Vermont Greenhouse Gas Emissions Inventory Update
1990 - 2008

Vermont Agency of Natural Resources
Department of Environmental Conservation
Air Pollution Control Division

September 2010

VERMONT

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Acknowledgments

This greenhouse gas (GHG) inventory was produced by the Air Pollution Control Division (APCD) of the Vermont Department of Environmental Conservation (DEC)[1]. The APCD is grateful for data contributions and reviews of earlier drafts of this report made by other DEC staff, as well as the Vermont Agency of Transportation, Vermont Department of Public Service, Vermont Department of Forests, Parks & Recreation and the University of Vermont Transportation Research Center. In particular, thanks are due to the following individuals who provided essential data and / or critical review of earlier drafts of this document:

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Most calculations were done with the help of the U.S. Environmental Protection Agency (EPA) State Greenhouse Gas Inventory Tool (SIT). This inventory was created using revised SIT modules available through February 26, 2010, and methodologies utilized by the Center for Climate Strategies (CCS) to produce the *"Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030"*. Special thanks are due to Andrea Denny of the US EPA State and Local Climate Change Program, and Lauren Pederson & Aaron Beaudette of ICF International, for updated materials and guidance provided in using the SIT modules.

[1] Questions regarding this inventory may be directed to Jeff Merrell of the Vermont DEC - Air Division at jeff.merrell@state.vt.us

Acronyms and Key Terms

APCD	Vermont Air Pollution Control Division
CCS	The Center for Climate Strategies
CH_4	Methane
CO_2	Carbon Dioxide
DEC	Vermont Department of Environmental Conservation
DPS	Vermont Department of Public Service
DSM	Demand-Side Management
EIA	Energy Information Administration
GCCC	Governor's Commission on Climate Change
GHG	Greenhouse Gas
GWh	Gigawatt hours
HEV	Hybrid Electric Vehicle
$MMTCO_2e$	Million Metric Tons Carbon Dioxide Equivalent
N_2O	Nitrous Oxide
NEG-ECP	The Conference of New England Governors and Eastern Canadian Premiers
ODS	Ozone-Depleting Substances
RCI	Residential-Commercial-Industrial
SEDS	State Energy Data System
SIT	State (Greenhouse Gas) Inventory Tool
US DOE	United States Department of Energy
US EPA	United States Environmental Protection Agency
VMT	Vehicle Miles Traveled
VTrans	Vermont Agency of Transportation

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Executive Summary

- Vermont's 2008 greenhouse gas (GHG) emissions have declined approximately 10% from 2005 levels, which equates to gross annual GHG emissions that are roughly 3% higher than 1990 levels. These estimates were developed using methodologies consistent with the *"Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030"* developed by the Center for Climate Strategies (CCS), updated inventory tools from the US EPA, and most recently available data from a variety of in-state and national sources.

- Vermont's GHG emissions are largely attributable to the combustion of fossil fuels for energy (e.g., transportation, residential – commercial – industrial heating).

- The recent decline in GHG emissions is due largely to:
    - Reduced consumption of transportation fuels brought about by a reduction in vehicle use (i.e., vehicle miles traveled), slight improvements to overall vehicle fleet efficiency, and increased utilization of available mass transit options.
    - Continued gains in demand side management (DSM) from utilities such as Efficiency Vermont
    - An increased reliance on low or non-GHG emitting electrical generation sources, and a reduced dependence on higher emitting sources

- From 1990 to 2008, Vermont's forests continued to increase in biomass (growth), although growth rates (and therefore carbon uptake) has slowed.

- Vermont's GHG emissions have been declining over the past several years. However, further substantial reductions from actions, like those included in the recommendations of the GCCC and its Plenary Group, will be required to produce a decline in emissions large enough to meet Vermont's future goals.

- Based on assumptions used in this analysis, Vermont will fall short of its 2012 goal of reducing GHG emissions to 25% below 1990 levels. Likewise, further steep emissions reductions will be required to meet the 2028 goal (50% below 1990 levels).

- Despite the need for additional bold steps in upcoming years to attain these reduction goals, Vermont's forecasted 2012 emissions indicate that a return to 1990 level emissions is possible over the next few years. This represents a level of progress similar to other Northeast states, and is compatible with the region-wide goals of the Conference of the New England Governors and Eastern Canadian Premiers (NEG-ECP), which committed to reducing region-wide GHG emissions to 1990 levels by 2010.

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Introduction

The revisions to Vermont's statewide greenhouse gas (GHG) emissions inventory presented herein are intended to be the first in a series of ongoing periodic inventory updates. These updates, required under Act 209[2], build upon the extensive inventory efforts undertaken as part of the Governor's Commission on Climate Change (GCCC) process. These continued efforts will facilitate tracking of progress made towards Vermont's GHG emissions reduction goals (established through executive order and state legislation)[3] which are aligned with those adopted in 2001 by the Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP).[4]

The *"Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030"* developed by the Center for Climate Strategies (CCS) was produced using the most recent data available at that time. Depending on the emissions sector, the last year of available historical data ranged between 2000 and 2005. This GHG inventory update utilizes 2007 and 2008 data recently made available through the various data sources specified in each section. Unless otherwise noted, this inventory utilizes methodologies outlined within the CCS inventory document. Readers should refer to the CCS document to view the comprehensive background materials, caveats, and other details provided there.[5]

This document focuses on historic and contemporary statewide GHG emissions, as well as the emissions trend relative to the statewide GHG emissions reduction goals. The statewide GHG emissions reduction goals established under Executive Order 07-05 [6] and Vermont statute [7] are to reduce statewide GHG emissions from the 1990 baseline by:

- 25 percent by 2012
- 50 percent by 2028
- And if practicable using reasonable efforts, 75 percent by 2050

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[2] Act 209 – "AN ACT RELATING TO ENERGY INDEPENDENCE AND ECONOMIC PROSPERITY" was passed by the Vermont Legislature and signed by the Governor on June 11, 2008. (For the complete text of this bill, see: http://www.leg.state.vt.us/docs/legdoc.cfm?URL=/docs/2008/acts/ACT209.HTM)

[3] Vermont's GHG reduction goals were established under Executive order #07-05 (see: http://governor.vermont.gov/tools/index.php?topic=ExecutiveOrders&id=1623&v=Article) and codified into law by the Vermont Legislature as Act 168 AN ACT RELATING TO ESTABLISHING GREENHOUSE GAS REDUCTION GOALS AND A PLAN FOR MEETING THOSE GOALS (see: http://www.leg.state.vt.us/docs/legdoc.cfm?URL=/docs/2006/acts/ACT168.HTM)

[4] See: http://www.negc.org/documents/NEG-ECP%20CCAP.PDF

[5] To view the GHG inventory and projections (1990-2030) prepared by the Center for Climate Strategies for the GCCC process, please visit: http://www.anr.state.vt.us/air/Planning/docs/Final%20VT%20GHG%20Inventory%20&%20Projection.pdf

[6] Executive Order Establishing the Governor's Commission on Climate Change (http://governor.vermont.gov/tools/index.php?topic=ExecutiveOrders&id=1623&v=Article)

[7] 10 V.S.A. § 578 (http://www.leg.state.vt.us/statutes/fullsection.cfm?Title=10&Chapter=023&Section=00578)

Since the CCS inventory document was finalized, there have been significant events that diminish the accuracy of some of the original projections, and complicate the production of revised projections. These events largely impact the Transportation and Energy Supply sectors, and include the following:

- After decades of continued increases, there was an unexpected and substantial decline in vehicle miles traveled (VMT) and transportation fuel consumption during 2007 and 2008. This particular decline was driven primarily by higher fuel prices and the economic downturn. It is very difficult to predict how transportation fuel consumption, VMT, consumer vehicle choices, etc. will trend as Vermont moves closer to the near-term 2012 goal.
- A comprehensive analysis has not yet been undertaken to establish how recent (April 2010) federal rules pertaining to GHG emissions standards and improved Corporate Average Fuel Economy (CAFE) standards for light-duty vehicles will have an impact on Vermont's transportation GHG emissions in 2012 and subsequent years. The California GHG emissions standards are effective in Vermont and several other states beginning with 2009 model year vehicles. The new Federal standards will supplant the California GHG emissions standards for model years 2012 through 2016. The Federal standards will provide somewhat weaker GHG reduction benefits within Vermont and the other states that adopted California standards, but will provide greater overall GHG emissions reductions by making the standards effective nationally. An analysis will be included in future periodic inventory updates.
- The composition of Vermont's post-2012 electricity supply mix is unclear at this time, largely due to the recent uncertainty regarding the continued operation of the Entergy Vermont Yankee nuclear facility, which provided approximately one-third of the electricity consumed in Vermont during 2007 – 2008.

As a result of these major uncertainties, no attempt has been made in this inventory to update the emissions projections to 2020, or 2030. However, an effort has been made to clearly benchmark 2008 emissions against the impending 2012 short-term goal. During 2008, Vermont's estimated gross GHG emissions were 8.37 MMTCO2e, which is approximately 3% higher than estimated gross GHG emissions during 1990 (Table I-1).

Table I-1. Summary of Vermont Historic GHG Emissions by Sector (Million Metric Tons CO_2 equivalent (MMTCO2e).

Sector	***Year***					
	1990	***1995***	***2000***	***2005***	***2007***	***2008***
Electricity Supply & Demand (consumption-based)	**1.09**	**0.77**	**0.44**	**0.64**	**0.35**	**0.34**
Coal	0	0	0	0	0	0
Natural Gas	0.047	0.01	0.018	0.003	0.005	0.004
Oil	0.014	0.013	0.058	0.011	0.01	0.01
Wood (CH_4 & N_2O)	0.003	0.005	0.009	0.009	0.01	0.01
System Purchases & Net Imported Electricity	1.03	0.75	0.35	0.62	0.32	0.32
Residential / Commercial / Industrial (RCI) Fuel Use	**2.43**	**2.43**	**2.88**	**2.98**	**2.71**	**2.63**
Coal	0.02	0.008	0.003	0.0003	0.0003	0.0003
Natural Gas	0.31	0.37	0.50	0.44	0.46	0.45
Oil	2.06	2.00	2.34	2.49	2.20	2.13
Wood (CH_4 & N_2O)	0.05	0.05	0.04	0.04	0.05	0.05

Sector	Year					
	1990	1995	2000	2005	2007	2008
Transportation	**3.22**	**3.77**	**3.99**	**4.20**	**4.13**	**3.93**
Onroad Gasoline	2.64	2.82	3.20	3.29	3.19	3.04
Onroad Diesel	0.41	0.84	0.66	0.69	0.70	0.65
Rail / Ships / Boats	0.06	0.03	0.04	0.02	0.03	0.02
Jet Fuel & Aviation Gasoline	0.08	0.06	0.07	0.17	0.18	0.19
Other	0.02	0.03	0.02	0.02	0.02	0.03
Fossil Fuel Industry	**0.012**	**0.012**	**0.012**	**0.014**	**0.016**	**0.015**
Natural Gas Distribution	0.011	0.011	0.011	0.013	0.015	0.014
Natural Gas Transmission	0.0007	0.0008	0.0008	0.0009	0.0011	0.001
Industrial Processes	**0.12**	**0.25**	**0.27**	**0.30**	**0.29**	**0.30**
ODS Substitutes	0	0.06	0.15	0.21	0.23	0.24
Electric Utilities (SF6)	0.05	0.04	0.03	0.02	0.02	0.02
Semiconductor Manufacturing (HFC, PFC & SF6)	0.07	0.11	0.06	0.03	0.03	0.03
Limestone & Dolomite Use	0	0.03	0.02	0.03	0.009	0.009
Soda Ash Use	0.006	0.006	0.006	0.005	0.005	0.005
Waste Management	**0.24**	**0.28**	**0.31**	**0.29**	**0.27**	**0.27**
Solid Waste	0.18	0.22	0.25	0.23	0.21	0.21
Wastewater	0.06	0.06	0.06	0.06	0.06	0.06
Agriculture	**1.0**	**0.93**	**0.96**	**0.92**	**0.88**	**0.88**
Enteric Fermentation	0.59	0.56	0.56	0.53	0.52	0.52
Manure Management	0.12	0.12	0.14	0.15	0.13	0.13
Agricultural Soils	0.29	0.24	0.26	0.24	0.23	0.23
TOTAL GROSS EMISSIONS	8.11	8.45	8.86	9.34	8.65	8.37
Change relative to 1990	-	*+4%*	*+9%*	*+15%*	*+7%*	*+3%*

Vermont's statewide total gross GHG emissions account for about 0.12% of total gross GHG emissions from the United States. Both the U.S. as a whole and Vermont exhibited a decline in GHG emissions during 2008 (Figure I-1), as well as in GHG emissions per capita and per unit of economic input (Figure I-2).

