Report to the Joint Standing Committee on Environment and Natural Resources 131st Legislature, Second Session

Tenth Biennial Report on Progress toward Greenhouse Gas Reduction Goals

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Bureau of Air Quality
Maine Department of Environmental Protection

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Executive Summary

The results of the Maine Department of Environmental Protection's (the Department's) analysis of gross greenhouse gas (GHG) emissions for 1990-2021 show that Maine's GHG emissions were 30% lower in 2021 than in 1990. Emissions have consistently been at least 10% lower than 1990 levels since 2016. With data now available through December 31, 2021, Maine has achieved the goal of reducing GHG emissions to 10% lower than 1990 levels by January 1, 2020, as set forth in 38 M.R.S. §576 (2003) and continues to work toward the 2030 and 2050 GHG emissions reduction goals required by 38 M.R.S. §576-A[1]. These goals are to reduce gross GHG emissions to at least 45% below 1990 levels by January 1, 2030, and to at least 80% below 1990 levels by 2050. Results of the analysis of net GHG emissions estimate that, as of 2021, approximately 91% of Maine's GHG emissions are balanced by carbon sequestered in Maine's environment. The data suggest Maine is on target to meet the 2045 carbon neutrality requirement of 38 M.R.S. §576-A, sub-§2-A.[2]

The Department's analysis of the most current GHG data available indicates:

- 94% of gross GHG emissions in Maine are the result of energy consumption, and CO_2 emissions from the combustion of fossil fuels account for 65% of Maine's 2021 gross GHG emissions. Annual emissions in the energy source category have been reduced by 41% since the high in 2002 and 30% since 1990 (Figure 2; Appendix A, Table A1).
- Maine is approximately 91% of the way to reaching carbon neutrality, which means 91% of gross GHG emissions are balanced by sequestration in the environment.
- Annual CO_2 emissions from fossil fuel[3] combustion in the electric power sector have decreased by 79% since they peaked in 2002, largely by replacing high carbon fuels with lower carbon energy sources, primarily natural gas and renewable sources (Appendix B).
- The total emissions from the transportation sector were 9% lower in 2021 than they were in 1990; however, proportionally, the transportation sector was responsible for 49% of Maine's CO_2 emissions from the combustion of fossil fuels in 2021, up from 43% in 1990 (Appendix B).
- Maine continues to reduce its GHG intensity and emissions per dollar. GHG emissions per billion Btu (BBtu) of energy consumed in 2021 were 14% less than the highest GHG intensity in 1997. GHG emissions per million dollars of state gross domestic product (GDP) were 59% less in 2021 than in 1990 (Appendix G).

[1] https://legislature.maine.gov/statutes/38/title38sec576-A.html
[2] Effective August 8, 2022, https://legislature.maine.gov/legis/bills/getPDF.asp?paper=HP1045&item=3&snum=130
[3] Fossil fuels are non-renewable fuels including petroleum, natural gas, and coal.

I. Introduction

In 2003, Maine's *An Act To Provide Leadership in Addressing the Threat of Climate Change* ("the Act"), enacted as Public Law 2003, Chapter 237, established greenhouse gas (GHG) reduction goals. The Act set a goal for reduction of GHG emissions within the state, in the short term, to 1990 levels by January 1, 2010, and to 10% less than 1990 levels by 2020 (38 M.R.S. §576).[4] In 2019, 38 M.R.S. §576-A[5] was enacted to expand the original GHG emissions goals of 38 M.R.S. §576. These goals are to reduce gross GHG emissions to at least 45% below 1990 levels by January 1, 2030, and to at least 80% below 1990 levels by 2050. This legislation also created the Maine Climate Council, which is an assembly of scientists, industry leaders, bipartisan local and state officials, and engaged citizens tasked with advising the Governor and the Legislature on ways to meet these emissions reduction goals as well as ways to prepare for and adapt to the consequences of climate change. On September 23, 2019, Governor Mills signed an executive order adding the goal of achieving carbon neutrality in Maine by 2045.[6] This carbon neutrality goal was codified in 38 M.R.S. §576-A, sub-§2-A on August 8, 2022.[7]

The Department is submitting this report to the Joint Standing Committee on Environment and Natural Resources as well as the Joint Standing Committee on Energy, Utilities, and Technology pursuant to 38 M.R.S. §578[8], which requires the Department to evaluate the state's progress toward meeting the GHG reduction goals and submit a report of its evaluation by December 1, 2022, and by that date every two years thereafter. Since 2022, this report includes an estimate of both gross anthropogenic GHG emissions (i.e., emissions from human activity) and net GHG emissions (i.e., a carbon budget). The net GHG emissions inventory includes gross GHG emissions to the atmosphere (reported in carbon dioxide equivalents) and carbon sequestered by the environment.

The gross GHG emissions inventory is used to assess Maine's progress toward meeting the gross GHG reductions set out in 38 M.R.S. §576-A. The net GHG emissions inventory is used to gauge Maine's progress toward reducing net GHG emissions and achieving the 2045 carbon neutrality goal of 38 M.R.S. §576-A, sub-§2-A. This report summarizes the findings of the Department's tenth quantitative evaluation of Maine's progress toward meeting statutory GHG emission reduction goals since the development of Maine's original Climate Action Plan in 2004.

[4] This law was built on a New England Governors and Eastern Canadian Premiers resolution calling for similar reductions. https://www.coneg.org/wp-content/uploads/2019/01/2017-rccap-final.pdf
[5] 38 M.R.S. §576-A, https://legislature.maine.gov/statutes/38/title38sec576-A.html
[6] Governor Mills' carbon neutrality executive order: https://www.maine.gov/governor/mills/sites/maine.gov.governor.mills/files/inline-files/Executive%20Order%209-23-2019_0.pdf
[7] 38 M.R.S. §576-A, sub-§2-A, https://legislature.maine.gov/legis/bills/getPDF.asp?paper=HP1045&item=3&snum=130
[8] 38 M.R.S. §578, https://legislature.maine.gov/statutes/38/title38sec578.html

II. Methods

Chapter 167
As required by 38 M.R.S. §576-A, the Department adopted rule Chapter 167, *Tracking and Reporting Gross and Net Annual Greenhouse Gas Emissions* in 2021.[9] This rule was most recently updated on February 6, 2024. This rule establishes methods for the calculation of both gross and net annual GHG emissions, and the Department used these methods to measure progress toward Maine's GHG reduction goals. Please refer to Chapter 167 for additional details on the methods used to develop the complete gross and net GHG emissions inventories shared in this report.

GHGs
The following GHGs are included in the evaluation of gross GHG emissions:

- carbon dioxide (CO_2)
- methane (CH_4)
- nitrous oxide (N_2O)
- perfluorocarbons (PFC)
- hydrofluorocarbons (HFC)
- nitrogen trifluoride (NF_3)
- sulfur hexafluoride (SF_6)

State Inventory Tool
The Department utilized the State Inventory Tool (SIT)[10], a computer model developed by the U.S. Environmental Protection Agency (EPA), to complete much of the gross biennial GHG inventory. The SIT provides states with a comprehensive, standardized approach to estimating GHG emissions. This tool considers the same sources that are in the national GHG inventory and is based on the recommendations of the Intergovernmental Panel on Climate Change (IPCC). Since activity data are the driving force for emissions estimation, the tool contains default activity data while at the same time providing flexibility for states to input state-specific data. Default data are based on national databases, and much of the data in these national databases are compilations of state-submitted data; however, some data are modeled when state-specific data are unavailable. The Department augments the SIT with data from Maine state programs when available (e.g., state vehicle miles travelled, industrial-process-specific data, and solid waste data) to best estimate GHG emissions in Maine.

Most of the inventory data in the SIT comes from the U.S. Department of Energy's Energy Information Administration (EIA).[11] The EIA breaks the energy source category down into five energy sectors — electrical power, industrial, commercial, residential, and transportation — to align with policies and programs for GHG emission reductions that target each of these sectors

[9] Chapter 167, *Tracking and Reporting Gross and Net Annual Greenhouse Gas Emissions*, is available online: https://www.maine.gov/sos/cec/rules/06/chaps06.htm.
[10] EPA updated its State Inventory Tool (SIT) for greenhouse gases through 2021 in February 2024: https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool. Most of the inventory data in the SIT comes from the Department of Energy's Energy Information Administration (EIA), and at the time of this report, EIA data were available through 2021.
[11] The State Energy Data System (SEDS) is the source of the U.S. Energy Information Administration's (EIA) energy statistics. These data are typically released two years after a reporting year. For example, the 2021 data used by EPA in the SIT was released in June 2023. https://www.eia.gov/state/seds/seds-data-complete.php?sid=US.

separately. For some of the categories, this information is apportioned to the states from national and regional inventories. For this Tenth Biennial Report, the Department performed a comprehensive analysis of the data provided in the tool and updated it with information from Maine reporting programs. At the time of this report, the most recent quality assured EIA data were available through 2021.

Biogenic Emissions

Pursuant to 38 M.R.S. §577, gross GHG emissions now include biogenic emissions for the entire reporting period (1990 through 2021). Since biogenic emissions are not included in the SIT, the Department added biogenic emissions into the gross GHG inventory based on state and national data sources. Biogenic emissions include emissions from the combustion of carbon that were originally removed from the atmosphere by photosynthesis and would eventually naturally be released back to the atmosphere through degradation processes. Biogenic emissions include those from the combustion of biofuels, such as wood, ethanol, biodiesel, and biogenic waste. The term wood used here includes wood, wood waste, and wood-derived fuels, including black liquor. Biogenic waste refers to biomass waste, which includes municipal solid waste from biogenic sources, landfill gas, sludge waste, and agricultural byproducts. Biogenic emissions also include emissions from organic waste, such as landfill off-gassing and wastewater treatment.

Units

GHG emissions are expressed in units of carbon dioxide (CO_2) or carbon dioxide equivalents (CO_2e). Emissions values are expressed in millions of metric tons of CO_2 ($MMTCO_2$) when only CO_2 is considered. Emissions values are expressed in millions of metric tons of CO_2 equivalent ($MMTCO_2e$) when additional GHGs are included and converted to CO_2e. Each type of GHG traps heat in the atmosphere differently, and some are far more potent than others. Emissions from GHGs other than CO_2 are converted to carbon dioxide equivalent emissions using 100-year global warming potential (GWP) values reported by the IPCC. Results in both $MMTCO_2$ and $MMTCO_2e$ units are included throughout this report. Fuel consumption values are expressed in billions of British thermal units (BBtu).

Source Categories and Energy Sectors

GHG inventory results are often broken down by source category or energy sector. Source categories include energy, industrial processes, agriculture, and waste. These categories represent the category of activity generating the GHG emissions (e.g., are the emissions the result of an activity that consumes a source of energy or are they the result of an industrial process?). Results for gross GHG emissions in $MMTCO_2e$ are reported by source category.

The energy source category (representing emissions produced during the consumption of energy) is the source of most GHG emissions and encompasses energy-consuming entities, such as electric power producers, and energy consumption activities from the following sectors: industrial, commercial, transportation, and residential. The agriculture category captures emissions from livestock, manure management, plant and soil residue, and cultivation practices. The industrial processes category encompasses non-combustion activities that create emissions, such as cement production, semiconductor manufacture, and electrical power transmission and distribution. The waste category includes emissions from solid waste disposal and wastewater treatment activities.

The energy source category can be further broken down into the economic sectors that consume energy. The five energy consuming sectors are residential, commercial, industrial, transportation,

and electric power. (The electric power sector includes emissions from facilities that produce electricity through the consumption of an energy source, e.g., the combustion of fossil fuels.) Emissions from the combustion of fossil fuels within the energy source category are presented by energy sector (i.e., energy consuming economic sector) in $MMTCO_2$, which includes CO_2 emissions only, as well as $MMTCO_2e$. (See Appendix C for energy sector definitions.)

Note: The industrial processes source category is not the same as the industrial sector within the energy source category. The industrial processes source category represents emissions from industrial processes that do not involve the production of energy (e.g., refrigeration, air conditioning, fire extinguishing, foam blowing, and sterilization), while the industrial energy sector describes emissions from fuels combusted to generate energy within an industrial setting (e.g., fuel oil or natural gas combusted in a boiler or engine).

Economic Analysis

To show the relationship between economic activity and GHG emissions, the Department has included an analysis of GHG emissions relative to state gross domestic product (GDP) in real dollars adjusted for inflation.[12] These data are shown in Appendix G.

Net GHG Inventory (Maine Carbon Budget)

Researchers at the University of Maine, Bates College, Maine Forest Service, Gulf of Maine Research Institute, Bigelow Laboratories, and the Maine Natural Areas Program developed an estimate of the State of Maine's Carbon Budget[13] in collaboration with the Department. Data from their analysis are presented here as the net GHG inventory and represent a 5-year data window ending in 2021. Estimates of net GHG emissions were made for each of the following categories: gross emissions, wood products, forestland, agriculture, urban, inland wetlands, inland waters, coastal wetlands, and coastal waters. The difference between carbon emitted and carbon sequestered from each of these categories was used to estimate the net carbon emissions. Additional details about the methodology for this analysis can be found in Chapter 167.

Carbon Markets

Because participation in carbon markets is growing in Maine, the Department collaborated with the University of Maine to tally the carbon offset credits reserved by Maine landowner participation in carbon market projects. Currently, there is no single formal tracking system for Maine forestland enrolled in carbon markets; details about Maine land allocated to carbon offsets were collected from the Berkely Carbon Trading Project Voluntary Registry Offsets Database v9.[14]

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[12] Economic data inflation adjusted, chained 2012 dollars for 1997-2021.

[13] Hayes, D., Brewer, A., Daigneault, A., Enterline, C., Fernandez, I., Frank, J., Johnson, B., Knapp, S., Legaard, K., Price, N., Puryear, K., Simons-Legaard, E., Stevens, A., Wei, X., Weiskittel, A. (2024). The State of Maine's Carbon Budget (Version 2, 2017 - 2021). https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/.

[14] Ivy S. So, Barbara K. Haya, Micah Elias. (2023, December). Voluntary Registry Offsets Database v9, Berkeley Carbon Trading Project, University of California, Berkeley. Retrieved from: https://gspp.berkeley.edu/faculty-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database

III. Results and Discussion

A. Gross Greenhouse Gas Emissions

The Department's current analysis utilizing data through the end of 2021 indicates that Maine is continuing to realize a decline in GHG emissions from a peak in 2002, primarily due to decreased use of fossil fuels. Figure 1 shows the trend in Maine's GHG emissions from 1990 to 2021. Total estimated annual GHG emissions in Maine increased from 31.4 $MMTCO_2e$ in 1990 to a peak of 37.1 $MMTCO_2e$ in 2002. By 2009, emissions were below 1990 levels, reaching a low in 2012, rebounding slightly 2013-2015, and trending downward again through 2020. The COVID-19 pandemic led to a dip in 2020 GHG emissions to 21.6 $MMTCO_2e$. While gross GHG emissions bounced back from pandemic levels in 2021 to 21.9 $MMTCO_2e$, emissions in 2021 were lower than the 2019 pre-pandemic emissions of 23.4 $MMTCO_2e$. Maine has reduced gross GHG emissions by 30% between 1990 and 2021 (Appendix A, Table A3) and by 41% between 2002 and 2021. A similar figure with biogenic emissions excluded along with a complete analysis of Maine's GHG emissions by source category for each year, both with and without biogenic emissions, can be found in Appendix A. GHG emissions per capita follow the gross trend. While the population of Maine has increased by 11% between 1990 and 2021, GHG emissions per capita have decreased 37% over this time frame (Appendix A, Figure A2).

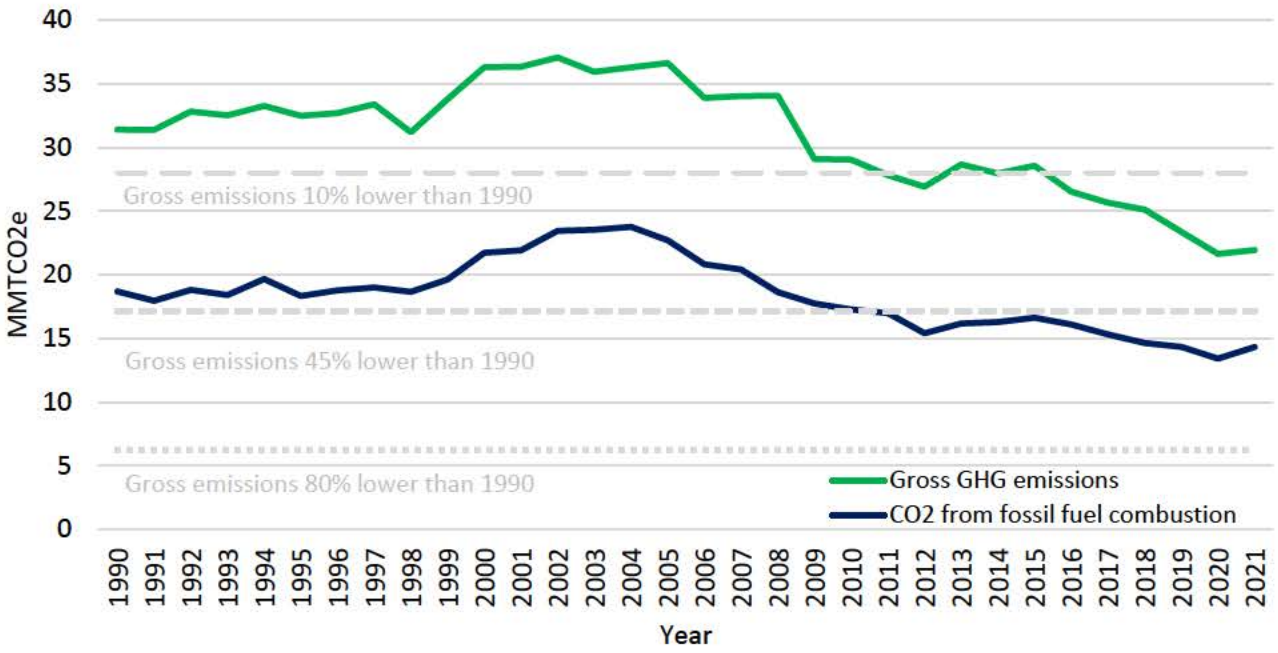

Figure 1. Maine's gross greenhouse gas emissions 1990-2021 (including biogenic emissions)

i. Emissions by Source Category

The energy source category, which includes the combustion and distribution of fuels, is the largest source of emissions, accounting for 94% of Maine's gross GHG emissions in 2021. The agricultural, industrial processes, and waste source categories combined only contributed 6% of the 2021 GHG emissions total (Figure 2; Appendix A, Tables A1 and A4).

