Vermont's LEAP Model Baseline Scenario Draft Updates and Results

Presentation for Climate Council Meeting

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Agenda

Background and introduction to the Vermont LEAP model

Summary of sectoral Baseline scenario updates and results

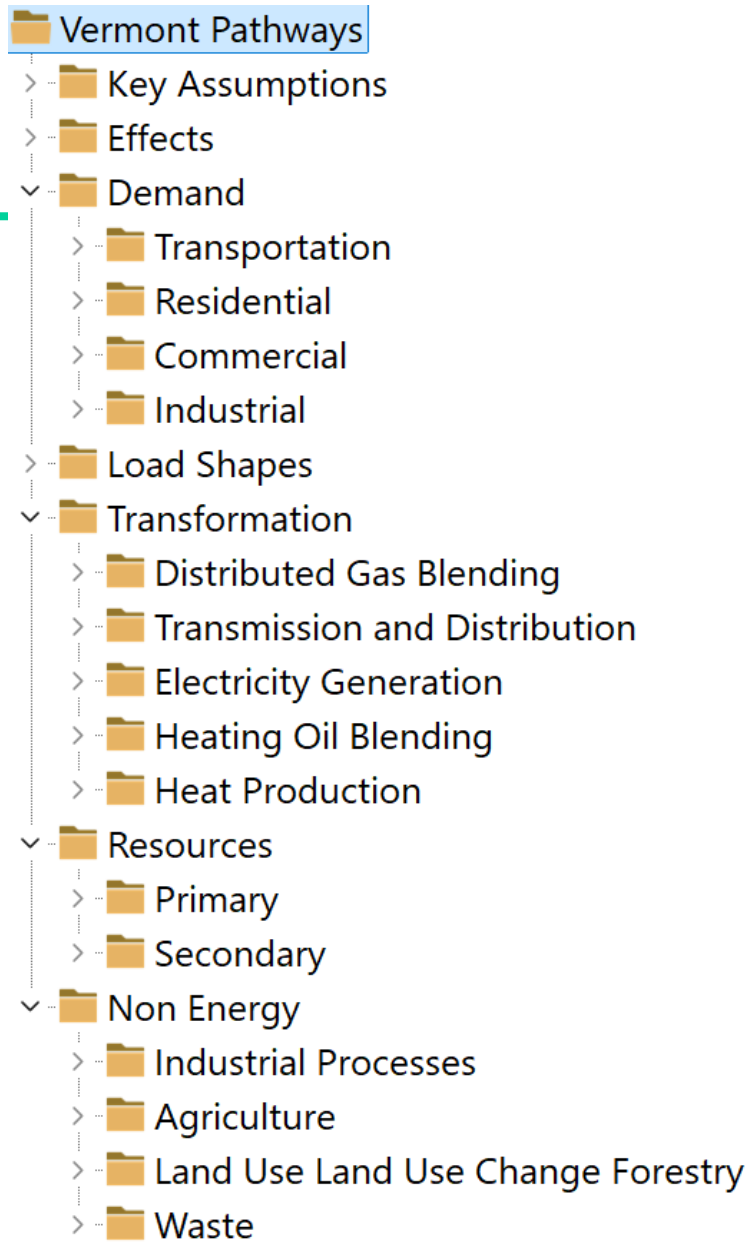
Economy-wide Baseline scenario emission results

Next steps

Questions and discussion

The Vermont LEAP model

- GHG emissions model for VT, developed using LEAP and NEMO
- Models energy consumption and production in all sectors, associated GHGs, non-energy GHGs, costs of one scenario vs. another
- Modeling period: 2015-2050 with projections starting in 2024
- Emissions coverage: Major GHGs (CO2, CH4, N2) and local air pollutants (CO, NOx, NMVOC, PM10, PM2.5, BC, OC, SO2, NH3), SF6



Vermont applications

2021:	Initial development of VT LEAP Model for VT Comprehensive Energy Plan (SEI, NESCAUM, Public Service Department)
Later in 2021:	Development of Central Mitigation Scenario for VT Climate Action Plan (Cadmus, EFG, ANR, SEI)
2022/2023:	Public Service Department-led work for Regional Planning Commissions (PSD, SEI)
2022/2023:	Marginal abatement cost analysis of individual actions within Central Mitigation Scenario (Cadmus, EFG, ANR, SEI)
2023:	Analysis of thermal sector policies (inc. partial model update) (EFG, SEI, ANR)
	Model v3.27 used as the starting point for this Baseline update

2025: Full model update for next CAP

Goals, in two streams:

1. Baseline Scenario Updates (now)
    1. Update current or recently-available historical data that feed into Baseline Scenario
    2. Align current/historical GHG emissions from all sectors with latest GHG inventory
        - Including non-energy GHGs from AFOLU, waste, IPPU
    3. Incorporate new trends or other forecasts
    4. Make structural changes to improve transparency, general ease-of-use, ability to incorporate subsequent data updates, and ease of reporting
2. Mitigation Scenario Updates (next)
    1. Updated mitigation measures and scenarios for next Climate Action Plan

Baseline scenario: updates and results

Updates to cross-cutting data

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
First scenario year	Modified to 2024, to reflect more recent data	Set to 2020
State-level population and housing units	*Historical:* Updated with U.S. Census Bureau 2020-2024 data *Projections:* Updated with 2024 release of projections from University of Virginia Weldon Cooper Center	*Historical:* from U.S. Census Bureau, Population Division (2019). *Projections:* based on State Population projections from University of Virginia Weldon Cooper Center, Demographics Research Group (2018).
Vermont by-county population	Updated with Vermont Department of Health 2020-2023 updates	Historical data (2000-2019) from Vermont Department of Health
Gross state product	Updated with BEA data released 28-Mar-2025	U.S. Bureau of Economic Analysis (BEA), annual GDP by state, data released 2-Oct-2020. Projections based on historical average annual growth rate (AAGR).
Heating and cooling degree-days	Based on World Bank Climate Change Knowledge Portal (2025), ensemble model for CMIP6, SSP2-4.5	Based on Northeast Regional Climate Center, “Climate Data Grapher.” Values for RCP 4.5