Figure I-1. Historical VT & US Gross GHG Emissions

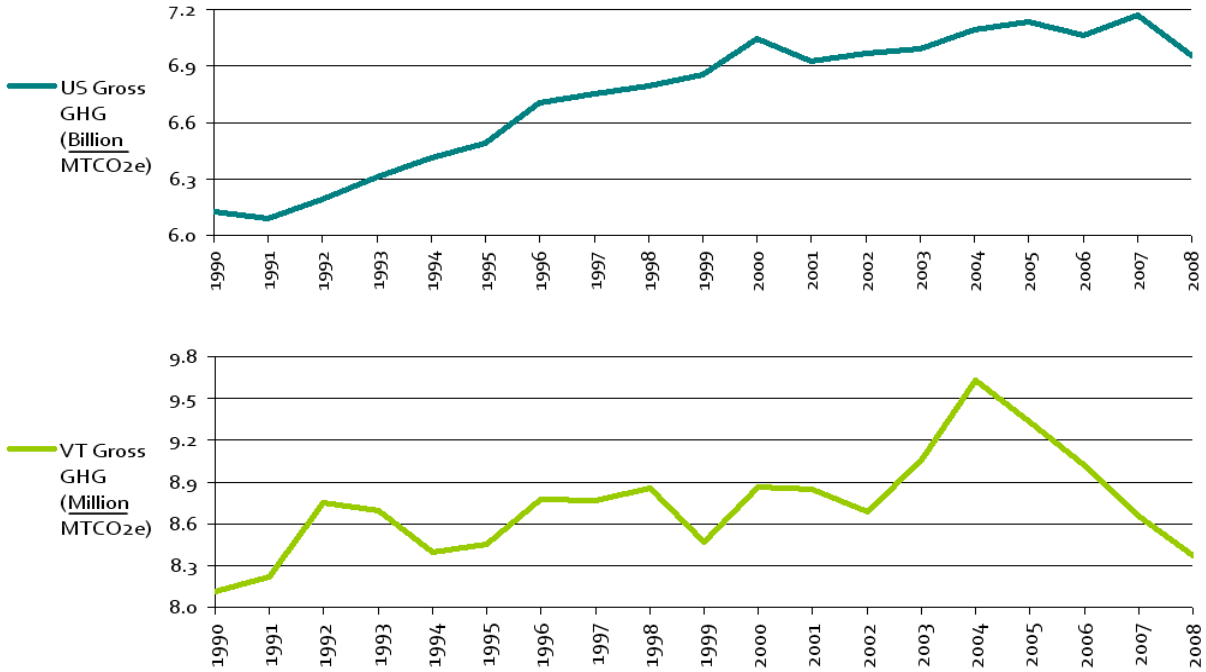
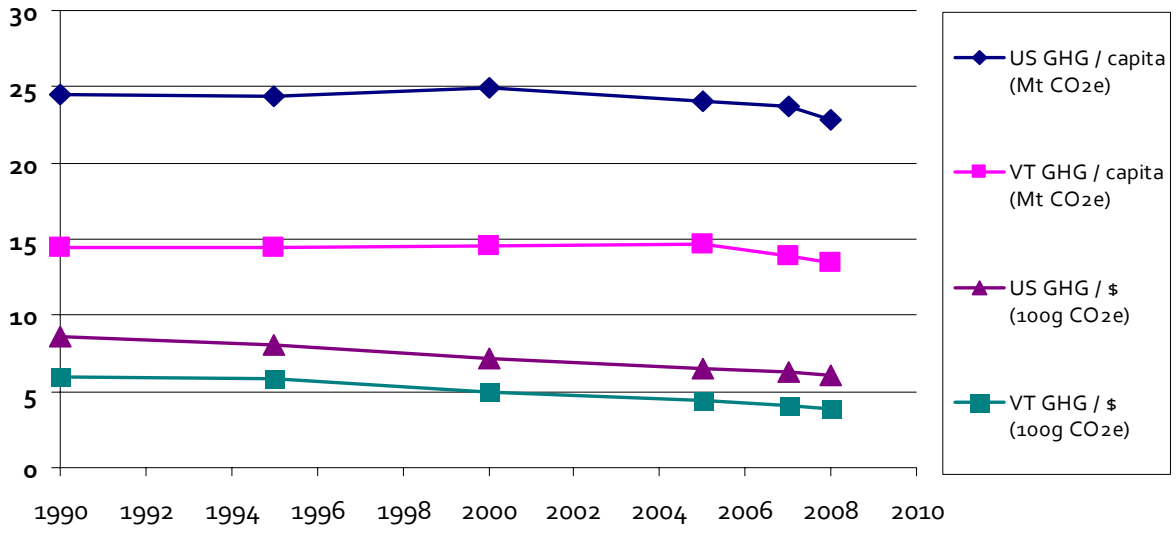


Figure I-2. Historical VT & US Gross GHG Emissions per Capita and per Unit Gross Product [8]



The relative contribution from each sector to Vermont's total gross GHG emissions (Figure I-3) remained roughly comparable to the 2000 levels reported in the CCS inventory and forecast document. The relative GHG contribution from the Transportation sector grew from slightly more than 44% (in 2000) to almost 47% (in 2008), despite actual emissions reductions within this sector. This was largely caused by a decrease in GHG emissions from all other sectors except the Fossil Fuel Industry (i.e., Natural Gas Transmission & Distribution) sector, which saw a modest increase (Figure I-4, Table I-2).

[8] GDP data source: Bureau of Economic Analysis – US Dept. of Commerce - http://www.bea.gov/regional/gsp/

Figure I-3. 2008 Gross GHG Emissions by Sector, Vermont and the United States[9]

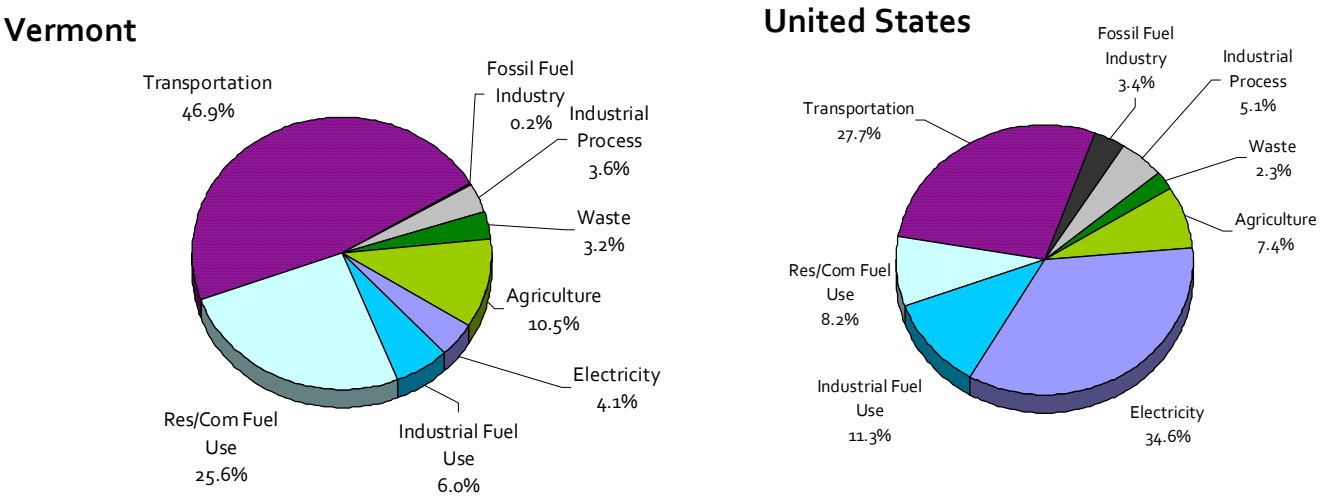
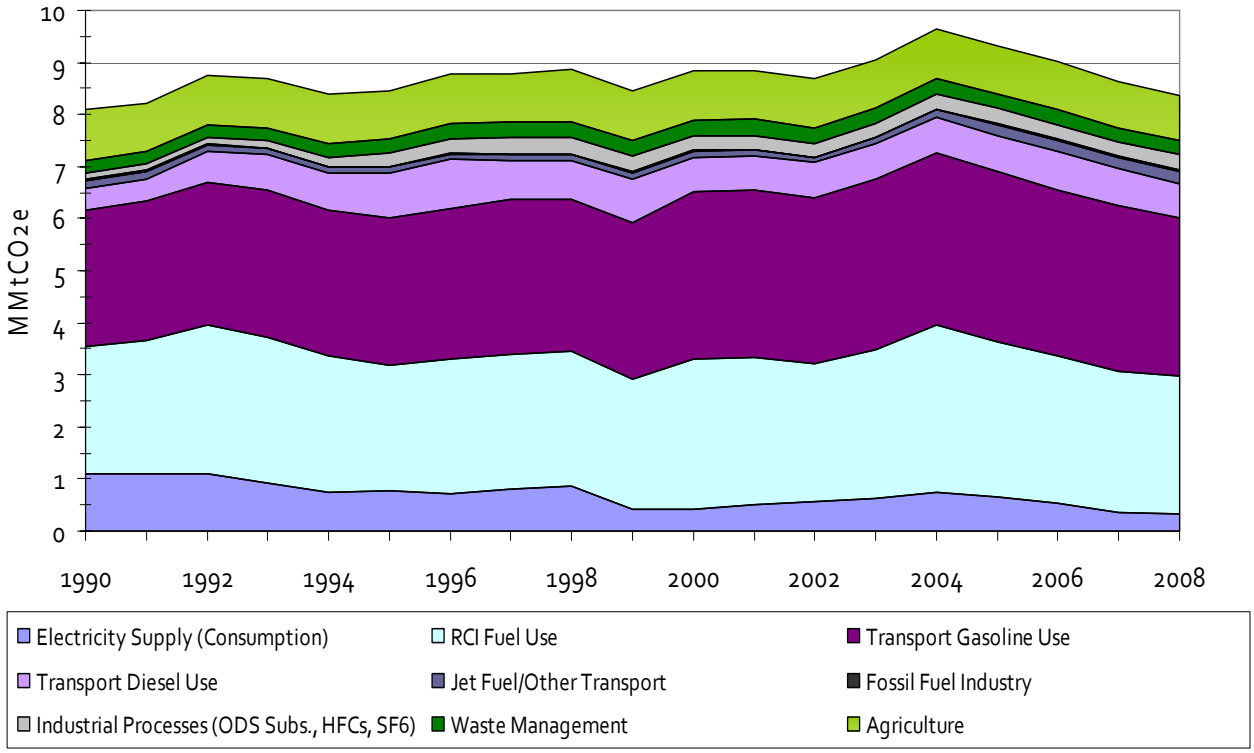