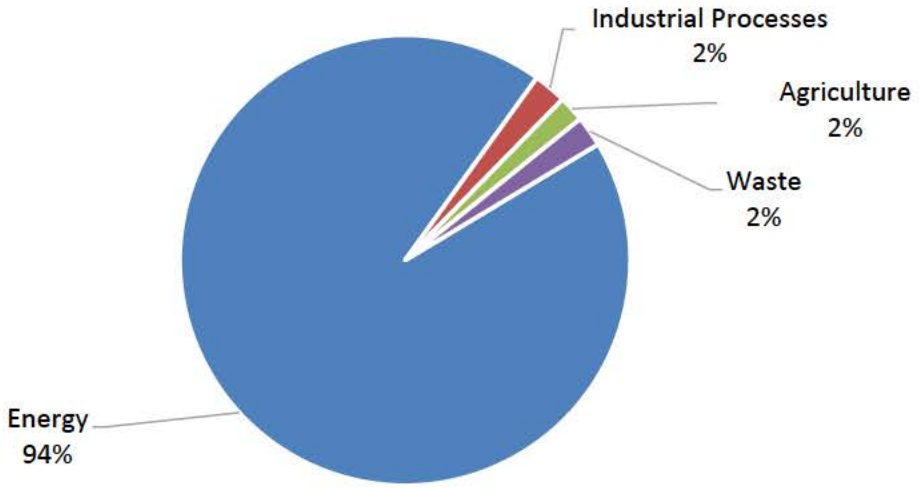

Figure 2. Gross greenhouse gas emissions by source category for 2021 (including biogenic emissions)

ii. Energy Emissions and Consumption

Demand for and consumption of energy drive the clear majority of Maine's GHG emissions. Figure 3 illustrates the energy sources used to meet Maine's energy demands from 1990 through 2021. In 2021, total energy consumption in Maine was 29% less than in 1990 (Appendix D).

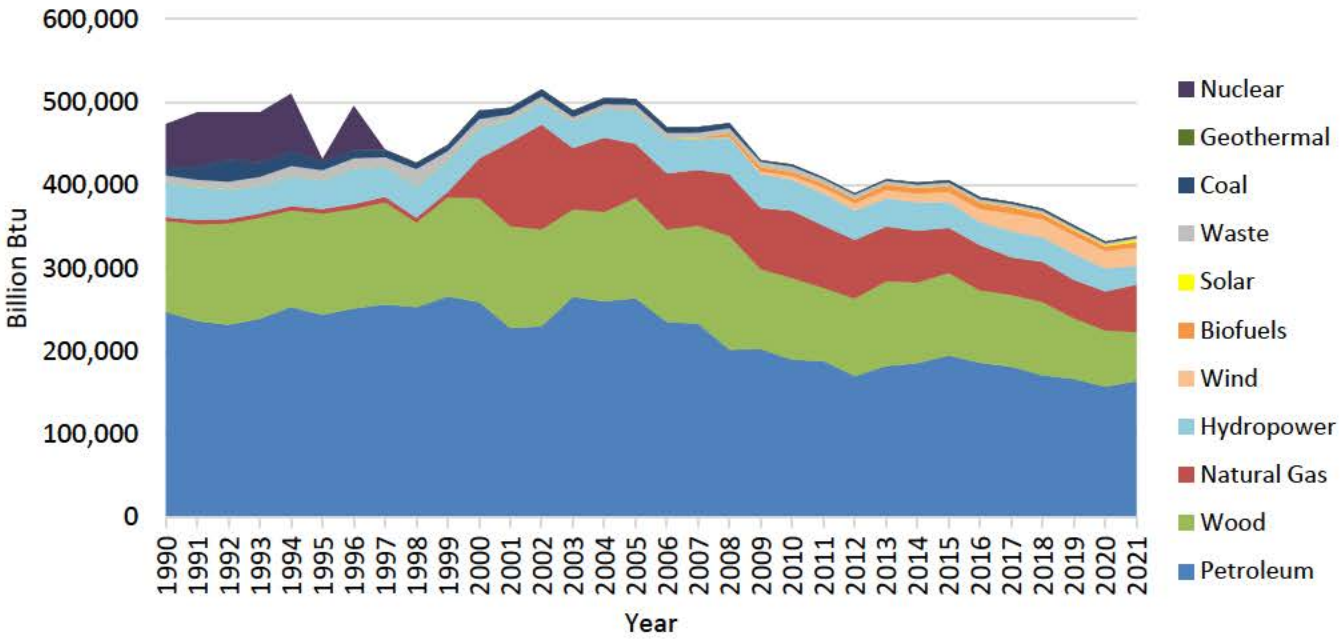

Figure 3. Maine energy consumption (BBtu) 1990-2021[15] (Biofuels include biodiesel and fuel ethanol.)

Emissions of CO_2 from the combustion of fossil fuels account for 65% of Maine's gross GHG emissions in 2021. Although Maine still relies on petroleum to meet some energy demands, including heating more than 60% of residential buildings,[16] CO_2 emissions continue to decline in large part because of the use of lower carbon fuels, increased efficiencies, and increased use of renewable sources of energy.

a. Petroleum Consumption

Most CO_2 emissions from energy consumption in Maine come from the combustion of petroleum products.[17] Figure 4 illustrates the consumption of various types of petroleum, broken down into distillate fuel; motor gasoline; propane and liquefied petroleum gas; jet fuel and aviation gasoline; petroleum coke, asphalt, road oil, and lubricants[18]; residual fuel oil; and kerosene (data in Appendix F). This analysis allows planners to assess the relative consumption of various fuels.

The petroleum products being consumed (i.e., combusted) in Maine consist primarily of motor gasoline, distillate fuel, and propane. In 2021, combustion of petroleum products accounted for 49% of all energy consumed (Appendix D), 51% of gross GHG emissions, and 78% of CO_2

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[15] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php, file name: use_all_btu.csv). State wood data replaces EIA data for years and sectors it is available.

[16] https://www.maine.gov/governor/mills/news/governors-energy-office-releases-updated-guide-help-maine-people-save-money-and-stay-warm

[17] Petroleum products are a subset of fossil fuels. These are non-renewable fuels and include fuels such as motor gasoline, distillate fuel, propane, residual fuel oil, and kerosene. Petroleum products do not include biodiesel or fuel ethanol, which are renewable fuel sources and are accounted for separately.

[18] While asphalt, road oil, and lubricants are petroleum products, the consumption or use of these types of petroleum generally do not produce significant CO_2 emissions.

emissions from the combustion of fossil fuels (Appendix B). As illustrated in Figure 4, the reduction in residual fuel oil consumption, 97% since 1990, is a large driver of the overall decline in GHG emissions. Residual fuel oil consumption has historically occurred primarily in the industrial and electric power sectors, both of which have driven the reduction visible in Figure 4.

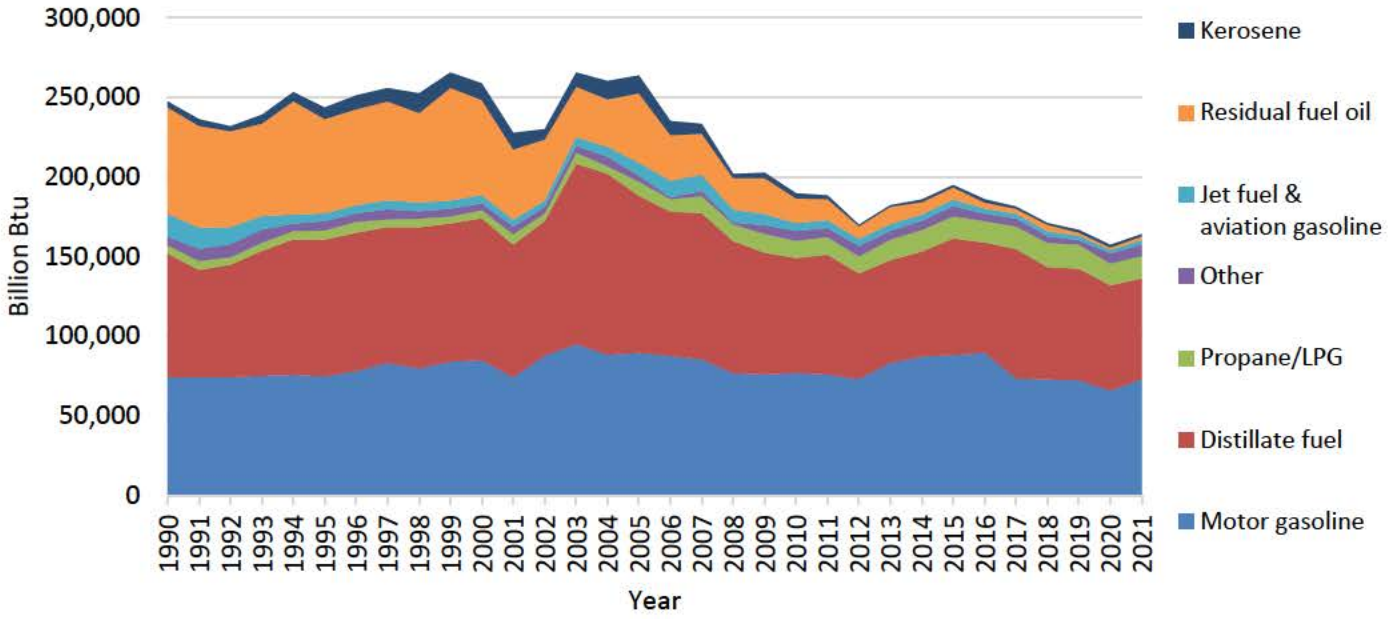

Figure 4. Maine petroleum use by fuel type (BBtu) 1990-2021[19] (This figure does not include ethanol or biodiesel. "Other" includes asphalt, road oil, lubricants, and petroleum coke.)

Since 1990, the aggregate CO_2 emissions from petroleum combustion (in all energy sectors) have decreased by 36% (Appendix B). Comparably, petroleum consumption also declined by 34% between 1990 and 2021 (Figure 4, Appendix D). This may be explained in part by transitions to lower carbon fuels. For example, there has been a 1,152% increase in natural gas consumption since 1990, from 4,572 BBtu (1% of Maine's energy consumption) in 1990 to 57,234 BBtu (17% of Maine's energy consumption) in 2021 (Appendix D).

Figure 5 illustrates the trend in petroleum consumption by sector since 1990. Between 1990 and 2021, all energy sectors have decreased petroleum consumption. The transportation sector has been the leading consumer of petroleum for all years, with a 15% decrease in petroleum consumption during the reporting period (Appendix D). The residential sector has reduced petroleum consumption by only 13%, while the commercial, industrial, and electric power sectors have achieved significant reductions of 35%, 69% and 97%, respectively.

[19] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php, file name: use_all_btu.csv)

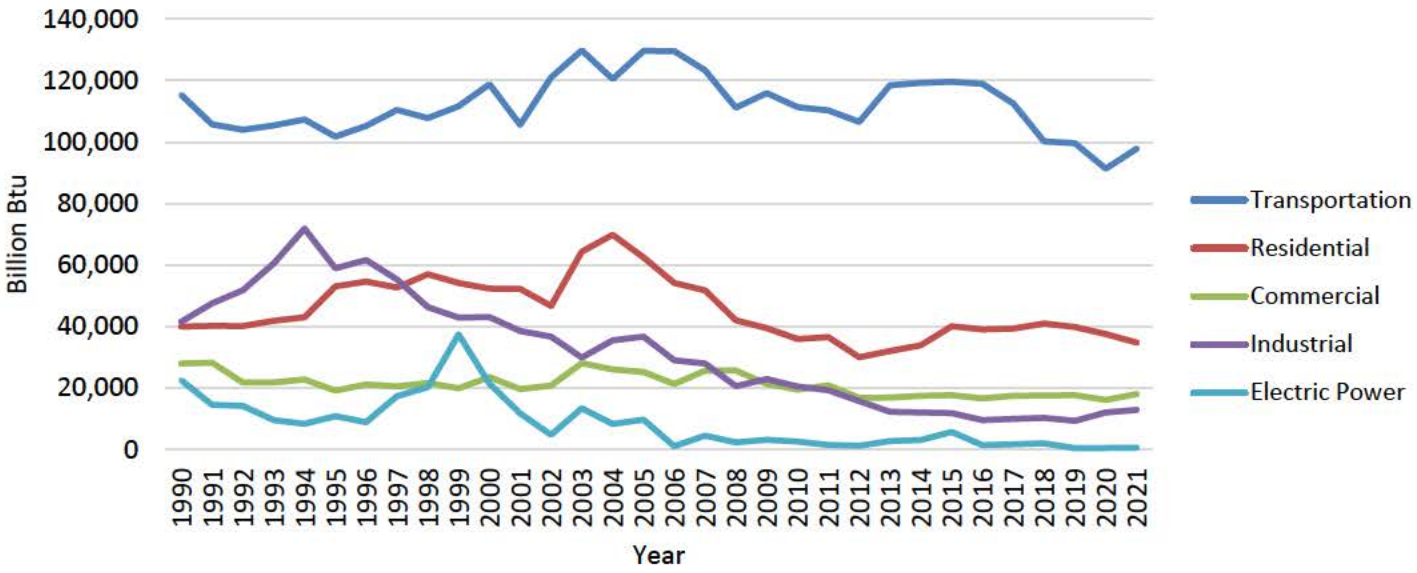

Figure 5. Maine petroleum consumption by sector (BBtu) 1990-2021

b. CO_2 Emissions from Combustion of Fossil Fuels

CO_2 is the largest component of most combustion-based GHG emissions, and fossil fuels are consumed in most combustion-based energy-production processes. Figure 6 illustrates the relative CO_2 emissions from the combustion of fossil fuels from each energy sector (within the energy source category) in 2021. This figure shows that the transportation sector produced almost half (49%) of all CO_2 emissions generated from fossil fuel combustion in Maine in 2021. The residential sector accounted for the next highest contribution at 19%.

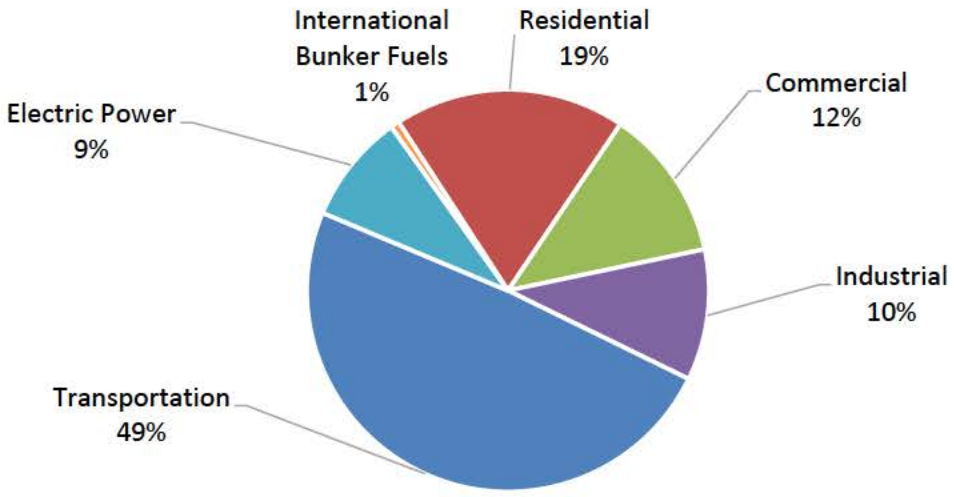

Figure 6. CO_2 emissions from fossil fuel combustion by sector for 2021 (data in Appendix B)

Figure 7 shows the trend in CO_2 emissions from combustion of fossil fuels by sector since 1990. The transportation sector has been the leading contributor of CO_2 emissions for all years 1990 to 2021, with a 12% decrease of CO_2 emissions during that period. The industrial, electric power, and commercial sectors reduced CO_2 emissions by 51%, 39%, and 22%, respectively, between 1990 and 2021. While the trend in CO_2 emissions from residential combustion of fossil fuel shows variability over the reporting period, there has been an overall decrease of 11% since 1990. A complete table of CO_2 emissions from the combustion of fossil fuels over the analysis period is presented in Appendix B.

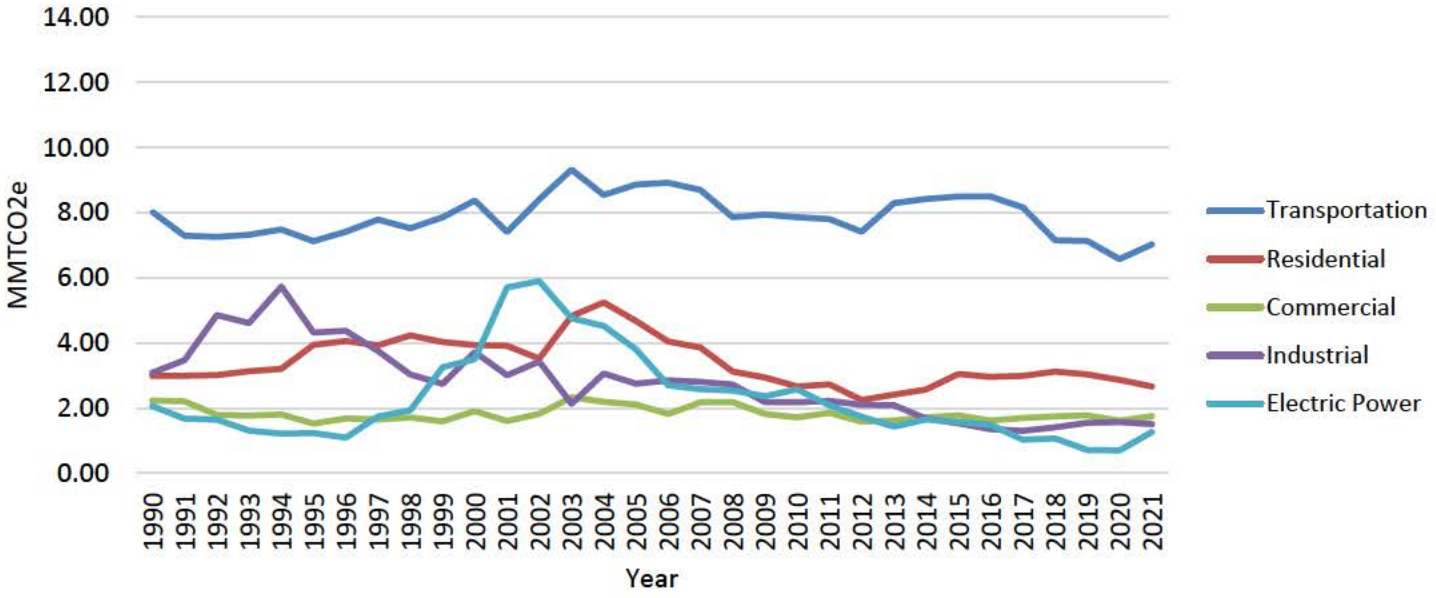

Figure 7. CO_2 emissions from the combustion of fossil fuels by energy sector 1990-2021 (data in Appendix B)

c. Emissions and Consumption by Energy Sector

Emissions of CO_2 from fossil fuel combustion are often a primary focus when assessing GHG emissions; however, additional GHGs, such as CH_4 and N_2O, are produced to a much lesser extent during the fossil fuel combustion process, and combustion of renewable fuels also generates biogenic GHG emissions that must be considered in a complete gross GHG inventory. The time series data presented in Figure 8 show the emissions by energy sector within the energy source category from 1990 to 2021. These emissions include all GHG emissions produced through the production of energy, including non-CO_2 GHG emissions and biogenic GHG emissions from the combustion of renewable fuels. For ease of comparison, Figure 7 and Figure 8 are presented with the same y-axis ($MMTCO_2e$) scale.

