, the updated paths are steeper, that is, they require a larger annual change to hit the CEP targets than the initial pathways.

As discussed throughout this Profile, pandemic-related changes to travel behavior in 2020 and 2021 impacted several of the transportation metrics specified in the CEP. In many cases, currently available data do not capture or do not yet fully capture these changes and there is a great deal of uncertainty about the extent to which they will persist into the future. Consequently, there is likely to be significant volatility in the trends presented here over the next several years of data reporting.

Several data collection and methodological changes implemented since the 2019 Profile should also be noted when comparing these findings to past editions of the Profile. Notably, updates to historical energy usage estimates by the U.S. EIA and GHG emissions calculations methodologies by VT ANR resulted in substantial changes in the State's energy use and GHG emissions and now show Vermont closer to achieving its energy and GHG targets than in the past. In addition, the metrics related to commute mode share now include individuals who work from home in the commuter pool so the share of other modes differs from past Profiles, as discussed in Section 2.2.

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 progress given the long active life of cars and trucks. Thus, where the State is not currently on pace to achieve a particular goal or objective should not be taken to mean that the target cannot be achieved but may indicate that additional policy

[8] Current trends are calculated based on the last five years of data using a least squares linear fitting process. This method finds the straight line which minimizes the sum of the squared residuals between the line and the empirical data points.

measures are warranted. Nonetheless, a substantial gap between the extrapolated path and the linear trend required to meet the CEP targets may be evidence that additional policies may need to be implemented to achieve these targets.

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: Progress lagging target.

- 2015 Baseline: 48.3 trillion Btu[9]
- 2025 Target: 38.6 trillion Btu
- Extrapolated 2025 Value: 40.7 trillion Btu
- Average Reduction (2020-25) Needed to Achieve Target: 1.3 trillion Btu /yr

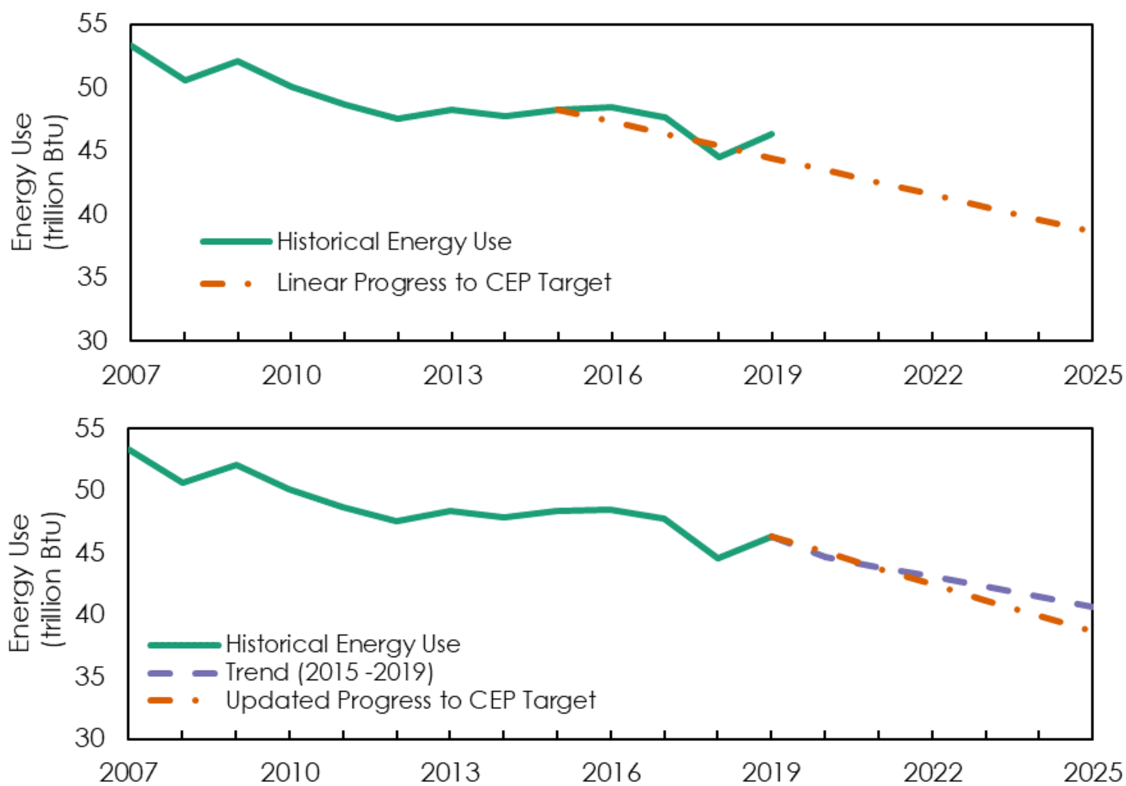


Figure 7-1. Trends in total transportation energy use

Outlook: The decline in energy consumption largely reflects a modest drop in VMT from 2007 and improvements in vehicle fuel efficiency during the 2010s. The current trend in the SEDS data approaches the reductions required by the CEP but is strongly influenced by the historically low energy use estimate for 2018. Cross-checking these estimates with VJFO fuel sales data indicates that caution is merited with regards to this trend, as fuel sales did not decline comparably in 2018.

Data Sources: U.S. EIA State Energy Data System (SEDS).

[9] Note, the 2015 baseline energy use and 2025 target reported in the 2019 Profile were 49 and 39.2 trillion Btus respectively. Current values reflect ongoing methodological changes implemented by the EIA's SEDS program.

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: Progress lagging target.

