

Vermont

GHG Emissions Inventory Update

Vermont Greenhouse Gas Emissions Inventory and Forecast: 1990 – 2017

Presentation to the House Energy and Technology Committee

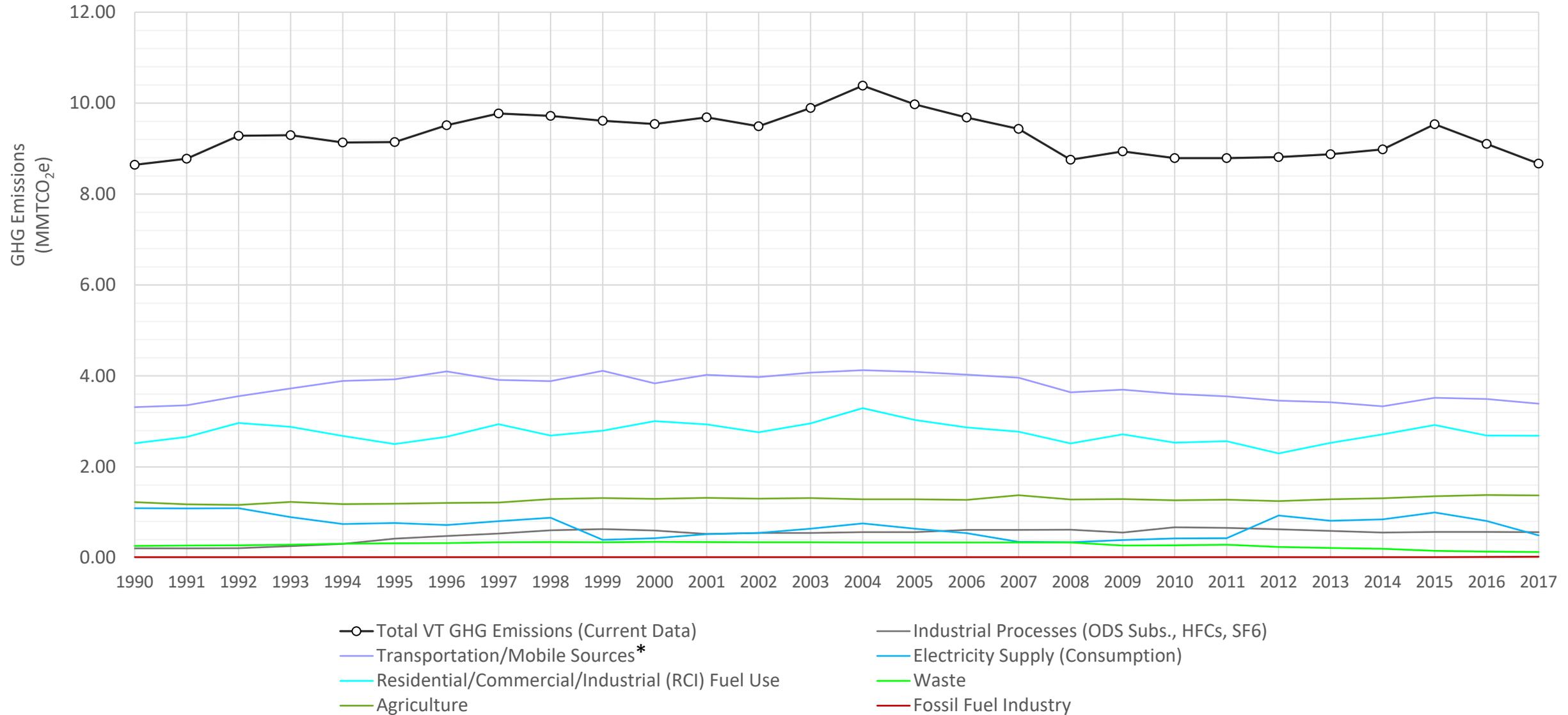
May 18, 2021



The Greenhouse Gas Emissions Inventory

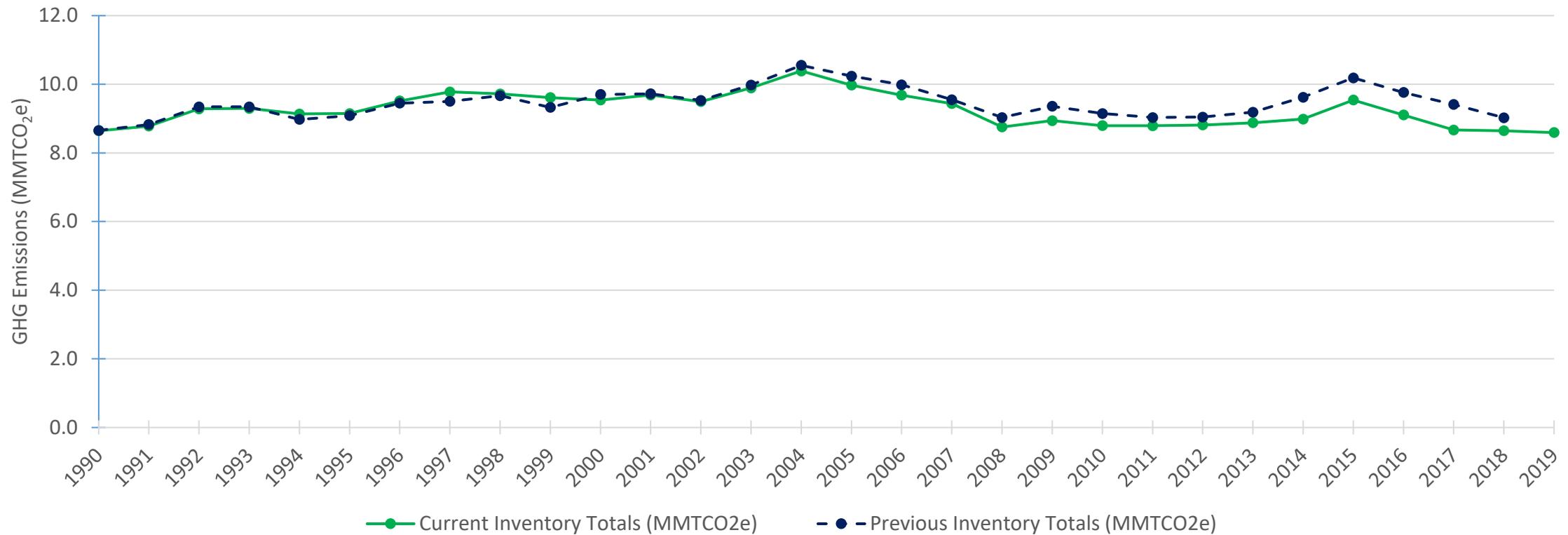
- What is the Greenhouse Gas Emissions Inventory report?
 - Inventory of anthropogenic GHG emissions for Vermont, published annually
 - Required by state statute (10 V.S.A. § 582)
 - Total (gross) annual emissions (not including biogenic CO₂ in gross annual totals)
 - Attempt to quantify and sum GHG emissions from all applicable sectors in Vermont
 - Inventory relies heavily on federal datasets and EPA tools and therefore often lags several years behind the calendar year when the emissions occurred (current inventory 1990-2017)
 - Includes emissions of gases covered in international agreed upon protocol in million metric tons of CO₂ equivalent (MMTCO₂e)
 - CO₂, CH₄, N₂O, HFCs, PFCs, SF₆, NF₃
 - Methodologies consistent with accepted GHG inventory standards/protocols
 - Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030 (2007) report, IPCC, EPA
 - Inventory uses 100-year global warming potential values from the IPCC AR4 report per IPCC GHG inventory guidance