While the industrial sector was the highest GHG-emitting energy sector at the beginning of the reporting period, energy emissions from the transportation sector have remained higher than the industrial sector since 2012. The transportation, industrial, commercial, and electric power sectors have reduced GHG emissions between 1990 and 2021 by 9%, 58%, 12%, and 41%, respectively. For the transportation, commercial, and electric power sectors, the decreases are linked to reduced combustion of fossil fuels. In the industrial sector, the reduction since 1990 is due to a decrease in

combustion of both high carbon fossil fuels and combustible renewables. Emissions from fossil fuels were 51% lower in 2021 than in 1990 for the industrial sector, and emissions from combustible renewable fuels were 61% lower. With an 11% increase in population over the reporting period, residential sector emissions have decreased by only 0.4% over the 1990-to-2021 time frame.[20] CO_2 emissions from the combustion of fossil fuels within the residential sector were 11% lower in 2021 compared to 1990, while emissions from combustion of renewable fuels have increased by 26% in this sector.

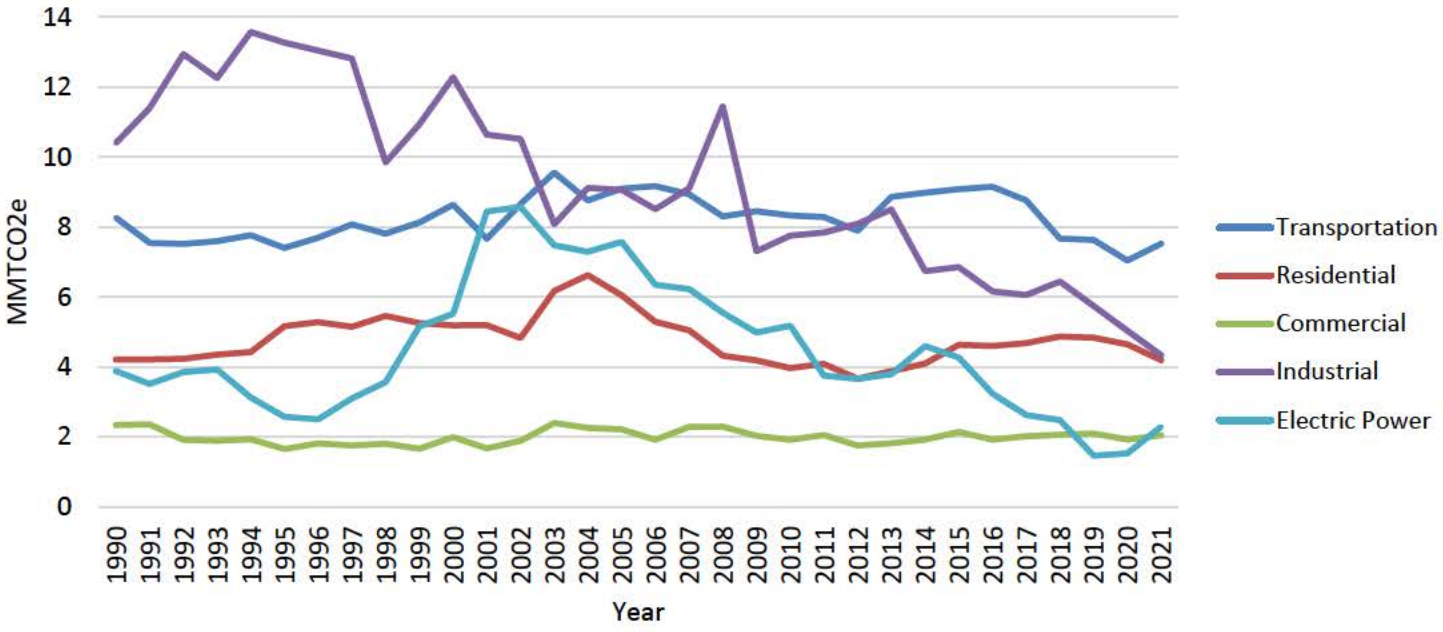

Figure 8. Energy source category emissions by sector 1990-2021

Electric Power

At 2.28 $MMTCO_2e$, the electric power sector generated 10% of Maine's gross GHG emissions in 2021 and 41% less emissions than in 1990 (Appendix A, Table A3). CO_2 from the combustion of fossil fuels accounted for 1.3 $MMTCO_2$, which was 55% of the emissions from this sector in 2021 and 39% less than in 1990. This was 9% of the state's total CO_2 emissions from fossil fuels and a 79% decline from the 2002 peak (Appendix B). Nuclear-, petroleum-, and coal-powered generation have been largely replaced with generation using natural gas and wood as fuel as well as wind-generated power (Appendix E, Figure E1). In 2021, natural gas combustion accounted for 84% of the fossil-fuel-based CO_2 emissions from this sector. Renewable resources (hydropower, wood, wind, waste, solar, and geothermal) provided 66% of the energy sources consumed by electricity generating facilities in 2021, up from 37% in 1990. Combustion of wood within the electric power sector amounted to 1.02 $MMTCO_2e$, which is 45% of the GHG emissions from this sector and 43% less than in 1990.

[20] Population estimates by the U.S. Census Bureau show an 11% increase in population from 1990 to 2021, from 1,231,296 to 1,372,247 (https://www.census.gov/programs-surveys/popest/data/data-sets.html)

The CO_2 emissions from electricity generation in Maine are accounted for by fuel type, and the end-use consumption of electricity does not create GHG emissions directly; however, detailing the electricity use by sector as well as the electricity imports and exports from the state gives a more complete picture of energy use in Maine. Maine was a net importer of electricity in 2021. Maine imported a net total (i.e., imports minus exports) of 8,333 BBtu of electricity domestically and 7,568 BBtu internationally in 2021, for a total import value of 15,901 BBtu (Appendix E, Figure E2). In 2021, 44% of Maine's electricity was consumed by the residential sector, 34% by the commercial sector, and 22% by the industrial sector (Appendix E, Figure E3). EIA's energy consumption dataset indicates that the transportation sector did not consume a measurable amount of electricity between 1990 and 2021. Electricity consumed by charging electric vehicles at residences or elsewhere cannot be isolated from total electricity consumption at this time. This is an area of interest for future reports.

Emissions from electricity can be assessed in two ways: based on electricity produced or electricity consumed. For Maine's gross GHG estimates, emissions from electricity produced in the state, whether it was consumed in the state or exported, were included; this is physically what is emitted to the atmosphere within Maine's borders and is the most accurate representation of actual emissions within the state. CO_2 emissions estimates from electricity consumption, however, are also critical for determining Maine's contribution to global carbon emissions based on Maine's demand for electricity. Emissions estimates based on electricity consumption include emissions from all electricity generated to meet the electricity consumption demand in the state of Maine. These emissions include electricity generated in the state and consumed in the state as well as electricity generated outside of the state and imported into Maine. These emissions do not include electricity generated in the state and exported for consumption elsewhere. Electricity consumption data by sector as well as electricity import and export data are available in Appendix E.

Figure 9 illustrates the difference in CO_2 emissions based on electricity consumption and electricity production from 1990 to 2021. While biogenic emissions data from the combustion of renewable fuels used to generate electricity are not available for emissions based on electricity consumption, they are available for emissions based on electricity production, so the figure includes a time series of emissions estimates from the production of electricity both with and without biogenic emissions. All three time series show a decline in emissions from 1990 to 2021. The data show a 41% decrease in CO_2 emissions from the production of electricity during that time frame, including emissions from the use of renewable fuels combusted to generate electricity, and a 73% decrease from the peak in 2002. There was a 70% decrease in emissions based on the consumption of electricity in Maine from 1990 to 2021; however, these data exclude emissions from combustion of renewable fuels to generate electricity.

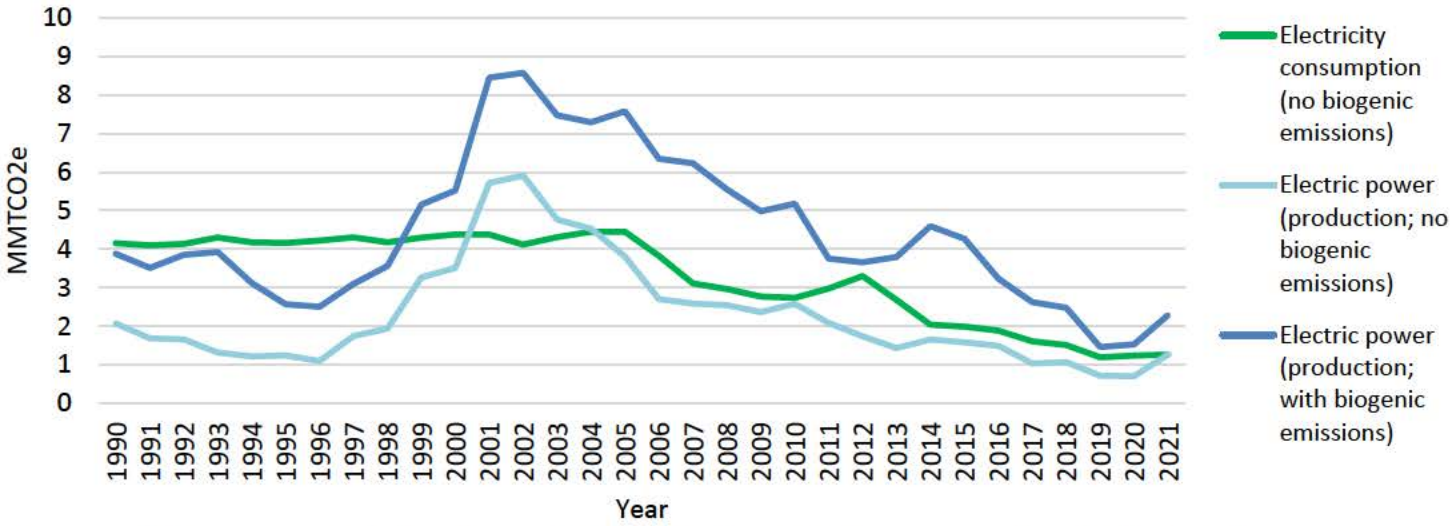

Figure 9. CO_2 emissions from fuel combusted to generate electricity (electricity production) compared to indirect CO_2 emissions based on electricity consumed. (Note: Electricity consumption data with biogenic emissions is not available)

The breakdown of emissions based on electricity consumption for each energy sector is shown in Figure 10. The industrial sector has seen the greatest decline in emissions based on electricity consumption, with an 84% decrease from 1990 to 2021.[21]

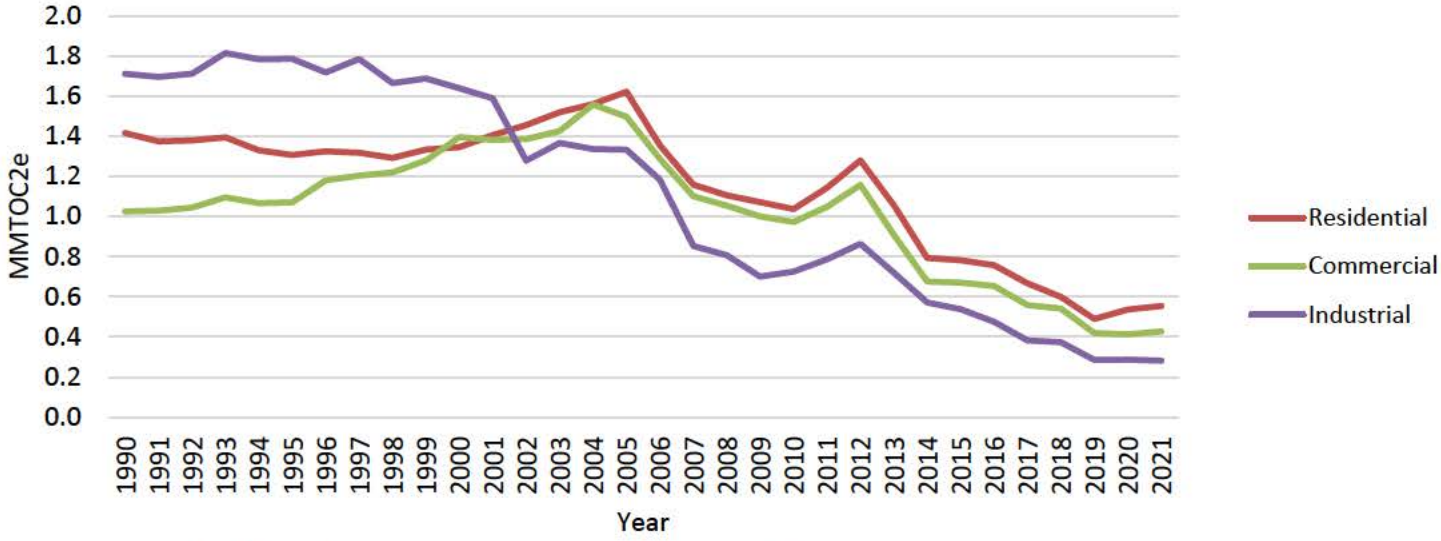

Figure 10. Indirect CO_2 emissions from the consumption of electricity by energy sector (biogenic emissions are not available for consumption-based electricity emissions data; transportation emissions not measurable during this period).

[21] Emissions based on electricity consumption from the industrial sector do not include consumption of on-site generated electricity.

Industrial

The industrial sector generated 20% of Maine's gross GHG emissions in 2021 with 4.33 MMTCO2e, 58% less than in 1990 (Appendix A, Table A4). The combustion of fossil fuels accounted for 1.51 MMTCO2e, which was 35% of the emissions from this sector in 2021 and 51% less than in 1990. The industrial sector was responsible for 10% of the state's total fossil-fuel-based CO2 emissions (Appendix B). In 2021, almost twice as much energy was generated using natural gas in the industrial sector compared to generation using petroleum. In this sector, 41% of the energy consumed was from renewable energy sources (wood, hydropower, waste, and fuel ethanol), compared to 59% in 1990 (Appendix E, Figure E4). Combustion of wood within the industrial sector amounted to 2.82 MMTCO2e in 2021, which was 65% of the GHG emissions from this sector and 61% less than in 1990.

Commercial

The commercial sector generated 9% of Maine's gross GHG emissions in 2021 with 2.04 $MMTCO_2e$, 12% less than in 1990 (Appendix A, Table A4). CO_2 from the combustion of fossil fuels accounted for 1.76 $MMTCO_2e$, which was 86% of the emissions from this sector in 2021 and 22% less than in 1990. The commercial sector was responsible for 12% of the state's total fossil-fuel-based CO_2 emissions (Appendix B). During this same period, there was a 458% increase in the use of natural gas and a 35% decrease in the use of petroleum. Combustion of petroleum accounts for 72% of CO_2 emissions from the combustion of fossil fuels in the sector. In 2021, renewable energy sources provided 10% of the energy used by this sector, up from 7% in 1990 (Appendix E, Figure E5). Combustion of wood within the commercial sector amounted to 0.27 $MMTCO_2e$ in 2021, which was 13% of the GHG emissions from this sector.

Residential

The residential sector generated 19% of Maine's gross GHG emissions in 2021 with 4.19 $MMTCO_2e$, 0.4% less than in 1990 (Appendix A, Table A4). CO_2 from the combustion of fossil fuels accounted for 2.68 $MMTCO_2e$, which was 64% of the emissions from this sector in 2021 and 11% less than in 1990. The residential sector was responsible for 19% of the state's total fossil-fuel-based CO_2 emissions (Appendix B). Exceeding the commercial sector in the consumption of distillate fuel, this sector is highly dependent upon petroleum products and is significantly impacted by fuel price fluctuations. In 2021, petroleum accounted for 94% of all the CO_2 emissions from fossil fuels in this sector and 48% of the energy consumption (Appendix E, Figure E6). The national average for petroleum consumption (BBtu) by the residential sector for 2021 was only 8.3%.[22] Emissions of CO_2 from residential petroleum combustion peaked in 2004 at 5.2 $MMTCO_2$ and have declined by 52% between 2004 and 2021. Between 2005 and 2021, the cost of home heating oil increased from $1.93 per gallon (February 2005) to $3.88 per gallon (February 2014) and $3.15 per gallon (December 2021)[23], which incentivized residents to find more economical heating fuels, to make homes more energy efficient, and to invest in higher efficiency heating equipment. The use of both cordwood and wood pellets as a fuel replaced a portion of this heating load, and Maine saw four pellet mills begin operations from 2006 to 2008.[24] Wood accounted for 22% of the residential energy consumption in 2021, up from 19% in 1990. Combustion of wood amounted to

[22] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php, file name: use_US.csv)

[23] Maine Governor's Energy Office. Heating Oil Prices, https://www.maine.gov/energy/index.php/heating-fuel-prices

[24] Northeast Pellets, Corinth Wood Pellets, Geneva Wood Fuels, and Maine Woods Pellets.

1.51 $MMTCO_2e$, 36% of the gross GHG emissions from this sector. The residential sector, along with the transportation sector, has been the least served by natural gas. In 2021, 4% of the residential energy consumed was natural gas, up from 1% in 1990.

Transportation

The transportation sector generated 34% of Maine's gross GHG emissions in 2021 with 7.52 $MMTCO_2e$, 9% less than in 1990 (Appendix A, Table A4). CO_2 from the combustion of fossil fuels accounted for 7.1 $MMTCO_2e$, which was 94% of the emissions from this sector in 2021 and 14% less than in 1990. The transportation sector was responsible for 49% of the state's total CO_2 emissions from the combustion of fossil fuels, up from 43% in 1990 (Appendix B). Petroleum accounts for 99% of the fossil-fuel-based CO_2 emissions and 98% of the energy consumed by the transportation sector (Appendix E, Figure E7). The transportation sector consumed 7% less energy in 2021 than in 1990. CO_2 emissions from the combustion of fossil fuel in the transportation sector decreased by 12% over the reporting period. The larger decrease in emissions relative to the smaller decrease in energy consumed is attributed in part to improved efficiency of mobile fuel combustion technology. Combustion of biofuels within the transportation sector, including fuel ethanol and biodiesel, generated 0.42 $MMTCO_2e$ in 2021, 6% of the GHG emissions from this sector.

d. Emissions from Combustion of Renewable Fuels

Renewable energy resources include fuel ethanol, biodiesel, wood and wood waste products including black liquor[25], non-wood biomass waste, hydroelectric, wind, solar, and geothermal. Combustible renewable fuels (predominately wood, fuel ethanol, and biodiesel) generate biogenic GHG emissions, and these emissions are included in the gross GHG emission totals of this report.