- 2015 Baseline: 5.5%
- 2025 Target: 10%
- Extrapolated 2025 Value: 7%
- Average Growth (2020-2025) Needed to Achieve Target: 0.65%

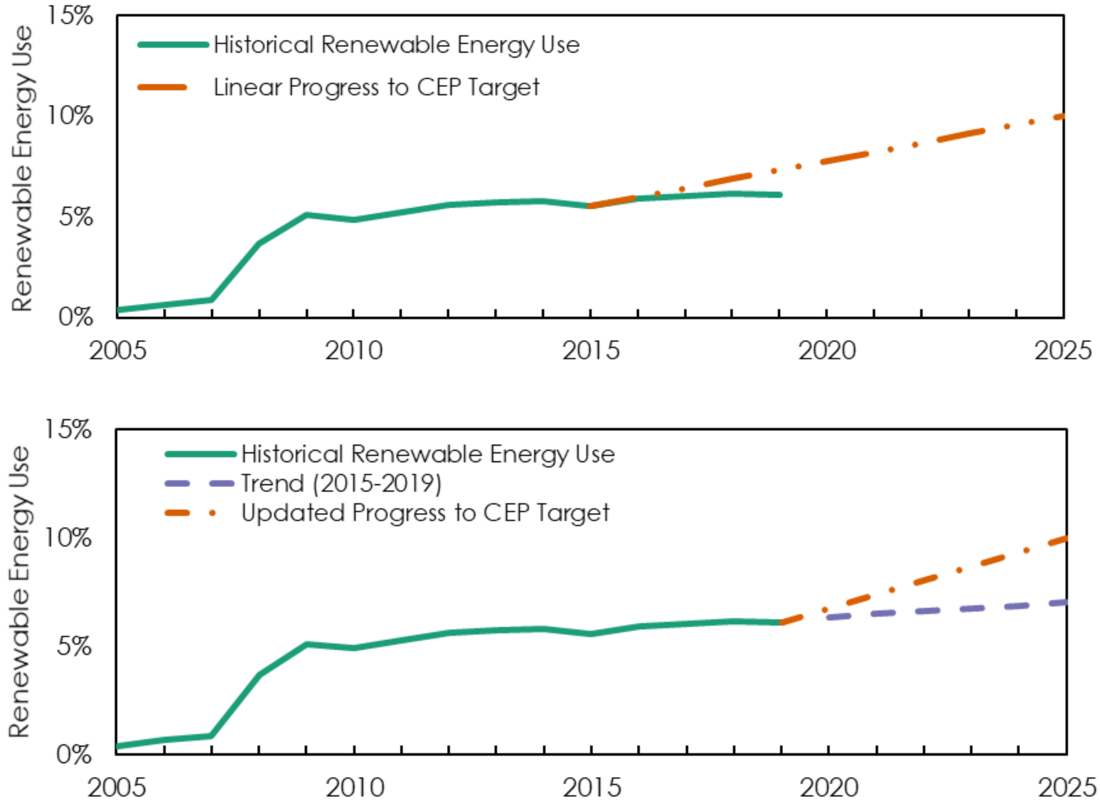


Figure 7-2. Trends in renewable energy use

Outlook: There is relatively little potential for growth in blended ethanol sales in the near future as ethanol sales are limited by the E10 blend wall and the CEP does not support the promotion of E-85 infrastructure because of environmental concerns about ethanol production. Significant growth in biodiesel and renewable electricity for PEV charging will be needed to achieve this goal. Biodiesel use peaked in 2017 and has declined over the past two years. PEV registrations are increasing but not as quickly as envisioned in the CEP.

Data Sources: Ethanol and biodiesel use is estimated in the U.S. EIA SEDS. Electricity for PEV charging is estimated based on VDMV registration data.

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: Progress lagging target.

- 1990 Baseline: 3.32 million metric tons CO_2e
- 2025 Target: 2.32 million metric tons CO_2e
- Extrapolated 2025 Value: 3.48 million metric tons CO_2e
- Average Reduction (2019-2025) Needed to Achieve Target: 0.16 MMT CO_2e/yr

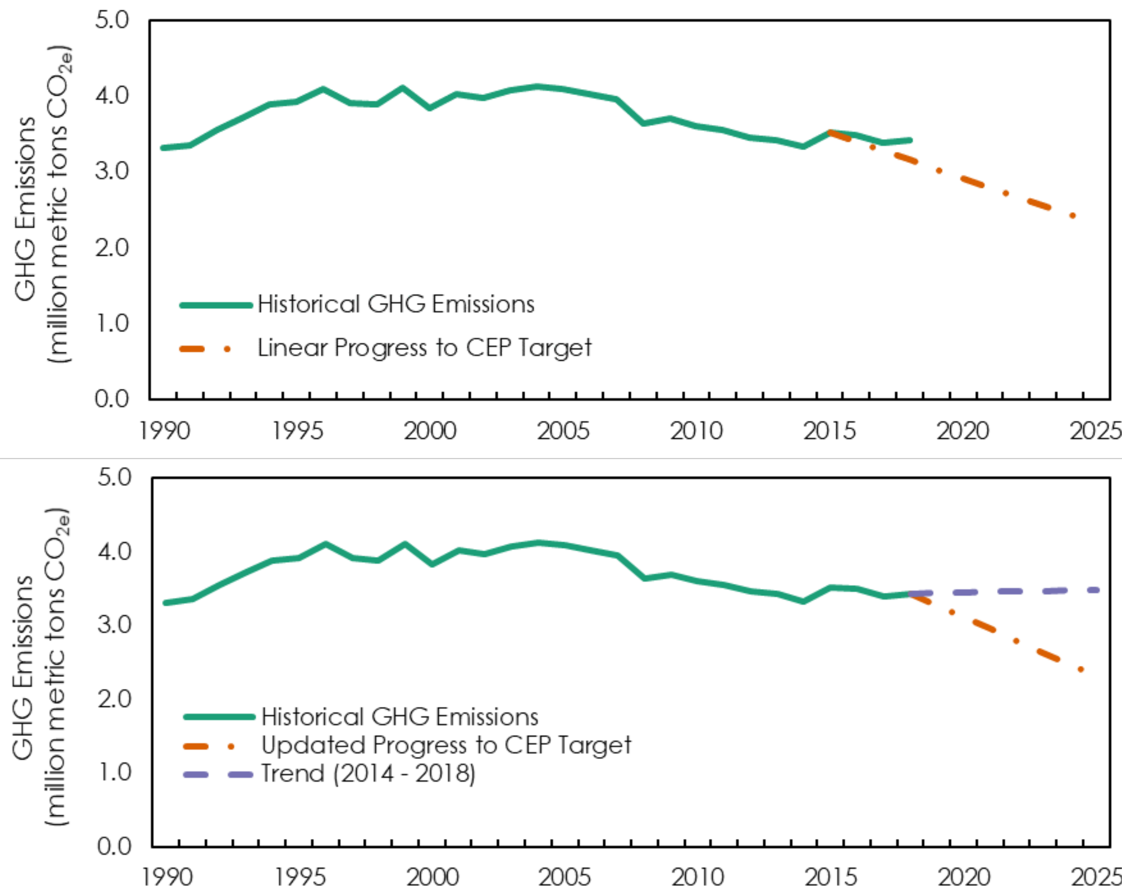


Figure 7-3. Trends in GHG emissions

Outlook: VT ANR's updated GHG calculation methodology shows only a very modest increase in GHG emissions rates from 2013-2018. Over this period, vehicle energy efficiency and GHG intensity have improved, reflecting fleet turnover, tightening CAFE standards, and increasing PEV registrations. At the same time, VMT has increased, negating some of the benefits of a cleaner fleet. Further reducing GHG emissions will require a combination of reducing VMT and reducing the GHG intensity per mile traveled by increasing fuel economy and switching to vehicles with lower LCA GHG profiles.

