

# VERMONT

## Greenhouse Gas Emissions Inventory

Update: Brief

1990 - 2015

June 2018

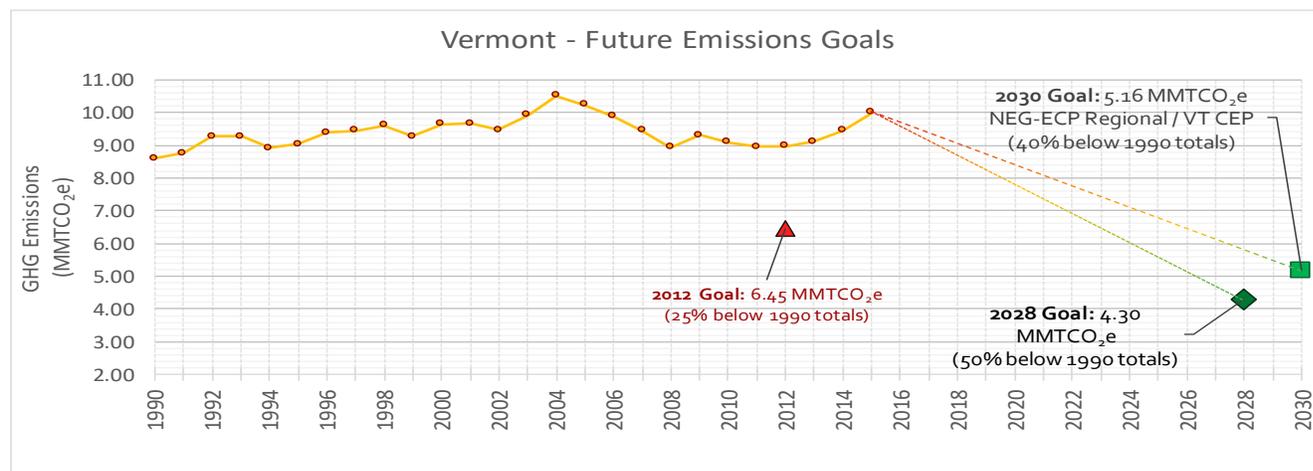


Department of Environmental Conservation  
Air Quality and Climate Division

Going forward Greenhouse Gas Emissions Inventory Update reports will be designated as either “Comprehensive” or as “Brief.” Comprehensive reports will provide a greater level of detail on certain sectors and graphics than the reports designated as “Brief,” and will coincide with the calendar year releases of the triennial National Emissions Inventory (NEI) compiled by the U.S. Environmental Protection Agency (EPA). This is due mainly to the fact that several sectors in the inventory report are based on calculations and data from the NEI, as well as various other tools and datasets from the EPA and other agencies. In many cases EPA’s release of this national level inventory enables more robust analyses for the given year and provides additional emissions estimate checks for individual sectors.

## Introduction - Emissions Summary

Greenhouse gas (GHG) emissions estimates in Vermont continued to rise for calendar year 2015, increasing from 9.45 million metric tons CO<sub>2</sub> equivalent (MMTCO<sub>2</sub>e) in 2014 to 9.99 MMTCO<sub>2</sub>e in 2015. This increase puts Vermont approximately 16% above the 1990 baseline value of 8.59 MMTCO<sub>2</sub>e and adds to the difficulty of reaching the statewide goal of 50% below 1990 emissions levels by 2028<sup>1</sup> (Figure 1). The global warming potential values in this report are from the IPCC AR4 report and are consistent with those in the previous report (1990-2014). Data sources and methodologies are consistent between the 2014 and 2015 reports, and emissions estimates in this report supersede all previous Vermont Greenhouse Gas Emissions Inventory Update report values.



**Figure 1. Vermont Historic GHG Emissions Estimates and Future Emissions Reduction Goals**

The only sector to show a decrease in emissions totals from 2014 to 2015 was the waste sector, however the emissions reductions in this sector were overcome by the emissions increases in the other six sectors. Although the emissions from several sectors are difficult to predict, due to winter heating needs and utility purchase decisions for electricity, the overall trend in the past several years has been a steady increase in total greenhouse gas emissions in the state.

This report attempts to provide comprehensive and accurate greenhouse gas emissions totals for the State of Vermont from 1990 through 2015 (Table 1). The gases included in this inventory are based on those named by the United Nations Framework Convention on Climate Change (UNFCCC) in the Kyoto Protocol<sup>2</sup> and include carbon dioxide (CO<sub>2</sub>), methane (CH<sub>4</sub>), nitrous oxide (N<sub>2</sub>O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF<sub>6</sub>). Nitrogen trifluoride (NF<sub>3</sub>) has also been included as it was added to the original list of six greenhouse gases previously specified in the Kyoto Protocol.

The emissions estimates generated for this report were developed using methodologies consistent with the *Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030*<sup>3</sup> developed by the Center for Climate Strategies (CCS), the most current State Inventory Tool (SIT) modules from the U.S. Environmental Protection Agency, and methodologies developed by the Vermont Agency of Natural Resources and the Vermont Department of Public Service, utilizing data available from a variety of in-state and national sources including the Vermont Agency of Transportation, Vermont Legislative Joint Fiscal Office (JFO), the Vermont Department of Public Service, U.S. Department of Energy, U.S. Department of Agriculture, and others. Greenhouse gas emissions data have been calculated and are summarized by sector from 1990-2015 in the tables and graphs that follow.<sup>4</sup>

<sup>1</sup> Vermont Statute 10 V.S.A. § 578: <http://legislature.vermont.gov/statutes/section/10/023/00578>

<sup>2</sup> Source: [http://unfccc.int/kyoto\\_protocol/items/3145.php](http://unfccc.int/kyoto_protocol/items/3145.php)

<sup>3</sup> Source: <http://dec.vermont.gov/air-quality/climate-change>

<sup>4</sup> Primary Authors: C. Smythe and J. Merrell, VT DEC – AQCD: [collin.smythe@vermont.gov](mailto:collin.smythe@vermont.gov) and [jeff.merrell@vermont.gov](mailto:jeff.merrell@vermont.gov)

