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June 19, 2024

Ms. Suzanne MacDonald, Chair
Board of Directors, Efficiency Maine
168 Capitol St Ste 1, Augusta, ME 04330

Dear Madam Chair,

On behalf of the Board of Directors of the Professional Logging Contractors of the Northeast (PLC), please accept these comments regarding Efficiency Maine Trust's (EMT) overview of its draft three-year strategic plan (Triennial Plan VI) for fiscal years 2026-2028.

The PLC was formed in 1995 to represent independent timber harvesting and hauling businesses in a rapidly changing forest industry. Today, the PLC remains the sole voice of independent logging and associated trucking contractors throughout the state of Maine and also represents contractors throughout the region.

As of 2021, harvesting and hauling contractors in Maine employed over 3,000 people directly and were indirectly responsible for the creation of an additional 2,500 jobs. This employment and the investments that contractors make contribute $582 million annually to Maine's economy. Our membership, which includes 190 contractor members in the state, is responsible for more than 80% of the wood harvested in Maine annually.

As context, wood for energy production – electricity, heating and combined heat and power – is a critical part of Maine's forest economy. In 2020, the harvest and processing of biomass, firewood and pellets comprised 1.75 million tons, which represents 15 percent of the statewide wood harvest by Maine landowners and contractors.

These markets are critical to the forest industry supply chain. Landowners received an estimated $2.6 million in stumpage payments for biomass. Loggers and truckers also generated $33.7 million in economic activity associated with harvesting and trucking of biomass fuel. As such, it is beyond frustrating to have EMT advocate for a policy change that would harm this industry even further.

On page 35 of the overview, it states: *"Pellet boiler/furnace measure in homes does not screen cost-effective, and frustrates near-term goals for "gross" carbon reductions. Staff recommends discontinuing the measure, concentrating available RGGI funds on weatherization. (Biomass measures in non-residential buildings will remain eligible through other programs.)* Quite frankly, this recommendation is not only offensive to those who make a living in the woods of Maine, but it is confusing and contradictory.

It is unfortunate that in the most forested state in the country, after years of work to get modern wood heating systems, which are also carbon beneficial, incentivized for residential and commercial use, this triennial plan suddenly pulls the rug out from underneath them. It actually suggests that residential systems are no longer cost effective, but commercial systems are. Further, these very same residential systems now suddenly hinder carbon reduction, even though the state's own Department of Environmental Protection says otherwise. This contradiction has not gone unnoticed.

It is no secret that Maine is a colder state than most and has a robust history of burning wood as a heat source. Wood is a carbon neutral fuel source and this sustainable fuel source can be recycled from fiber byproducts, rather than simply going to waste and creating the same greenhouse gas (GHG) through decomposition. According to the The Maine Department of Environmental Protection's (DEP) 9th Biennial Report on Progress toward Greenhouse Gas Reduction Goals (attached), it recognizes that due to the cyclic nature of forest sequestration (page 21) wood products that are burned do not release any new GHG into the atmosphere vs. wood that decays naturally. This scientific fact, which was tested, analyzed and reported by an agency of Maine state government, runs counter to the justification by Efficiency Maine Trust to discontinue the residential biomass rebate program in the triennial plan.

It is also firmly established that modern wood energy systems, after installation, save users large amounts of money which otherwise would be spent on fossil fuels. Put simply, instead of spending $700 million a year on heating with fossil fuels in the state, which introduces net new GHG's into the atmosphere, and exporting over $581 million of that to other states and countries before the fuel is consumed, a larger share of that money should stay circulating within the state's economy and would provide greater benefits than just warmth.

There has been a lot of work put into the development of modern wood heating systems. Further incentivization and marketing would have a huge impact on the market for the products and could solve some of the problems Maine loggers are seeing with down markets for timber byproducts. With all of the work done on technological upgrades and the proven efficiency of wood and pellet boilers, why the sudden change in philosophy? We have a great natural resource here in Maine in our forests, why not use them to their full potential?

The Efficiency Maine plan should not be a one-size-fits-all approach. Not every home in Maine would benefit from a heat pump. There are many situations where the benefits of a modernized wood/pellet boiler would create more cost savings over the life of the product than heat pumps. Wood boilers/furnaces have a 30-year warranty, which would ensure decarbonization for that period of time, compared to a heat pump that has a 10-year projected lifespan and would need to be installed three times to levy the same life expectancy as a wood application. That is a dramatic difference in life expectancy of the products as well as waste generated by three appliances vs. one.

In addition, the use of wood pellets over heating oil provides a significant carbon offset and lowers the use of fossil fuels and the introduction of new GHG's in the atmosphere. One ton of wood pellets is equivalent to about 120 gallons of heating oil, not only making pellets a more economical choice when used for heating, but a carbon beneficial option because GHG's from wood are carbon neutral and actually offset the introduction of new GHG's into the atmosphere from fossil fuel.

Lastly, we would like to offer that the statement made in the justification for eliminating the residential biomass incentive is confusing. To state that Efficiency Maine Trust should eliminate the residential incentive, but, "*Biomass measures in non-residential buildings will remain eligible through other programs,"* is not only contradictory, but counter intuitive. Why should one incentive remain on the one hand, but be taken away on the other? If it is good enough for commercial applications from a carbon basis, then it should also be good enough for residential applications. To eliminate it with justification based upon cost and net carbon reduction for residential applications, but the incentive should continue for commercial applications, makes absolutely no sense.

Thank you for your time and consideration of our comments. The PLC believes that removing the incentives for wood and pellet boiler/furnace measures for residential use would be shortsighted. Modern wood systems are technologically advanced, efficient, and provide for their own circular economy, while remaining carbon neutral throughout the process. The continued push to electrify all aspects of everyday life is concerning, and to eliminate the incentive from other viable alternative heating sources would be a mistake. Please do not remove the incentive for wood-based alternatives in residential applications from the Efficiency Maine plan.

Respectfully,

Dana A. Doran

Dana Doran
Executive Director

Report to the Joint Standing Committee on
Environment and Natural Resources
130th Legislature, Second Session

Ninth Biennial Report on Progress toward Greenhouse Gas Reduction Goals

July 2022

Bureau of Air Quality
Maine Department of Environmental Protection

MAINE DEPARTMENT OF ENVIRONMENTAL PROTECTION
17 State House Station | Augusta, Maine 04330-0017
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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 1990-2019 show that Maine's GHG emissions were 25% lower in 2019 than in 1990. Emissions have consistently been at least 10% lower than 1990 levels since 2016. With data now available through December 31, 2019, 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). If emissions continue to decrease at current rates, Maine emissions are projected to be slightly higher than required by the goals of 38 M.R.S. §576-A[1]; however, the data in this report predate the State's climate action plan *Maine Won't Wait*, released in December 2020, which lays out strategies to ensure Maine meets these targets when fully implemented. Results of the analysis of net GHG emissions estimate that, as of 2016, approximately 75% of Maine's GHG emissions are offset by carbon sequestered in Maine's environment, and projected 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:

- 91% of gross GHG emissions in Maine are the result of energy consumption, and CO_2 emissions from the combustion of fossil fuels account for 60% of Maine's 2019 gross GHG emissions. Annual emissions in the energy source category have been reduced by 38% since the high in 2002 and 26% since 1990 (Figure 2; Appendix A, Table A1).
- Maine is approximately 75% of the way to reaching carbon neutrality, which means 75% of gross GHG emissions are offset by sequestration in the environment.
- Annual CO_2 emissions from fossil fuel[3] combustion in the electric power sector have decreased by 91% 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 8% lower in 2019 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 2019 (Appendix B).
- Maine reduced its GHG intensity and emissions per dollar, creating 29% less GHG emissions per billion Btu (BBtu) of energy in 2019 than the high in 2002, and 53% less GHG emissions per million dollars of state gross domestic product (GDP) in 2019 than in 1990 (Appendix G).

The Maine Climate Council is tasked with recommending policies to reduce Maine's GHG emissions and meet targets in law, which include a 45% gross GHG reduction by 2030 and 80% by 2050. *Maine Won't Wait* was released by the Maine Climate Council on December 1, 2020, and outlines steps to achieve Maine's gross GHG reduction and climate change adaptation goals.[4] The plan, which will be updated every four years, includes a focus on electrification of the transportation and heating sectors, increased energy efficiency efforts, and additional data-based strategies to support continued emissions reductions.

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[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.
[4] https://www.maine.gov/climateplan/the-plan

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 for 2010, 2020, and beyond. The Act set a goal for reduction of GHG emissions within the State, in the short term, to 1990 levels by January 1, 2010; to 10% less than 1990 levels by 2020; and for reductions sufficient to eliminate any dangerous threat to climate in the long term (38 M.R.S. §576).[5] In 2019, 38 M.R.S. §576-A[6] 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.[7] This carbon neutrality goal was codified in 38 M.R.S. §576-A, sub-§2-A (effective August 8, 2022).[8]

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[9], 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. Beginning in 2022, this report includes an estimate of net GHG emissions (i.e., a carbon budget), which includes both gross anthropogenic GHG emissions (i.e., emissions from human activity) to the atmosphere and carbon sequestered by the environment.

The gross GHG 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 estimate is used to gauge Maine's progress toward the 2045 carbon neutrality goal of 38 M.R.S. §576-A, sub-§2-A. This report summarizes the findings of the Department's ninth quantitative evaluation of Maine's progress toward meeting statutory GHG reduction goals since the development of Maine's original Climate Action Plan in 2004.

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5 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

6 38 M.R.S. §576-A, https://legislature.maine.gov/statutes/38/title38sec576-A.html

7 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

8 38 M.R.S. §576-A, sub-§2-A (effective August 8, 2022), https://legislature.maine.gov/legis/bills/getPDF.asp?paper=HP1045&item=3&snum=130

9 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.*[10] 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 the 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)[11], 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).[12] 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

[10] Chapter 167, *Tracking and Reporting Gross and Net Annual Greenhouse Gas Emissions*, was adopted on July 7, 2021 and is available on the DEP website: https://www.maine.gov/sos/cec/rules/06/096/096c167.docx

[11] EPA updated its State Inventory Tool (SIT) for greenhouse gases through 2019 in March 2022: 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 was available through 2019.

[12] 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 2019 data used by EPA in the SIT was released in October 2021.

separately. For some of the categories, this information is apportioned to the states from national and regional inventories. For this Ninth 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, EIA data were available through 2019.

Biogenic Emissions
Pursuant to 38 M.R.S. §577, gross GHG emissions now include biogenic emissions for the entire reporting period. 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 was 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 waste. Wood includes wood, wood waste, and wood-derived fuels, including black liquor. 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 used to create 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 is responsible for most GHG emissions and encompasses energy-consuming entities, such as electric power producers, and energy consumption 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 municipal solid waste disposal and wastewater treatment activities.

The energy source category can be further broken down into energy sectors. The five energy sectors are residential, commercial, industrial, transportation, and electric power. Emissions from the combustion of fossil fuels are presented by energy 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 energy sector. 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.[13] These data are shown in Appendix G.

Net GHG Inventory (Maine Carbon Budget)
Researchers at the University of Maine, Bates College, and the Maine Forest Service developed an estimate of the State of Maine's Carbon Budget[14] in collaboration with the Department. Data from their analysis are presented here as the net GHG inventory and represent a 10-year data window ending in 2016. Estimates of net GHG emissions were made for each of the following categories: fossil fuels, waste, forests, wood products, wetlands, agriculture, urban, inland waters, 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 handful of available out-of-state carbon market registries.

III. Results and Discussion

A. Gross Greenhouse Gas Emissions

The Department's current analysis utilizing data through the end of 2019 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 2019. Total estimated annual GHG emissions in Maine increased from 32.2 $MMTCO_2e$ in 1990 to a peak of 38.5 $MMTCO_2e$ in 2002. By 2009, emissions were below 1990 levels, reaching a low in 2012, rebounding slightly 2013-2015, and trending downward again through 2019, with emissions

[13] Economic data inflation adjusted, chained 2012 dollars.
[14] Bai, X., Daigneault, A., Fernandez, I., Frank, J., Hayes, D., Johnson, B., Wei, X., Weiskittel, A. (2020). State of Maine's Carbon Budget, 2006-2016 (version 1.0). https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/

calculated at 24.2 $MMTCO_2e$ in 2019. This is a reduction in gross GHG emissions of 25% between 1990 and 2019 (Appendix A, Table A3) and a reduction of 37% between 2002 and 2019. 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 9% between 1990 and 2019, GHG emissions per capita have decreased 31% over this time frame (Appendix A, Figure A2).

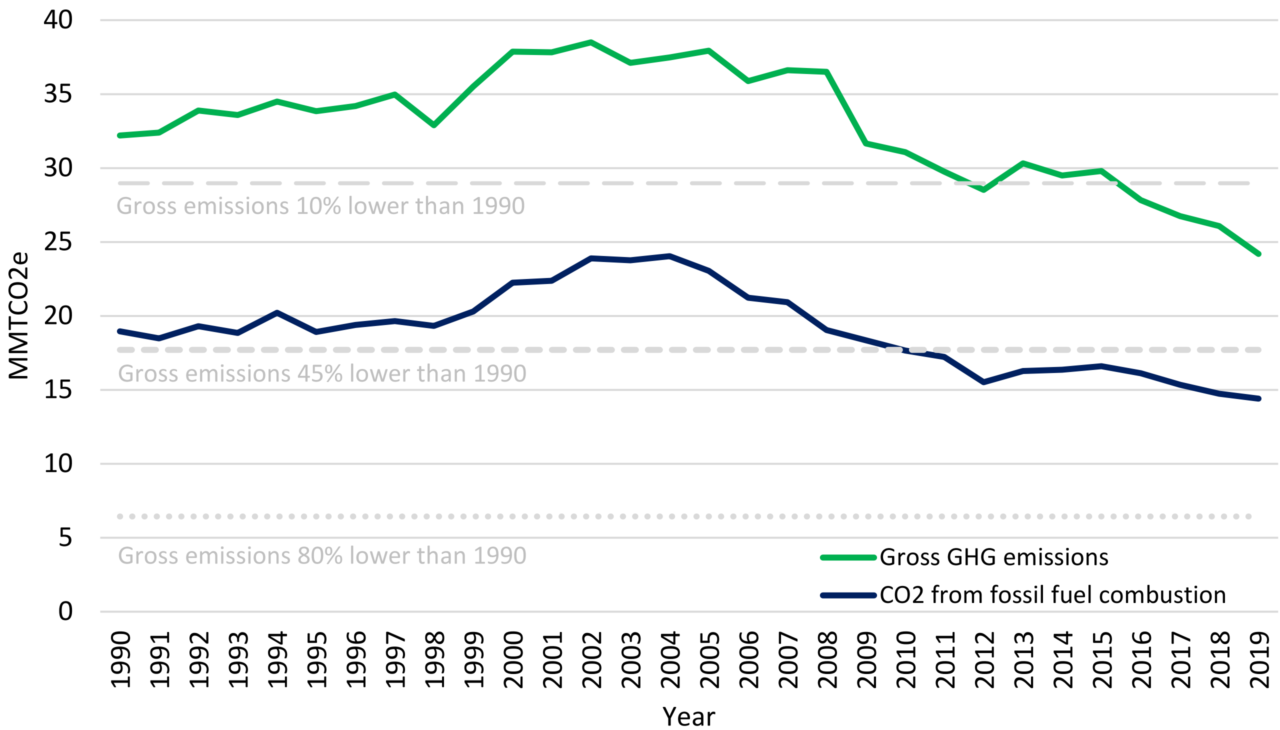

Figure 1. Maine's greenhouse gas emissions 1990-2019 (including biogenic emissions)

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 91% of Maine's gross GHG emissions in 2019. The agricultural, industrial processes, and waste source categories combined only contributed 9% of the 2019 GHG emissions total (Figure 2; Appendix A, Tables A1 and A4).