Updates to transportation sector (1/2)

Non-road sectors

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Final energy intensities	Updated with SEDS 2023 and AEO 2023	Based on EIA's 2018 State Energy Data System (SEDS 2018) and EIA's 2020 Annual Energy Outlook (AEO 2020)

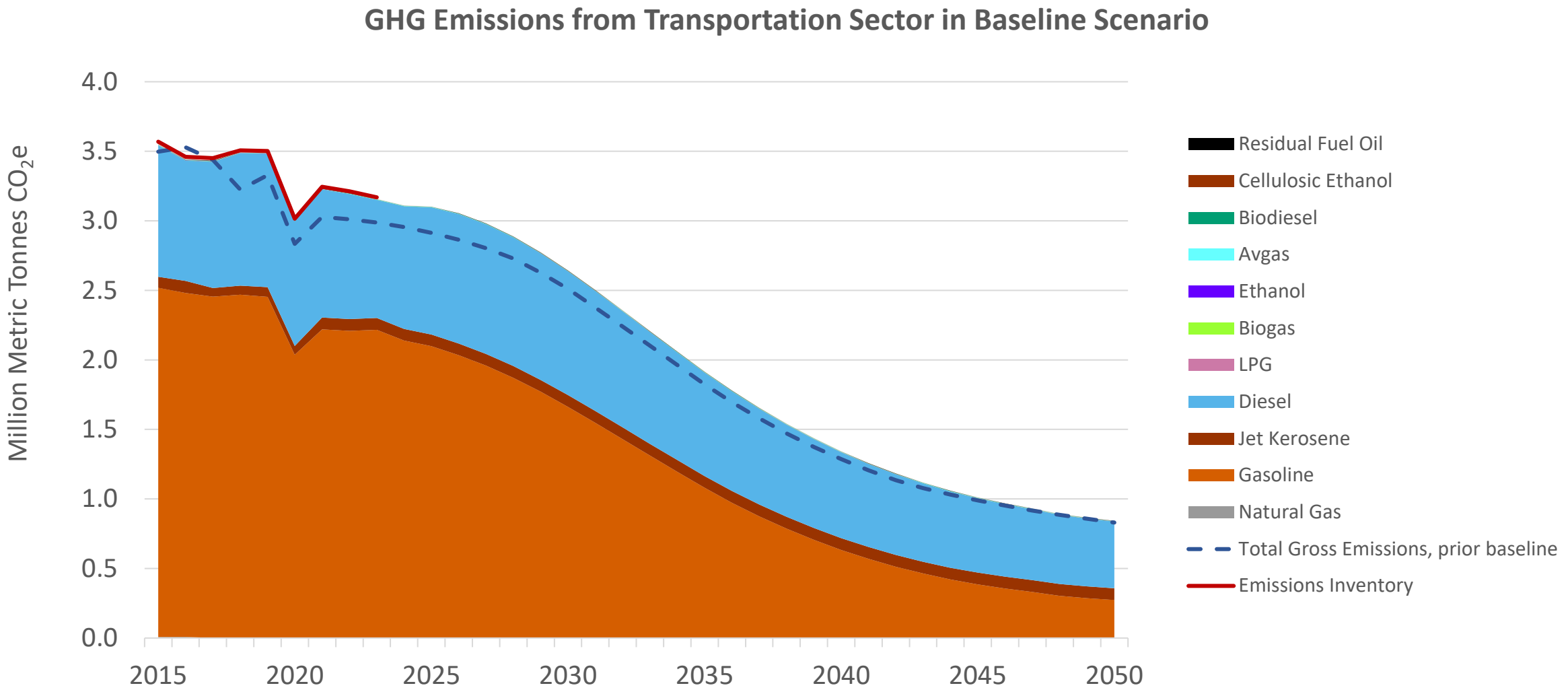
Road sectors

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Historical energy consumption	Switched to a top-down representation based on SEDS 2023 and AEO 2023	Calculated based on stock turnover model. 2019 vehicle stocks from Vermont's DMV and stocks for earlier years estimated based on Federal Highway Administration (FHWA) Highway Statistics and EV stock data from University of Vermont's Transportation Research Center (UVM TRC)
Model structure	Restructured vehicle categories to reflect motorcycles, passenger cars, and weight classes 1-8 grouped according to applicable policies. Distinction between classes 2a-2b, and 7-8 straight trucks and tractors. Simplified vehicle technologies where possible (e.g. removed unused technologies and differentiation among PHEVs with different driving ranges).	4 weight categories (passenger cars, light trucks, medium duty and heavy duty). Differentiation among EV and PHEVs with different driving ranges.
Vehicle stock	Updated with DMV registration data for 2023	Based on Vermont's DMV registration data for 2019
Stock Vintage Profiles	Updated based on DMV Registration data for 2023	Based on Argonne National Laboratory VISION model, version 2020 (VISION 2020)

