1990–2021
with preliminary look at 2022

Connecticut Greenhouse Gas Emissions Inventory

Connecticut Department of
Energy & Environmental Protection

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Introduction

For over two decades, Connecticut has been a U.S. leader in addressing climate change. A key part of that effort is reducing greenhouse gas (GHG) emissions and tracking those reductions.

Through the state's Greenhouse Gas Emissions Inventory, first published in 2003, the Department of Energy and Environmental Protection (DEEP) provides a report card on more than 30 years of GHG emissions in the state, from 1990 to 2021, and tracks progress toward the state's statutory GHG emission-reduction targets.[1] This report also provides a preliminary estimate of 2022 GHG emissions, based on EPA's State Inventory Tool (SIT) and preliminary data from EPA's State Energy Data System (SEDS).[2] While this inventory analyzes statewide GHG emissions, DEEP recognizes the negative impacts of climate change and other non-GHG air pollution often are concentrated in Connecticut's most overburdened communities. When implementing policies and programs to reduce GHG emissions, the state must accordingly place environmental and climate justice at the center of those strategies and work to prioritize solutions that reverse historic harms.

The main takeaways from the report are that, as of 2021: emissions increased from 2020 and based on preliminary data, they increased again in 2022; transportation remains the top emitter in the state and has not decreased significantly from 1990 levels; residential use of fossil fuels for heating continues to be the second-largest emitter in the state; and electric-sector emissions continue to decrease. While Connecticut has met its initial goal for 2020 emissions set by Connecticut statutes, further sharp reductions are needed to meet statutory medium- and long-term goals. For the first time, this inventory estimates carbon sequestration from the natural and working lands sector. The report concludes by assessing progress towards emissions reductions in each of the sectors, including a review of policies and programs underway to further mitigate GHG emissions and impacts.

[1] An Act Concerning Connecticut Global Warming Solutions.

[2] Connecticut's greenhouse gas inventory relies heavily on data sets compiled by the U.S. EPA and released annually in its State Inventory Tool (SIT). The latest SIT was released in 2023 and contains data necessary to produce this inventory through 2021. While the information available for 2022 is preliminary, DEEP will update these results in its next greenhouse gas inventory, as needed, when EPA releases final data, which is expected to occur later in 2024. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis.

The state first set targets in its 2008 Global Warming Solutions Act (GWSA), Connecticut Public Act 08-98, which established a mandate to reduce statewide GHG emissions 10 percent below 1990 levels by 2020 and 80 percent below 2001 levels by 2050.2 In 2018, to guide progress toward the 2050 target, the GWSA was amended by Public Act No. 18-82 to add a medium-term target of 45 percent emissions reductions below the 2001 level by 2030. In 2022, the Connecticut Legislature codified Governor Lamont's Executive Order 3 with the passage of Public Act No. 22-5, requiring Connecticut's electric grid to be carbon free by 2040.

In 2020, Connecticut met an emission-reduction goal set by the GWSA: reducing statewide GHG emissions by 10 percent from 1990 levels. Reaching the next goal — 45 percent reduction in GHG emissions from 2001 levels by 2030 — requires an average reduction of 1.1 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) each year between 2022 and 2030. Connecticut has not yet achieved this rate. Since 2004, when the state's GHG emissions peaked, the average rate of reduction of emissions has been 1.0 $MMTCO_2e$ per year; however, the rate of reductions has decreased somewhat in recent years. Since 2014, emission reductions have averaged 0.9 $MMTCO_2e$ per year, meaning the annual rate of emissions reduction will need to increase 22 percent for the state to meet the 2030 goal. If the rate of annual emissions reduction remains at 0.9 $MMTCO_2e$ per year, Connecticut will not reduce emissions 45 percent until 2032. The state will need to substantially increase the pace of reductions to reach the next GWSA goals: reducing emissions 45 percent from 2001 levels by 2030 and 80 percent from 2001 levels by 2050.

Inventory Highlights

Connecticut met its statutory GWSA target of 10 percent emissions reductions between 1990 and Jan. 1, 2020. Through 2019, Connecticut had economy-wide emissions of 38.6 $MMTCO_2e$ — a decrease of 13.9 percent since 1990.

Emissions in 2021 increased 6 percent from 2020.

This inventory addresses carbon sequestration from the state's natural and working lands. It indicates Connecticut's forests and urban trees serve as a nature-based solution removing an estimated 6.3 $MMTCO_2e$ (net) from the atmosphere in 2021.

In 2021, Connecticut's GHG emissions were 34.7 million metric tons (MMT) of carbon dioxide equivalent (CO_2e). DEEP estimates that emissions increased to 35.0 $MMTCO_2e$ in 2022, which is 28 percent below 2001 levels, driven largely by reductions in the electric power sector since 2010.[3]

In the 2021 inventory, DEEP noted that declines in GHG emissions in 2020 and 2021 were likely driven by the economic downturn associated with the COVID-19 pandemic and that emissions were likely to rebound as the economy recovered.[4] Hence, the 6 percent increase in emissions since 2020 is an expected outcome and underscores the need to intensify efforts to reduce emissions.

[3] DEEP's accounting for electricity is based on consumption within the state, not generation. DEEP moved to a consumption-based model for electricity in 2013. Connecticut is home to many fossil-fueled power plants and is a net exporter of electricity to the New England power grid. Accounting for electricity generated in Connecticut but exported for consumption in other states (generation-based model), 42.7 $MMTCO_2e$ of emissions were generated in Connecticut, a 7 percent increase from 2020.

[4] DEEP_GHG_Report_90-21_Final.pdf (ct.gov) (Apr. 2023).

1990-2021 Emissions

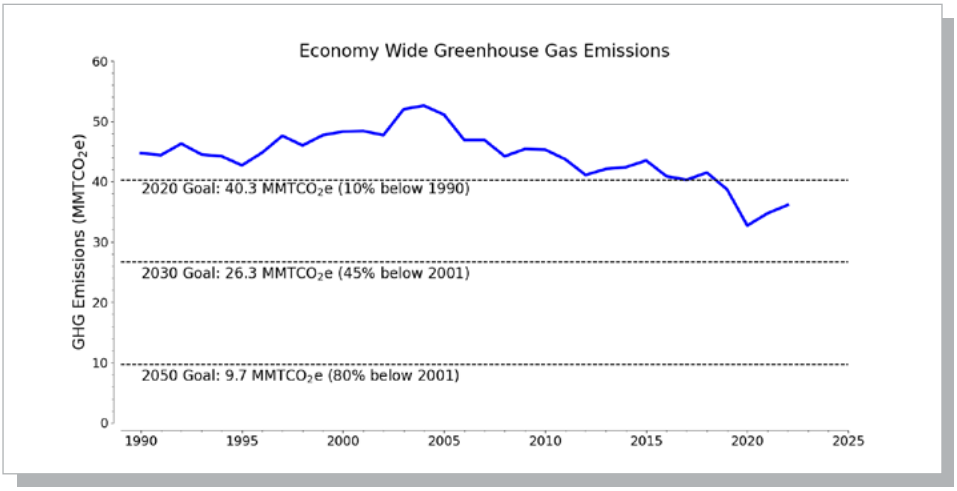

FIGURE 1: Total economy-wide GHG emissions from Connecticut through 2022. Economy-wide results are depicted based on consumption-based accounting for the electric power sector adopted in the previous inventory. Also shown are the state's statutory emissions-reduction goals for 2020, 2030, and 2050.

Figure 2 shows that most of the progress in reducing GHG emissions since 1990 has occurred in the electricity sector, which accounted for 27 percent of emissions in 1990 but only 9 percent in 2021. The largest share of the state's GHG emissions in 2021 were from the transportation sector, at 43 percent of economy-wide emissions, followed by emissions from residential and commercial buildings (use of fossil fuels for heating) at a combined 33 percent in 2021. Transportation emissions began to return to their pre-pandemic level and remain at roughly their 1990 level; they are twice as high as residential emissions and are expected to remain at elevated levels in the near future. Figure 2 shows individual sector contributions to total GHG emissions from 1990 to 2022, while Figure 3 displays the percentage contribution of each sector to total GHG emissions for select years. Table 1 displays emissions totals for each individual sector for select years.