Figure I-4. Vermont Gross GHG Emissions by Sector (1990-2008)



[9] (US data source: US EPA -DRAFT INVENTORY OF U.S. GREENHOUSE GAS EMISSIONS AND SINKS: 1990-2008, March 2010) http://www.epa.gov/climatechange/emissions/usinventoryreport.html

Table I-2. Summary of Vermont GHG Emissions Trends (2005 to 2008) by Sector

Sector	2005 Emissions (MMTCO2e)	2008 Emissions (MMTCO2e)	Percent Change in Emissions
Electricity Consumption	0.64	0.34	↓ 47%
Residential / Commercial / Industrial (RCI) Fuel Use	2.98	2.63	↓ 12%
Transportation	4.20	3.93	↓ 6%
Fossil Fuel Industry	0.014	0.015	↑ 7%
Industrial Processes	0.30	0.30	0%
Waste Management	0.29	0.27	↓ 7%
Agriculture	0.92	0.88	↓ 4%
TOTAL GROSS EMISSIONS	9.34	8.37	↓ 10.5%

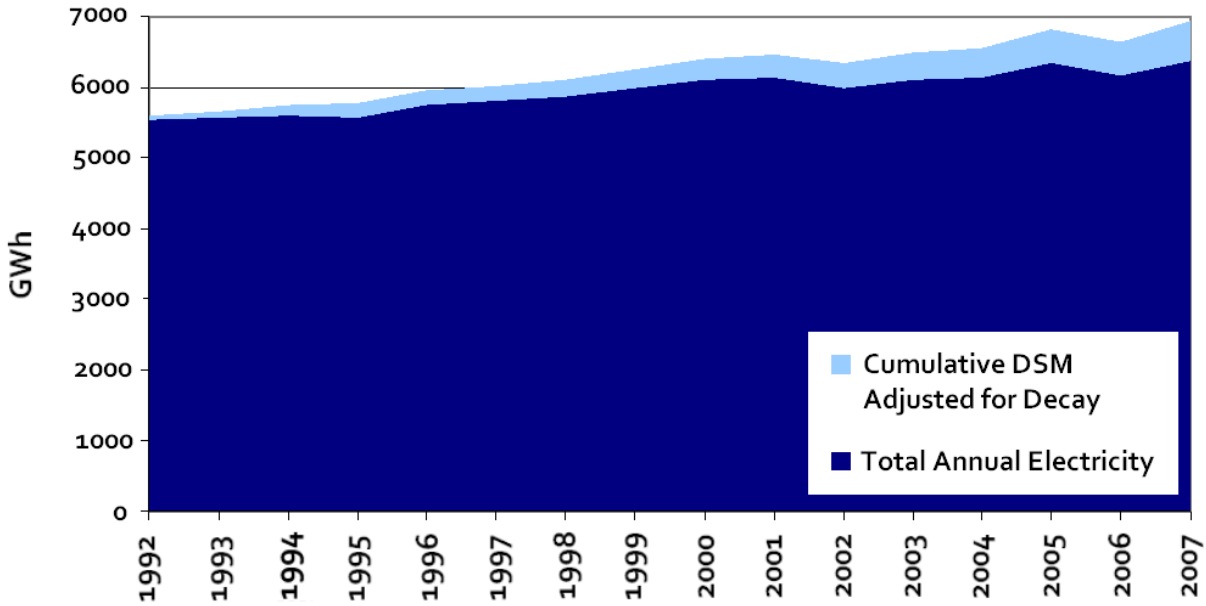
Historical GHG emissions (1990-2008) from each Vermont sector are examined in greater detail in the sections that follow. The final summary section provides a preliminary analysis of Vermont's GHG emissions trend relative to the near-term goal of reducing GHG emissions 25% below 1990 emissions levels by 2012.

Vermont's Greenhouse Gas Emissions by Sector

Electricity Supply & Demand (ESD)

Greenhouse Gas emissions associated with electricity in Vermont have been estimated through a consumption-based approach, using the methodology outlined by CCS in the previous inventory and forecast document. Total statewide electricity consumption, accounting for savings from demand-side management (DSM) efforts, was roughly equivalent in both 2005 and 2007, with totals of 6,298 and 6,222 Gigawatt hours (GWh) respectively (Figure ESD-1).[10]

Figure ESD-1. Vermont's Electricity Usage: With and Without DSM, 1992-2007



Estimates produced by CCS for 2005 reflect GHG emissions associated with the Vermont-specific electricity supply mix (Figure ESD-2a)[10]. Comparing this supply mix between 2005 and 2007 (Figure ESD-2b)[10] made it possible to apply supply mix-specific scaling factors to the 2005 values to estimate 2007 emissions. The decline in consumption-based GHG emissions between 2005 and 2007 from this sector results from an increased reliance on low or non-GHG emitting sources such as "Hydro (other)", "Other Renewable" and "HQ" sources, and a reduced dependence on higher emitting sources such as "System A" electricity (see Figure ESD-3)[10].

[10] Source: Vermont DPS - http://publicservice.vermont.gov/pub/other/utilityfactsfinaldraft2008.doc

Figure ESD-2a. VT Electric Energy Supply by Resource (2005)

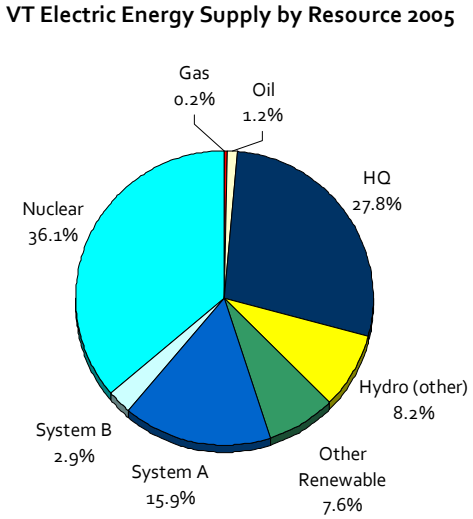


Figure ESD-2b. VT Electric Energy Supply by Resource (2007)

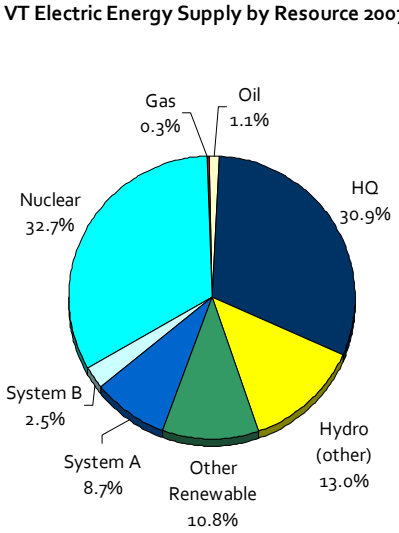
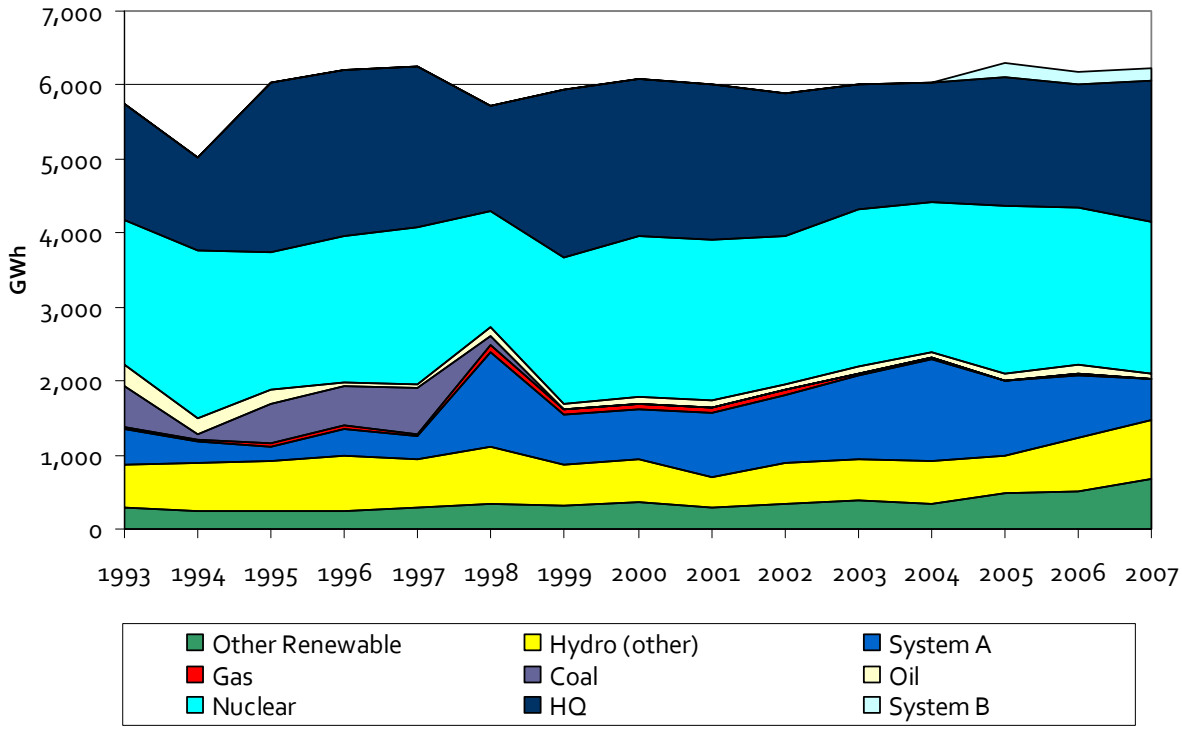
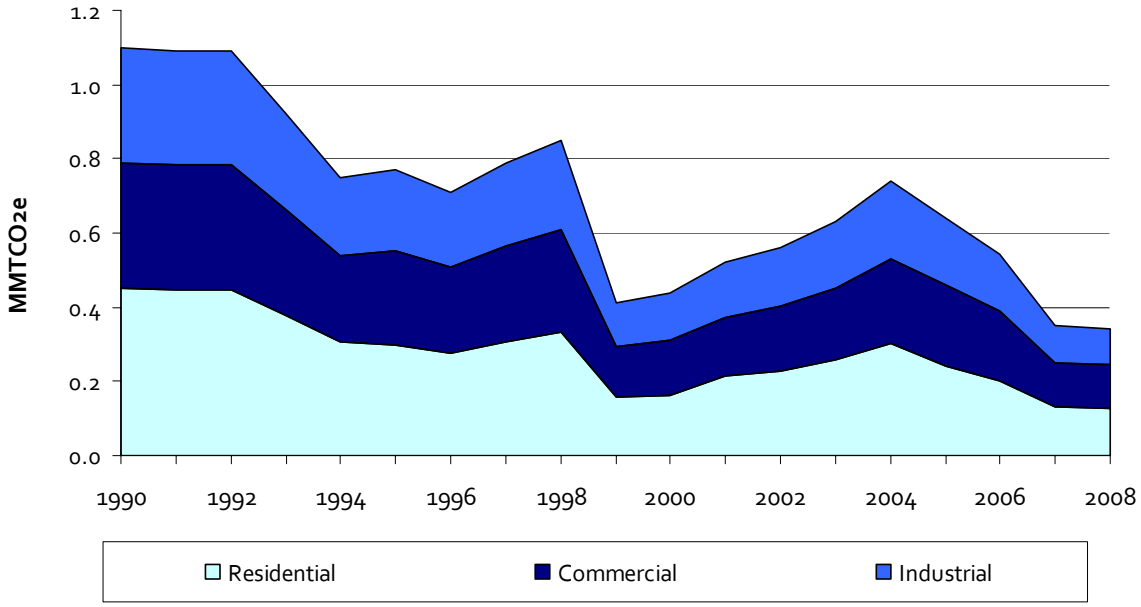


Figure ESD-3. Vermont Historical Electric Energy Supply by Resource (1993-2007)



Individual utility data for 2008 have not yet been compiled by the Vermont Department of Public Service, but 2008 total utility sales (in GWh) were down approximately 1.9% from 2007. For the purpose of estimating 2008 emissions, the assumption made herein is that the electric supply resource mix shown in Figure ESD-3 was not substantially different between 2007 and 2008. This assumption will be adjusted as necessary in a future inventory update.

