Report to the Joint Standing Committee on
Environment and Natural Resources
129th Legislature, Second Session

Eighth Biennial Report on Progress toward Greenhouse Gas Reduction Goals

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Executive Summary

The Department of Environmental Protection's (the Department) analysis of energy consumption, industrial processes, agriculture, and waste management data for the most recent years available, 2016 and 2017[1], found that Maine is on track to meet the medium-term goal of reducing greenhouse gas (GHG) emissions to 10% less than 1990 levels by January 1, 2020, as set forth in 38 M.R.S.A. §576 (2003). Gross statewide GHG emissions increased from the initially measured levels in 1990, reaching a peak in 2002. By 2008, emissions were below 1990 levels, reaching a low in 2012, rebounding slightly 2013-2015, and trending downward again in 2016 and 2017. Emissions have remained at least 10% lower than 1990 levels since 2012, and as of 2017 were 17.5% lower than 1990 levels.

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

- 90% of GHG emissions in Maine are the result of energy consumption, mostly produced by combustion of petroleum products. Annual emissions in this source category have been reduced by 35% since the high in 2002 and 14% since 2010 (Figure 2, Table A1).
- Statewide carbon dioxide (CO_2) emissions remain at least 10% lower than 1990 levels in large part because of the use of lower carbon fuels such as natural gas and increased efficiencies.
- Annual CO_2 emissions from fossil fuel combustion in the electric power sector have decreased by 83% since they peaked in 2002 largely by replacing high carbon fuels with natural gas and renewable sources (Appendix B).
- The transportation sector was responsible for 54% of Maine's CO_2 emissions in 2017, an increase from the 1990 contribution, 44% (Appendix B).
- Maine is creating 25% less GHG emissions per billion Btu (BBtu) of energy in 2017 than the high in 2002 (Appendix G).
- In 2017, Maine's annual GHG emissions per million dollars of state gross domestic product (GDP) were 45% less 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% GHG reduction by 2030 and 80% by 2050. The updated Climate Action plan is due by December 1, 2020. Increased energy efficiency efforts, and other incentives to encourage the electrification of transportation and heating sectors will also support continued emissions reductions, especially as an updated renewable portfolio standard policy transitions Maine's electricity grid from 40% to 80% renewable energy by 2030.

[1] EPA updated its State Inventory Tool (SIT) for greenhouse gasses through 2017 in December 2019: 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 2017.

I. Introduction

In 2003, Maine's *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.A. §576). In 2019, 38 M.R.S.A. §576-A was enacted to expand the original GHG emissions goals of 38 M.R.S.A. §576. The new goals are to reduce gross emissions to at least 45% of 1990 levels by January 1, 2030 and to at least 80% of 1990 levels by 2050. This new legislation also created the Maine Climate Council, which is 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.

The Department is submitting this report to the Joint Standing Committee on Environment and Natural Resources pursuant to 38 M.R.S.A. §578, which required the Department to evaluate the State's progress toward meeting these reduction goals and submit a report of its evaluation by January 1, 2006, and by that date every two years thereafter. This report summarizes the findings of the Department's eighth quantitative evaluation of Maine's progress towards meeting statutory GHG reduction goals since the development of the original 2004 Climate Action Plan.

In January 2012, the Department reported that Maine met the short-term goal of reducing GHG emissions to 1990. Over that reporting period, Maine's real GDP increased while energy consumption and GHG emissions declined. Analysis of data for the current report shows a continuing trend of GHG emissions remaining 10% below 1990 (Appendix A).

This report addresses anthropogenic GHG emissions, i.e., emissions resulting from human activity, from within Maine using analytical methods that are consistent with the U.S. Environmental Protection Agency's (EPA) national inventory development and methods used by other New England states. The GHGs inventoried are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC), and sulfur hexafluoride (SF_6).

II. Methodology

The Department utilized the State Inventory Tool (SIT)[2], a computer model developed by EPA, which was augmented with data from state programs (e.g., state vehicle miles travelled, industrial process specific data, and solid waste data) to estimate GHG emissions in Maine. The SIT model was developed by EPA to provide 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. Since activity data is 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 is based on national databases. Much of the data in these national databases are compilations of state-submitted data; however, some data is modelled where state-specific data is unavailable.

[2] https://www.epa.gov/statelocalenergy/download-state-inventory-and-projection-tool

The GHG emissions are expressed in units of carbon dioxide equivalents (CO_2e). Emissions values are expressed in millions of metric tons of CO_2 ($MMTCO_2$) or millions of metric tons of CO_2 equivalent ($MMTCO_2e$). The SIT provides results for gross emissions in $MMTCO_2e$ by source category (i.e., industrial processes, agriculture, waste, and energy). Gross emissions include CO_2 as well as other greenhouse gases, such CH_4 and N_2O. The SIT provides sector-specific (i.e., residential, commercial, industrial, transportation, and electric utilities) results from fossil fuel combustion in $MMTCO_2$, which includes CO_2 emissions only. Results in both units are included throughout this report. Since CO_2 is the largest component of most combustion-sourced GHG emissions, and since fossil fuels are combusted in most combustion-based energy-production processes, a measure of CO_2 from the combustion of fossil fuels is presented in Appendix B. Fuel consumption values are expressed in billions of British thermal units (BBtu).

The EPA method for estimating GHG emissions is to break down activities that create emissions into source categories. The SIT estimates GHG emissions from the following source categories:

- Energy
- Agriculture
- Industrial Processes
- Waste

The energy category is responsible for most GHG emissions and encompasses energy consuming entities, such as electric power producers, and 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 waste water treatment activities.

Most of the inventory data in the SIT comes from the Department of Energy's Energy Information Administration (EIA). For some of the categories, this information is apportioned to the states from national and regional inventories. For this Eighth 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 was available through 2017.

The EIA breaks the energy source category down into five sectors — electrical generators, industrial, commercial, residential, and transportation — to align with policies and programs for GHG emission reductions that target each of these sectors separately. (See Appendix C for sector definitions.)

Renewable resources include fuel ethanol, wood and waste products including black liquor[3] and sludge, hydroelectric, wind, solar, and geothermal. Non-combustible renewable energy sources, such as hydropower, wind, and solar, do not produce GHG emissions. Emissions from combustible renewable energy sources in Maine, such as biomass and biofuel, are typically balanced by the

[3] Black liquor from pulp and paper manufacturing

sequestration of carbon from such resource pools. For these reasons, and for consistency with previous reports, GHG emissions from renewable resources were not included in this report; however, information on energy consumption from renewable sources is included in Appendix D. Future reports may organize and present this information differently to reflect the Maine Climate Council's determinations about how to account for emissions from renewable sources and carbon sequestration.

Most CO_2 emissions from energy consumption in Maine come from petroleum products. To better assess the consumption of various types of petroleum, this category was 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.[4] This analysis could allow planners to assess the relative consumption of various fuels and help in the development of future programs.

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.[5] This data is shown in Appendix G.

III. Results and Discussion

A. Gross GHG Emissions

The Department's current analysis utilizing data through the end of 2017 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 GHG emissions from 1990 – 2017. Total estimated annual GHG emissions in Maine increased from 21.23 million metric tons of carbon dioxide equivalents ($MMTCO_2e$) in 1990 to a peak of 26.53 $MMTCO_2e$ in 2002. Emissions have since declined, with emissions calculated at 17.5 $MMTCO_2e$ in 2017. This equals a reduction in annual GHG emissions of 17.5% between 1990 and 2017 (a reduction of 34% between 2002 and 2017). A complete analysis of Maine's GHG emissions by source for each year can be found in Appendix A.