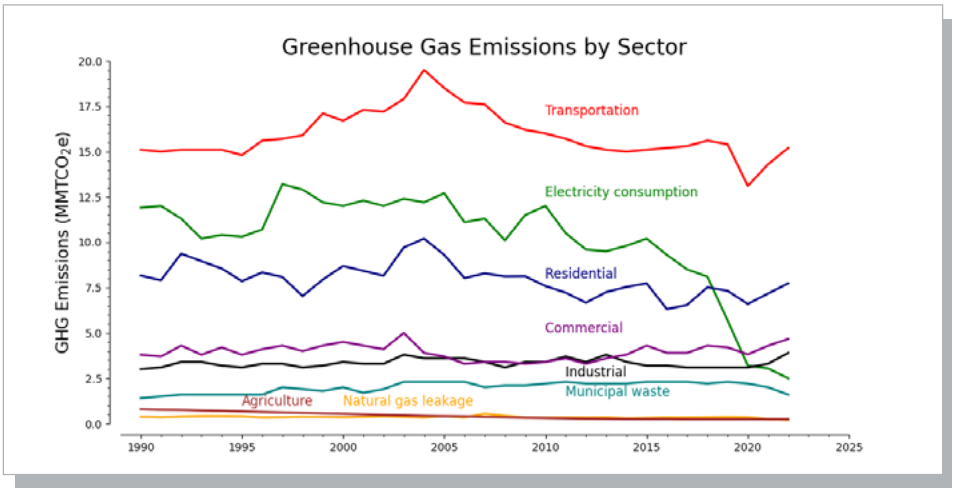

FIGURE 2: Sector specific GHG emissions 1990-2022

Preliminary 2022 Results

This inventory relies on the SEDS databases maintained by the Energy Information Administration (EIA) for inputs into the SIT developed by the EPA. This tool is a publicly available interactive model consisting of multiple modules to update existing inventories and to complete an inventory for a new year. Data available in SEDS are updated throughout the year as they are gathered by various federal agencies, typically with a one-to two-year lag time between the year of emissions and the release of the data. With this update, for example, information about jet fuel consumption in the transportation sector for 2022 was available in October 2023, while data for the consumption of diesel fuel in the same sector was not available until March 2024. SEDS data are considered preliminary as they are first released and may be revised by EIA. For this reason, this report will focus on the 2021 final data. Complete data for the 2022 cycle are anticipated to be available by late June 2024.

Due to the preliminary nature of data available for 2022, all results related to 2022 may be revised once the EIA releases finalized updates. Figure 1 displays Connecticut's GHG emissions from 1990-2022. and a summary of 2022 GHG emissions follows.

The top three emitting sectors in 2022 comprise over three-quarters of the state's total emissions: transportation (42 percent), residential heating with fossil fuels (21 percent), and commercial building heating with fossil fuels (13 percent). The remaining 24 percent of emissions in 2022 are, coincidentally, the total amount that emissions must be reduced to meet the 2030 statutory target: 8.4 $MMTCO_2e$.

Updates on individual sectors in 2022:

- **Transportation:** 14.9 $MMTCO_2e$. This is a 4 percent increase over 2021 and only 1 percent lower than 1990 emissions from this sector.
- **Residential:** 7.3 $MMTCO_2e$. Only a 1 percent increase over 2021 and a 10 percent decrease from 1990.
- **Commercial:** Emissions were 4.4 $MMTCO_2e$, a 5 percent increase over the previous year – expected as commercial buildings were reopening as the pandemic receded – and a 16 percent increase from 1990.
- **Industrial:** 3.9 $MMTCO_2e$, an 18 percent increase over 2021 and a 30 percent increase from 1990.
- **Electric Power:** Emissions in 2022 were 2.5 $MMTCO_2e$ and 16 percent below 2021 as electricity demand slightly decreased and more renewables came online. Electricity consumption emissions were down 80 percent from 1990.
- **Waste:** 1.6 $MMTCO_2e$, a decrease of 29 percent from the previous year and 14 percent higher than 1990. The decrease is a result of reduced operation of waste-to-energy facilities in the state and municipal solid waste being landfilled out of state (which is not counted in Connecticut's GHG inventory.) Had the estimated 860,000 tons of waste that was exported for landfilling been landfilled in Connecticut, 100,000-150,000 $MTCO_2e$ of emissions would have been added to the inventory, about 9 percent of the total emissions from waste disposal.
- **Agriculture:** 0.2 MMT CO_2e. Negligible change from 2021 and 50 percent lower than 1990.
- **Natural Gas:** 0.2 $MMTCO_2e$. Negligible change from 2021 and 75 percent lower than 1990, primarily due to replacement of leak-prone metal pipe in the gas distribution system.

TABLE 1: GHG Emissions in $MMTCO_2e$ by sector for select years.

All Values in $MMTCO_2e$	**1990** *(baseline)*	**2001** *(baseline)*	**2010**	**2021**	**2022** *(preliminary)*
Agriculture	0.4	0.4	0.3	0.3	0.2
Natural Gas Leakage	0.8	0.5	0.3	0.2	0.2
Commercial	3.8	4.3	3.4	4.3	4.4
Electric Power (Consumption)	11.9	12.3	12.0	3.0	2.5
Industrial	3.0	3.3	3.4	3.3	3.9
Residential	8.3	8.5	7.7	7.2	7.3
Transportation	15.1	17.3	16.0	14.3	14.9
Waste	1.4	1.7	2.2	2.0	1.6
Total	44.7	48.4	45.3	34.7	35.0

Transportation

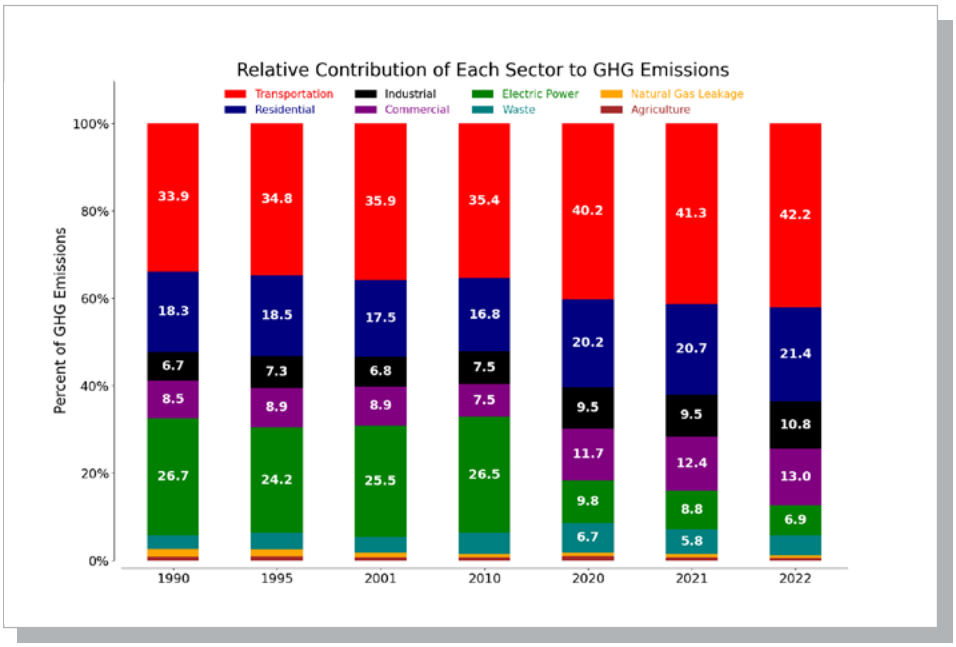

FIGURE 3: Top: Percentage of total GHG emissions from various sectors for select years. Color scheme as in Figure 2.