GHG Emissions by Sector (1990 – 2017)



* Methodology update to be discussed later in presentation

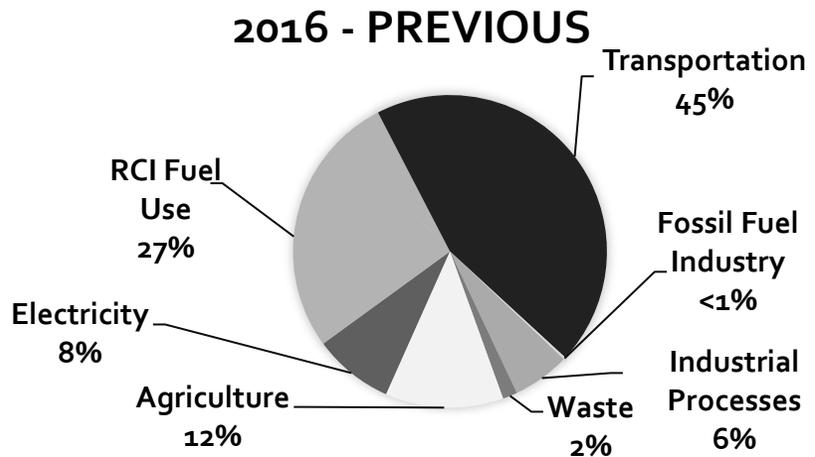
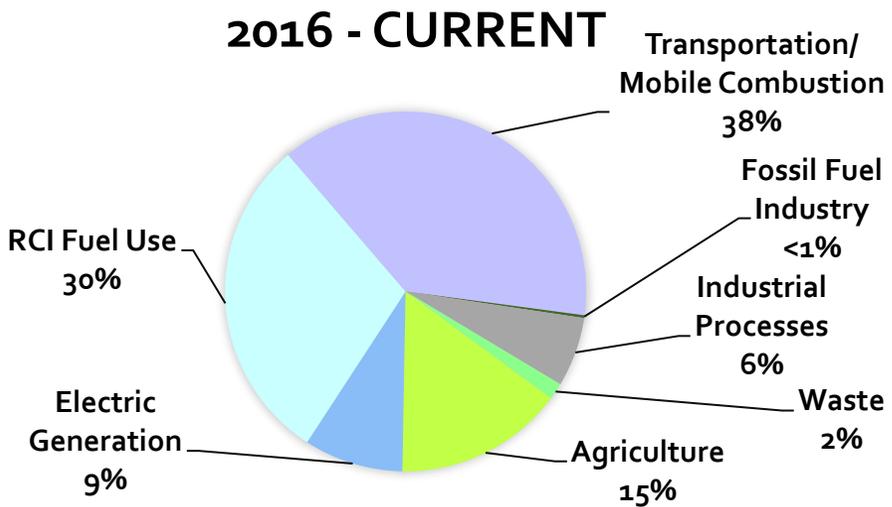
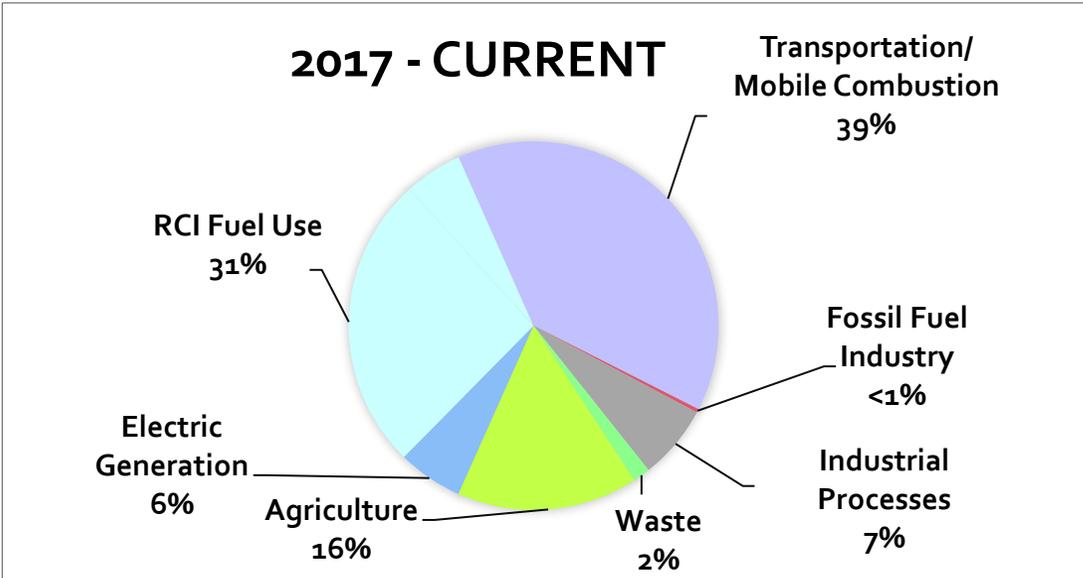
Comparison to Previous Inventory



- Transportation methodology update
 - Using EPA fuel-based SIT module for CO₂ instead of NEI methodology for 2011 – 2017
- Other changes due to updates to SIT modules and changes to historic values in federal datasets