Data Sources: The Vermont Greenhouse Gas Inventory produced by VT ANR.

7.4 Objective 1: Per Capita VMT

Objective: Hold VMT per capita to 2011 base year value of 11,390.

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

Current Status: Progress lagging target.

- 2011 Baseline: 11,390 miles
- 2030 Target: 11,390 miles
- Extrapolated 2030 Value: 11,892 miles
- Average Reduction (2020-2030) Needed to Achieve Target: 34.8 miles

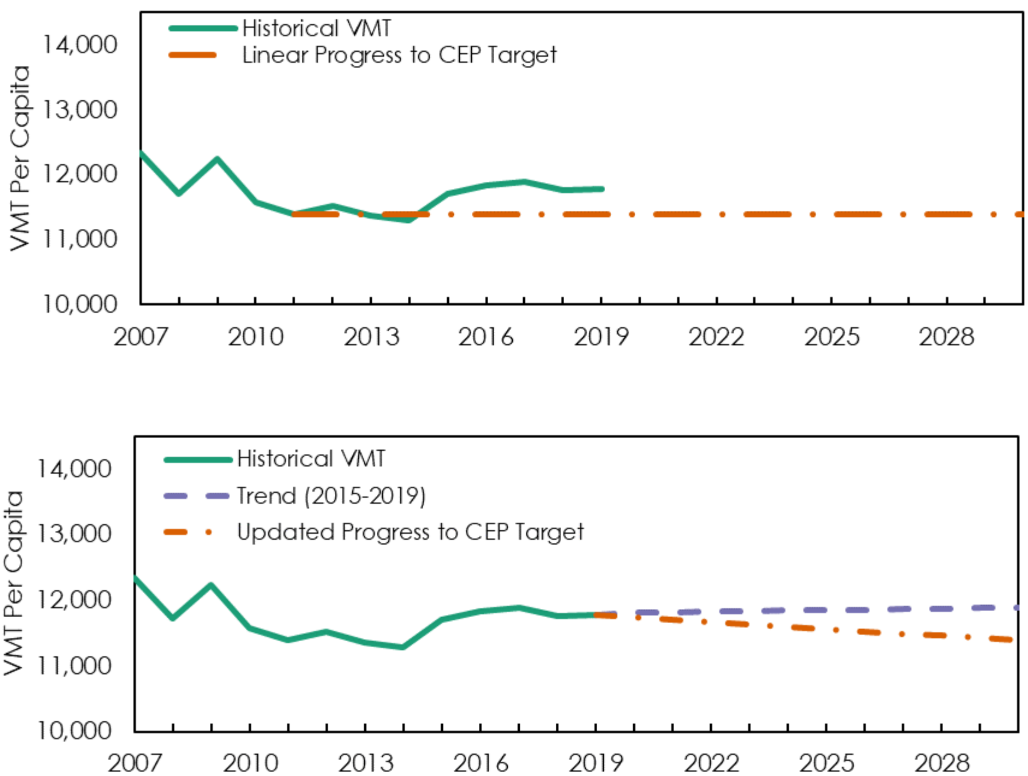


Figure 7-4. Trends in per capita VMT

Outlook: Per capita, VMT increased marginally from 2011 to 2019. The 2023 Profile will likely show a significant drop in VMT for 2020 and a subsequent rebound in 2021 due to pandemic-related travel disruptions.

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

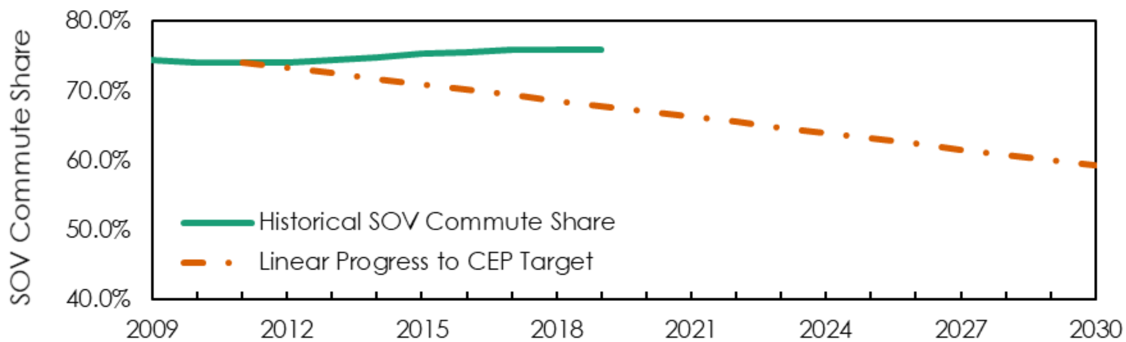
7.5 Objective 2: Reduce SOV Commute Trips

Objective: Reduce the 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: 74.4%
- 2030 Target: 59.3%
- Extrapolated 2030 Value: 77.2%
- Average Reduction (2020-2030) Needed to Achieve Target: 1.5% per year



