Vermont

Vermont's Current Greenhouse Gas (GHG) Emissions Profile

Vermont Greenhouse Gas Emissions Inventory and Forecast Brief: 1990 – 2016

ANR Presentation to the Vermont Climate Council

December 21, 2020

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

Climate Change Definitions

- Climate Change Mitigation
  - Mitigation: A human intervention that either reduces greenhouse gas emissions or enhances the storage of greenhouse gases
  - Mitigation Measures: Technologies, processes or practices that contribute to mitigation

- Climate Adaptation
  - Refers to adjustments in ecological, social, or economic systems in response to actual or expected climatic stimuli and their effects or impacts.

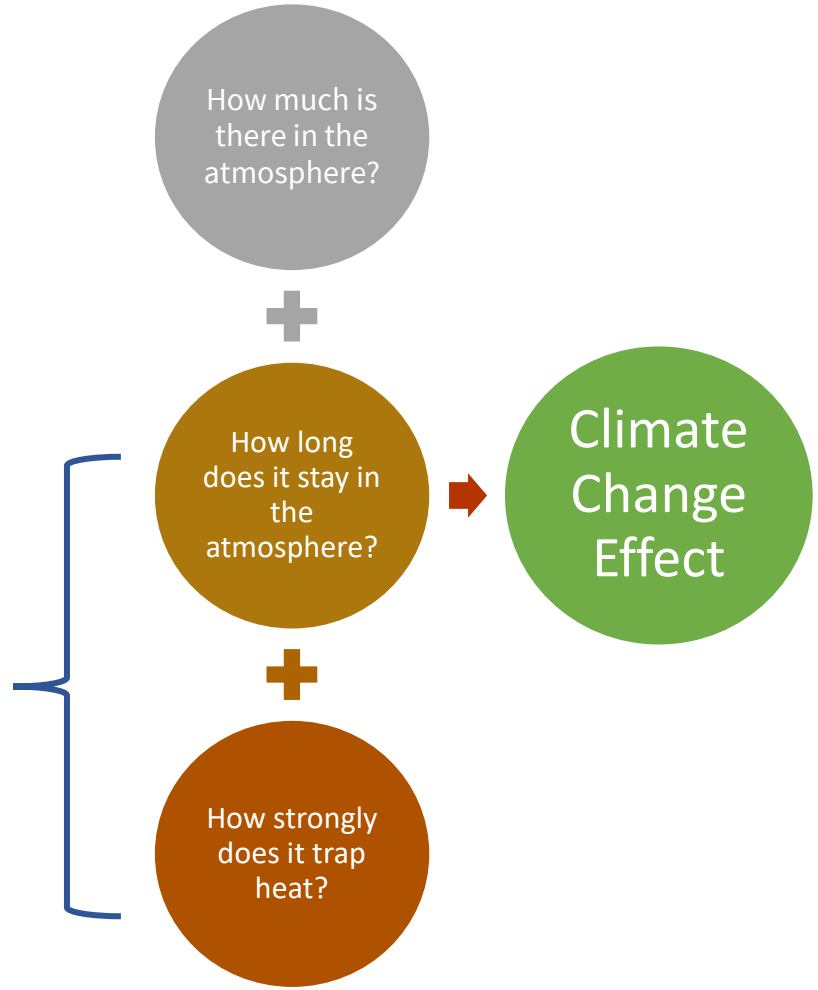
- Climate Resilience
  - The capacity of individuals, communities, and natural and built systems to withstand and recover from climatic events, trends, and disruptions.

Climate Change Definitions

- Greenhouse gas (GHG)
  - Gases that trap heat in the atmosphere
  - Carbon dioxide (CO_2) is the primary
  - Expressed as mass (typically in metric tons (MT))

- Anthropogenic GHG emissions
  - GHG emissions from human activity
  - Focus of GHG Inventory and Act 153

- Biogenic GHG sources
  - GHG sources that are produced through natural processes
  - Excludes fossil fuels



- Global Warming Potential (GWP)
  - Measure of warming potency
  - Expressed over a defined time period since the length of time a GHG stays in the atmosphere varies
    - Vermont GHG Inventory uses UNCC Inventory Framework, which sets baseline of 100 years
  - Expressed as a mass equivalent to a comparable amount of carbon dioxide ($MTCO_2e$)
    - GWPs: CO_2 = 1 ; methane = 25; fluorinated gases = 12,200 to 22,800 (100-year timeframe)

Climate Change Definitions

- Gross emissions
  - Total anthropogenic GHG emissions

- Carbon sequestration
  - The active process of removing CO_2 from the atmosphere and storing it in another form that cannot immediately be released (like wood).
  - Expressed as a negative value per unit time ($MTCO_2e$/year).

- Carbon storage
  - The total amount of carbon contained in a plant-based ecosystem (forest, wetland, farm field, etc.)
  - Ex. In a forest, carbon storage reflects all of the carbon stored in that forest or a part thereof, such as trees, soil, leaf litter, dead wood, etc.

