Vermont

Vermont Greenhouse Gas Emissions Inventory and Forecast 1990 - 2016

ANR Report to House Committee on Energy and Technology
January 14, 2020

https://dec.vermont.gov/sites/dec/files/aqc/climate-change/documents/_Vermont_Greenhouse_Gas_Emissions_Inventory_and_Forecast_1990-2016.pdf

Why Produce the Greenhouse Gas Emissions Inventory?

And why is the "current" inventory update only through 2016?

Why produce the GHG Emissions Inventory?

- **Required by state statute (10 V.S.A. § 582)**
- **To track greenhouse gas emissions in Vermont (from 1990 – 2016)**
- **To better understand sector contributions which can help to guide actions for greenhouse gas mitigation and track progress toward our state emissions targets**
- **To be a participant in a larger scale (regional, national, worldwide) effort to understand, track, and combat anthropogenic driven global warming**

Why the lag time for inventory release?

- **Large amount of data from multiple sectors required for models/modules**
- **Use of EPA tools (default data available varies as well as tool release dates)**
- **Data availability for calculations in many sectors is lagging (some by multiple years)**
- **Potential inaccuracies in generating estimates based on assumptions/projections**
- **Lag in inventory release is typical of GHG inventories**

Greenhouse Gas Emissions Inventory Releases in the Region

State	Calendar Year of Inventory	Date of Release
Connecticut	2017	1/1/2020
Massachusetts	2016	12/1/2018
New York	2016	7/1/2019
Rhode Island	2016	10/28/2019
Vermont	2016	1/1/2020
Maine	2015	1/1/2018
New Hampshire	2015	NA

Dataset Example

U.S. Energy Information Administration (EIA) – State Energy Data System (SEDS)

- Major data source for the Residential/Commercial/Industrial Fuel use sector
  - Estimates for fuel use in many sectors (residential, commercial, industrial, transportation, etc.)
  - Based on a national total apportioned to states by state level sales data

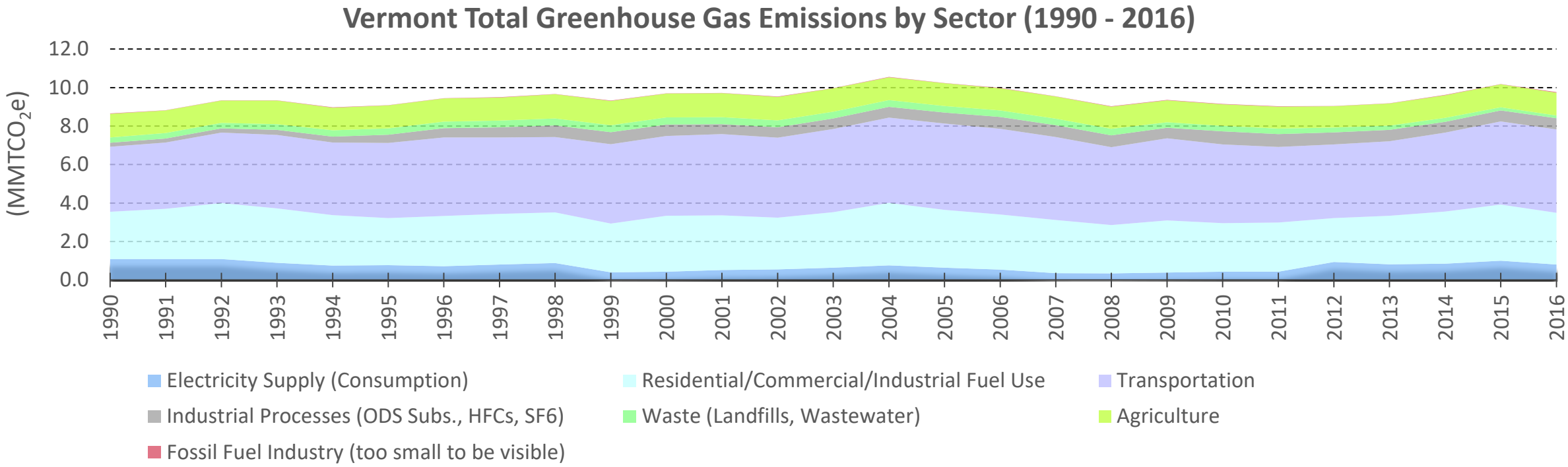
- 2017 SEDS data released 6/28/2019

- EPA
  - Incorporates new SEDS data into the emissions estimation tools
  - Updates other necessary data and emission factors
  - Releases tools for state use

	A	B	C	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI
1	Data_Status	State	MSN	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
7029	2018P	VT	DFACP	1245	1690	1518	1565	1498	1506	1636	1589	1464	1548	1709	1691	1661	1694	1664	1856	1906	1792
7030	2018P	VT	DFCCP	1040	1009	865	971	1036	858	812	766	561	701	668	647	527	567	619	826	576	555
7031	2018P	VT	DFEIP	159	87	31	57	45	12	8	9	6	3	5	7	2	8	8	5	8	15
7032	2018P	VT	DFICP	381	366	338	445	586	560	509	396	519	533	551	678	608	497	539	521	550	591
7033	2018P	VT	DFRCP	2450	2220	2114	2371	2696	2257	2119	2157	1869	2022	1675	1769	1428	1622	1767	1885	1738	1784
7034	2018P	VT	DFTCP	5276	5371	4866	5408	5861	5194	5085	4917	4420	4807	4607	4791	4227	4388	4597	5092	4777	4737
7035	2018P	VT	DFTXP	5116	5284	4835	5351	5816	5181	5077	4909	4414	4804	4602	4785	4225	4380	4589	5087	4769	4722
7036	2018P	VT	ELEXP	362	0	0	26	14	38	80	116	41	41	32	2	16	4	25	13	7	9
7037	2018P	VT	ELIMP	4280	2999	2433	1942	1952	2160	2509	2604	2534	2605	2458	2524	11515	11742	11182	10804	8962	10345
7038	2018P	VT	ELISP	-4134	-2460	-1819	-2170	-1246	-1491	-3272	-1969	-3130	-3949	-3036	-3365	-11712	-12901	-12251	-6888	-4999	-6718
7039	2018P	VT	ELNIP	3917	2999	2433	1916	1938	2121	2429	2488	2493	2563	2426	2522	11499	11739	11157	10791	8955	10336

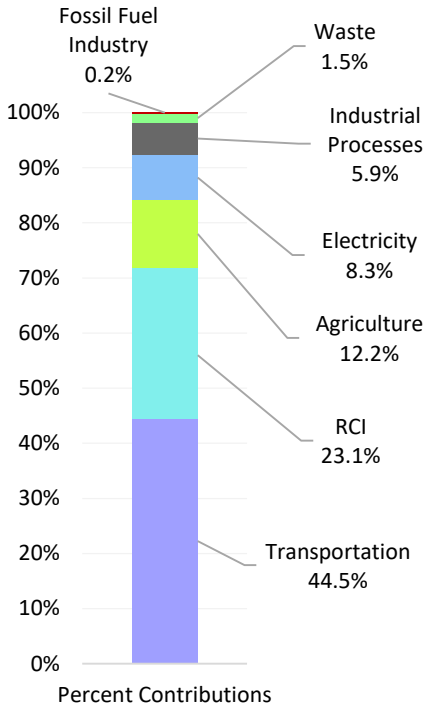
Vermont –Emissions Totals Comparison by Sector