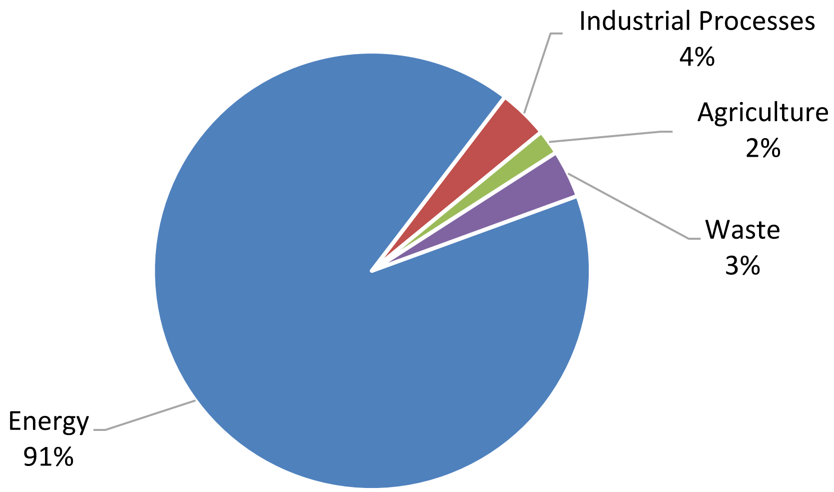

Figure 2. Emissions by source category for 2019 (including biogenic emissions)

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 2019. In 2019, total energy consumption in Maine was 26% less than in 1990 (Appendix D).

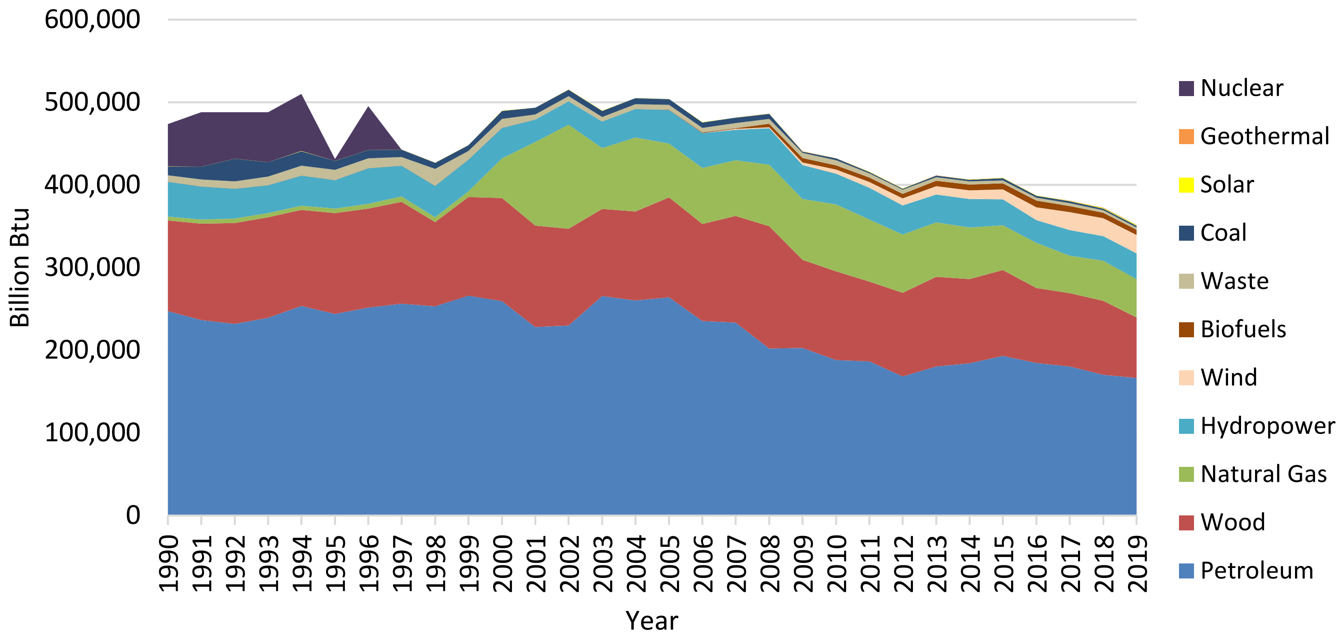

Figure 3. Maine energy consumption (BBtu) 1990-2019[15]
(Biofuels include biodiesel and fuel ethanol)

[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.

Emissions of CO_2 from the combustion of fossil fuels account for 60% of Maine's gross GHG emissions in 2019. Although Maine still relies on petroleum to meet some energy demands, including heating more than 60% of residential buildings, 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 petroleum products.[16] 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; 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 in Maine consist primarily of motor gasoline, distillate fuel, and propane. In 2019, combustion of petroleum products accounted for 47% of all energy consumed (Appendix D), 49% of gross GHG emissions, and for 82% of CO_2 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.

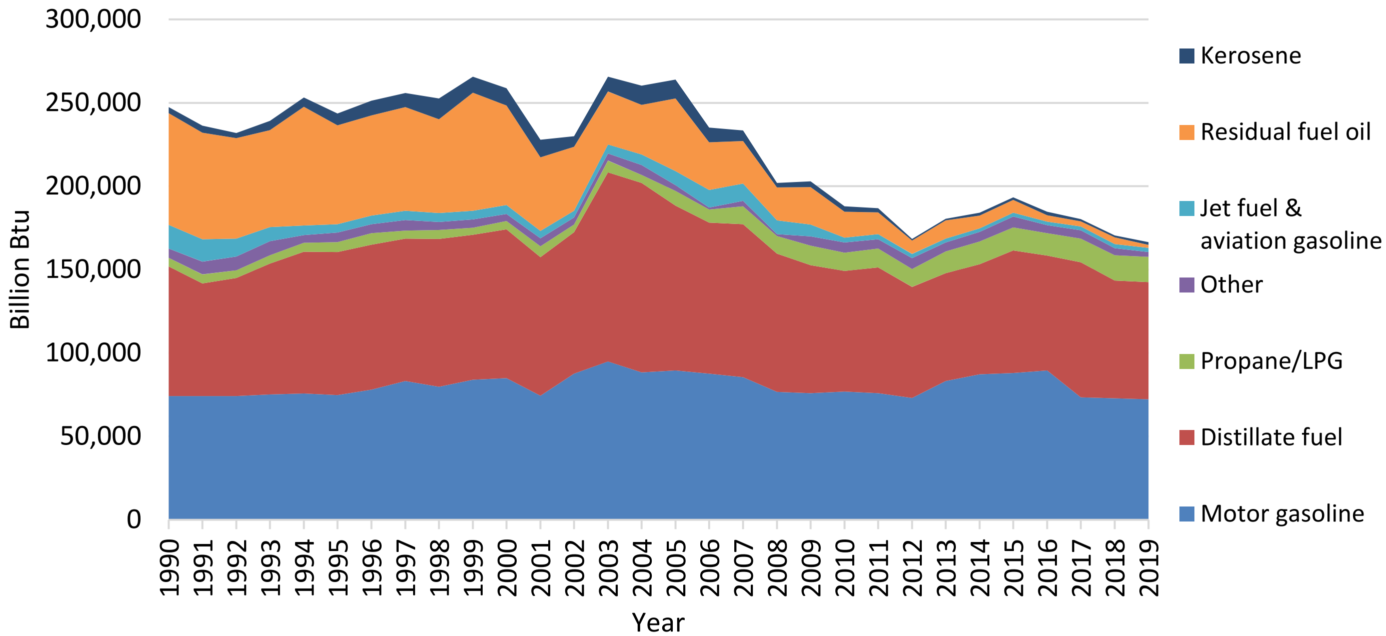

Figure 4. Maine petroleum consumption by fuel type (BBtu) 1990-2019[17] (This figure does not include ethanol or biodiesel. "Other" includes asphalt, road oil, lubricants, and petroleum coke.)

[16]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.
[17] Data Source: EIA State Energy Data System (https://www.eia.gov/state/seds/seds-data-complete.php, file name: use_all_btu.csv)

Since 1990, the aggregate CO_2 emissions from petroleum combustion (in all energy sectors) have decreased by 33% (Appendix B). Comparably, petroleum consumption also declined by 33% between 1990 and 2019 (Figure 4, Appendix D). This may be explained in part by transitions to lower carbon fuels. For example, there has been a 912% increase in natural gas consumption since 1990, from 4,572 BBtu in 1990 to 46,291 BBtu in 2019 (Appendix D).

Figure 5 illustrates the trend in petroleum consumption by sector since 1990. Between 1990 and 2019, all energy sectors have decreased petroleum consumption. The transportation sector has been the leading consumer of petroleum for all years, with a 14% decrease in petroleum consumption during the reporting period (Appendix D). The residential sector has reduced petroleum consumption by only 0.4%, while the commercial, industrial, and electric power sectors have achieved significant reductions of 37%, 78% and 98%, respectively.

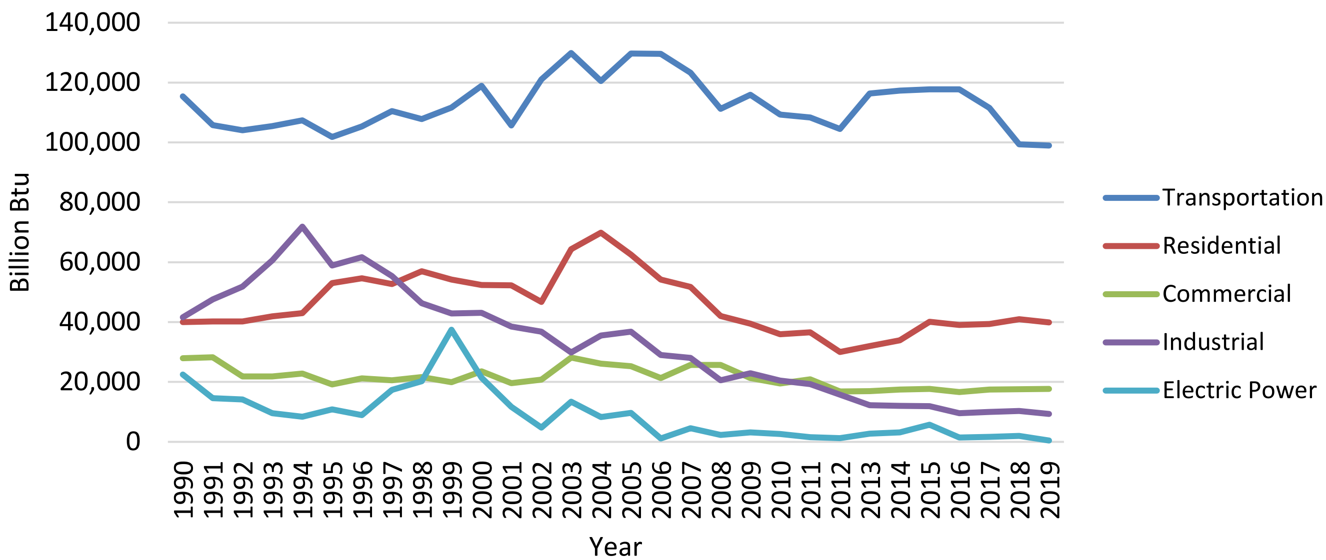

Figure 5. Maine petroleum consumption by sector (BBtu) 1990-2019

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 2019. This figure shows that the transportation sector produced almost half (49%) of all CO_2 emissions generated from fossil fuel combustion in Maine in 2019. The residential sector accounted for the next highest contribution at 21%.

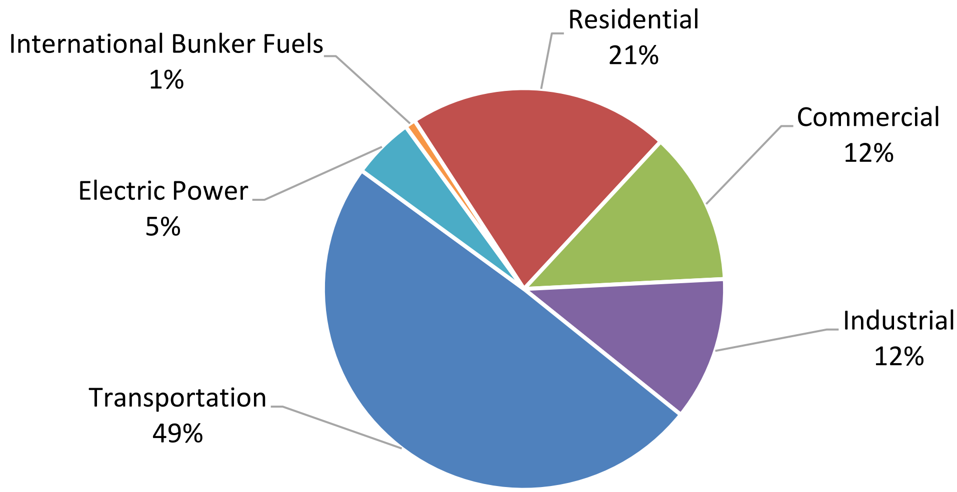

Figure 6. CO_2 emissions from fossil fuel combustion by sector for 2019 (data in Appendix B)

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 2019, with an 11.5% decrease of CO_2 emissions during that period. The industrial, electric power, and commercial sectors reduced CO_2 emissions by 51%, 65%, and 21%, respectively, between 1990 and 2019. While the trend in CO_2 emissions from residential combustion of fossil fuel shows variability over the reporting period, there has been an overall increase of 1% over the reporting period. A complete table of CO_2 emissions from the combustion of fossil fuels over the reporting period is presented in Appendix B.

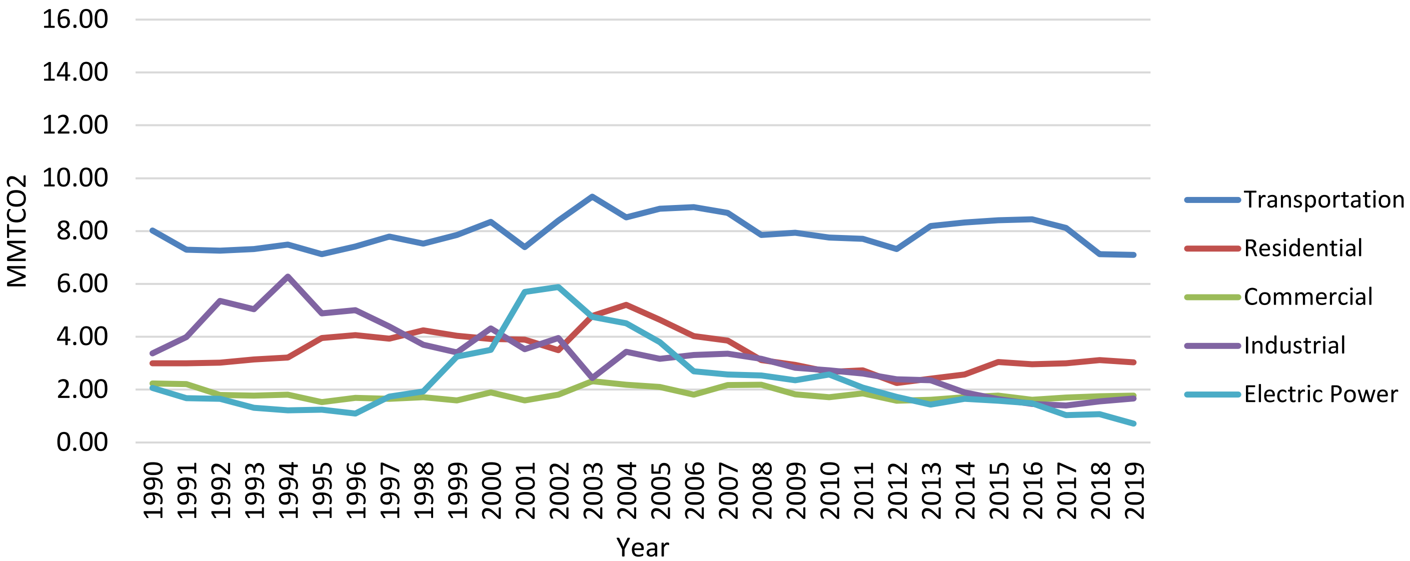

Figure 7. CO_2 emissions from the combustion of fossil fuels by sector 1990-2019 (data in Appendix B)

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 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 timeseries presented in Figure 8 show the emissions by energy sector within the energy source category from 1990 to 2019. These emissions include all GHG emissions produced through the production of energy, including non-CO_2 GHG emissions and GHG emissions from 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 2009. The transportation, industrial, commercial, and electric power sectors have reduced GHG emissions between 1990 and 2019 by 8%, 53%, 10%, and 41%, respectively. For the transportation, commercial, and electric power sectors, the decreases are linked to reduced combustion of fossil fuels. For the industrial sector, the emissions from fossil fuels and combustible renewable fuels are both approximately 50% lower than in 1990. Residential sector emissions have increased by 15% over the 1990-to-2019 time frame.[18] CO_2 emissions from the combustion of fossil fuels within the residential sector are similar in 2019 to what they were in 1990, while emissions from combustion of renewable fuels have increased by 50%.