- Net flux
  - The rate of change in stored carbon

- Net emissions
  - Gross emissions minus carbon sequestration

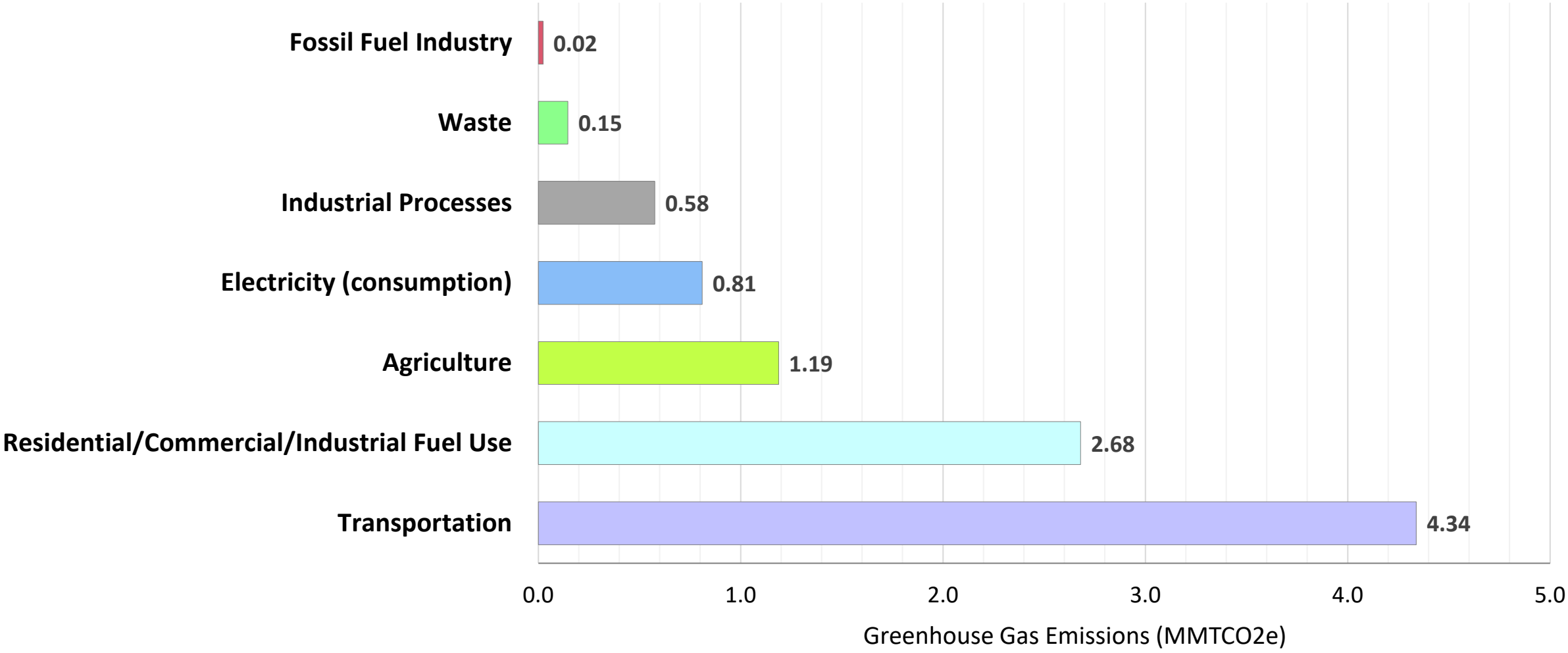
Things to consider as we review the inventory…

- We cannot measure every source of GHG emissions
  - We base the inventory on the information we have and the best available estimation tools/procedures, which we regularly update
- The GHG inventory involves policy decisions about what to count and what not to AND how to avoid double counting
  - Ex. The GHG inventory does not include CO_2 emissions from the burning of landfill and anaerobic digester gas nor wood for heat.
- Emissions sources are analyzed – this is not a carbon life-cycle analysis
- Renewable vs. clean
- Inventory – you will hear about three inventories over the course of the next two meetings, one GHG and two programmatic

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 CO_2)
      - Attempt to quantify and sum GHG emissions from all applicable sectors in Vermont
    - Inventories rely heavily on federal datasets and therefore often lag several year behind the calendar year when the emissions occurred
    - Includes emissions of gases covered in international agreed upon protocol in million metric tons of CO_2 equivalent (MMTCO2e)
      - CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3
    - Methodologies consistent with accepted GHG inventory standards/protocols
      - Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030 (2007) report, IPCC, EPA

Vermont Greenhouse Gas Emissions by Sector – 2016



Sectors are defined in the *Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030* report