- Total emissions trends by sector shown over time
- Overall emissions totals for 2016 are still 13% above 1990 baseline but declined from 2015 levels
- Updated historical federal datasets (EIA SEDS) and methodologies changed totals for some previous years
  - Residential/Commercial/Industrial (RCI) Fuel Use
  - Agriculture (module data)
  - Industrial Processes (methodology change)
- Value for 2015 is higher than in previous report mainly due to SEDS data updates in the RCI sector



Vermont – Sector Ups and Downs

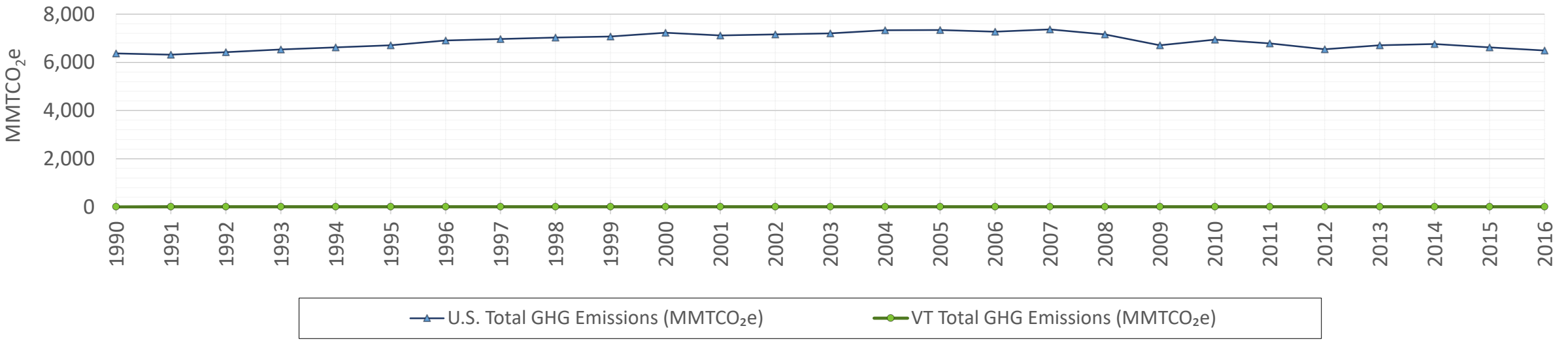
Sector	Million Metric Tons CO_2 Equivalent: $MMTCO_2e$								Change relative to 1990	Change relative to 2015
	1990	1995	2000	2005	2010	2014	2015	2016		
Electricity Supply & Demand (consumption based)	**1.09**	**0.77**	**0.43**	**0.64**	**0.43**	**0.84**	**1.00**	**0.81**	↓	↓
Residual System Mix	1.03	0.75	0.35	0.62	0.36	0.81	0.96	0.79		
Residential / Commercial / Industrial (RCI) Fuel Use	**2.45**	**2.45**	**2.90**	**3.00**	**2.53**	**2.71**	**2.92**	**2.68**	↑	↓
Oil, Propane & Other Petroleum	2.06	2.00	2.34	2.49	2.01	2.06	2.20	1.95		
Transportation	**3.38**	**3.91**	**4.15**	**4.49**	**4.09**	**4.10**	**4.33**	**4.34**	↑	→
Onroad Gasoline	2.64	2.81	3.20	3.29	2.90	3.03	3.16	3.19		
Onroad Diesel	0.41	0.84	0.66	0.69	0.70	0.54	0.57	0.54		
Fossil Fuel Industry	**0.018**	**0.016**	**0.016**	**0.017**	**0.017**	**0.018**	**0.019**	**0.023**	↑	↑
Natural Gas Transmission	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.02		
Industrial Processes	**0.21**	**0.42**	**0.59**	**0.57**	**0.67**	**0.56**	**0.57**	**0.58**	↑	→
Waste Management	**0.27**	**0.33**	**0.36**	**0.34**	**0.28**	**0.21**	**0.16**	**0.15**	↓	↓
Solid Waste	0.21	0.27	0.30	0.28	0.21	0.14	0.10	0.08		
Agriculture	**1.23**	**1.19**	**1.24**	**1.18**	**1.13**	**1.18**	**1.19**	**1.19**	↓	→
TOTAL GROSS EMISSIONS	**8.65**	**9.09**	**9.70**	**10.24**	**9.15**	**9.62**	**10.19**	**9.76**		
Change relative to 1990 (baseline)	**–**	**+ 5%**	**+ 12%**	**+ 18%**	**+ 6%**	**+ 11%**	**+ 18%**	**+ 13%**		

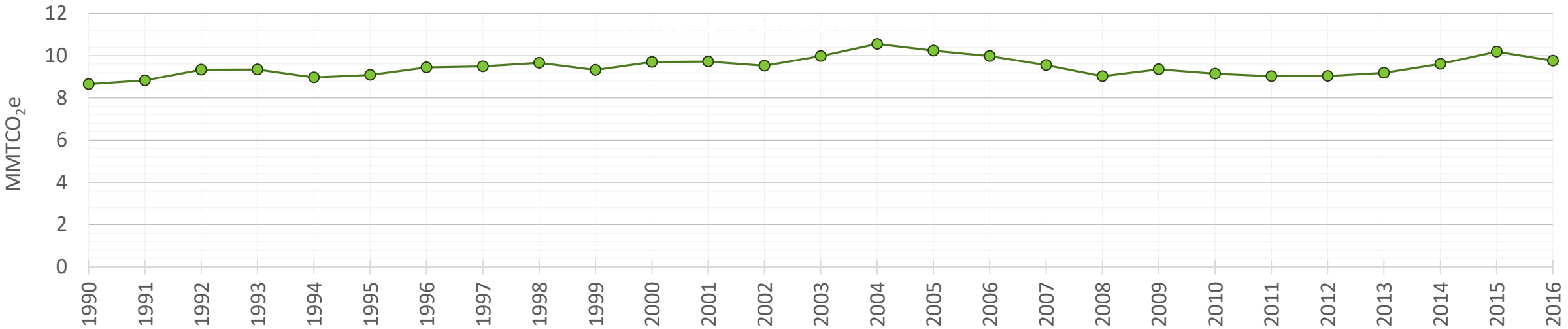


Only subsectors shown are those which contributed significantly to the positive or negative emissions changes within the sector.

Emission Comparison - Vermont and the U.S.