[4] Figure 4 and Appendix F

[5] Economic data inflation adjusted, chained 2012 dollars.

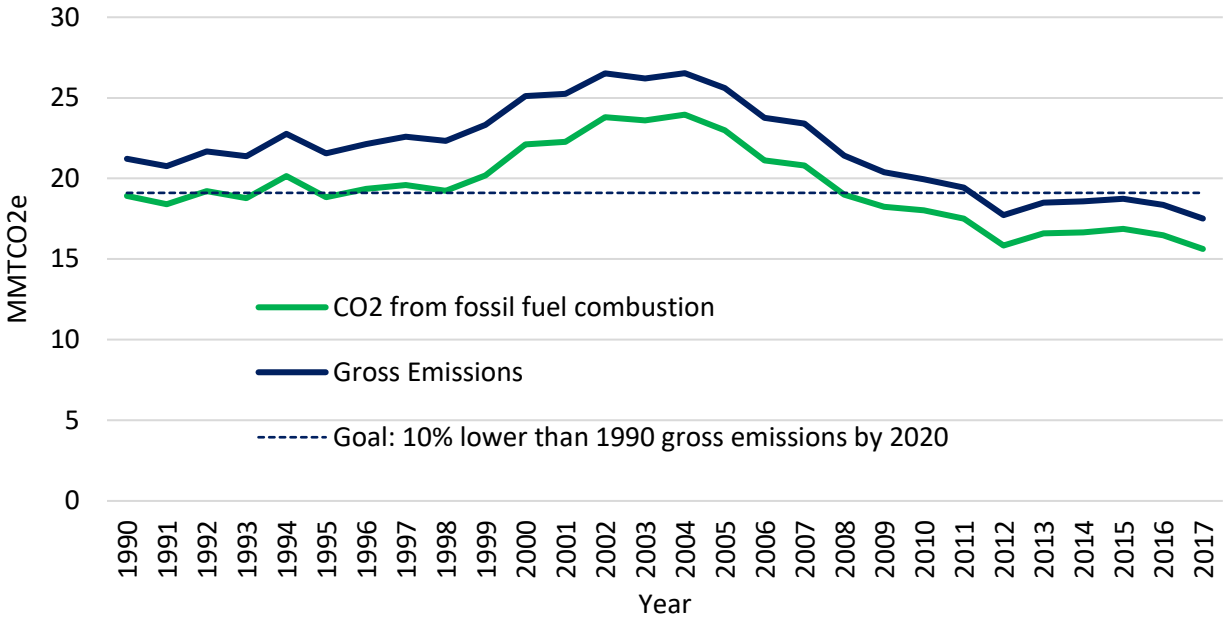

Figure 1. Maine's greenhouse gas emissions 1990-2017

The consumption of energy is the largest source of emissions, accounting for 90% of Maine's gross GHG emissions in 2017. Agricultural activity, industrial processes, and waste disposal combined only contributed 10% of the 2017 GHG emissions total (Figure 2).

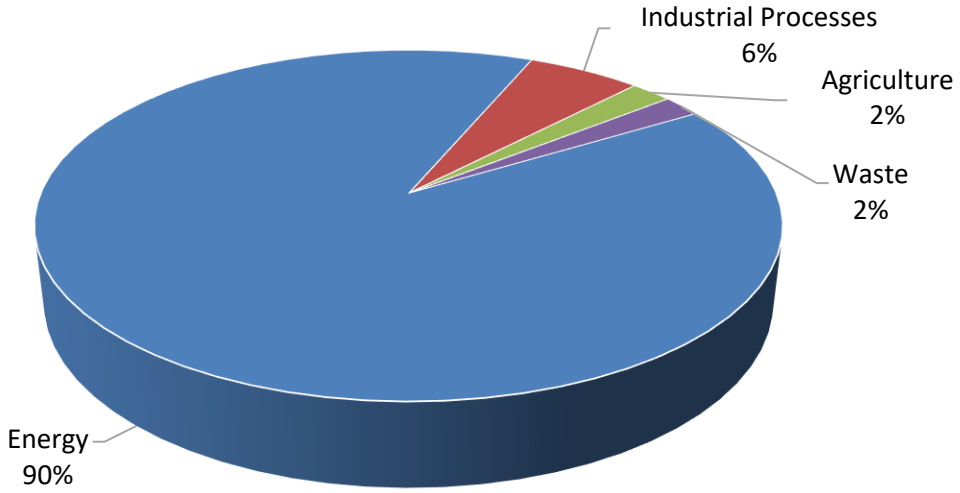

Figure 2. Emissions by source category for 2017 (data in Appendix A)

B. Energy 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 2017. In 2017, total energy consumption in Maine was 14% less than in 1990 (Appendix D).

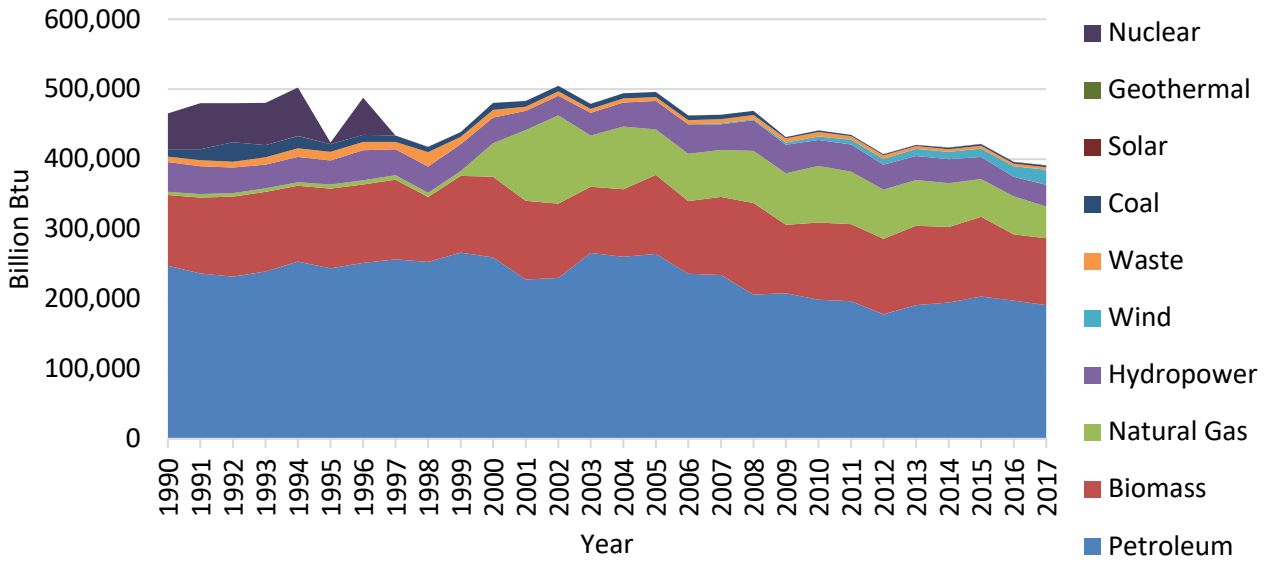

Figure 3. Maine energy consumption (BBtu) 1990-2017[6]

Although Maine still relies on petroleum to meet some energy demands, CO_2 emissions continue to decline in large part because of the use of lower carbon fuels, increased efficiencies, and increased renewable sources.

i. Petroleum Consumption

The petroleum products being consumed in Maine consist primarily of distillate fuel, motor gasoline, propane and liquefied petroleum gas (LPG), residual fuel oil, aviation fuels, and kerosene. In 2017, petroleum products accounted for 49% of all energy consumed (Appendix D) and for 84% of CO_2 emissions (Appendix B). The reduction in residual fuel oil consumption, 95% since 1990, is a large driver of the overall decline in GHG emissions.