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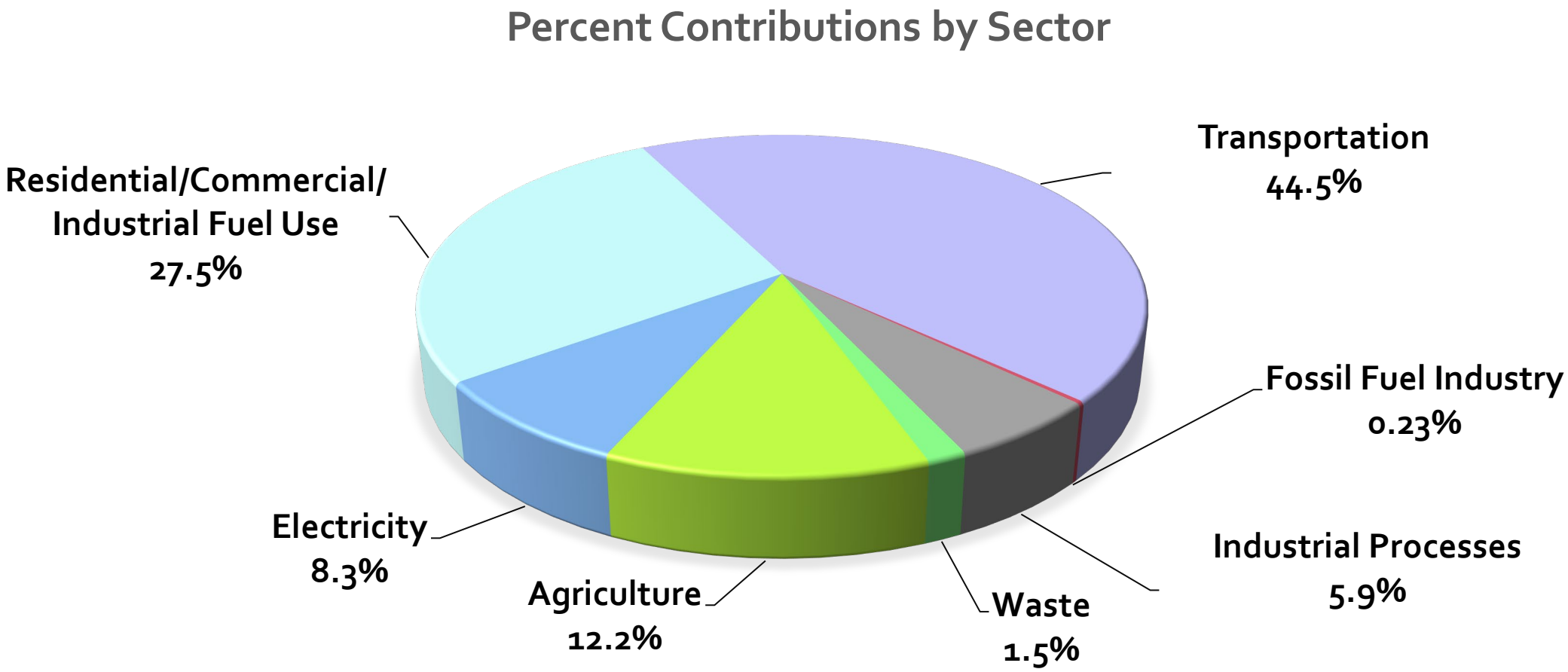

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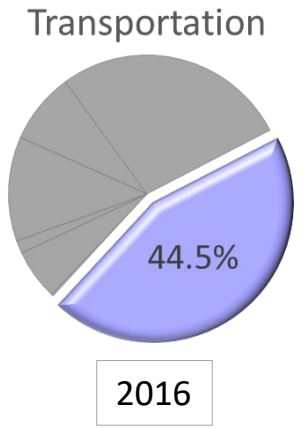
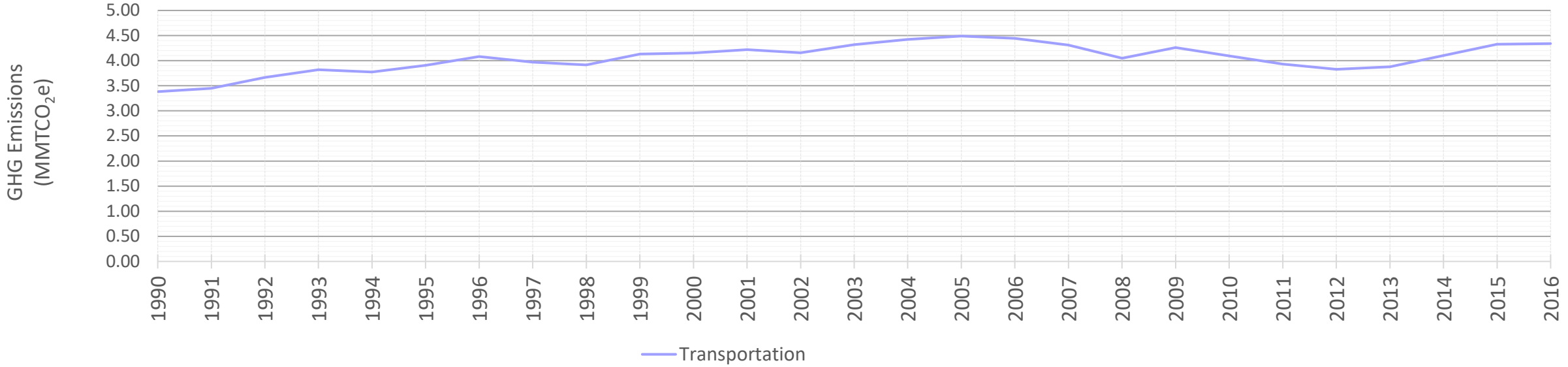
Vermont – Emissions by Sector (Details)