Table 1. Vermont Historic Greenhouse Gas Emissions by Sector<sup>5,6</sup>

Sector	Million Metric Tons CO <sub>2</sub> Equivalent: MMTCO <sub>2</sub> e					
	1990	2000	2005	2013	2014	2015
<b>Electricity Supply &amp; Demand (consumption based)</b>	<b>1.09</b>	<b>0.43</b>	<b>0.64</b>	<b>0.81</b>	<b>0.84</b>	<b>1.00</b>
Coal	0	0	0	0	0	0
Natural Gas	0.047	0.018	0.000	0.001	0.000	0.015
Oil	0.014	0.058	0.011	0.013	0.021	0.006
Wood (CH <sub>4</sub> & N <sub>2</sub> O)	0.003	0.010	0.014	0.015	0.014	0.015
Residual System Mix	1.03	0.35	0.62	0.78	0.81	0.96
<b>Residential / Commercial / Industrial (RCI) Fuel Use</b>	<b>2.41</b>	<b>2.86</b>	<b>2.98</b>	<b>2.46</b>	<b>2.60</b>	<b>2.78</b>
Coal	0.017	0.003	0.000	0	0	0
Natural Gas	0.314	0.496	0.440	0.494	0.550	0.621
Oil, Propane & Other Petroleum	2.057	2.341	2.494	1.875	1.957	2.085
Wood (CH <sub>4</sub> & N <sub>2</sub> O)	0.022	0.021	0.041	0.093	0.095	0.074
<b>Transportation</b>	<b>3.38</b>	<b>4.15</b>	<b>4.49</b>	<b>3.88</b>	<b>4.10</b>	<b>4.33</b>
Onroad Gasoline	2.64	3.20	3.29	2.73	3.03	3.16
Onroad Diesel	0.41	0.66	0.69	0.62	0.54	0.57
Jet Fuel & Aviation Gasoline	0.08	0.07	0.17	0.10	0.09	0.11
Rail / Ship / Boats / Other Nonroad	0.25	0.23	0.34	0.43	0.44	0.50
<b>Fossil Fuel Industry</b>	<b>0.0077</b>	<b>0.0040</b>	<b>0.0039</b>	<b>0.0047</b>	<b>0.0048</b>	<b>0.0050</b>
Natural Gas Distribution	0.0068	0.0030	0.0028	0.0036	0.0037	0.0039
Natural Gas Transmission	0.0009	0.0010	0.0011	0.0011	0.0011	0.0011
<b>Industrial Processes</b>	<b>0.21</b>	<b>0.59</b>	<b>0.59</b>	<b>0.60</b>	<b>0.57</b>	<b>0.58</b>
ODS Substitutes	0.00	0.17	0.21	0.31	0.32	0.33
Electric Utilities (SF <sub>6</sub> )	0.04	0.02	0.01	0.01	0.01	0.01
Semiconductor Manufacturing (HFCs, PFCs & SF <sub>6</sub> ) <sup>7</sup>	0.16	0.37	0.33	0.25	0.21	0.21
Limestone & Dolomite Use	0.00	0.02	0.03	0.03	0.04	0.03
Soda Ash Use	0.006	0.006	0.005	0.004	0.004	0.004
<b>Waste Management</b>	<b>0.27</b>	<b>0.36</b>	<b>0.34</b>	<b>0.22</b>	<b>0.21</b>	<b>0.17</b>
Solid Waste	0.21	0.30	0.28	0.15	0.14	0.10
Wastewater	0.061	0.067	0.068	0.069	0.069	0.069
<b>Agriculture</b>	<b>1.22</b>	<b>1.23</b>	<b>1.17</b>	<b>1.12</b>	<b>1.12</b>	<b>1.14</b>
Enteric Fermentation	0.70	0.69	0.63	0.64	0.64	0.64
Manure Management	0.18	0.22	0.23	0.20	0.20	0.21
Agricultural Soils	0.35	0.33	0.31	0.29	0.29	0.29
<b>TOTAL GROSS EMISSIONS</b>	<b>8.59</b>	<b>9.64</b>	<b>10.22</b>	<b>9.10</b>	<b>9.45</b>	<b>9.99</b>
Change relative to 1990 (baseline)	—	+ 12%	+ 19%	+ 6%	+ 10%	+ 16%

<sup>5</sup> Note: Grey text in the transportation sector indicates that the data was projected from EPA MOVES Model data produced for the National Emissions Inventory for 2011 and 2014 – produced on a triennial basis.

<sup>6</sup> Totals may not sum exactly due to independent rounding.

<sup>7</sup> Semiconductor data from 2011 – 2015 is from the [EPA FLIGHT Tool](#), projected back to 1990 based on sector trends from the U.S. Emissions Inventory “[Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2014](#)” and National SIT values.

## Vermont and the United States – Emissions Comparison

Although greenhouse gas emissions generated in Vermont make up an extremely small percentage of the U.S. total, approximately 0.1% historically, Vermont’s emissions have increased from 2011 through 2015 (Figure 2).

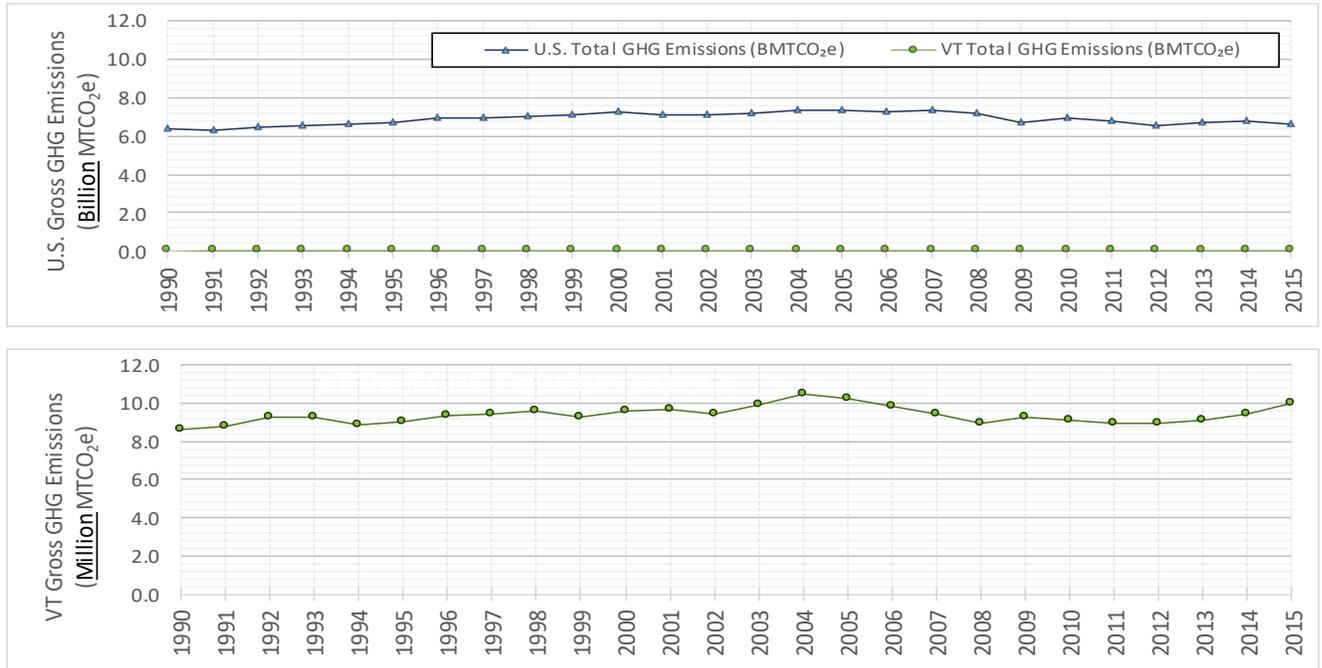


Figure 2. Vermont and the U.S.<sup>8</sup> – Historical Gross GHG Emissions Comparison (1990 – 2015).