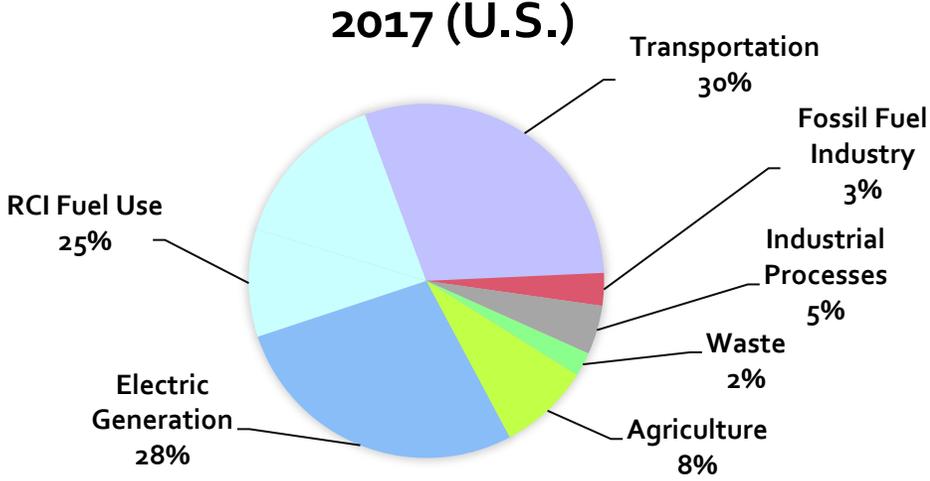
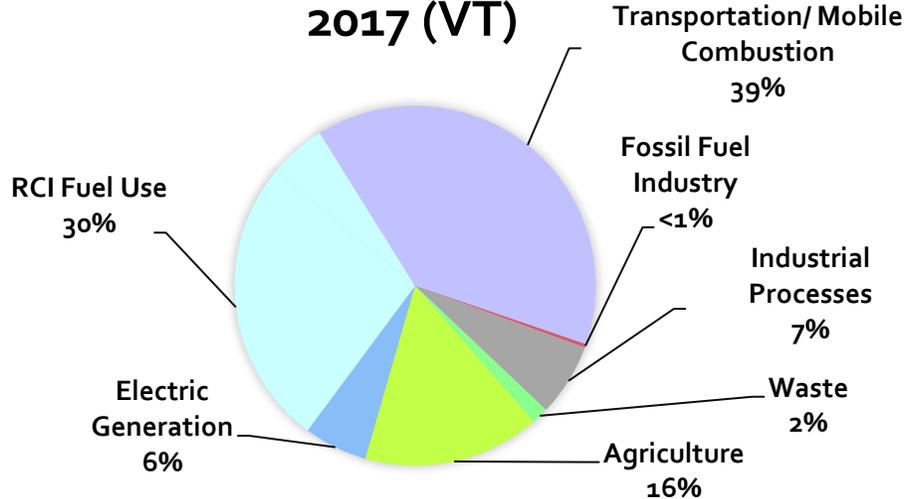
Vermont - Relative contributions by sector

- Decrease in transportation totals has influenced the percent contributions from the other sectors



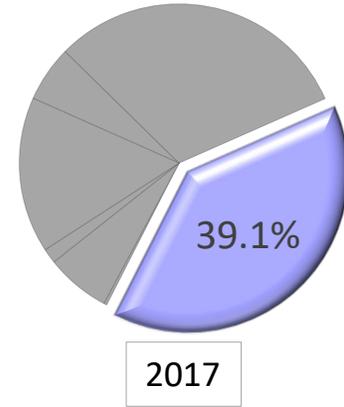
Vermont and the U.S.

- Transportation contribution in VT is still larger than in the U.S. but less so with methodology update
 - RCI fuel use and agricultural sectors also have larger percent shares than the U.S.



Transportation/Mobile Sources

Transportation

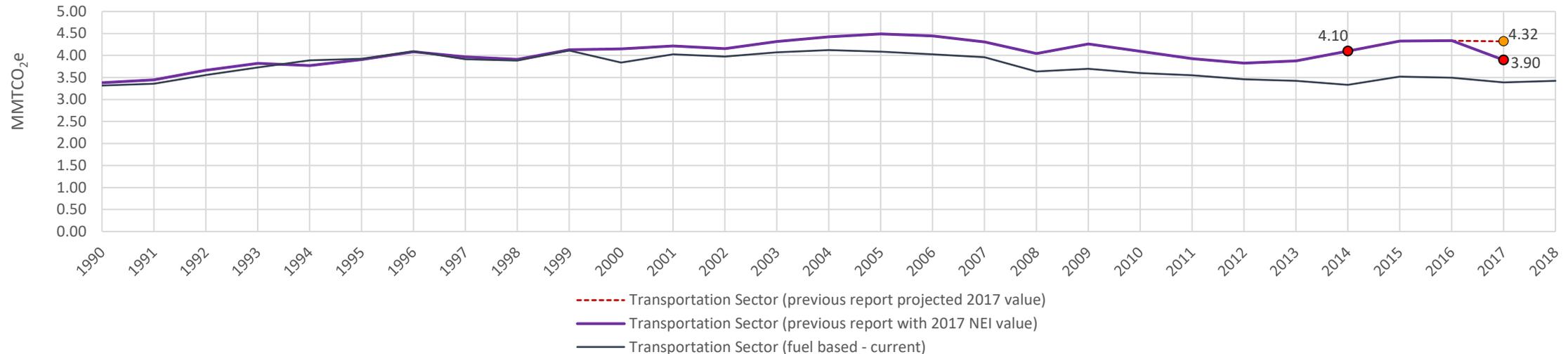


- Methodology Update

- Previous methodology

- Used National Emissions Inventory (NEI) values for onroad transportation (for available years)
 - Adjusted years between NEI values by percent changes in VMT and fuel sales (2011 – 2016)
 - NEI values calculated with EPA MOVES model which is mainly based on vehicle miles traveled (VMT)
 - 2017 NEI values did not reflect changes seen in VMT and fuel sales
 - Between 2014 and 2017 saw a 5% increase in VMT (~365 million miles) and a 7% decrease in GHG emissions
 - Discussions with EPA and in-house MOVES runs were unable to resolve this issue
 - Decision to adopt alternative methodology

- Nonroad transportation methodology also changed by necessity due to the update (but was and still is fuel consumption based)



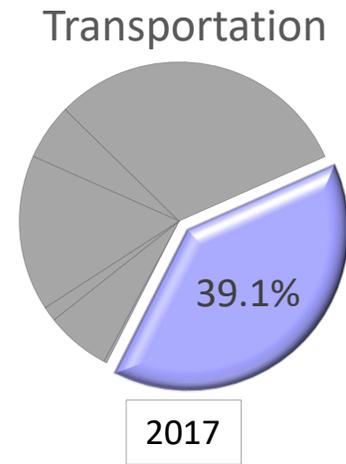
Transportation/Mobile Sources Continued...