Connecticut's transportation sector emitted 14.3 $MMTCO_2e$ in 2021, a 10 percent increase above the low emissions of 2020 attributed to the impacts of the COVID-19 pandemic. Transportation accounted for over 40 percent of statewide emissions and had a larger carbon footprint than the next two sectors (residential and commercial, from use of fossil fuels) combined. As emissions in other sectors decrease, the overall fraction of the state's GHG emissions from transportation has risen by 8 percent from the 1990 baseline, as shown in Figure 3. In 2021,

Transportation emissions alone make up 54 percent of the GWSAs 2030 emissions target. Combustion of gasoline accounted for 11 $MMTCO_2e$, or 72 percent of the sector's emissions. Diesel fuel-powered vehicles were responsible for another 2.8 MMT of GHG emissions, 20 percent of the total. Emissions from combustion of gasoline had fallen only 4 percent since 1990 despite the average vehicle fuel economy improving nearly 30 percent over the same period.[5,6]

[5] Highlights of the Automotive Trends Report | US EPA
[6] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

Emissions reductions due to improved fuel economy have been almost entirely offset by increased emissions from driving more. Total vehicle miles traveled (VMT) on Connecticut's streets and highways has increased from 26.3 billion miles to 29.9 billion miles from 1990 to 2022 (Figure 5). This represents an increase of 3 percent in VMT during the same time period. The importance of reducing the emissions from this sector cannot be overstated.

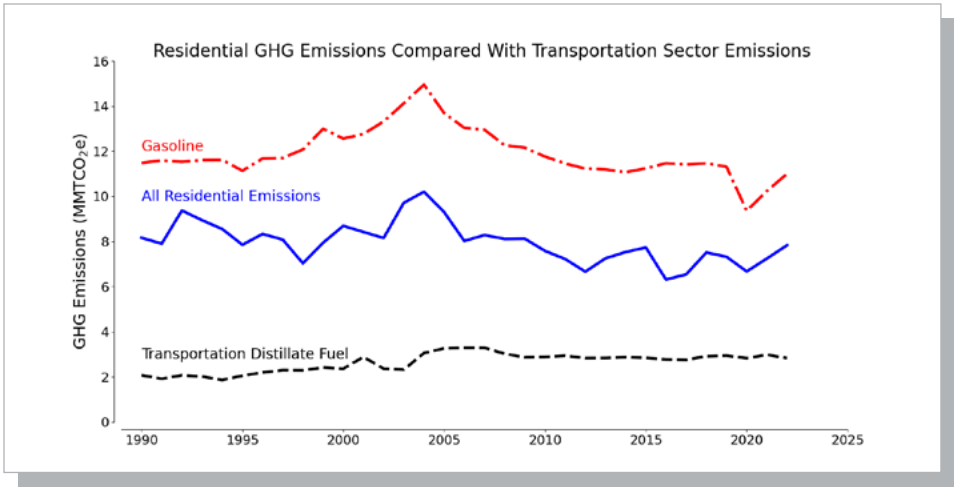

FIGURE 4: Emissions due to gasoline consumption alone exceed those of the residential sector.

As it currently stands, gasoline emissions alone exceed emissions from use of fossil fuels in the residential sector (Figure 6).

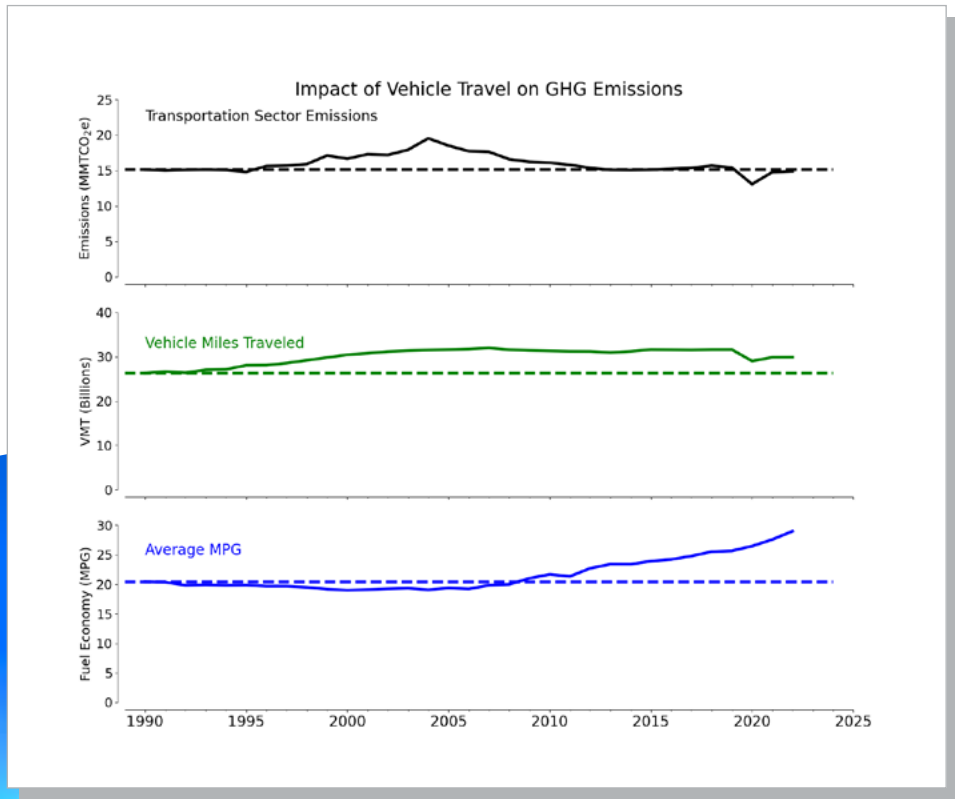

FIGURE 5: Top: total transportation sector GHG emissions, 1990–2022. Middle: annual vehicle miles traveled (VMT), 1990–2022. Bottom: Average fuel economy for vehicles sold in the US 1990-2022. The dashed line represents 1990 values in all three panels. Improvements in average fuel economy have been offset by increase in VMT. Source: CT DOT, USDOT

Residential

Residential-sector emissions comprised just over 20 percent of economy-wide emissions in 2021. These emissions were mostly due to space heating and water heating with fossil fuels, with fossil fuels used in home cooking and laundry accounting for the remainder. About 37 percent of Connecticut households utilized natural gas for these purposes in 2022, while around 36 percent of households relied on delivered heating oil and 6 percent on propane.[7]

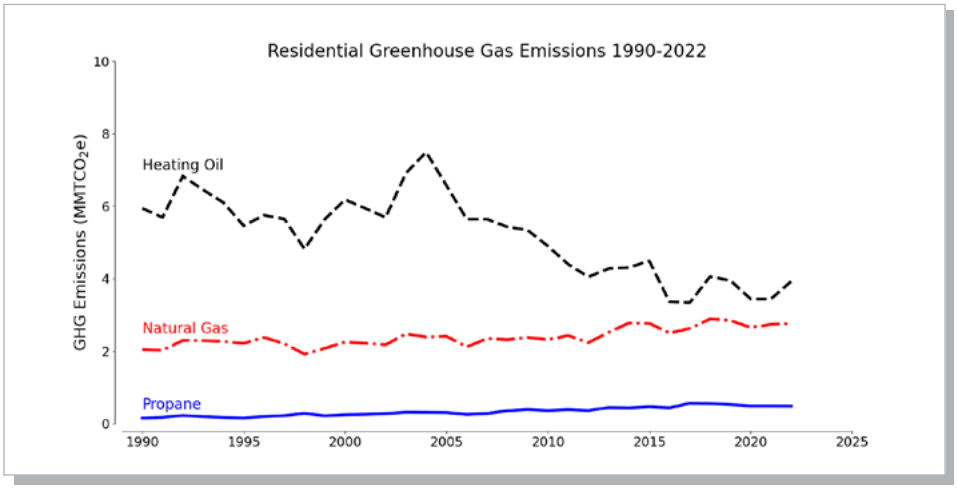

FIGURE 6: Residential GHG emissions from delivered fuels (Heating oil: Black, and Propane: Blue) compared with natural gas service (Red). Heating oil is responsible for over 60 percent of residential emissions in 2023, despite serving less than half of CT households.