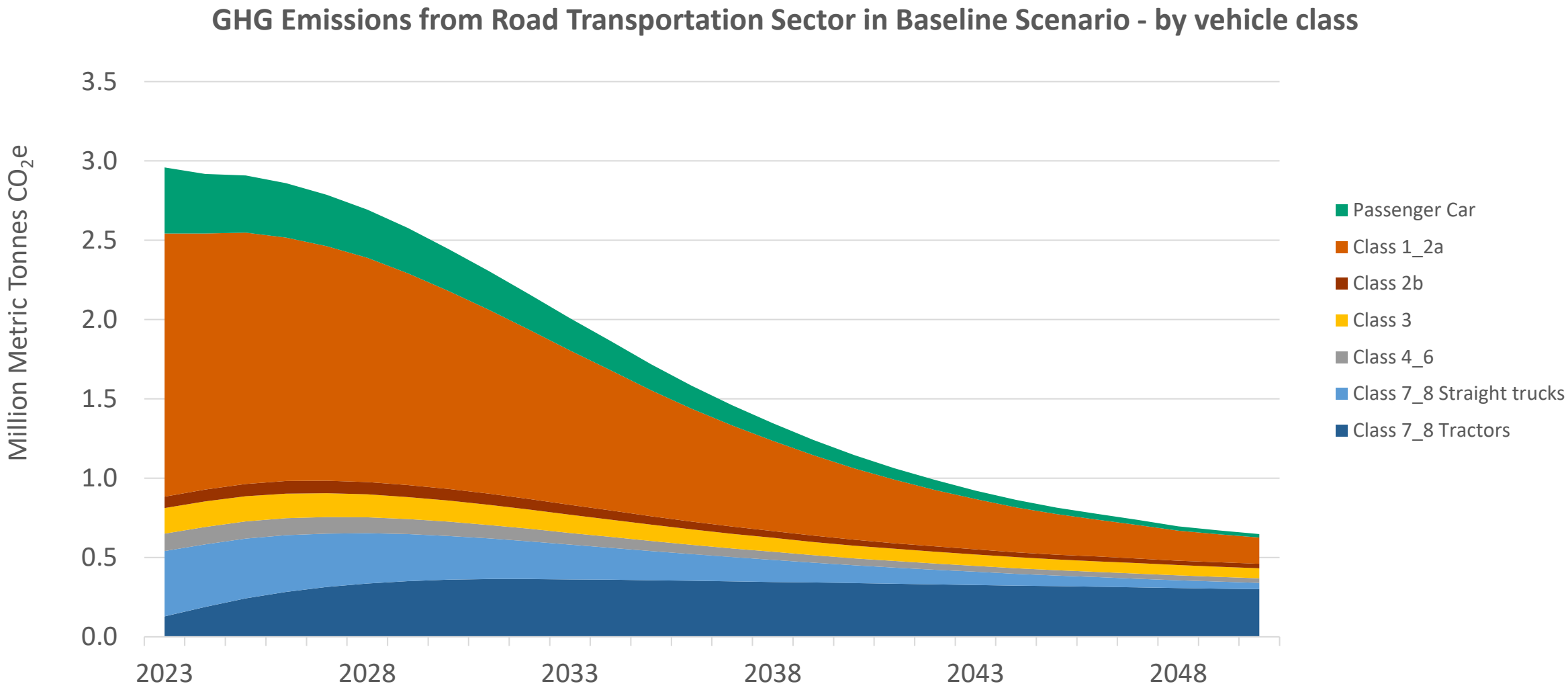
Updates to transportation sector (2/2)

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Vehicle sales	For passenger cars and classes 1-2, based on AEO 2025 projections for New England downscaled to Vermont using FHWA Highway Statistics 2023. For Classes 3-8, based on VISION 2022 downscaled to Vermont using FHWA Highways Statistics 2023.	Based on US projections from VISION 2020 and FHWA Highway Statistics 2019 data used to downscale to Vermont. Advanced Clean Cars II and Advanced Clean Trucks implemented in the Baseline.
Vehicle survival profiles	Updated based on VISION 2022	Based on VISION 2020
Vehicle miles traveled and mileage degradation profiles	Derived from National Renewable Energy Laboratory (NREL) 2024 Transportation Annual Technology Baseline	Based on VISION 2020
Fuel economies	Based on VISION 2022	Based on VISION 2020
Biodiesel and ethanol blending ratios	Updated based on SEDS 2023 and VISION 2022	Based on SEDS 2018 and VISION 2020
Vehicle costs	Derived from NREL 2024 Transportation Annual Technology Baseline	Based on a multiple sources including data from Cadmus, and publications from Journal of Cleaner Production and the International Council on Clean Transportation
Device shares for PHEVs	Derived from VISION 2022	Based on VISION 2020
CO2 emission factors	Updated based on SIT 2025	Based on US EPA State Inventory Tool (SIT) 2020
Calibration	Calibrated energy consumption to SEDS 2023 and emissions to most recent VT GHG Emissions Inventory through 2023	Calibration of fuel consumption based on SEDS 2018 and AEO 2020, and VMT calibration to FHWA 2019 Statistics and projections from UVM Transportation Research Center (2019)