- Current Methodology

- EPA State Inventory Tool (SIT) module based on fuel combustion (for CO₂)
- Updated methodology uses fuel totals for the entirety of the 1990 – 2017 time series
- Utilize Vermont fuel sales data
- Much less granular approach but doesn't rely on estimated/modeled input data
- Unable to differentiate between onroad and nonroad for CO₂
- Estimates based on fuel sales method is suggested by IPCC

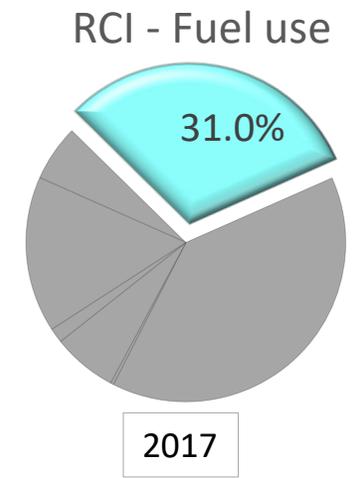
- Regional Methodology Comparison

- MA: EPA SIT fuel-based methodology (for CO₂)
- CT: EPA SIT fuel-based methodology (for CO₂)
- RI: VMT based methodology (MOVES) for onroad
- ME: EPA SIT fuel-based methodology (for CO₂)
- NH: Direct EIA estimates (for CO₂)
- NY: SIT mobile combustion module (VMT based)



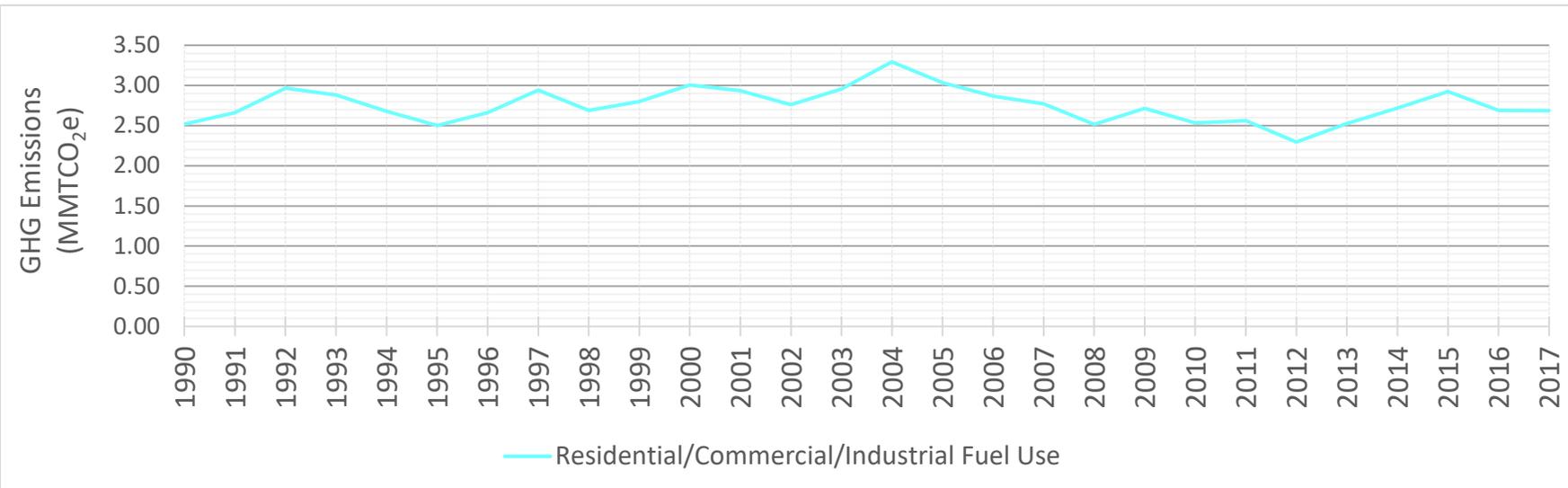
Residential/Commercial/Industrial Fuel Use (RCI)

- Methodology unchanged from previous inventory (SIT module updates)
- Emissions from building energy use (heating buildings, heating water, and cooking, etc.)
- Based on EPA State Inventory Tool modules
 - Use federal data for estimates and supplemental wood use data
- Emissions from the sector remained level from 2016 to 2017



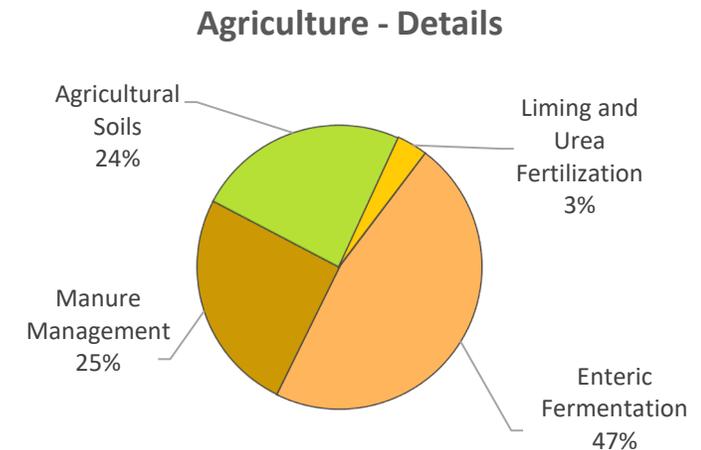
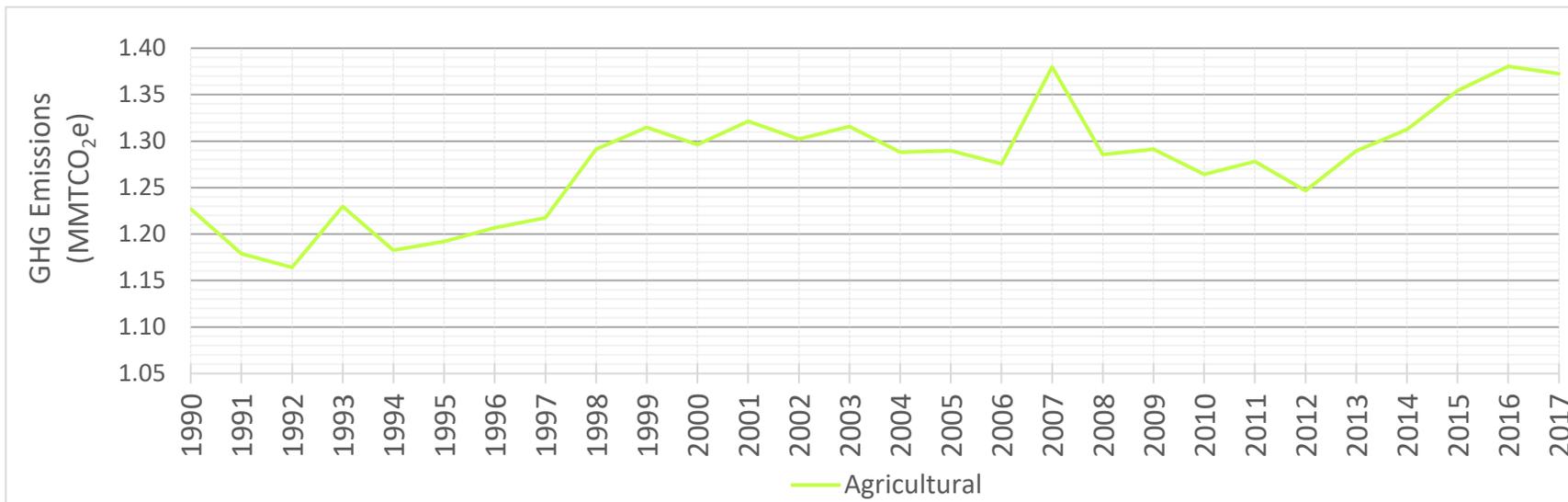
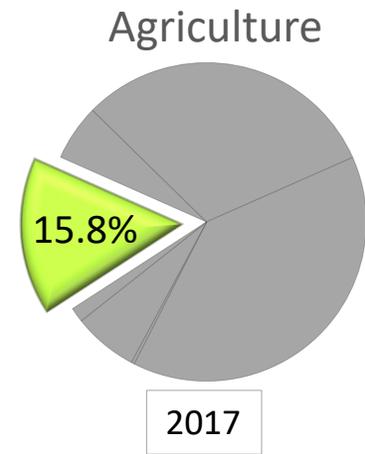
RCI Sector (2017)	MMTCO ₂ e	% of Total
Residential	1.47	54.8%
Commercial	0.77	28.7%
Industrial	0.44	16.5%
Total	2.69	100.0%