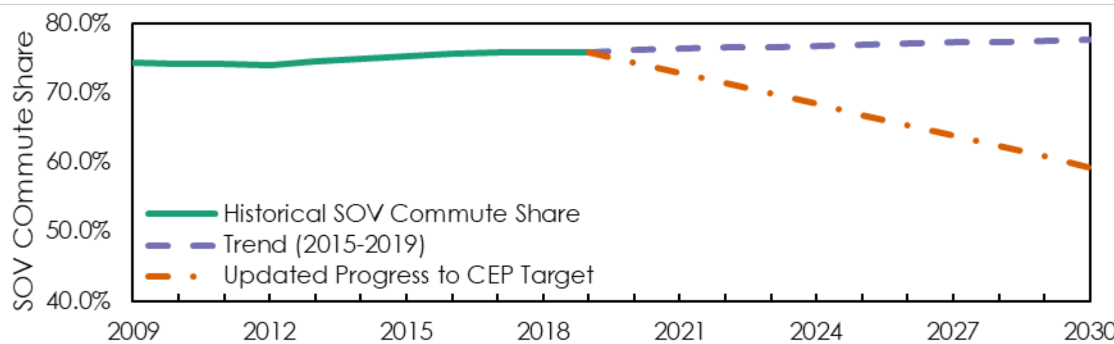


Figure 7-5. Trends in SOV commute mode share

Outlook: Achieving the CEP target will require an average decrease in SOV commute share of 1.5% per year from 2019 through 2030. SOV commute share increased from 2011 through 2019. Pandemic-related changes to travel behavior resulted in an increase in telecommuting but it is unclear how persistent these changes will be.

Data Sources: American Community Survey.

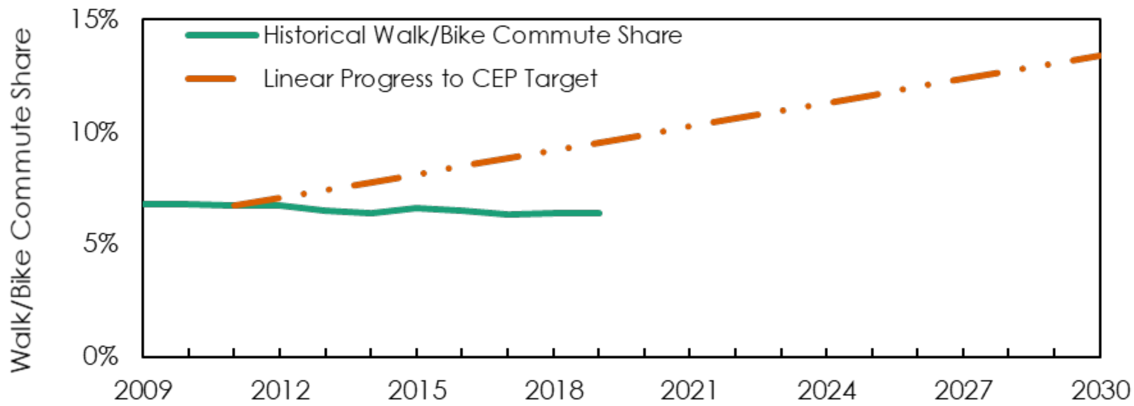
7.6 Objective 3: Increase Bike/Ped Commute Trips

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

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

Current Status: Progress lagging target.

- 2011 Baseline: 6.7%%
- 2030 Target: 13.4%
- Extrapolated 2030 Value: 6.23%
- Average Growth (2020-2030) Needed to Achieve Target: 0.6% per year



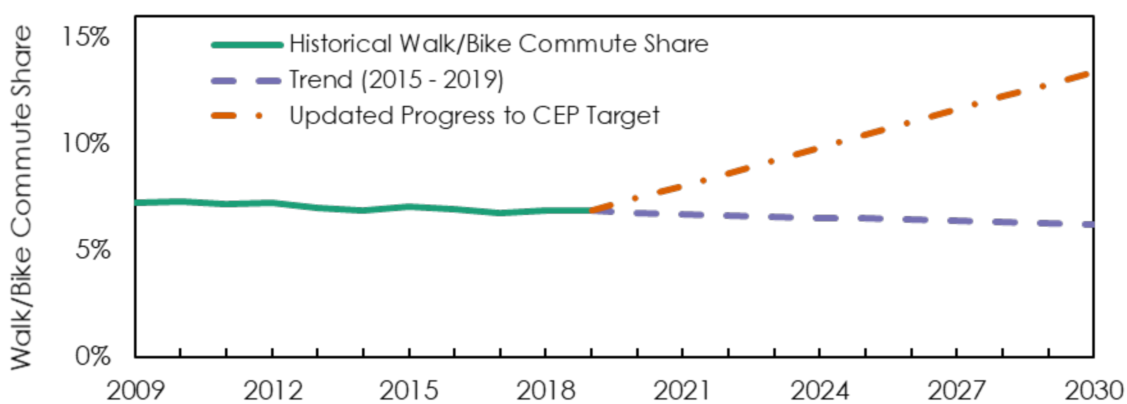


Figure 7-6. Trends in walk/bike commute mode share

Outlook: Achieving the CEP target will require an average increase in bicycle/pedestrian commute share of 0.6% per year from 2020 through 2030 but recent data show a gradual downward trend in bicycle/pedestrian commute share. Pandemic-related changes to travel behavior resulted in an increase and telecommuting but it is unclear how persistent these changes will be.

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: 1,140
- 2030 Target: 3,426
- Extrapolated 2030 Value: 2,274
- Average Growth (2022-2030) Needed to Achieve Target: 188 parking spaces per year