Figure ESD-4. Historical GHG Emissions from Electricity Consumption in Vermont by Sector (1990-2008)



	1990	1995	2000	2005	2007	2008
Residential	0.45	0.3	0.16	0.24	0.13	0.13
Commercial	0.34	0.25	0.15	0.22	0.12	0.12
Industrial	0.31	0.22	0.13	0.18	0.1	0.1
TOTAL	**1.1**	**0.77**	**0.44**	**0.64**	**0.35**	**0.34**

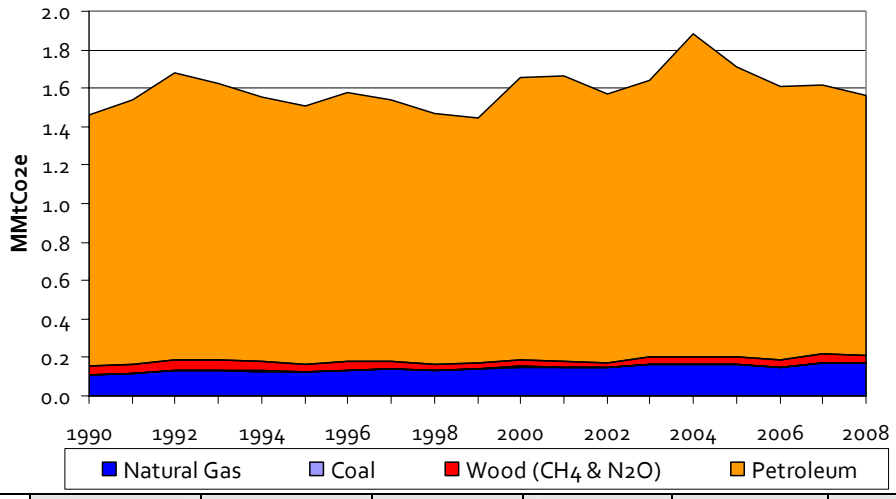
Annual emissions from this sector vary according to the resources that constitute the "supply mix"; but in general have exhibited a declining trend from 1990 to present (Figure ESD-4). Estimated 2008 consumption-based GHG emissions are approximately 47% below 2005 levels, and nearly 69% below 1990 levels. However, continuation of this trend is uncertain, as the composition of Vermont's future electricity supply mix is unknown at this time. This is due in part to the recent uncertainty regarding the continued operation of the Entergy Nuclear Vermont Yankee facility which currently supplies about one third of the electricity consumed within Vermont. Future GHG emissions from this sector will increase unless Vermont's utilities engage in contracts with electricity providers that offer low or no-GHG emissions characteristics to meet the impending 2012 supply gap. In addition, strong consumer demand-side management (DSM) efforts will be of enhanced importance in the future if each kilowatt-hour used by a consumer is associated with higher GHG emissions.

Residential, Commercial, and Industrial (RCI) Fuel Use

Greenhouse Gas emissions from direct fuel combustion were estimated using the United States Environmental Protection Agency's (US EPA) State Greenhouse Gas Inventory Tool (SIT) modules updated through February 26, 2010. Revisions were made to the SIT using the most recent data available from the United States Department of Energy (US DOE) Energy Information Administration (EIA) State Energy Data System (SEDS) which includes 2007 data released between December 2008 and May 2009.[11] The SIT default residential wood combustion data were replaced with data from in-state surveys completed by the VT Departments of Public Service (1998) and Forests, Parks & Recreation (2008).[12]

Total fuel combusted in the residential, commercial, and industrial (RCI) sector declined between 2005 and 2007, and individual fuels varied somewhat in their relative contribution to gross GHG emissions. Although demand side management (DSM) practices such as weatherization and heating system efficiency improvements continue to play an important role in reducing emissions; it is not feasible with the available data to resolve exactly how much of this decline may be attributed to them. Actual 2008 data were not yet available for this sector, so 2008 emissions were scaled to 2007 data using statewide average heating degree day (HDD) data.[13] There are slight differences between these estimates and previous estimates prepared by CCS, which are attributed to the SIT data updates mentioned previously. According to the most recent estimates for 2008, GHG emissions from the residential sector were approximately 8% (0.14 MMTCO2e) lower than 2005 emissions, but nearly 8% higher than 1990 emissions (Figure RCI-1).

Figure RCI-1. Residential Sector GHG Emissions from Fuel Combustion



	1990	1995	2000	2005	2007	2008
Petroleum	1.32	1.35	1.48	1.51	1.40	1.35
Natural Gas	0.11	0.12	0.15	0.16	0.17	0.17
Wood	0.03	0.03	0.02	0.04	0.04	0.04
Coal	0.004	0.001	0.0003	0.0003	0.0003	0.0003
TOTAL	**1.46**	**1.50**	**1.66**	**1.71**	**1.61**	**1.57**

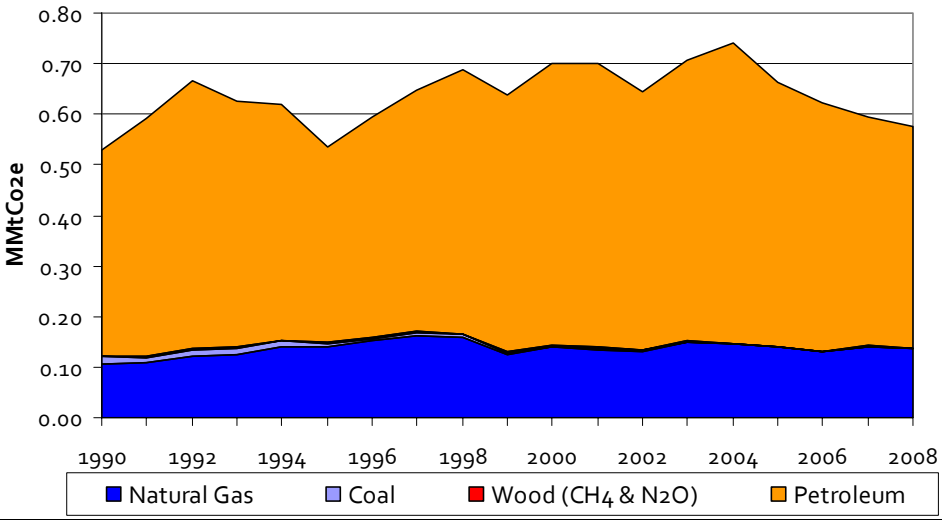
[11] Data available from: http://www.eia.doe.gov/emeu/states/_seds_updates.html

[12] Historical usage survey available from the Vermont Department of Public Service at: http://publicservice.vermont.gov/pub/other/residential_wood_fuel_assessment1998.pdf; Recent 2007-08 draft survey courtesy – Vermont Department of Forests, Parks & Recreation (not yet published).

[13] Calendar year 2008 had approximately 97% of the total HDD recorded for calendar year 2007 in Vermont (http://www7.ncdc.noaa.gov/CDO/CDODivisionalSelect.jsp)

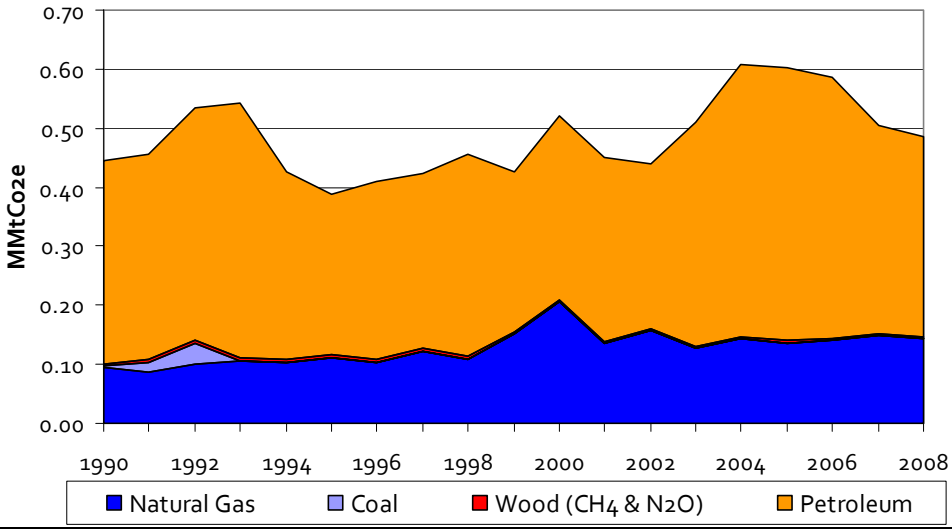
Commercial Sector fuel combustion GHG emissions declined by approximately 14% (0.09 MMTCO2e) between 2005 and 2008. This represents an increase from 1990 levels of roughly 8% (Figure RCI-2). Similarly, Industrial fuel combustion GHG emissions declined by approximately 17% (0.10 MMTCO2e) between 2005 and 2008. This corresponds to an increase from 1990 levels of 11% (Figure RCI-3).