Transportation

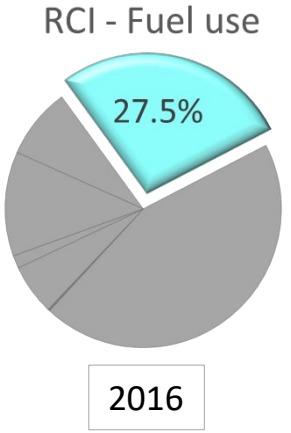


- Transportation sector is the largest contributing sector in the inventory
  - *Final Vermont Greenhouse Gas Inventory and Reference Case Projections, 1990-2030 report estimated emissions using the EPA State Inventory Tool (SIT)*
  - *On-road values are now either from or based on the National Emissions Inventory (NEI) - (triennial 2011 and 2014)*
    - *NEI on-road transportation values generated using EPA Motor Vehicle Emissions Simulator model (MOVES)*
      - *Detailed county level inputs (vehicle populations, age distributions, vehicle miles travelled (VMT), etc.)*
      - *Model focused mainly on VMT*
      - *EPA runs for all states (except CA)*
    - *Non-NEI years interpolated or extrapolated by adjusting NEI values using JFO fuel sales data and VMT data*

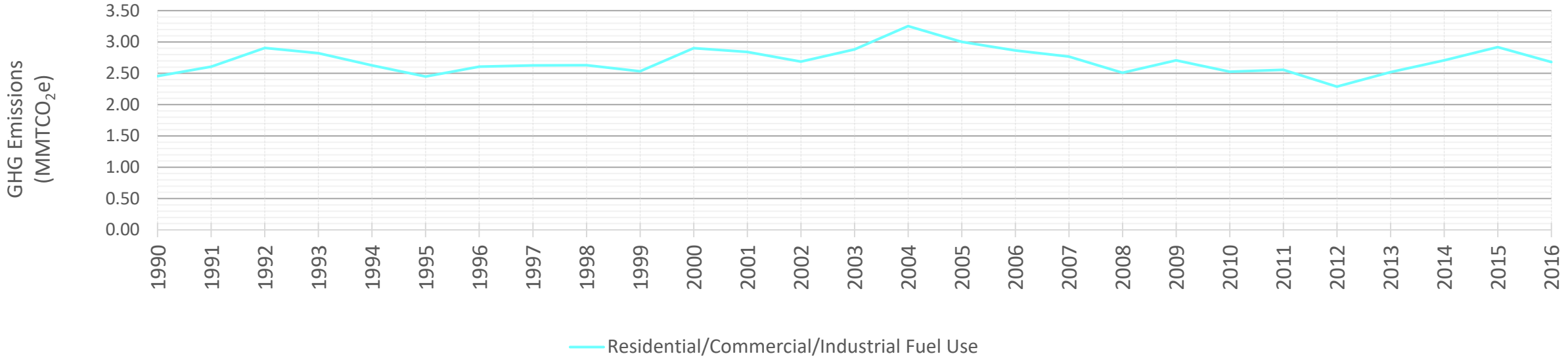


Vermont – Emissions by Sector (Details)

Residential, Commercial & Industrial (RCI) – Fuel Use

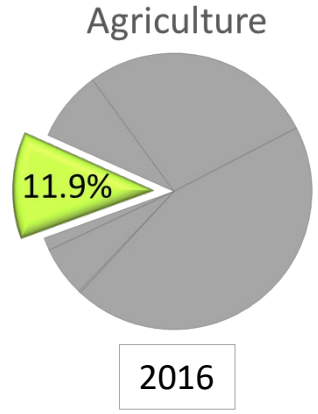


- RCI emissions – Second largest emitting sector in the inventory (heating buildings, water heating, cooking)
  - *EPA SIT tool used for RCI sector calculations*
  - *Mainly relies on EIA State Energy Data System (SEDS) data*
    - *Estimated fuel consumption by subsector*
  - *CO_2 from oil and propane (especially residential) – main contributor*
  - *CO_2 from wood combustion is not included in totals (biogenic origin)*
    - *CH_4 and N_2O from wood combustion is included*

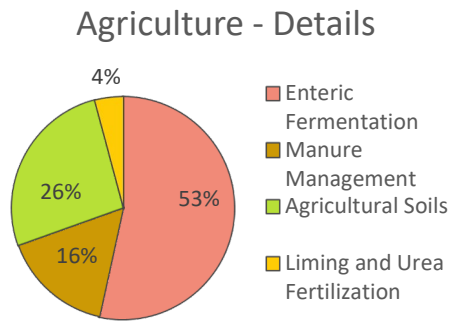


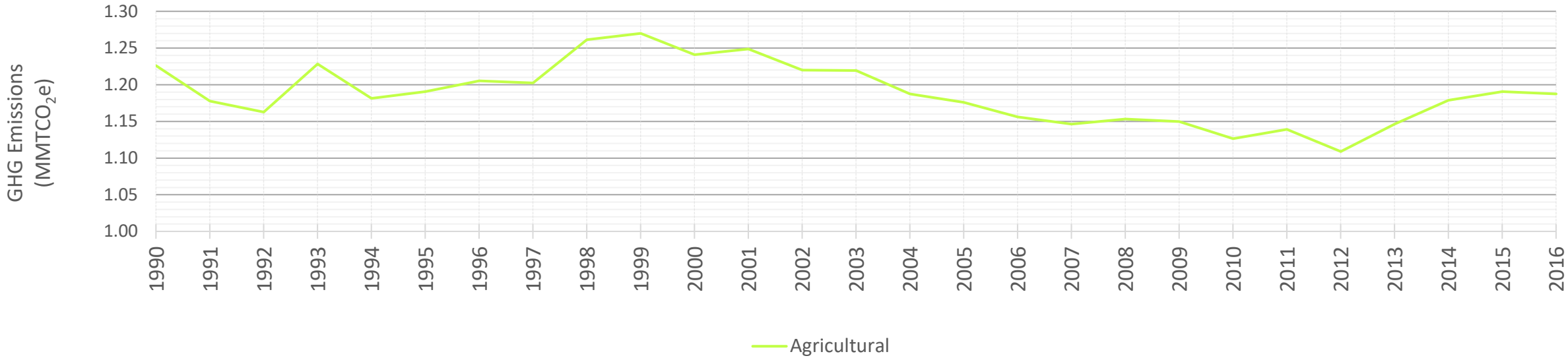
Vermont – Emissions by Sector (Details)