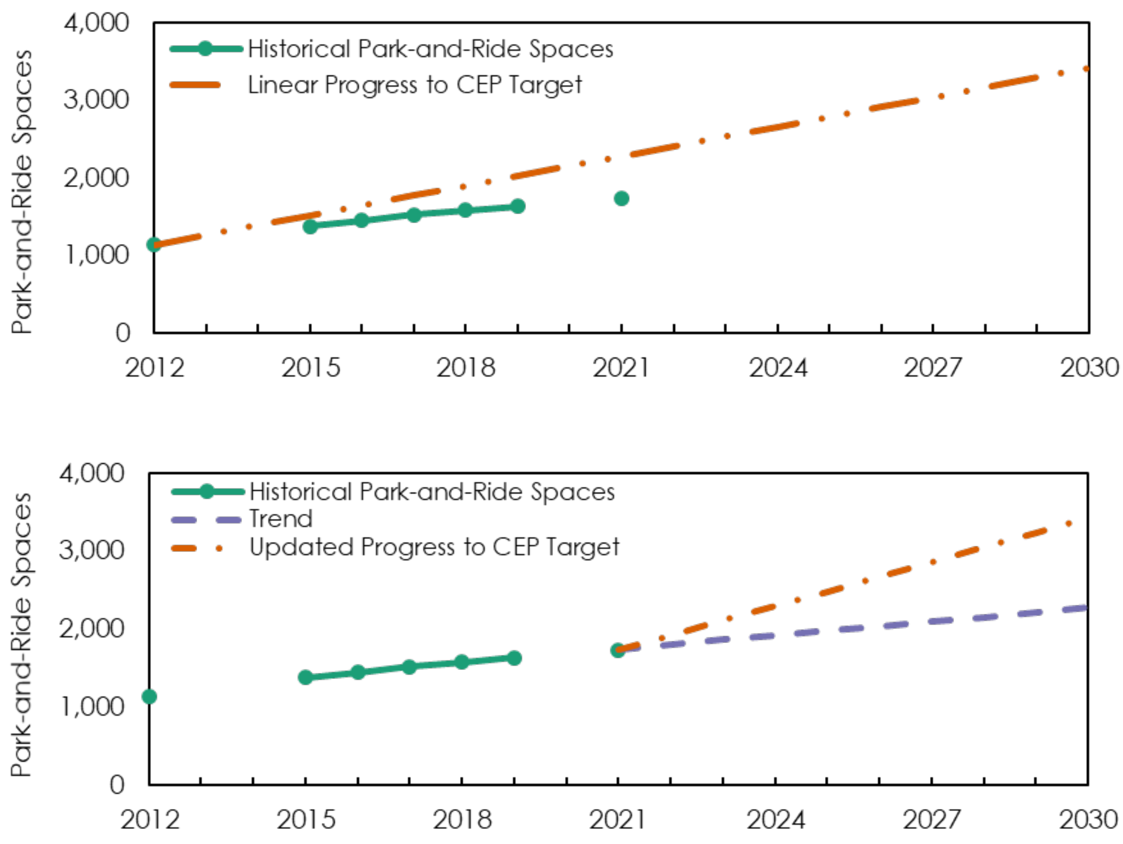


Figure 7-7. Trends in state park-and-ride spaces

Outlook: Achieving this target will require an average increase of 188 park-and-ride spaces per year from 2022 through 2030.

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: 4.57 million trips
- 2030 Target: 8.7 million trips
- Extrapolated 2030 Value: 3.87 million trips (or 5.14 million trips if the pandemic had not affected transit and 2020 and 2021 maintained 2019 ridership levels)
- Average Growth (2021-2030) Needed to Achieve Target: 454,500 trips/year (or 397,000 trips/year from 2022 to 2030 if the pandemic had not affected transit and 2020 and 2021 maintained 2019 ridership levels)

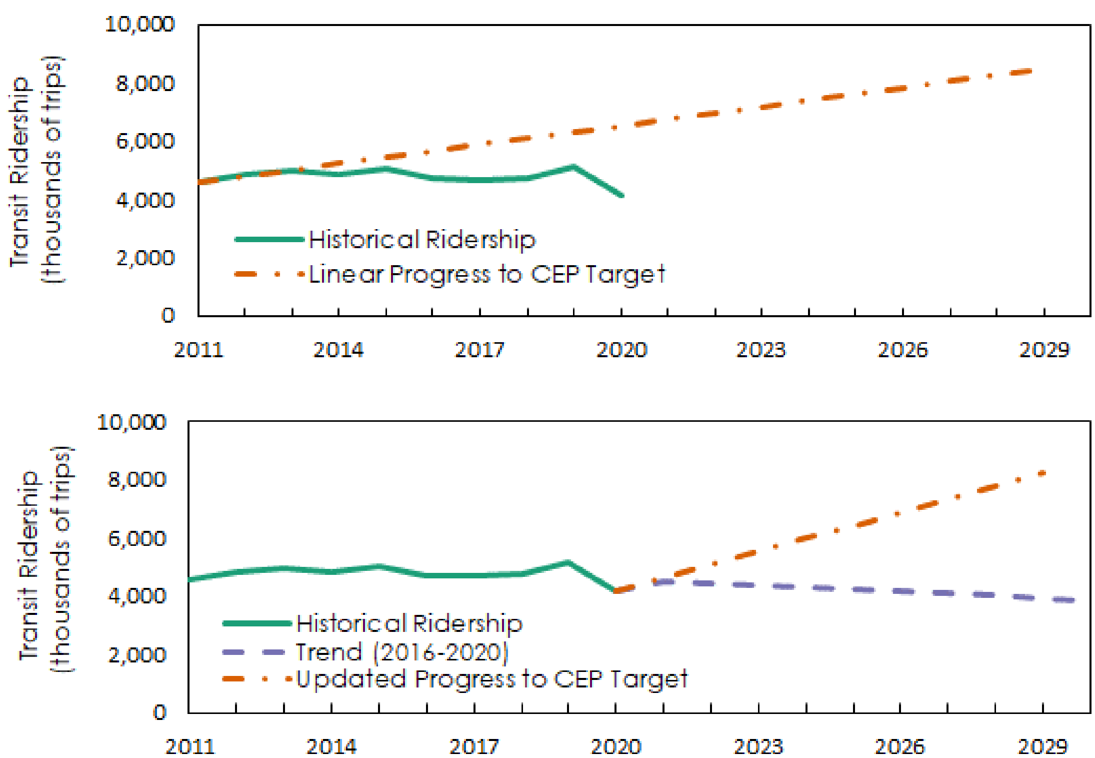


Figure 7-8. Trends in public transit ridership

Outlook: Achieving the CEP target of 8.7 million trips will require an average annual increase of over 450,000 trips per year from 2021 through 2030. The number of transit rides peaked in FY 2019 and then decreased sharply in 2020, driven at least in part by pandemic-related travel disruptions. If the pandemic had not affected transit and ridership in 2020 and 2021 had remained at 2019 levels, an annual increase of close to 400,000 trips would be required from 2022 through 2030.