Figure RCI-2. Commercial Sector GHG Emissions from Fuel Combustion



	1990	1995	2000	2005	2007	2008
Petroleum	0.41	0.39	0.56	0.52	0.45	0.44
Natural Gas	0.11	0.14	0.14	0.14	0.14	0.14
Wood	0.002	0.002	0.002	0.001	0.001	0.001
Coal	0.01	0.01	0.002	0.00002	0.00002	0.00002
TOTAL	**0.53**	**0.54**	**0.70**	**0.66**	**0.59**	**0.57**

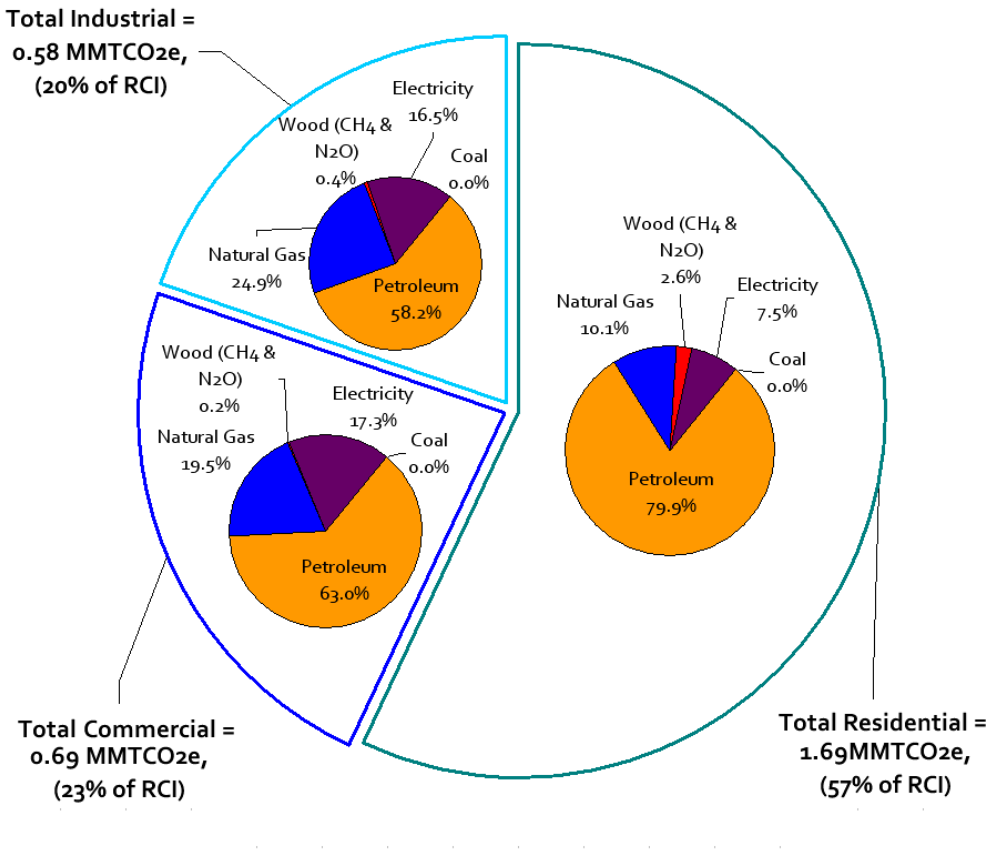
Figure RCI-3. Industrial Sector GHG Emissions from Fuel Combustion



	1990	1995	2000	2005	2007	2008
Petroleum	0.34	0.27	0.31	0.46	0.35	0.34
Natural Gas	0.10	0.11	0.20	0.14	0.15	0.15
Wood	0.004	0.006	0.005	0.004	0.002	0.002
Coal	0.003	0	0	0	0	0
TOTAL	**0.45**	**0.39**	**0.52**	**0.60**	**0.50**	**0.50**

Figure RCI-4 provides a summary of the estimated 2008 direct GHG emissions associated with the combustion of fossil fuels and wood biomass, as well as the share of emissions associated with the generation of electricity consumed by each sector. Note that the emissions associated with electricity supply and demand are accounted for in the earlier Electricity Supply & Demand (ESD) section of this report. Inclusion of indirect emissions associated with electricity consumption in Figure RCI-4 is intended to provide a basis for comparison vs. the emissions associated with direct on-site consumption of fuel by the RCI sectors. The emissions are not double-counted in this inventory.

Figure RCI-4. 2008 RCI GHG Emissions (including electricity consumption)



TOTAL RCI GHG EMISSIONS (including electricity consumption) = 2.97 MMTCO2e
TOTAL RCI GHG EMISSIONS (on-site fuel combustion only) = 2.63 MMTCO2e

Transportation

Energy use in the transportation sector declined between 2005 and 2008. According to Vermont tax data[14], annual statewide gasoline consumption during 2007 was slightly less than 350 million gallons. This is a reduction from 2005 levels of roughly 2.5%. Gasoline consumption declined an additional 3.3% from 2007 levels during 2008. Diesel fuel consumption increased somewhat between 2005 and 2007, but then declined nearly 8.5% between 2007 and 2008. The overall decline in transportation fuel consumption was likely caused by high fuel prices at the pumps during 2007 and 2008 (Figure T-1), which also translated into a reduction in statewide annual vehicle miles traveled (VMT) (Figure T-2) . Fuel consumption continued to decline in 2009 despite slightly lower prices.

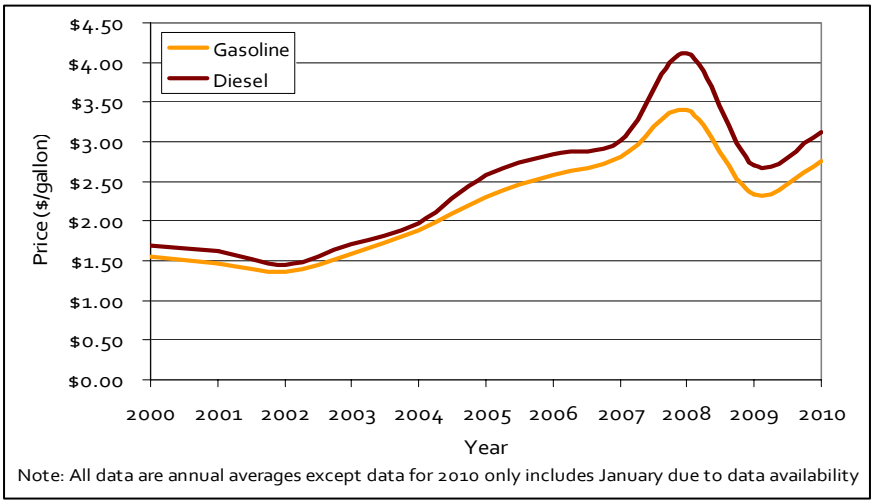


Figure T-1. Vermont Average Fuel Prices (2000 through January 2010)[15]

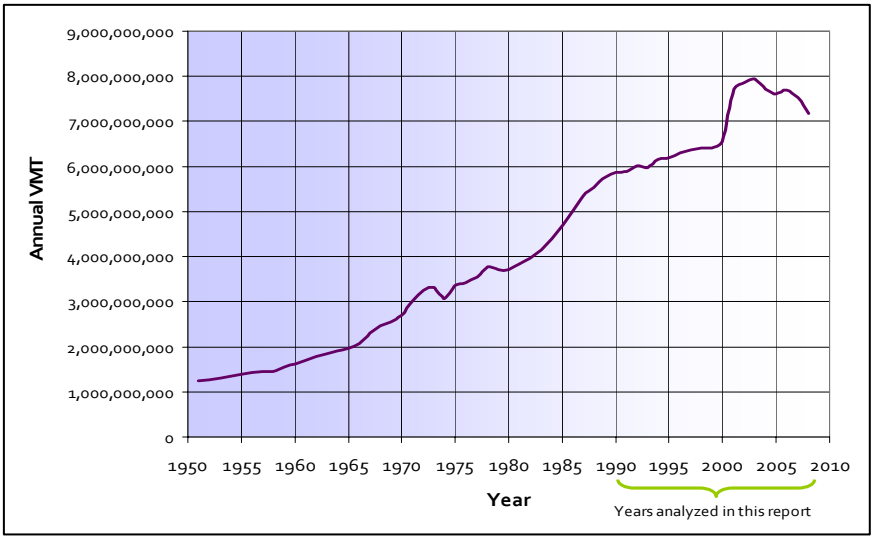


Figure T-2. Vermont Annual Vehicle Miles Traveled (VMT) (1950-2008)[16]

[14] Source: Vermont Department of Motor Vehicles and Legislative Joint Fiscal Office
http://www.leg.state.vt.us/JFO/Transportation/Gas%20&%20Diesel%20Tax%20Revenue%20and%20Gallons%20-%20Monthly%20Update.xls

[15] Data source: Vermont Department of Public Service Fuel Price Reports available at
http://publicservice.vermont.gov/pub/vt-fuel-price-report.html

[16] Data source: Vermont Agency of Transportation (VTrans)
http://www.aot.state.vt.us/Planning/Documents/HighResearch/Publications/avmthist%201920%20to%202008.pdf

Other factors contributing to the decline in GHG emissions from this sector include slight increases in new light duty vehicle fleet fuel economy[17], a consumer shift away from full-size pickups and sport utility vehicles towards smaller, more fuel efficient "basic economy" vehicles and hybrid electric vehicles (HEV). The number of HEVs registered in Vermont increased from 1,510 vehicles in 2005 to 4,565 vehicles in 2008, yielding a 202% increase over this period. Although this is a substantial increase over a short period of time, HEVs currently make up less than 1% of the overall fleet. A combination of expanded service, enhanced promotion, and change in human behavior resulted in an increased ridership trend for most of Vermont's transit providers between 2005 and 2008. Passenger rail also garnered increases, with Amtrak Ridership increasing approximately 40% between 2005 and 2008.[18]

Greenhouse gas emissions from the Transportation sector were calculated using methodologies described by CCS in the previous inventory and forecast document. Annual transportation fuel consumption data from Vermont tax records were entered into the EPA SIT to estimate CO_2 emissions. Methane (CH_4) and Nitrous Oxide (N_2O) emissions were estimated using Vermont-specific VMT combined with vehicle-specific emission factors for CH_4 and N_2O based on appropriate engine technology, vehicle age distribution, and annual VMT accumulation by vehicle type.[19] Note that the original CCS estimates utilized 2002 as the most recent data year, and projected emissions for subsequent years including 2005. This update relies on actual statewide VMT, in-state gasoline and diesel transportation fuel consumption, and other data available through 2008. As a result, the revised transportation GHG emissions estimate for 2005 differs slightly from the original projections prepared by CCS.

In December 2009, The US EPA made available a new onroad transportation emissions modeling tool known as MOVES2010.[20] For comparison purposes, this new tool was used to evaluate Vermont's onroad transportation GHG emissions for 2007. Preliminary results using a mix of default MOVES2010 input data and state-specific inputs derived from available VTrans data are in reasonably good agreement with estimates produced by the SIT (see Table T-1).