Agriculture



- Agricultural emissions estimated using EPA SIT tool
  - *Default data used from US Department of Agriculture (USDA)*
    - *Animal populations*
    - *Crop data*
    - *Soils data*
  - *Enteric Fermentation is the main emissions source in the sector (ruminant animal digestive process)*
  - *CO_2 from agricultural processes not included in totals (biogenic origin) – almost entirely CH_4, N_2O*
  - *Anaerobic digesters – beneficial for CH_4 from manure management*





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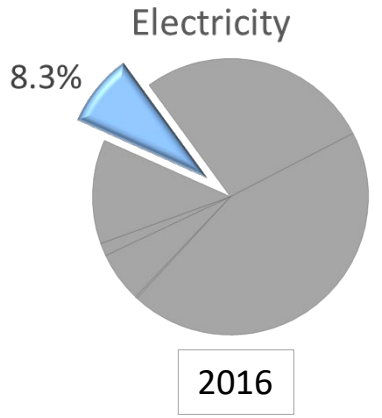
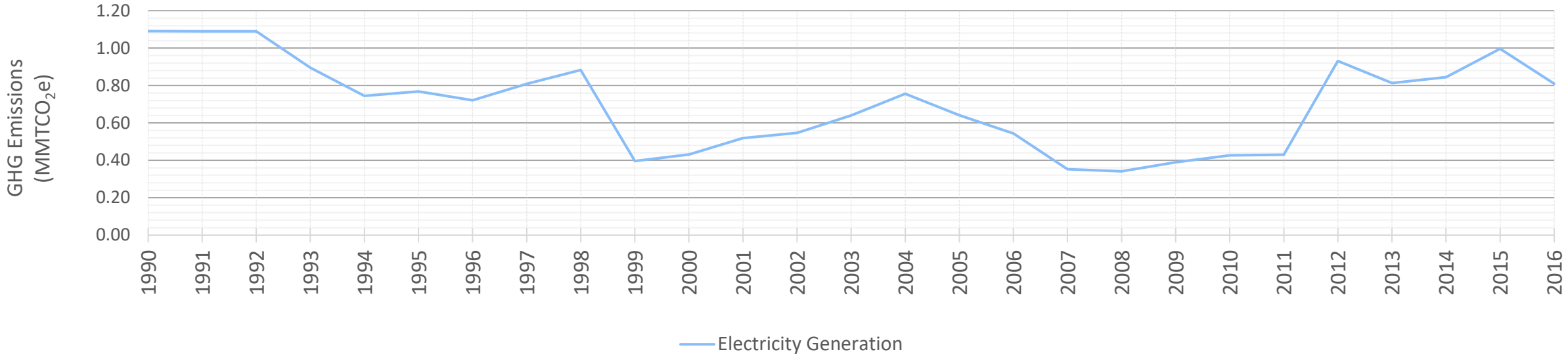


Electricity (Consumption/Purchase Based)

- Electricity related emissions are consumption (purchase) based (not generation based)
  - *Based on electricity purchase decisions of utilities by generation source type (data from Public Service Dept.)*
    - *kWh totals used have been adjusted for sales/purchases of renewable energy credits (RECs)*
  - *Emission factors by generation type from Independent System Operator - New England (ISO – NE)*
  - *Emissions depend almost entirely 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 electricity purchases of hydro and nuclear energy make Vermont's electricity portfolio low GHG emitting
  - *Potentially significant GHG CH_4 emissions from hydro electricity – varies geographically*



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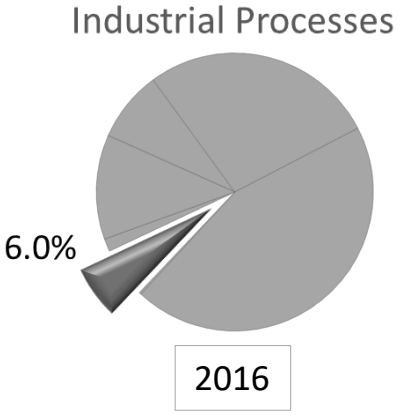
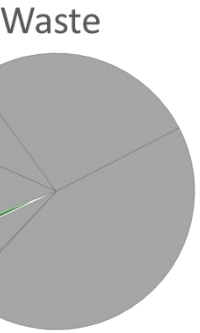


Industrial Processes

- Vermont does not have many of the Industrial Process emissions sources covered in this sector
- Majority of emissions in the Industrial Processes (IP) sector are from two sources
    - *ODS (Ozone Depleting Substances) Substitutes, and Semiconductor Manufacturing*
        - *Updated methodology for ODS substitutes – utilizing a CA developed tool for U.S. Climate Alliance (USCA) for estimates*
        - *Semiconductor manufacturing emissions are from EPA FLIGHT tool (reported facility level)*
        - *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)*