Wood

The trend in GHG emissions from the combustion of wood by each energy sector can be seen in Figure 11. Wood combustion accounted for 26% (5.63 $MMTCO_2e$) of Maine's gross GHG emissions in 2021, down 46% from 10.40 $MMTCO_2e$ in 1990 (Appendix A, Table A4). The industrial sector outstripped other sectors in the use of wood for energy over the reporting period, contributing 50% of the GHG emissions from wood in 2021 (and 61% less than in 1990).[26] The electric power sector has historically been the second largest contributor to emissions from wood combustion; however, in 2017, the electric power sector emissions from this renewable fuel fell below residential sector emissions and have remained lower through 2021. Electric power emissions from wood combustion were 1.02 $MMTCO_2e$ in 2021, 43% lower than in 1990. The use of wood for energy has increased by 26% in the residential sector, from 1.20 $MMTCO_2e$ in 1990 to 1.51 $MMTCO_2e$ in 2021. In comparison to other sectors, the commercial sector relies very little on this renewable fuel for energy, with emissions increasing from 0.09 $MMTCO_2e$ in 1990 to 0.27 $MMTCO_2e$ in 2021.

[25] Black liquor from the kraft pulping process.

[26] Industrial wood combustion includes the combustion of both biomass (including bark) and black liquor solids.

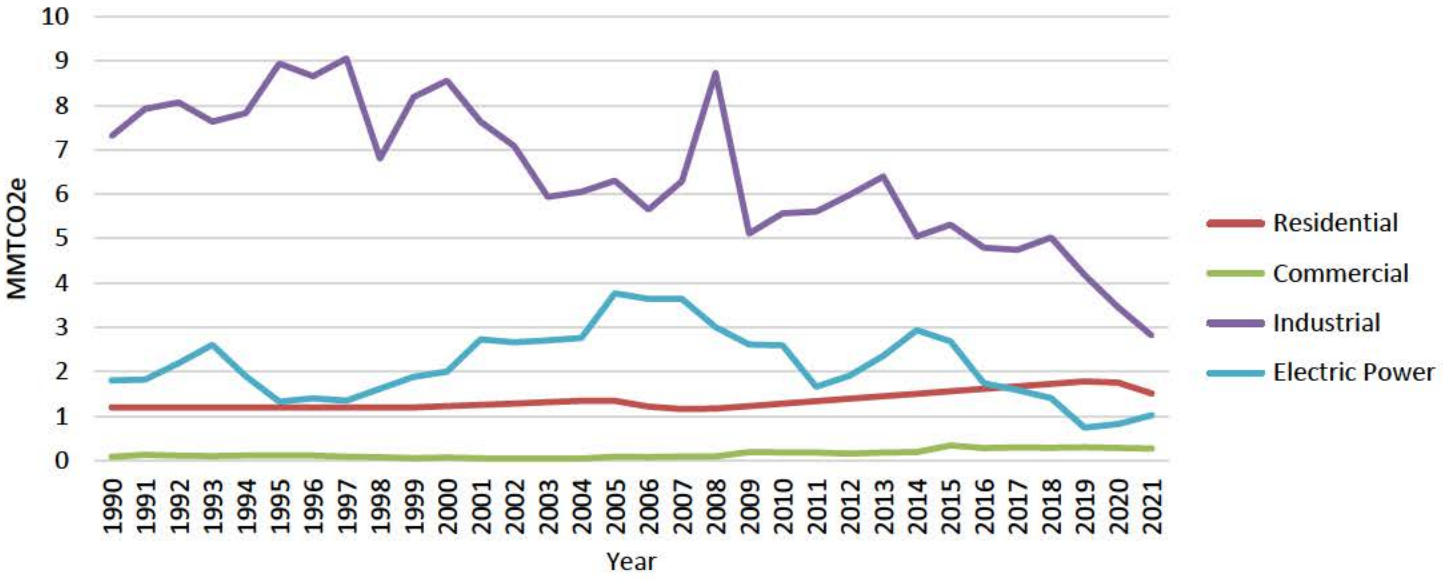

Figure 11. Greenhouse gas emissions from the combustion of wood by energy sector (1990-2021)

Fuel Ethanol and Biodiesel

The transportation sector utilizes two renewable fuel sources to generate energy: fuel ethanol and biodiesel. Biodiesel is currently limited to the transportation sector, while fuel ethanol is consumed in the industrial and commercial sectors as well, albeit in significantly lower quantities. The transportation sector began mixing fuel ethanol with motor gasoline in 2005, and biodiesel use by the sector began shortly thereafter in 2007. The time series of emissions for both fuel types by sector can be seen in Figure 12. While consumption of both renewable fuels has grown, they represent a minor contribution to Maine's gross GHG emissions. In 2021, fuel ethanol emissions were 0.4 $MMTCO_2e$ (1.8% of gross GHG), and biodiesel emissions were 0.0 $MMTCO_2e$ (0.2% of gross GHG).

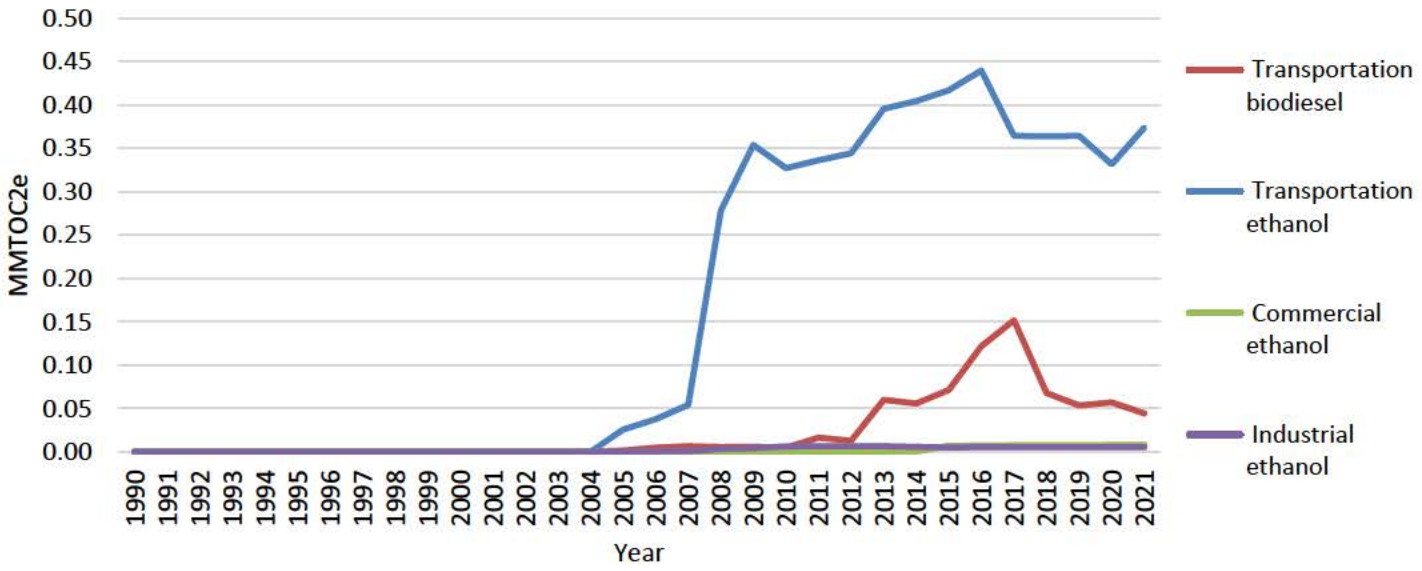

Figure 12. Greenhouse gas emissions from the combustion of ethanol and biodiesel by energy sector (1990-2021)

iii. Economic Analysis of Gross Greenhouse Gas Emissions

Maine's state GDP generally increased through the period from 1990 to 2006, remained relatively flat from 2006 to 2013, and gradually increased again from 2013 to 2019, as shown in Figure 13. It is also evident that emissions of CO_2e had increased overall from 1990 to 2002, at which point they began a marked decrease through 2021. Since 1990, Maine's state GDP grew 71%, from $37 billion in 1990 to $63 billion in 2021.[27] During the same period, energy consumption declined 28%, from 473,831 BBtu to 338,343 BBtu. From 1990 through 2002, GHG emissions increased and tracked very closely with state GDP; however, in 2005, GHG emissions began to decrease significantly (Figure 13, Appendix G).

[27] U.S. Bureau of Economic Analysis, Regional Data, http://www.bea.gov/iTable/index_regional.cfm; Department of Administrative and Financial Services

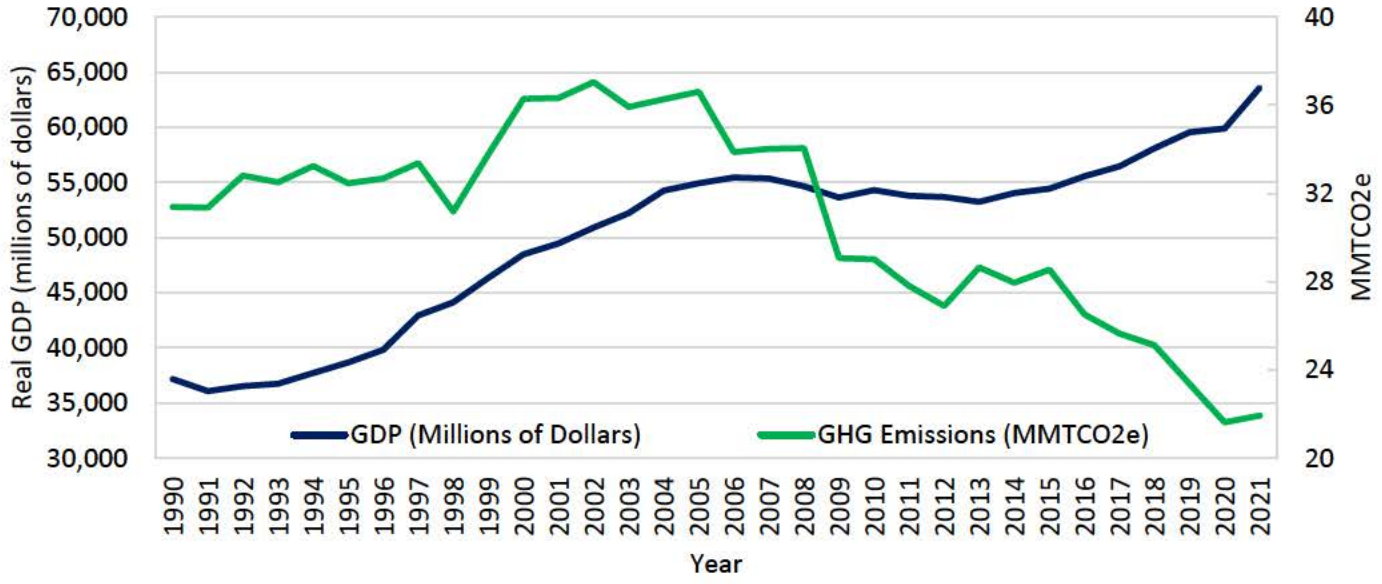

Figure 13. Gross greenhouse gas emissions and state gross domestic product (GDP)

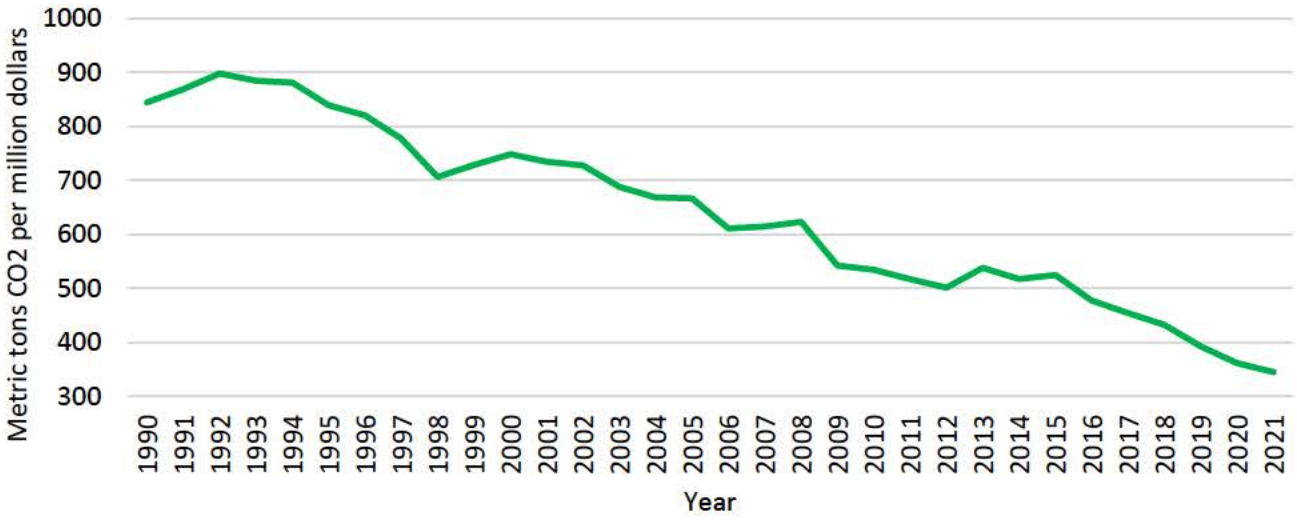

Figure 14. Gross greenhouse gas emissions per state GDP (metric tons CO_2e per million dollars)

Figure 14 illustrates the declining trend in emissions per million dollars of state GDP. This 59% decrease from 1990 to 2021 indicates that the Maine economy is transitioning to lower carbon emitting fuels, more efficient equipment, and industries that require less energy per dollar of state GDP.

B. Net Greenhouse Gas Emissions

Net GHG estimates are used to assess Maine's progress toward reducing net GHG emissions and achieving carbon neutrality by 2045.

i. Maine Carbon Budget

A second version of the Maine carbon budget was compiled by Maine scientists in support of Maine's goals of reducing net GHG emissions and achieving carbon neutrality.[28] The Maine carbon budget illustrated in Figure 15 for a five-year window ending in 2021 shows that Maine is approximately 91% of the way to being carbon neutral. This means 91% of 2021 gross anthropogenic GHG emissions are balanced by sequestration in the environment based on the methodology used in this analysis.

The contributions of major GHG emissions sources (gross anthropogenic emissions, environmental emissions, and outgassing) and sinks (uptake of carbon) are quantified in Figure 15, and the figure depicts how carbon flows through the Maine carbon cycle.[29] The primary source and sink buckets are in boxes along the middle of the figure: gross emissions, wood products, forestland, agriculture, urban areas, inland wetlands, inland waters, coastal wetlands, and coastal waters. Within each of those boxes the sources and sinks of carbon are quantified. Positive numbers represent emissions to the atmosphere, and negative numbers indicate uptake of carbon by the environment. Numbers within the circles above each box indicate the net exchange of carbon with the atmosphere, and numbers within the bottom row of circles indicate flow of carbon within the environment between categories (e.g., to wood products or inland and coastal waters). The two large circles in the blue area at the top are the totals: the emissions sequestered by the environment and the gross GHG emissions remaining in the atmosphere.

Maine's significant forest cover (approximately 89% of the land area of the state) results in the state having a large capacity to store carbon. The recent high accumulation rate of forest carbon via tree growth is offsetting a high percentage of anthropogenic gross GHG emissions. With an estimated net uptake of 22.2 $MMTCO_2e$ per year, the forest, including live biomass, dead biomass, and soils, represents the largest category of annual GHG removal from the atmosphere for the period of measurement. Of this net annual uptake, 14.8 $MMTCO_2e$ is sequestered in the forestland (total carbon stored within the green box in Figure 15), 6 $MMTCO_2e$ is harvested, and 1.4 $MMTCO_2e$ leaves the forest through aquatic transport. While some carbon from wood harvested in Maine remains stored in wood products, the decay of wood as well as the combustion of wood for energy result in a release of GHG to the atmosphere of 4.4 $MMTCO_2e$. Agriculture (0.2 $MMTCO_2e$) and urban environments (0.9 $MMTCO_2e$) are also net emitters of GHG. Processes in inland wetlands, inland waters, and coastal waters result in net emissions (0.7, 0.8, and 0.6 $MMTCO_2e$, respectively), while coastal wetlands sequester 0.07 $MMTCO_2e$. In total, environmental emissions, outgassing, and

[28] Hayes, D., Brewer, A., Daigneault, A., Enterline, C., Fernandez, I., Frank, J., Johnson, B., Knapp, S., Legaard, K., Price, N., Puryear, K., Simons-Legaard, E., Stevens, A., Wei, X., Weiskittel, A. (2024). The State of Maine's Carbon Budget (Version 2, 2017 - 2021). https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/.

[29] Biomass combusted for energy is not explicitly listed in these data; however, these biogenic emissions are indirectly accounted for through the forest carbon stock change assessment method used for this analysis.