Transportation sector results



Transportation sector results



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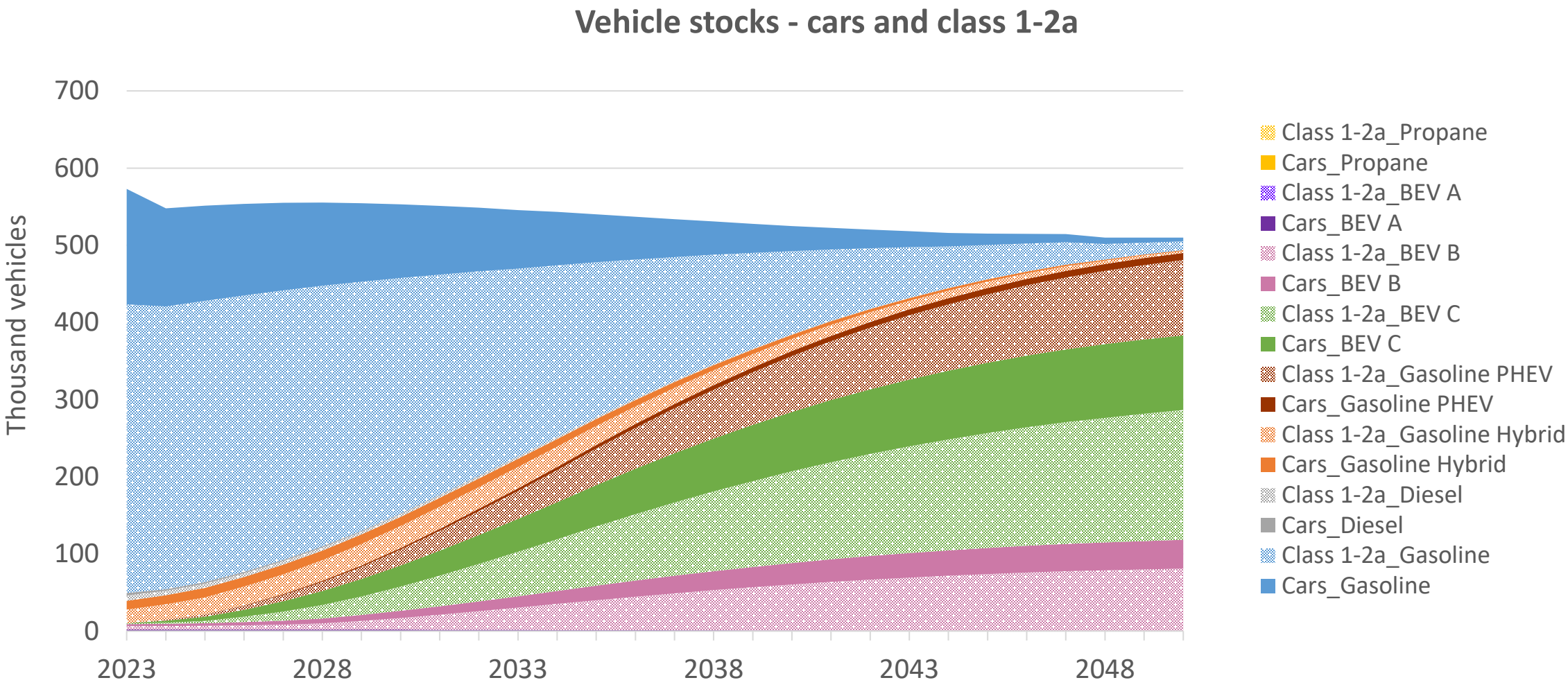