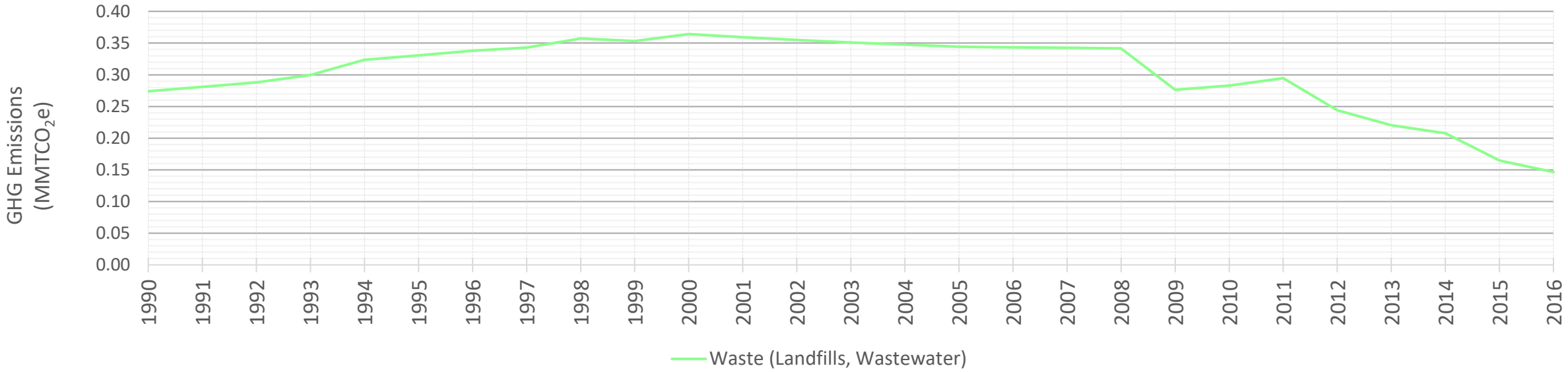
Vermont – Emissions by Sector (Details)

Waste (Landfills & Wastewater)



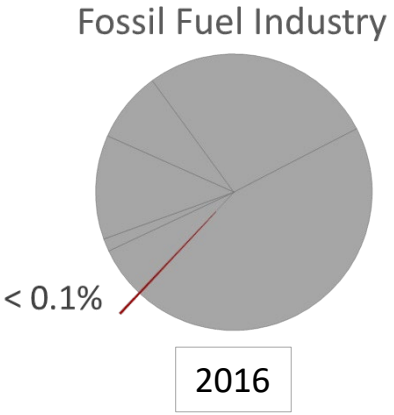
2016

- More emissions from solid waste sector than wastewater – equalizing over time
  - *One active landfill in Vermont currently – emissions drop as closed landfills age*
  - *Landfill gas to energy (LFGTE) combust CH_4 from landfill gas (LFG) – CO_2 not included in totals (biogenic origin)*
  - *Emissions calculated using reported LFG totals, fugitive emissions assumptions, combustion efficiencies (engines/flares)*
- Vermont Universal Recycling and Composting Law
  - *Law prohibits recyclables (2015) and food scraps (2020) in landfills*

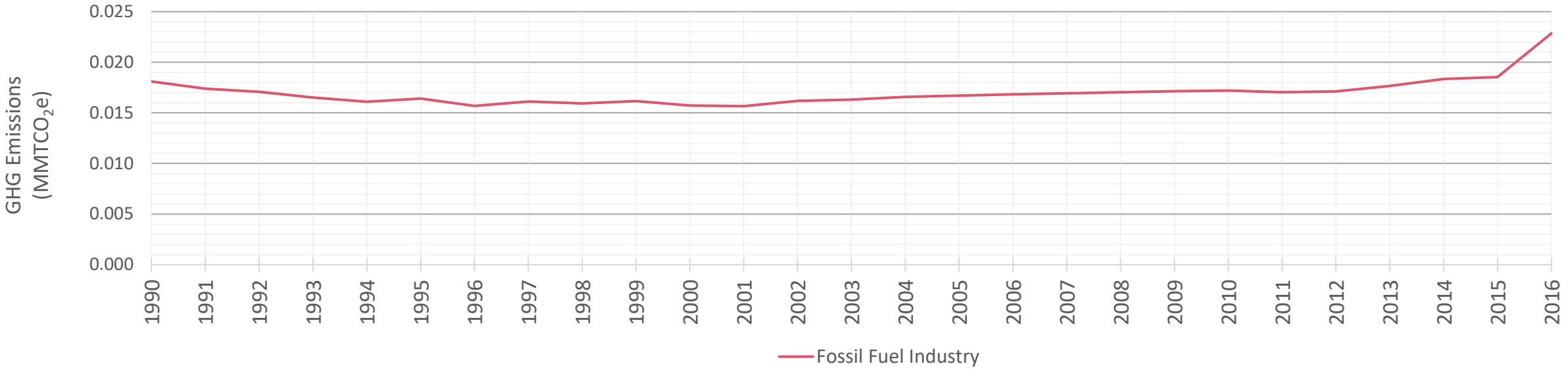


Vermont – Emissions by Sector (Details)

Fossil Fuel Industry



- Emissions increased from 2015 to 2016 with the extension of a 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*
  - *Emissions calculated using miles of lines and number of services combined with leakage rates*