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

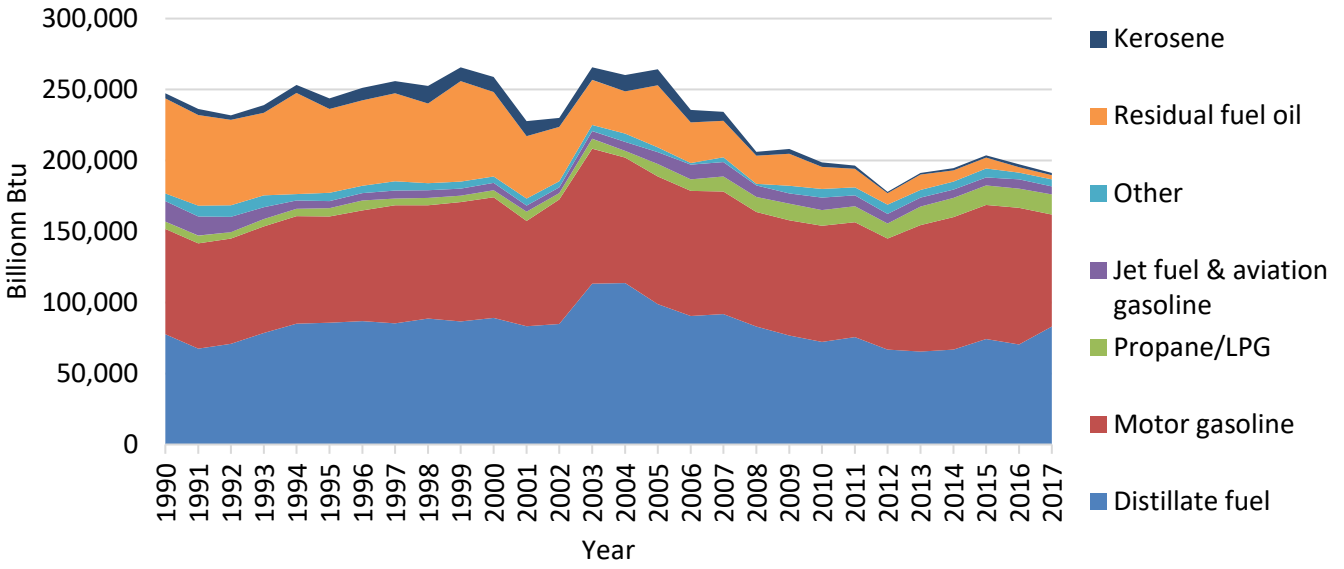

Figure 4. Maine petroleum consumption by fuel type (BBtu) 1990-2017[7] ("Other" includes asphalt, road oil, lubricants, and petroleum coke.)

Since 1990, the aggregate carbon dioxide emissions from petroleum combustion (in all sectors) has decreased by 26% (Appendix B). Comparably, petroleum consumption declined by 23% between 1990 and 2017 (Figure 4, Appendix D). This may be explained in part by an increase in natural gas use. There has been an 887% increase in natural gas consumption since 1990, from 4,572 BBtu in 1990 to 45,127 BBtu in 2017 (Appendix D). Figure 5 illustrates the trend in petroleum consumption by sector since 1990. The transportation sector has been the leading consumer of petroleum for all years 1990-2017, with a 6% increase in petroleum consumption during that period (Appendix D). All other sectors have reduced consumption of petroleum since 1990.

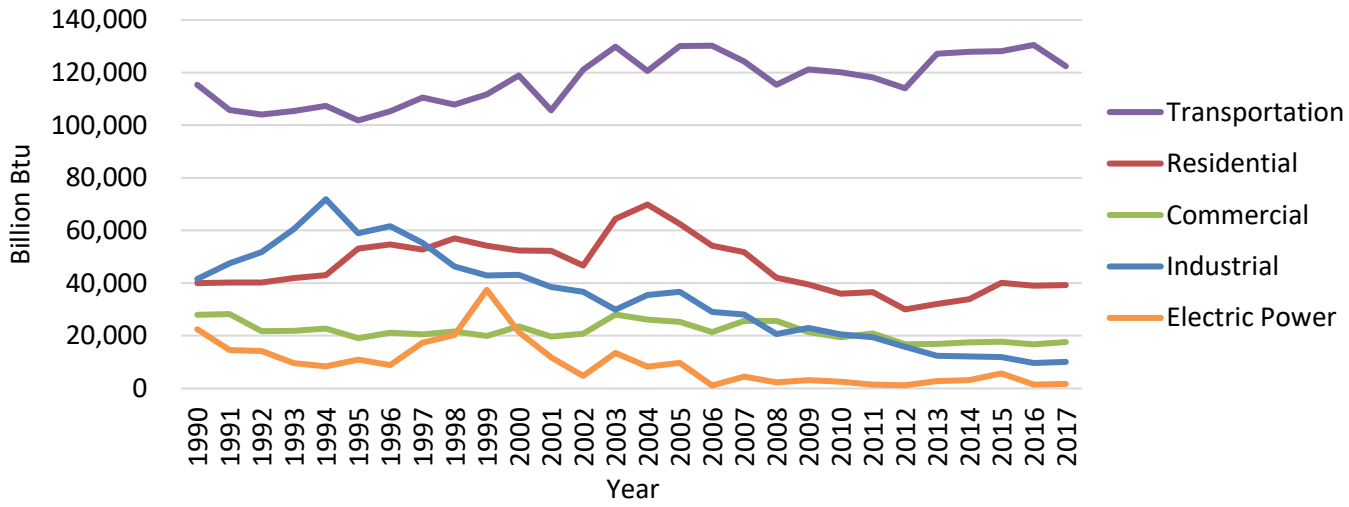

Figure 5. Maine petroleum consumption by sector (BBtu) 1990-2017

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

ii. Combustion CO_2 Emissions by Sector

Figure 6 illustrates the relative CO_2 emissions from the combustion of fossil fuels from each sector in 2017. This figure shows that the transportation sector produced over half of all CO_2 emissions in Maine in 2017. The residential sector accounted for the next highest amount of emissions at 19%.