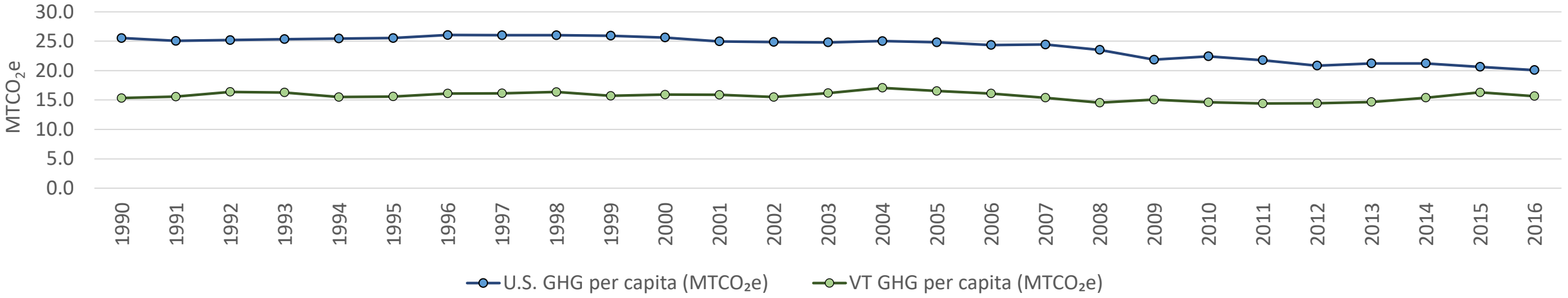
- Vermont accounted for approximately 0.15% of total U.S. greenhouse gas emissions in 2016

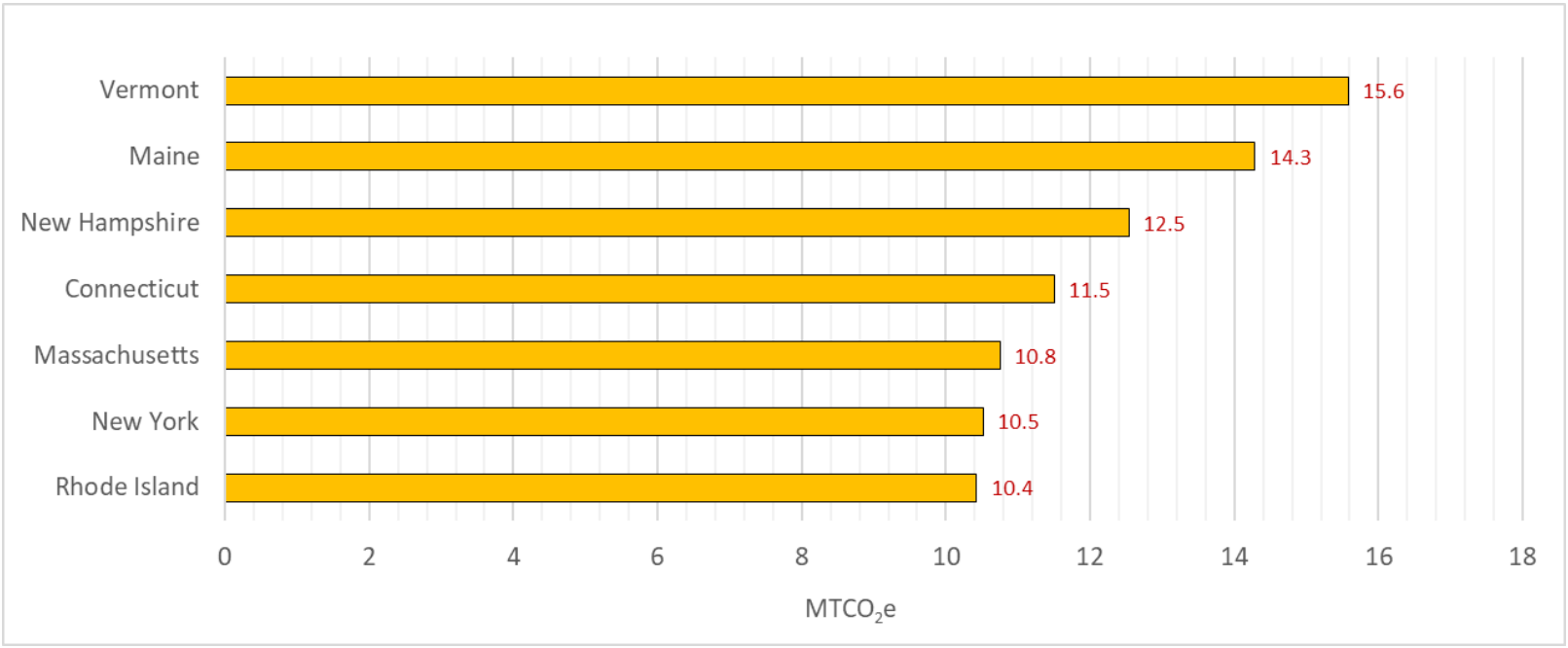




Emission Comparison - Vermont and the U.S. (Continued…)

- Vermont producing less emissions on a per capita basis than the U.S. as a whole



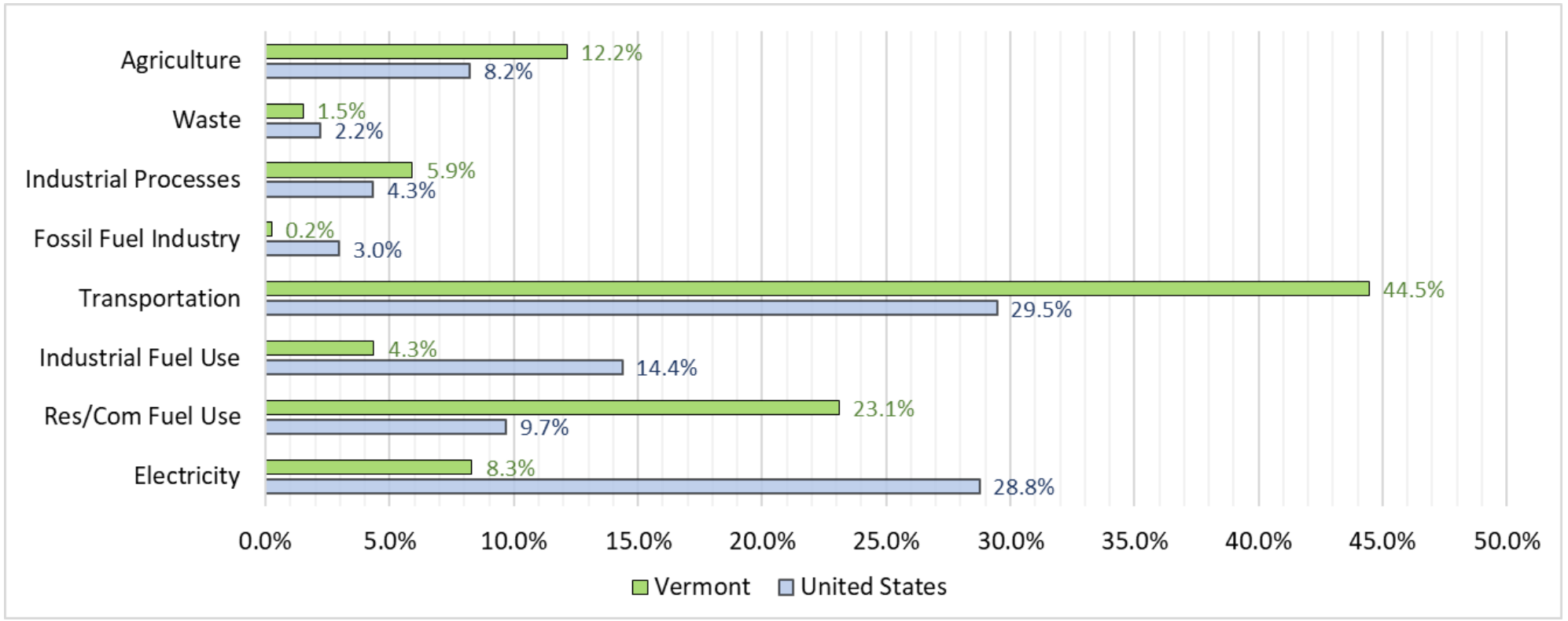


But has higher per capita emissions than any other state in our region.