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
- 2030 Target: 400,000 boardings and alightments
- Extrapolated 2030 Value: 0 boardings and alightments (or 67,722 alightments if the pandemic had not affected rail and 2020 and 2021 maintained 2019 boarding levels)
- Average Growth (2021-2030) Needed to Achieve Target: 35,457 boardings and alightments (or 34,120 boardings from 2022 to 2030 if the pandemic had not affected rail and 2020 and 2021 maintained 2019 boarding levels)

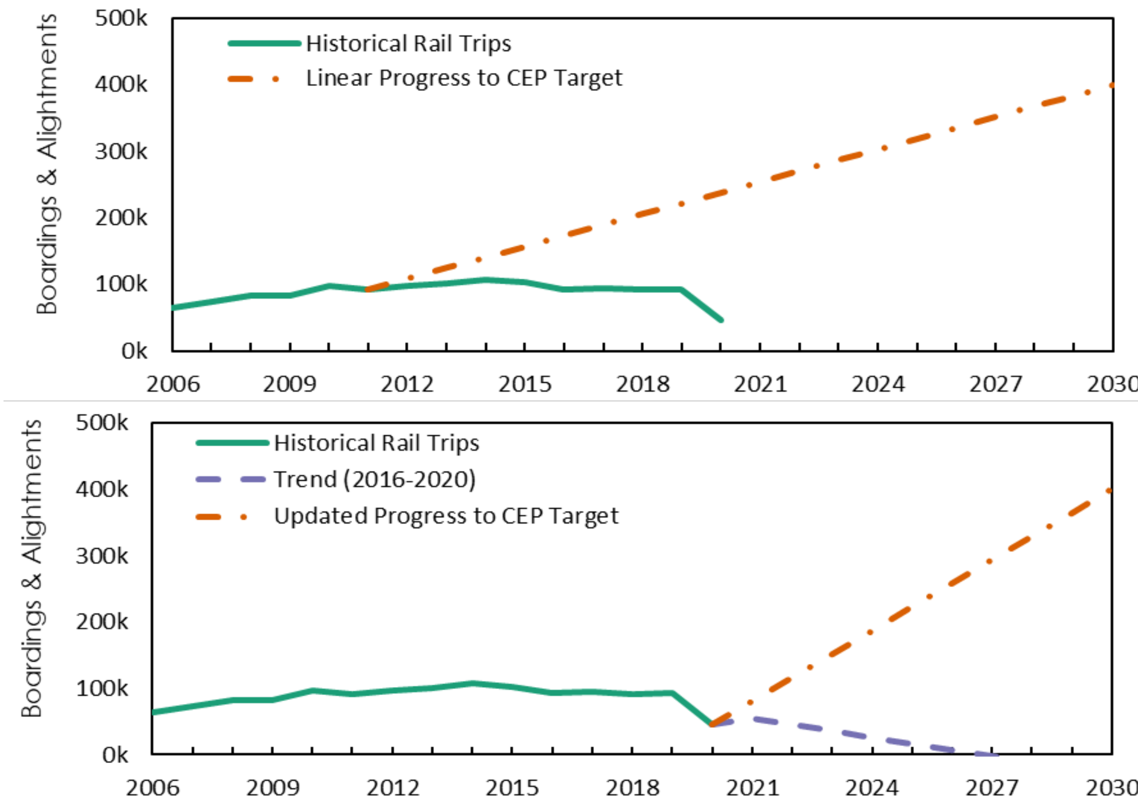


Figure 7-9. Trends in passenger rail trips

Outlook: Achieving the CEP target will require an average annual increase of over 35,000 boardings and alightments per year. FY 2020 boardings and alightments dropped significantly reflecting pandemic-related service closures. If the pandemic had not affected rail and boardings in 2020 and 2021 had remained at 2019 levels, an annual increase of 34,120 boarding and alightments would be required from 2022 through 2030.

Data Source: VTrans.

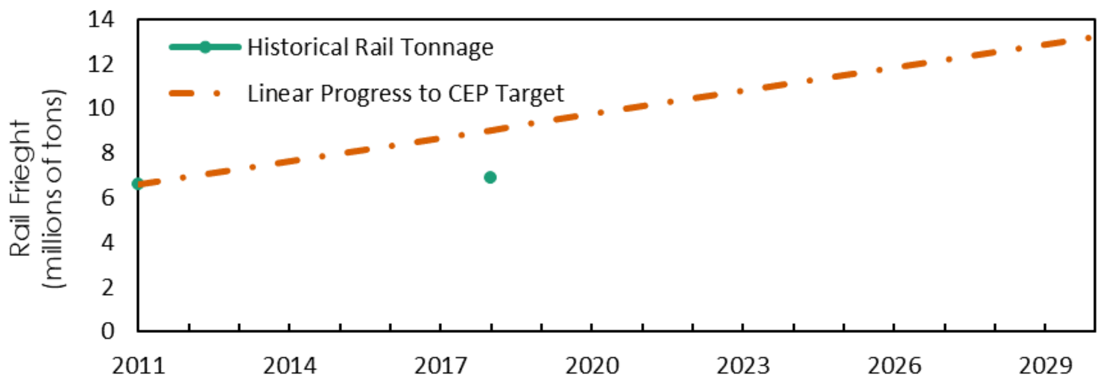
7.10 Objective 7: Increase Rail-Based Freight

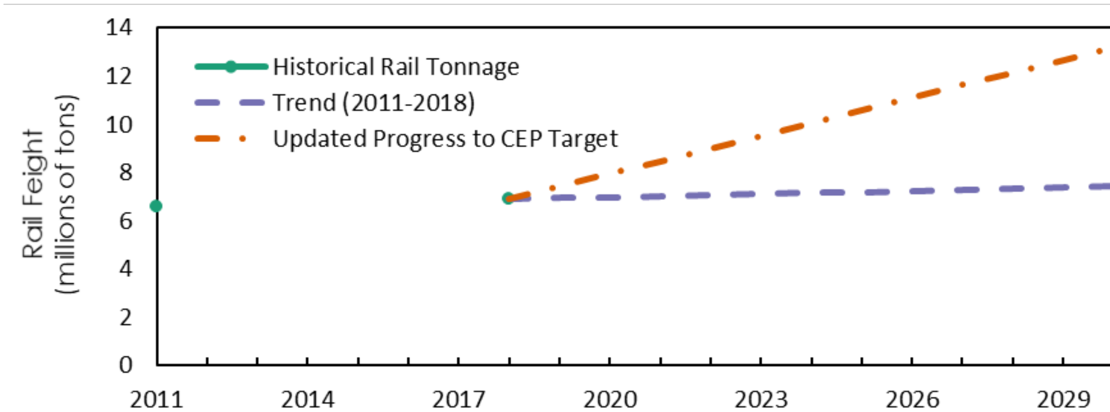
Objective: Double the amount of rail freight tonnage in the state from 2011 levels by 2030.