<sup>8</sup> U.S. data source: [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2015](https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf) (April 2017).  
[https://www.epa.gov/sites/production/files/2017-02/documents/2017\\_complete\\_report.pdf](https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf)

Vermont has a lower per capita CO<sub>2</sub>e emissions than the national average, however, the difference between the two has been decreasing (Figure 3).

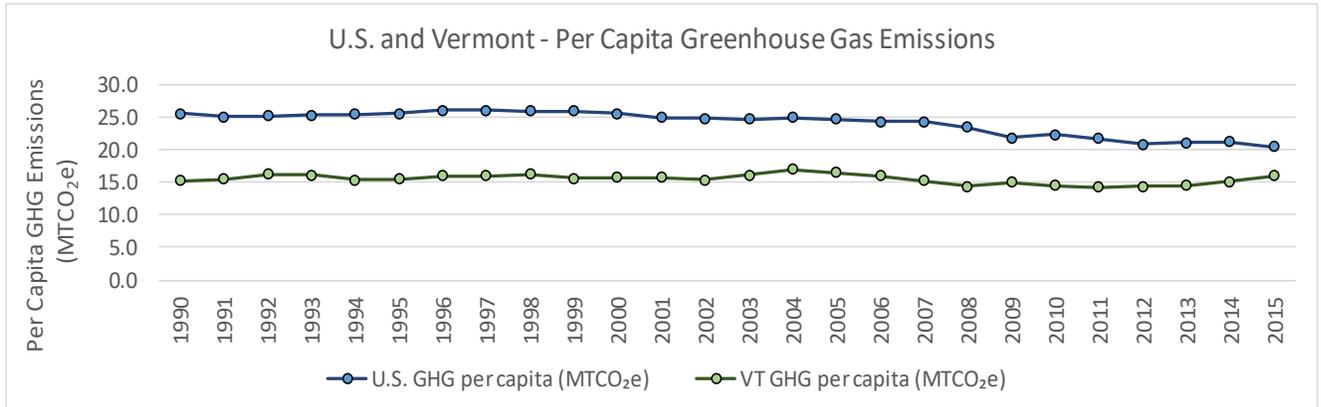


Figure 3. VT & U.S. Gross GHG Emissions per Capita<sup>9,10,11</sup> (1990 – 2014).

Economic growth in Vermont and the U.S. has increased from the 1990 baseline levels at a much faster rate than GHG emissions (Figure 4), indicating that over time each unit of goods and services produced has resulted in a smaller release of GHG emissions.

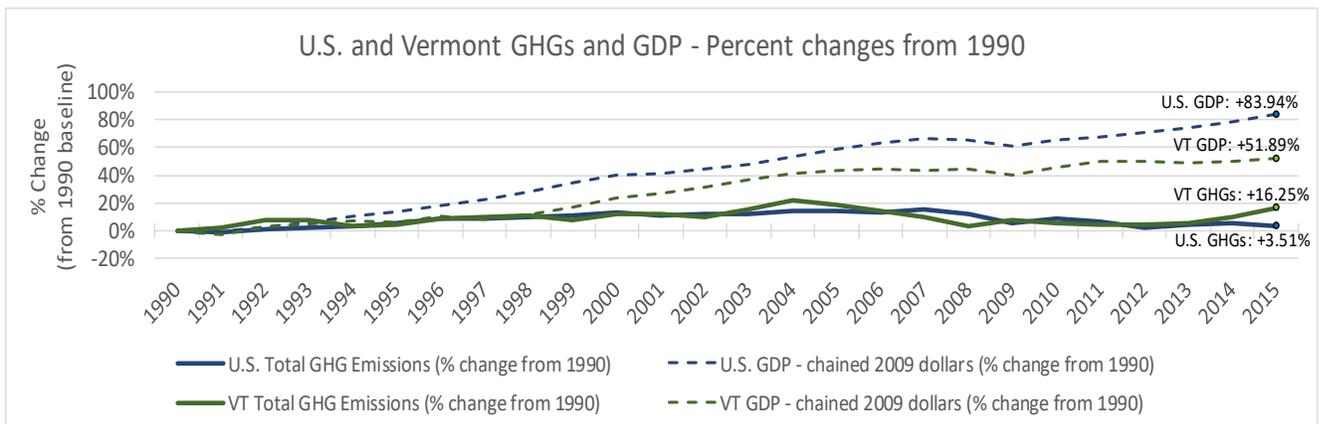


Figure 4. VT & U.S. Percent Change GDP vs. Percent Change GHG Emissions<sup>9,10,11</sup> (1990 – 2014).

Figure shows percent changes in GHG emissions and GDP for VT and the U.S. from the baseline 1990 levels.

<sup>9</sup> State and US Population Data: United States Census Bureau (<https://www.census.gov/programs-surveys/popest/data/tables.html>)

<sup>10</sup> Department of Commerce - U.S. Bureau of Economic Affairs – National GDP data (<http://www.bea.gov/national/index.htm>)

<sup>11</sup> Department of Commerce - U.S. Bureau of Economic Affairs – State GDP data ([http://www.bea.gov/iTable/index\\_regional.cfm](http://www.bea.gov/iTable/index_regional.cfm))

There are several sectors in VT which contribute significantly higher percentages and should be areas of focus for state mitigation efforts. These sectors include Transportation, Residential / Commercial fuel use, and Agriculture (Figure 5). It should be noted that the percentage contribution for transportation is somewhat inflated in Vermont due to the comparative lack of large GHG emissions point sources, including industrial manufacturing and electricity generation facilities.

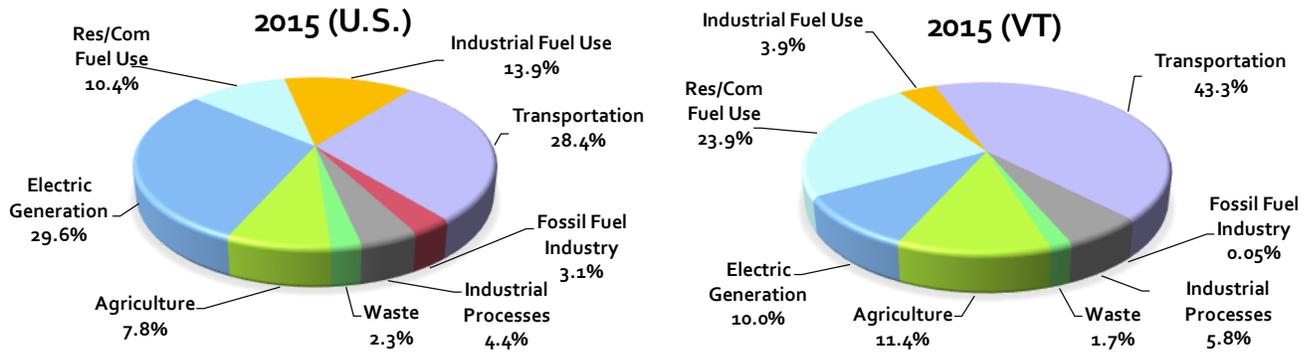


Figure 5. Sector Emissions Contribution Percentages Comparison (2015) – U.S. and Vermont<sup>12</sup>