RCI Residential Sector (2017)	MMTCO ₂ e	% of Total
Fuel Oil	0.76	51.8%
Propane	0.40	27.1%
Natural Gas	0.19	13.1%
Kerosene	0.03	1.7%
Wood (CH ₄ and N ₂ O only)	0.09	6.3%
Total	1.47	100.0%



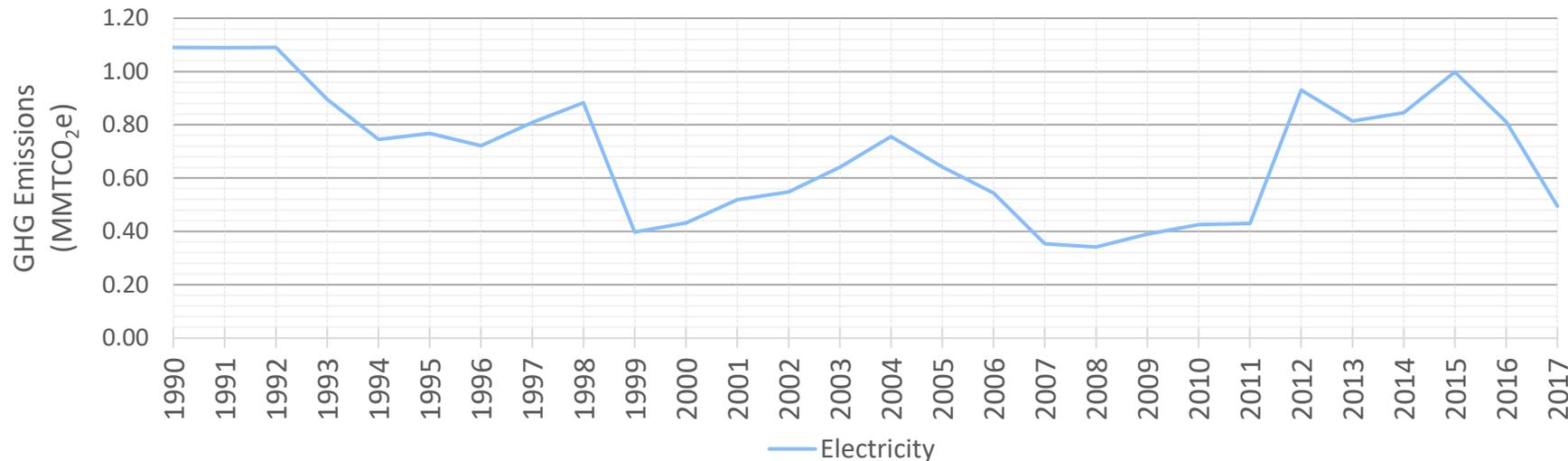
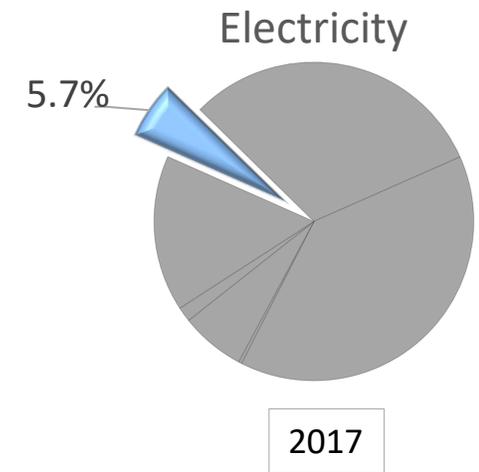
Agriculture

- Methodology unchanged from previous inventory (SIT module updates)
- EPA State Inventory Tool module for estimating agricultural emissions
 - CO₂ is biogenic
 - Enteric fermentation, manure management, agricultural soils, liming and urea fertilization
- Based on EPA defaults (mainly USDA data)
- Approximately 72% of emissions based on animal populations (enteric fermentation, manure management)
- Actively working with Agency of Agriculture to evaluate datasets and methodology for potential areas of improvement



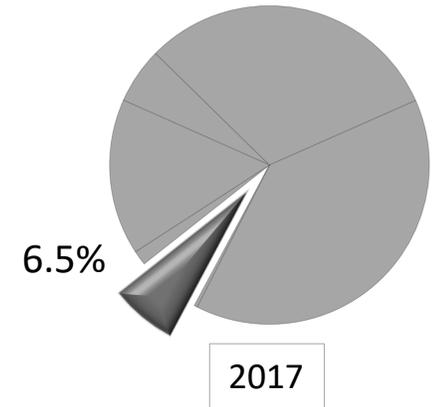
Electricity (Consumption)

- Methodology unchanged from previous inventory
- Main reason for GHG emissions reductions seen since 2015
- Not a true consumption-based inventory methodology (but only sector to include emissions occurring outside the state)
- Emissions declining steeply in this sector since 2015 (continues through 2019)
- Based on MWh purchase decisions made by utilities
 - Calculations/accounting method includes sales and retirements of RECs
 - Renewable Energy Standard (RES) requirements
- Consideration of REC accounting methodology and emissions from hydro reservoirs is ongoing