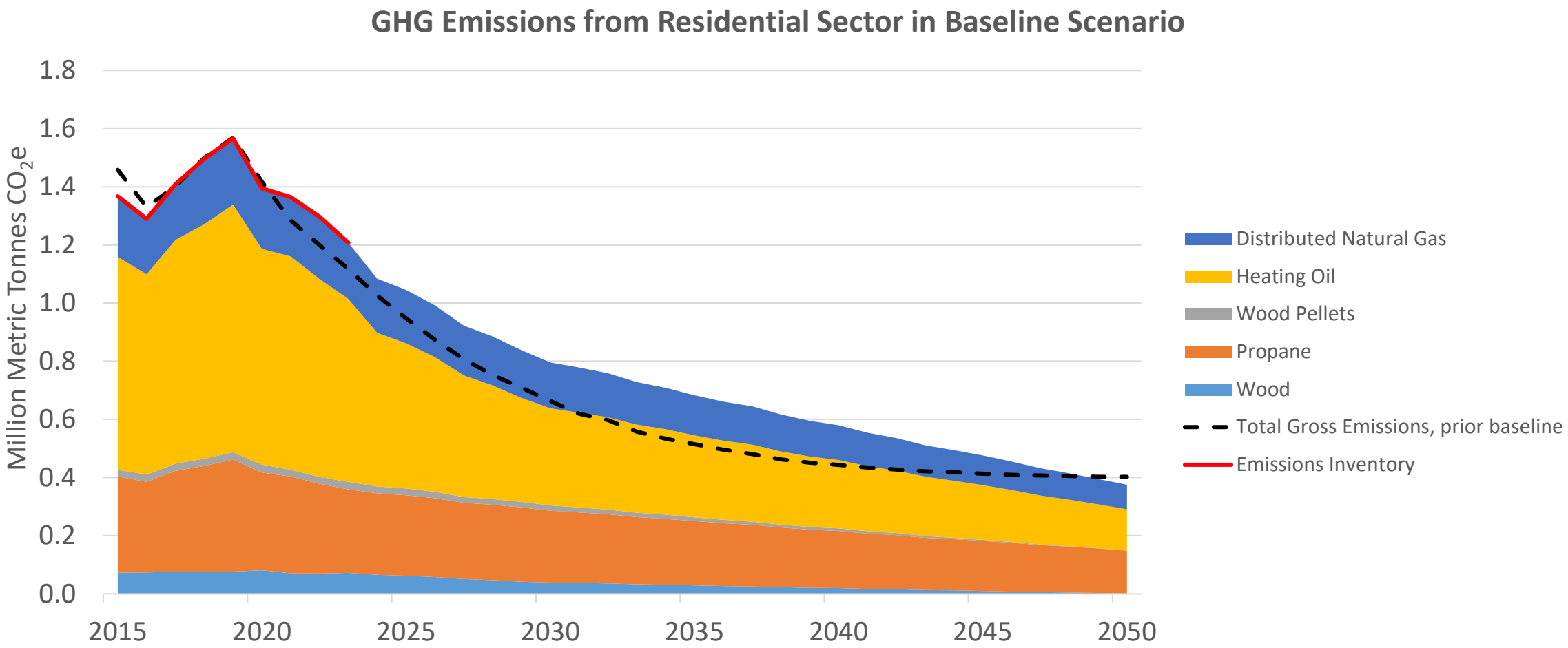
Updates to residential sector

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Mode structure (household characteristics)	New structure disaggregated by *income group*, building type, and ownership, and shell type (for space heating/cooling only).	Previous structure disaggregated by locality (urban/rural), building type, ownership, and shell type (for space heating/cooling only).
Mode structure (end-use categories)	Major end-use categories remain the same. Simplified the Other category by combining all smaller end-uses.	Previous structure end-use categories included Cooking, Refrigeration, Space Heating, Space Cooling, Water Heating, and Other. The Other category was broken down into 10 smaller end-uses (washing machines, dryers, dishwashers, TVs, lighting, etc.).
Household activity levels	Updated based on RECS 2020 and latest building retrofit data from Vermont's Office of Economic Opportunity (OEO).	Based on RECS 2015. Shell type (e.g., retrofits) data from multiple departments and utilities (OEO, VEIC, VGS, Efficiency Vermont).
Device shares	Updated historical based on RECS 2020 and Efficiency Vermont (heat pumps shares). Projections from US EIA's 2025 AEO and Efficiency Vermont/DPS (heat pumps).	Historical based on RECS 2015. Projections based on US EIA's 2020 AEO, Efficiency Vermont (washer, fridges, water heating) and VELCO/Itron (heat pump shares)
Energy intensities	Simplified model to use Final Energy Intensities across all devices. Updated data based on RECS 2020.	Previous model utilized both Final and Useful Energy Intensities. Data based on RECS 2015 and Efficiency Vermont.
Efficiencies	Updated based on US EIA's Updated Buildings Sector Appliance and Equipment Costs and Efficiencies and NMR Group et al.'s latest on-site reports for existing single-family, multifamily and new construction homes.	Based on NMR Group et al.'s on-site reports for existing single-family, multifamily and new construction homes and NESCAUM.
Load shapes	Updated based on NREL RESTOCK.	Based on data from Hall, Frederick. "Load Shapes for Heat Pumps & (Managed) EV Charging," July 21, 2021.

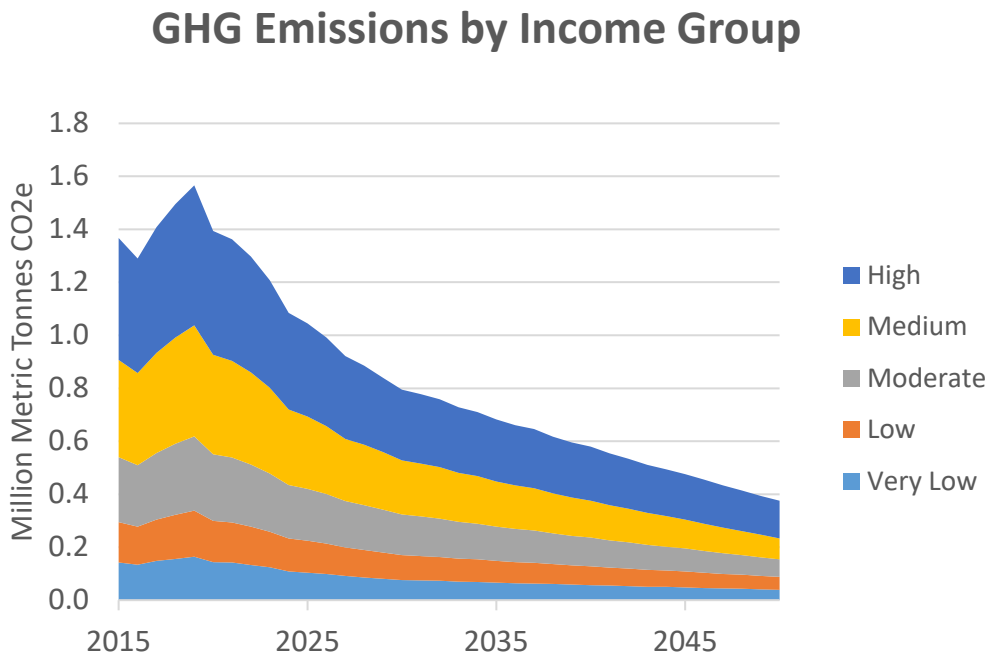
Updates to residential sector

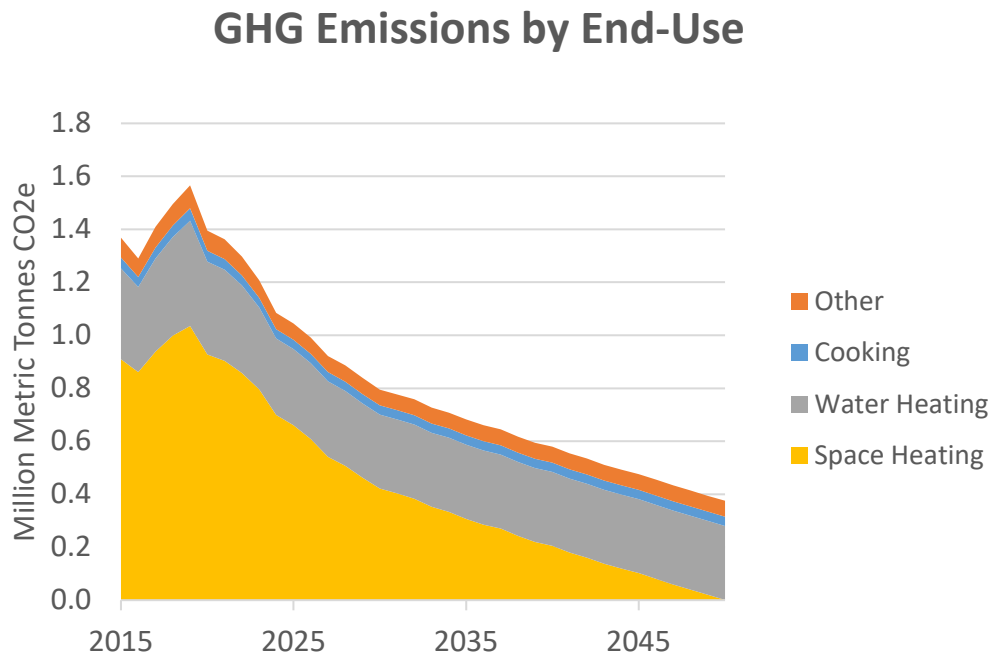
	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Climate projections (heating and cooling degree days)	Updated based on US EIA's 2025 AEO.	Based on Northeast Regional Climate Center. "Climate Data Grapher."
CO2 emission factors	Updated CH4, N2O, and fossil CO2 emission factors from SIT 2025.	Based on US EPA State Inventory Tool (SIT) 2020, NESCAUM and LEAP-IBC.
Calibration	Calibrated to most recent VT GHG Emissions Inventory through 2023.	Calibrated using SEDS.