<sup>12</sup> U.S. data source: [Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2015](https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf) (redistributed to match VT sector categories). [https://www.epa.gov/sites/production/files/2017-02/documents/2017\\_complete\\_report.pdf](https://www.epa.gov/sites/production/files/2017-02/documents/2017_complete_report.pdf)

## Vermont GHG Emissions – Sector Details

Statewide greenhouse gas emissions have remained relatively constant in Vermont historically, with some variation and fluctuation within sectors (Figure 6). Overall emissions are still below the peak levels in 2004, but annual emissions levels have generally been increasing since 2011, with an overall slight upward trend from the 1990 baseline.

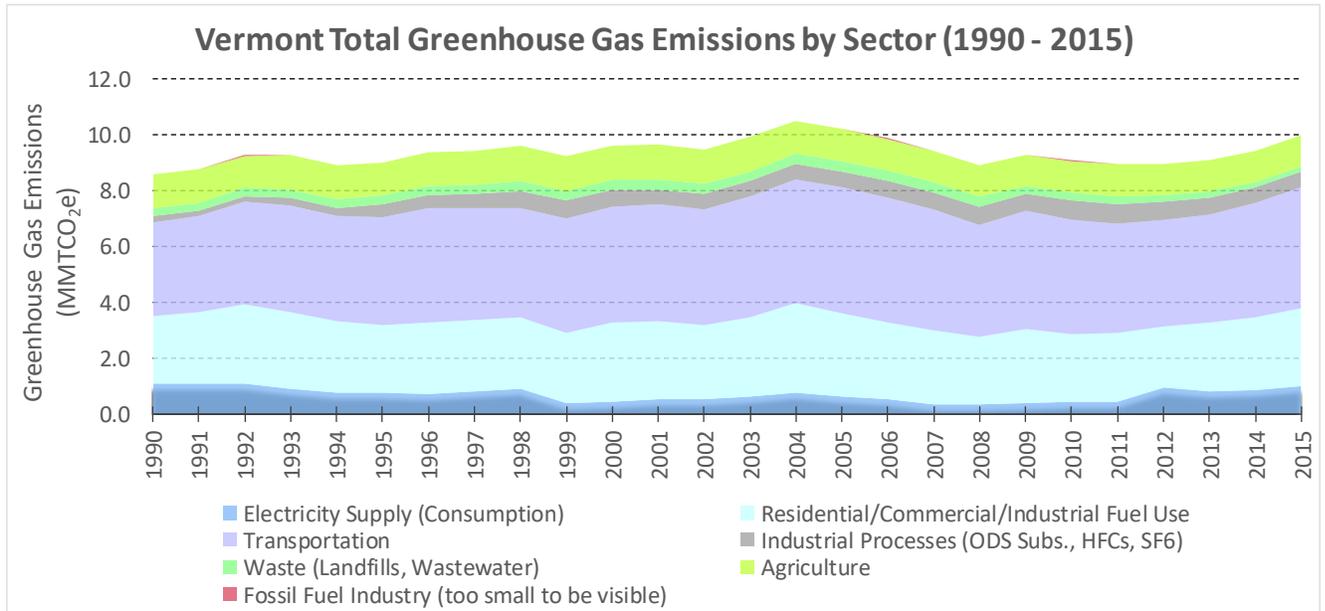


Figure 6. Historic Gross Vermont GHG Emissions.

Figures 7 – 13 show the GHG emissions trends within individual sectors.

### Transportation

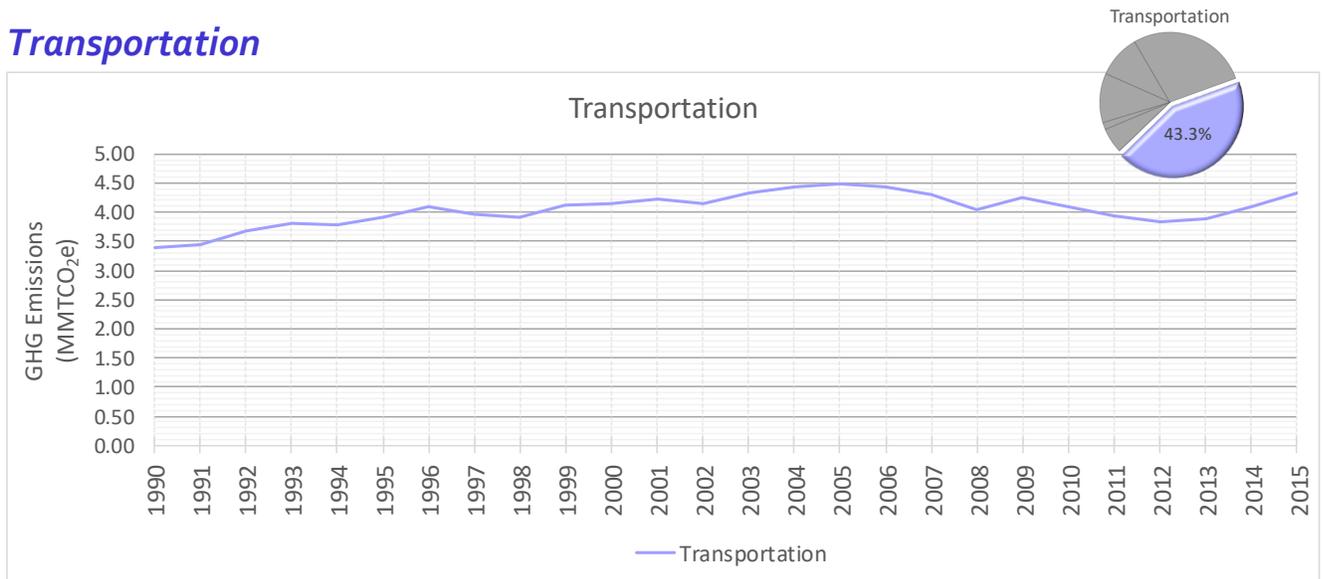


Figure 7. Vermont Transportation Sector GHG Emissions (1990 – 2015).