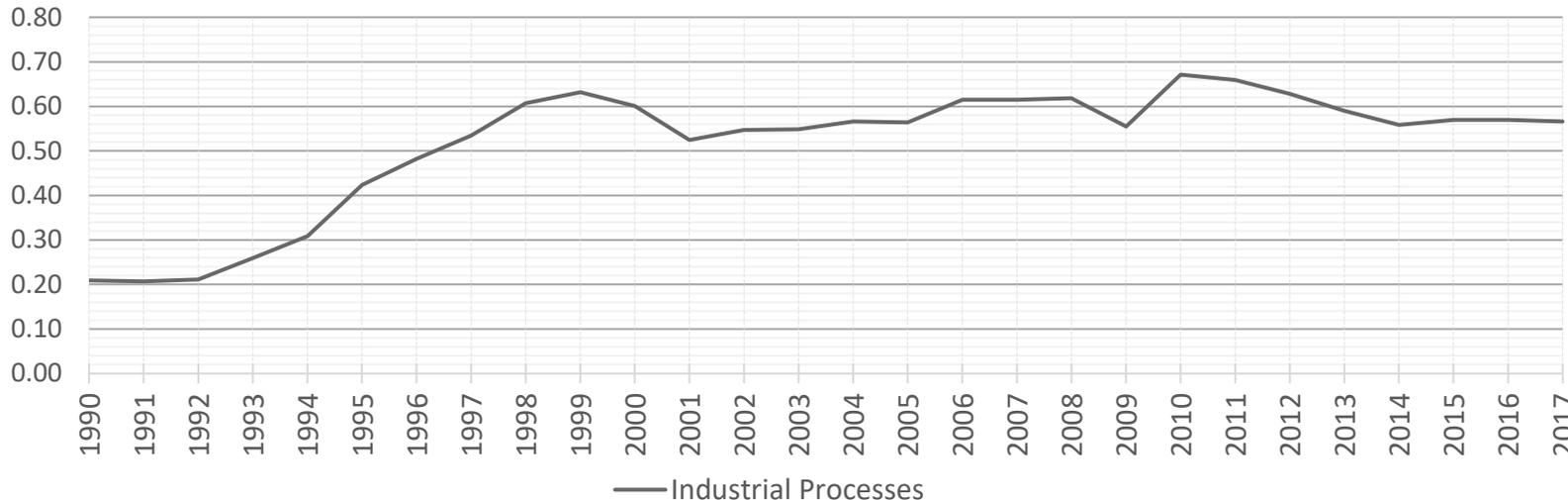
Industrial Processes

- Methodology unchanged from previous inventory
- Two main contributing categories (semiconductor manufacturing, ODS substitutes)
- Three calculation methods
 - EPA SIT module (limestone and dolomite use, Electric Utilities, Soda Ash Use, Urea Consumption)
 - Semiconductor manufacturing (HFCs, PFCs, SF₆, NF₃)
 - Fluorinated gases used in manufacturing process
 - ODS Substitutes (HFCs)
 - Tool developed by CA for U.S. Climate Alliance states
 - Will incorporate Act 65 reductions (but won't show up until first prohibition date)



* Data from EPA Overview of Greenhouse Gasses

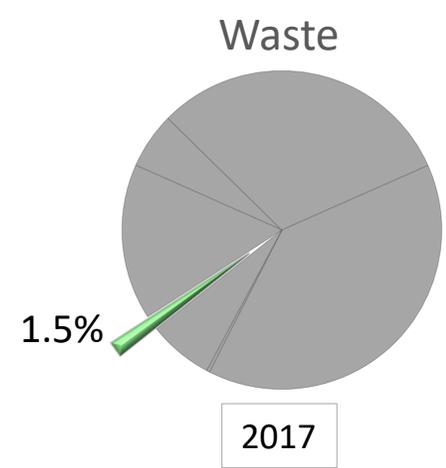
GHG Category	AR4 GWP Value	Atmospheric Lifetime (years)
CO ₂	1	Variable
CH ₄	25	12
N ₂ O	298	114
HFCs	124 - 14,800	1 - 270
PFCs	7,390 - 12,200	2,600 - 50,000
NF ₃	17,200	740
SF ₆	22,800	3,200



Industrial Processes	MMTCo ₂ e (2017)	Percent of Total
ODS Substitutes	0.34	59.6%
Semiconductor Manufacturing (HFC, PFC & SF ₆)	0.19	34.1%
Limestone & Dolomite Use	0.02	4.2%
Electric Utilities (SF ₆)	0.01	1.1%
Soda Ash Use	0.00	0.7%
Urea Consumption	0.00	0.4%
Total	0.57	100.0%

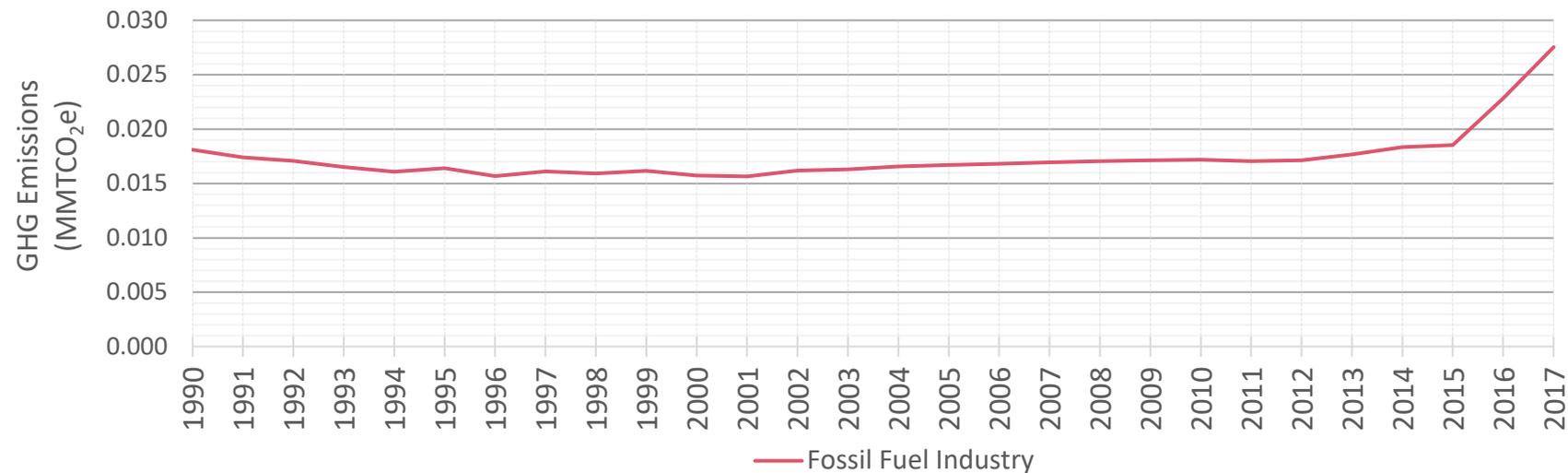
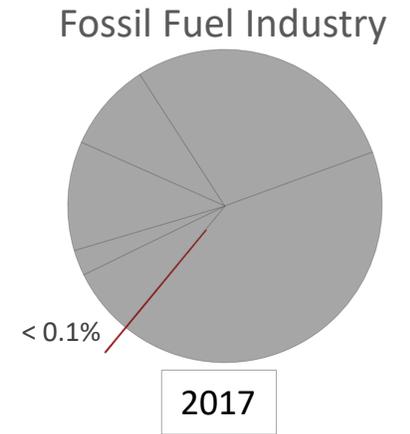
Waste