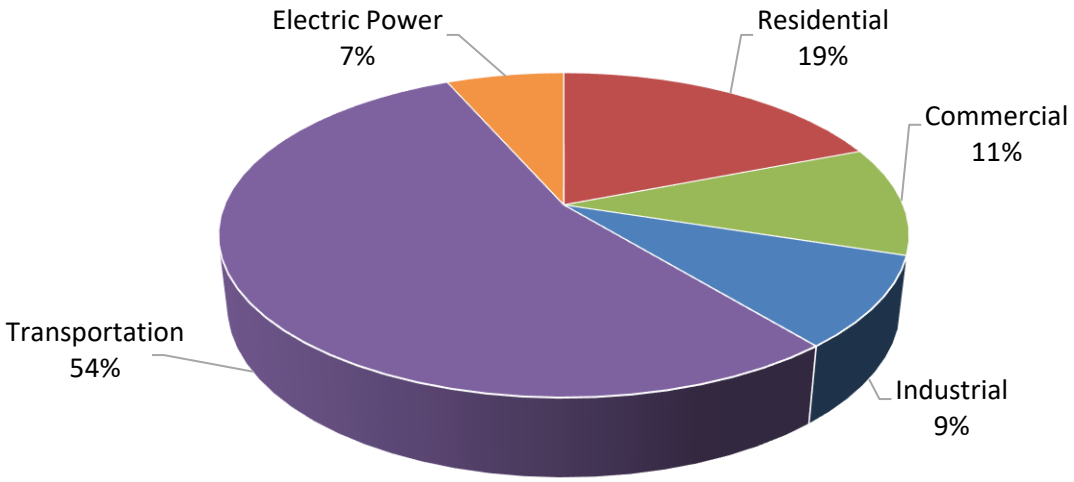

Figure 6. CO_2 emissions from fossil fuel combustion by sector for 2017 (data in Appendix B)

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 1990-2017, with a 2.5% increase of CO_2 emissions during that period. The industrial, electric utility, and commercial sectors reduced emissions by 58%, 50%, and 24% respectively between 1990 and 2017. While the trend in CO_2 emissions from residential combustion of fossil fuel shows variability over the reporting period, the decrease is minimal, at 0.3%. More detail about emissions and energy consumption for the individual sectors can be found in the subsequent sections.

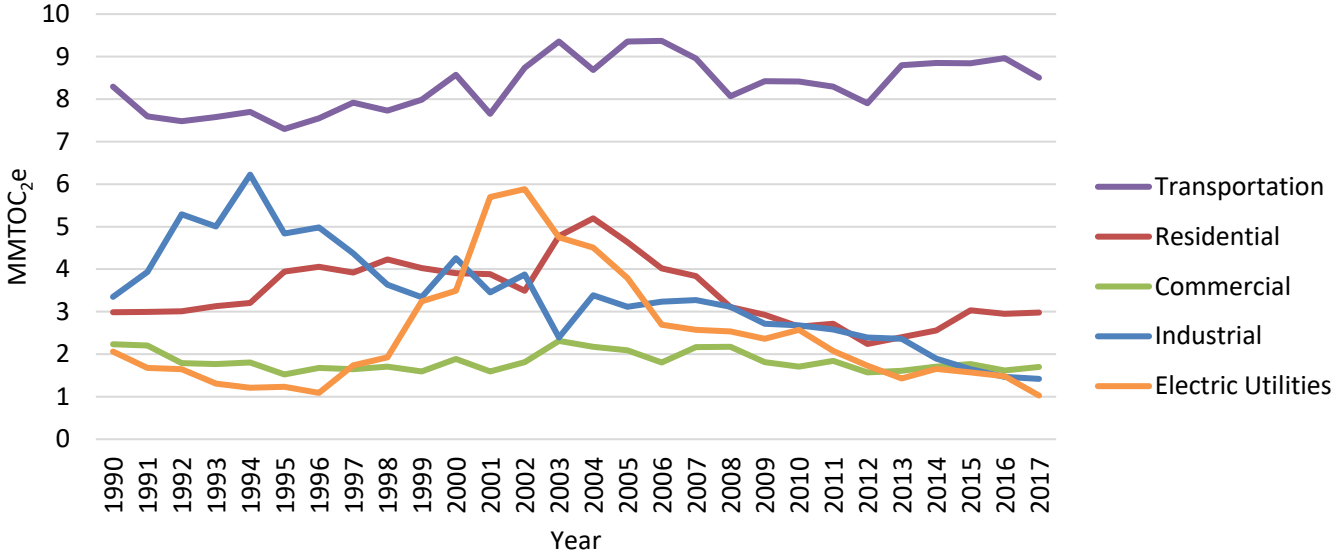

Figure 7. CO_2 emissions from the combustion of fossil fuels by sector for 2017 (data in Appendix B)

a. Electric Generators

In 2017, Maine's electric utility generators emitted 1.03 $MMTCO_2$ from the combustion of fossil fuels, 7% of the state's total CO_2 emissions, which is an 82% 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 (Appendix E, Figure E1). In 2017, natural gas combustion accounted for 72% of the CO_2 emissions from this sector. Renewable resources (hydropower, wood[8], wind, waste[9], solar, and geothermal) provided 71% of the energy consumed by these facilities in 2017, up from 37% 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 exported 14,165 billion Btu of electricity in 2017 and imported 15,001 BBtu, for a net import value of 836 BBtu (Appendix E, Figure E3). In 2017, 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 E2). EIA's energy consumption dataset indicates that the transportation sector did not consume a measurable amount of electricity between 1990 and 2017.

b. Industrial

Maine's industrial sector emitted 1.42 $MMTCO_2$ from the combustion of fossil fuels in 2017, 9% of the state's total CO_2 emissions (Appendix B), and 58% lower than 1990 levels. In 2017, natural gas provided almost twice as much energy to the industrial sector than petroleum did. In this sector, 58% of the energy consumed was from renewable resources (wood, hydropower, and waste), only 1% less than in 1990 (Appendix E, Figure E4).

c. Commercial

The commercial sector emitted 1.70 $MMTCO_2$ from fossil fuels in 2017, 11% of the state's total CO_2 emissions (Appendix B), which is an overall 24% reduction in CO_2 emissions from this sector from 1990 – 2017. During this same period, there was a five-fold increase in the use of natural gas and a 41% decrease in the use of petroleum. Petroleum continues to account for 71% of CO_2 emissions in the sector. In 2017, renewable resources provided 11% of the energy used by this sector, up from 7% in 1990 (Appendix E, Figure E5).

d. Residential

In 2017, the residential sector emitted 2.98 $MMTCO_2$ from fossil fuel consumption, 19% of the state's total CO_2 emissions (Appendix B). This sector is highly dependent upon petroleum products and is significantly impacted by fuel price fluctuations. In 2017, petroleum accounted for 95% of all the CO_2 emissions from this sector and 52% of the energy consumption (Appendix E, Figure E6). The national average for petroleum consumption (BBtu) by the residential sector is only 8%.[10] Emissions from residential petroleum use peaked in 2004 at 5.20 $MMTCO_2$ and have declined by

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[8] "Wood" includes wood and wood-derived fuels, including black liquor.