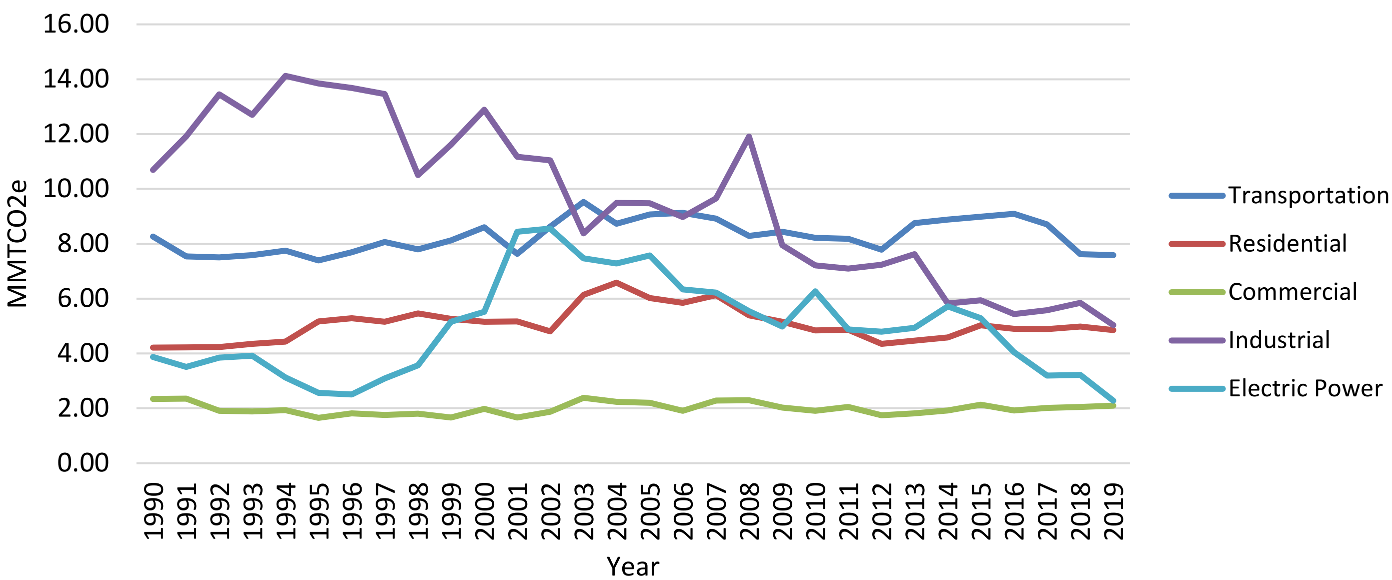

Figure 8. Energy source category emissions by sector

Electric Power

At 2.28 $MMTCO_2e$, the electric power sector generated 9% of Maine's gross GHG emissions in 2019, 41% less than in 1990 (Appendix A, Table A3). The combustion of fossil fuels accounted for

[18] Population estimates by the U.S. Census Bureau show a 9% increase in population from 1990 to 2019, from 1,227,928 to 1,334,212 (https://www.census.gov/programs-surveys/popest/data/data-sets.html)

0.71 $MMTCO_2$, which was 31% of the emissions from this sector in 2019 and 65% less than in 1990. This was 5% of the State's total CO_2 emissions from fossil fuels and a 99% drop 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 2019, natural gas combustion accounted for 72% of the fossil-fuel-based CO_2 emissions from this sector. Renewable resources (hydropower, wood, wind, waste, solar, and geothermal) provided 84% of the energy consumed by electricity generating facilities in 2019, up from 37% in 1990. Combustion of wood within the electric power sector amounted to 1.56 $MMTCO_2e$, which is 69% of the GHG emissions from this sector and 13% less than in 1990.

The CO_2 emissions from electricity are accounted for in the generation of electricity 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 2019. Maine imported a net total (i.e., imports minus exports) of 472 BBtu of electricity domestically and 13,717 BBtu internationally in 2019, for a total import value of 14,189 BBtu (Appendix E, Figure E2). In 2019, 41% of Maine's electricity was consumed by the residential sector, 35% by the commercial sector, and 24% 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 2019. 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 in 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 2019. 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 timeseries of emissions estimates from the production of electricity both with and without biogenic emissions. All three timeseries show a decline in emissions from 1990 to 2019. 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 71% decrease in emissions based on the consumption of electricity in Maine; however, these data exclude emissions from combustion of renewable fuels to generate electricity.

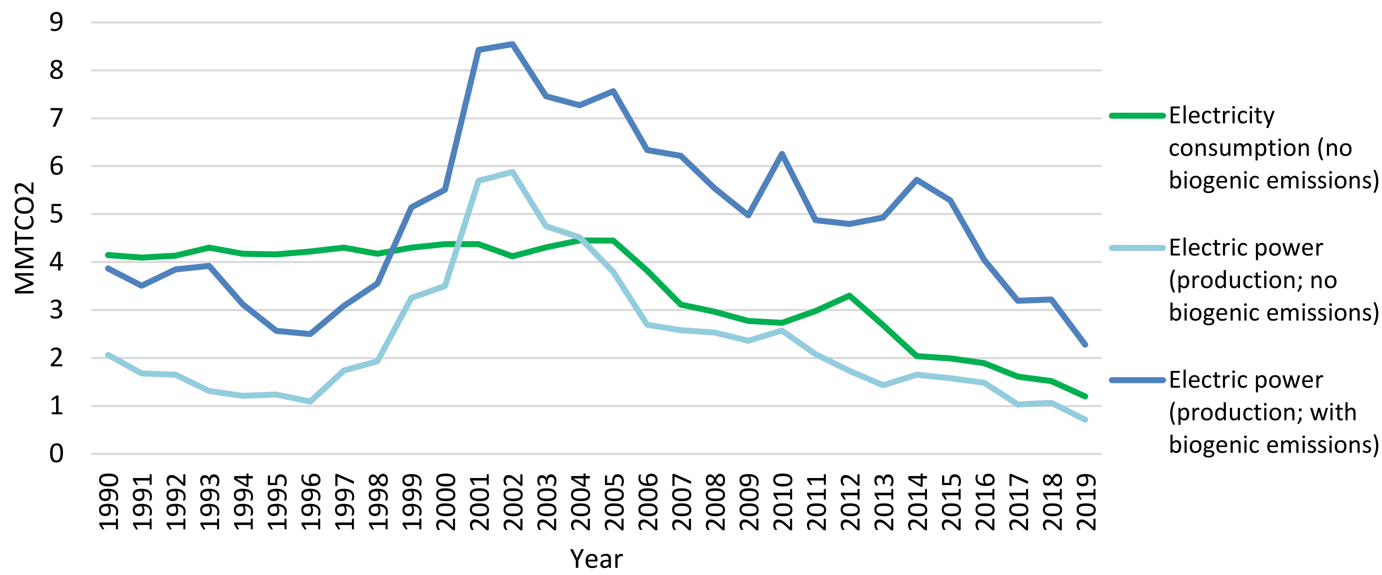

Figure 9. CO_2 emissions from fuel combusted to generate electricity (electricity production) compared to indirect CO_2 emissions based on electricity consumed. (Note: Electricity consumption data with biogenic emissions is not available)

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 83% decrease from 1990 to 2019.[19]

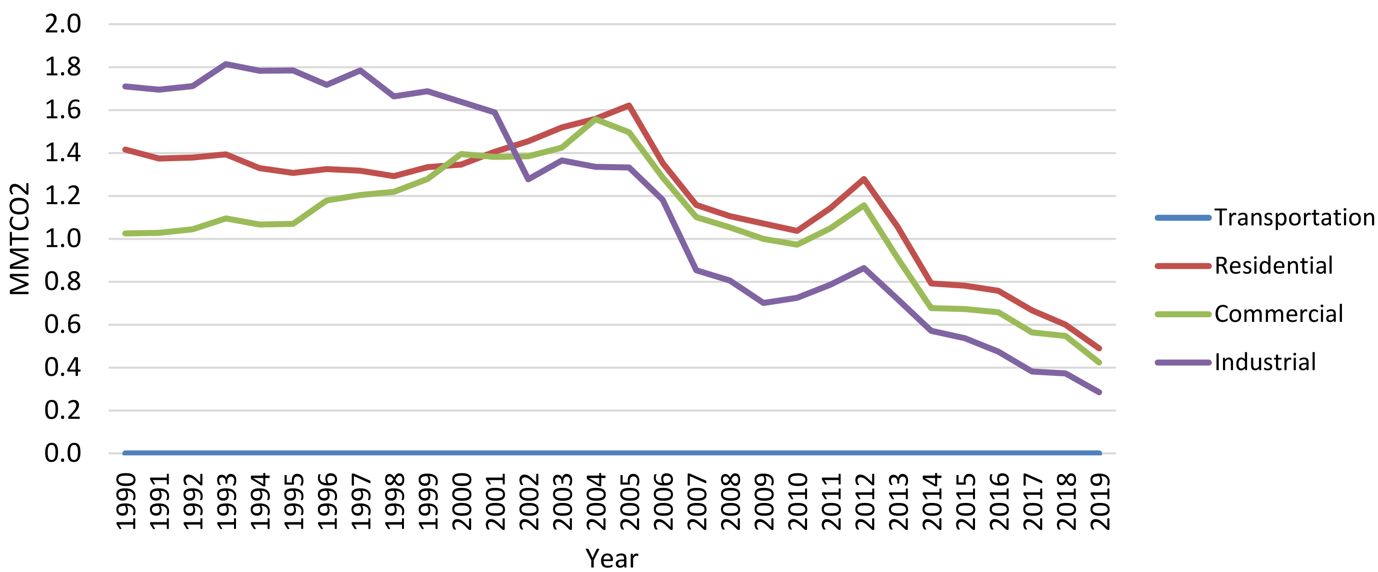

Figure 10. Indirect CO_2 emissions from the consumption of electricity by energy sector (biogenic emissions are not available for consumption-based electricity emissions data; transportation emissions not measurable during this period).

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

Industrial

The industrial sector generated 21% of Maine's gross GHG emissions in 2019 with 5.04 $MMTCO_2e$, 53% less than in 1990 (Appendix A, Table A4). The combustion of fossil fuels accounted for 1.67 $MMTCO_2e$, which was 33% of the emissions from this sector in 2019 and 51% less than in 1990. The industrial sector was responsible for 12% of the State's total fossil-fuel-based CO_2 emissions, and the 2019 levels were 51% lower than 1990 levels (Appendix B). In 2019, twice as much energy was generated using natural gas in the industrial sector compared to generation using petroleum. In this sector, 47% 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 3.36 $MMTCO_2e$ in 2019, which was 67% of the GHG emissions from this sector and 54% less than in 1990.

Commercial

The commercial sector generated 9% of Maine's gross GHG emissions in 2019 with 2.10 $MMTCO_2e$, 10% less than in 1990 (Appendix A, Table A4). The combustion of fossil fuels accounted for 1.78 $MMTCO_2e$, which was 85% of the emissions from this sector in 2019 and 21% less than in 1990. The commercial sector was responsible for 12% of the State's total fossil-fuel-based CO_2 emissions (Appendix B), and the 2019 levels represented a 21% reduction in CO_2 emissions from this sector from 1990 to 2019. During this same period, there was a 510% increase in the use of natural gas and a 40% decrease in the use of petroleum. Petroleum continues to account for 69% of CO_2 emissions in the sector. In 2019, renewable energy sources provided 9% 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 0.30 $MMTCO_2e$ in 2019, which was 14% of the GHG emissions from this sector.

Residential

The residential sector generated 20% of Maine's gross GHG emissions in 2019 with 4.85 $MMTCO_2e$, 15% more than in 1990 (Appendix A, Table A4). The combustion of fossil fuels accounted for 3.05 $MMTCO_2e$, which was 63% of the emissions from this sector in 2019 and 1% more than in 1990. The residential sector was responsible for 21% 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 2019, petroleum accounted for 94% of all the CO_2 emissions from this sector and 50% of the energy consumption (Appendix E, Figure E6). The national average for petroleum consumption (BBtu) by the residential sector for 2019 was only 8.7%.[20] Emissions from residential petroleum use peaked in 2004 at 5.1 $MMTCO_2$ and have declined by 50.1% between 2004 and 2019. Between 2005 and 2014, the cost of home heating oil increased from $1.93 per gallon (February 2005) to $3.88 per gallon (February 2014)[21], 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.[22] Wood

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

[21] Maine Governor's Energy Office. Archived Heating Oil Prices. http://www.maine.gov/energy/fuel_prices/archives.shtml, December 2004 to December 2013.

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

accounted for 24% of the residential energy consumption in 2019, up from 19% in 1990. Combustion of wood amounted to 1.80 $MMTCO_2e$, 37% of the GHG emissions from this sector. The residential sector, along with the transportation sector, has been the least served by natural gas. In 2019, 4% of the residential energy consumed was natural gas, up from 1% in 1990.

Transportation
The transportation sector generated 31% of Maine's gross GHG emissions in 2019 with 7.58 $MMTCO_2e$, 8% less than in 1990 (Appendix A, Table A4). The combustion of fossil fuels accounted for 7.17 $MMTCO_2e$, which was 94% of the emissions from this sector in 2019 and 13% 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 42% in 1990 (Appendix B). Petroleum accounts for 100% of the fossil-fuel-based CO_2 emissions and 97% of the energy consumed by the transportation sector (Appendix E, Figure E7). The transportation sector consumed 9% more energy in 2019 than in 1990. CO_2 emissions from the combustion of fossil fuel in the transportation sector decreased by 12% over the reporting period. The decrease in emissions relative to the increase 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 2019, 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[23], 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 7.03 $MMTCO_2e$ of Maine's gross GHG emissions in 2019, down 32% from 10.40 $MMTCO_2e$ in 1990 (Appendix A, Table A4). With the exception of 2014, when the electric power sector took the lead, the industrial sector outstripped other sectors in the use of wood for energy over the reporting period, contributing 48% of the GHG emissions from wood in 2019 (and 54% less than in 1990).[24] The electric power sector has historically been the second largest contributor to emissions from wood combustion; however, in 2019 the electric power sector emissions from this renewable fuel fell below residential sector emissions. Electric power emissions from wood combustion were 1.56 $MMTCO_2e$ in 2019, 13% lower than in 1990. The use of wood for energy has increased by 50% in the residential sector, from 1.20 $MMTCO_2e$ in 1990 to 1.80 $MMTCO_2e$ in 2019. 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 0.3 $MMTCO_2e$ in 2019.

[23] Black liquor from the kraft pulping process.
[24] Industrial wood combustion includes the combustion of both biomass (including bark) and black liquor solids.