Residential sector results

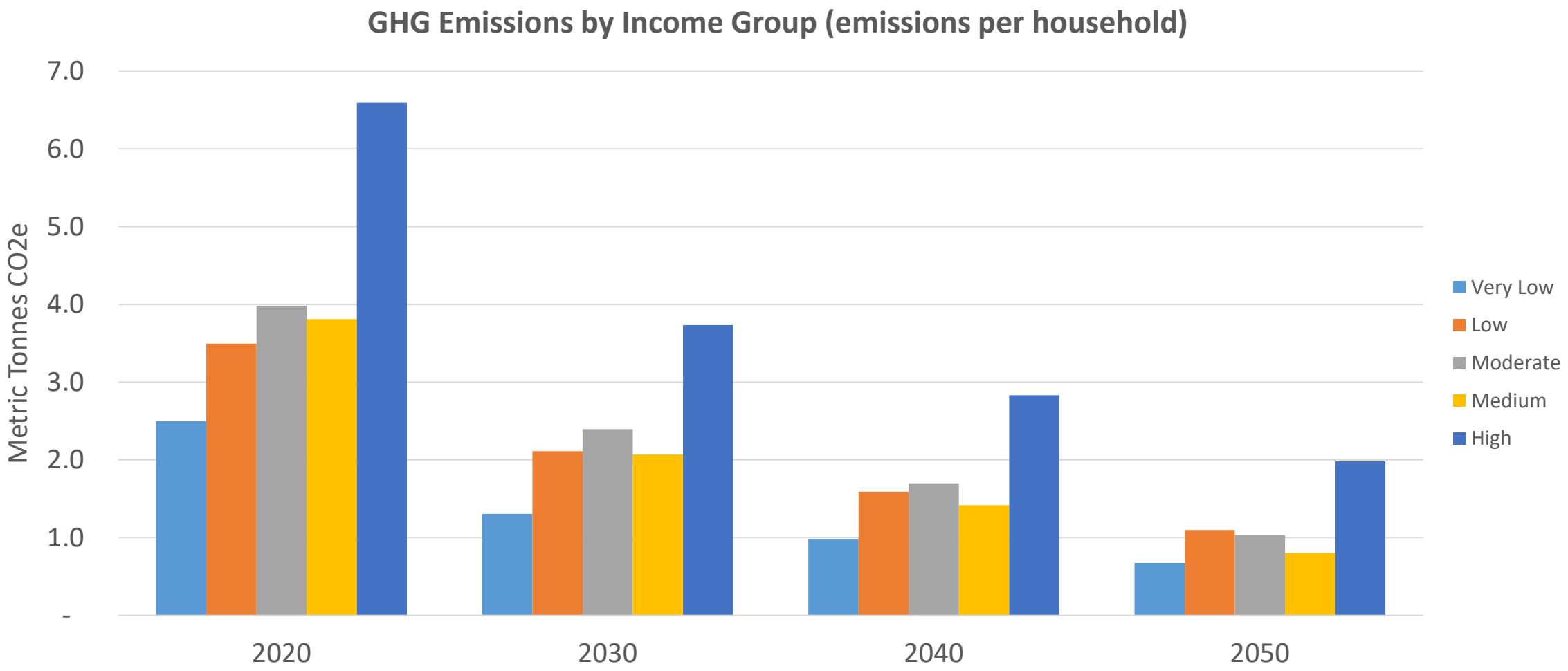


Residential sector results





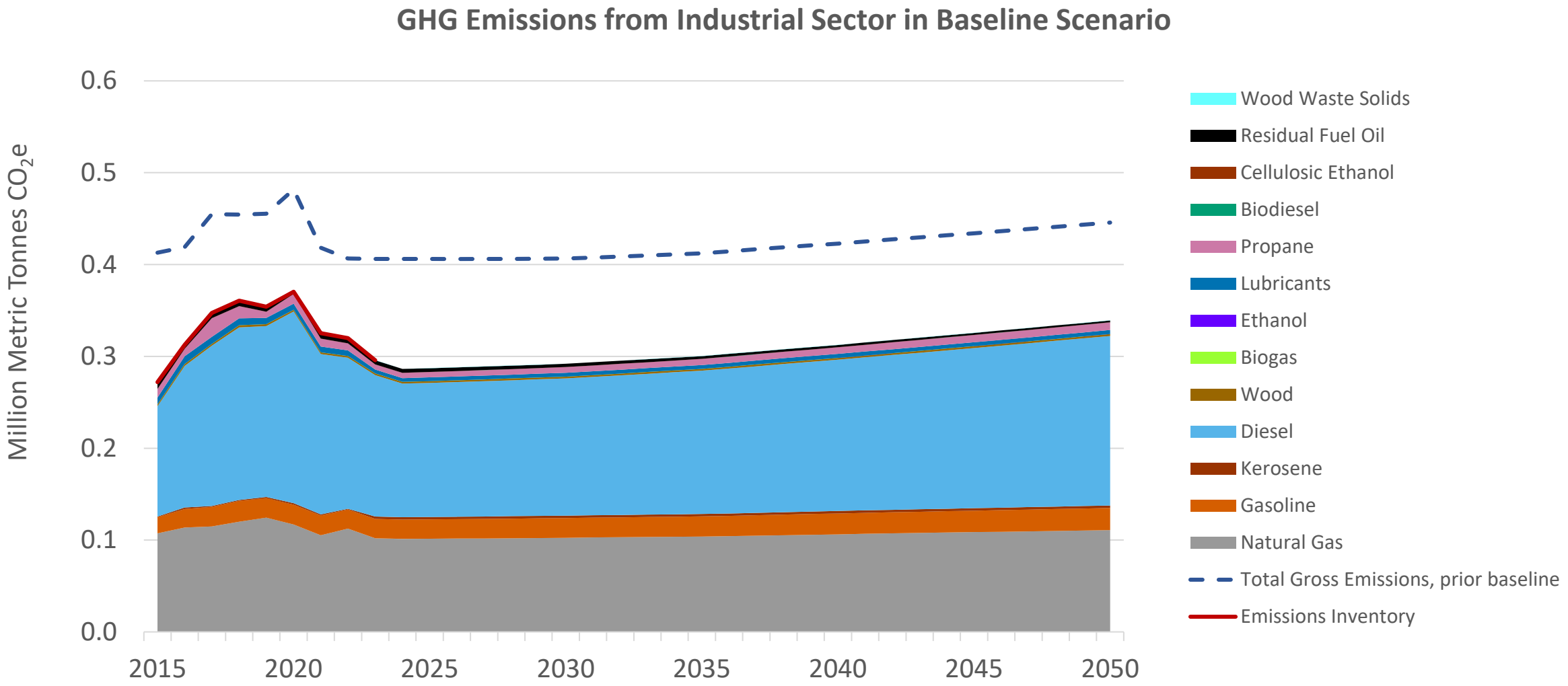
Residential sector results



Updates to industrial sector

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Historical energy consumption and projections	Updated using SEDS 2023 and AEO 2025 Reference Case	Historical consumption based on SEDS 2018. Projections based on growth rates from AEO 2020 Reference Case
Calibration	Calibrated to most recent VT GHG Emissions Inventory through 2023	

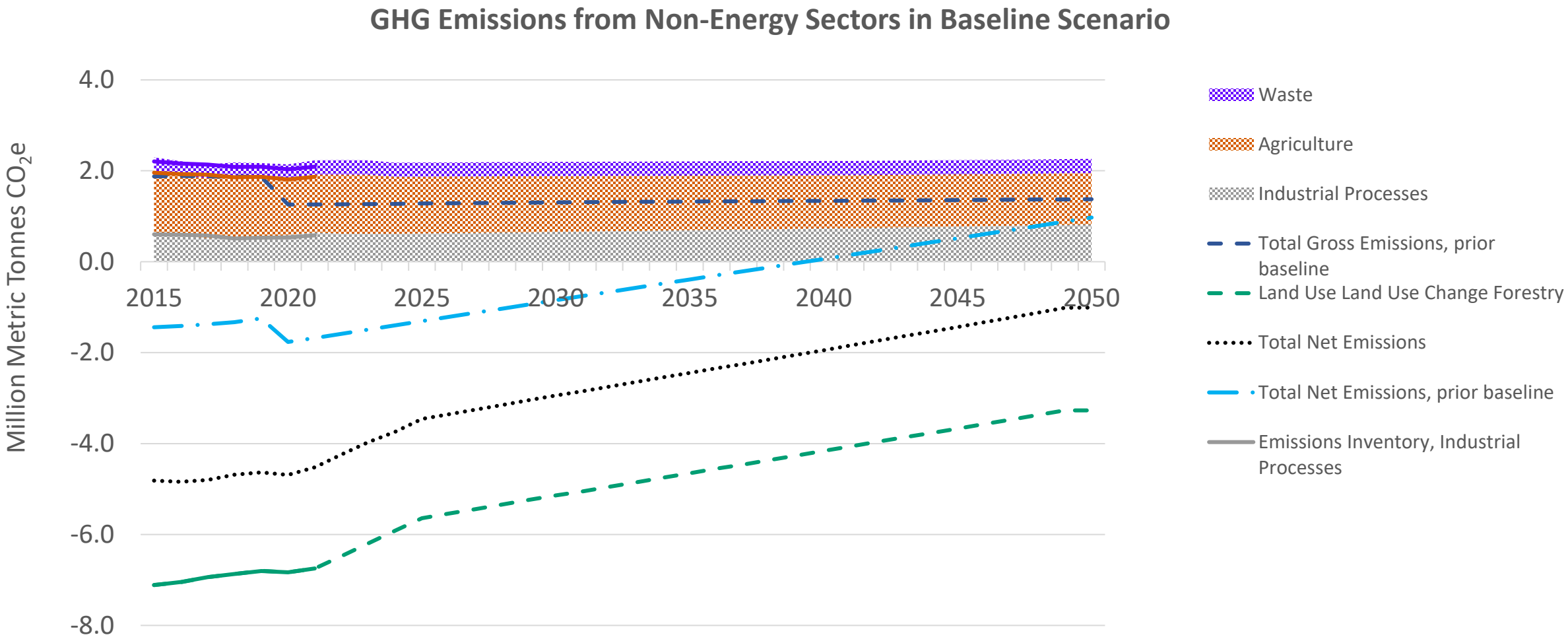
Industrial sector results



Updates to non-energy sector

	Implemented Changes to Baseline	Previous Baseline Scenario (v3.27)
Historical emissions	For LULUCF, updated based on VT GHG Emissions Inventory through 2023. For all other sectors, updated based on SIT 2025.	Based on US EPA State Inventory Tool (SIT) 2020 and 2016 GHG VT Emissions Inventory.
LULUCF Projections	Updated based on Kosiba, A. M. (2025). *Vermont Forest Carbon Inventory*. University of Vermont, Extension College of Agriculture and Life Sciences	
Calibration	Calibrated to most recent VT GHG Emissions Inventory through 2023	