U.S. data from EPA 1990-2017 Sources and Sinks report. Regional state data values based on GHG inventory report data for states from 2016 (ME is from 2015) and NH was estimated using the EIA value and an average percentage contribution of the energy related emissions from the other states in the region. Population data is from U.S. Census Bureau for 2018.

Emission Comparison - Vermont and the U.S. (Continued)

- Higher percentage of GHGs from transportation sector
- Higher residential and commercial fuel use percentage from winter heating
- Emissions from electricity consumption sector lower in VT due mostly to large hydro purchases
- Low number of large emission point sources in Vermont enlarges percent contributions from all other sectors



Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018
Electricity Supply & Demand (Consumption - based)	0.43	0.43	0.93	0.81	0.84	1.00	0.81	***0.49***	***0.19***
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.00*	*0.00*
Natural Gas	0.01	0.01	0.00	0.00	0.00	0.01	0.00	*0.01*	*0.00*
Oil	0.04	0.04	0.01	0.01	0.02	0.01	0.00	*0.00*	*0.00*
Wood (CH_4, N_2O)	0.01	0.01	0.01	0.02	0.01	0.01	0.01	*0.01*	*0.01*
Residual System Mix	0.36	0.37	0.90	0.78	0.81	0.96	0.79	*0.47*	*0.17*
Residential/ Commercial/ Industrial (RCI) Fuel Use	2.53	2.56	2.29	2.52	2.71	2.92	2.68	***2.69***	***2.72***
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	*0.00*	*0.00*
Natural Gas	0.44	0.45	0.43	0.51	0.57	0.64	0.65	*0.65*	*0.65*
Oil, Propane, & Other Petroleum	2.01	2.03	1.78	1.93	2.06	2.20	1.95	*1.96*	*1.98*
Wood (CH_4, N_2O)	0.07	0.07	0.08	0.08	0.08	0.08	0.08	*0.08*	*0.08*
Transportation	4.09	3.93	3.83	3.88	4.10	4.33	4.34	***4.32***	***4.22***
Onroad Gasoline	2.90	2.75	2.70	2.73	3.03	3.16	3.19	*3.21*	*3.13*
Onroad Diesel	0.70	0.65	0.63	0.62	0.54	0.57	0.54	*0.54*	*0.52*
Jet Fuel & Aviation Gasoline	0.09	0.10	0.10	0.10	0.09	0.11	0.12	*0.10*	*0.10*
Rail/Ships/Boats/Other Nonroad	0.41	0.43	0.40	0.43	0.44	0.50	0.49	*0.48*	*0.48*
Fossil Fuel Industry	0.02	0.02	0.02	0.02	0.02	0.02	0.02	***0.03***	***0.03***
Natural Gas Distribution	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*
Industrial Processes	0.67	0.66	0.63	0.59	0.56	0.57	0.58	***0.57***	***0.56***
ODS Substitutes	0.25	0.26	0.28	0.29	0.31	0.32	0.33	*0.34*	*0.34*
Electric Utilities (SF_6)	0.01	0.01	0.01	0.01	0.01	0.01	0.01	*0.01*	*0.01*
Semiconductor Manufacturing (HFC, PFC & SF_6)	0.39	0.36	0.32	0.25	0.21	0.21	0.21	*0.19*	*0.18*
Limestone & Dolomite Use	0.02	0.02	0.02	0.03	0.04	0.03	0.03	*0.03*	*0.03*
Soda Ash Use	0.00	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*
Waste Management	0.28	0.29	0.24	0.22	0.21	0.16	0.15	***0.14***	***0.15***
Solid Waste(CH_4, N_2O)	0.21	0.23	0.18	0.15	0.14	0.10	0.08	*0.07*	*0.08*
Wastewater	0.07	0.07	0.07	0.07	0.07	0.07	0.07	*0.07*	*0.07*
Agriculture	1.13	1.14	1.11	1.15	1.18	1.19	1.19	***1.16***	***1.16***
Enteric Fermentation	0.62	0.63	0.62	0.64	0.64	0.64	0.63	*0.63*	*0.63*
Manure Management	0.21	0.21	0.20	0.20	0.20	0.19	0.19	*0.19*	*0.19*
Agricultural Soils	0.29	0.29	0.28	0.30	0.32	0.31	0.31	*0.29*	*0.29*
Liming and Urea Fertilization	0.01	0.00	0.00	0.01	0.03	0.05	0.05	*0.05*	*0.05*
Gross Emissions Total	9.15	9.03	9.04	9.19	9.62	10.19	9.76	***9.41***	***9.02***

Emissions Estimates for 2017 & 2018

- Estimated emissions for 2017 and 2018 calculated wherever data was available

- Where data for standard methodology wasn't available values were either carried forward or adjusted based on other indicators

Calculated Value
Value Carried Forward
Differing methodology

Longer-Term Emissions Forecasts (5 and 10 year period – as required in statute)

- Difficult to predict emissions accurately without any existing data or indicators
- Attempting to incorporate many assumptions and variables that are uncertain, unknown, or based on other projections
  - Annual Energy Outlook (AEO2019)
- Estimates can be highly dependent on future policies or emissions reductions strategies, programs, or incentives
- More of a directional indicator by sector – however even directionality is sometimes uncertain

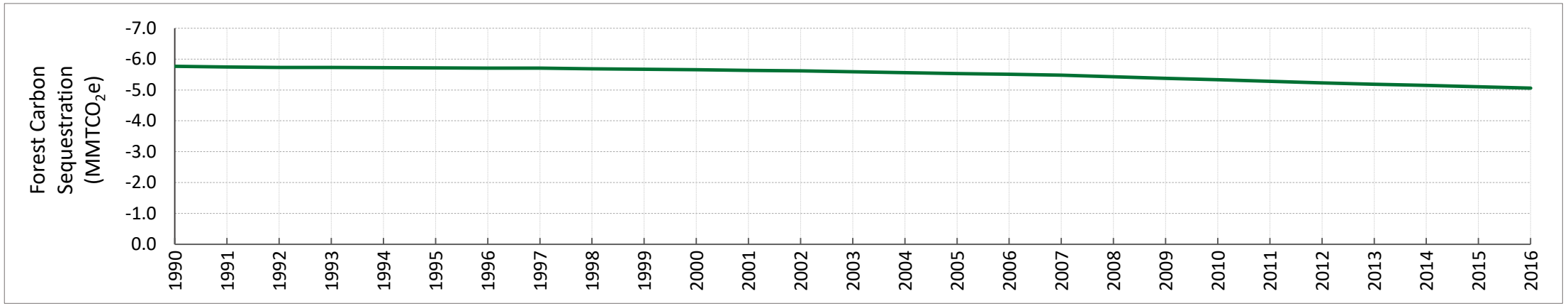
Sector	**2021**	**2026**
Transportation	3.95	3.57
Residential/ Commercial/ Industrial (RCI) Fuel Use	2.54	2.38
Electricity Supply & Demand (Consumption - based)	0.19	0.19
Industrial Processes	0.53	0.52
Agriculture	1.16	1.16
Waste Management	0.14	0.12
Fossil Fuel Industry	0.03	0.03
Total	**8.53**	**7.97**