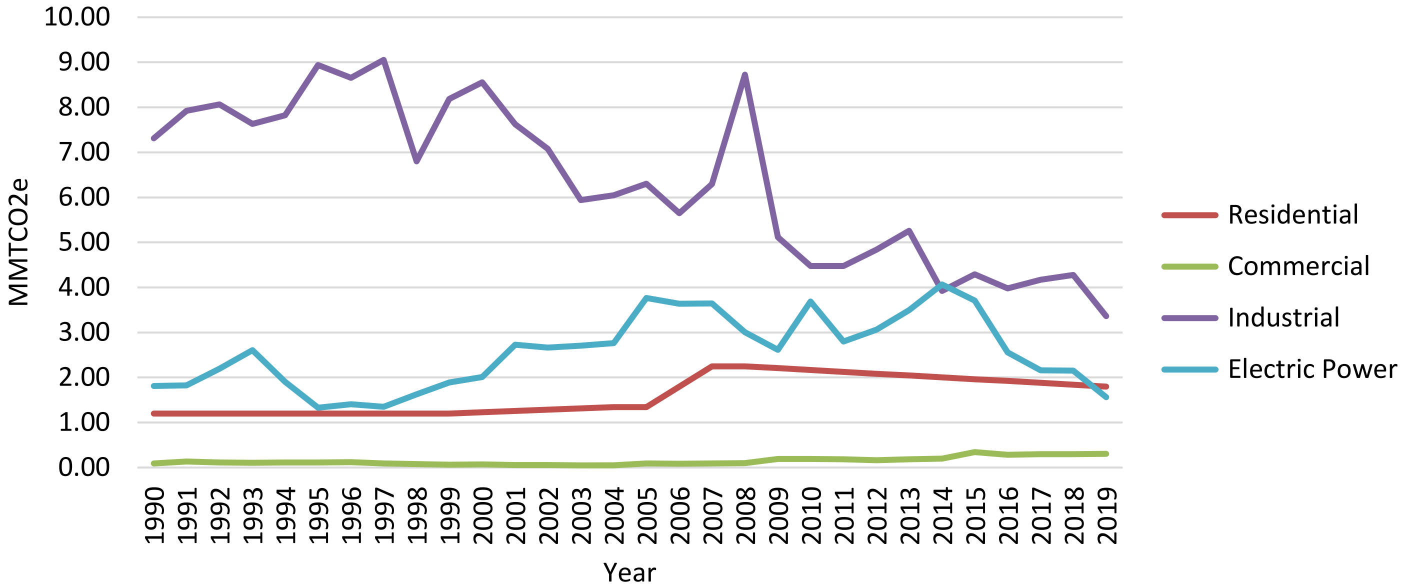

Figure 11. GHG emissions from the combustion of wood by energy sector (1990-2019)

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 timeseries 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 2019, fuel ethanol emissions were 0.4 MMTCO$_2$e (1.6% of gross GHG), and biodiesel emissions were 0.05 MMTCO$_2$e (0.2% of gross GHG).

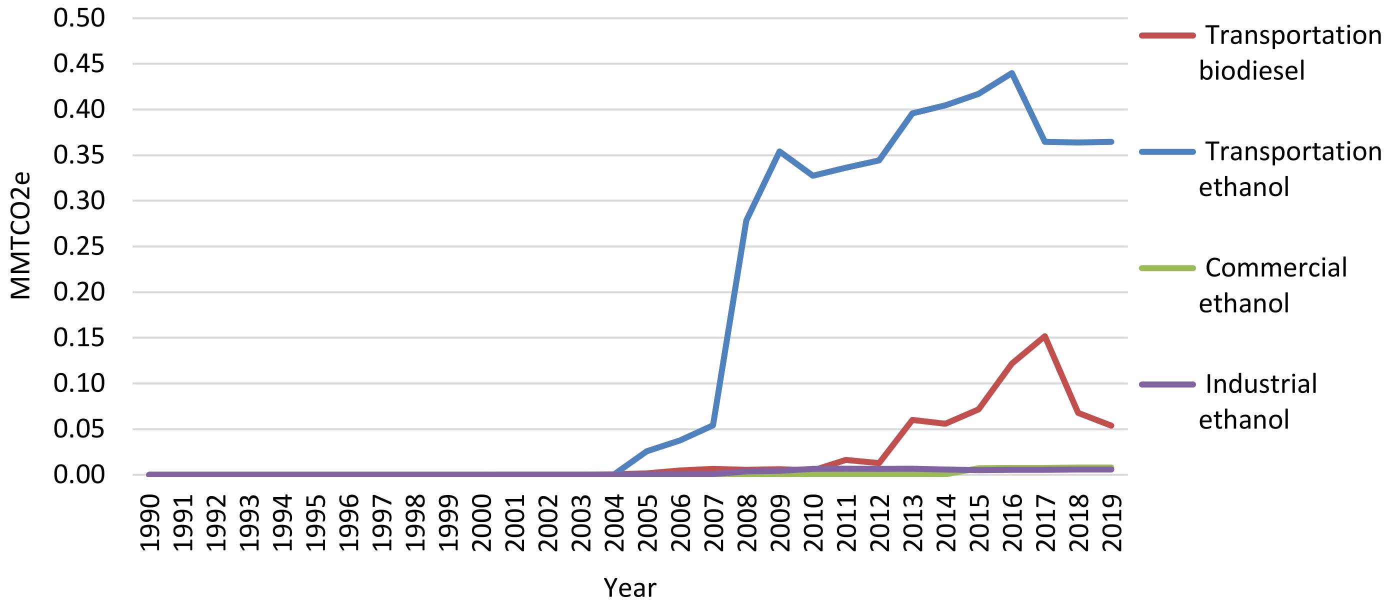

Figure 12. GHG emissions from the combustion of ethanol and biodiesel by energy sector (1990-2019)

iii. <u>Economic Analysis of Gross Greenhouse Gas Emissions</u>

Maine's real 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 2019. Since 1990, Maine's real GDP grew 59%, from $37 billion in 1990 to $59 billion in 2019.[25] During the same period, energy consumption declined 11%, from 430,659 BBtu to 383,725 BBtu. From 1990 through 2002, GHG emissions increased and tracked very closely with real GDP; however, in 2005, GHG emissions began to decrease significantly (Figure 13, Appendix G).

[25] U.S. Bureau of Economic Analysis, Regional Data, http://www.bea.gov/iTable/index_regional.cfm

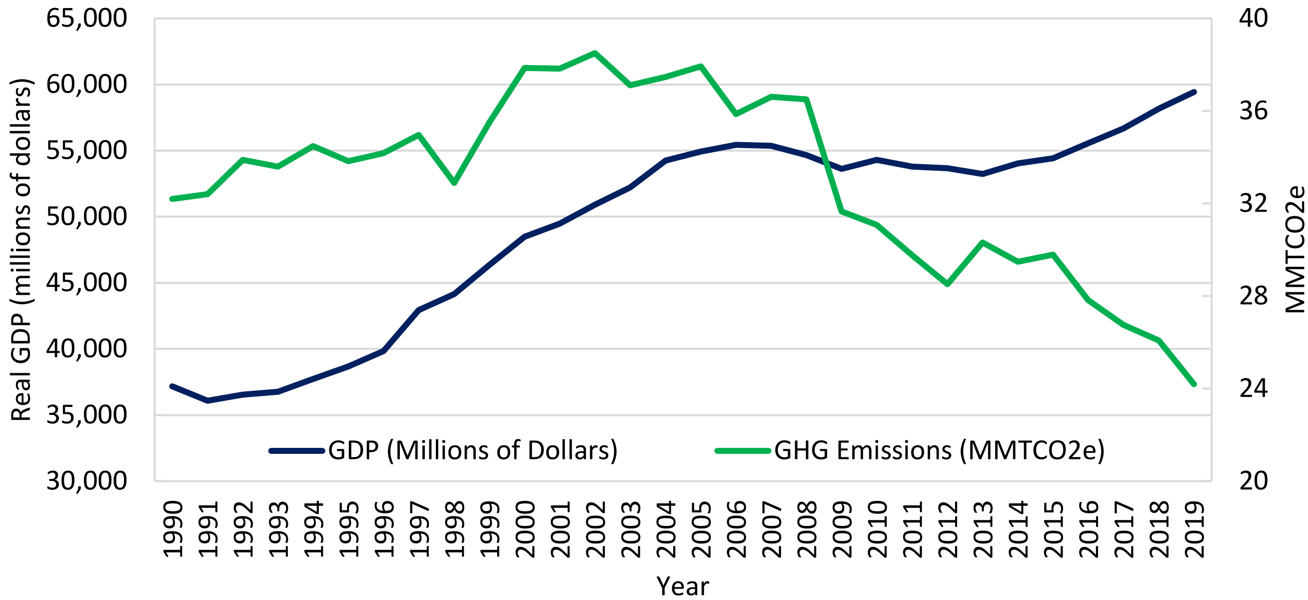

Figure 13. Total GHG emissions and real gross domestic product (GDP)

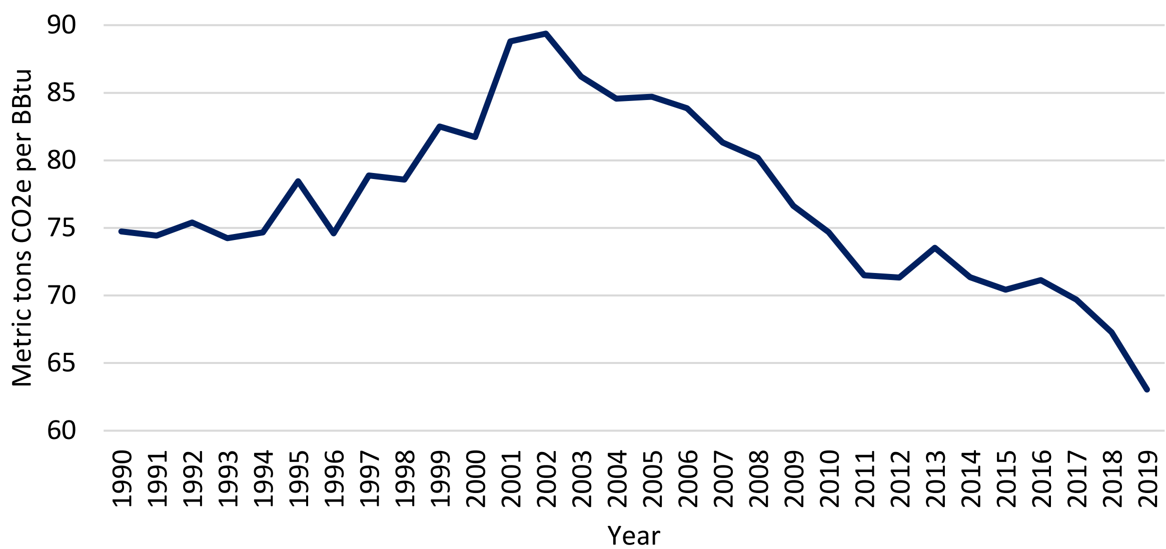

Figure 14. GHG emissions per unit of energy used

Figure 14 shows the GHG emissions per unit of energy input has declined since 2002. This 30% decrease between 2002 and 2019 is the result of a transition to lower carbon fuels and more efficient use of all fuels.

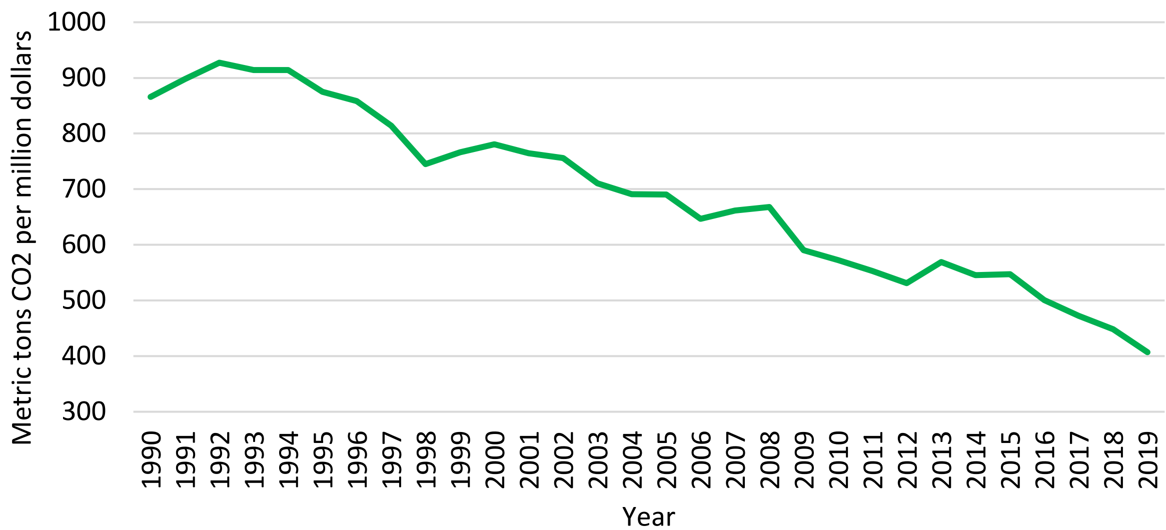

Figure 15. GHG emissions per GDP (metric tons CO_2e per million dollars)

Figure 15 illustrates the declining trend in emissions per million dollars of GDP. This 53% decrease from 1990 to 2019 indicates that the Maine economy is transitioning to lower carbon emitting fuels, more efficient equipment, and industries that require less energy per dollar of GDP.

B. Net Greenhouse Gas Emissions

Net GHG estimates are used to assess Maine's progress toward achieving carbon neutrality by 2045. Through a collaboration with the University of Maine and others,[26] the Department included a preliminary estimate of net emissions (a carbon budget) based on the 10-year period ending in 2016.

i. <u>Maine Carbon Budget</u>

The Maine carbon budget illustrated in Figure 16 shows that Maine is approximately 75% of the way to being carbon neutral, which means 75% of 2016 gross GHG emissions are balanced by sequestration in the environment. The contributions of major GHG emissions sources (gross emissions or outgassing) and sinks (total uptake) are quantified, and the figure depicts how carbon flows through the Maine carbon cycle. Maine's significant forest cover (approximately 89%) results in the State having a large capacity to store carbon, and in recent past, a high accumulation rate of forest carbon via tree growth, offsetting a high percentage of anthropogenic emissions. The forests, including dead biomass, live biomass, and soils, sequester -26.24 $MMTCO_2$ per year. Wetlands and urban biomass also sequester carbon at -0.20 and -0.41 $MMTCO_2$, respectively. The decay of wood products (including wood combusted for energy) and agriculture are net GHG emitters, and both inland and coastal waters outgas, resulting in a net release of GHG to the atmosphere. Emissions, outgassing, and uptake of carbon in the environment result in a net uptake of -13.56 $MMTCO_2$ per

[26] Bai, X., Daigneault, A., Fernandez, I., Frank, J., Hayes, D., Johnson, B., Wei, X., Weiskittel, A. (2020). State of Maine's Carbon Budget, 2006-2016 (version 1.0). https://crsf.umaine.edu/forest-climate-change-initiative/carbon-budget/

year, which is 75% of the 2016 gross anthropogenic emissions (17.97 $MMTCO_2e$).[27] Note that numbers within the top row of boxes in Figure 16 indicate the net exchange of carbon with the atmosphere, with positive numbers representing emissions to the atmosphere and negative numbers indicating uptake of carbon by the environment. Numbers within the bottom row of boxes indicate flow of carbon within the environment among compartments (e.g., to wood products or inland and coastal waters).

This first-ever carbon budget for Maine was a preliminary effort by Maine scientists in support of Maine's carbon neutrality goals. There are many uncertainties with this type of comprehensive carbon accounting, and major efforts are already underway to improve on the initial Maine carbon budget, update the data through 2021 for the next biennial report, and identify research needs.