### Residential/Commercial/Industrial (RCI) Fuel Use

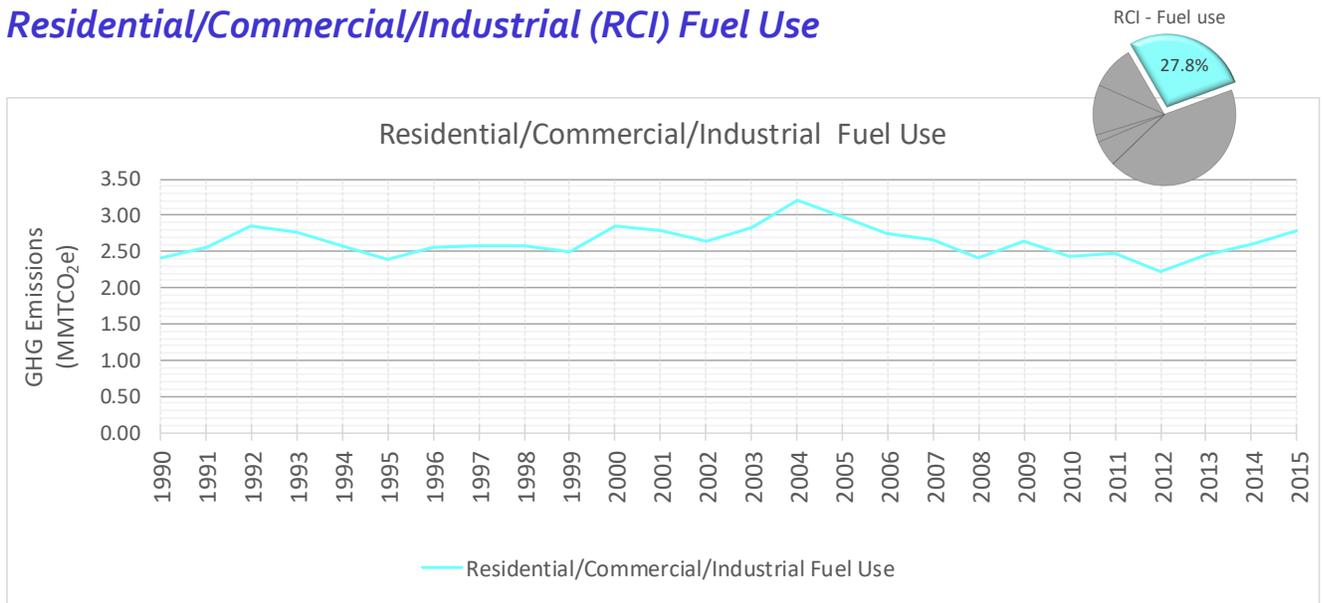


Figure 8. Vermont Residential/Commercial/Industrial Fuel Use Sector GHG Emissions (1990 – 2015).

## Agriculture

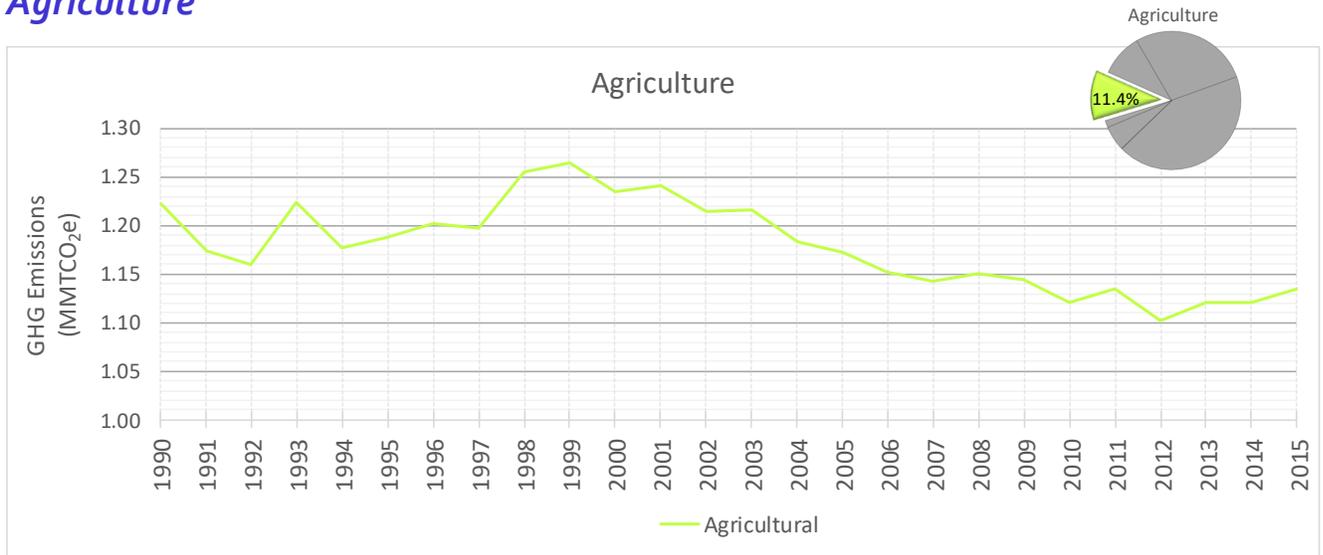


Figure 9. Vermont Agricultural Sector GHG Emissions (1990 – 2015).

## Electricity

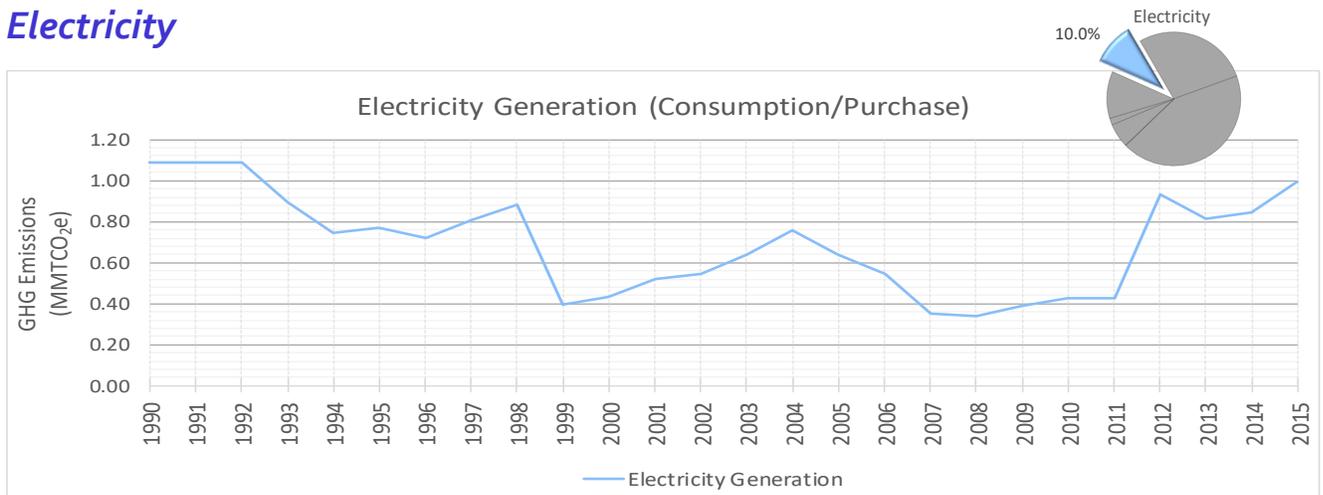


Figure 10. Vermont Electricity Sector GHG Emissions (1990 – 2015).