Non-energy sector results



Updates to commercial sector

Note: implementation of changes to Baseline in this sector is currently underway

	Changes to Baseline	Previous Baseline Scenario (v3.27)
Total floorspace for each model building category	Update based on CBECS 2018	Based on EIA's Commercial Building Consumption Survey (CBECS) 2012
Energy consumption by fuel	Updated using SEDS 2023	Based on SEDS 2018
Model structure for heating and cooling end-uses	Subdivide energy use among existing, retrofitted and newly-constructed building shells.	Distinction between buildings that have undergone HVAC, insulation and weatherization retrofits.
End-use technology shares for each building category	Update based on CBECS 2018 and the "2021 Vermont Business Sector Market Characterization and Assessment Study"	Based on CBECS 2012 and the “2016 Vermont Business Sector Market Characterization and Assessment Study.”
Device efficiencies and energy consumption characteristics for end-uses represented in model	Update based on National Renewable Energy Laboratory’s ComStock 2024 model and CBECS 2018	Based on Navigant Consulting (2018). “Technology Forecast Updates - Residential and Commercial Building Technologies - Reference Case” and CBECS 2012
Load shapes for heat pumps and other electrified devices	Update based on NREL ComStock 2024 model	Hall, Frederick. “Load Shapes for Heat Pumps & (Managed) EV Charging,” July 21, 2021

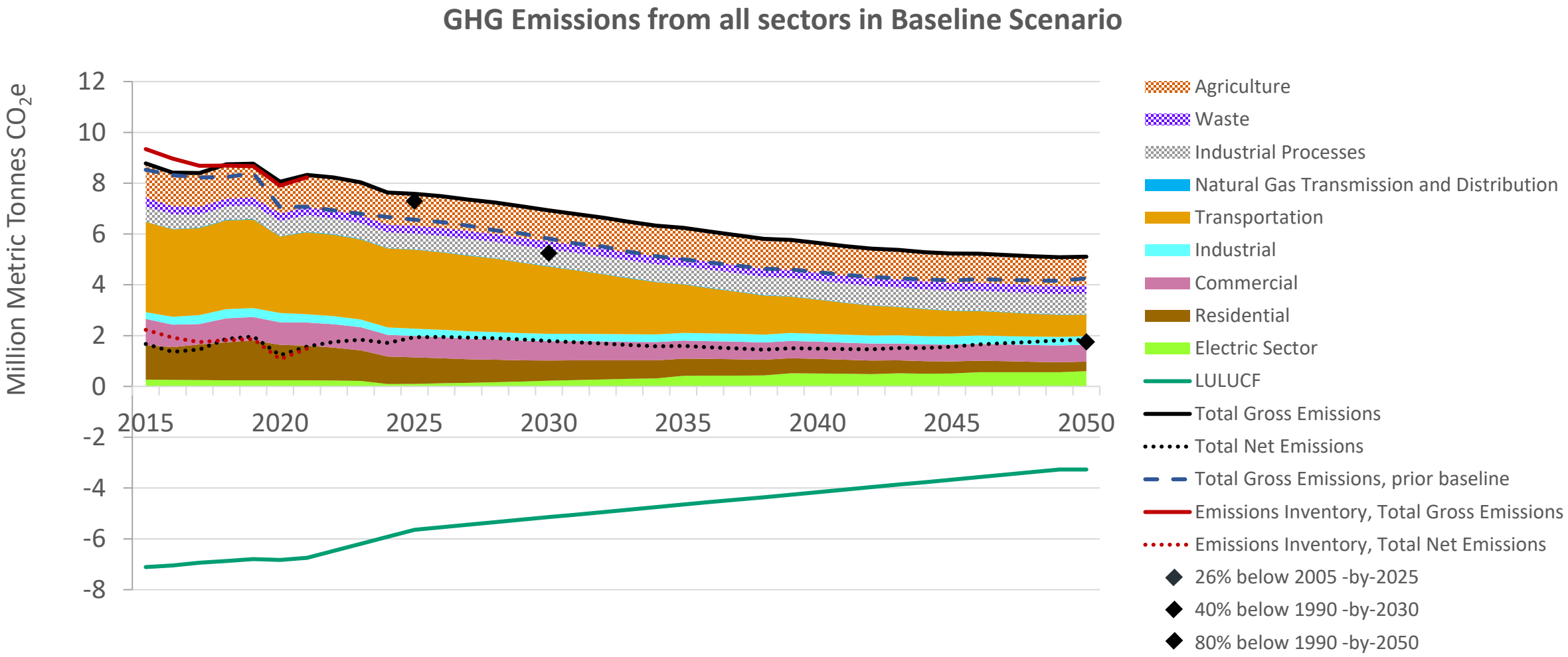
Updates to electricity consumption data

Note: implementation of changes to Baseline in this sector is currently underway

	Changes to Baseline	Previous Baseline Scenario (v3.27)
Contracted energy purchases	Update with more recent data from VT Department of Public Service	Based on information provided by VT Department of Public Service in 2021
Share of energy purchases from QC, NY, and NB qualifying as renewable under VT RES	Update with more recent data from NEPOOL	New England Power Pool and APX. "NEPOOL Generation Information System", GIS Certification Statistics for imported certifications, 01/2016 - 12/2019.
Electricity generation and storage capacity by technology within VT and across ISO-NE	Update with more recent data from IEA, ISO-NE, and VEPP	Several sources including CELT Report, EIA-860, ISO-NE FCA 15, VEPP's standard offer program
Costs for electricity generation and storage technologies (time permitting)	Update with more recent data from NREL ATB 2024	Various sources, including AEO 2015, AEO 2020, and ATB 2020
Capacity credits for electricity generation and storage technologies (time permitting)	Update with more recent data from ISO-NE	Based on ISO-NE 15th forward capacity auction in 2021

Revised Baseline Update Results

Note: these are draft results. Updates to the commercial, electricity sector, and NG T&D are still not reflected in this chart.



Coming up…

- Finalize the Baseline updates for the commercial and power sectors
- Set levers to explore sensitivity around policy rollbacks:
  - Number of weatherization and heat pump retrofit projects
  - Cost of heat pumps
  - Appliance efficiency standards
  - Implementation of Advanced Clean Cars II and Advanced Clean Trucks
  - Others?
- Mitigation modeling

Questions and discussion


Thank you!