[9] "Waste" includes biomass waste, which includes municipal solid waste from biogenic sources, landfill gas, sludge waste, agricultural byproducts, etc. Before 2001, waste also includes non-biomass waste (municipal solid waste from non-biogenic sources and tire-derived fuels). (35-A M.R.S. § 3210)

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

43% in 2017. Between 2005 – 2014, the cost of home heating oil increased from $1.93 per gallon (February 2005) to $3.88 per gallon (February 2014)[11], which incentivized residents to find more economical heating fuels, to make homes more energy efficient, and invest in higher efficiency heating equipment. The use of wood pellets as a fuel replaced a portion of this heating load, as Maine saw four pellet mills begin operations from 2006 – 2008.[12] Wood accounted for 23% of the residential energy consumption in 2017, up from 7% in 1990. This sector exceeds the commercial sector in consumption of distillate fuel and, along with the transportation sector, has been the least served by natural gas, although this may change as the infrastructure for natural gas distribution expands. In 2017, 4% of the residential energy consumed was natural gas, up from 1% in 1990.

e. Transportation

In 2017, the transportation sector emitted 8.50 MMTCO$_2$ from fossil fuel combustion, 54% of the state's total CO$_2$ emissions, up from 44% of the CO$_2$ emissions in 1990 (Appendix B). Petroleum accounts for 99.5% of the CO$_2$ emissions and 98.8% of the energy consumed by the transportation sector (Appendix E, Figure E7). Primarily due to an increase in vehicle miles traveled, the transportation sector consumed 7% more energy in 2017 than in 1990, with total CO$_2$ emissions decreasing by 2.5%. The decrease in CO$_2$ emissions relative to the increase in energy consumed is attributed in part to the increased use of ethanol in this sector. Since ethanol is considered a renewable resource in this inventory, emissions from ethanol are omitted from emissions totals.

C. Economic Analysis

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 2017, as shown in Figure 8. It is also evident that emissions of CO$_2$e had increased overall from 1990 – 2002, at which point they began a marked decrease through 2012. Since 1990, Maine's real GDP grew from $37 billion in 1990 to $56 billion in 2017.[13] During the same period, energy consumption declined from 457,234 BBtu to 392,002 BBtu. From 1990 through 2002 greenhouse gas emissions increased and tracked very closely with real GDP; however, in 2005, GHG emissions began to decrease significantly (Figure 8 and Appendix G).

[11] Maine Governor's Energy Office. Archived Heating Oil Prices. http://www.maine.gov/energy/fuel_prices/archives.shtml, December 2004 to December 2013.
[12] Northeast Pellets, Corinth Wood Pellets, Geneva Wood Fuels, and Maine Woods Pellets.
[13] U.S. Bureau of Economic Analysis. Regional Data (http://www.bea.gov/iTable/index_regional.cfm)

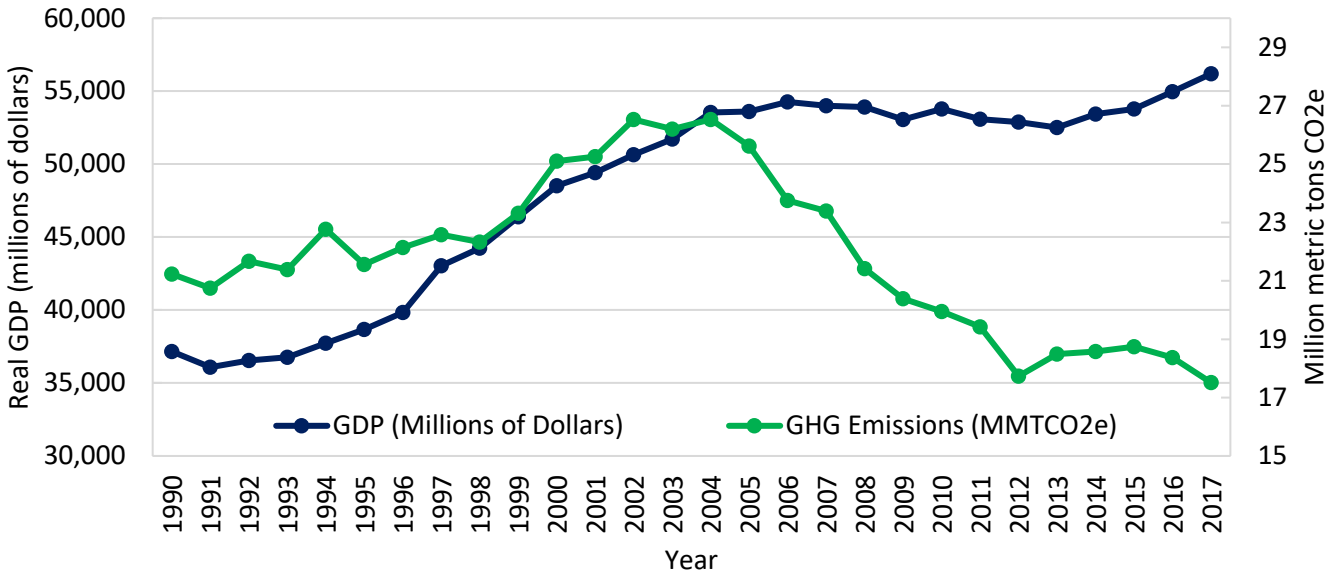

Figure 8. Total GHG emissions and real gross domestic product (GDP)

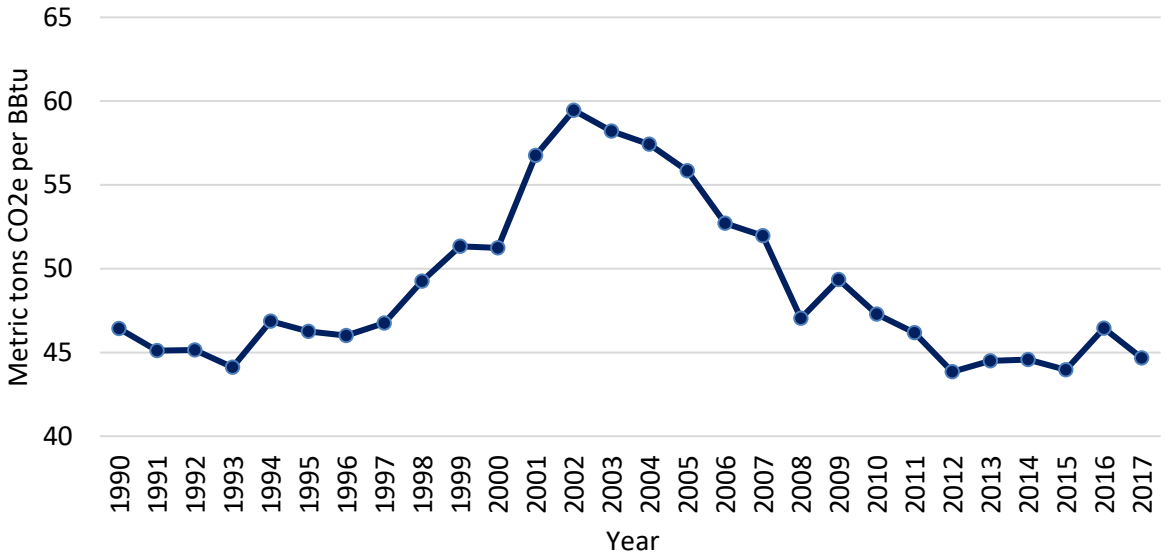

Figure 9. GHG emissions per unit of energy used

Figure 9 shows the GHG emissions per unit of energy input has declined since 2002 because of a transition to lower carbon fuels, like natural gas, and more efficient use of all fuels.