Preliminary Emissions Estimates (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 methods or indicators
- 1990 – 2017 Emissions Inventory report expected to be released quarter 1, 2021

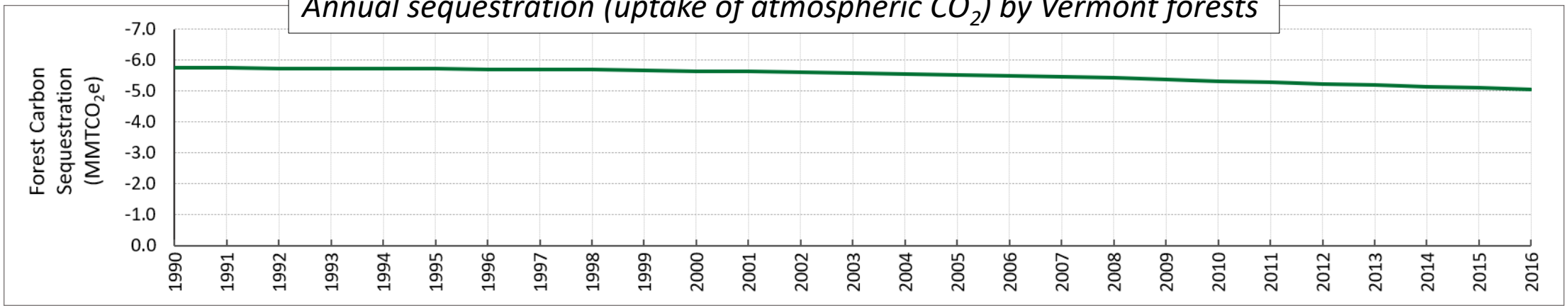
Sector	2010	2011	2012	2013	2014	2015	2016	2017	2018
Transportation	4.09	3.93	3.83	3.88	4.10	4.33	4.34	*4.32*	*4.22*
Residential/ Commercial/ Industrial (RCI) Fuel Use	2.53	2.56	2.29	2.52	2.71	2.92	2.68	*2.69*	*2.72*
Agriculture	1.13	1.14	1.11	1.15	1.18	1.19	1.19	*1.16*	*1.16*
Electricity Supply & Demand (Consumption - based)	0.43	0.43	0.93	0.81	0.84	1.00	0.81	*0.49*	*0.19*
Industrial Processes	0.67	0.66	0.63	0.59	0.56	0.57	0.58	*0.57*	*0.56*
Waste Management	0.28	0.29	0.24	0.22	0.21	0.16	0.15	*0.14*	*0.15*
Fossil Fuel Industry	0.02	0.02	0.02	0.02	0.02	0.02	0.02	*0.03*	*0.03*
Gross Emissions Total	9.15	9.03	9.04	9.19	9.62	10.19	9.76	*9.41*	*9.02*

Calculated Value
Value Carried Forward
Differing methodology

Forestry & Land Use

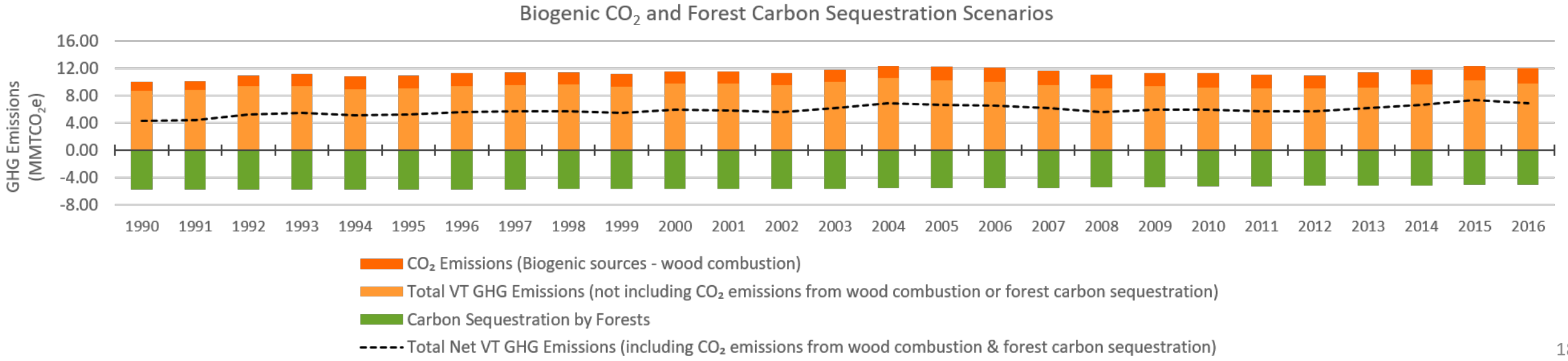
- Land Use, Land-Use Change and Forestry (LULUCF) Sector
  - Important piece of the carbon cycle (forest carbon sequestration data is available and tracked separately)
    - Utilizes same approach taken by other states in the region (standard GHG inventory convention)
  - Difficult to quantify emissions, sequestration, and fluxes accurately annually
- Vermont forest carbon sequestration rate provided by Forest Service from National Inventory Report (NIR)
  - Based on Forest Inventory Analysis (FIA) data
    - Above-ground forest biomass, below-ground biomass, deadwood, litter, soil organic carbon
  - Sequestration rate has been slowly declining over time
- GHG emissions in the inventory on which the reduction targets are based are annual gross anthropogenic emissions (not net)