Forestry & Land Use

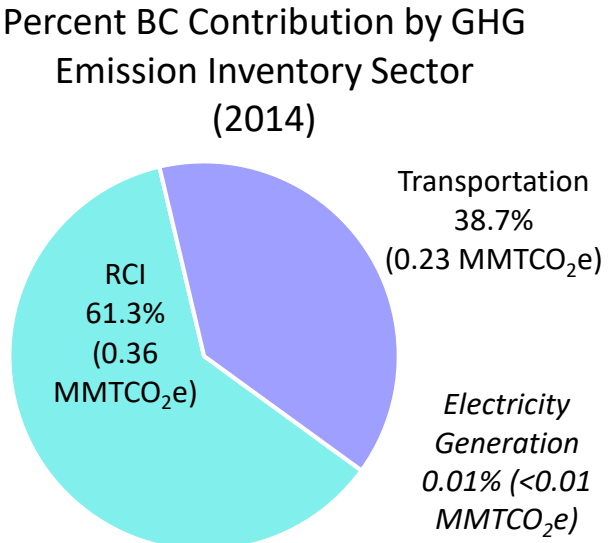
- Carbon sequestration values for forests are from updated FIA data for Vermont based on:
  - *Aboveground biomass, belowground biomass, dead wood, litter, and soil organic carbon (complex interactions)*
  - *Sequestration values and biogenic CO_2 emissions from combustion have been excluded from the totals in this inventory*
  - *Sequestration values continue to slowly decline as the amount of forested land also slowly decreases*

Graph 1: *Annual sequestration (uptake of atmospheric CO_2) by Vermont forests*

Graph 2: *Previously used indicators of forest sequestration potential (totals driven by aboveground biomass)*



Black Carbon (BC) – to be updated in 1990 – 2017 report

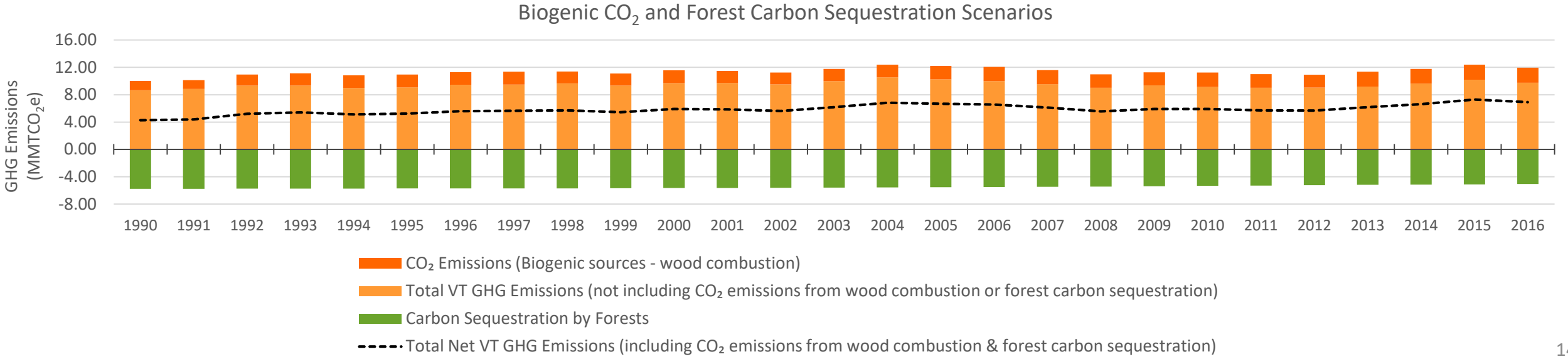


- Component of particulate matter (PM) from incomplete combustion of fossil fuels, biofuels, or biomass
- Significant health impacts and climate forcing properties
- **Health impacts:**
  - Respiratory and cardiovascular disease, cancer, birth defects, premature death
- **Climate Impacts**
  - Absorption of incoming and outgoing solar radiation by dark-colored particles (**direct - warming**)
  - Lowering of albedo (surface reflectance) – particularly on snow – leading to increased melting (**indirect – warming**)
  - Influence cloud formation and properties (**warming/cooling impacts unclear**)
- Short-lived climate pollutant (several days to two weeks) – potential for regional results from mitigation efforts
  - Mitigation strategies must be coupled with long-term/long lived GHG reduction strategies (CO_2, F-gases)
- BC always co-emitted with organic carbon (OC) and ratio differs for different sources. Organic carbon has climate cooling properties (reflective) and so BC source category is important when estimating emissions and effects.
- Main VT sources (anthropogenic):
  - Residential wood combustion
  - Diesel engines (onroad and nonroad)
  - ❖ *Diesel engines well established as climate warming, RWC not as clear (VT cold climate/snow makes more certain – indirect effects)*

Emissions data from 2014NEIv2 – elemental carbon fraction of PM (used as a surrogate) and grouped into inventory categories

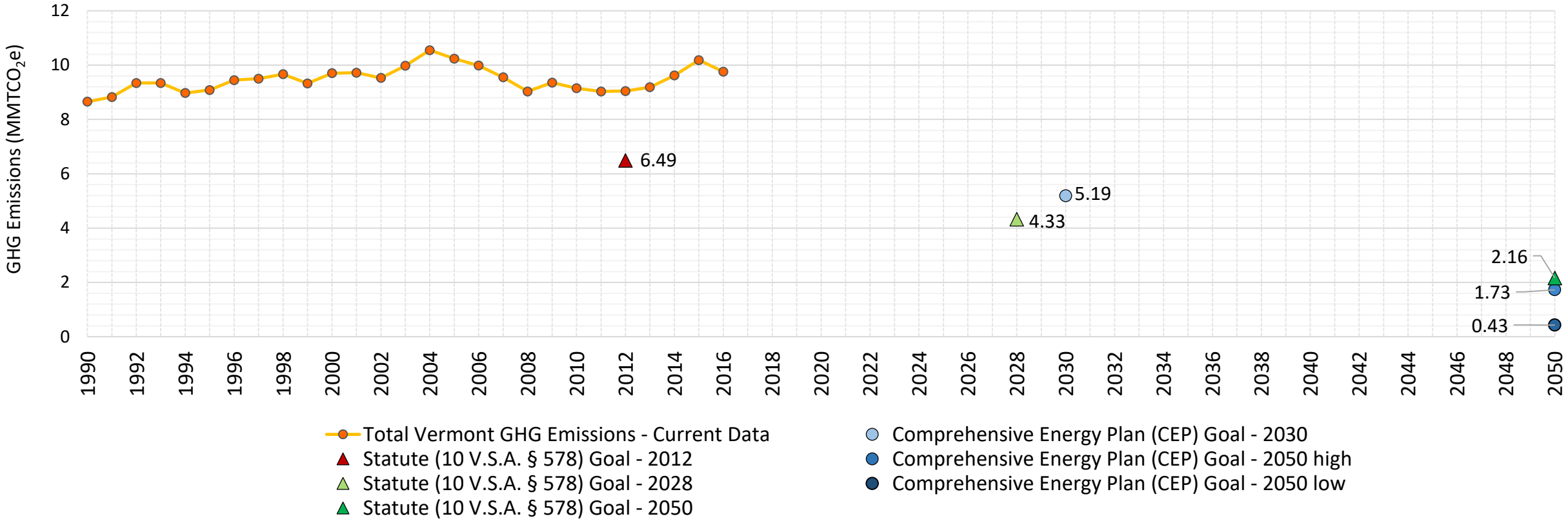
Biogenic CO_2 from Wood Combustion & Forest Carbon Sequestration Scenarios