Table T-1. Comparison of SIT and MOVES2010 draft output

	US EPA SIT output	MOVES2010 draft output
2007 Gasoline GHG emissions (MMTCO2e)	3.19	3.11
2007 Diesel GHG emissions (MMTCO2e)	0.704	0.697
TOTAL	**3.89**	**3.81**

[17] From the US EPA report – "Light-Duty Automotive Technology, Carbon Dioxide Emissions, and Fuel Economy Trends: 1975 Through 2009" (http://www.epa.gov/oms/fetrends.htm#summary)

[18] From The Vermont Transportation Energy Report – UVM Transportation Research Center (August 2009) http://www.uvm.edu/~transctr/cleancty/pdf/VT-Transportation-Energy-Report2009.pdf

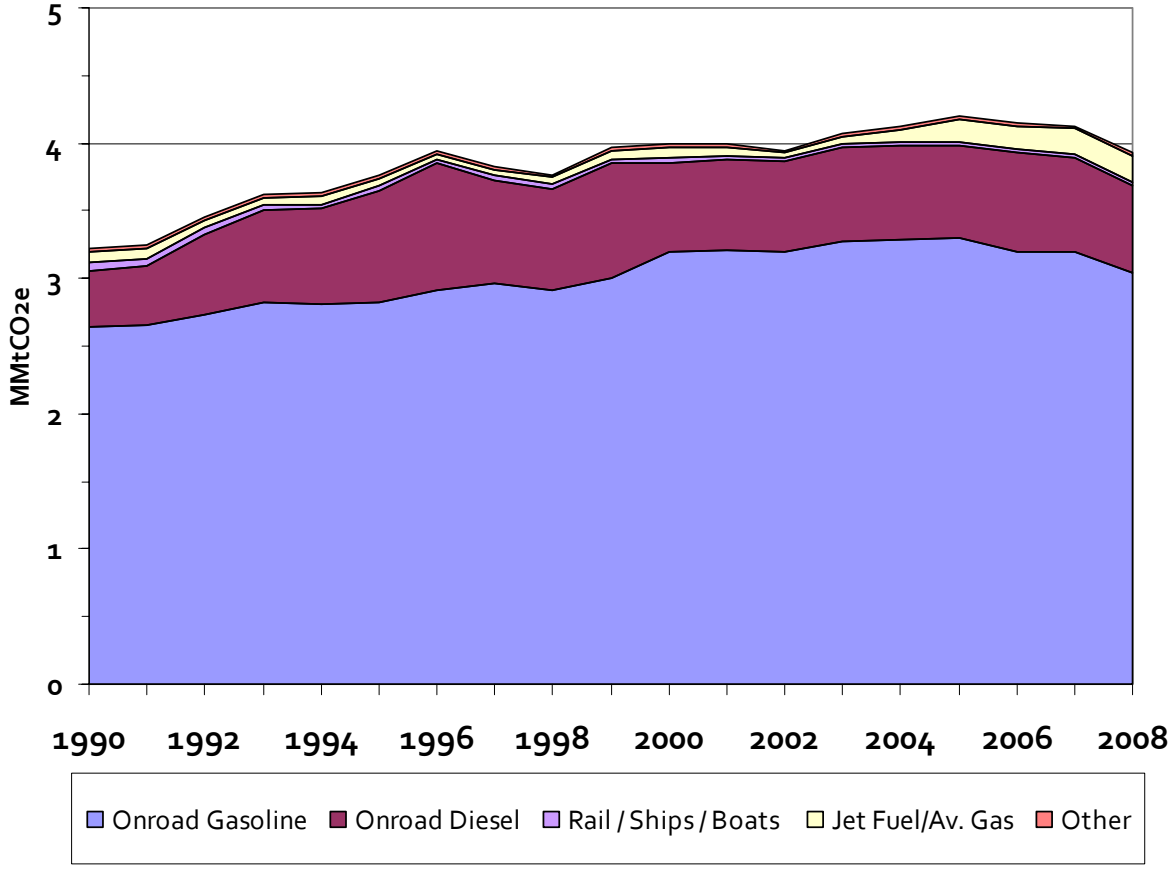
[19] Vehicle age distributions are based upon national defaults, and annual VMT accumulation by vehicle type was generated using VTrans Automatic Vehicle Classification Reports in conjunction with Annual Vehicle Miles Travelled (AVMT) by County and Functional Class

[20] MOVES2010 and supporting materials can be downloaded at http://www.epa.gov/otaq/models/moves/

In addition to being able to generate an annual emissions inventory, MOVES2010 has the capability to produce fine-scale emissions estimates for specific vehicle types, road types, spatial scales and time scales. However, various circumstances (including unfamiliarity with all the intricacies of the model, difficulties related to data collection, availability and formatting, extensive computer run times, etc.) prevented generation of a finer-scale transportation emissions inventory for Vermont at this time. Future inventory updates would benefit from the refinement of existing data, as well as development of additional Vermont-specific data inputs that would facilitate a more detailed evaluation of transportation emissions using the MOVES2010 model.

Greenhouse gas emissions for the Transportation Sector during 2007 were approximately 4.13 MMTCO2e, which is nearly 2% lower than the revised 2005 estimates; while 2008 emissions declined an additional 5% from 2007 levels to 3.93 MMTCO2e (Figure T-3). Transportation GHG emissions for 2008 were approximately 22% higher than 1990 levels.

Figure T-3. Transportation GHG Emissions (1990-2008)

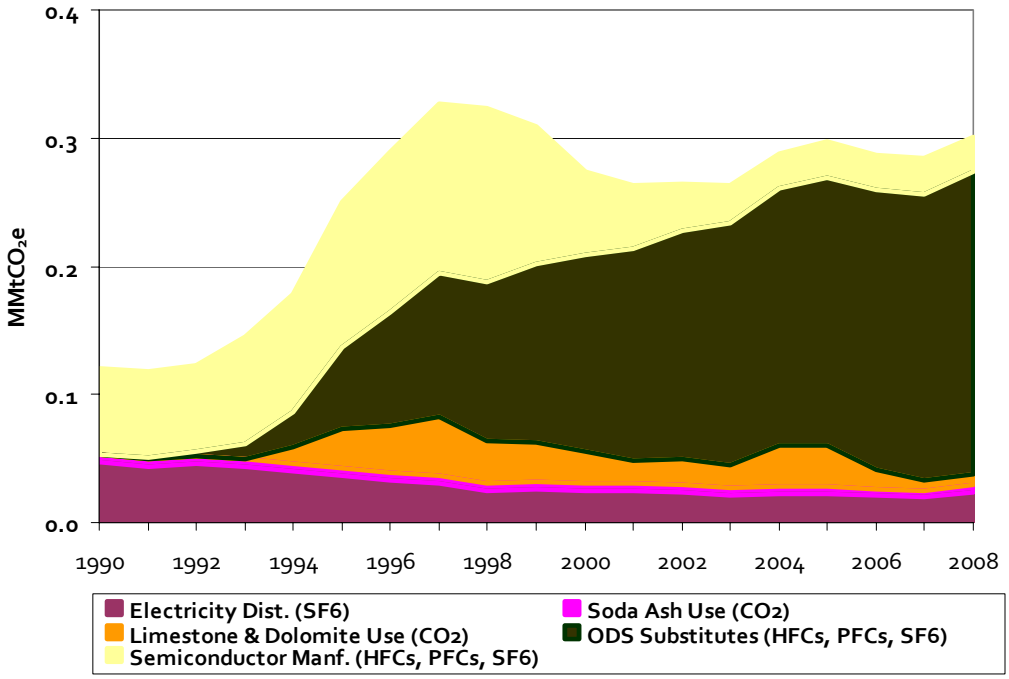


	1990	1995	2000	2005	2007	2008
Onroad Gasoline	2.64	2.82	3.20	3.29	3.19	3.04
Onroad Diesel	0.41	0.84	0.66	0.69	0.70	0.65
Rail /Ships / Boats	0.06	0.03	0.04	0.02	0.03	0.02
Jet Fuel /Av. Gas	0.08	0.06	0.07	0.17	0.18	0.19
Other	0.02	0.03	0.02	0.02	0.02	0.03
TOTAL	**3.22**	**3.77**	**3.99**	**4.20**	**4.13**	**3.93**

Industrial Processes

Industrial Process emissions were estimated using default data contained in the latest version of the US EPA SIT revised on 2/26/2010. Discrepancies with the original CCS inventory reflect updated data contained in the SIT. All 2008 estimates, except for "ODS substitutes", were held constant from 2007 as that was the most current year of data available in the SIT. Emissions of "ODS substitutes" were adjusted for national growth rates, as this is the only category of industrial process GHG emissions where substantial growth (approximately 5.8% annually) is expected in future years. Emissions from this sector for 2008 were approximately equal to 2005 levels, but roughly 150% higher than 1990 levels

Figure IP-1. GHG Emissions from Industrial Processes, by Source

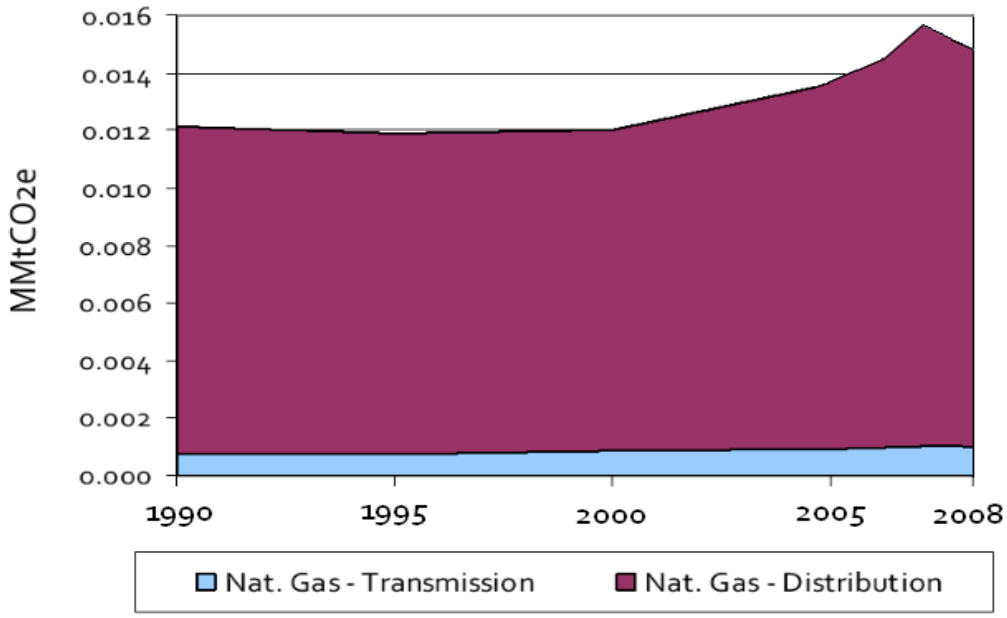


	1990	1995	2000	2005	2007	2008
Limestone & Dolomite Use	0	0.03	0.02	0.03	0.009	0.009
Soda Ash Use	0.006	0.006	0.006	0.005	0.005	0.005
ODS Substitutes	0	0.06	0.15	0.21	0.23	0.24
Electric Utilities (SF6)	0.05	0.04	0.03	0.02	0.02	0.02
Semiconductor Manufacturing (HFC,PFC, SF6)	0.07	0.11	0.06	0.03	0.03	0.03
TOTAL	**0.12**	**0.25**	**0.27**	**0.30**	**0.29**	**0.30**

Natural Gas Transmission & Distribution

Methane emissions associated with natural gas transmission & distribution for 1990-2005 were calculated by CCS using the "Natural Gas and Oil" US EPA SIT module. Emissions estimates for 2007 and 2008 were scaled to 2005 emissions based on total Vermont natural gas pipeline and distribution use data obtained from the US Department of Energy.[21]

Figure NG-1. Methane (CH_4) Emissions from the Fossil Fuel Industry



	1990	1995	2000	2005	2007	2008
Natural Gas - Transmission	0.0007	0.0008	0.0008	0.0009	0.0011	0.0010
Natural Gas - Distribution	0.011	0.011	0.011	0.013	0.015	0.014
TOTAL	**0.012**	**0.012**	**0.012**	**0.014**	**0.016**	**0.015**