## Industrial Processes

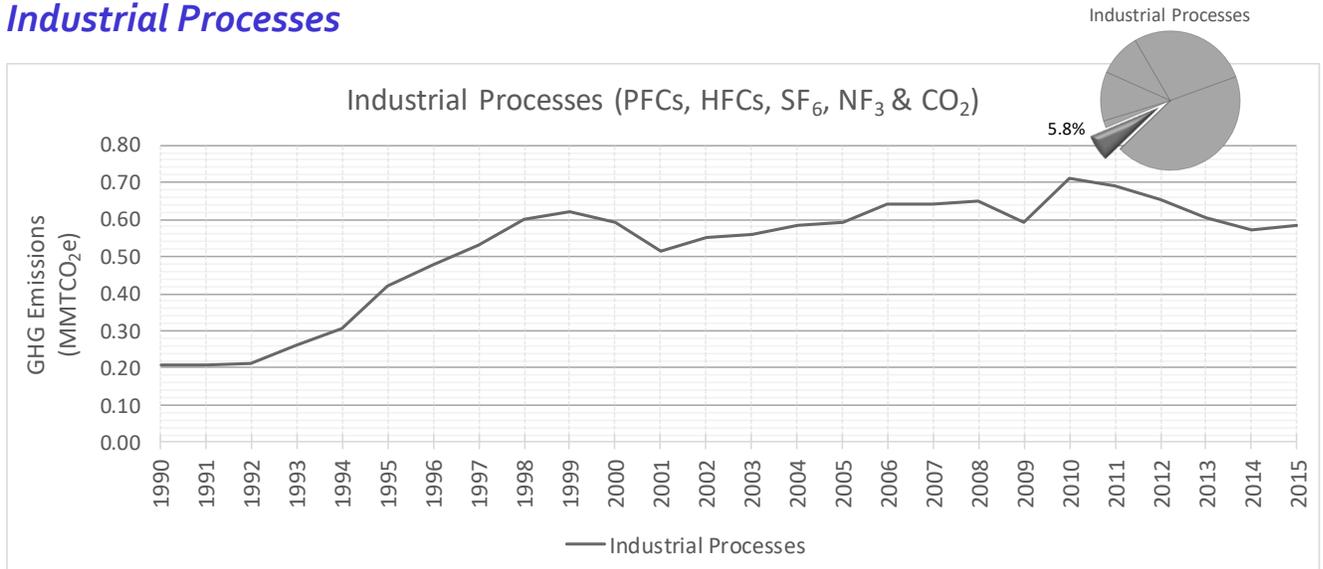


Figure 11. Vermont Industrial Processes Sector GHG Emissions (1990 – 2015).

## Waste - Municipal Solid Waste & Wastewater

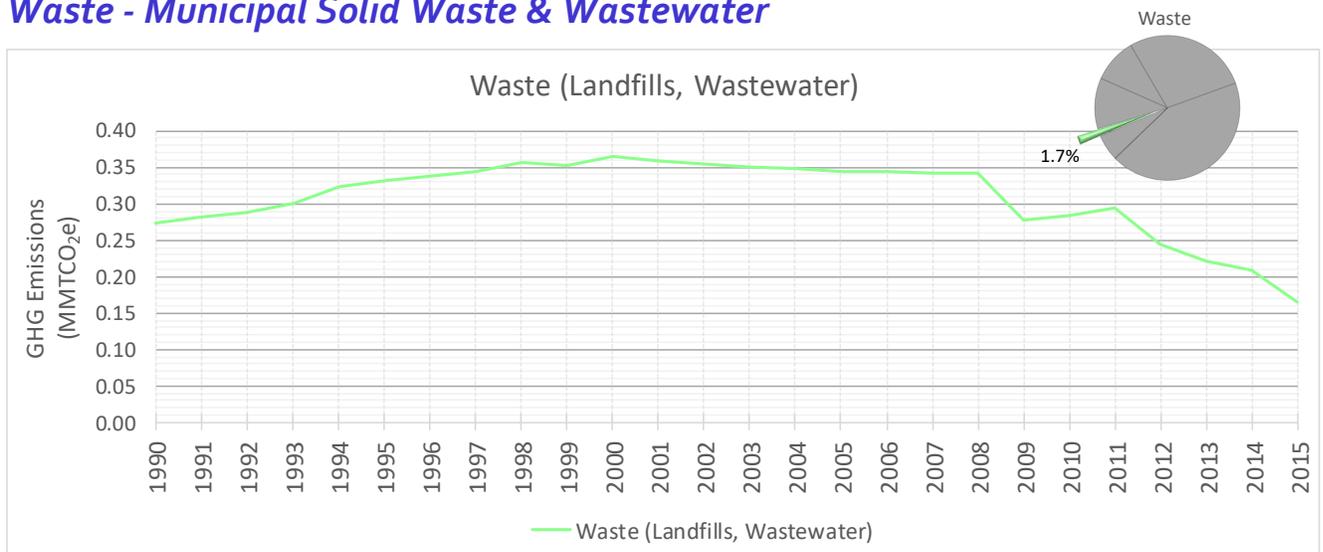


Figure 12. Vermont Waste (Landfills & Wastewater) Sector GHG Emissions (1990 – 2015).