- CO_2 from wood combustion would contribute to GHG emissions if counted at the point of combustion (RCI, electricity)
  - Claims of carbon neutrality depend on several factors
    - If the fuel being combusted is a logging residue or not
    - Forest management practices for area regrowth
    - Timescales under consideration
- Timescales for carbon neutrality for wood combustion for non-residue sources are relatively long when compared to GHG reduction goals
- Carbon sequestration by forests is significant, but challenging to quantify and depends on management practices
  - Growing trees are almost always beneficial – but amount of sequestration by forests depends on many factors
- Graph below illustrates different emission scenarios including contributions from biogenic CO_2 from wood combustion and carbon sequestration by forests



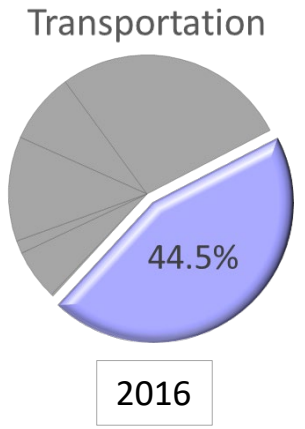
Vermont – Total Emissions Trends and Goals

- Emissions decreased from 2015 to 2016 due mainly to reductions in the RCI and electricity sectors
  - Progress, but much more will be necessary to make meaningful progress toward future goals



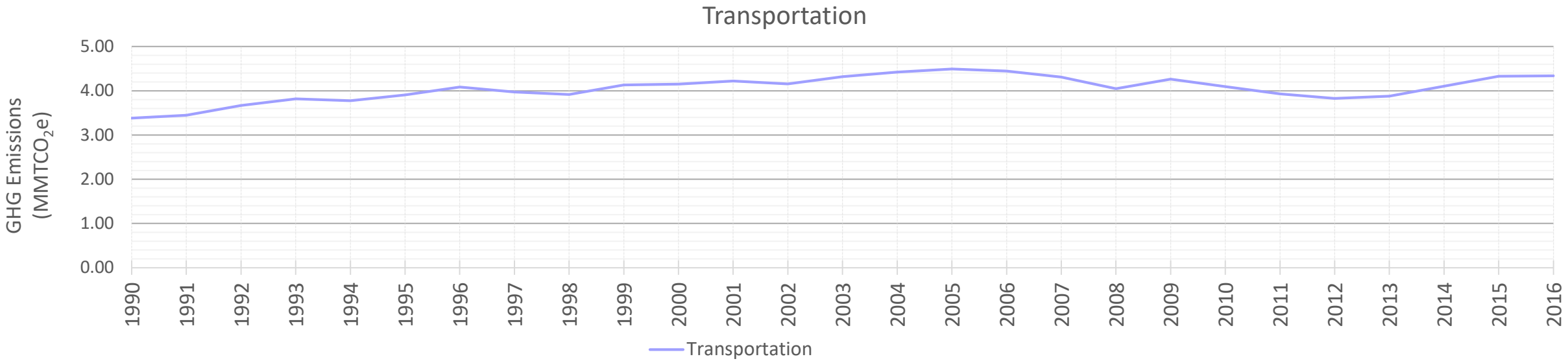
Questions?

Vermont – Emissions by Sector (Details)



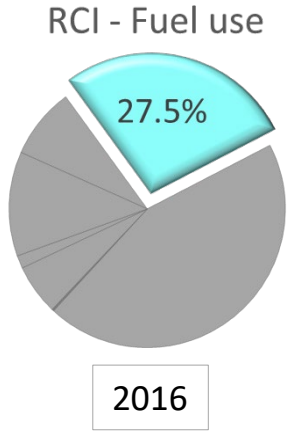
Transportation

- Transportation sector emissions increasing since 2012 but only 0.01 MMTCO2e increase from 2015 to 2016
  - *Gas and diesel sales down in 2016 but VMT up (likely due to fuel efficiency improvements or modeling methods)*
  - *For onroad data the NEI data is used (triennial 2011 and 2014) – other years post 2011 based on these*
    - *For 2016 the 2014 NEI (and 2015 estimated value) adjusted with JFO gasoline and diesel sales and VMT data*
  - *Vermont is a Section 177 state – adopted CA LEV / ZEV*
    - *Federal GHG emissions standards rollback implications*
    - *CA waiver revocation implications*
- Unclear what 2017 NEI will show (awaiting 2017 NEI MOVES runs) but gasoline sales down, diesel sales up, and VMT up (7.36 billion in 2016 to 7.42 billion in 2017)

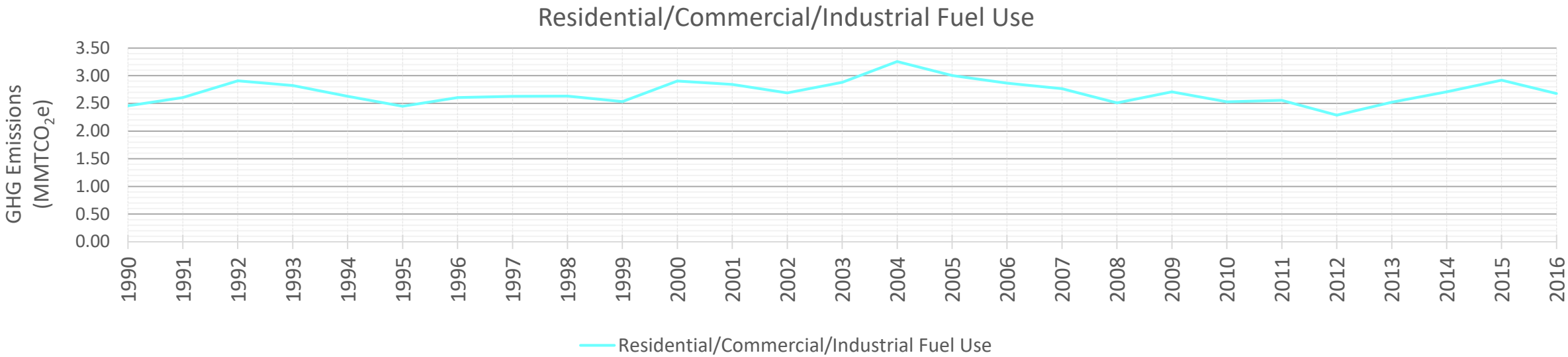


Vermont – Emissions by Sector (Details)