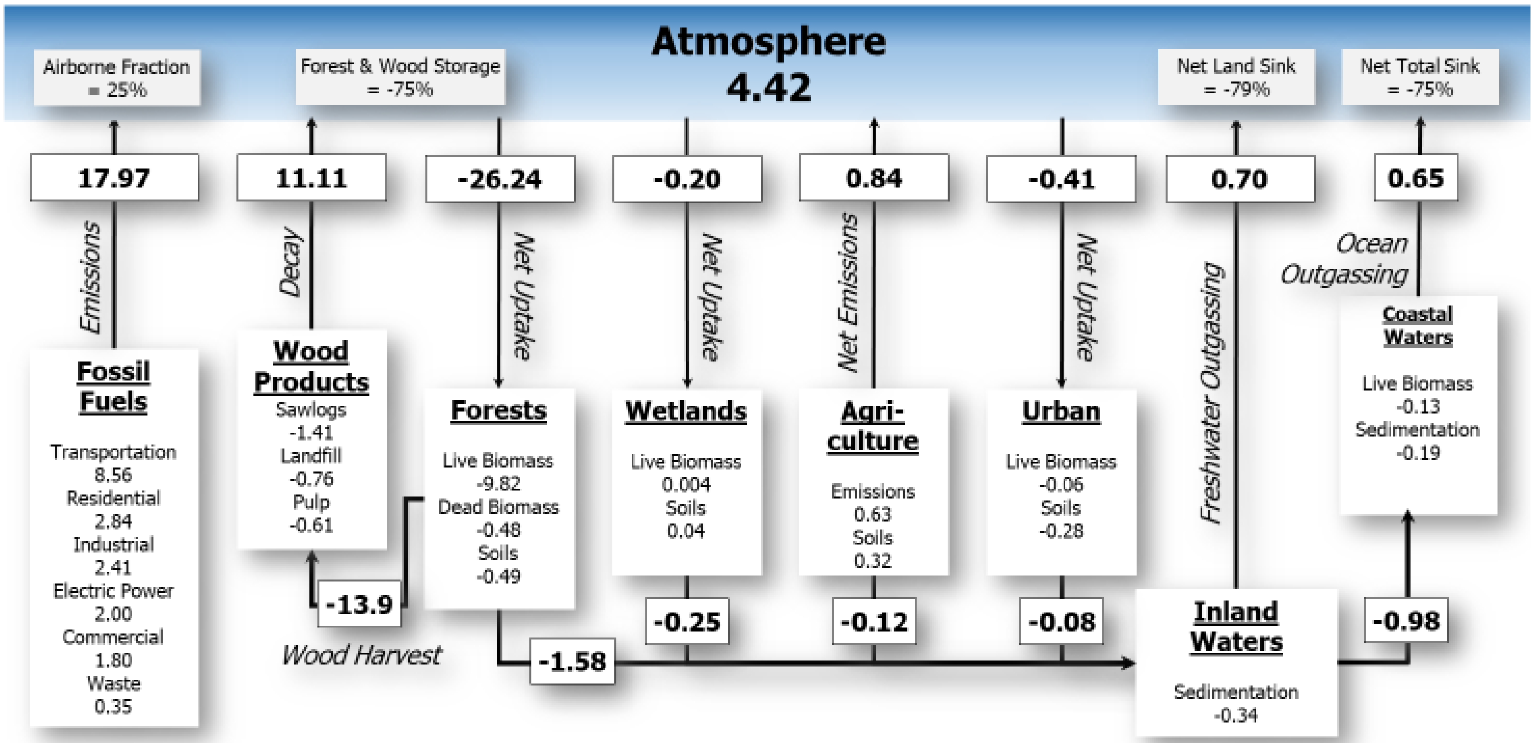

Figure 16. Maine's Carbon Budget in $MMTCO_2e$ (based on a 10-year period ending in 2016)

ii. Forest Carbon Markets

Participation in carbon markets is growing in Maine, nationally, and internationally. As of 2016, there were six forestry projects with listed carbon offset credits. Project durations ranged from 4 to 93 years. The annual average sum of these six Maine forest projects was 0.9 $MMTCO_2e$/yr.[28] While this number is relatively small compared to Maine's gross and net GHG emissions, the Department will continue to track participation in these projects and report carbon allocated to these projects for

[27] 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.
[28] Data related to Maine's participation in carbon markets that ware compiled by the University of Maine Forest Policy and Economics Lab (run by Dr. Adam Daigneault) can be found here: https://bit.ly/3M1v9ie

consideration in assessing Maine's progress toward achieving carbon neutrality by 2045. Among the recommendations listed in the final report of the Governor's Task Force on the Creation of a Forest Carbon Program[29] was exploration of the development of a voluntary credit-based and/or practice-oriented carbon program for woodland owners of 10-10,000 acres. Such a program could expand participation in carbon markets and increase carbon storage in Maine's forests.

iii. Net GHG Emissions Timeseries

While this initial carbon budget is a robust snapshot of Maine's progress toward meeting our carbon neutrality goal, it is a single point in time. A timeseries is useful in determining historical and projected trends to better assess Maine's trajectory toward carbon neutrality. Figure 17 shows historical (1990-2019) and projected (2020-2050) 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.[30] This figure shows forest contributions to carbon uptake in the form of growth, wood products, and wood energy that together determine carbon removed from the atmosphere. Subtracting Total Forest Sector C from Gross GHG Emissions w/Biogenic gives the net annual emissions of GHG. Annual net GHG equal to zero is carbon neutrality. Note: This timeseries is not as robust as the Maine Carbon Budget in terms of the data included because not all data were are available for the entire timeseries.

Maine has a statutory requirement to achieve carbon neutrality by 2045. The projected data in Figure 17 suggest Maine could reach carbon neutrality by 2033; however, this projection is based on a number of assumptions including: a continuous glide path of gross GHG emissions meeting the *Maine Won't Wait* climate action plan 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 and may have sold their offsets to entities located outside the state.

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[29] Recommended by *Maine Won't Wait* and established by executive order on January 13, 2021. Final report: https://www.maine.gov/future/sites/maine.gov.future/files/inline-files/MaineForestCarbonTaskForce_Final Report.pdf

[30] Forest carbon data is collected by the Maine Forest Service in collaboration with the Forest Inventory and Analysis National Program (FIA). The data is processed by FIA and summarized by Domke et al. (2021). The University of Maine used these primary data sources to isolate the forest carbon data for Maine used in the timeseries.

- Burrill, Elizabeth A.; DiTommaso, Andrea M.; Turner, Jeffery A.; Pugh, Scott A.; Menlove, James; Christiansen, Glenn; Perry, Carol J.; Conkling, Barbara L. 2021. The Forest Inventory and Analysis Database: database description and user guide version 9.0.1 for Phase 2. U.S. Department of Agriculture, Forest Service. 1026 p. [Online]. Available at web address: http://www.fia.fs.fed.us/library/database-documentation/.
- Domke, Grant M.; Walters, Brian F.; Nowak, David J.; Smith, James, E.; Nichols, Michael C.; Ogle, Stephen M.; Coulston, J.W.; Wirth, T.C. 2021. Greenhouse gas emissions and removals from forest land, woodlands, and urban trees in the United States, 1990–2019. Resource Update FS–307. Madison, WI: U.S. Department of Agriculture, Forest Service, Northern Research Station. 5 p. [plus 2 appendixes]. https://doi.org/10.2737/FS-RU-307.

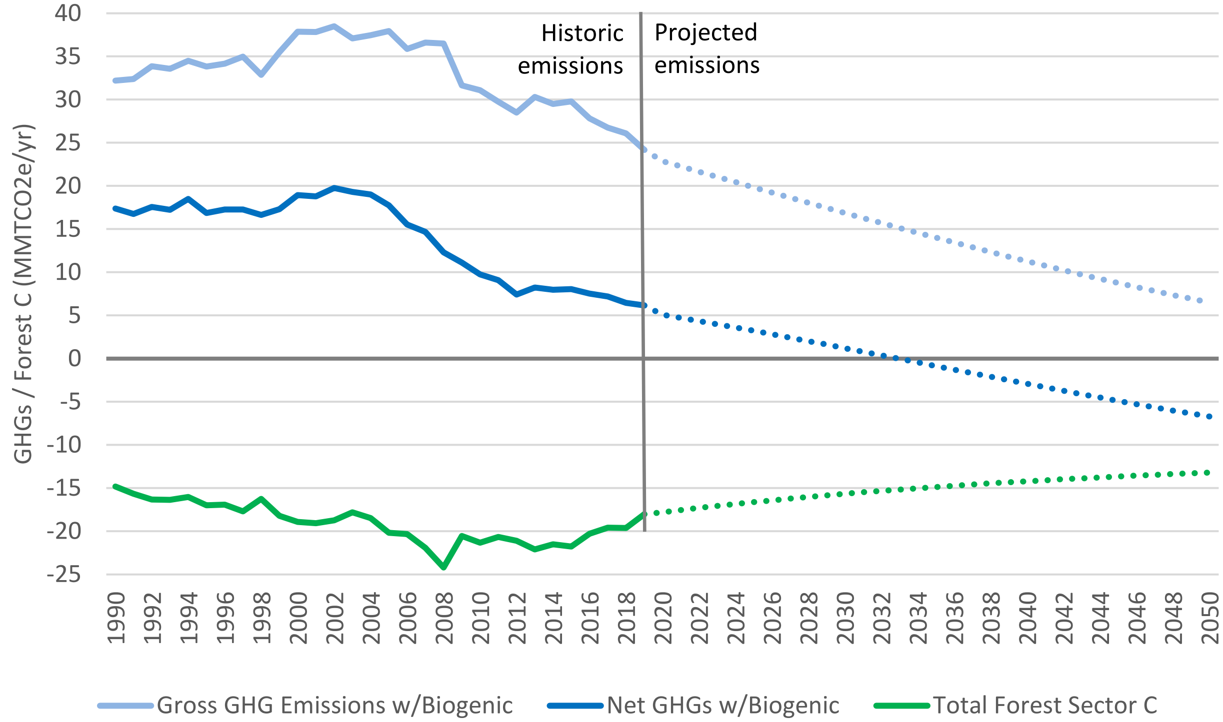

Figure 17. Maine GHG Emissions and Forest Sector Carbon (1990-2050)[31]
(Projected data are based on several assumptions listed at the bottom of page 22, including that Maine meets the statutory gross GHG reduction goals and the high rate of forest carbon sequestration continues.)

IV. Conclusion

This ninth 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 2019 as well as the first estimate of net GHG emissions. The data in Appendix A show that in 2019, Maine's GHG emissions were 25% 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. Future emissions data will be used to continue to track Maine's progress toward meeting the State's gross GHG requirements of 45% below 1990 levels by January 1, 2030 and 80% below 1990 levels by 2050 (Figure 18).

[31] The forest sector timeseries 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/

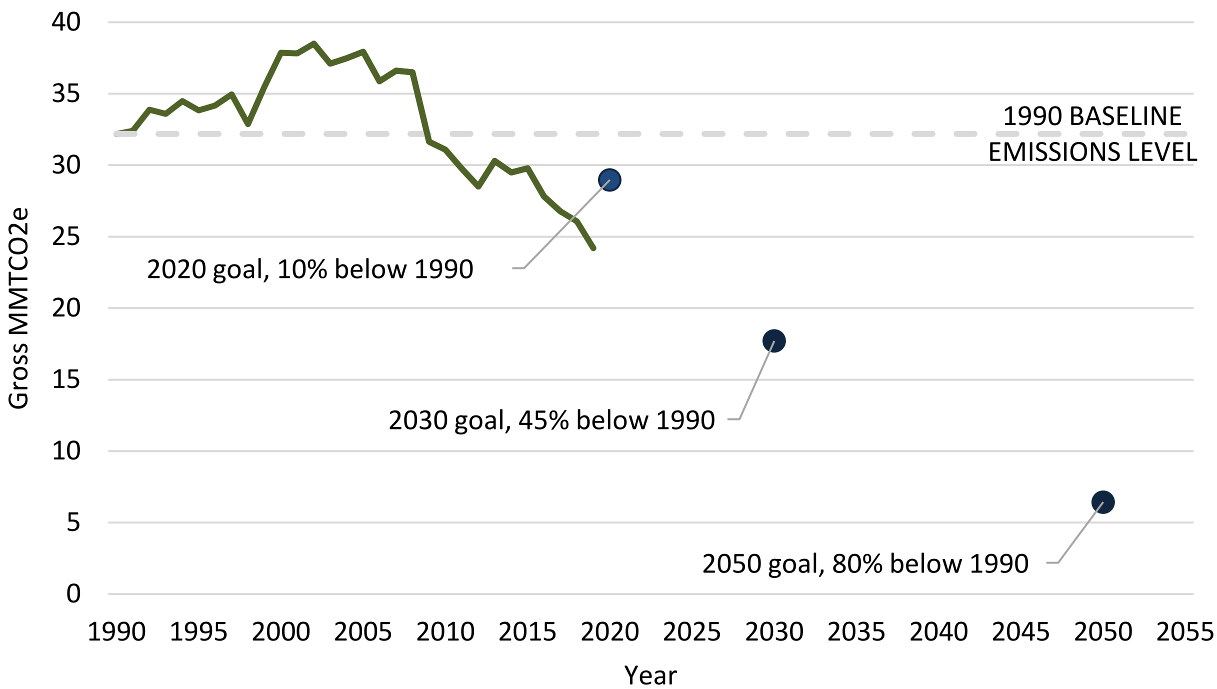

Figure 18. Maine's greenhouse gas emissions 1990-2019 with 2020, 2030, and 2050 reduction goals

To meet the emissions reduction and carbon neutrality goals, Maine should focus on policies and programs that support the reduction of GHG emissions from all sectors; however, reductions in CO_2 emissions from the combustion of fossil fuels in the transportation and residential sectors could have the biggest effect as these are the sectors with both the highest CO_2 emissions and the greatest consumption of fossil fuels. The Maine Climate Council's recommendations in *Maine Won't Wait* prioritize these sectors and should ensure emissions will reach the targets in Maine law if fully implemented and achieved.

V. Appendices

Appendix A: Maine Greenhouse Gas Emissions in $MMTCO_2e$

Table A1. Maine's Greenhouse Gas Emissions by Source Category in MMTCO2e (1990 - 2019) (Including Biogenic Emissions)

	Energy	Industrial Processes	Agriculture	Waste	Gross Emissions
1990	29.67	0.85	0.55	1.12	32.19
1991	29.86	0.84	0.54	1.16	32.40
1992	31.20	0.90	0.54	1.24	33.88
1993	30.72	1.00	0.57	1.30	33.59
1994	31.60	0.98	0.53	1.39	34.49
1995	30.83	1.10	0.53	1.38	33.84
1996	31.12	1.10	0.57	1.39	34.18
1997	31.68	1.20	0.63	1.46	34.96
1998	29.36	1.27	0.67	1.58	32.88
1999	31.96	1.28	0.67	1.60	35.51
2000	34.43	1.24	0.55	1.64	37.86
2001	34.36	1.22	0.60	1.65	37.83
2002	35.27	1.22	0.63	1.38	38.50
2003	34.06	1.18	0.64	1.22	37.11
2004	34.53	1.24	0.67	1.05	37.48
2005	34.86	1.26	0.72	1.09	37.93
2006	32.69	1.29	0.75	1.13	35.87
2007	33.50	1.34	0.78	1.00	36.62
2008	33.62	1.25	0.78	0.85	36.51
2009	29.06	1.07	0.71	0.81	31.65
2010	28.69	0.90	0.61	0.88	31.08
2011	27.34	1.04	0.49	0.88	29.75
2012	26.20	0.92	0.50	0.89	28.51
2013	27.88	1.01	0.51	0.90	30.31
2014	27.17	0.97	0.47	0.88	29.49
2015	27.55	0.92	0.48	0.84	29.79
2016	25.58	0.92	0.46	0.86	27.82
2017	24.53	0.92	0.46	0.84	26.76
2018	23.88	0.90	0.47	0.83	26.08
2019	22.00	0.89	0.45	0.85	24.19

Table A2. Maine's Greenhouse Gas Emissions by Source Category in MMTCO2e (1990 - 2019) (Excluding Biogenic Emissions)

	Energy	Industrial Processes	Agriculture	Waste	Gross Emissions
1990	19.26	0.85	0.55	0.73	21.40
1991	18.78	0.84	0.54	0.75	20.92
1992	19.63	0.90	0.54	0.81	21.88
1993	19.17	1.00	0.57	0.87	21.61
1994	20.56	0.98	0.53	0.91	22.97
1995	19.24	1.10	0.53	0.91	21.78
1996	19.74	1.10	0.57	0.92	22.33
1997	19.99	1.20	0.63	0.96	22.77
1998	19.66	1.27	0.67	0.97	22.57
1999	20.63	1.28	0.67	0.99	23.56
2000	22.57	1.24	0.55	1.02	25.38
2001	22.69	1.22	0.60	1.02	25.53
2002	24.19	1.22	0.63	0.78	26.82
2003	24.05	1.18	0.64	0.73	26.60
2004	24.32	1.24	0.67	0.66	26.89
2005	23.33	1.26	0.72	0.69	25.99
2006	21.48	1.29	0.75	0.70	24.23
2007	21.17	1.34	0.78	0.65	23.93
2008	19.26	1.25	0.78	0.59	21.88
2009	18.56	1.07	0.71	0.56	20.90
2010	17.84	0.90	0.61	0.59	19.93
2011	17.40	1.04	0.49	0.59	19.52
2012	15.69	0.92	0.50	0.60	17.71
2013	16.43	1.01	0.51	0.60	18.57
2014	16.51	0.97	0.47	0.58	18.54
2015	16.75	0.92	0.48	0.56	18.71
2016	16.26	0.92	0.46	0.57	18.21
2017	15.49	0.92	0.46	0.56	17.43
2018	14.87	0.90	0.47	0.55	16.79
2019	14.54	0.89	0.45	0.57	16.45