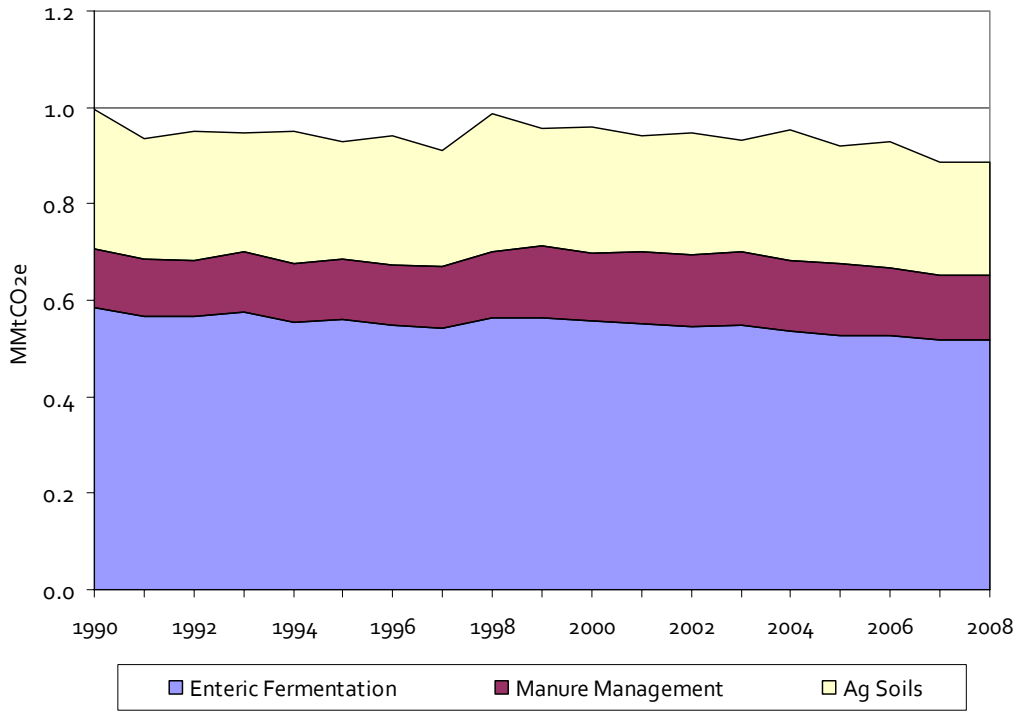
Vermont Gas doubled the number of customers served between 1990 and 2007.[22] This increase in service infrastructure can result in a higher possibility of leaks within the system, which form the basis of GHG emissions from this sector. However, GHG emissions estimates have not doubled along with the increase in service infrastructure. This is due to enhanced DSM measures, as well as the fact that aging infrastructure has been upgraded to polyethylene pipe that is less prone to leakage. Future emissions from this sector are likely to increase if the customer base and infrastructure continue to grow as expected.[23] Emissions from this sector in 2008 were 7% higher than 2005 levels, and 27% higher than 1990 levels.

[21] Data obtained from http://tonto.eia.doe.gov/dnav/ng/hist/na1480_svt_2a.htm
[22] According to Vermont Gas' Nov 2007 newsletter http://www.vermontgas.com/about/archives/VTG11.07.pdf
[23] Vermont Department of Public Service http://publicservice.vermont.gov/natural-gas/natural-gas.html

Agriculture

Agricultural emissions were estimated using the most recent version of the US EPA SIT "Methane and Nitrous Oxide Emissions from Agriculture" module revised by EPA on 2/26/2010. Slight differences between previous CCS estimates and this update reflect a number of revised emission factors, major crop, and livestock population estimates available in the SIT. These data were released in February 2009 through the United States Department of Agriculture 2007 Census of Agriculture.[24] Since 2007 is the most recent year for which data are available, this inventory update assumes that key agricultural activities in Vermont did not change substantially between 2007 and 2008. Dairy cattle populations used for manure management emissions estimates were adjusted to account for emissions reductions associated with the Cow Power program.[25] As shown in Figure AG-1, total gross emissions have been fairly constant since 1990. Emissions for 2008 were approximately 4% lower than 2005 levels and 12% lower than 1990 levels. Emission trends from this sector are not expected to change dramatically in near-term future years, and will likely decline slightly as a result of increased diversion of manure to anaerobic digesters that facilitate electricity generation from the associated methane emissions.

Figure AG-1. Gross GHG Emissions from Agriculture



	1990	1995	2000	2005	2007	2008
Enteric Fermentation	0.59	0.56	0.56	0.53	0.52	0.52
Manure Management	0.12	0.12	0.14	0.15	0.13	0.13
Ag Soils	0.29	0.24	0.26	0.24	0.23	0.23
TOTAL	**1.0**	**0.93**	**0.96**	**0.92**	**0.88**	**0.88**

[24] Data available from the USDA National Agricultural Statistics Service at http://www.agcensus.usda.gov/

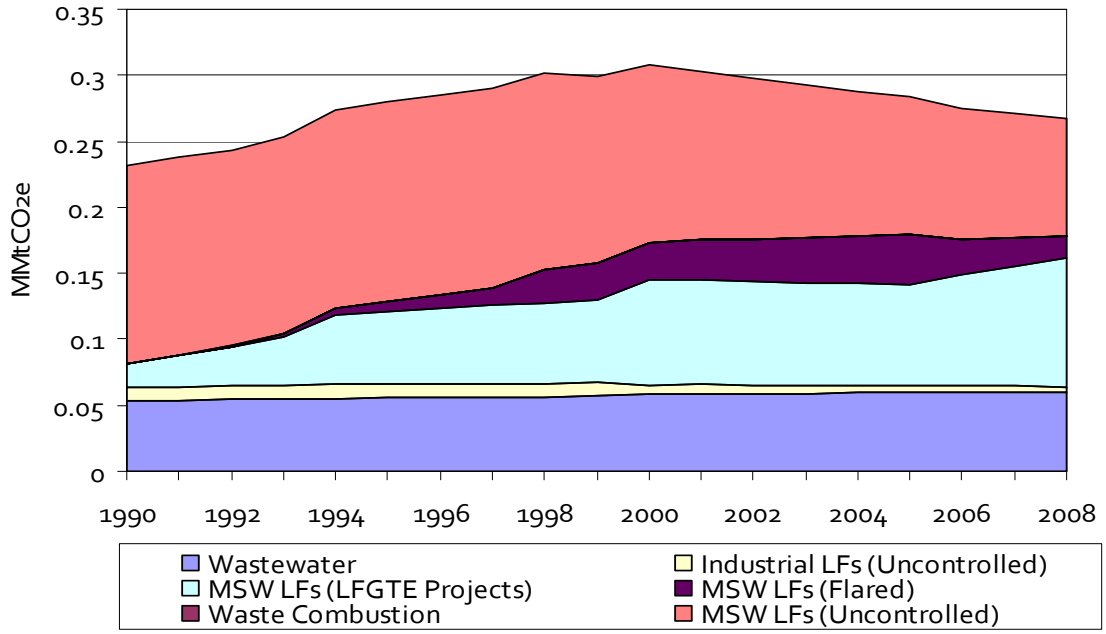
[25] According to Central Vermont Public Service (CVPS), there are currently 6 farms with a total of 5,980 cows. http://www.cvps.com/cowpower/Our%20Farms.html

Waste Management

Emissions from wastewater and solid waste management were estimated using the methodologies described by CCS and the most recent versions (2/16/10) of the appropriate US EPA SIT modules. Statewide annual flows and emissions from wastewater management have remained relatively constant.

Emissions from solid waste management at landfills continue to exhibit the declining trend that began between 2000 and 2005 (Figure WM-1). This is due to the fact that most of the smaller landfills in Vermont have been closed for more than 10 years and are releasing less methane each year as the onsite organic materials continue to breakdown. In addition, the 2 large landfills that still accept solid waste in state continue to implement more effective landfill gas capture and methane destruction methods. Existing landfill gas to energy (LFGTE) projects in Vermont have been successful not only in reducing the GHG emissions emitted directly from landfills, but also by providing indirect GHG benefits via generation of electricity. One additional LFGTE project became operational during 2009.[26] The overall decline in GHG emissions from this sector is likely to continue in the future.

Figure WM-1. Vermont GHG Emissions from Waste Management



	1990	1995	2000	2005	2007	2008
Wastewater	0.05	0.06	0.06	0.06	0.06	0.06
Industrial LFs (Uncontrolled)	0.01	0.01	0.007	0.006	0.005	0.004
MSW LFs (LFGTE Projects)	0.02	0.05	0.08	0.08	0.09	0.1
MSW LFs (Flared)	0	0.008	0.03	0.04	0.02	0.02
MSW LFs (Uncontrolled)	0.15	0.15	0.13	0.10	0.09	0.09
Waste Combustion	0.0004	0.0004	0	0	0	0
TOTAL	**0.24**	**0.28**	**0.31**	**0.29**	**0.27**	**0.27**

[26] For more information, see http://www.anr.state.vt.us/dec/wastediv/solid/Moretown_Landfill.htm

Forestry & Land Use [27]

Statewide forest carbon accounting is heavily influenced by the following:

- Area of forest land,
- Biomass accumulation (tree and vegetation growth),
- Forest type (hardwood vs. softwood), and
- Disturbances (e.g., 1998 ice storm, mortality from exotic insects, etc.)

From 1990 to 2008, Vermont's forests continued to increase in biomass (growth), although there has been a slowing of growth rate (and therefore carbon uptake). Acres of forest land increased until 2000 when we began seeing an overall decrease in acres of forest land in the state. Although there has been a slow rate of change in forested acres, this has influenced the carbon uptake potential of forests. Preliminary results from national forest carbon models used by the US Forest Service show a decrease in the amount of carbon uptake annually. This change has not been verified quantitatively, and is unavailable at this time.

Regardless of the changes in annual carbon sequestration rates, forests remain a tremendous asset in storing carbon, therefore reducing total atmospheric greenhouse gas (GHG) concentrations. Maintaining existing forest land will continue to be a priority in mitigating GHG emissions in Vermont.

[27] Data sources: Forest carbon calculations were provided by the USDA Forest Service, based on Forest Inventory and Analysis (FIA) data and FIADB4.0.

Conclusions

As stated earlier, there are a number of key uncertainties that make forecasting statewide gross GHG emissions beyond 2012 exceedingly difficult. This summary will focus on putting Vermont's historic gross GHG emissions in context with the near-term (2012) and mid-term (2028) reduction goals. Figure C-1 shows Vermont's statewide estimates of historic gross GHG emissions from 1990 through 2008. The future emissions reduction trajectories that will be required to meet the 2012 and 2028 goals are also plotted in the figure. Vermont's GHG emissions have been declining over the past several years. However, further substantial reductions from actions, like those included in the recommendations of the GCCC and its Plenary Group, will be required to continue the decline in emissions to meet the goals.

Despite the substantial uncertainties, an attempt has been made to forecast a likely "Assumed Emissions Trajectory" for 2012 based on the sector-specific assumptions provided below in Table C-1.