Residential, Commercial & Industrial – Fuel Use

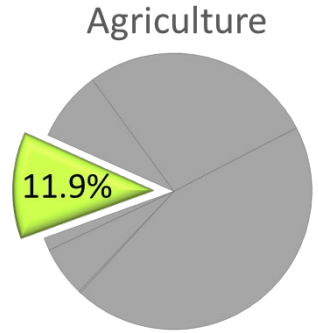


- RCI emissions – emissions in 2016 down from 2015 (but heavily influenced by heating demand)
  - *Decrease attributed to lower heating demand - Heating Degree Days down in 2016*
  - *CO_2 from oil and propane (especially residential) – main contributor*
  - *CO_2 from wood combustion is not included in totals (current position of EPA & inventory protocol – carbon neutral)*
    - *CH_4 and N_2O from wood combustion is included*
- Data sources input into State Inventory Tool (SIT) module (for CH_4 and N_2O)
  - *VT Residential Fuel Survey data (Residential wood), Reported wood totals - AQCD database (Commercial/Institutional, Industrial)*



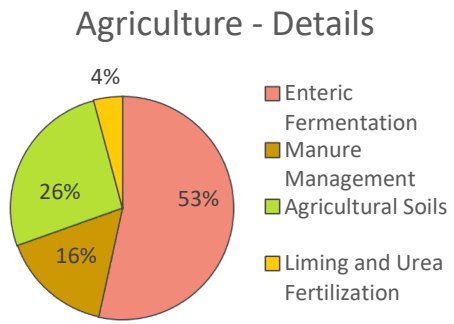
Vermont – Emissions by Sector (Details)

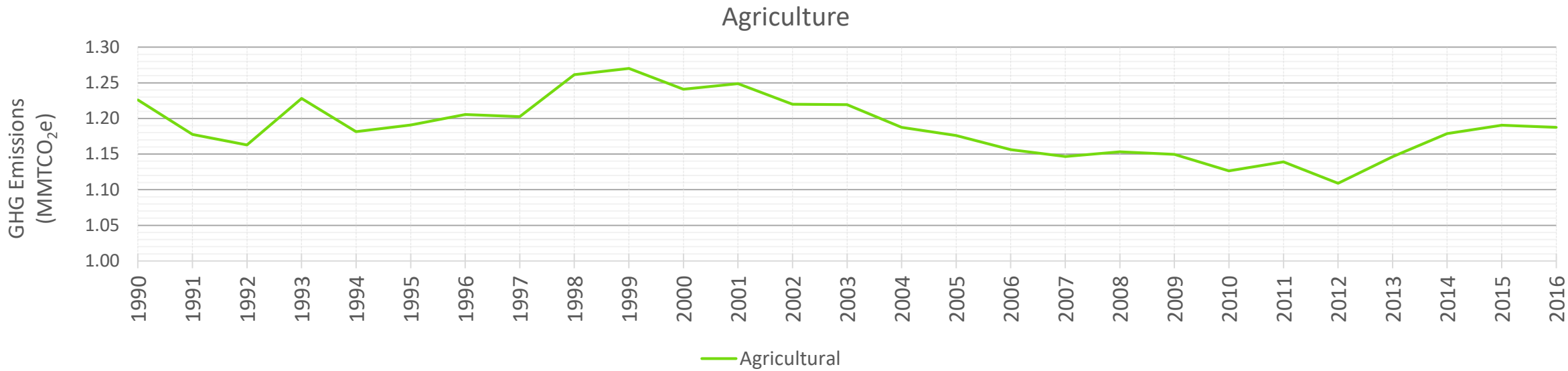
Agriculture



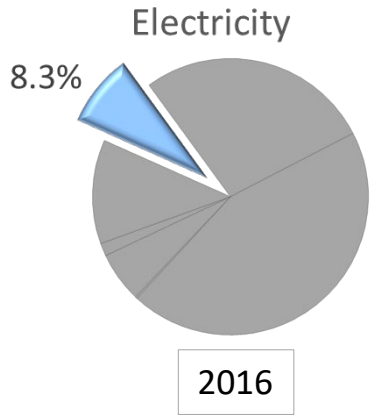
2016

- Agricultural emissions have decreased slightly from 2015 to 2016.
  - *Addition of Liming and Urea Fertilization category (adjusts current and historic emissions by very small amounts)*
  - *Enteric Fermentation is the main emissions source in the sector*
  - *CO_2 from agricultural processes not included in totals (considered biogenic)*
  - *Anaerobic digesters – beneficial for CH_4 from manure management but need formaldehyde controls*



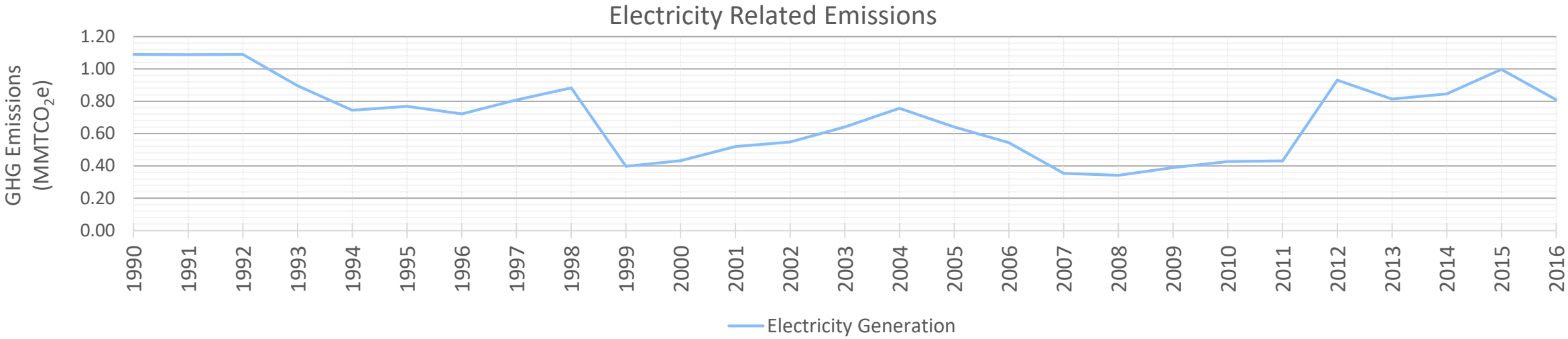


Vermont – Emissions by Sector (Details)

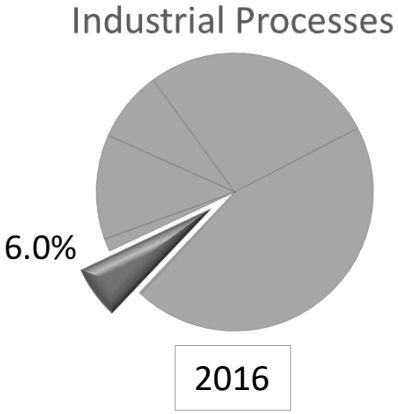


Electricity (Consumption/Purchase Based)