## Fossil Fuel Industry

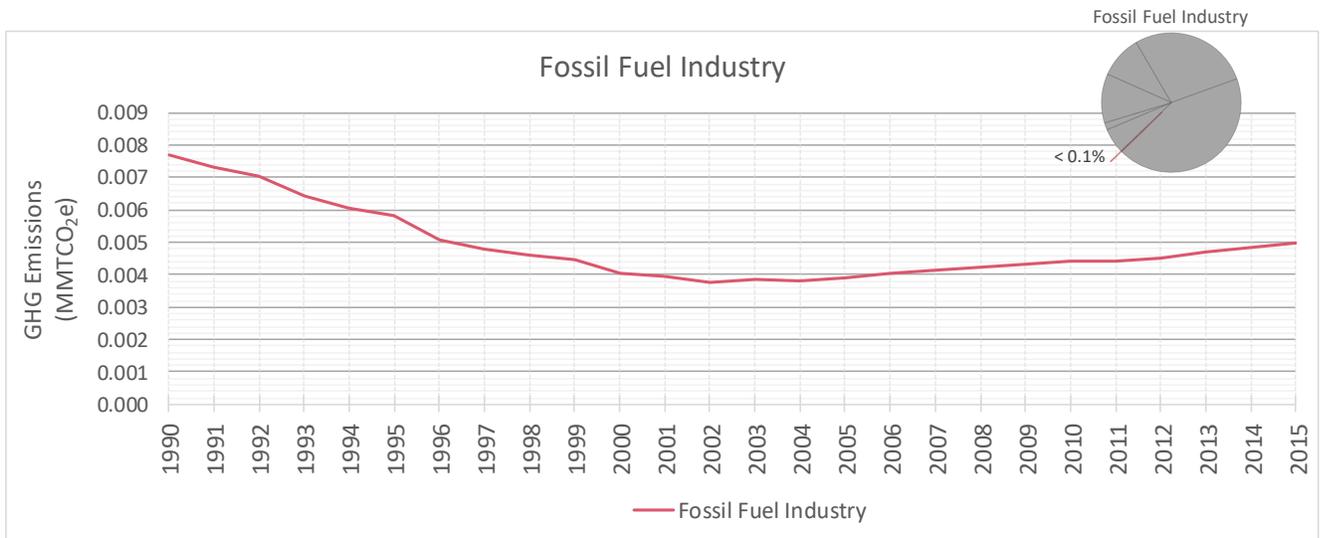
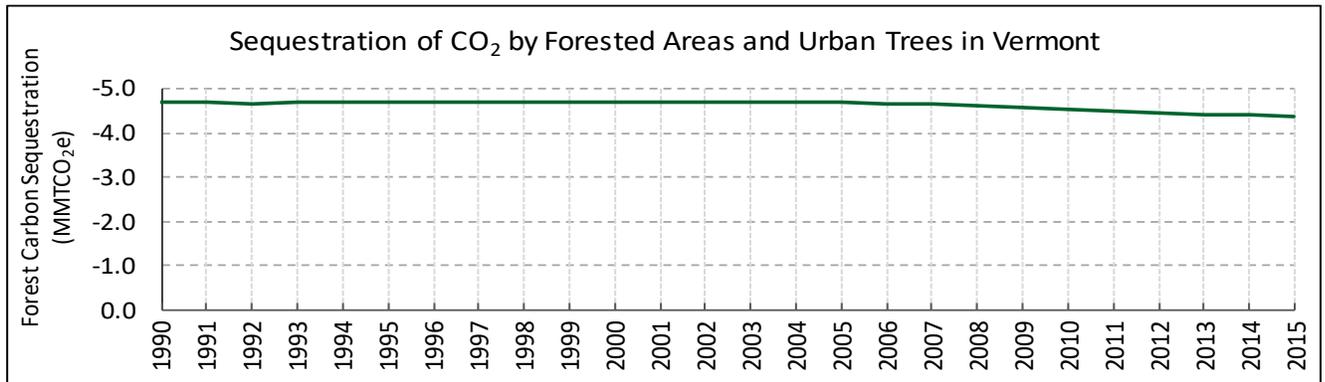


Figure 13. Vermont Fossil Fuel Industry Sector GHG Emissions (1990 – 2015).

## Forestry & Land Use<sup>13</sup>

Forest carbon sequestration estimates (Figure 14) have been generated using data from the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015.<sup>14</sup> Acres of forested land and aboveground forest biomass are shown in Figure 15 as indicators for carbon sequestration trends (as in inventories prior to the 2013 report). The estimates of carbon sequestration by forests in Vermont are included in this section, however these totals are not reflected in the values shown in Table 1.



\* Negative values represent carbon sequestration (as opposed to positive emissions).

Figure 14. Estimates of Carbon Sequestration by Forests and Urban Trees in Vermont.

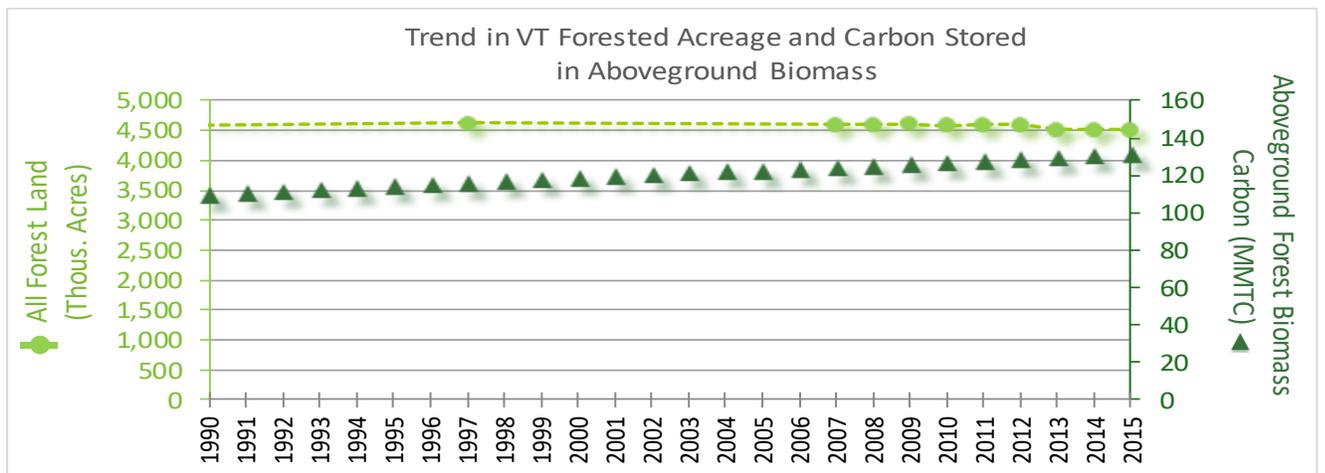


Figure 15. Forest Land and Aboveground Forest Biomass Estimates Using Previous Methodologies.

<sup>13</sup> This section developed in collaboration with Sandy Wilmot (VT Dept. of Forests, Parks and Recreation - retired).

<sup>14</sup> Forest Sequestration data source: Domke, G.M., Smith, J.E., Walters, B.F., Nichols, M., Coulston, J.W. In review. Forest land category sections of the Land Use, Land Use Change, and Forestry chapter, and Annex. In: US Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015. EPA 430-R-17-XXX.

## Black Carbon (BC)

Black carbon (BC) estimates were shown in the 2014 Greenhouse Gas Emissions Inventory Report<sup>15</sup> and were extracted as the elemental carbon (EC) fraction of PM<sub>2.5</sub> emissions from the 2017 National Emissions Inventory version 2. Unfortunately, the NEI is only produced triennially, and Vermont does not have the necessary estimates of PM<sub>2.5</sub> from all of the applicable sectors to generate BC estimates for years between NEI cycles. Black carbon totals will be included in future inventory reports that coincide with the release of NEI reports.

## Conclusions and Recommendations

Estimates of greenhouse gas emissions in Vermont for 2015 show a continued rise from 2014 levels. State totals are still below the 2004 peak level, however, the total estimated emissions for 2015 are approximately 16% above the levels of the 1990 baseline, and the third highest in the current inventory record (only 2004 and 2005 were higher). Vermont’s greenhouse gas emissions remain at levels well above its reduction goals established in state statute (10 V.S.A. § 578) and in the Comprehensive Energy Plan (Figure 16).<sup>16</sup> Each successive year of increasing emissions levels makes achieving the state’s emission reduction goals significantly more difficult.