Figure C-1. Vermont GHG Emissions Relative to Reduction Goals

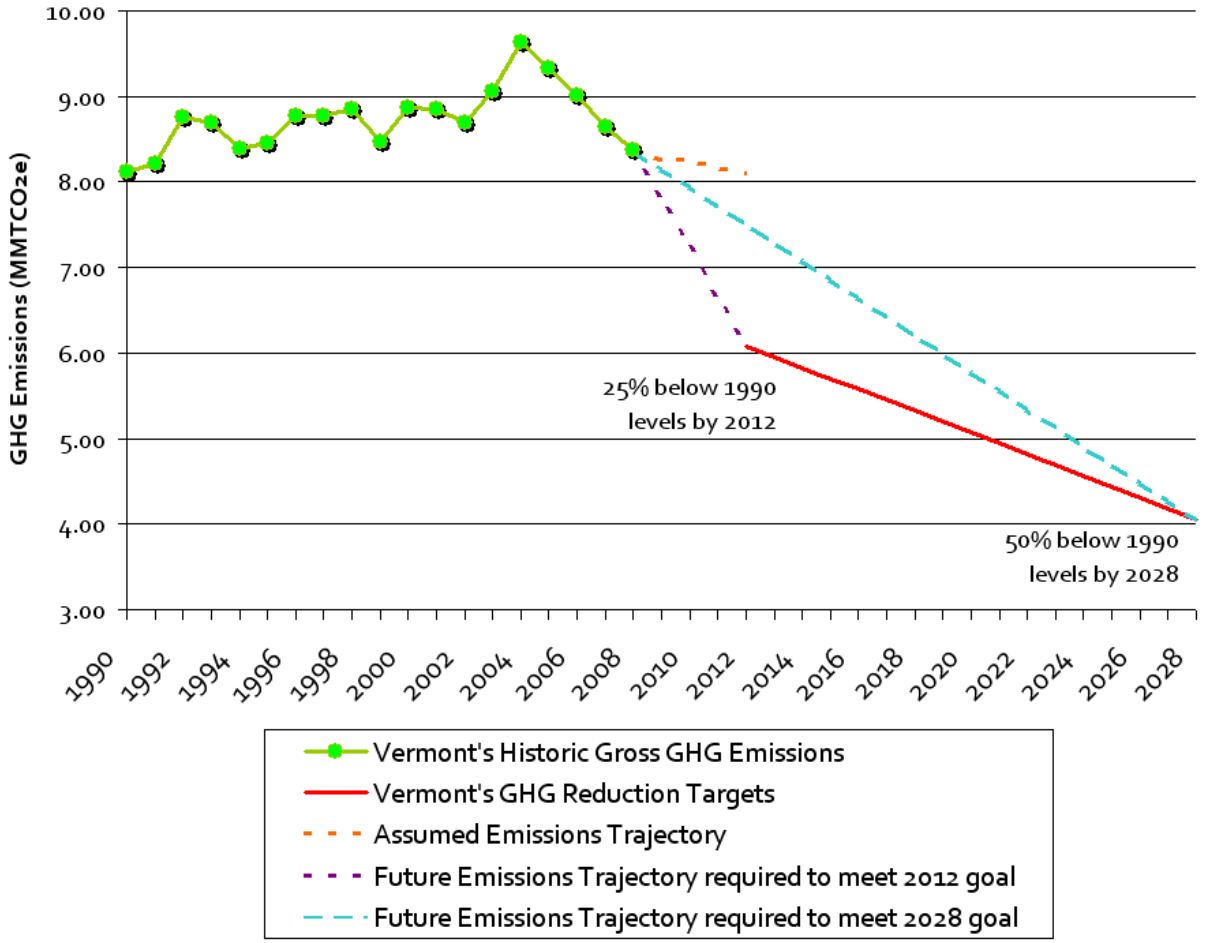


Table C-1. Forecasted 2012 Vermont GHG Emissions and Associated Assumptions

GHG Emissions Sector	Assumption	Forecasted 2012 Emissions (MMTCO2e)
Electricity Consumption	2008 emissions levels held constant through 2012	0.35
Residential / Commercial / Industrial Fuel Use	2008 emissions levels held constant through 2012. Historically, emissions from this sector have been relatively constant. This assumption is potentially complicated by expected emissions reductions from efficiency and weatherization, emissions increases from population growth, and the variability of emissions due to changes in annual heating demand.	2.63
Transportation	2008 emissions adjusted to 2009 using available Vermont transportation fuel data for 2009. 2009 -2012 transportation fuel consumption was held flat, while accounting for expected annual emissions reductions due to adoption of California GHG emissions standards[28]	3.65
Fossil Fuel Industry	2008 emissions from natural gas transmission & distribution grown by 3% per year to 2012[29]	0.017
Industrial Processes	2008 emissions levels held constant through 2012 for all categories except ODS substitutes. Emissions associated with ODS substitutes were grown by 5.8% per year[30]	0.37
Waste Management	Historic annual emissions trend (slight decline ~1.5% per year) extended to 2012	0.26
Agriculture	Historic annual emissions trend (slight decline of ~1% per year) extended to 2012	0.84
TOTAL GROSS EMISSIONS		8.12

Assuming these assumptions accurately characterize 2012 GHG emissions, Vermont will fall short of its 2012 goal (6.08 MMTCO2e) by approximately 2 MMTCO2e. Likewise, further steep emissions reductions will be required to meet the 2028 goal (4 .06 MMTCO2e). Despite the need for additional bold steps in upcoming years to attain these reduction goals, Vermont's forecasted 2012 emissions indicate that a return to a 1990 emissions level is possible over the next few years. In fact, Vermont's 2008 gross GHG emissions were only approximately 3% higher than 1990 emissions. This rate of progress is comparable to other states in the northeast, including Connecticut (2007 emissions were 4% higher than 1990)[31], Maine (2008 emissions were 2.5% higher than 1990)[32], and New York (2007 emissions were 2.5% higher than 1990).[33]

[28] From methodology developed by CCS

[29] Vermont Department of Public Service (http://publicservice.vermont.gov/natural-gas/natural-gas.html)

[30] Methodology utilized by CCS based on US EPA 2004 ODS substitutes cost study report.

[31] 2009 Connecticut GHG Inventory Update
http://www.ct.gov/dep/lib/dep/air/climatechange/inventory/2009_connecticut_ghg_inventory-2010-0127.pdf

[32] Maine DEP – Third Biennial Report on Progress toward Greenhouse Gas Reduction Goals (Jan 2010)
http://www.maine.gov/dep/air/greenhouse/pdf/Third%20Biennial%20Report%20FINAL%20ALL%20PAGES%20CORRECTED%2002192010.pdf

[33] NYSERDA - New York State Greenhouse gas Emissions Inventory and Forecasts for the 2009 State Energy Plan (http://www.nysenergyplan.com/Supporting_Documents/Greenhouse%20Gas%20Emissions%20Inventory%20&%20Forecasts.pdf)

Vermont and ten neighboring state and provincial governments that are members of the Conference of New England Governors and Eastern Canadian Premiers (NEG-ECP) made a commitment in August 2001 to collaborate in reducing region-wide GHG emissions to 1990 levels by 2010. This regional Climate Change Action Plan[34] recognized that GHG emissions reductions "*...may not be achieved in equal measure by each jurisdiction... that differences in emissions characteristics and inventories, social and political systems, economic profiles (including transportation / utility / industrial infrastructures), and resources will lead to varying approaches among the jurisdictions in contributing to the regional goals. However, each jurisdiction in the region commits to participate in the achievement of the regional goals and work with the other states and provinces in the region on this important effort".*

Preliminary data suggest that the NEG-ECP region may have been successful in meeting this 2010 reduction goal. At this time, it is unclear exactly how much of the region-wide GHG emissions reduction can be attributed to economic decline versus policies, projects and personal choices. As Vermont and the other NEG-ECP jurisdictions strive to regain stable economic footing, emphasis must be placed on incorporating policies and actions that also support continued reductions in energy consumption and GHG emissions.

An excellent example of this integrated approach can be seen in Vermont's ongoing electric demand-side management (DSM) programs, which continue to achieve reductions in energy consumption and GHG emissions, while providing long-term financial savings to Vermonters. Highlights of some DSM program benefits are described below:

Efficiency Vermont: [35]

- *"As a result of energy efficiency investments made from 2000 through 2008, Efficiency Vermont has saved approximately 565 million kWh, and Vermont is using 9 percent less electricity than it would have without these energy efficiency investments."*
- *"In 2008, for the second time, energy efficiency savings completely offset electric energy load growth..."*
- *"In total, Vermonters will save more than $66 million over the life of the efficient products and practices Efficiency Vermont put in place in 2008"*
- *"These same energy efficiency investments will also benefit Vermont's environment by, over their lifetime, eliminating hundreds of tons of air pollutants and over four-hundred-thirty-thousand tons of carbon dioxide."*

Burlington Electric Department: [36]

- *"...energy efficiency investments save Burlington consumers over $9 million of retail electric costs annually."*
- *"During 2009 alone, BED saved 5,470 Megawatt hours (MWh) of energy from efficiency measures installed, which will result in 62,961 MWh of savings over the useful life of the installed measures (2009 measures have a weighted average lifetime of 12 years). This is equivalent to providing energy to about 1,100 Burlington residential customers for 12 years."*

[34] The Climate Change Action Plan of the NEG-ECP (August 2001) can be found at: http://www.negc.org/documents/NEG-ECP%20CCAP.PDF

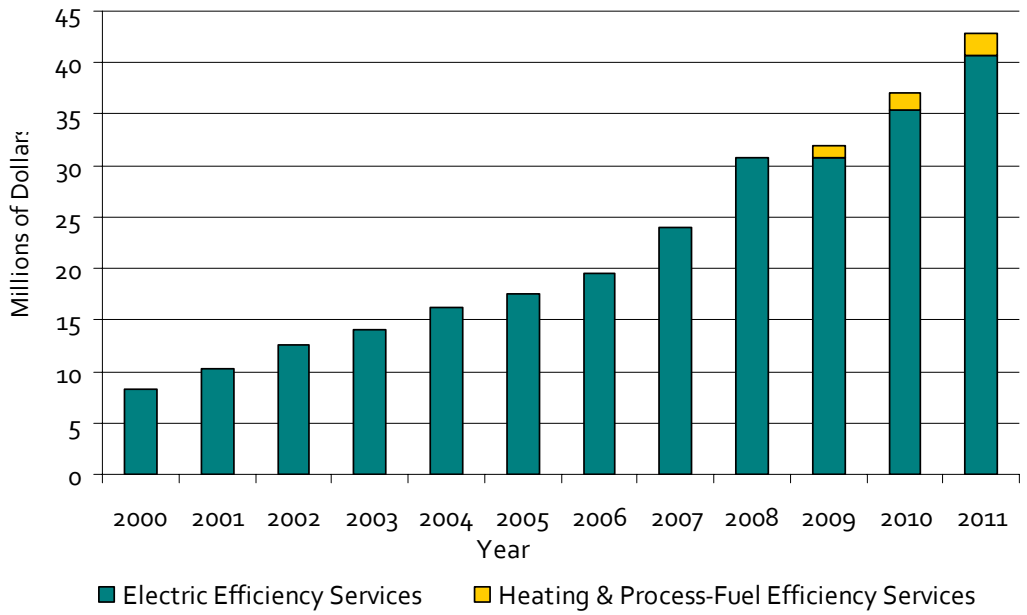
[35] Excerpts taken from the Vermont Public Service Board website: http://psb.vermont.gov/utilityindustries/eeu/generalinfo/evtaccomplishments

[36] Excerpts taken from Burlington Electric Department 2009 Energy Efficiency Annual Report: https://www.burlingtonelectric.com/ELBO/assets/2009%20DSM%20Annual%20Report%20Master.pdf

Energy Efficiency Utility Program Budgets: [37]

Vermont law requires that revenues gained from Efficiency Vermont's and Burlington Electric Department's participation in the regional forward capacity market be used to provide energy efficiency services to heating and process-fuel customers. Historic (actual) and future (estimated) budgets for both "Electric Efficiency" and "Heating & Process-Fuel Efficiency" services are shown below in Figure C-2.

Figure C-2. Energy Efficiency Utility Program Budgets.



The historical increase in funding for electric efficiency services has provided important emissions reductions and economic benefits to Vermonters. The recent addition of funding for heating and process fuel efficiency is another key step. It is vital that the alignment of economic and emissions reduction goals continues to spread to other sectors if Vermont and the NEG-ECP region remain committed to reaching future GHG emissions reduction milestones, rather than a return to business-as-usual.

[37] Source: Vermont Public Service Board (http://psb.vermont.gov/utilityindustries/eeu/generalinfo/budgets)

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VERMONT