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

Current Status: Progress lagging target.

- 2011 Baseline: 6.6 million tons.
- 2030 13.2 million tons
- Extrapolated 2030 Value:7.4 million tons
- Average Growth (2019-2030) Needed to Achieve Target: 0.53 million tons/yr





Outlook: Achieving the CEP target will require an average annual increase of over half a million tons per year. This exceeds the total growth in rail freight tonnage from 2011-2018.

Data Source: VTrans.

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.[10]

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

Status: Progress lagging target

- 2011 Baseline: 0.0%
- 2025 Target: 10% PEVs
- Extrapolated 2025 Value: 1.28% PEVs
- Average Growth (2021-2025) Needed to Achieve Target: 1.9% PEVs per year

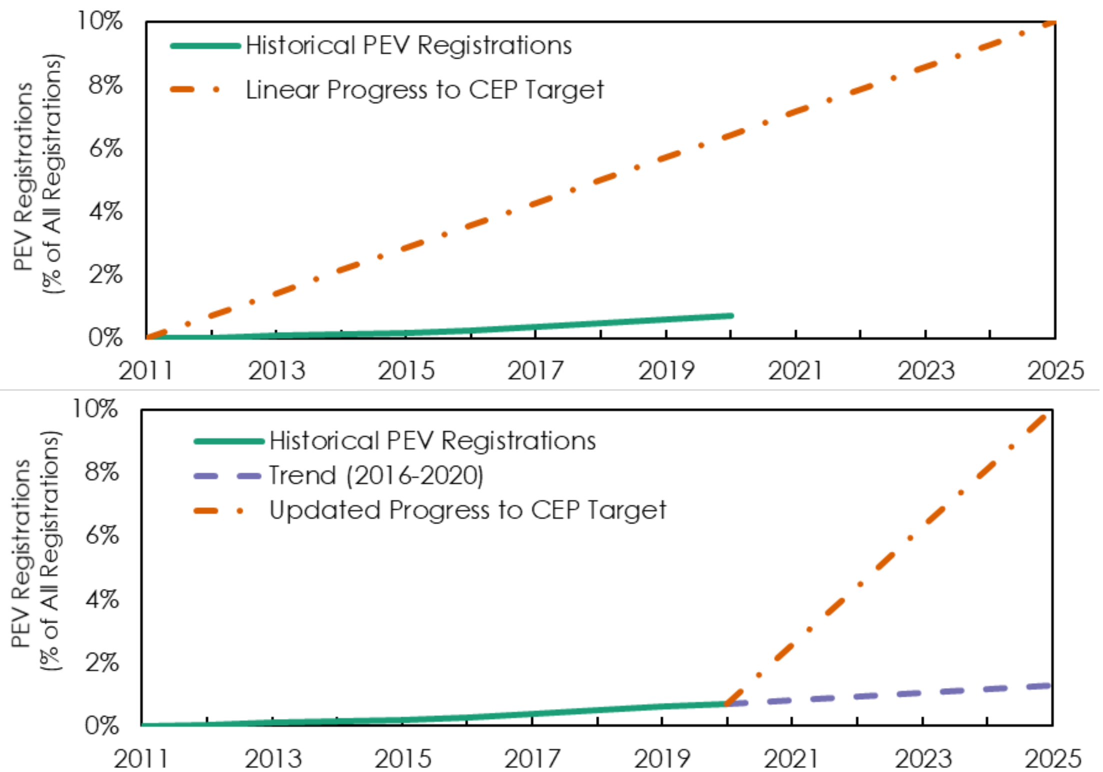


Figure 7-10. Trends in PEV registrations

Outlook: Achieving the CEP target will require an average annual increase in PEV registrations of 1.28% of the vehicle fleet from 2021 through 2025. This equates to approximately 8,000 new PEV registrations each year. To date, the largest annual increase in PEV registrations occurred in 2017 which saw an increase of 805 PEV registrations. In 2020, the number of PEVs registered in Vermont increased by 644.

[10] Throughout the Profile, "the fleet" is assumed to refer to all on-road vehicles registered in Vermont unless specifically indicated otherwise. Thus achieving this objective would require that the number of electric vehicles registered in Vermont equal 10% of all on-road vehicle registrations by 2025. Registered vehicles in this target include publicly-owned vehicles, buses, and trucks regardless of weight class.

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: Unknown: additional data is required to evaluate this objective.

This objective is challenging to measure as vehicle specifications provide only limited insight into the energy sources that a vehicle uses. A heavy-duty diesel vehicle (even one that has been modified to run on B100) may operate using different biodiesel blends at different times depending on factors such as cost and availability. Similarly, a CNG vehicle may operate on either conventional or renewable natural gas at different points in time and a PEV can be charged on electricity generated from renewable or non-renewable sources.

However, fuel use itself (rather than the number of vehicles that are renewably powered) can provide some insight into the extent of renewable energy used in the heavy-duty fleet. Since diesel is the dominant fuel used by heavy-duty vehicles and it is less commonly used by light-duty vehicles, biodiesel consumption as a share of diesel consumption is an indicator of the State's progress toward increasing renewable energy use in the heavy-duty fleet. As shown in 7-11, biodiesel currently supplies just over 3% of total diesel energy consumed in Vermont. This data is presented without graphical trend lines or because it is not a direct measure of this objective.