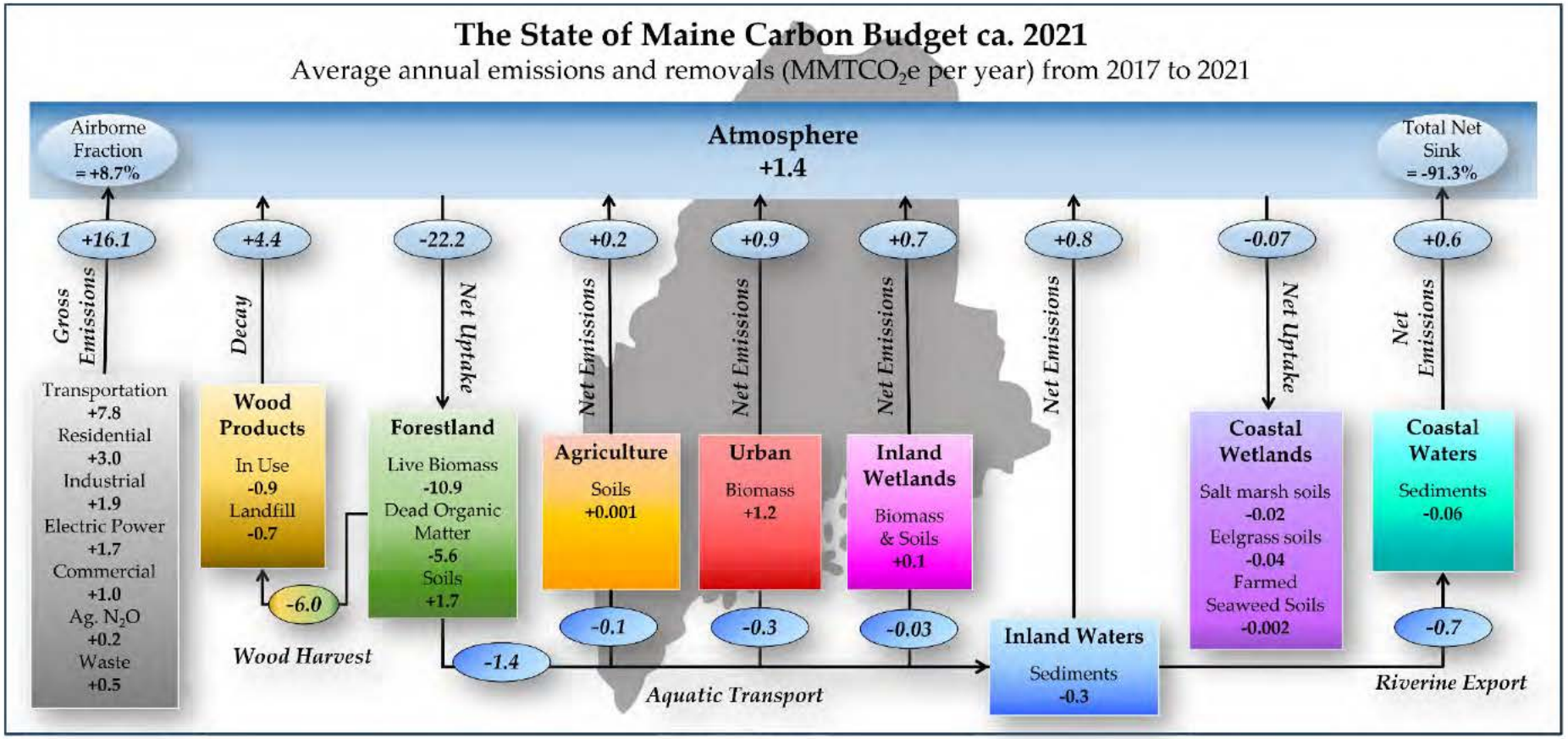

Figure 15. Maine's carbon budget in $MMTCO_2e$ (based on a five-year period ending in 2021)

uptake of carbon in the environment result in a net uptake of 14.7 $MMTCO_2e$ per year, which is 91% of the 2021 gross anthropogenic GHG emissions (16.1 $MMTCO_2e$). That leaves 8.7% of Maine's gross GHG emissions (or 1.4 $MMTCO_2e$) as net annual emissions to the atmosphere.

There are many uncertainties with this type of comprehensive carbon accounting, and efforts are already underway to improve future estimates of the Maine carbon budget, update the data through 2023 for the next biennial report, and identify research needs.

ii. Forest Carbon Markets

Participation in carbon markets is growing in Maine, in the nation, and internationally. Figure 16 shows both the carbon credits issued and the credits retired for all Maine land enrolled in carbon markets since the first credits were issued in 2003. Carbon credits are issued when they are approved in a carbon market project and available to a project owner to sell. Carbon credits are retired when they are "used," i.e., when the issued credits are purchased by another entity and used to offset their carbon emissions. When carbon credits are used, they are retired and removed from the market to avoid double counting.

As of 2021, there were 24 forestry projects with listed carbon offset credits in Maine.[30] The annual average sum of the credits retired in these 24 Maine forest projects for the five-year window considered in Maine's net inventory (2017-2021) was 1.2 $MMTCO_2e/yr$. While this number is relatively small compared to Maine's gross and net GHG emissions, the Department will continue to track participation and report carbon allocated to these projects for consideration in assessing Maine's progress in reducing net greenhouse gas emissions and towards Maine's 2045 carbon neutrality goal.

If the forested land in Maine enrolled in carbon markets results in credits leaving the state, the carbon sequestration values in Maine's carbon budget can be adjusted. The 14.7 $MMTCO_2e$ sequestered annually by Maine's environment (as reported in 2024 for the years 2017-2021) should be reduced by any carbon credited in carbon markets during this same five-year period (1.2 $MMTCO_2e$) that were sold outside of Maine. If it is assumed that all Maine carbon credits sold during this period were sold out of state, then the total carbon sequestered becomes 13.5 $MMTCO_2e$ (14.7 $MMTCO_2e$ minus 1.2 $MMTCO_2e$). Instead of 91% of gross GHG emissions being offset by sequestration in the environment in Maine for this reporting period, the offset would be adjusted for carbon credits sold out of state and counted elsewhere, and the Maine offset becomes 84%.

At present, there are not complete data sets on carbon offsets generated in Maine or where carbon credit buyers are located. The carbon offset market in Maine is small, but growing, and no official state policy exists to date on the specifics of net carbon exchange calculations. Several initiatives are emerging in the state to continuously improve our tracking of greenhouse gases and carbon cycling. Therefore, in this report we continue to lead with a net carbon exchange calculation without assumptions about carbon offsets sold but present both calculations (with and without carbon offsets), to the best of our ability, to guide the ongoing discussions on this issue.

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[30] Ivy S. So, Barbara K. Haya, Micah Elias. (2023, December). Voluntary Registry Offsets Database v9, Berkeley Carbon Trading Project, University of California, Berkeley. Retrieved from: https://gspp.berkeley.edu/faculty-and-impact/centers/cepp/projects/berkeley-carbon-trading-project/offsets-database

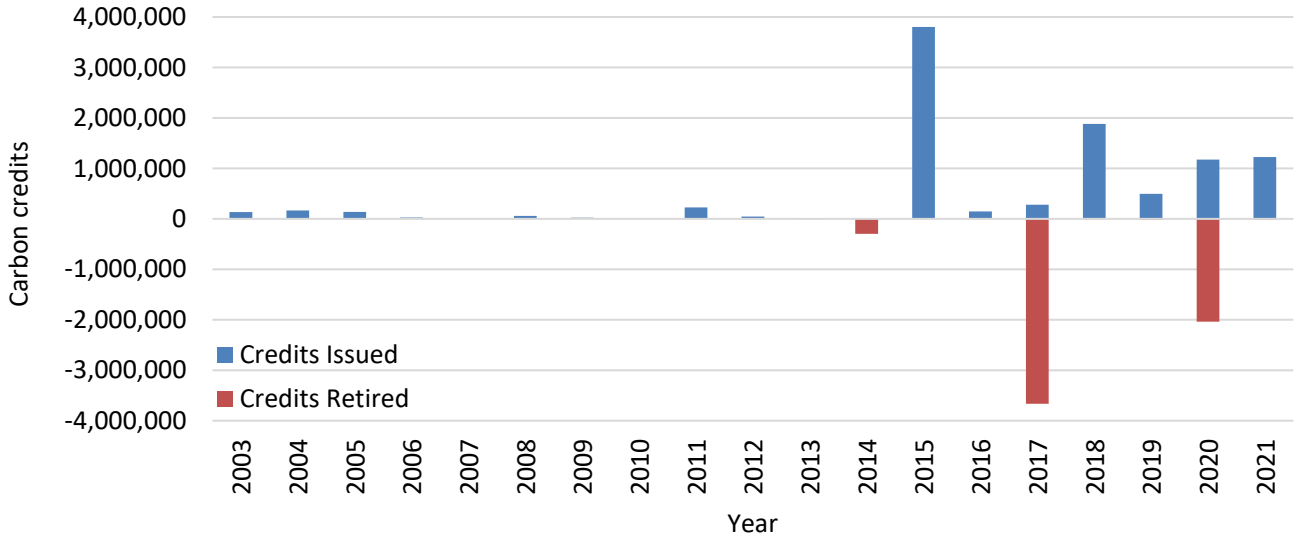

Figure 16. Maine forest carbon project offset issuance and Retirement (tCO_2e)
(Note: 1 carbon credit is equal to 1 $MTCO_2e$.)

iii. Net GHG Emissions Time Series

While this second estimate of Maine's carbon budget is a robust snapshot of Maine's progress toward meeting the statutory carbon neutrality goal, it represents a single point in time. A time series is useful in determining historical and projected trends to better assess Maine's trajectory toward reducing net GHG emissions and achieving carbon neutrality. Figure 17 shows historical (1990-2021) and projected (2022-2050) Maine GHG emissions based on the Department's gross historical GHG emission calculations, projected gross GHG emissions to achieve the 2030 and 2050 gross GHG emission statutory reduction requirements, and forest carbon data from the University of Maine.[31] This figure illustrates forest contributions to carbon uptake in the form of growth, wood products, and wood energy that together determine carbon removed from the atmosphere.

[31] Forest carbon data are collected by the Maine Forest Service in collaboration with the Forest Inventory and Analysis National Program (FIA). The data are processed by FIA (Burrill et al., 2023), and carbon stocks and sequestration are estimated using methods described in Westfall et al (2023) and Hayes et al (2024). The University of Maine used these primary data sources to isolate the forest carbon data for Maine used in the time series.

- Westfall, James A.; Coulston, John W.; Gray, Andrew N.; Shaw, John D.; Radtke, Philip J.; Walker, David M.; Weiskittel, Aaron R.; MacFarlane, David W.; Affleck, David L.R.; Zhao, Dehai; Temesgen, Hailemariam; Poudel, Krishna P.; Frank, Jereme M.; Prisley, Stephen P.; Wang, Yingfang; Sánchez Meador, Andrew J.; Auty, David; Domke, Grant M. 2023. A national-scale tree volume, biomass, and carbon modeling system for the United States. Gen. Tech. Rep. WO-104. Washington, DC: U.S. Department of Agriculture, Forest Service. 60 p. https//doi.org/10.2737/WO-GTR-104.
- Burrill, Elizabeth A.; Christensen, Glenn. Conkling, Barbara L., DiTommaso, Andrea M.; Lepine, Lucie.; Perry, Carol J.; Pugh, Scott A.; Turner, Jeffery A., Walker, David; Williams, Mary A.; 2023. The Forest Inventory and Analysis Database: database description and user guide Phase 2, Version 9.1. U.S. Department of Agriculture, Forest Service. 1066 p. [Online]. Available at web address: https://www.fs.usda.gov/research/understory/forest-inventory-and-analysis-database-user-guide-nfi.
- Hayes, D., Brewer, A., Daigneault, A., Enterline, C., Fernandez, I., Frank, J., Johnson, B., Knapp, S., Legaard, K., Price, N., Puryear, K., Simons-Legaard, E., Stevens, A., Wei, X., Weiskittel, A. (2024). The State of Maine's Carbon Budget (Version 2, 2017 - 2021). https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/.

Subtracting Total Forest Sector Carbon from Gross GHG Emissions w/Biogenic results in net annual emissions of GHG. Annual net GHG emissions equal to zero is carbon neutrality. Note: This time series is not as robust as the Maine Carbon Budget in terms of the data included because not all data are available for the entire time series beginning in 1990.

Maine has a statutory requirement to reduce GHG emissions and achieve carbon neutrality by 2045. The data in Figure 17 suggest Maine is approximately at carbon neutrality now; however, as noted above, these data are not as inclusive as the 2017-2021 carbon budget, which is the formal assessment of Maine's net GHG emissions for this reporting period and indicates Maine is 91% carbon neutral. Note that this net time series is based on a number of assumptions including a continuous glide path of gross GHG emissions meeting the statutory gross GHG reduction goals (a 45% reduction from 1990 emissions by 2030, and an 80% reduction from 1990 emissions by 2050). The projected data also assume that the relatively high rate of forest carbon sequestration in the recent past compared to previous years will be maintained indefinitely. The data do not consider potential increases or decreases in future forest carbon sequestration rates in Maine due to management, new incentives, forest disturbance, or natural forest successional processes. Finally, these data are not adjusted for forests enrolled in carbon markets that may have sold their offsets to entities located outside the state.

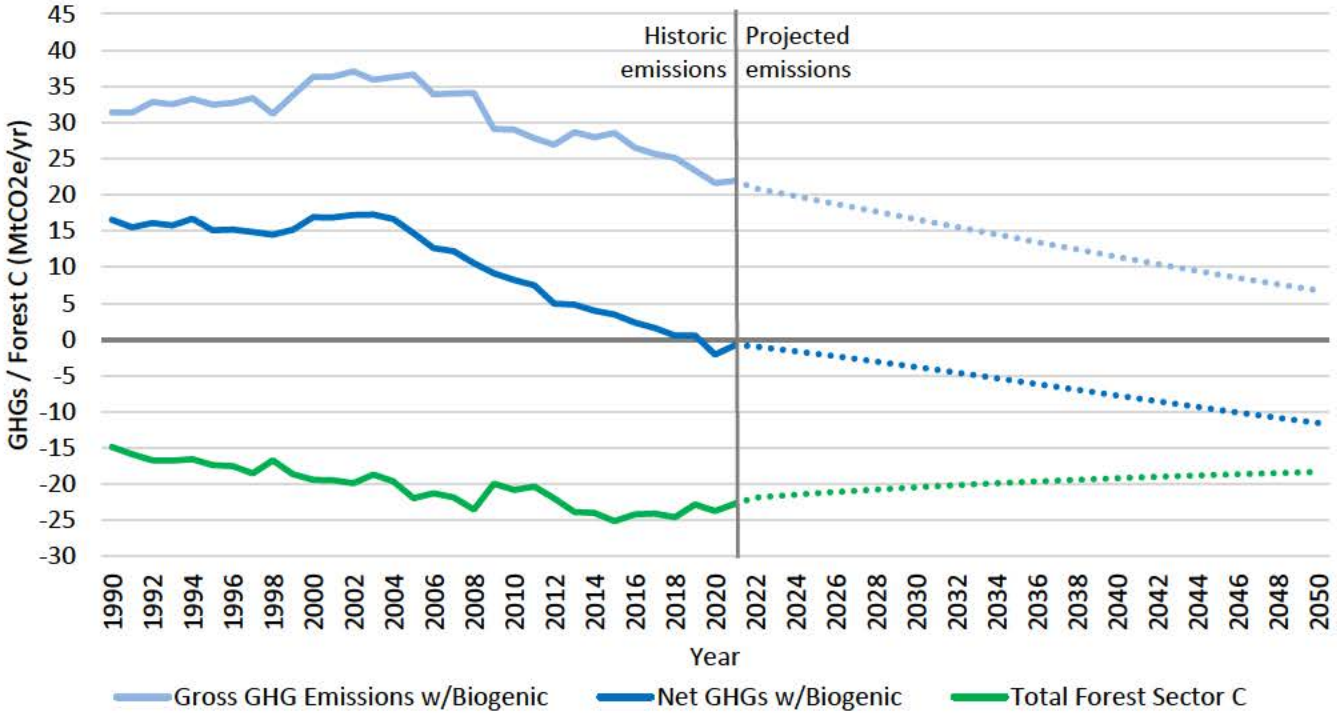

Figure 17. Maine greenhouse gas emissions and forest sector carbon (1990-2050)[32] (Projected data are based on several assumptions listed at the beginning of this section, including that Maine meets the statutory gross greenhouse gas reduction goals and the high rate of forest carbon sequestration continues.)

[32] The forest sector time series and projection data were developed and provided by the University of Maine. The data for this figure are accessible on Dr. Adam Daigneault's lab website at the University of Maine at https://umaine.edu/forestpolicy/models-and-data/

IV. Conclusion

This tenth biennial report on Maine's progress toward statutory GHG reduction targets provides an updated analysis of gross GHG emissions for the period of 1990 to 2021 as well as an estimate of net GHG emissions for the five-year period ending in 2021. The data in Figure 18 (Appendix A) show that in 2021, Maine's GHG emissions were 30% below 1990 levels, and that Maine has met the reduction target of 10% below 1990 levels by January 1, 2020. Figure 17 illustrates that Maine is also well positioned to meet the 2045 carbon neutrality goal with continued progress on gross GHG emissions reductions. The slope of the gross GHG emissions line between 2002 and 2021 (Figure 18) suggests Maine is on track to meet the statutory gross GHG reduction goals in 2030 and 2050. As it becomes available, future emissions data will be used to continue to track Maine's progress toward meeting the state's gross GHG goals of 45% below 1990 levels by January 1, 2030, and 80% below 1990 levels by 2050 (Figure 18).

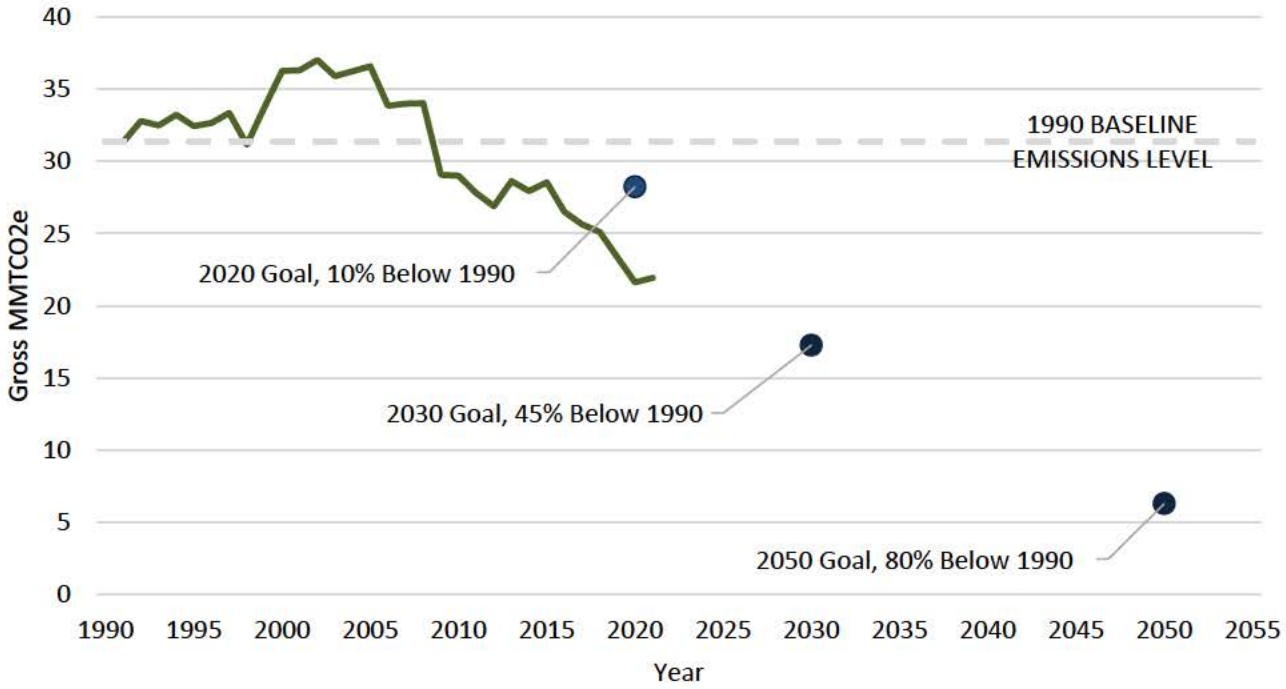

Figure 18. Maine's gross greenhouse gas emissions, including biogenic, 1990-2021 with 2020, 2030, and 2050 reduction goals.