As with transportation, decarbonizing the residential sector is essential to Connecticut meeting its 2030 and 2050 climate goals. Figure 6 compares the GHG contributions of various fossil fuels combusted in Connecticut homes.

Commercial

Commercial sector emissions comprised just over 12 percent of economy-wide emissions in 2021, making it the third-highest source of emissions in the state behind the transportation and residential sectors. Emissions in this sector increased by less than 1 percent from 2020 to 2021. Commercial sector emissions were mostly due to continued use of oil and natural gas for heating.

[7] The other major source of home heating is electricity, which heats 17 percent of homes through electric resistance and heat pumps. Emissions from this electricity consumption are included in the Electricity sector figures.

Electric Power

For some time, Connecticut has generated more electricity than it consumes, exporting surplus power to the rest of New England and New York. Emissions associated with the generation of exported power continue to rise as more and more of the region's electricity is generated in Connecticut power plants that employ natural gas. In 2021, emissions due to electricity consumption in Connecticut totaled around 3.0 $MMTCO_2e$, while emissions from electricity generated here were 11.0 $MMTCO_2e$. Under global standards for GHG inventories, electricity emissions are accounted on the basis of a jurisdiction's consumption from its regional electricity grid.

In 2021, non-biogenic (i.e., fossil fuel) emissions from electricity consumption were down 75 percent from 1990. Much of this decline is due to the state's power purchase agreement with the Millstone nuclear power plant. This facility generated over 17 million MWh of zero carbon electricity in 2021, approximately 58 percent of the state's energy demands.[8] If Millstone had been retired, as had been discussed prior to the state contract, the region would have required an additional 17 million MWh to be generated by other facilities, likely using fossil fuels. Natural gas produces about 0.97 pounds of GHG emissions per kWh of electricity produced.[9] In the absence of Millstone, natural gas power plants would have generated an additional 7.5 $MMTCO_2e$ of emissions in New England. Connecticut's share of those increased emissions would increase total Connecticut GHG emissions by about 20 percent. Connecticut's electricity consumption GHG emissions are calculated as follows.

First non-biogenic emissions from Connecticut's electric load that is served by Class I, Class II, or Class III renewable energy credits (RECS) that are used to satisfy the state's Renewable Portfolio Standards (RPS) requirements are determined by multiplying the fuel source by an appropriate emission factor. Each REC represents 1 megawatt-hour of energy and is subtracted from the Connecticut load that must be satisfied from the rest of the grid. The calculation is likewise performed for every state in the region from data sourced from ISO-NE and the EIA. Likewise, certificates that are generated by Millstone belong to Connecticut and are used to further satisfy the state's load. Finally, any remaining load that is not accounted for by the certificates is determined, and the emissions are tallied by applying an emission factor for the remaining ISO-NE system mix. Biogenic emissions (emissions generated by burning wood products and other biomass), which by international standard are assumed to be net-zero for GHG inventory practices, were 3.7 $MMTCO_2e$; and had they been included in the electric sector calculation as was the case in the Connecticut inventory until 2018, total electric-sector emissions would have been 6.2 $MMTCO_2e$, approximately 52 percent of 1990 electric sector emissions.

[8] Electricity data browser - Millstone (eia.gov)
[9] Frequently Asked Questions (FAQs) - U.S. Energy Information Administration (EIA)

Industrial Processes

The industrial sector continues to present a unique and growing challenge for decarbonization. About 1.8 MMT of the total 3.9 $MMTCO_2e$ were from the combustion of fossil fuels. But the rest of the sector's emissions stemmed from industrial processes such as dolomite use as well as emissions of non-CO2 greenhouse gases such as substitutes for ozone-depleting substances (e.g., HFCs and other refrigerants). HFC, PFC, NF_3, and SF_6 emissions cumulatively made up 1.9 $MMTCO_2e$ of emissions in 2021. These emissions have risen by roughly a factor of 8 since the baseline year 1990. Sulfur Hexafluoride (SF_6), a potent greenhouse gas that is used in circuit breakers, insulated electric substations, and other switchgear, is the main source of these emissions and comprises roughly 95 percent of these emissions in Connecticut.

Wastewater and Solid Waste

GHG emissions associated with treatment of wastewater and solid waste accounted for 6 percent of statewide emissions in 2021 and had increased 15 percent since 1990. Methane emissions related to decomposition of previously landfilled material had been a significant source of emissions in the past but has been declining since 2003. Connecticut has not had significant active landfilling within the state for nearly a decade, and methane outgassing from previously landfilled material will represent a diminishing proportion of emissions.

Carbon dioxide emitted to the atmosphere during combustion of plastics and synthetic fibers results in the bulk of GHG emissions in this sector. However, in July 2022, the Materials Innovation and Recycling Authority waste-to-energy facility closed,[10] and since the facility's closure, waste that previously would have been incinerated instead has been exported for landfilling in other states, mainly New York, Pennsylvania, and Ohio. Emissions from waste combustion fell 20 percent; and since the inventory methodology excludes waste-related emissions occurring in other states, there was no corresponding increase in landfill emissions. Waste exported from Connecticut will outgas methane if landfilled or will emit carbon dioxide if combusted. Under the conventions of GHG accounting, these emissions would be accounted in the inventory of the jurisdictions where these activities occur.

DEEP estimates that in excess of 860,000 tons per year, or 40 percent of MSW generated in the state requiring disposal, are being exported to other states, traveling an average of 407 miles, primarily to landfills in Pennsylvania, New York, and Ohio.[11] DEEP estimates that the increase in Connecticut waste exports will contribute an additional 100,000-150,000 $MTCO_2e$ to emissions in those states (equivalent to 10 percent of Connecticut's waste disposal emissions).

[10] MIRA, CT's trash 'innovation' agency, failed to solve a garbage crisis (ctinsider.com)
[11] SB-11--Fact-Sheet--AAC-Waste-Management.pdf

Agriculture

The three main sources of GHG emissions in Connecticut's agricultural sector are:

1. *methane released from enteric fermentation of organic material in the digestive tracts of farm animals;*
2. *methane emitted from manure management; and*
3. *emissions associated with soil runoff.*

While other jurisdictions also have significant emissions associated with agricultural residue burning, rice cultivation, and soil amending, such emissions are minor in Connecticut. In Connecticut, enteric fermentation remains the largest source of emissions in this sector; however, these emissions have declined roughly 50 percent as the number of cattle raised in state has declined. Soil runoff and manure management have been responsible for roughly equal emissions; however, in recent years soil runoff has declined significantly.