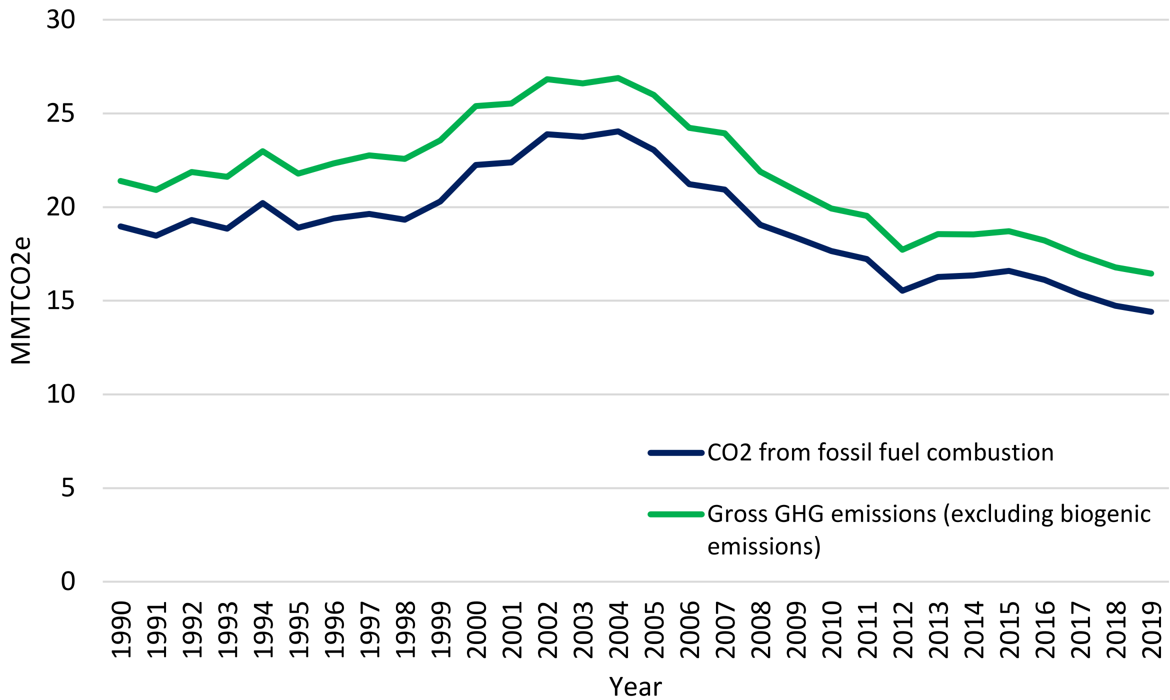

Figure A1. Maine's greenhouse gas emissions 1990-2019 (excluding biogenic emissions)

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

Year	% change	Year	% change	Year	% change
1990	0	2000	18%	2010	-3%
1991	1%	2001	18%	2011	-8%
1992	5%	2002	20%	2012	-11%
1993	4%	2003	15%	2013	-6%
1994	7%	2004	16%	2014	-8%
1995	5%	2005	18%	2015	-7%
1996	6%	2006	11%	2016	-14%
1997	9%	2007	14%	2017	-17%
1998	2%	2008	13%	2018	-19%
1999	10%	2009	-2%	2019	-25%

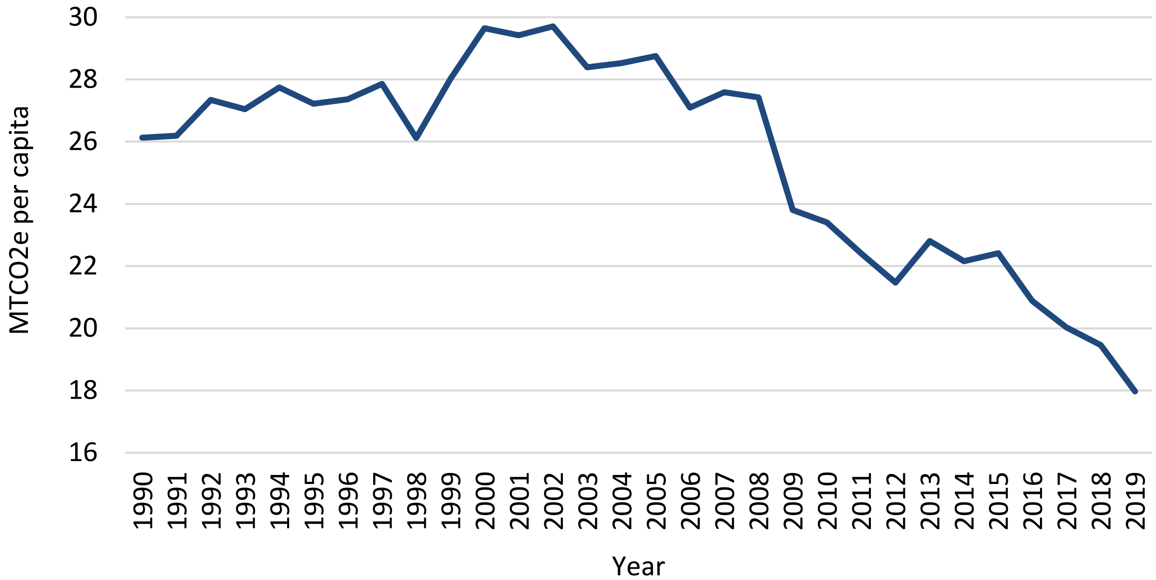

Figure A2. Maine's greenhouse gas emissions per capita 1990-2019
(GHG emissions include biogenic emissions)

Table A4. Maine's Gross Greenhouse Gas Emissions by Energy Sector with Source Category ($MMTCO_2e$; 1990 - 2019)

	Source category	1990	2000	2010	2015	2016	2017	2018	2019
ENERGY SECTOR EMISSIONS TOTAL		29.38	34.15	28.45	27.37	25.40	24.39	23.73	21.85
Residential Total		4.21	5.16	4.85	5.03	4.90	4.89	4.98	4.85
Fossil fuel combustion CO_2	Energy	3.00	3.91	2.66	3.05	2.96	2.99	3.12	3.03
Fossil fuel combustion CH_4 & N_2O	Energy	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
Wood combustion	Energy (biogenic)	1.20	1.23	2.17	1.96	1.92	1.88	1.84	1.80
Commercial Total		2.34	1.98	1.91	2.14	1.92	2.02	2.06	2.10
Fossil fuel combustion CO_2	Energy	2.24	1.90	1.71	1.78	1.62	1.70	1.74	1.77
Fossil fuel combustion CH_4 & N_2O	Energy	0.01	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	0.01
Wood combustion	Energy (biogenic)	0.09	0.07	0.19	0.34	0.28	0.30	0.29	0.30
Industrial Total		10.69	12.88	7.21	5.93	5.44	5.58	5.85	5.04
Fossil fuel combustion CO_2	Energy	3.37	4.32	2.73	1.64	1.45	1.40	1.56	1.66
Fossil fuel combustion CH_4 & N_2O	Energy	0.01	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	0.01
Wood combustion	Energy (biogenic)	7.31	8.55	4.47	4.29	3.98	4.17	4.28	3.36
Transportation Total		8.26	8.61	8.21	8.98	9.09	8.71	7.63	7.58
Fossil fuel combustion CO_2	Energy	8.02	8.35	7.75	8.40	8.44	8.12	7.12	7.10
Fossil fuel combustion CH_4 & N_2O	Energy	0.24	0.26	0.13	0.09	0.08	0.08	0.07	0.07
Ethanol combustion	Energy (biogenic)	0.00	0.00	0.33	0.42	0.44	0.36	0.36	0.36
Biodiesel combustion	Energy (biogenic)	0.00	0.00	0.00	0.07	0.12	0.15	0.07	0.05
Electric Power Total		3.88	5.52	6.26	5.29	4.05	3.19	3.22	2.28
Fossil fuel combustion CO_2	Energy	2.06	3.50	2.57	1.58	1.49	1.03	1.07	0.71
Fossil fuel combustion CH_4 & N_2O	Energy	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Wood combustion	Energy (biogenic)	1.81	2.01	3.69	3.71	2.56	2.16	2.15	1.56
NON-ENERGY SECTOR EMISSIONS TOTAL		2.81	3.72	2.63	2.42	2.42	2.37	2.35	2.35
Natural gas distribution system CH_4 fugitive emissions	Energy	0.01	0.01	0.02	0.03	0.03	0.03	0.04	0.04
CO_2 from combustion of international bunker fuels	Energy	0.28	0.27	0.22	0.15	0.15	0.11	0.12	0.12
Industrial processes	Industrial processes	0.85	1.24	0.90	0.92	0.92	0.92	0.90	0.89
Agriculture	Agriculture	0.55	0.55	0.61	0.48	0.46	0.46	0.47	0.45
Wastewater	Waste	0.32	0.40	0.38	0.35	0.35	0.34	0.34	0.35
Municipal solid waste	Waste	0.41	0.61	0.20	0.21	0.22	0.22	0.21	0.22
Solid waste (biogenic CO_2 emissions)	Waste (biogenic)	0.39	0.62	0.29	0.28	0.29	0.28	0.28	0.28
Gross GHG emissions		**32.19**	**37.86**	**31.08**	**29.79**	**27.82**	**26.76**	**26.08**	**24.19**

Appendix B: CO_2 Emissions from Fossil Fuel Combustion in Maine

Table B1. Carbon Dioxide Emissions from Fossil Fuel Combustion (1990 - 1999)

MMTCO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Residential Total	3.00	3.00	3.02	3.14	3.21	3.95	4.07	3.93	4.24	4.04
Coal	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	2.94	2.96	2.96	3.08	3.16	3.90	4.01	3.88	4.19	3.98
Natural Gas	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Commercial Total	2.24	2.21	1.79	1.77	1.81	1.53	1.69	1.65	1.72	1.60
Coal	0.08	0.03	0.07	0.05	0.01	0.01	0.01	0.01	0.01	0.01
Petroleum	2.06	2.08	1.60	1.60	1.67	1.39	1.54	1.50	1.58	1.45
Natural Gas	0.09	0.10	0.12	0.12	0.13	0.13	0.14	0.15	0.13	0.14
Industrial Total	3.37	3.98	5.36	5.04	6.28	4.89	5.01	4.39	3.69	3.41
Coal	0.52	0.86	1.95	1.00	1.08	0.65	0.54	0.44	0.32	0.27
Petroleum	2.74	3.01	3.30	3.95	5.10	4.13	4.35	3.82	3.26	3.01
Natural Gas	0.11	0.12	0.11	0.09	0.09	0.10	0.11	0.13	0.12	0.13
Transportation Total	8.02	7.29	7.26	7.32	7.48	7.12	7.41	7.79	7.52	7.86
Coal	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	7.25	7.32	7.48	7.12	7.41	7.78	7.52	7.86
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00
Electric Power Total	2.06	1.68	1.65	1.31	1.21	1.24	1.09	1.74	1.93	3.26
Coal	0.36	0.58	0.58	0.59	0.57	0.37	0.38	0.39	0.36	0.37
Petroleum	1.69	1.09	1.07	0.72	0.63	0.86	0.71	1.34	1.57	2.85
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03
International Bunker Fuels	0.28	0.31	0.23	0.26	0.22	0.18	0.14	0.13	0.22	0.14
Petroleum	0.28	0.31	0.23	0.26	0.22	0.18	0.14	0.13	0.22	0.14
Gross CO2 Emissions	**18.96**	**18.47**	**19.31**	**18.84**	**20.21**	**18.90**	**19.40**	**19.64**	**19.32**	**20.29**
Coal	0.99	1.46	2.61	1.65	1.67	1.03	0.92	0.85	0.69	0.65
Petroleum	17.74	16.74	16.42	16.92	18.27	17.58	18.17	18.45	18.32	19.29
Natural Gas	0.24	0.26	0.28	0.27	0.28	0.30	0.31	0.34	0.30	0.35

Table B2. Carbon Dioxide Emissions from Fossil Fuel Combustion (2000 - 2009)

MMTCO2	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009
Residential Total	3.91	3.89	3.50	4.79	5.21	4.65	4.03	3.85	3.12	2.94
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	3.85	3.83	3.44	4.73	5.14	4.58	3.97	3.79	3.06	2.87
Natural Gas	0.06	0.06	0.06	0.07	0.07	0.06	0.05	0.07	0.06	0.07
Commercial Total	1.90	1.60	1.81	2.32	2.18	2.10	1.81	2.18	2.18	1.82
Coal	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00
Petroleum	1.72	1.42	1.52	2.05	1.91	1.83	1.54	1.84	1.85	1.52
Natural Gas	0.17	0.16	0.28	0.26	0.27	0.27	0.26	0.33	0.33	0.31
Industrial Total	4.32	3.53	3.95	2.44	3.43	3.17	3.31	3.36	3.17	2.82
Coal	0.54	0.30	0.21	0.29	0.28	0.30	0.26	0.28	0.25	0.08
Petroleum	3.01	2.57	2.47	1.97	2.28	2.51	2.09	1.88	1.50	1.35
Natural Gas	0.77	0.66	1.27	0.18	0.88	0.35	0.96	1.20	1.41	1.39
Transportation Total	8.35	7.39	8.39	9.30	8.52	8.84	8.90	8.69	7.85	7.94
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	8.30	7.31	8.34	9.25	8.49	8.81	8.87	8.65	7.80	7.89
Natural Gas	0.05	0.07	0.05	0.05	0.04	0.03	0.03	0.04	0.05	0.05
Electric Power Total	3.50	5.70	5.88	4.75	4.51	3.80	2.69	2.58	2.53	2.36
Coal	0.40	0.44	0.54	0.41	0.41	0.36	0.36	0.34	0.31	0.08
Petroleum	1.63	0.88	0.36	1.01	0.62	0.73	0.08	0.34	0.17	0.24
Natural Gas	1.47	4.38	4.98	3.33	3.48	2.71	2.25	1.90	2.05	2.04
International Bunker Fuels	0.27	0.27	0.35	0.15	0.18	0.50	0.48	0.28	0.19	0.49
Petroleum	0.27	0.27	0.35	0.15	0.18	0.50	0.48	0.28	0.19	0.49
Gross CO2 Emissions	**22.24**	**22.38**	**23.89**	**23.75**	**24.04**	**23.05**	**21.23**	**20.93**	**19.05**	**18.36**
Coal	0.95	0.75	0.76	0.71	0.70	0.67	0.63	0.63	0.56	0.16
Petroleum	18.78	16.30	16.48	19.16	18.62	18.96	17.04	16.77	14.58	14.35
Natural Gas	2.52	5.33	6.64	3.88	4.72	3.42	3.56	3.53	3.91	3.86

Table B3. Carbon Dioxide Emissions from Fossil Fuel Combustion (2010 - 2019)

MMTCO2	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Residential Total	2.66	2.73	2.25	2.41	2.57	3.05	2.96	2.99	3.12	3.03
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	2.60	2.65	2.17	2.31	2.44	2.90	2.82	2.84	2.95	2.86
Natural Gas	0.07	0.08	0.08	0.10	0.13	0.15	0.14	0.15	0.17	0.17
Commercial Total	1.71	1.85	1.58	1.62	1.71	1.78	1.62	1.70	1.74	1.77
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	1.39	1.49	1.18	1.17	1.22	1.23	1.16	1.21	1.22	1.23
Natural Gas	0.32	0.36	0.40	0.44	0.49	0.55	0.47	0.49	0.53	0.54
Industrial Total	2.73	2.61	2.39	2.36	1.90	1.64	1.45	1.40	1.56	1.66
Coal	0.08	0.05	0.05	0.07	0.08	0.07	0.04	0.04	0.05	0.04
Petroleum	1.13	1.06	0.73	0.57	0.53	0.46	0.42	0.42	0.50	0.52
Natural Gas	1.52	1.49	1.61	1.72	1.29	1.11	1.00	0.93	1.01	1.11
Transportation Total	7.75	7.70	7.31	8.19	8.32	8.40	8.44	8.12	7.12	7.10
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	7.66	7.57	7.27	8.14	8.25	8.35	8.41	8.08	7.08	7.03
Natural Gas	0.10	0.13	0.04	0.05	0.07	0.05	0.04	0.04	0.05	0.06
Electric Power Total	2.57	2.08	1.73	1.43	1.65	1.58	1.49	1.03	1.07	0.71
Coal	0.14	0.09	0.08	0.09	0.13	0.18	0.17	0.16	0.15	0.16
Petroleum	0.19	0.11	0.09	0.21	0.23	0.43	0.11	0.13	0.15	0.03
Natural Gas	2.24	1.87	1.56	1.13	1.29	0.97	1.21	0.74	0.76	0.52
International Bunker Fuels	0.22	0.25	0.27	0.27	0.20	0.15	0.15	0.11	0.12	0.12
Petroleum	0.22	0.25	0.27	0.27	0.20	0.15	0.15	0.11	0.12	0.12
Gross CO2 Emissions	**17.66**	**17.22**	**15.53**	**16.27**	**16.36**	**16.59**	**16.11**	**15.34**	**14.73**	**14.41**
Coal	0.22	0.15	0.12	0.16	0.20	0.25	0.21	0.21	0.20	0.21
Petroleum	13.19	13.14	11.72	12.67	12.88	13.51	13.06	12.79	12.02	11.80
Natural Gas	4.24	3.93	3.69	3.44	3.27	2.83	2.85	2.35	2.51	2.40

Appendix C: Energy Sector Definitions[32]

- **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.