V. Appendices

Appendix A: Maine greenhouse gas emissions in $MMTCO_2e$

Table A1. Maine's gross greenhouse gas emissions by source category in MMTCO2e (1990 - 2021) (including biogenic emissions)

	Energy	Industrial Processes	Agriculture	Waste	Gross Emissions
1990	29.42	0.67	0.52	0.79	31.39
1991	29.38	0.66	0.51	0.81	31.36
1992	30.73	0.72	0.51	0.85	32.81
1993	30.32	0.79	0.53	0.87	32.51
1994	31.08	0.73	0.51	0.93	33.25
1995	30.29	0.77	0.50	0.91	32.46
1996	30.51	0.72	0.54	0.91	32.68
1997	31.06	0.77	0.59	0.95	33.38
1998	28.73	0.81	0.63	1.01	31.18
1999	31.32	0.81	0.63	1.02	33.78
2000	33.93	0.80	0.53	1.03	36.29
2001	33.93	0.80	0.56	1.04	36.33
2002	34.85	0.81	0.59	0.80	37.05
2003	33.87	0.75	0.60	0.70	35.92
2004	34.27	0.79	0.62	0.59	36.27
2005	34.54	0.80	0.67	0.61	36.61
2006	31.74	0.81	0.70	0.63	33.88
2007	31.91	0.83	0.72	0.56	34.02
2008	32.14	0.72	0.72	0.47	34.05
2009	27.47	0.49	0.66	0.45	29.07
2010	27.44	0.53	0.56	0.49	29.02
2011	26.34	0.51	0.47	0.49	27.81
2012	25.40	0.53	0.48	0.49	26.90
2013	27.20	0.46	0.49	0.49	28.65
2014	26.61	0.41	0.45	0.49	27.95
2015	27.20	0.41	0.47	0.47	28.55
2016	25.27	0.28	0.48	0.48	26.51
2017	24.30	0.39	0.49	0.47	25.65
2018	23.69	0.46	0.49	0.47	25.11
2019	21.93	0.46	0.49	0.47	23.37
2020	20.29	0.41	0.46	0.47	21.63
2021	20.52	0.52	0.41	0.48	21.93

Table A2. Maine's gross greenhouse gas emissions by source category in MMTCO2e (1990 - 2021) (excluding biogenic emissions)

	Energy	Industrial Processes	Agriculture	Waste	Gross Emissions
1990	19.01	0.67	0.52	0.55	20.75
1991	18.30	0.66	0.51	0.58	20.06
1992	19.16	0.72	0.51	0.61	20.99
1993	18.77	0.79	0.53	0.64	20.73
1994	20.04	0.73	0.51	0.68	21.96
1995	18.70	0.77	0.50	0.65	20.63
1996	19.14	0.72	0.54	0.68	21.07
1997	19.37	0.77	0.59	0.71	21.44
1998	19.03	0.81	0.63	0.72	21.19
1999	19.98	0.81	0.63	0.74	22.17
2000	22.07	0.80	0.53	0.76	24.17
2001	22.25	0.80	0.56	0.79	24.40
2002	23.77	0.81	0.59	0.56	25.72
2003	23.85	0.75	0.60	0.49	25.70
2004	24.06	0.79	0.62	0.43	25.90
2005	23.00	0.80	0.67	0.45	24.92
2006	21.10	0.81	0.70	0.46	23.07
2007	20.66	0.83	0.72	0.41	22.62
2008	18.86	0.72	0.72	0.35	20.65
2009	17.95	0.49	0.66	0.35	19.45
2010	17.47	0.53	0.56	0.37	18.93
2011	17.18	0.51	0.47	0.37	18.54
2012	15.57	0.53	0.48	0.38	16.97
2013	16.34	0.46	0.49	0.38	17.68
2014	16.45	0.41	0.45	0.38	17.68
2015	16.79	0.41	0.47	0.37	18.04
2016	16.25	0.28	0.48	0.38	17.39
2017	15.46	0.39	0.49	0.38	16.72
2018	14.79	0.46	0.49	0.37	16.12
2019	14.49	0.46	0.49	0.38	15.82
2020	13.55	0.41	0.46	0.37	14.80
2021	14.46	0.52	0.41	0.37	15.76

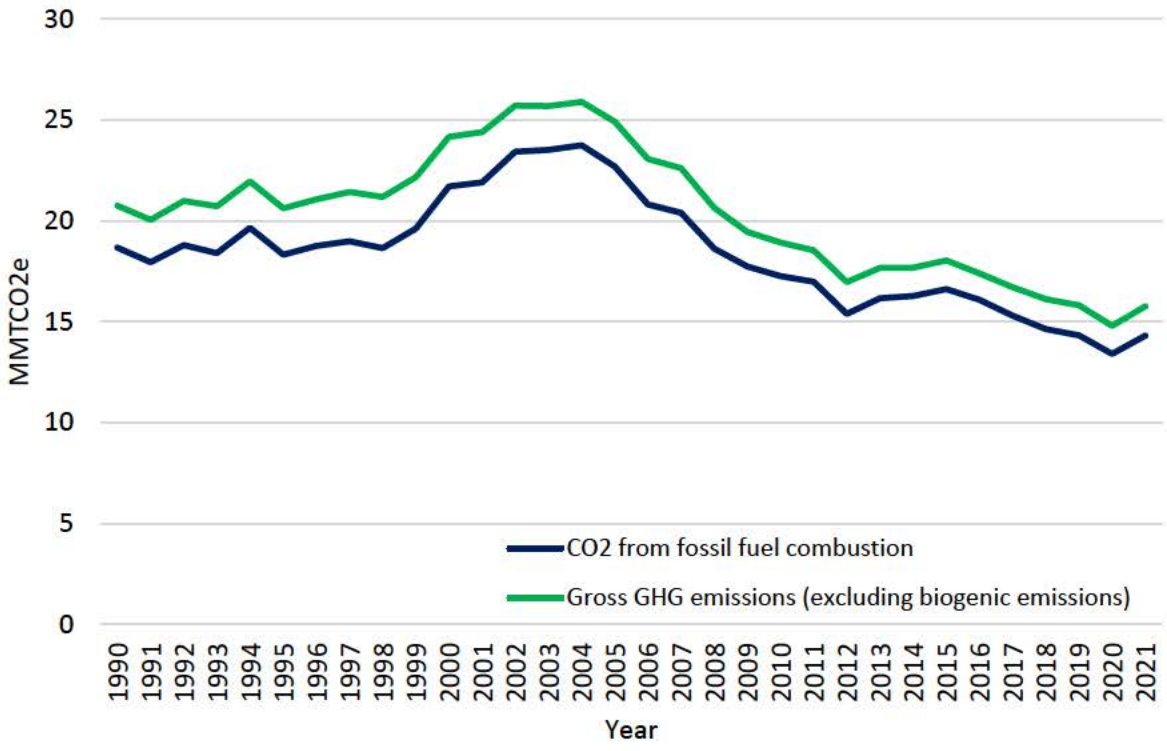

Figure A1. Maine's gross greenhouse gas emissions 1990-2021 (excluding biogenic emissions)

Table A3. Percent increases and decreases compared to the 1990 gross greenhouse gas emissions baseline (includes biogenic emissions; negative percentages indicate a reduction in emissions; positive percentages indicate an increase in emissions)

Year	% change	Year	% change	Year	% change
1990	0%	2001	16%	2012	-14%
1991	0%	2002	18%	2013	-9%
1992	5%	2003	14%	2014	-11%
1993	4%	2004	16%	2015	-9%
1994	6%	2005	17%	2016	-16%
1995	3%	2006	8%	2017	-18%
1996	4%	2007	8%	2018	-20%
1997	6%	2008	8%	2019	-26%
1998	-1%	2009	-7%	2020	-31%
1999	8%	2010	-8%	2021	-30%
2000	16%	2011	-11%		

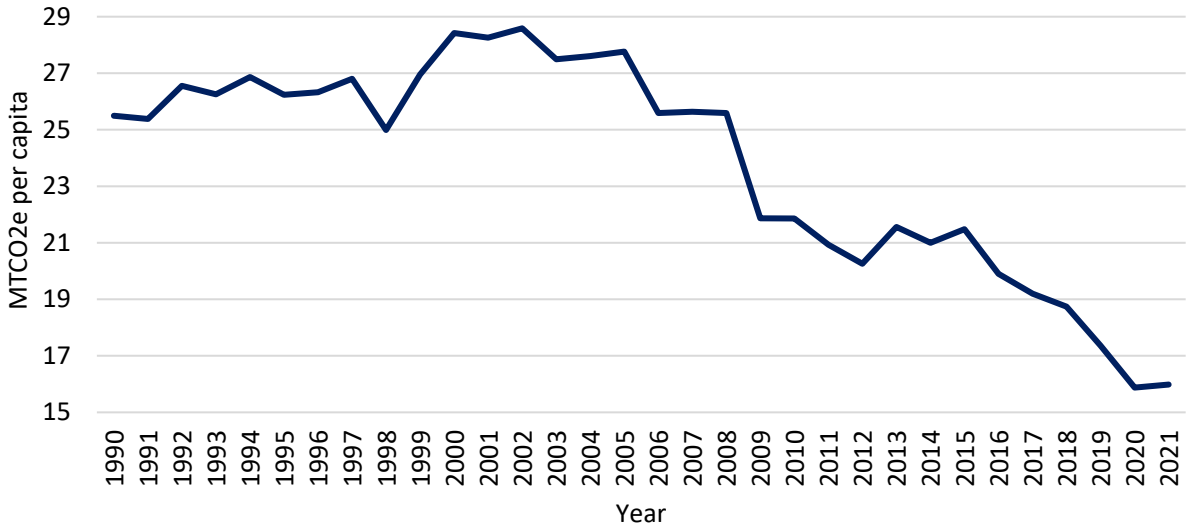

Figure A2. Maine's gross greenhouse gas emissions per capita 1990-2021
(Greenhouse gas emissions include biogenic emissions)

Table A4. Maine's gross greenhouse gas emissions by energy sector with source category ($MMTCO_2e$; 1990 - 2021)

	Source category	1990	2000	2010	2015	2019	2020	2021
ENERGY SECTOR EMISSIONS TOTAL		29.38	29.10	33.62	27.15	26.97	21.76	20.16
Residential Total		4.21	5.19	3.97	4.63	4.84	4.64	4.19
Fossil fuel combustion CO_2	Energy	2.99	3.94	2.67	3.05	3.03	2.87	2.67
Fossil fuel combustion CH_4 & N_2O	Energy	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Wood combustion	Energy (biogenic)	1.20	1.23	1.29	1.56	1.79	1.76	1.51
Commercial Total		2.34	1.99	1.92	2.14	2.10	1.92	2.04
Fossil fuel combustion CO_2	Energy	2.23	1.91	1.72	1.78	1.77	1.61	1.75
Fossil fuel combustion CH_4 & N_2O	Energy	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ethanol combustion	Energy (biogenic)	0.00	0.00	0.00	0.01	0.01	0.01	0.01
Wood combustion	Energy (biogenic)	0.09	0.07	0.19	0.34	0.30	0.29	0.27
Industrial Total		10.41	12.29	7.76	6.85	5.74	5.03	4.33
Fossil fuel combustion CO_2	Energy	3.09	3.72	2.18	1.53	1.55	1.57	1.51
Fossil fuel combustion CH_4 & N_2O	Energy	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Ethanol combustion	Energy (biogenic)	0.00	0.00	0.01	0.01	0.01	0.01	0.01
Wood combustion	Energy (biogenic)	7.31	8.55	5.57	5.31	4.18	3.46	2.82
Transportation Total		8.27	8.64	8.33	9.08	7.63	7.04	7.52
Fossil fuel combustion CO_2	Energy	8.02	8.37	7.86	8.49	7.13	6.58	7.03
Fossil fuel combustion CH_4 & N_2O	Energy	0.25	0.27	0.14	0.10	0.08	0.08	0.08
Ethanol combustion	Energy (biogenic)	0.00	0.00	0.33	0.42	0.36	0.33	0.37
Biodiesel combustion	Energy (biogenic)	0.00	0.00	0.00	0.07	0.05	0.06	0.04
Electric Power Total		3.88	5.52	5.18	4.27	1.46	1.53	2.29
Fossil fuel combustion CO_2	Energy	2.06	3.51	2.58	1.58	0.71	0.70	1.26
Fossil fuel combustion CH_4 & N_2O	Energy	0.01	0.01	0.00	0.00	0.00	0.00	0.00
Wood combustion	Energy (biogenic)	1.81	2.01	2.60	2.69	0.74	0.83	1.02
NON-ENERGY SECTOR EMISSIONS TOTAL								
Natural gas distribution system CH_4 fugitive emissions	Energy	0.04	0.04	0.03	0.04	0.04	0.04	0.04
CO_2 from combustion of international bunker fuels	Energy	0.28	0.27	0.27	0.19	0.13	0.08	0.10
Industrial processes	Industrial processes	0.67	0.80	0.53	0.41	0.46	0.41	0.52
Agriculture	Agriculture	0.52	0.53	0.56	0.47	0.49	0.46	0.41
Wastewater	Waste	0.15	0.17	0.17	0.16	0.16	0.16	0.16
Municipal solid waste	Waste	0.40	0.60	0.20	0.21	0.22	0.21	0.21
Solid waste (biogenic CO_2 emissions)	Waste (biogenic)	0.23	0.26	0.11	0.10	0.09	0.09	0.11
Gross GHG emissions		**31.39**	**36.29**	**29.02**	**28.55**	**23.37**	**21.63**	**21.93**

Appendix B: CO_2 emissions from fossil fuel combustion in Maine

Table B1. Carbon dioxide emissions from fossil fuel combustion (1990 - 2000)

MMTCO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Residential Total	2.99	3.00	3.01	3.13	3.21	3.94	4.06	3.93	4.23	4.03	3.94
Coal	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	2.94	2.95	2.95	3.07	3.16	3.89	4.00	3.87	4.18	3.98	3.87
Natural Gas	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06
Commercial Total	2.23	2.21	1.79	1.77	1.80	1.53	1.68	1.65	1.71	1.59	1.91
Coal	0.08	0.03	0.07	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Petroleum	2.06	2.08	1.60	1.60	1.66	1.39	1.54	1.50	1.57	1.45	1.73
Natural Gas	0.09	0.10	0.12	0.12	0.13	0.13	0.14	0.15	0.13	0.14	0.17
Industrial Total	3.09	3.47	4.86	4.61	5.73	4.32	4.37	3.75	3.04	2.75	3.72
Coal	0.51	0.83	1.89	0.98	1.06	0.64	0.51	0.42	0.31	0.26	0.50
Petroleum	2.47	2.53	2.87	3.55	4.58	3.58	3.76	3.21	2.61	2.36	2.48
Natural Gas	0.10	0.11	0.10	0.09	0.09	0.10	0.11	0.13	0.11	0.13	0.74
Transportation Total	8.02	7.29	7.26	7.32	7.49	7.12	7.41	7.79	7.52	7.86	8.37
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	8.02	7.29	7.26	7.32	7.48	7.12	7.41	7.78	7.52	7.86	8.32
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.05
Electric Power Total	2.06	1.68	1.65	1.31	1.21	1.24	1.09	1.74	1.93	3.26	3.51
Coal	0.36	0.58	0.58	0.59	0.57	0.37	0.38	0.39	0.36	0.37	0.40
Petroleum	1.69	1.09	1.07	0.72	0.63	0.86	0.71	1.34	1.57	2.85	1.63
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03	1.47
International Bunker Fuels	0.28	0.31	0.23	0.26	0.22	0.18	0.14	0.13	0.22	0.14	0.27
Petroleum	0.28	0.31	0.23	0.26	0.22	0.18	0.14	0.13	0.22	0.14	0.27
Gross CO2 Emissions	**18.67**	**17.95**	**18.80**	**18.40**	**19.66**	**18.33**	**18.76**	**18.99**	**18.65**	**19.62**	**21.71**
Coal	0.98	1.44	2.55	1.63	1.65	1.02	0.89	0.82	0.68	0.64	0.91
Petroleum	17.46	16.26	15.98	16.51	17.74	17.02	17.56	17.84	17.67	18.64	18.31
Natural Gas	0.23	0.26	0.27	0.27	0.27	0.29	0.30	0.33	0.30	0.34	2.49

Table B2. Carbon dioxide emissions from fossil fuel combustion (2001 - 2011)

MMTCO2	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Residential Total	3.91	3.52	4.82	5.25	4.67	4.05	3.86	3.12	2.94	2.67	2.73
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	3.85	3.46	4.76	5.18	4.61	3.99	3.79	3.06	2.87	2.60	2.65
Natural Gas	0.06	0.06	0.07	0.07	0.06	0.06	0.07	0.06	0.07	0.07	0.08
Commercial Total	1.60	1.82	2.33	2.19	2.11	1.82	2.18	2.18	1.82	1.72	1.86
Coal	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00
Petroleum	1.43	1.53	2.06	1.92	1.84	1.55	1.85	1.85	1.52	1.40	1.49
Natural Gas	0.16	0.29	0.27	0.27	0.27	0.26	0.33	0.33	0.31	0.32	0.36
Industrial Total	3.01	3.43	2.13	3.06	2.75	2.85	2.81	2.72	2.18	2.18	2.22
Coal	0.28	0.20	0.27	0.26	0.29	0.25	0.26	0.23	0.07	0.08	0.05
Petroleum	2.09	2.01	1.69	1.96	2.12	1.68	1.39	1.12	0.76	0.63	0.73
Natural Gas	0.64	1.22	0.17	0.84	0.34	0.92	1.15	1.37	1.35	1.47	1.44
Transportation Total	7.40	8.41	9.32	8.54	8.86	8.92	8.70	7.86	7.94	7.86	7.80
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	7.33	8.36	9.27	8.51	8.83	8.89	8.65	7.81	7.90	7.76	7.67
Natural Gas	0.07	0.05	0.05	0.04	0.03	0.03	0.04	0.05	0.05	0.10	0.13
Electric Power Total	5.71	5.90	4.76	4.52	3.80	2.70	2.58	2.54	2.36	2.58	2.08
Coal	0.44	0.54	0.41	0.41	0.36	0.36	0.34	0.31	0.08	0.14	0.09
Petroleum	0.88	0.36	1.01	0.62	0.73	0.08	0.34	0.17	0.24	0.19	0.11
Natural Gas	4.39	5.00	3.33	3.49	2.71	2.26	1.90	2.05	2.05	2.25	1.88
International Bunker Fuels	0.27	0.35	0.15	0.19	0.50	0.48	0.28	0.19	0.49	0.27	0.29
Petroleum	0.27	0.35	0.15	0.19	0.50	0.48	0.28	0.19	0.49	0.27	0.29
Gross CO2 Emissions	**21.91**	**23.43**	**23.52**	**23.75**	**22.70**	**20.81**	**20.41**	**18.63**	**17.74**	**17.27**	**16.98**
Coal	0.73	0.75	0.69	0.68	0.65	0.61	0.61	0.55	0.15	0.21	0.14
Petroleum	15.86	16.07	18.94	18.38	18.63	16.68	16.31	14.21	13.77	12.85	12.95
Natural Gas	5.32	6.61	3.89	4.70	3.41	3.52	3.49	3.87	3.82	4.21	3.89