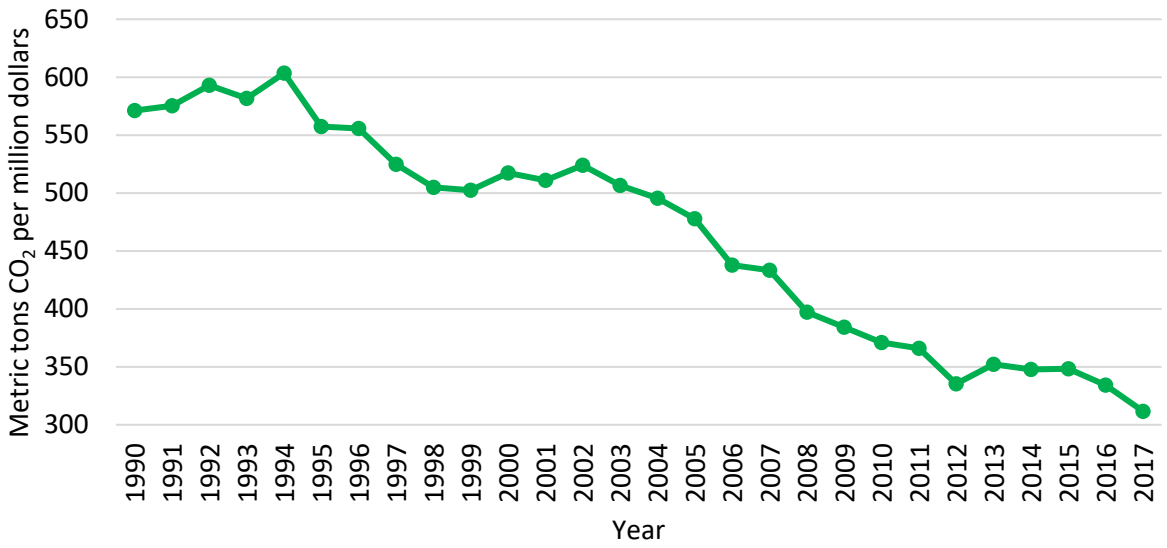

Figure 10. GHG emissions per GDP (metric tons CO_2e per million dollars)

Figure 10 illustrates the declining trend in emissions per million dollars of GDP, indicating that the Maine economy is transitioning to lower carbon emitting fuels, more efficient equipment, and industries that require less energy per dollar of GDP.

IV. Conclusion

This Eighth Biennial Report on Maine's progress toward statutory GHG reduction targets provides an updated analysis of gross GHG emissions for the period of 1990 – 2017. The Department's analysis continues to indicate that Maine has met the first statutory reduction target of reducing GHG emissions to 1990 levels by 2010. The data in Appendix A show that in 2017, Maine's GHG emissions were 17.5% below 1990 levels, and that Maine is on track to meet the second statutory reduction target of 10% below 1990 levels by 2020. Future emissions data will be used to continue to track Maine's progress toward meeting the extended emissions targets of 45% below 1990 levels by January 1, 2030 and 80% below 1990 levels by 2050 (Figure 11).

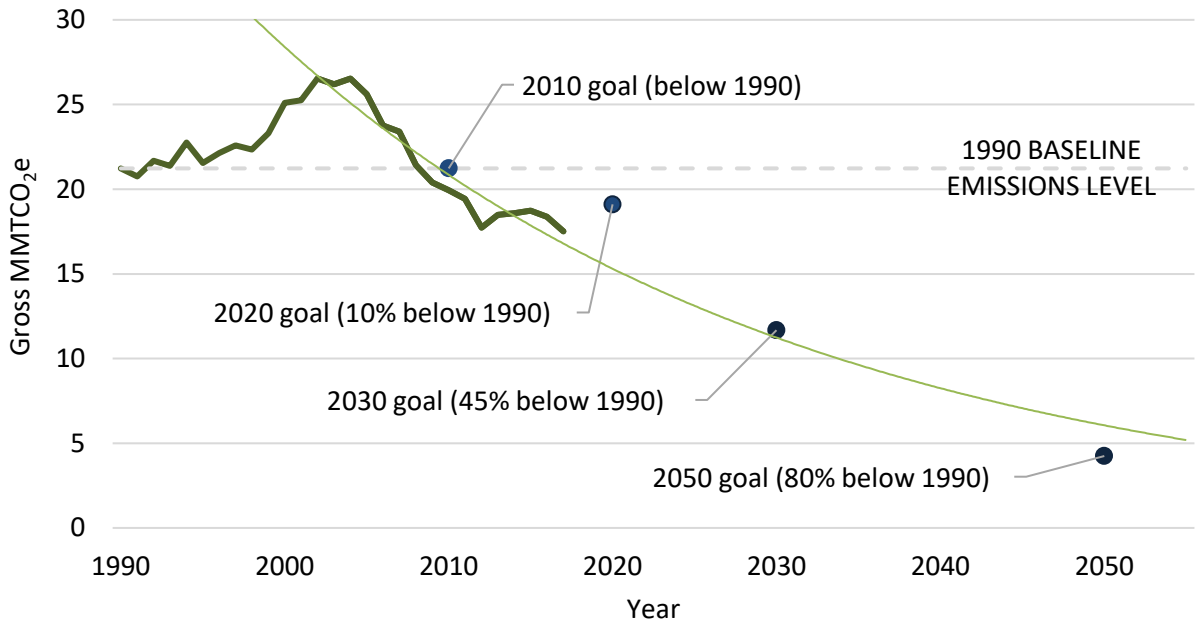

Figure 11. Maine's greenhouse gas emissions 1990-2017 with 2020, 2030, and 2050 reduction and emissions goals

To meet these emissions reduction 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. Our statewide emissions reduction goals could be met by considering the following recommendations:

- Maine should develop strategies to address emissions from the transportation sector which accounts for 54% of the CO2 emissions in Maine. The transportation sector is the only sector that has shown an increase in CO2 emissions from fossil fuels since 1990. Maine should consider initiatives to reduce emissions from this sector with strategies such as reducing vehicle miles traveled and increasing electric vehicle purchases, electric vehicle charging infrastructure, public transportation and ride sharing.
- Maine should continue to prioritize and advance efforts focused on decreasing the state's reliance on petroleum products, especially in the residential sector which is far greater than the national average.
- Maine should continue to pursue energy efficiency and conservation in both residential and commercial sectors.
- Maine should continue to advance renewable energy such as solar photovoltaics, onshore and offshore wind and advanced technologies such as energy storage to continue to reduce emissions.
- Maine should take a comprehensive view when considering emissions reduction strategies through interagency coordination and the Maine Climate Council to ensure proper coordination among all emissions reduction strategies.

- In order to best track GHG emissions trends and Maine's progress toward meeting reduction goals, Maine DEP recommends the Legislature revise the biennial report due date specified in 38 M.R.S.A. §576-A from December 1, 2021 to January 15, 2022, and every two years thereafter, to enable the use of the most recent data available. This shift will allow for inclusion of an additional year of data in historical trends and analysis.