[32] 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[33]

Coal	**1990**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**
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	421	465	537	449
Electric Power	3,808	4,216	3,764	1,418	1,846	1,773	1,704	1,577	1,711
Transportation	0	0	0	0	0	0	0	0	0
Total Coal	10,413	9,980	7,059	2,279	2,588	2,194	2,168	2,113	2,160

Petroleum	**1990**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**
Residential	40,004	52,368	62,507	35,961	40,099	39,058	39,324	41,001	39,848
Commercial	27,988	23,554	25,244	19,491	17,694	16,639	17,474	17,568	17,684
Industrial	41,572	43,109	36,763	20,488	11,872	9,586	10,006	10,316	9,332
Electric Power	22,502	21,414	9,708	2,591	5,691	1,455	1,703	2,017	452
Transportation	115,381	118,905	129,693	109,451	117,933	117,964	111,777	99,610	99,173
Total Petroleum	247,447	259,350	263,915	187,982	193,289	184,702	180,284	170,512	166,489

Biodiesel	**1990**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**
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	1,650	2,054	919	727
Total Biodiesel	0	0	23	65	969	1,650	2,054	919	727

Fuel Ethanol	**1990**	**2000**	**2005**	**2010**	**2015**	**2016**	**2017**	**2018**	**2019**
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	11	105	108	111	113	115
Industrial	0	0	6	93	75	79	81	82	83
Electric Power	0	0	0	0	0	0	0	0	0
Transportation	0	0	375	4,766	6,073	6,405	5,307	5,300	5,309
Total Fuel Ethanol	0	0	381	4,871	6,254	6,592	5,499	5,496	5,507

[33] 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	2016	2017	2018	2019
Residential	651	1,195	1,204	1,282	2,782	2,642	2,847	3,192	3,250
Commercial	1,686	3,194	5,019	6,055	10,380	8,814	9,247	9,938	10,285
Industrial	2,034	14,969	6,807	29,460	21,613	19,548	18,337	19,938	21,800
Electric Power	196	27,758	51,177	42,371	18,398	22,833	13,989	14,450	9,755
Transportation	5	932	612	1,821	1,030	673	704	851	1,201
Total Natural Gas	4,572	48,047	64,818	80,988	54,203	54,509	45,125	48,370	46,291

Waste	1990	2000	2005	2010	2015	2016	2017	2018	2019
Residential	0	0	0	0	0	0	0	0	0
Commercial	2,177	2,757	1,774	2,061	1,780	1,648	1,847	1,496	1,088
Industrial	3,131	2,758	1,382	1,625	658	510	314	433	519
Electric Power	2,459	5,321	2,442	2,670	1,335	1,412	1,354	1,366	1,241
Transportation	0	0	0	0	0	0	0	0	0
Total Waste	7,767	10,836	5,599	6,355	3,773	3,570	3,515	3,295	2,848

Wood	1990	2000	2005	2010	2015	2016	2017	2018	2019
Residential	12,625	12,928	14,140	22,808	20,664	20,235	19,807	19,378	18,949
Commercial	933	751	969	1,993	3,615	2,999	3,159	3,098	3,200
Industrial	76,963	90,083	66,375	47,697	44,379	41,005	43,756	44,843	34,795
Electric Power	19,040	21,136	39,682	35,149	35,134	26,400	22,214	22,182	16,344
Transportation	0	0	0	0	0	0	0	0	0
Total Wood	109,561	124,898	121,166	107,647	103,793	90,640	88,936	89,501	73,289

Hydro	1990	2000	2005	2010	2015	2016	2017	2018	2019
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	3,632	2,972	3,353	1,042	1,003
Electric Power	28,568	23,409	34,655	30,291	27,684	24,722	27,867	28,647	30,159
Transportation	0	0	0	0	0	0	0	0	0
Total Hydro	42,550	36,630	40,905	37,174	31,317	27,693	31,221	29,689	31,162

Wind	1990	2000	2005	2010	2015	2016	2017	2018	2019
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	12,075	15,391	21,493	21,707	22,208
Transportation	0	0	0	0	0	0	0	0	0
Total Wind	0	0	0	4,870	12,075	15,391	21,493	21,707	22,208

Appendix D (Continued)

Solar	1990	2000	2005	2010	2015	2016	2017	2018	2019
Residential	85	110	97	130	265	323	395	480	551
Commercial	0	0	0	8	58	95	131	176	283
Industrial	0	0	0	0	0	0	0	0	0
Electric Power	0	0	0	0	0	0	50	110	63
Transportation	0	0	0	0	0	0	0	0	0
Total Solar	85	110	97	139	323	418	577	765	897

Geothermal	1990	2000	2005	2010	2015	2016	2017	2018	2019
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	2016	2017	2018	2019
Coal	10,413	9,980	7,059	2,279	2,588	2,194	2,168	2,113	2,160
Petroleum	247,447	259,350	263,915	187,980	193,289	184,703	180,283	170,511	166,489
Biodiesel	0	0	23	65	969	1,650	2,054	919	727
Fuel Ethanol	0	0	381	4,871	6,254	6,592	5,499	5,496	5,507
Natural Gas	4,572	48,047	64,818	80,988	54,203	54,509	45,125	48,370	46,291
Waste	7,767	10,836	5,599	6,355	3,773	3,570	3,515	3,295	2,848
Wood	109,561	124,898	121,166	107,647	103,793	90,640	88,936	89,501	73,289
Nuclear	51,436	0	0	0	0	0	0	0	0
Hydro	42,550	36,630	40,905	37,174	31,317	27,693	31,221	29,689	31,162
Wind	0	0	0	4,870	12,075	15,391	21,493	21,707	22,208
Solar	85	110	97	139	323	418	577	765	897
Geothermal	0	5	11	70	72	72	72	72	72
Total	**473,831**	**489,856**	**503,974**	**432,438**	**408,656**	**387,432**	**380,943**	**372,438**	**351,650**
Interstate Electricity	-42,426	-30,206	-56,233	-25,402	-11,705	-17,371	-14,165	-3,721	472
International Electricity	7,587	13,153	8,141	6,303	16,091	16,873	15,001	14,481	13,717
Total Energy Consumption	**438,992**	**472,803**	**455,882**	**413,339**	**413,042**	**386,934**	**381,779**	**383,198**	**365,839**

Appendix E: Maine Energy Consumption by Sector[34]

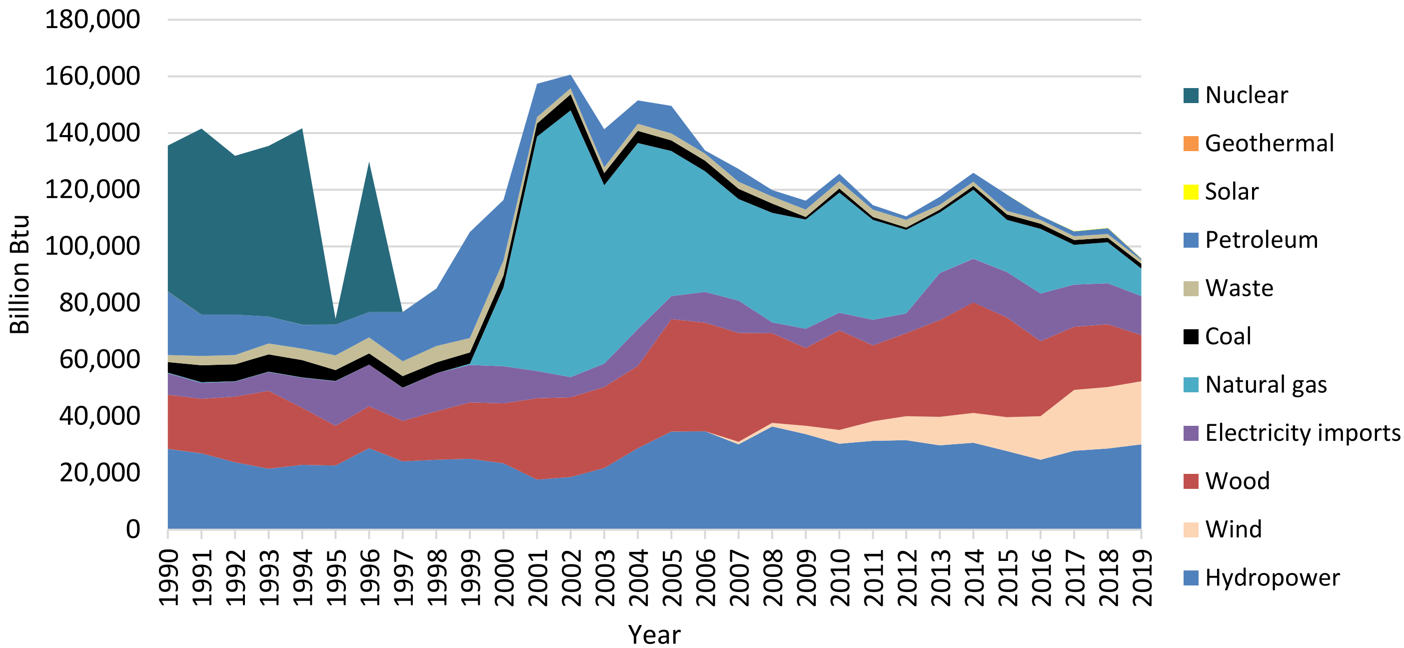

Figure E1. Energy consumption in the electric power sector

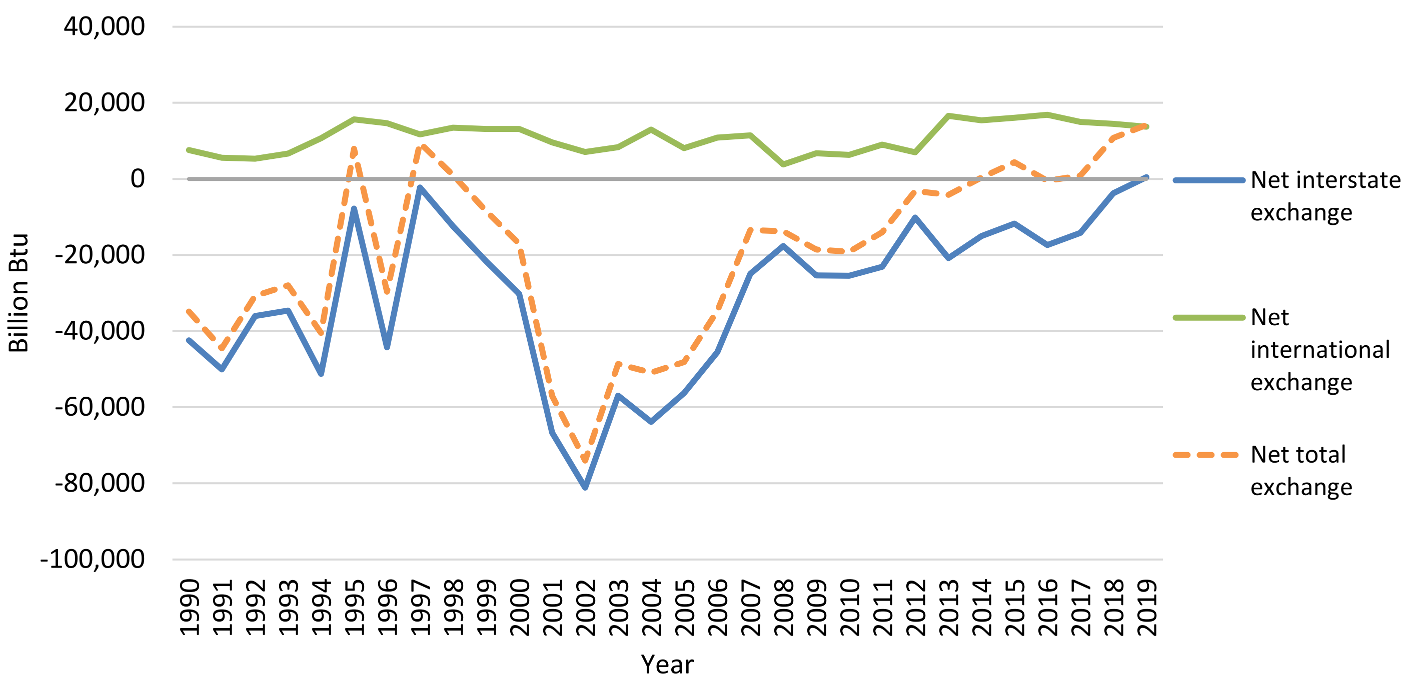

Figure E2. Electricity imports and exports from Maine. (Positive numbers represent imports of electricity to Maine, and negative numbers represent exports from Maine.)