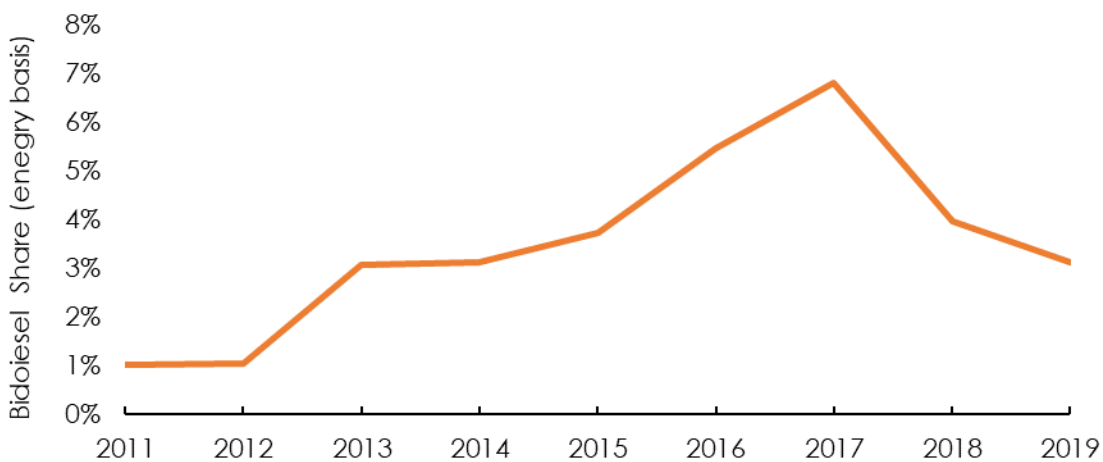


Figure 7-11. Biodiesel as a Share of Total Diesel Energy Consumption (U.S. EIA, 2021)

8 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 through TDM by a combination of reducing the distances that people must to travel to meet their needs, increasing vehicle occupancy, and by shifting passenger vehicle trips to rail, low energy, and GHG-intensity transit options, 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 energy efficiency 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.

8.1 Tracking Vermont's Progress

The 2021 Profile charts Vermont's progress toward the 2016 CEP targets five years after the targets were set and four to nine years before they are to be achieved, while also preceding the completion of the 2022 CEP. As the Profile demonstrates, the State is currently lagging behind the rate of change required to achieve each of the targets evaluated. Notably, several of the metrics related to travel behavior are currently trending in the opposite direction of the CEP targets. Per capita VMT and SOV commute mode share were both increasing modestly before the pandemic. Simultaneously, biking and walking commute mode shares, public transit ridership, and passenger rail ridership are were all showing slight declines prior to the pandemic. While progress on alternative transportation energy sources has incrementally advanced, this too has been slow relative to CEP targets. PEV registrations are increasing but remain substantially below the levels needed to reach the CEP target of 10% of the vehicle fleet by 2025. Renewable energy use has remained relatively flat and its growth potential may depend on a substantial increase in biodiesel or accelerated vehicle electrification.

The 2021 Profile also comes amidst major disruptions brought on by the COVID-19 pandemic, which resulted in lockdowns and dramatic changes in travel behavior in the spring of 2020 in Vermont and around the world. These changes persist to varying degrees as of the publication of this Profile. Much of the data recorded in the Profile does not yet reflect pandemic-related impacts and for those data sources that do, there is considerable uncertainty about how these changes will impact travel behavior going forward. Given this uncertainty, extra caution should be used when interpreting recent travel trends.

8.2 Strategies to Achieve CEP Targets

That the State's progress is lagging the CEP targets each of the 2016 goals and supporting objectives 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 infrastructure that supports safe walking and biking), public outreach/information sharing (e.g. the *Go! Vermont* program, partnerships with *Drive Electric Vermont*, the *Vermont Clean Cities Coalition,* and other groups), market mechanisms (e.g. PEV purchase rebates, carbon pricing systems), and regulatory requirements (e.g., a ZEV requirement for new passenger vehicles.) Some strategies extend beyond transportation systems to affect land use (e.g. comprehensive and coordinated land use planning, development standards to support smart growth, investments in affordable housing) and multiple strategies may be implemented in combination to achieve synergistic results.

Given the rapid changes envisioned in the CEP and competing needs for limited public resources, policy changes may not be sufficient in the near term to meet CEP objectives. To date, achieving VMT reductions and a cleaner vehicle fleet has proven challenging across the US and is particularly challenging in Vermont.

8.3 Data-Driven Policies and Innovations

The design and implementation of efficient, effective and equitable policies to meet the CEP goals in Vermont's rural Northern context requires Vermont-specific travel behavior data. Currently, most of the data we have about travel in Vermont is either collected at the national level with few Vermont data points while Vermont data sources touch on only a few aspects of how Vermonter's travel. Similarly, most transportation policy guidance, models and research has focused on urban areas. What works in a large urban area may not work the same or at all in Vermont. Our current understanding of how and why people travel in Vermont is therefore often uncertain and incomplete. In our assessment, a more complete and detailed understanding of why Vermonters travel the way they do and how they make travel choices are necessary ingredients in the formation of policies for achieving the CEP that are more likely to work while being fair and cost effective.

Currently, there is a lack of timely and comprehensive data about how Vermonters travel, why we travel as we do, and what strategies would effectively and equitably achieve the CEP goals. The 2017 NHTS travel behavior data does not contain a large enough sample of Vermont residents to track progress in Vermont or conduct Vermont-specific research. Investing in additional Vermont data collection in the NextGen NHTS to characterize travel outcomes and collecting additional data designed to provide insights about the factors that drive travel outcomes could provide a foundation for robust evaluation of energy and GHG-reduction strategies in the Vermont context. This data collection and research must be rigorous and unbiased in order to yield useful insights.

Vermont-specific data and analysis could be used to track progress, evaluate policy effectiveness and equity, design new policies, and adjust policies that are already in place. As an example, one area of research could evaluate the effectiveness 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?). Another area of research could determine what policy levers can be used to effectively achieve the CEP goals and objectives in Vermont. Research might evaluate the cost-effectiveness of different strategies for achieving clean vehicle objectives, including, but not limited to, vehicle technology mandates, PEV purchase incentives, carbon pricing, marketing and outreach, biodiesel requirements, and improved PEV charging infrastructure. Research could also target specific regions within the State to evaluate the effectiveness of TDM strategies such as investing in transit service, bicycle and pedestrian infrastructure, carpooling programs, and changes in land use. Another important research avenue is evaluating the effects of different strategies on the economy, the environment, and the health and wellbeing of different populations and communities in Vermont. This type of policy-oriented research can be used to develop innovative strategies to cost-effectively and equitably reduce energy and GHG emissions from transportation in Vermont.

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