Table B3. Carbon dioxide emissions from fossil fuel combustion (2012 - 2021)

MMTCO2	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Residential Total	2.25	2.42	2.57	3.05	2.96	2.99	3.12	3.03	2.87	2.67
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	2.17	2.31	2.44	2.90	2.82	2.84	2.95	2.86	2.70	2.50
Natural Gas	0.08	0.10	0.13	0.15	0.14	0.15	0.17	0.17	0.16	0.16
Commercial Total	1.58	1.62	1.72	1.78	1.62	1.70	1.75	1.77	1.61	1.75
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	1.18	1.17	1.22	1.23	1.15	1.21	1.22	1.23	1.12	1.25
Natural Gas	0.40	0.45	0.49	0.55	0.47	0.49	0.53	0.54	0.49	0.50
Industrial Total	2.10	2.09	1.68	1.53	1.36	1.30	1.41	1.55	1.57	1.51
Coal	0.04	0.06	0.07	0.06	0.04	0.04	0.05	0.04	0.03	0.00
Petroleum	0.51	0.37	0.36	0.40	0.35	0.37	0.39	0.45	0.39	0.40
Natural Gas	1.55	1.67	1.25	1.07	0.96	0.90	0.97	1.06	1.15	1.11
Transportation Total	7.41	8.29	8.42	8.49	8.50	8.16	7.16	7.13	6.58	7.03
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	7.37	8.25	8.35	8.44	8.46	8.12	7.11	7.06	6.52	6.93
Natural Gas	0.04	0.05	0.07	0.05	0.04	0.04	0.05	0.06	0.05	0.10
Electric Power Total	1.74	1.43	1.65	1.58	1.49	1.03	1.07	0.71	0.70	1.26
Coal	0.08	0.09	0.13	0.18	0.17	0.16	0.15	0.16	0.13	0.15
Petroleum	0.09	0.21	0.23	0.43	0.11	0.13	0.15	0.03	0.04	0.05
Natural Gas	1.57	1.13	1.29	0.97	1.21	0.74	0.76	0.52	0.53	1.06
International Bunker Fuels	0.31	0.32	0.25	0.19	0.17	0.12	0.14	0.13	0.08	0.10
Petroleum	0.31	0.32	0.25	0.19	0.17	0.12	0.14	0.13	0.08	0.10
Gross CO2 Emissions	**15.39**	**16.17**	**16.28**	**16.62**	**16.09**	**15.31**	**14.64**	**14.33**	**13.41**	**14.32**
Coal	0.12	0.15	0.20	0.24	0.21	0.20	0.20	0.20	0.15	0.15
Petroleum	11.63	12.62	12.85	13.58	13.07	12.79	11.97	11.77	10.87	11.23
Natural Gas	3.64	3.39	3.23	2.80	2.81	2.31	2.48	2.36	2.39	2.94

Appendix C: Energy sector definitions[33]

- **Electric power sector:** An energy-consuming sector that consists of electricity only and combined heat and power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public (i.e., North American Industry Classification System, or NAICS, code 22 plants). *Note: This sector includes electric power and independent power producers.*

- **Industrial sector:** An energy-consuming sector that consists of all facilities and equipment used for producing, processing, or assembling goods. The industrial sector encompasses the following types of activity: manufacturing (NAICS codes 31-33); agriculture, forestry, fishing and hunting (NAICS code 11); mining, including oil and gas extraction (NAICS code 21); and construction (NAICS code 23). Overall energy use in this sector is largely for process heat and cooling and powering machinery, with lesser amounts used for facility heating, air conditioning, and lighting. Fossil fuels are also used as raw material inputs to manufactured products. *Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the above-mentioned industrial activities.*

- **Commercial sector:** An energy-consuming sector that consists of service-providing facilities and equipment of businesses; federal, state, and local governments; and other private and public organizations, such as religious, social, or fraternal groups. The commercial sector includes institutional living quarters. It also includes sewage treatment facilities. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a wide variety of other equipment. *Note: This sector includes generators that produce electricity and/or useful thermal output primarily to support the activities of the above-mentioned commercial establishments.*

- **Residential sector:** An energy-consuming sector that consists of living quarters for private households. Common uses of energy associated with this sector include space heating, water heating, air conditioning, lighting, refrigeration, cooking, and running a variety of other appliances. The residential sector excludes institutional living quarters.

- **Transportation sector:** An energy-consuming sector that consists of all vehicles the primary purpose of which is transporting people and/or goods from one physical location to another. Included are automobiles; trucks; buses; motorcycles; trains, subways, and other rail vehicles; aircraft; and ships, barges, and other waterborne vehicles. Vehicles for which the primary purpose is not transportation (e.g., construction cranes and bulldozers, farming vehicles, and warehouse tractors and forklifts) are classified in the sector of their primary use.

[33] Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php)

Appendix D: Maine energy consumption in billion Btu

Table D1. Maine energy consumption in billion Btu[34]

Coal	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	214	9	6	0	0	0	0	0	0
Commercial	858	69	70	0	0	0	0	0	0
Industrial	5,533	5,687	3,219	862	742	537	449	329	0
Electric Power	3,808	4,216	3,764	1,418	1,846	1,577	1,711	1,327	1,588
Transportation	0	0	0	0	0	0	0	0	0
Total Coal	10,413	9,981	7,059	2,280	2,588	2,114	2,160	1,656	1,588

Petroleum	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	40,004	52,368	62,507	35,961	40,099	41,001	39,848	37,576	34,814
Commercial	27,988	23,554	25,238	19,409	17,724	17,599	17,716	16,180	18,107
Industrial	41,572	43,109	36,763	20,517	11,855	10,313	9,332	12,060	12,906
Electric Power	22,502	21,414	9,708	2,591	5,691	2,017	452	522	637
Transportation	115,381	118,905	129,693	111,402	119,640	100,235	99,662	91,367	97,861
Total Petroleum	247,447	259,350	263,909	189,880	195,009	171,165	167,010	157,705	164,325

Biodiesel	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0
Electric Power	0	0	0	0	0	0	0	0	0
Transportation	0	0	23	65	969	919	727	773	600
Total Biodiesel	0	0	23	65	969	919	727	773	600

Fuel Ethanol	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	11	105	113	115	117	119
Industrial	0	0	6	93	75	82	83	83	81
Electric Power	0	0	0	0	0	0	0	0	0
Transportation	0	0	375	4766	6073	5,300	5,309	4,831	5,445
Total Fuel Ethanol	0	0	381	4,870	6,253	5,495	5,507	5,031	5,645

[34] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php). Wood data is supplemented with state data for years and sectors when available.

Appendix D (Continued)

Natural Gas	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	651	1,195	1,204	1,282	2,782	3,192	3,250	3,080	3,058
Commercial	1,686	3,194	5,019	6,055	10,380	9,938	10,285	9,289	9,406
Industrial	2,034	14,969	6,807	29,460	21,613	19,938	21,800	23,581	22,763
Electric Power	196	27,758	51,177	42,371	18,398	14,450	9,755	10,109	20,095
Transportation	5	932	612	1,821	1,030	851	1,211	969	1,912
Total Natural Gas	4,572	48,048	64,819	80,989	54,203	48,369	46,301	47,028	57,234

Waste	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	0	0	0	0	0	0	0	0	0
Commercial	2,177	2,757	1,774	2,061	1,780	1,496	1,088	943	806
Industrial	3,131	2,758	1,382	1,625	658	433	519	342	417
Electric Power	2,459	5,321	2,442	2,670	1,335	1,366	1,241	1,258	1,146
Transportation	0	0	0	0	0	0	0	0	0
Total Waste	7,767	10,836	5,598	6,356	3,773	3,295	2,848	2,543	2,369

Wood	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	12,625	12,936	14,181	13,531	16,457	18,213	18,798	18,527	15,914
Commercial	933	751	969	1,993	3,615	3,098	3,200	3,055	2,889
Industrial	76,963	90,083	66,375	59,074	54,967	52,608	43,526	35,557	29,675
Electric Power	19,040	21,136	39,682	23,772	24,547	14,417	7,614	10,579	10,491
Transportation	0	0	0	0	0	0	0	0	0
Total Wood	109,561	124,906	121,207	98,370	99,586	88,335	73,137	67,718	58,969

Hydro	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0
Industrial	13,982	13,221	6,250	6,883	3,630	1,041	1,002	731	711
Electric Power	28,568	23,409	34,655	30,291	27,669	28,628	30,139	26,957	21,761
Transportation	0	0	0	0	0	0	0	0	0
Total Hydro	42,550	36,630	40,905	37,174	31,299	29,669	31,141	27,688	22,472

Wind	**1990**	**2000**	**2005**	**2010**	**2015**	**2018**	**2019**	**2020**	**2021**
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0
Electric Power	0	0	0	4,870	12,068	21,692	22,194	20,998	22,501
Transportation	0	0	0	0	0	0	0	0	0
Total Wind	0	0	0	4,870	12,068	21,692	22,194	20,998	22,501

Appendix D (Continued)

Solar	1990	2000	2005	2010	2015	2018	2019	2020	2021
Residential	85	110	97	130	265	480	550	653	749
Commercial	0	0	0	8	58	175	283	279	602
Industrial	0	0	0	0	0	0	0	0	0
Electric Power	0	0	0	0	0	109	63	243	1,393
Transportation	0	0	0	0	0	0	0	0	0
Total Solar	85	110	97	138	323	764	896	1,175	2,744

Geothermal	1990	2000	2005	2010	2015	2018	2019	2020	2021
Residential	0	5	11	70	72	72	72	72	72
Commercial	0	0	0	0	0	0	0	0	0
Industrial	0	0	0	0	0	0	0	0	0
Electric Power	0	0	0	0	0	0	0	0	0
Transportation	0	0	0	0	0	0	0	0	0
Total Geothermal	0	5	11	70	72	72	72	72	72

ALL SECTORS	1990	2000	2005	2010	2015	2018	2019	2020	2021
Coal	10,413	9,981	7,059	2,280	2,588	2,114	2,160	1,656	1,588
Petroleum	247,447	259,350	263,909	189,880	195,009	171,165	167,010	157,705	164,325
Biodiesel	0	0	23	65	969	919	727	773	600
Fuel Ethanol	0	0	381	4,870	6,253	5,495	5,507	5,031	5,645
Natural Gas	4,572	48,048	64,819	80,989	54,203	48,369	46,301	47,028	57,234
Waste	7,767	10,836	5,598	6,356	3,773	3,295	2,848	2,543	2,369
Wood	109,561	124,906	121,207	98,370	99,586	88,335	73,137	67,718	58,969
Nuclear	51,436	0	0	0	0	0	0	0	0
Hydro	42,550	36,630	40,905	37,174	31,299	29,669	31,141	27,688	22,472
Wind	0	0	0	4,870	12,068	21,692	22,194	20,998	22,501
Solar	85	110	97	138	323	764	896	1,175	2,744
Geothermal	0	5	11	70	72	72	72	72	72
Total	**473,831**	**489,866**	**504,009**	**425,062**	**406,143**	**371,889**	**351,993**	**332,387**	**338,519**
Interstate Electricity	-42,426	-30,206	-56,233	-25,402	-11,676	-3,642	584	10,646	8,333
International Electricity	7,587	13,153	8,141	6,303	16,091	14,481	13,717	9,463	7,568
Total Energy Consumption	**438,992**	**472,813**	**455,917**	**405,963**	**410,558**	**382,728**	**366,294**	**352,496**	**354,420**

Appendix E: Maine energy consumption by sector[35]

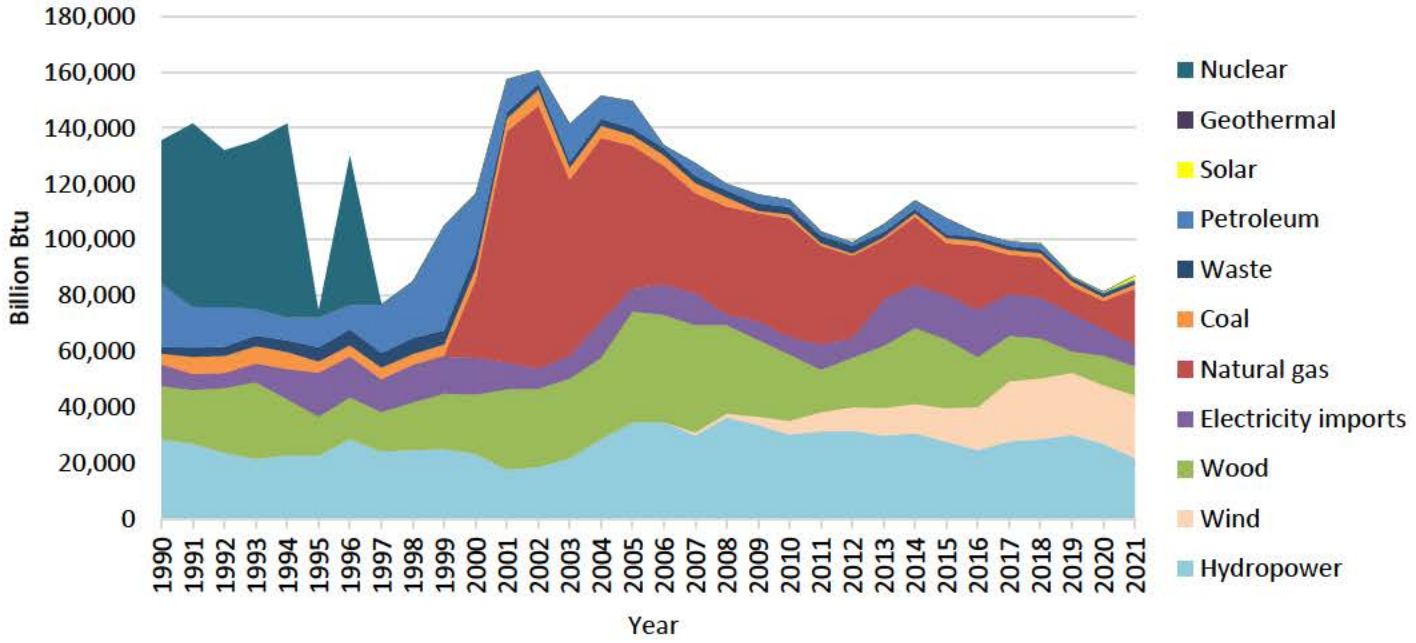

Figure E1. Energy consumption in the electric power sector

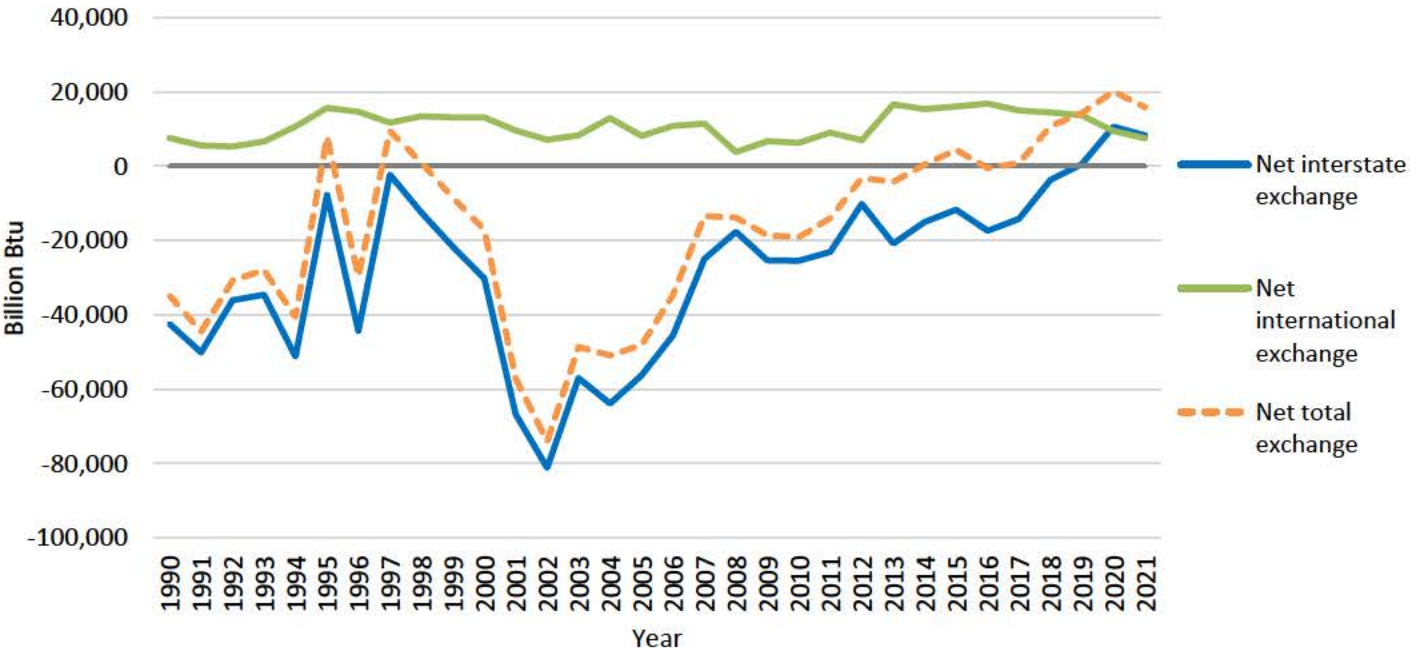

Figure E2. Electricity imports and exports from Maine. (Positive numbers represent imports of electricity to Maine, and negative numbers represent exports from Maine.)

[35] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php, file name: use_all_btu.csv). Wood data is supplemented with state data for years and sectors when available.