- Methodology unchanged from previous inventory (updated wastewater SIT module)
- Includes CH₄ and N₂O emissions from solid waste and wastewater
 - CO₂ is biogenic
 - Solid Waste
 - Emissions from landfills (CH₄) is reported by facilities with landfill-gas-to-energy (LFGTE) equipment that submit data to ANR (for years since 2009)
 - Wastewater
 - Estimates from an EPA SIT module with EPA defaults



Fossil Fuel Industry

- Methodology unchanged from previous inventory
- Sector includes fugitive emissions of CH₄ from transmission and distribution of natural gas
 - Emissions estimates use EPA SIT module for transmission of natural gas and a similar approach for distribution based on miles of pipeline and different leakage rates



2018 and 2019 Preliminary GHG Estimates (MMTCO₂e)

Sector	1990	2005	2012	2013	2014	2015	2016	2017	2018	2019
Electricity Supply & Demand (Consumption - based)	1.09	0.64	0.93	0.81	0.84	1.00	0.81	0.49	0.18	0.13
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.05	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.00	0.00
Oil	0.01	0.01	0.01	0.01	0.02	0.01	0.00	0.00	0.00	0.00
Wood (CH ₄ , N ₂ O)	0.00	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
Residual System Mix	1.03	0.62	0.90	0.78	0.81	0.96	0.79	0.47	0.17	0.11
Residential/ Commercial/ Industrial (RCI) Fuel Use	2.52	3.04	2.30	2.53	2.72	2.92	2.69	2.69	2.93	2.93
Coal	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas	0.32	0.44	0.43	0.51	0.57	0.64	0.65	0.65	0.75	0.75
Oil, Propane, & Other Petroleum	2.12	2.52	1.78	1.93	2.06	2.19	1.95	1.94	2.08	2.08
Wood (CH ₄ , N ₂ O)	0.07	0.07	0.09	0.09	0.09	0.09	0.10	0.10	0.10	0.10
Transportation	3.32	4.09	3.46	3.42	3.33	3.52	3.49	3.39	3.43	3.40
Motor Gasoline (Onroad and Nonroad) (CO ₂)	2.57	3.14	2.58	2.56	2.49	2.58	2.54	2.52	2.55	2.53
Diesel (Onroad and Nonroad) (CO ₂)	0.45	0.65	0.70	0.70	0.69	0.76	0.76	0.71	0.72	0.72
Hydrocarbon Gas Liquids, Residual Fuel, Natural Gas (CO ₂)	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Jet Fuel & Aviation Gasoline (CO ₂)	0.08	0.13	0.10	0.10	0.09	0.11	0.12	0.10	0.11	0.11
Non-Energy Consumption - Lubricants (CO ₂)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
All Mobile (CH ₄ , N ₂ O)	0.19	0.14	0.05	0.05	0.04	0.04	0.04	0.04	0.03	0.02
Fossil Fuel Industry	0.02	0.03	0.03	0.03						
Natural Gas Distribution	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Natural Gas Transmission	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.02
Industrial Processes	0.21	0.56	0.63	0.59	0.56	0.57	0.57	0.57	0.56	0.59
ODS Substitutes	0.00	0.18	0.28	0.29	0.31	0.32	0.33	0.34	0.34	0.36
Electric Utilities (SF ₆)	0.04	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Semiconductor Manufacturing (HFC, PFC & SF ₆)	0.16	0.33	0.32	0.25	0.21	0.21	0.21	0.19	0.18	0.20
Limestone & Dolomite Use	0.00	0.03	0.02	0.03	0.04	0.03	0.03	0.02	0.02	0.02
Soda Ash Use	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Urea Consumption	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Waste Management	0.26	0.34	0.24	0.22	0.20	0.15	0.14	0.13	0.14	0.14
Solid Waste(CH ₄ , N ₂ O)	0.21	0.28	0.18	0.15	0.14	0.10	0.08	0.07	0.08	0.08
Wastewater	0.05	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Agriculture	1.23	1.29	1.25	1.29	1.31	1.35	1.38	1.37	1.37	1.37
Enteric Fermentation	0.70	0.63	0.62	0.64	0.64	0.63	0.64	0.64	0.64	0.64
Manure Management	0.18	0.33	0.32	0.32	0.32	0.34	0.36	0.35	0.35	0.35
Agricultural Soils	0.35	0.32	0.30	0.32	0.33	0.33	0.33	0.33	0.33	0.33
Liming and Urea Fertilization	0.00	0.00	0.00	0.01	0.03	0.05	0.05	0.05	0.05	0.05
Gross Emissions Total	8.64	9.97	8.81	8.88	8.98	9.54	9.10	8.67	8.64	8.59

* Value Carried Forward from Previous Year

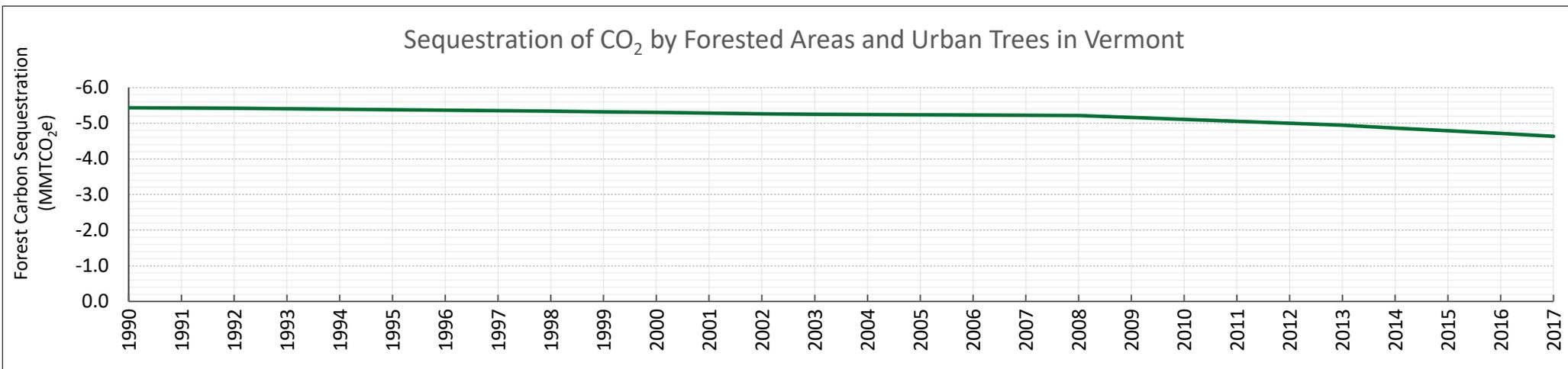
Five- and Ten-year Projections

Inventory Sector	(MMTCO ₂ e) 2022	(MMTCO ₂ e) 2027
Transportation/Mobile	3.25	3.36
Residential/Commercial/Industrial (RCI) Fuel Use	2.62	2.51
Agriculture	1.30	1.30
Industrial Processes	0.61	0.64
Electricity	0.08	0.07
Waste	0.13	0.13
Fossil Fuel Industry	0.03	0.04
Total	8.02	8.04

