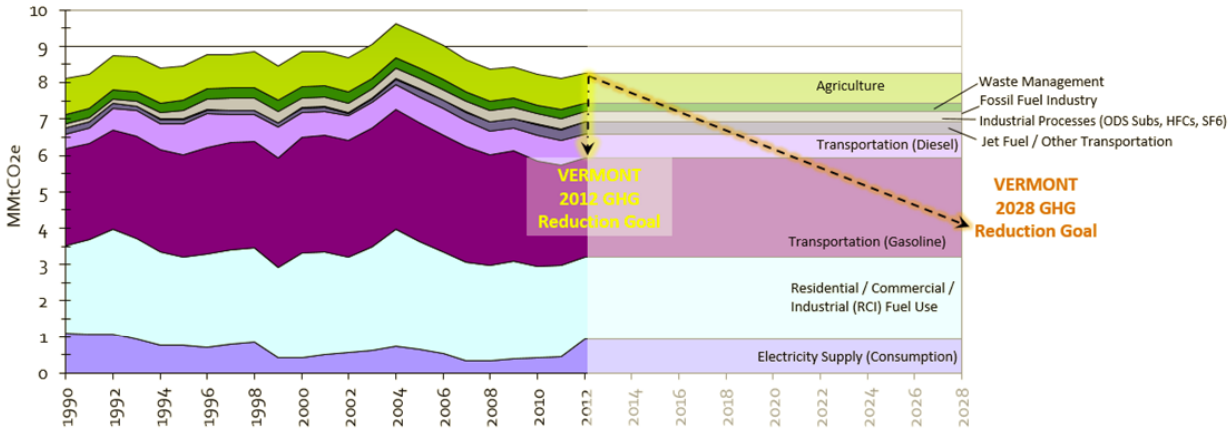
Exhibit 4-6. GHG Emissions by Source, 1990-2028 (Millions of Metric Tons)



Source: Vermont Agency of Natural Resources

4.3 Goals for 2025 and Beyond

In 2014-2015, at the request of the Legislature, the DPS conducted the Total Energy Study (TES), an extensive modeling exercise that analyzed the viability of a variety of technology and policy "pathways" that could increase the share of renewable energy consumed in Vermont's to 90% of all primary energy used by 2050. The Total Energy Study yielded many insights about the scale, immediacy, and direction of the near-term changes in energy consumption patterns that will be necessary for the success of such a long-term transition. That analysis has informed this CEP's adoption of a set of interim goals set for 2025 to serve as guideposts along the way to 2050.

Specifically, these 2025 goals are:

1. **Reducing per-capita primary energy consumption by 15%.** The work done for the Total Energy Study revealed that total primary energy consumption will have to decrease by one third or more by 2050 in order to bring the 90% renewable goal into reach. Amplifying the recent trend toward lower per-capita site energy consumption will be critical to the achievement of Vermont's renewable energy goals. Importantly, a reduction in consumption on this scale does not imply a regime of energy austerity or any restriction on growth in manufacturing output. It is possible to provide an increased level of energy service, compared with Vermont today, with significantly less waste.

2. **Increasing renewable energy consumption to 25% of total primary energy consumption**, as established by 10 V.S.A. § 580(a)**.** The modeling scenarios composed for the Total Energy Study showed that Vermont will need to look increasingly to electricity and biofuels (both liquid and solid) to meet its 90% by 2050 goal. DPS has concluded that achieving an interim 25% by 2025

goal could require cumulative increases in electricity end use of 10% to 15%, and cumulative increases in biofuel end use by as much as 20%, over the next 10 years.

There are a variety of ways in which changes in future sector-specific energy consumption patterns could combine to meet these 2025 benchmarks. DPS has developed an illustrative scenario, detailed further in Section 4.4, in which renewable energy consumption in building and transportation sectors follow unique trajectories. In this scenario, achieving an overall goal of 25% renewables by 2025 depends on:

1. **Increasing the share of renewable energy used in buildings to 30% of all primary building energy consumption, up from around 20% today.**

   Energy use in non-industrial buildings (both residences and commercial business places) currently makes up over 45% of total end-use consumption, a share that has been generally stable over the last 40 years. Heat energy (space and water heating combined) currently represents around 70% of overall building site energy requirements. About three quarters of this demand for heat energy is met with fossil fuels, primarily distillates — but increasingly over the past two decades also with propane and natural gas, which currently supply 25% and 15% of all non-industrial building heat respectively. Wood heat supplies around a quarter of non-industrial building site heat energy, mainly to households, up from only 10% in the 1990s. Electricity currently supplies very little of building site heat energy.

   Increasing adoption of heat pumps and wood heating technology has the potential to displace a significant amount of the fossil fuels that Vermonters rely on for space and water heating.[22]

2. **Increasing the share of renewable energy used for transportation to 10% of all transportation primary energy consumption, up from around 6% today**.

   Currently, transportation uses of energy make up almost 45% of total energy end uses — a share that has risen steadily since the 1970s, when it stood at roughly 30%. Gasoline provides the overwhelming majority of end-use transportation energy — and has for the last 40 years, though the share provided by diesel has gradually increased, from around 10% four decades ago to more than 20% in 2013. Since the mid-2000s, ethanol blends have reduced the amount of fossil fuel motor gasoline consumption by 5% to 7% annually.