V. Appendices

Appendix A: Maine's greenhouse gas emissions in $MMTCO_2e$

Table A1. Maine's greenhouse gas emissions in $MMTCO_2e$ (1990 - 2003)

Sector	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Energy	19.37	18.87	19.71	19.27	20.65	19.33	19.85	20.10	19.74	20.69	22.60	22.74	24.22	24.00
Industrial Processes	0.85	0.84	0.90	1.01	0.99	1.13	1.14	1.26	1.32	1.33	1.28	1.26	1.25	1.21
Agriculture	0.50	0.50	0.50	0.51	0.51	0.49	0.53	0.58	0.61	0.60	0.50	0.52	0.53	0.53
Waste	0.51	0.54	0.56	0.59	0.62	0.60	0.62	0.65	0.67	0.69	0.71	0.74	0.53	0.46
Gross Emissions	**21.23**	**20.75**	**21.67**	**21.38**	**22.77**	**21.56**	**22.14**	**22.58**	**22.33**	**23.31**	**25.11**	**25.25**	**26.53**	**26.20**

Table A2. Maine's greenhouse gas emissions in $MMTCO_2e$ (2004 - 2017)

Sector	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Energy	24.33	23.33	21.42	21.08	19.22	18.44	18.20	17.68	15.99	16.73	16.78	16.98	16.60	15.73
Industrial Processes	1.26	1.28	1.31	1.35	1.27	1.08	0.91	0.97	0.95	0.98	1.06	1.02	1.03	1.04
Agriculture	0.54	0.58	0.60	0.59	0.60	0.56	0.49	0.43	0.44	0.42	0.39	0.39	0.38	0.38
Waste	0.40	0.42	0.43	0.37	0.32	0.32	0.35	0.35	0.36	0.36	0.36	0.35	0.36	0.36
Gross Emissions	**26.53**	**25.61**	**23.76**	**23.40**	**21.41**	**20.39**	**19.95**	**19.43**	**17.73**	**18.49**	**18.58**	**18.74**	**18.37**	**17.51**

Appendix B: CO_2 emissions from fossil fuel combustion in Maine

Table B1. Carbon Dioxide Emissions from Fossil Fuel Combustion in Maine (1990 – 2003)

MMTCO2	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Residential Total	2.99	2.99	3.01	3.13	3.20	3.94	4.05	3.92	4.23	4.03	3.90	3.88	3.49	4.78
Coal	0.02	0.01	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	2.93	2.95	2.95	3.07	3.15	3.89	4.00	3.87	4.18	3.97	3.84	3.82	3.43	4.71
Natural Gas	0.03	0.04	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.06	0.07
Commercial Total	2.23	2.21	1.79	1.77	1.80	1.52	1.68	1.65	1.71	1.59	1.89	1.59	1.81	2.31
Coal	0.08	0.03	0.07	0.05	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00
Petroleum	2.06	2.08	1.60	1.59	1.66	1.39	1.53	1.49	1.57	1.45	1.71	1.42	1.52	2.04
Natural Gas	0.09	0.10	0.12	0.12	0.13	0.13	0.14	0.15	0.13	0.14	0.17	0.16	0.29	0.27
Industrial Total	3.35	3.94	5.29	5.00	6.22	4.84	4.98	4.37	3.64	3.34	4.26	3.45	3.87	2.39
Coal	0.52	0.84	1.91	0.98	1.06	0.64	0.53	0.44	0.31	0.26	0.53	0.30	0.21	0.29
Petroleum	2.72	2.98	3.28	3.93	5.07	4.09	4.34	3.80	3.20	2.95	2.96	2.49	2.39	1.93
Natural Gas	0.11	0.12	0.11	0.09	0.09	0.10	0.12	0.13	0.12	0.13	0.77	0.66	1.27	0.18
Transportation Total	8.29	7.59	7.48	7.58	7.70	7.30	7.55	7.92	7.73	7.99	8.57	7.65	8.74	9.36
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	8.29	7.59	7.48	7.58	7.70	7.29	7.55	7.91	7.73	7.99	8.52	7.58	8.69	9.31
Natural Gas	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.05	0.07	0.05	0.05
Electric Power Total	2.06	1.68	1.65	1.31	1.21	1.23	1.09	1.74	1.92	3.25	3.49	5.70	5.88	4.75
Coal	0.36	0.57	0.57	0.58	0.57	0.37	0.38	0.39	0.35	0.36	0.39	0.43	0.53	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	0.88	0.36	1.01
Natural Gas	0.01	0.01	0.01	0.01	0.01	0.01	0.00	0.00	0.00	0.03	1.47	4.39	5.00	3.34
Gross CO2 Emissions	**18.92**	**18.41**	**19.22**	**18.78**	**20.14**	**18.84**	**19.35**	**19.60**	**19.23**	**20.19**	**22.12**	**22.28**	**23.79**	**23.59**
Coal	0.98	1.44	2.57	1.63	1.65	1.02	0.92	0.84	0.68	0.63	0.93	0.73	0.74	0.70
Petroleum	17.70	16.70	16.37	16.88	18.22	17.52	18.13	18.42	18.25	19.21	18.67	16.20	16.39	19.00
Natural Gas	0.24	0.26	0.28	0.27	0.28	0.30	0.31	0.34	0.31	0.35	2.53	5.35	6.66	3.90

Table B2. Carbon Dioxide Emissions from Fossil Fuel Combustion in Maine (2004 – 2017)

MMTCO2	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Residential Total	5.20	4.63	4.02	3.84	3.11	2.93	2.65	2.72	2.24	2.40	2.56	3.03	2.95	2.98
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	5.13	4.57	3.96	3.77	3.05	2.86	2.58	2.64	2.16	2.30	2.43	2.89	2.81	2.83
Natural Gas	0.07	0.06	0.06	0.07	0.06	0.07	0.07	0.08	0.08	0.10	0.13	0.15	0.14	0.15
Commercial Total	2.18	2.09	1.81	2.17	2.17	1.81	1.71	1.85	1.58	1.61	1.71	1.77	1.61	1.70
Coal	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	1.90	1.82	1.54	1.84	1.84	1.51	1.39	1.48	1.18	1.16	1.21	1.22	1.15	1.21
Natural Gas	0.27	0.27	0.26	0.33	0.33	0.31	0.32	0.36	0.40	0.45	0.49	0.55	0.47	0.49
Industrial Total	3.39	3.12	3.23	3.27	3.11	2.72	2.68	2.58	2.39	2.36	1.90	1.65	1.47	1.42
Coal	0.28	0.30	0.26	0.27	0.24	0.07	0.08	0.05	0.05	0.06	0.08	0.07	0.04	0.04
Petroleum	2.24	2.47	2.02	1.79	1.45	1.24	1.07	1.03	0.74	0.57	0.53	0.46	0.42	0.42
Natural Gas	0.88	0.35	0.96	1.21	1.42	1.41	1.53	1.50	1.61	1.73	1.29	1.12	1.01	0.95
Transportation Total	8.69	9.35	9.37	8.96	8.07	8.42	8.41	8.30	7.91	8.80	8.85	8.84	8.97	8.50
Coal	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Petroleum	8.65	9.32	9.34	8.91	8.01	8.37	8.31	8.16	7.86	8.75	8.78	8.78	8.93	8.46
Natural Gas	0.04	0.03	0.03	0.04	0.05	0.05	0.10	0.13	0.04	0.05	0.07	0.05	0.04	0.04
Electric Power Total	4.51	3.79	2.69	2.57	2.53	2.36	2.57	2.08	1.73	1.43	1.65	1.57	1.49	1.03
Coal	0.40	0.35	0.35	0.33	0.30	0.08	0.13	0.09	0.08	0.09	0.12	0.17	0.16	0.16
Petroleum	0.62	0.73	0.08	0.34	0.17	0.24	0.19	0.11	0.09	0.21	0.23	0.43	0.11	0.13
Natural Gas	3.49	2.72	2.26	1.90	2.05	2.04	2.25	1.88	1.56	1.13	1.29	0.98	1.21	0.74
Gross CO2 Emissions	**23.96**	**22.99**	**21.12**	**20.81**	**18.99**	**18.24**	**18.02**	**17.52**	**15.85**	**16.60**	**16.66**	**16.86**	**16.48**	**15.63**
Coal	0.68	0.66	0.62	0.61	0.55	0.15	0.21	0.14	0.12	0.15	0.20	0.24	0.20	0.20
Petroleum	18.54	18.90	16.94	16.65	14.52	14.21	13.55	13.43	12.03	12.99	13.18	13.77	13.41	13.05
Natural Gas	4.73	3.43	3.57	3.54	3.93	3.87	4.26	3.95	3.70	3.46	3.28	2.85	2.87	2.37