Natural Gas Distribution

DEEP's calculation of emissions from the natural gas-distribution system uses emission factors developed during the Washington State University Natural Gas Methane Study.[12] Distribution pipelines are assumed to leak at a constant rate, with methane escaping more rapidly from older cast iron gas pipe than from newer plastic pipe. The EPA estimates that nationwide 181 $MMTCO_2e$ of methane was emitted from natural gas systems in 2021, with 52 percent of those emissions occurring during the production process.[13] Another 25 percent of the emissions occurred during transmission and storage of natural gas. These processes occur outside Connecticut and hence are not included in the state's GHG inventory; and methane leaking from the distribution system within the state remains a small fraction of the inventory. Because Connecticut's natural gas consumption is one percent of the national total, DEEP estimates that 1.8 $MMTCO_2e$ of methane — 9 times more than the 0.2 $MMTCO_2e$ accounted in the inventory – leaked into the atmosphere outside of Connecticut's borders in order to facilitate natural gas consumption in Connecticut.[14]

Natural and Working Lands

The natural and working lands (NWLs) sector includes forests and woodlands, grasslands and shrublands, croplands and rangelands, wetlands, and urban green spaces. NWLs can absorb and store carbon in plants and soils, serving as a "carbon sink," partially offsetting emissions from other sectors. Protecting NWLs is critical to limiting global warming to 1.5 degrees Celsius; the IPCC report[15] identifies no path to net-zero emissions by 2050 without carbon removal provided by natural and working lands. The forests that cover about 60 percent of Connecticut's land area can sequester 4 to 40 tons of carbon dioxide per year per hectare. Although DEEP is still in the process of developing a methodology to account for carbon

[12] Key Results | Natural Gas Methane Study | Washington State University (wsu.edu)
[13] Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2021 – Main Report (epa.gov)
[14] CT_Energy Sector Risk Profile.pdf
[15] Climate Change 2021: The Physical Science Basis | Climate Change 2021: The Physical Science Basis (ipcc.ch)

emissions and sinks from all the natural and working lands resources in future inventories, a preliminary estimate for 1990 to 2021 is available through EPA's State Inventory Tool. Using this tool, DEEP estimates that Connecticut's forests and urban trees removed a net of 6.3 $MMTCO_2e$ from the atmosphere in 2021. This level increased somewhat from a low of 5.9 $MMTCO_2e$ net removal in the mid-1990s but is largely unchanged since 1990. The agency estimates that about 4 net $MMTCO_2e$ was removed from the atmosphere by Connecticut forests and another 2 net $MMTCO_2e$ was removed by urban trees in 2021. This initial estimate of carbon sequestration from Connecticut's forests was included in the inventory per Governor Lamont's Executive Order 21-3 directive to DEEP to "evaluate the feasibility and reliability of monitoring and reporting on negative carbon emissions from Connecticut's forests as part of the greenhouse gas inventory report required by the GWSA." As a first step in this evaluation, the carbon sequestration potential is reported here but is not included in this inventory's tables or figures reporting progress towards the statutory GHG reduction targets, which do not include a net zero target.

Progress Toward Connecticut's Emissions Reduction Targets

Compared with the 1990 baseline, 2021 consumption-based emissions were down 28 percent; in order for Connecticut to achieve the 2030 goal of 45 percent reduction from 2001, an average of 1.0 $MMTCO_2e$ must be cut from the state's GHG emissions annually, or 3 percent of total 2021 emissions. This is approximately the same average reduction the state has achieved annually since emissions peaked in 2004. Since 2014, emissions have declined an average of 0.9 $MMTCO_2e$ per year. Figure 7 depicts economy-wide emissions as well as the historical trend extrapolated to 2050 in conjunction with Connecticut's climate goals. If this historical trend were to hold without intervention, the state would emit 207 $MMTCO_2e$ in excess of current goals between 2022 and 2050, equivalent to nearly 6 times the current annual emissions. In 2050, the projected emissions total of 22.7 $MMTCO_2e$ would be 2.3 times higher than the emissions goal the GWSA mandates for that year.

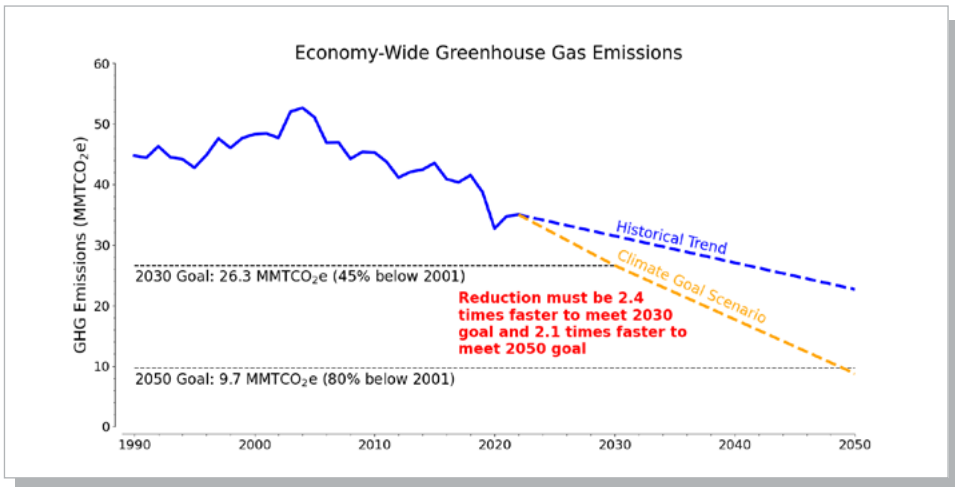

FIGURE 7: Historical economy wide GHG emissions 1990-2022 shown with a solid blue line. A trendline depicting future emissions based on the average rate of change in emissions from 2001-2022 projected out to 2050 is depicted with a blue dashed line. The average rates of emissions decline required to achieve the GWSA 2030 and 2050 targets are depicted with the orange dashes lines.

In the following sections, DEEP presents an overview of strategies and progress toward meeting GWSA mandates in individual sectors. While the GWSA does not explicitly set targets for reduction in specific sectors, it is instructive to consider how emission trends in individual sectors relate to the economy-wide targets. In the following sections, DEEP treats each sector as if the economy-wide goals – 45 percent reduction from the 2001 baseline by 2030 and 80 percent reduction from the same baseline by 2050 – applied to individual sectors.

A partial exception is made in the case of electricity, which the statute requires to be carbon-neutral by 2040. The average rate of change in emissions between 2001 and 2022 serves as the basis for projecting emissions out to 2050. These projections then are used as the basis for calculating the nominal reductions – and rate of increased reduction – needed to bring each sector's emissions trajectory in line with the economy-wide 2030 and 2050 goals established by the GWSA.

Assessing Progress in Reducing Electric Power Sector Emissions

Emissions reductions in the Electric sector since peaking two decades ago stemmed partly from investments in carbon-neutral renewables such as solar and wind and partly from shifting power plants from coal to natural gas. Since 2019 the dramatic decline in emissions is the consequence from the power purchase agreement with the Millstone Nuclear plant granting Connecticut ownership of all RECs generated by the facility that is in effect from 2019 through 2029. In 2021, roughly 7 percent of Connecticut's electricity consumption was supplied by solar photovoltaic or wind resources; in contrast, State-owned RECs from Millstone satisfy the equivalent of 58 percent of Connecticut's electricity demand for 2021 and 2022. Electricity consumption was responsible for 11.9 $MMTCO_2e$ of emissions in 1990, and emissions decreased by a cumulative 75 percent, to 3.0 $MMTCO_2e$, in 2021. Continuing that trajectory would put the state's electricity consumption on a path to meet the 2050 goal; but crucial electrification of heating and transportation will make that ideal path hard to follow. And in the meantime, the state is not on track to meet the statutory mandate of carbon-free electricity consumption by 2040.[16]

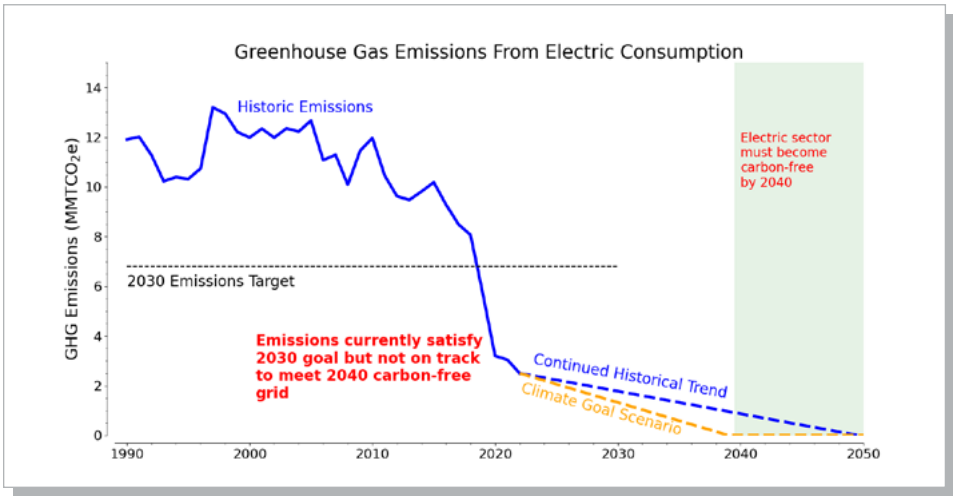

FIGURE 8: Electric consumption emissions depicted as in Figure 7. While the GWSA statutory targets appear to be met, Connecticut has a superseding statutory requirement for a carbon-free electric supply by 2040. As electrification of other uses increases, it will be important to maintain progress toward this requirement.