- Based on emissions projection curves put together by the Rhodium Group (for their ClimateDeck and Taking Stock reports) applied to 2019 inventory estimates
- Based on a “V” shaped economic recovery from COVID

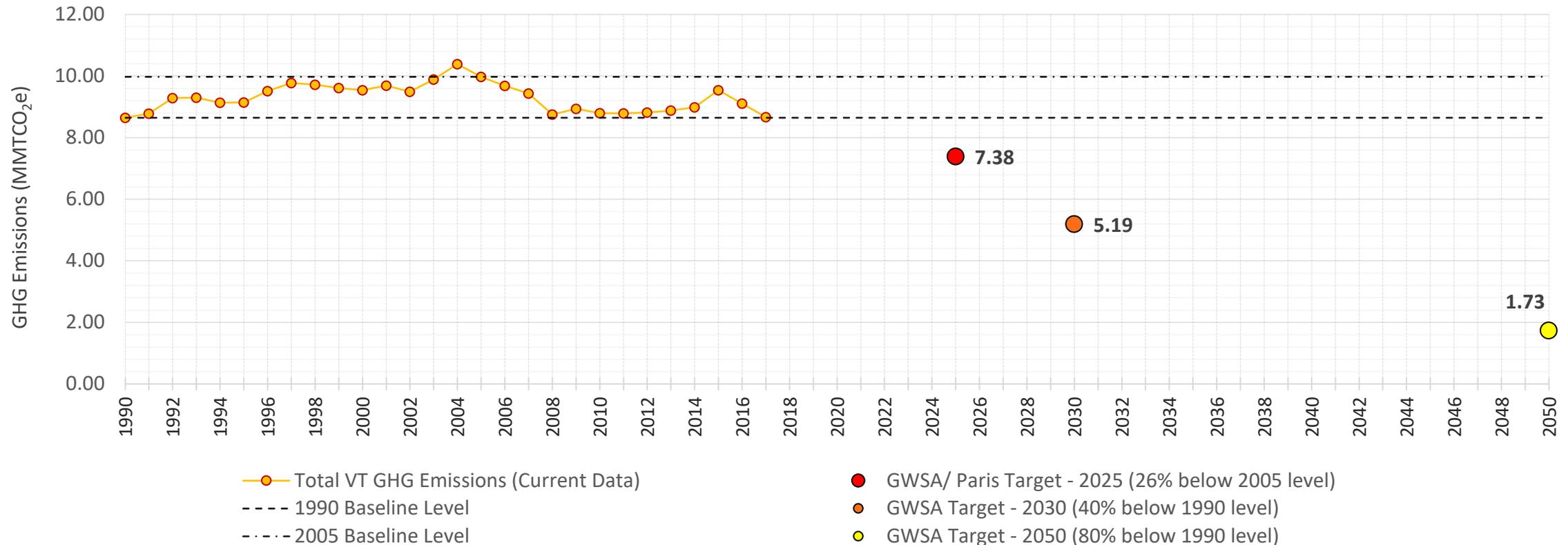
Land-use, land use change, and forestry (LULUCF)

- Sector is not comprehensive as the existing data (and EPA SIT module) is currently not reliable for all components
 - This is consistent with other states in the region (but work is underway to improve this)
- Include forest-based data for Vermont from the Inventory of U.S. Greenhouse Gas Emissions and Sinks (Forest Inventory and Analysis data)
- Inventory LULUCF sector includes:
 - Forest land remaining forest land, land converted to forest land, forest land converted to land, and urban trees
 - Not currently capturing carbon fluxes for croplands, grassland, wetlands, or settlements
- Rate of sequestration has been gradually declining over time



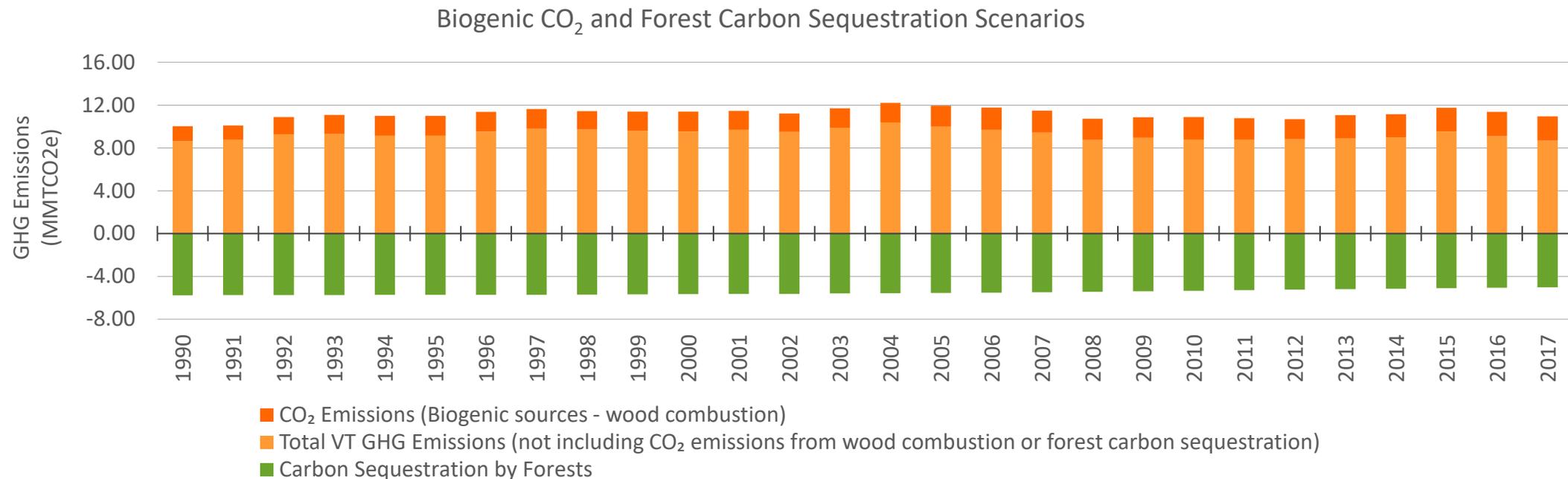
Updated GHG Goal Tracking

- Updated targets based on GWSA
 - 26% below 2005 levels by 2025
 - 40% below 1990 levels by 2030
 - 80% below 1990 levels by 2050
- Currently at our 1990 baseline level and 13% below our 2005 emissions level



Biogenic CO₂ and Forest Carbon Sequestration Scenarios

- Inclusion of biogenic CO₂ emissions is not comprehensive because existing data (and EPA SIT module) is currently not reliable or available for all portions of the land-use, land use change, and forestry sector (where it would be captured)
- Biogenic CO₂ estimates from wood combustion “at the stack” shown below currently include only the electricity sector and the RCI sector



Questions?