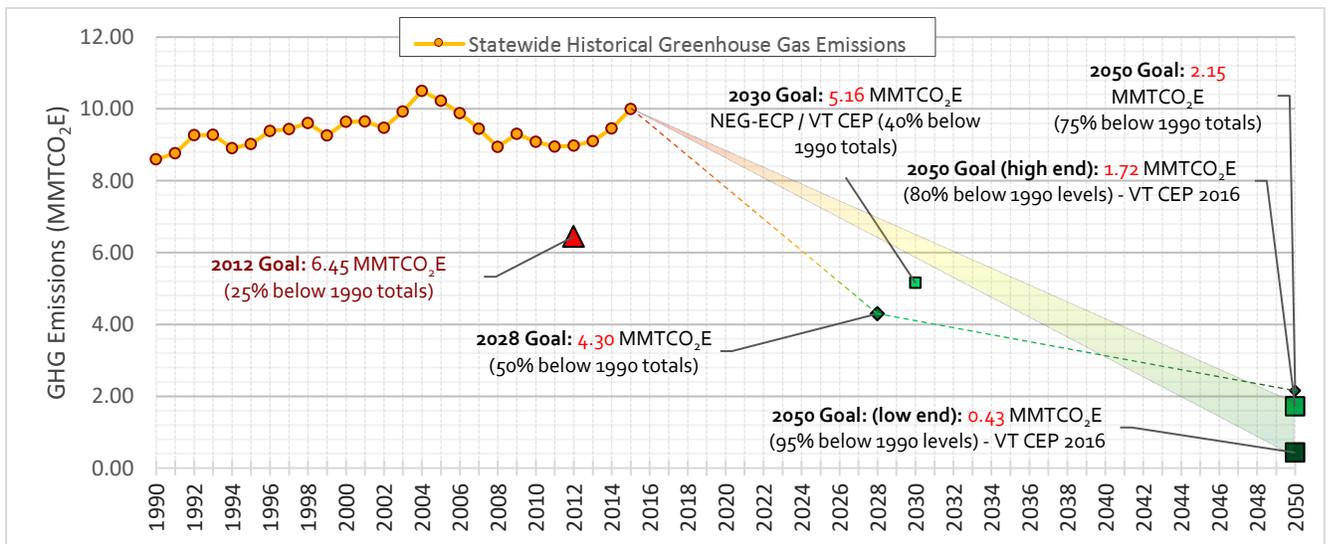


Figure 16. GHG Emissions Trends and Goals for Vermont.

<sup>15</sup> VT DEC Greenhouse Gas Emissions Inventory Report 1990-2014

<sup>16</sup> VT Dept. of Public Service – Comprehensive Energy Plan 2016:

[https://outside.vermont.gov/sov/web/services/Shared%20Documents/2016CEP\\_Final.pdf](https://outside.vermont.gov/sov/web/services/Shared%20Documents/2016CEP_Final.pdf)

### Biogenic CO<sub>2</sub> Emissions & Forest Carbon Sequestration – Additional Information

Carbon dioxide emissions from the combustion or decomposition of biologically based materials (biogenic CO<sub>2</sub>) have not been included in the totals reported in this, or previous inventory reports (per IPCC guidelines). Calculations have been completed to estimate the at-the-stack biogenic CO<sub>2</sub> emissions from the residential/commercial and industrial fuel use sector (RCI), as well as for the electricity generation sector. Estimates of biogenic CO<sub>2</sub> from the waste and agricultural sectors have not been included in these estimates.

Emissions totals in Table 1 of this report do not include carbon sequestration by forests or biogenic CO<sub>2</sub> emissions. Several factors influenced this decision including the debate about the carbon neutrality of biogenic CO<sub>2</sub>, the complexity of quantifying carbon sequestration, and a desire to maintain consistency with previous reports. Figure 17 illustrates several scenarios relating to the inclusion of sequestration and biogenic CO<sub>2</sub>. The actual net emissions are likely in the range of the dashed black line, which includes biogenic CO<sub>2</sub> emissions and carbon sequestration.

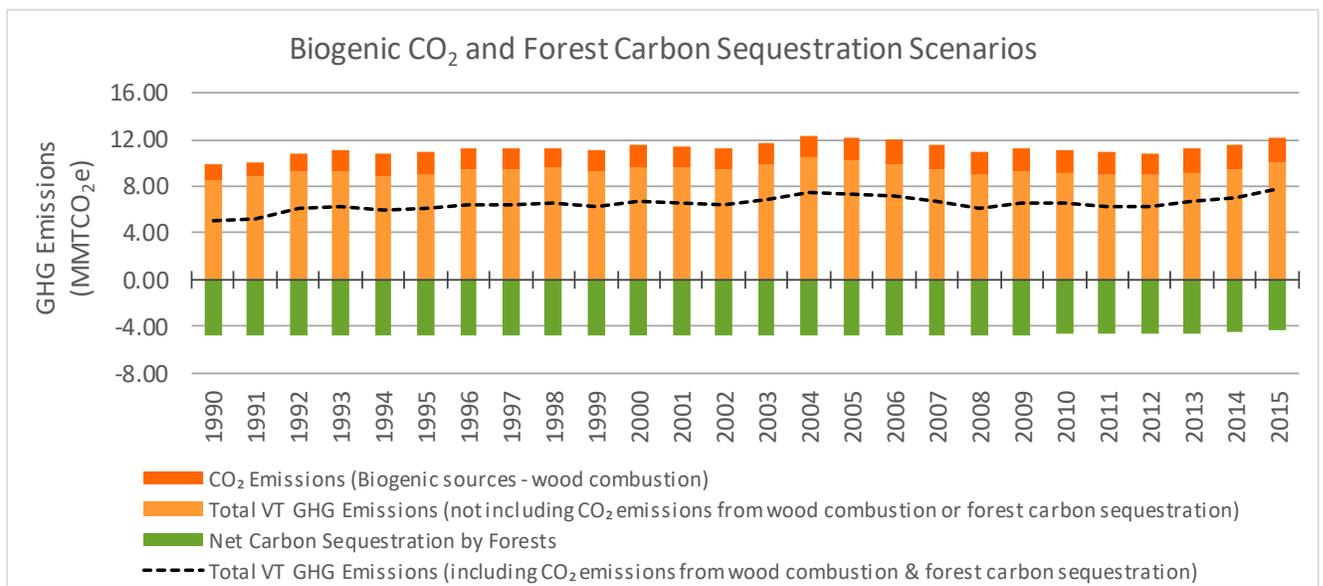


Figure 17. Vermont GHG Emissions Scenarios – Biogenic CO<sub>2</sub> and Forest Carbon Sequestration.