Assessing Progress in Reducing Transportation Sector Emissions

Transportation emissions remain the state's biggest challenge in reaching its climate goals. Figure 9 shows that the historical trend is inadequate and that transportation emissions absent intervention are on track to decline only 20 percent of current levels by 2050. Notably, the projected transportation emissions total for 2050 exceeds the economy-wide GWSA target by more than 25 percent.

[16] An Act Concerning Climate Change Mitigation

It's important to note that this inventory reflects Connecticut's participation in California's Low-Emission Vehicle (LEV) and Zero-Emission Vehicle (ZEV) regulations, as allowed under Section 177 of the Clean Air Act. However, starting in 2025, the state will no longer participate in the California program and will instead default to the EPA's pollution standards for cars. DEEP is actively assessing the impact of this policy change on the state's ability to meet the 2030 GWSA target.

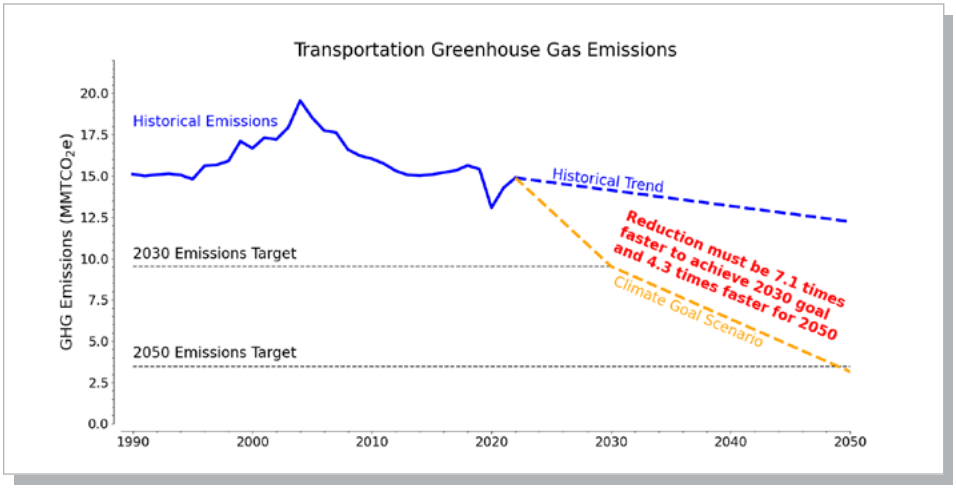

FIGURE 9: Transportation emissions depicted as in Figure 7. Reductions must increase by a 700 percent if the 2030 guideline is to be met for this sector and a 430 percent increase in the rate of emissions reduction must occur to meet the 2050 guideline.

In addition, Connecticut follows two strategies geared toward reducing transportation emissions. First, the state is working to leverage federal funding from the U.S. Department of Transportation to expand zero-emission electric vehicle (ZEEV) charging infrastructure and from the Inflation Reduction Act to provide rebates for individual EV purchases. Second, the state is boosting the Connecticut Hydrogen and Electric Automobile Purchase Rebate program by investing part of the proceeds from Regional Greenhouse Gas Initiative auctions into the program. The combined strategy will advance the necessary zero-emission infrastructure for transportation decarbonization and provide additional assistance for individuals wishing to purchase a ZEEV – which currently are still the overwhelming minority of vehicles on the road in Connecticut. In 2022 roughly 100,000 ZEEV or hybrid electric vehicles were registered, compared to over 2.6 million gasoline powered cars.[17] The average age of a vehicle in operation in the United States is now over 12 years[18]; even with increased ZEEV adoption, over 130,000 cars were sold in the state in 2022[19] and internal combustion engines will make up a large fraction of the state's transportation fleet for decades to come. In response to Governor Lamont's Executive Order 21-3,[20] the Department of Transportation (DOT) has set a target to reduce the annual VMT per person 5 percent from the pre-pandemic baseline by 2030.

Assessing Progress in Reducing Residential Sector Emissions

As shown in Figure 10, Connecticut winters are becoming milder, reducing heating burdens, which is partly responsible for declining emissions in the residential sector. However, the figure also shows that these reduced winter heating demands are being partially offset by increased summer cooling demands. Both trends are expected to persist for decades. As the summer trend continues, the number of days in which households require air conditioning will increase, making it increasingly important that the electricity required to run air conditioners is provided by a low-and ultimately zero-carbon grid.

[17] Alternative Fuels Data Center: Vehicle Registration Counts by State (energy.gov)
[18] Average Age of Automobiles and Trucks in Operation in the United States | Bureau of Transportation Statistics (bts.gov)
[19] New Car Sales by State - Full Year 2022 Vehicle Sales Report (factorywarrantylist.com)
[20] Executive-Order-No-21-3.pdf (ct.gov)

While residential emissions show a more encouraging decline than the transportation sector, the rate of decline is not in line with the GWSA's economy-wide goals. As can be seen in Figure 10, the average rate of emissions decline must be nearly 7 times faster to align with the 2030 goal and over 4 times faster to align with the 2050 goal. The historic trend in residential emissions projected out to 2050 would encompass 62 percent of the economy-wide 2050 mandate.

One promising way to reduce residential emissions is widespread adoption of electric heat pumps for residential space and cooling and water heating. Electrification incentives provided under the federal Inflation Reduction Act in many cases reduce the cost of heat pump installation by 30 percent. Additional generous incentives are provided by EnergizeCT.[21]

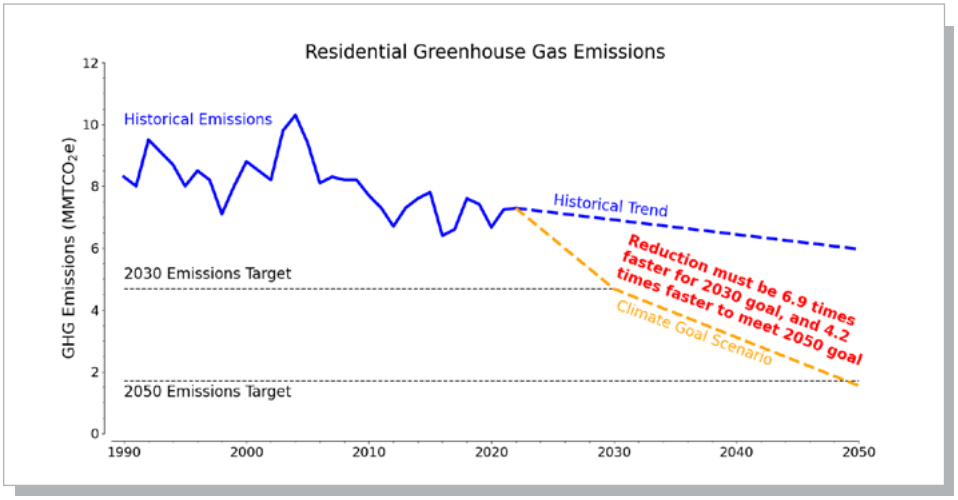

Figure 10 – Residential sector emissions. The average rate of emissions decline must increase by a factor of nearly 7 align with Connecticut's 2030 economy-wide climate target and by a factor of more than 4 to align with the 2050 target.