[22] In the scenario presented in section 4.4, renewable energy use for industrial purposes follows a similar trajectory as the non-industrial buildings sector, reaching 30 % renewable by 2025. This is achieved mostly as a consequence of normal growth in non-heating electric consumption, which is supplied by increasingly renewable source energy. This path is distinct from the commercial and residential sectors, which meet their 30% benchmark targets in part by growing their electric heat loads. In addition, there is a moderate amount of displacement of industrial fossil fuels with biofuels. But because of the highly variable nature of industrial energy use and the large amount of uncertainty regarding the substitutability of various process fuels, hitting the overall interim goals in DPS's illustrative scenario does not depend critically on changes in industrial energy end-use patterns.

Higher concentrations of liquid biofuels in diesel stocks have the potential to displace a significant amount of the petroleum that Vermonters rely on for heavier duty transportation. Increasing adoption of electric vehicles has the potential to displace a significant amount of the gasoline Vermonters rely on to fuel their light-duty transportation.

In achieving these 2025 benchmarks, the electricity consumption of each end-use sector is sourced increasingly from renewable generation. Under the Renewable Energy Standard (RES) enacted by Act 56, electric utilities are required by 2017 to supply 55% of their retail electricity sales from renewable resources. By 2032, Act 56 requires that 75% of retail electricity sales be supplied by renewable resources. These requirements imply an average annual increase in the share of renewable electricity of more than 1% per year for the 15 years following 2017.

By the year 2025, Vermont's electric power supply is expected to be around 67% renewable. And as the renewable share of Vermont's electric power supply grows to meet the requirements of Act 56, the contribution of electricity consumption to the achievement of each sector's 2025 benchmark goals also grows.

Section 4.4.2 of this chapter looks more closely at the individual sector pathways described above, and the role that electrification plays in making them more achievable.

4.3.1 Revisiting GHG Targets

Vermont has long been among the U.S. states and subnational jurisdictions setting the most aggressive goals for reducing the emissions of carbon dioxide and other pollutants that disrupt earth's climate.

In 2001, before Vermont or any of the other New England states had developed a climate plan, the New England Governors and Eastern Canadian premiers jointly embraced a regional goal to reduce the total emissions from the participating states and provinces to 1990 emissions levels by 2010; 10% below 1990 levels by 2020; and 75% to 85% below 2001 levels by 2050.

In 2006, Vermont's Legislature set a long-term goal of reducing the state's own GHG emissions by 75% below 1990 levels by 2050. Interim targets were also set for the years 2012 and 2028. In 1990, Vermont emitted just over eight million metric tons of GHGs.

Since then, better information both about the current status of emissions and the potential effectiveness of different energy solutions has created a better understanding of the levels of emission reductions we could achieve in the near and long terms. The Total Energy Study has shown that the state's 2028 goal will be extremely difficult to reach — but the 2050 goal is achievable if Vermont keeps pursuing policies and investments that support a rapid transition to clean, efficient, renewable energy.

Vermont's leaders are continuing to embrace bold, long-term goals for reducing GHG emissions, motivated by the seriousness of the climate crisis and the economic benefits that will come to those

communities, states, and regions that make earlier transitions to low-carbon economies. These goals are well-aligned with the energy goals established in both the 2011 and this 2015 CEP.

In spring 2015, Vermont joined the first group of signatories, along with jurisdictions from seven countries and three continents, to sign California's bold "Under Two Memorandum of Understanding." The parties to the MOU jointly agreed to pursuing emission reductions consistent with a trajectory of 80% to 95% below 1990 levels by 2050, and/or achieving a per-capita annual emission goal of less than two metric tons by the same year. By signing the MOU, Vermont strengthened its 2050 goal beyond its initial statutory goals established nearly a decade ago.

In summer 2015, the Northeastern Governors and Eastern Canadian Premiers (NEGECP) passed a new climate resolution, in which they jointly reaffirmed the original 2050 goal, set back in 2001, and committed to making bigger reductions sooner. The resolution established a regional 2030 "progress marker range" of 35% to 45% below 1990 levels by 2030. This interim goal is closely aligned with the trajectory necessary for meeting the longer-term goals in the California MOU. In short, the multiple goals and agreements all line up on a very similar pathway to a sustainable, low-carbon future.

Informed by this progress on GHG reduction goals, this CEP establishes two goals for reduction in GHG emissions from Vermont's energy use, which are consistent with the renewable energy and energy use goals also established here:

- 40% reduction below 1990 levels by 2030;
- 80% to 95% reduction below 1990 levels by 2050.

GHG Accounting and Sustainability

Vermont's comprehensive energy planning efforts will also help the state gain a more complete understanding of the true carbon footprint of its energy choices. To accomplish this, the state intends to explore tools that will facilitate a more comprehensive accounting of life-cycle energy/carbon intensity, along with the energy and emissions associated with the direct use of a particular fuel or technology. The ideal methodology would enable concurrent comparison of all attributes of our energy choices — including GHG emissions, other pollutant emissions, land use changes, economic effects, etc. — and would be universally accepted and applied.

Current analysis methods (including those developed by the EPA, the State of California, and the European Union) focus on accounting for direct and indirect GHG emissions from particular fuel/feedstock pathways. These methodologies are not consistent with each other, particularly in the way they account for indirect emissions. There is also ongoing academic research in this field. Particularly promising are the efforts of the National Renewable Energy Laboratory, which is currently attempting to harmonize the wide variety methodologies used to produce life-cycle assessments of different electricity generation technologies. The state will continue to monitor developments in this area, both independently and in conjunction with other states in the region, with the goal of adopting a