[34] 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)

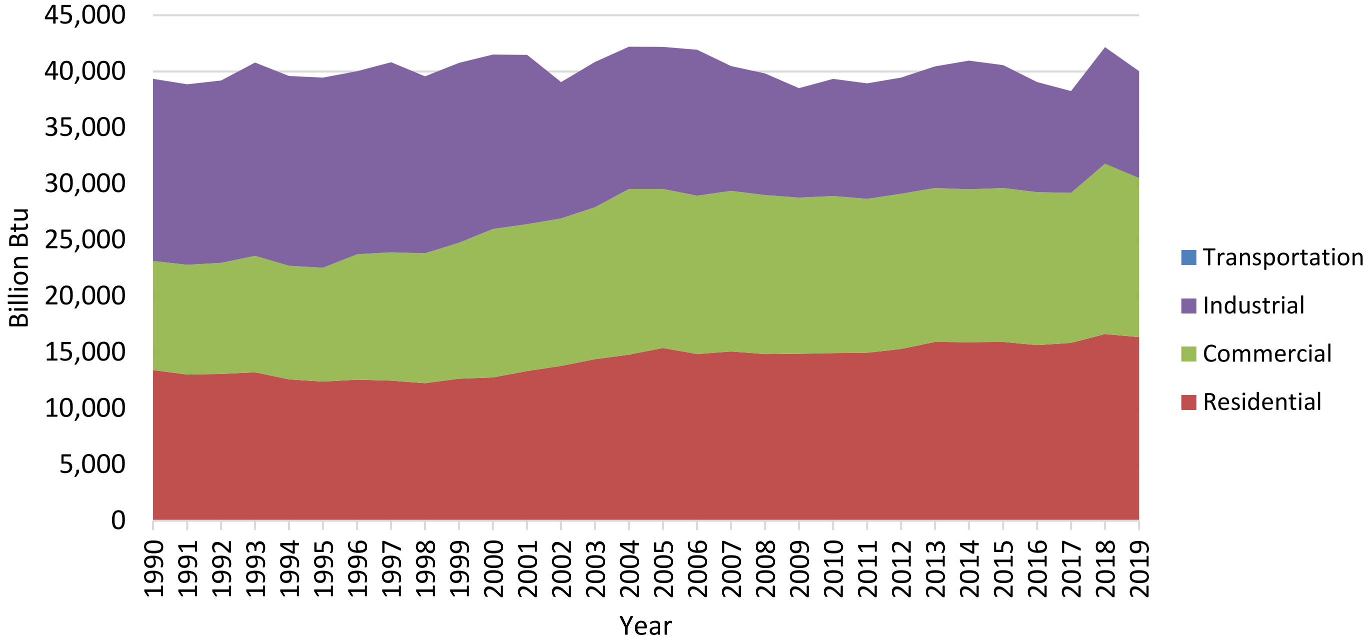

Figure E3. Electric power consumption by sector

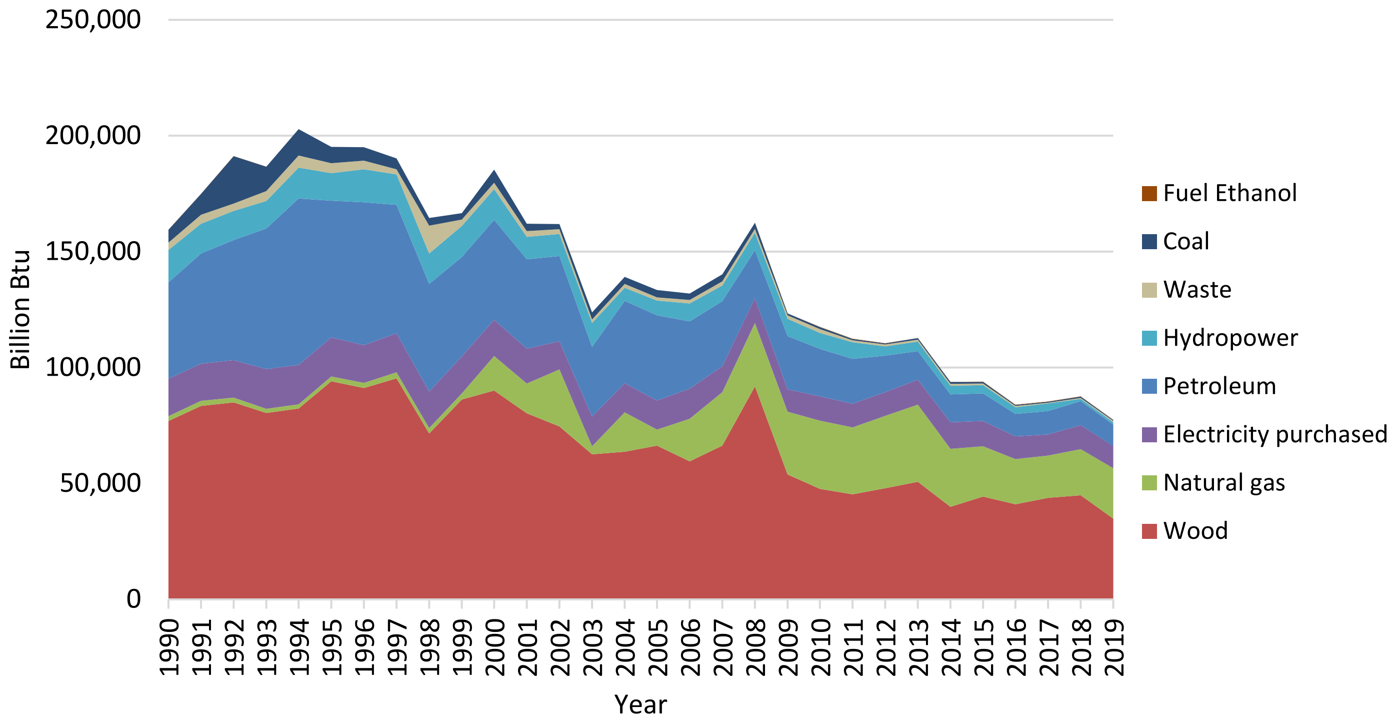

Figure E4. Energy consumption in the industrial sector

Appendix E (Continued)

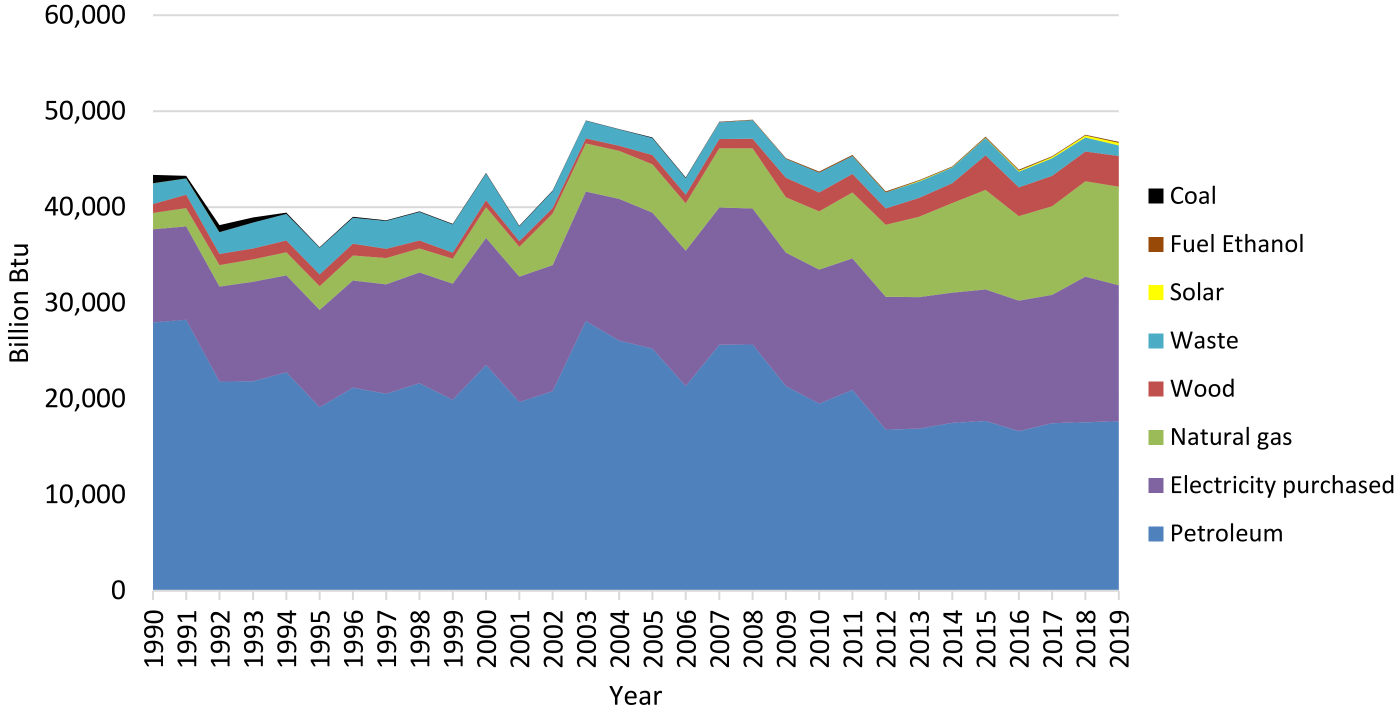

Figure E5. Energy consumption in the commercial sector

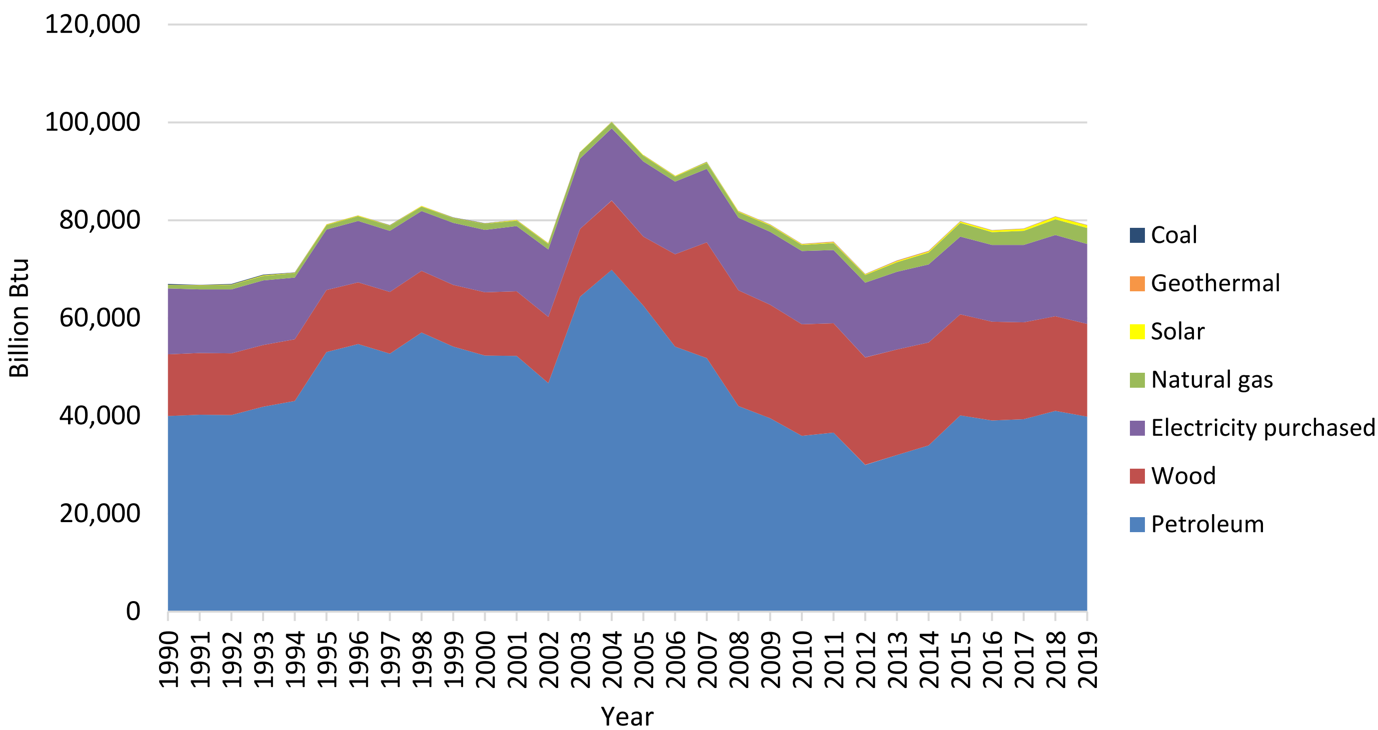

Figure E6. Energy consumption in the residential sector

Appendix E (Continued)

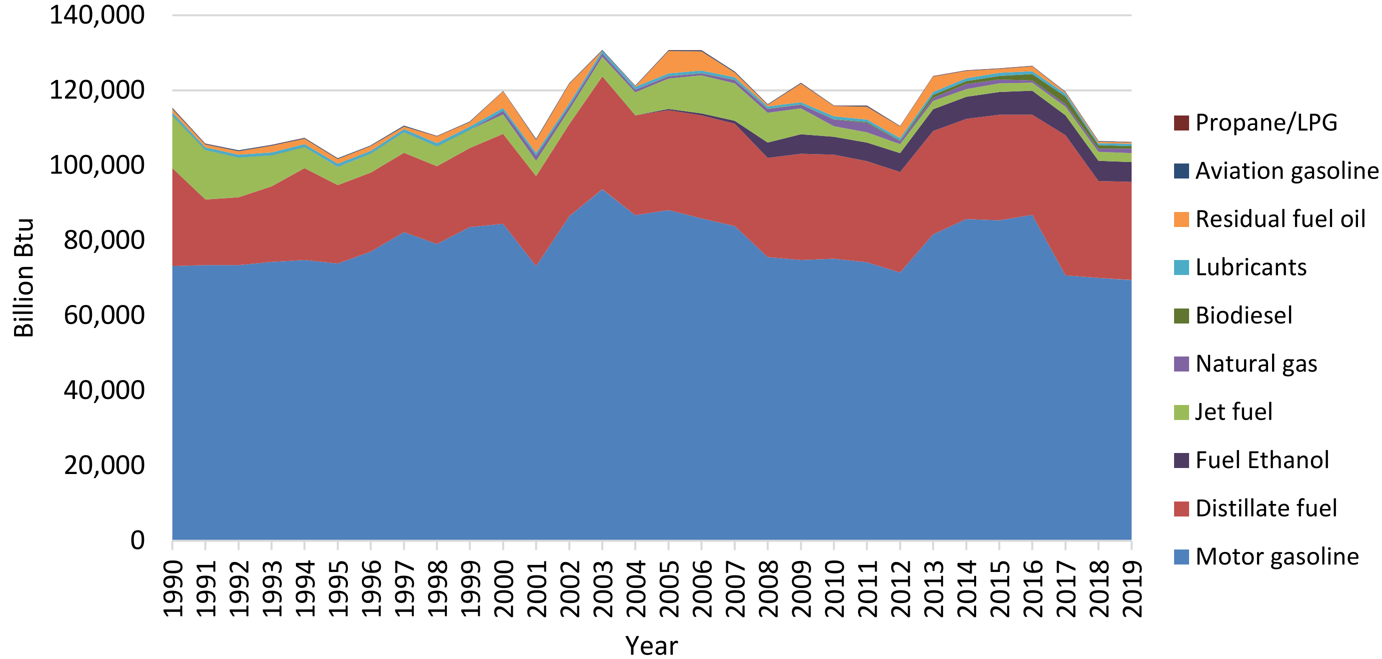

Figure E7. Energy consumption in the transportation sector

Appendix F: Petroleum Consumption by Fuel Type in Billion Btu

Table F1. Petroleum consumption by fuel type in billion Btu[35]

Fuel Type	1990	2000	2005	2010	2015	2016	2017	2018	2019
Motor Gasoline*	74,206	84,921	89,543	76,915	88,094	89,574	73,439	72,802	72,256
Distillate Fuel Oil**	77,654	89,129	98,729	72,274	73,348	68,898	81,034	70,728	70,291
Propane/LPG	5,201	5,035	8,832	10,873	13,840	13,466	14,115	15,143	15,154
Other***	5,501	4,838	3,640	6,217	6,453	4,691	4,911	4,155	2,852
Jet Fuel & Aviation Gasoline	14,327	5,276	8,284	2,966	2,390	2,182	2,371	2,524	2,456
Residual Fuel Oil	66,833	59,723	43,593	15,457	7,632	3,798	3,008	3,939	1,823
Kerosene	3,726	10,429	11,295	3,278	1,533	2,095	1,405	1,221	1,656
Total	247,448	259,351	263,916	187,980	193,290	184,704	180,283	170,512	166,488

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

35 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	GDP (millions of dollars) [36]	GHG Emissions ($MMTCO_2e$) [37]	Total energy per GDP (BBtu per million dollars) [38]	GHG emissions per GDP (tons CO_2e per million dollars)	GHG emissions per energy input (tons CO_2e per BBtu) [39]
1990	37,168	32.19	11.59	866	74.75
1991	36,082	32.40	12.06	898	74.43
1992	36,539	33.88	12.30	927	75.41
1993	36,755	33.59	12.31	914	74.24
1994	37,725	34.49	12.24	914	74.66
1995	38,681	33.84	11.15	875	78.45
1996	39,834	34.18	11.50	858	74.61
1997	42,942	34.96	10.32	814	78.89
1998	44,140	32.88	9.48	745	78.58
1999	46,351	35.51	9.29	766	82.50
2000	48,490	37.86	9.56	781	81.72
2001	49,471	37.83	8.61	765	88.80
2002	50,910	38.50	8.46	756	89.37
2003	52,210	37.11	8.24	711	86.21
2004	54,256	37.48	8.17	691	84.57
2005	54,927	37.93	8.15	691	84.70
2006	55,448	35.87	7.71	647	83.86
2007	55,360	36.62	8.13	661	81.31
2008	54,654	36.51	8.33	668	80.17
2009	53,630	31.65	7.70	590	76.62
2010	54,305	31.08	7.66	572	74.69
2011	53,789	29.75	7.74	553	71.49
2012	53,680	28.51	7.45	531	71.34
2013	53,239	30.31	7.74	569	73.53
2014	54,038	29.49	7.65	546	71.36
2015	54,426	29.79	7.77	547	70.42
2016	55,565	27.82	7.04	501	71.15
2017	56,663	26.76	6.78	472	69.69
2018	58,179	26.08	6.66	448	67.29
2019	59,434	24.19	6.46	407	63.04

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