Assessing Progress in Reducing Commercial Buildings Sector Emissions

Figure 12 shows Connecticut's commercial emissions along with the projections required to meet the mandated climate goals. A sharp decline in commercial emissions occurred between 2005 and roughly 2015, driven by the replacement of petroleum-fueled equipment with natural gas-fired equivalents. This trend has since reversed as heating oil use stabilized in this sector while natural gas use has continued to increase. Overall commercial emissions increased slightly from 2001 to 2022 and are on track to make up 45 percent of the economy-wide emissions target for 2050.

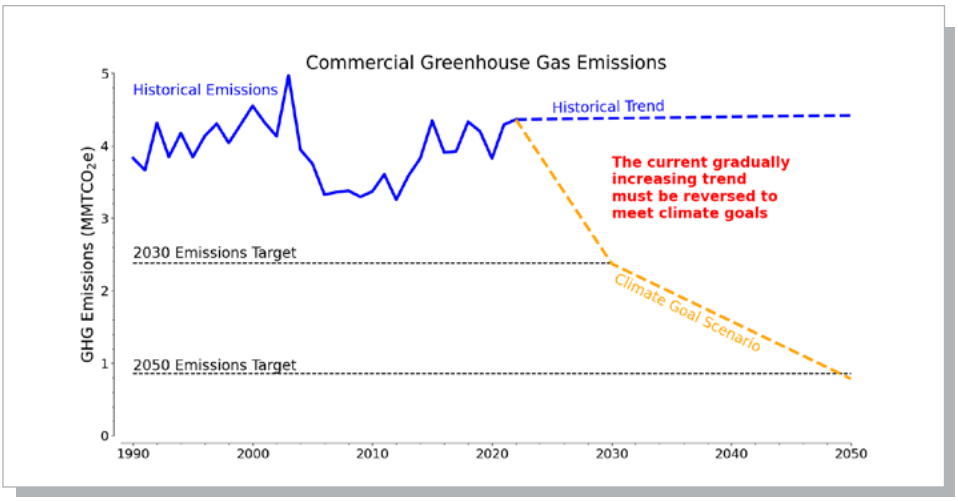

Figure 11: Commercial sector emissions depicted as in Figure 7. Commercial emissions show a trend of gradually increasing and then eventually exceeding 1990 levels as Connecticut recovered from the great recession. If this trend continues unabated, Commercial emissions by 1950 would comprise 45 percent of the 2050 economy-wide target.

[21] Home Page | EnergizeCT

The United States has nearly 6 million commercial buildings that cumulatively consume nearly 7 quadrillion BTU annually.[22] About 72 percent of this energy consumption is from major fuels consumed within the building. The Conservation and Load Management (C&LM) plan is an energy efficiency plan developed by the states' electric and gas utilities with input from the Energy Efficiency Board and is updated annually.[23] The C&LM plan funds many programs to improve the energy efficiency of commercial and industrial customers. This includes services to aid in retrofitting existing buildings and to fund equipment replacement and renovations to existing buildings. Other offerings include incentives for enrolling high-demand equipment in demand-response programs.[24]

In 2019, Governor Lamont's Executive Order 1 launched the State's GreenerGovCT initiative.[25] This initiative sets ambitious goals for state agencies to reduce GHG emissions, reduce water use, and reduce disposed solid waste at state facilities over the course of 10 years. To monitor progress toward the goals laid out in the order, the state has developed an online dashboard.[26] Annual progress reports are issued to update the public on the effectiveness of this initiative.[27]

Executive Order 21-3 directed DEEP to develop strategies to achieve the GHG reductions mandated by the GWSA. In 2022, DEEP held a series of public meetings detailing strategies to decarbonize energy use in buildings, with a major focus on replacing fossil fuel-reliant HVAC equipment with energy-efficient heat pumps.[28]

Assessing Progress in Reducing Industrial Processes Sector Emissions

Figure 12: Industrial sector emissions depicted as in previous figures. The projected trend shows increasing emissions to 2050, however is heavily influenced by preliminary results from 2022. Even omitting this point, however, would yield a trend showing some emissions increase since 1990.

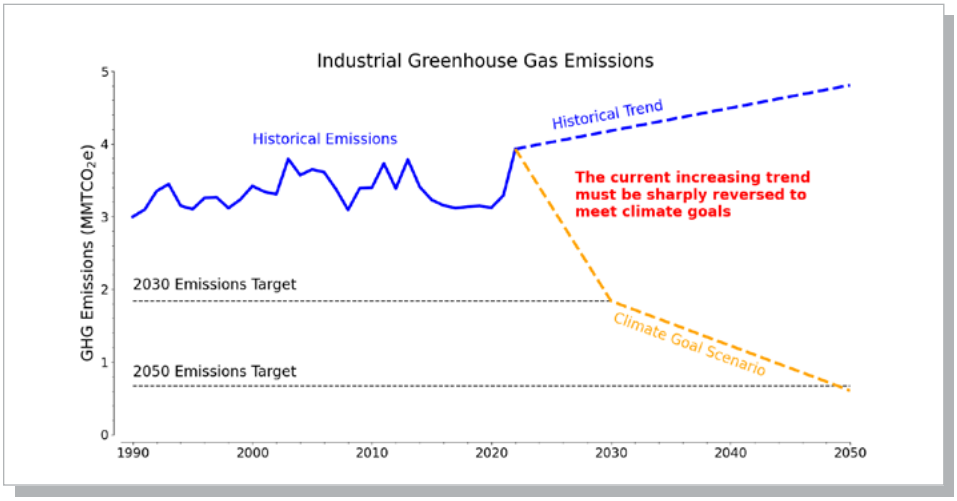

Figure 12 shows a widening gap between the 2001-2022 trajectory of industrial process emissions and economy-wide GWSA targets for 2030 and 2050. (Even if the preliminary 2022 data were omitted, the historical trend would not show a decline sufficient to bring the sector's emissions in line with the targets.)

[22] Use of energy in commercial buildings - U.S. Energy Information Administration (EIA)
[23] Conservation and Load Management (ct.gov)
[24] 2022-2024 (ct.gov)
[25] executive-order-no-1.pdf (ct.gov)
[26] GreenerGov CT Dashboard | Connecticut Data
[27] 2022 Progress Report (ct.gov)
[28] Comprehensive Energy Strategy (ct.gov)

As electrification of heating progresses, refrigerants with less potent global warming potential will be employed and HFC production will be phased out. It will be essential that when equipment relying on legacy refrigerants is retired, these chemicals are not allowed to escape into the atmosphere. Effective handling of refrigerants to minimize release of these industrial gases is essential; however, Connecticut has no formal refrigerant-management system. Because much of Connecticut's strategy for decarbonization relies heavily on decarbonizing electricity consumption and then implementing electrification of the most GHG-intensive parts of the economy, the release of SF_6 from various components of the electricity distribution system is a cause for concern. As aging transmission equipment is replaced with newer ones that require smaller amounts of SF_6 to operate, care must be taken to prevent leaks from decommissioned systems.

Assessing Progress in Natural and Working Lands, Agriculture, and Natural Gas Distribution Sectors Emissions

Although the Natural and Working Lands, Agriculture, and Natural Gas Distribution sectors contribute marginally to GHG emissions in Connecticut when compared to the other sectors discussed above, the State also has strategies to address their carbon footprint.

DEEP has developed a comprehensive Materials Management Strategy[29] to address the recent reduction in the state's waste disposal capacity. It calls for "diverting, through source reduction, reuse and recycling, not less than sixty percent of the solid waste generated in the state after January 1, 2024."[30] Highlights of the strategy include expansion of municipal composting programs and deployment of anaerobic digesters to break down organic waste. Emissions due to treatment of wastewater have remained relatively constant since the early 1990s.