- Electricity related emissions in 2016 down from 2015 levels (1.0 to 0.81 $MMTCO_2e$)
  - *Electricity related emissions are variable (purchase based)*
  - *Emissions mostly depend on makeup and amount of ISO-NE residual mix purchased by utilities*
  - *Renewable Energy Standard (RES) – 30 V.S.A. § 8004 – RE and REC portfolio requirements (2017+)*
- Large purchases from Hydro Quebec make Vermont's electricity portfolio low GHG emitting
  - *Potentially significant GHG CH_4 emissions from hydro – varies geographically – many states do not consider large hydro renewable*

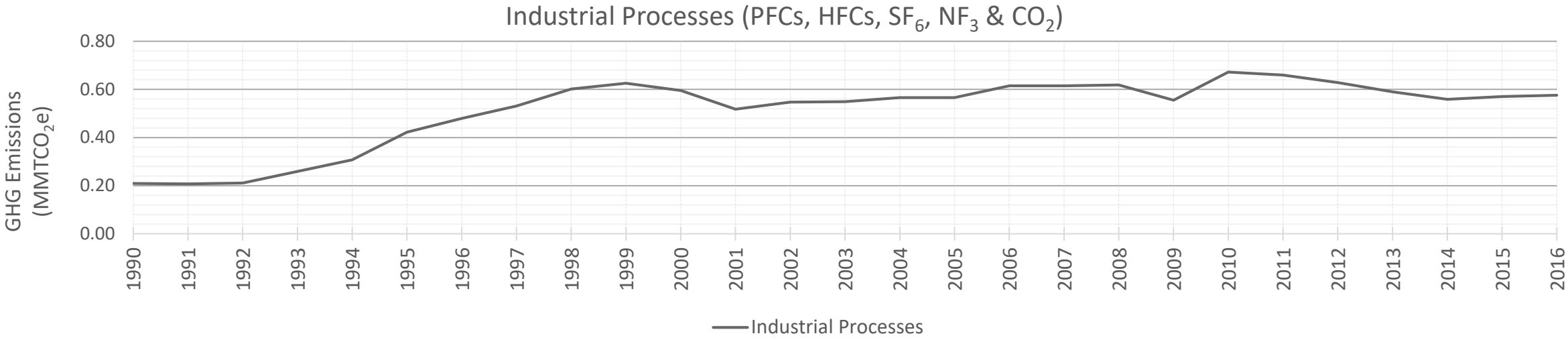


Vermont – Emissions by Sector (Details)



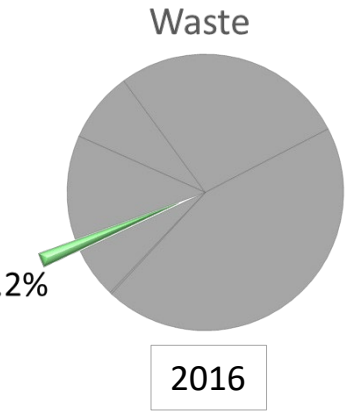
Industrial Processes

- Emissions from industrial processes show a very slight increase from 2015 to 2016.
- Majority of emissions from Industrial Processes sector are from two sources
  - *ODS (Ozone Depleting Substances) Substitutes, and Semiconductor Manufacturing*
  - *Updated methodology – utilizing a CA developed tool for U.S. Climate Alliance for estimates*
  - *Main emissions from this sector are from HFCs, PFCs, SF_6, and NF_3 which are not only extremely potent (high GWP) greenhouse gases, but in some cases have extraordinarily long atmospheric lifetimes (mostly all anthropogenic sources)*

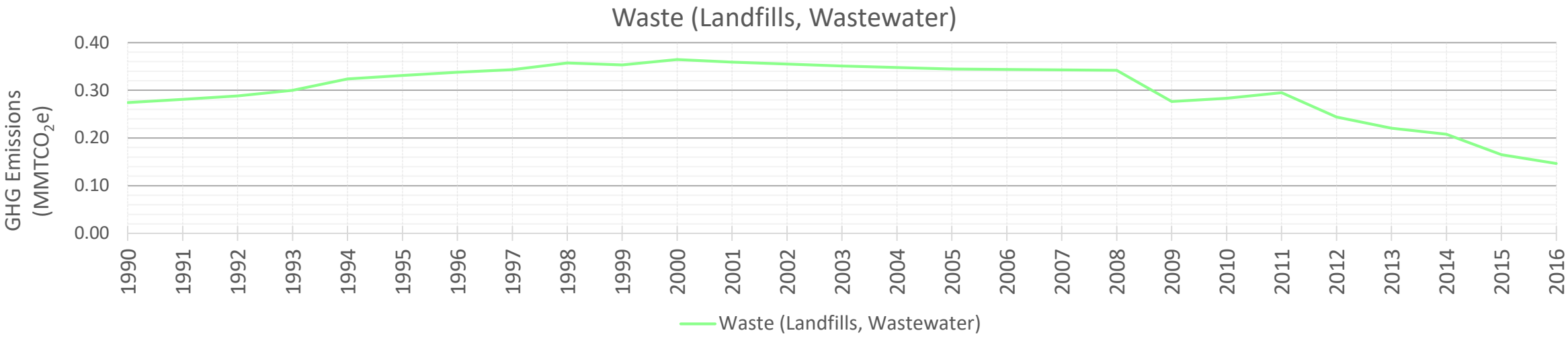


Vermont – Emissions by Sector (Details)

Waste (Landfills & Wastewater)

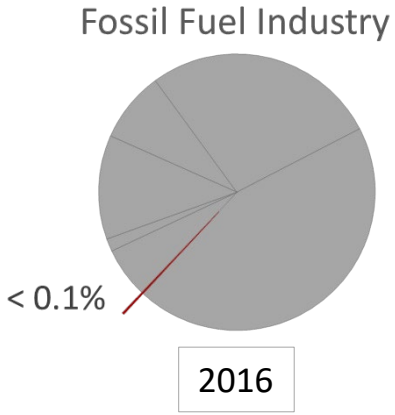


- More emissions from solid waste sector than wastewater – equalizing over time
  - *One active landfill in VT currently (Coventry) – Emissions drop as closed landfills age*
  - *LFGTE (4 sites) reduced CH_4 from landfill gas (LFG) – emits biogenic CO_2 (not included in totals)*
- Vermont Universal Recycling and Composting Law
  - *Law prohibits recyclables (2015) and food scraps (2020) in landfills*
  - *GHG benefits of composting somewhat unclear – less LFG from landfills (with LFGTE) and more CO_2/CH_4 from backyards/facilities*



Vermont – Emissions by Sector (Details)

Fossil Fuel Industry



- Emissions increased between 2015 and 2016 with the extension of the pipeline to Addison county, but total emissions from the sector remain very small

- The majority of emissions from the Fossil Fuel Industry sector are from the distribution of natural gas
  - *Emissions from leaks in pipes and unintentional releases from services and components*
  - *Currently only one supplier (Vermont Gas – VGS) serving Chittenden, Franklin, and Addison Counties*