Annual sequestration (uptake of atmospheric CO_2) by Vermont forests

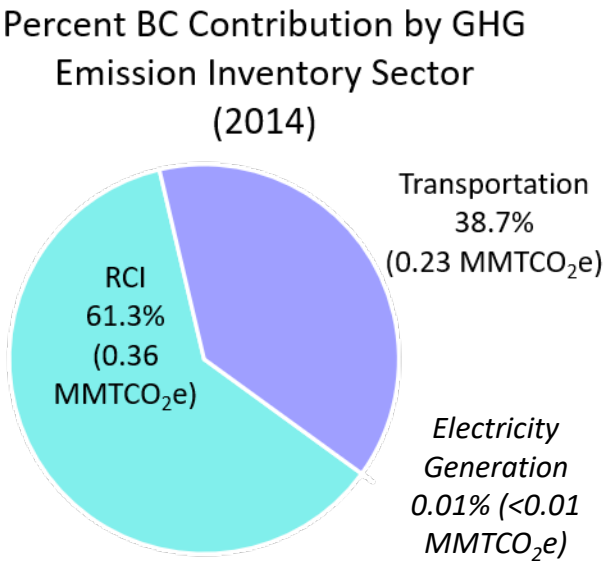


Biogenic CO_2 from Wood Combustion & Forest Carbon Sequestration Scenarios

- Biogenic CO_2 not included in the gross inventory totals
  - Biogenic CO_2 emissions would be captured in the Land Use sector
  - Carbon in shorter term storage (trees, etc.) versus removal from long term geologic storage (fossil fuels)
  - CO_2 from combustion/decomposition of biomass is assumed to be re-sequestered over time
    - Forest management practices for regrowth is important
    - Timescales under consideration
    - Estimates on timescales for carbon neutrality for wood combustion vary but are relatively long when compared to GHG reduction goals
    - Wood being used for wood products is much better from a CO_2 perspective than combustion (long term storage)
- Including CO_2 from wood combustion in gross annual totals it would contribute significantly to (increase) GHG emissions (RCI, electricity)



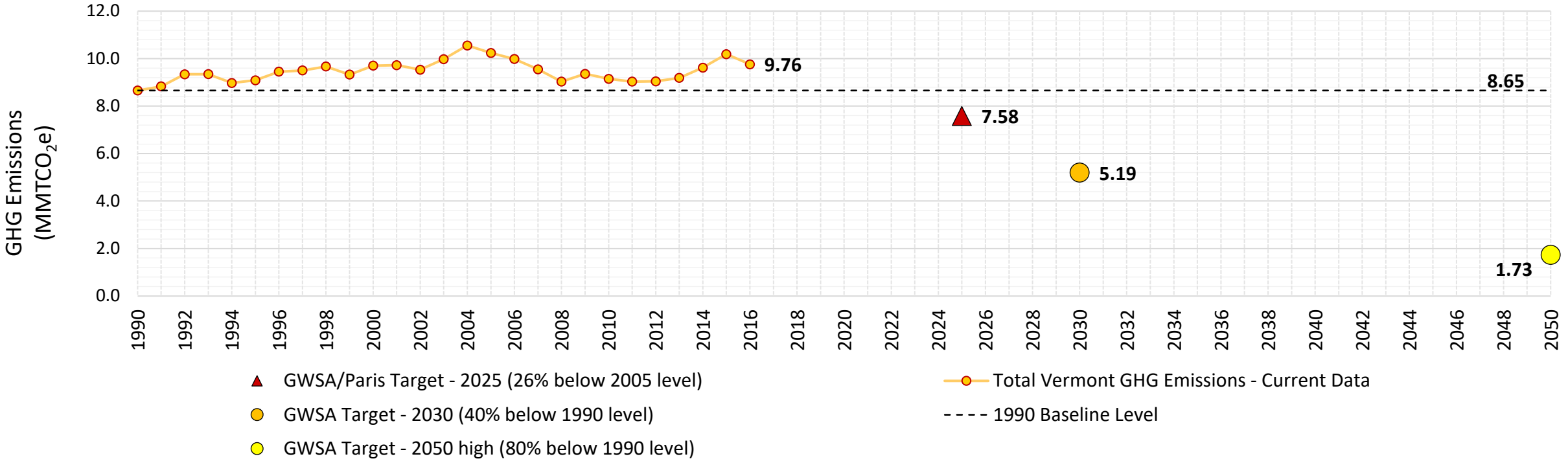
Black Carbon (BC)
to be updated in 1990 – 2017 report



- Not a gas – but important climate forcing agent
  - 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 (CO2, 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 (on-road and non-road)
  - Diesel engines well established as climate warming, RWC not as clear (VT cold climate/snow makes more certain – indirect effects)

Vermont – Total Emissions Trends and Goals

- Emissions in 2016 are 4.7% below 2005 emissions levels
  - Goal: 26% below 2005 levels by 2025
- Emissions in 2016 are 13% above 1990 baseline levels
  - Goal: 40% below 1990 levels by 2030
  - Goal: 80% below 1990 levels by 2050
- Emissions decreased from 2015 to 2016 due mainly to reductions in the RCI and electricity sectors
  - Much more will be necessary to make meaningful progress toward future reduction targets



Questions?