Appendix E (Continued)

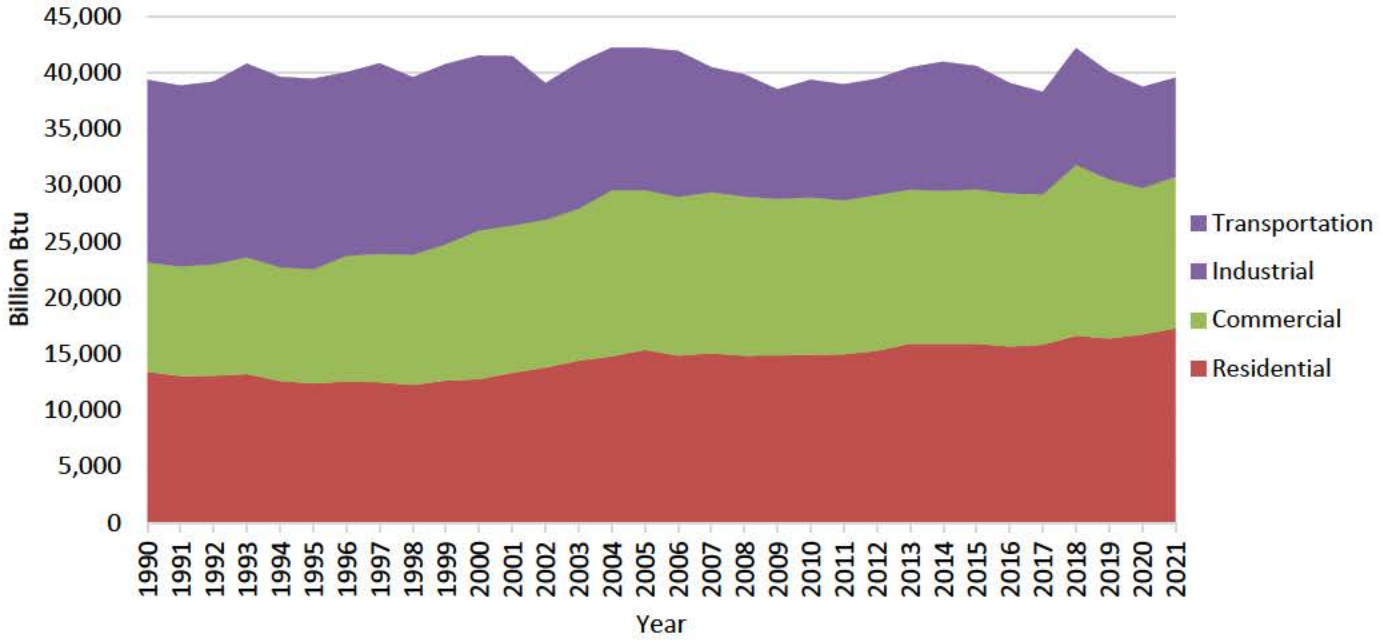

Figure E3. Electric power consumption by sector

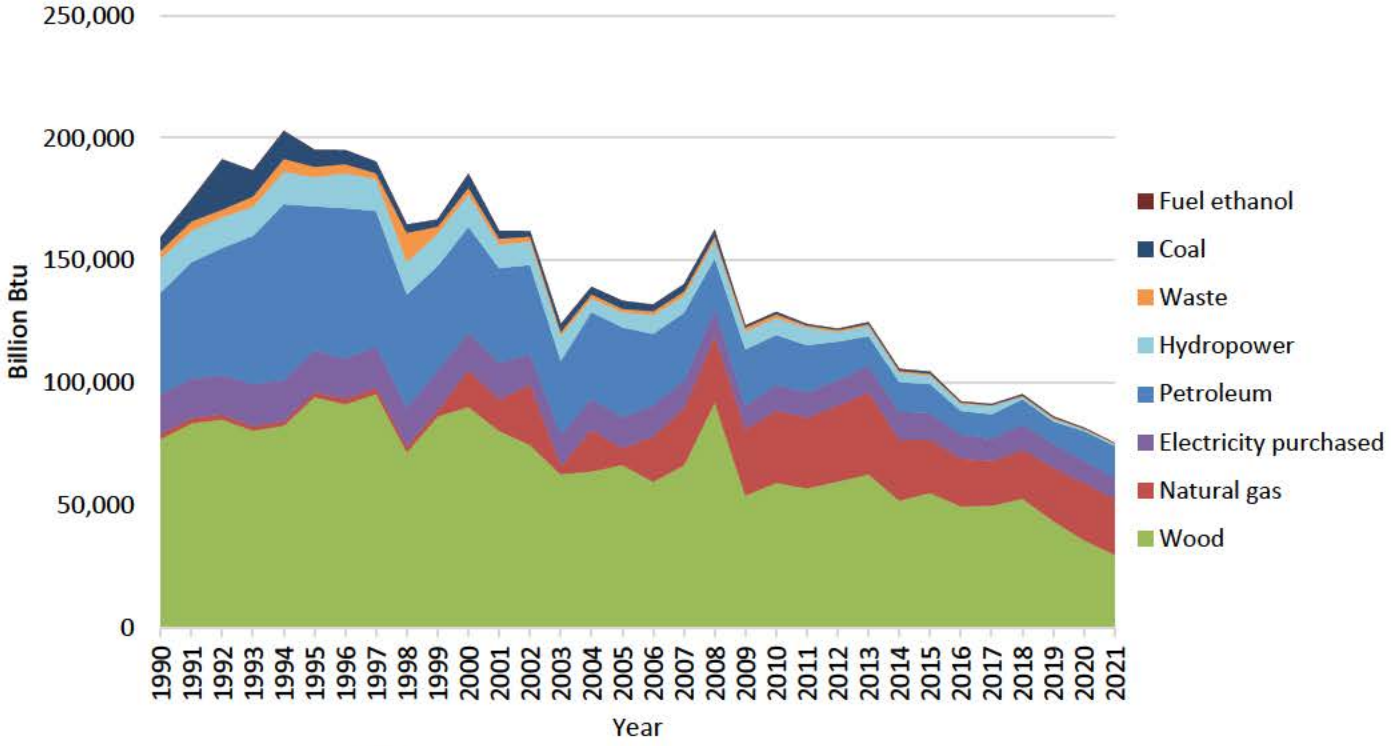

Figure E4. Energy consumption in the industrial sector

Appendix E (Continued)

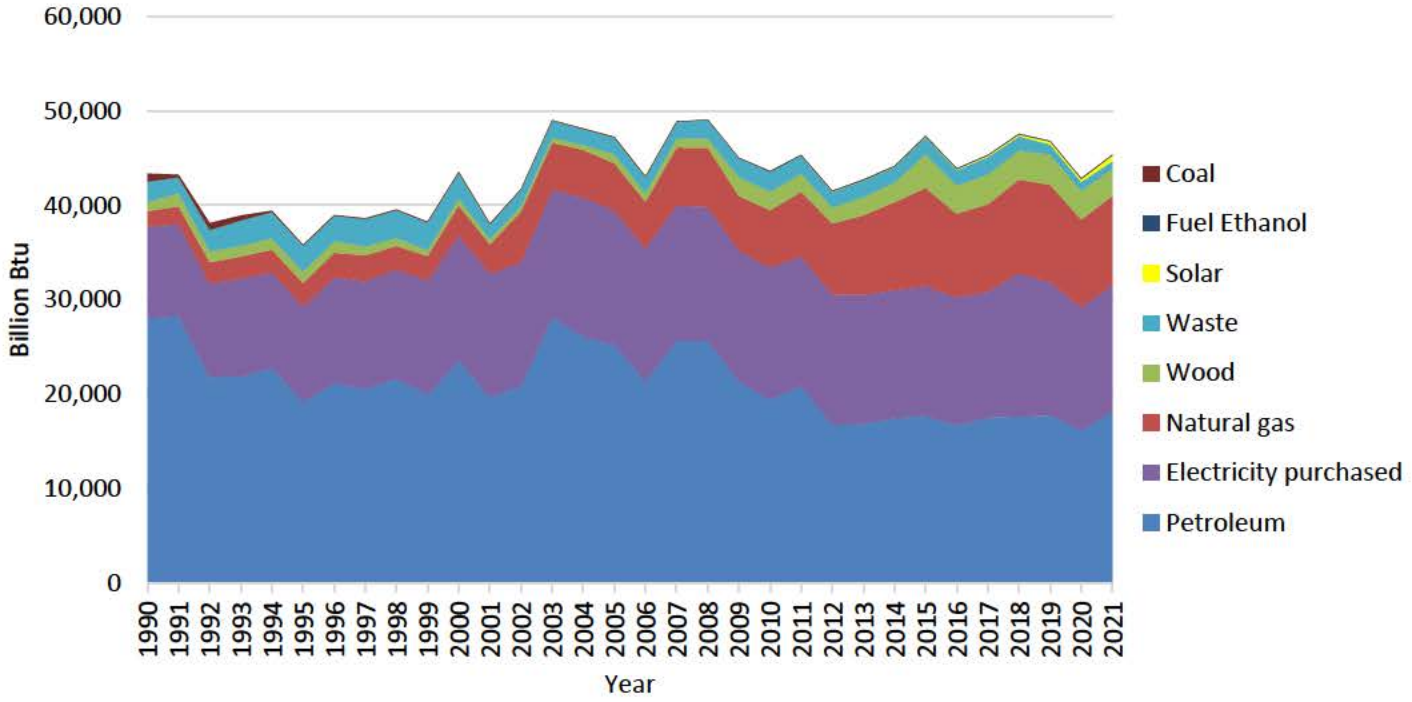

Figure E5. Energy consumption in the commercial sector

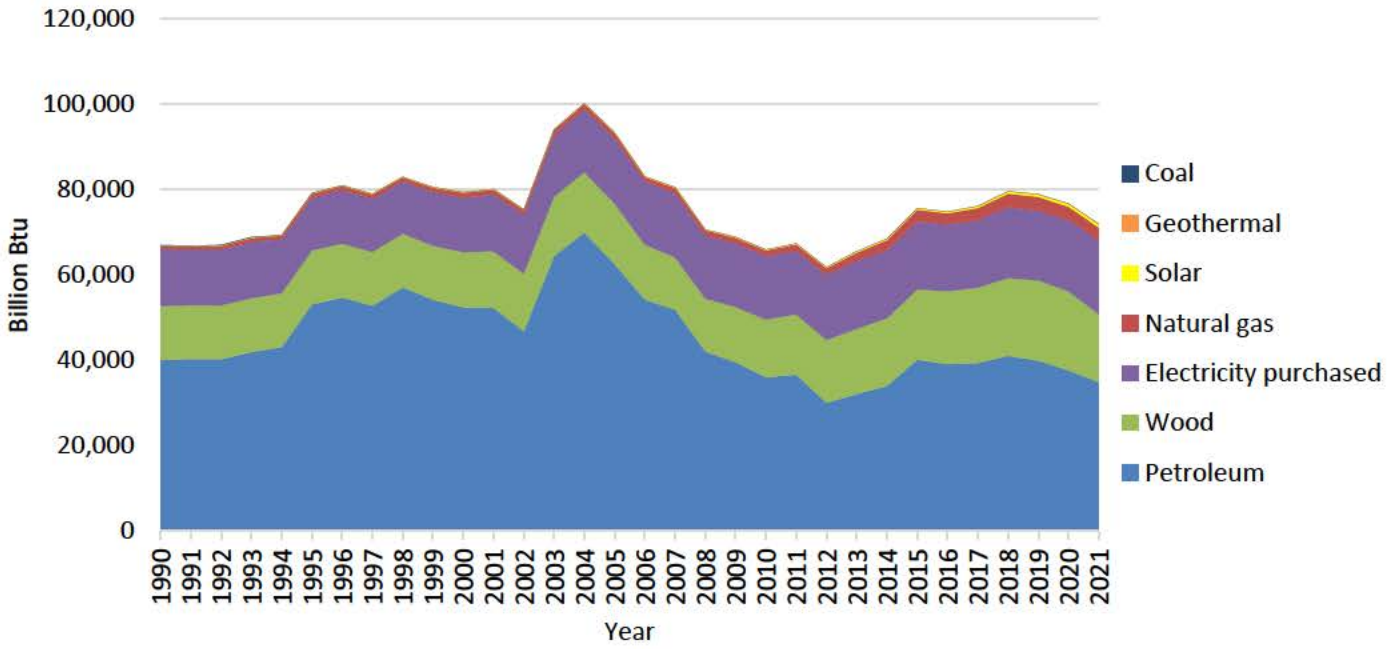

Figure E6. Energy consumption in the residential sector

Appendix E (Continued)

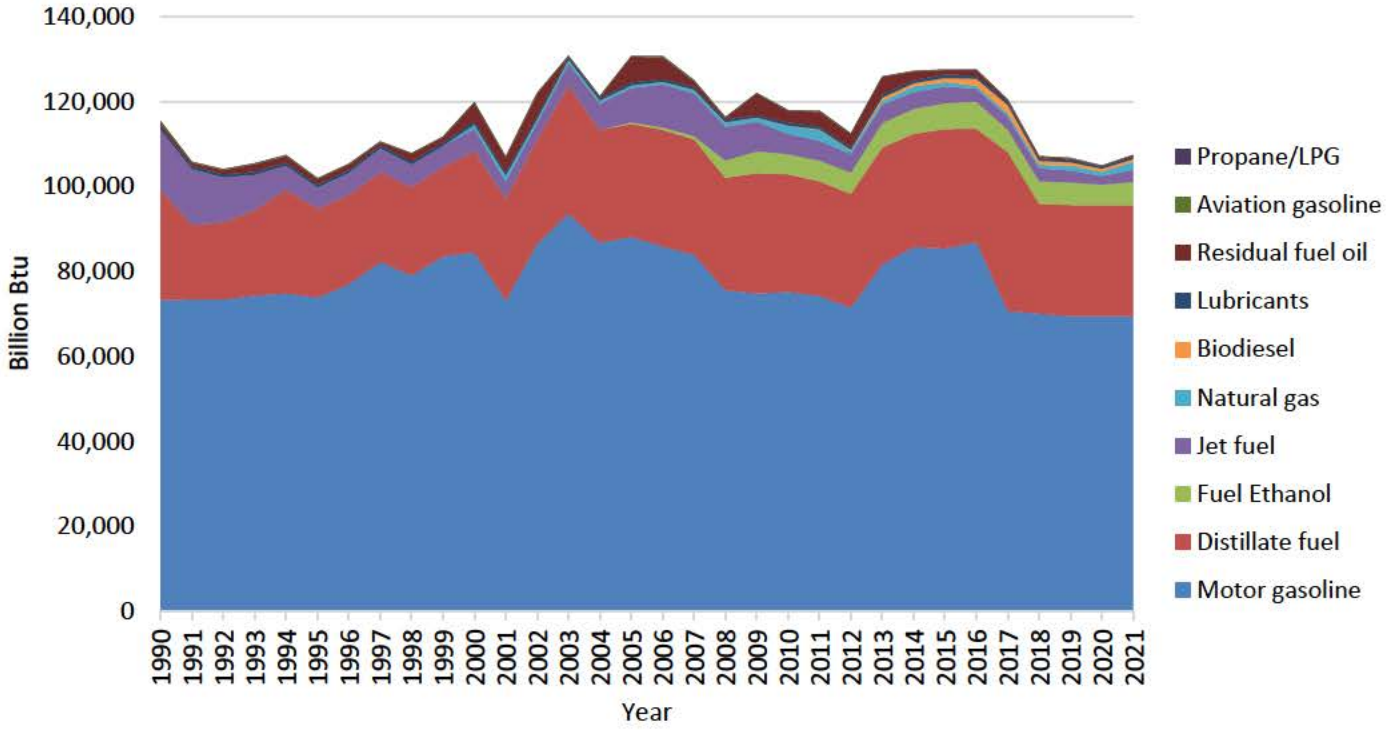

Figure E7. Energy consumption in the transportation sector

Appendix F: Petroleum use by fuel type in billion Btu

Table F1. Petroleum use by fuel type in billion Btu[36]

Fuel Type	1990	2000	2005	2010	2015	2018	2019	2020	2021
Motor Gasoline*	74,206	84,921	89,543	76,915	88,095	72,802	72,257	65,797	73,054
Distillate Fuel Oil**	77,654	89,129	98,752	72,145	73,340	70,657	70,075	66,204	63,221
Propane/LPG	5,201	5,035	8,832	10,873	13,840	15,143	15,154	13,604	14,103
Other***	5,501	4,301	3,574	6,183	6,453	4,130	2,833	6,428	7,117
Jet Fuel & Aviation Gasoline	14,327	5,276	8,284	4,945	4,079	3,143	2,939	2,095	2,972
Residual Fuel Oil	66,833	59,723	43,593	15,457	7,632	3,939	1,823	1,518	2,277
Kerosene	3,726	10,429	11,295	3,278	1,533	1,221	1,656	1,777	1,378
Total	247,448	258,814	263,873	189,796	194,972	171,035	166,737	157,423	164,122

*Excluding fuel ethanol
**Excluding biodiesel
***Asphalt, road oil, lubricants, and petroleum coke

[36] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php)

Appendix G: Economic analysis input data

Table G1. Economic analysis input data

Year	State GDP (millions of dollars) [37]	GHG Emissions ($MMTCO_2e$) [38]	Total energy per state GDP (BBtu per million dollars) [39]	GHG emissions per state GDP (tons CO_2e per million dollars)	GHG emissions per energy input (tons CO_2e per BBtu) [40]
1990	37,168	31.39	12.75	845	66.25
1991	36,082	31.36	13.52	869	64.27
1992	36,539	32.81	13.35	898	67.24
1993	36,755	32.51	13.28	884	66.62
1994	37,725	33.25	13.53	881	65.15
1995	38,681	32.46	11.15	839	75.26
1996	39,834	32.68	12.44	820	65.95
1997	42,942	33.38	10.31	777	75.37
1998	44,140	31.18	9.67	706	73.03
1999	46,351	33.78	9.67	729	75.34
2000	48,490	36.29	10.10	748	74.09
2001	49,471	36.33	9.97	734	73.62
2002	50,910	37.05	10.12	728	71.88
2003	52,210	35.92	9.38	688	73.33
2004	54,256	36.27	9.31	668	71.81
2005	54,927	36.61	9.18	667	72.64
2006	55,448	33.88	8.47	611	72.10
2007	55,360	34.02	8.49	614	72.36
2008	54,654	34.05	8.69	623	71.70
2009	53,630	29.07	8.02	542	67.60
2010	54,305	29.02	7.83	534	68.28
2011	53,789	27.81	7.61	517	67.94
2012	53,680	26.90	7.27	501	68.93
2013	53,239	28.65	7.65	538	70.35
2014	54,038	27.95	7.46	517	69.32
2015	54,426	28.55	7.46	525	70.30
2016	55,565	26.51	6.94	477	68.76
2017	56,469	25.65	6.73	454	67.52
2018	58,100	25.11	6.40	432	67.55
2019	59,553	23.37	5.91	392	66.43
2020	59,881	21.63	5.55	361	65.12
2021	63,595	21.93	5.32	345	64.82

[37] Bureau of Economic Activity, U.S. Department of Commerce (https://www.bea.gov/)
[38] Appendix A
[39] Appendix D, "Total Net Electricity"/ State GDP
[40] Appendix D