On the Natural Gas Distribution front, the amount of methane that leaks from the natural gas transmission and distribution systems is largely dependent on the material that composes the pipelines. Replacing older cast iron portions of the system with more robust PVC pipelines provides the best way to reduce these emissions. Home electrification, the use of heat pumps for commercial heating, and induction cooktops for cooking will reduce the use of natural gas as well as fugitive methane emissions.

Regarding the Natural and Working Lands Sector, the Governor's Council on Climate Change 2021 report recommended a number of strategies for maintaining Connecticut's natural and working lands as an important carbon sink.[31] These included recommendations for monitoring forests for excess tree mortality and promoting species diversification in Connecticut's low-diversity second-growth forests. The report also recommended implementing a policy of "no net loss" of forests by providing landowners with incentives to preserve forest land and by creating markets for long-lived forest products.[32] Similarly, strategies were recommended for preserving the state's wetlands and improving soil health.[33]

[29] Comprehensive Materials Management Strategy (ct.gov)
[30] Final Adopted Comprehensive Materials Management Strategy, Revised 12-14-2016 (ct.gov)
[31] https://portal.ct.gov/-/media/deep/climatechange/gc3/gc3_phase1_report_jan2021.pdf
[32] Forests Sub-Group Final Report (ct.gov)
[33] gc3_wnl_wetlands_final_report_111320.pdf (ct.gov)

Conclusion

This report provides an update to the previously released report for the years 1990-2021, including final results for 2021 and preliminary results for 2022. Connecticut has made great progress in decarbonizing the electricity consumption sector, but deployment of more energy efficiency and zero emission resources is imperative if the state is to achieve the goal of net-zero emissions in this sector by 2040.

The transportation, residential building, and commercial building sectors remain the state's most carbon intensive. The circumstances of the COVID-19 pandemic in the past few years represented an anomalous era characterized by widescale behavioral changes leading to dramatic year-to-year GHG reductions. Reversal of those behavioral changes is now apparent, especially in the transportation sector.

It is important to evaluate these trends and seek legislative and regulatory changes to maximize GHG emissions reductions while also complementing other public policy and safety goals. DEEP values the opportunity to work with all parties to chart a path to meeting the requirements of the Global Warming Solutions Act and to meaningfully address and mitigate the climate crisis for the benefit of all of Connecticut's residents.

Appendix A: Detailed Electric Sector Calculations

TABLE 2

RPS Fuel Source	CT MWh	EF for CO2 (lb/mmbtu)	lbs of CO2	EF for CH4 (lb/mmbtu)	lbs of CH4
Biogas	1,727.00	114.795	2,512,702	0.00705	12
Biomass	599,777.00	206.794	2,468,169,697	0.01587	9,520
Digester gas	10,369.00	205.691	27,032,056	0.02425	251
Fuel cell	604,957.00	700.000	423,469,900	0.00661	4,001
Hydroelectric/Hydropower	581,023.00	-	-	0.00705	4,099
Landfill gas	561,020.00	114.795	817,906,956	-	-
Natural Gas	111,961.00	116.999	99,555,026	-	-
Solar Photovoltaic	1,324,761.00	-	-	-	-
Wind	1,916,634.00	-	-	-	-
Wood	753,202.00	206.794	3,099,571,353	0.00661	4,982
Nuclear	16,740,592.00	-	-	0.00705	118,101
Diesel	4,215.00	161.290	7,886,113	0.06280	265
Natural Gas	1,096,963.00	116.999	975,412,692	0.00220	2,418
Oil	3,897.00	205.691	9,298,305	-	-
Trash-to-energy	902,035.00	202.629	3,363,131,602	-	-

TABLE 3

Total (Settled/Reserved + Millstone) (MWh)	25,213,133
CT Load including pumping (MWh)	28,423,000
RECs-Load Difference (MWh)	3,209,867
Biogenic Recs	17,921,392
Non-Biogenic Load	-
Emission factor (lb/MWh)	782
Difference * regional EF (lbs)	2,509,112,505
TOTAL Settled & Load (lbs)	5,606,745,315
$MMTCO_2e$	2.5

Appendix B: Biogenic GHG emissions

Beginning with the 2021 GHG inventory, DEEP began following the international standard regarding biogenic emissions within the report. This standard calls for emissions from biogenic sources to be reported separately than anthropogenic sources. For Connecticut, this will manifest mostly in the following ways:

- Connecticut's Renewable Portfolio Standards treat biogenic fuel sources such as wood preferably. While the biomass share of the state's electricity profile is being phased down, these sources still exist and produce emissions
- Most of the gasoline sold in the state is a 10 percent blend by volume.
- As of July 1, 2022, Connecticut requires home heating oil to contain a 5 percent biodiesel mix.

Electricity generated from biogenic fuels came to 3.6 $MMTCO_2e$ in 2021 and 3.7 $MMTCO_2e$ in 2022. Ethanol consumption in gasoline emitted 0.8 $MMTCO_2e$ in 2021 and 2022. Verified data on the true biodiesel blend in Connecticut's motor diesel and heating oil supply are unavailable however EIA data estimate that total biodiesel consumption in Connecticut to be 1 trillion BTU in 2021 and 800 billion BTU in 2022.[34] Emissions from this fuel add a negligible amount to the emissions total.

Appendix C: Electric Generation Based Results

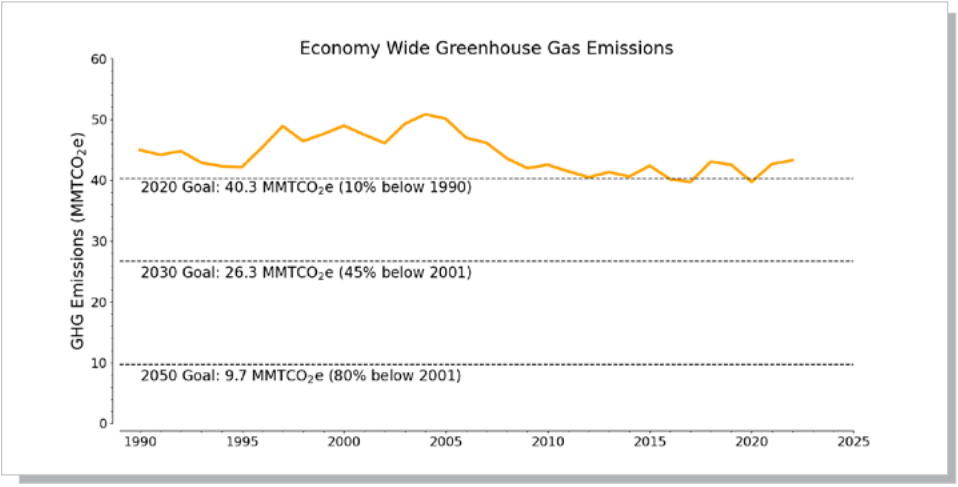

**Figure 13: As in Figure 1 except with emissions for electricity generated within Connecticut's borders is considered.*

While DEEP began reporting emissions based on electricity consumption in the 2013 inventory, previous editions have also included GHG emissions based on electricity generated within the state. In the past, both methods yielded similar results. As New England states have phased out coal fueled electricity production natural gas fueled generators have been located in Connecticut to produce electricity for consumption in other parts of the region. While electricity consumption within Connecticut has become cleaner due to the environmental attributes of Millstone and the procurement of renewables, carbon dioxide is a global pollutant and sustained improvements to the entire regional grid are required. In 2022 and 2023, 11.0 and 10.8 $MMTCO_2e$ were emitted generating electricity in Connecticut. This is not much of an overall improvement on the 12.1 $MMTCO_2e$ generated in 1990. Figure 14 depicts total GHG emissions from 1990-2022 considering electricity production.

[34] U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

portal.ct.gov/DEEP