Appendix C: Sector definitions[14]

- **Electric Power Sector:** An energy-consuming sector that consists of electricity-only and combined-heat-and-power plants within the North American Industry Classification System (NAICS) 22 category whose primary business is to sell electricity, or electricity and heat, to the public. *Note: This sector includes electric utilities 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 whose primary purpose 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 whose 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. In this report, natural gas used in the operation of natural gas pipelines is included in the transportation sector.

[14] 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[15]

Coal	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
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	690	815	742	421	465
Electric Power	3,808	4,216	3,764	1,418	967	1,328	1,846	1,773	1,704
Transportation	0	0	0	0	0	0	0	0	0
Total Coal	10,413	9,980	7,059	2,279	1,657	2,142	2,588	2,194	2,168

Petroleum	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
Residential	40,004	52,368	62,507	35,961	32,044	33,949	40,099	39,058	39,324
Commercial	27,988	23,554	25,244	19,502	16,914	17,499	17,799	16,747	17,585
Industrial	41,572	43,109	36,769	20,581	12,372	12,166	11,952	9,667	10,058
Electric Power	22,502	21,414	9,708	2,591	2,758	3,116	5,691	1,455	1,703
Transportation	115,381	118,905	130,091	120,147	127,181	127,863	128,110	130,487	122,481
Total Petroleum	247,447	259,350	264,319	198,782	191,269	194,592	203,650	197,414	191,151

Natural Gas	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
Residential	651	1,195	1,204	1,282	1,947	2,434	2,782	2,642	2,847
Commercial	1,686	3,194	5,019	6,055	8,398	9,327	10,380	8,814	9,247
Industrial	2,034	14,969	6,807	29,460	33,308	24,914	21,613	19,548	18,337
Electric Power	196	27,758	51,177	42,371	21,362	24,397	18,398	22,833	13,989
Transportation	5	932	612	1,821	871	1,350	1,030	673	706
Total Natural Gas	4,572	48,047	64,818	80,988	65,886	62,423	54,203	54,509	45,127

Fuel Ethanol*	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
Residential	0	0	0	0	0	0	0	0	0
Commercial	0	0	0	11	10	8	105	108	111
Industrial	0	0	6	93	97	87	75	79	81
Electric Power	0	0	0	0	0	0	0	0	0
Transportation	0	0	375	4,766	5,762	5,924	6,073	6,405	5,307
Total Fuel Ethanol	0	0	381	4,871	5,869	6,018	6,254	6,592	5,499

*Not included in sector totals because included in petroleum

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

Appendix D (continued)

Waste	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
Residential	0	0	0	0	0	0	0	0	0
Commercial	2,177	2,757	1,774	2,061	1,710	1,627	1,780	1,648	1,847
Industrial	3,131	2,758	1,382	1,625	733	799	658	510	316
Electric Power	2,459	5,321	2,442	2,670	1,772	1,471	1,335	1,412	1,354
Transportation	0	0	0	0	0	0	0	0	0
Total Waste	7,767	10,836	5,599	6,355	4,215	3,896	3,773	3,570	3,517

Wood	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
Residential	4,292	3,474	6,037	15,327	16,209	16,404	24,515	17,006	17,138
Commercial	933	751	969	1,993	1,958	2,075	3,615	2,999	3,154
Industrial	76,963	90,083	66,375	63,441	69,071	63,199	56,059	48,253	48,378
Electric Power	19,040	21,136	39,682	29,623	25,906	26,591	29,626	26,600	27,170
Transportation	0	0	0	0	0	0	0	0	0
Total Wood	101,227	115,443	113,062	110,383	113,144	108,269	113,815	94,859	95,840

Hydro	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
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	4,169	3,727	3,632	2,972	3,353
Electric Power	28,568	23,409	34,655	30,291	29,802	30,730	27,684	24,722	27,867
Transportation	0	0	0	0	0	0	0	0	0
Total Hydro	42,550	36,630	40,905	37,174	33,970	34,457	31,317	27,693	31,221

Wind	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
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	9,996	10,436	12,075	15,391	21,493
Transportation	0	0	0	0	0	0	0	0	0
Total Wind	0	0	0	4,870	9,996	10,436	12,075	15,391	21,493

Solar	**1990**	**2000**	**2005**	**2010**	**2013**	**2014**	**2015**	**2016**	**2017**
Residential	85	110	97	130	229	234	265	323	395
Commercial	0	0	0	8	36	37	58	95	131
Industrial	0	0	0	0	0	0	0	0	0
Electric Power	0	0	0	0	0	0	0	0	50
Transportation	0	0	0	0	0	0	0	0	0
Total Solar	85	110	97	139	265	271	323	418	577

Appendix D (continued)

Geothermal	1990	2000	2005	2010	2013	2014	2015	2016	2017
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	2013	2014	2015	2016	2017
Coal	10,413	9,980	7,059	2,279	1,657	2,142	2,588	2,194	2,168
Petroleum	247,447	259,350	264,319	198,782	191,269	194,592	203,650	197,414	191,151
Natural Gas	4,572	48,047	64,818	80,988	65,886	62,423	54,203	54,509	45,127
Waste	7,767	10,836	5,599	6,355	4,215	3,896	3,773	3,570	3,517
Wood	101,227	115,443	113,062	110,383	113,144	108,269	113,815	94,859	95,840
Nuclear	51,436	0	0	0	0	0	0	0	0
Hydro	42,550	36,630	40,905	37,174	33,970	34,457	31,317	27,693	31,221
Wind	0	0	0	4,870	9,996	10,436	12,075	15,391	21,493
Solar	85	110	97	139	265	271	323	418	577
Geothermal	0	5	11	70	72	72	72	72	72
Total Energy Consumed	**465,497**	**480,401**	**495,870**	**441,040**	**420,474**	**416,558**	**421,816**	**396,120**	**391,166**
Electricity Exports	-15,851	-3,509	-45,285	-25,394	-21,452	-14,988	-11,705	-17,502	-14,165
Electricity Imports	7,587	13,153	8,141	6,303	16,626	15,397	16,091	16,873	15,001
Net Energy Consumed	**457,233**	**490,045**	**458,726**	**421,949**	**415,648**	**416,967**	**426,202**	**395,491**	**392,002**

Appendix E: Maine energy consumption by sector (figures)[16]

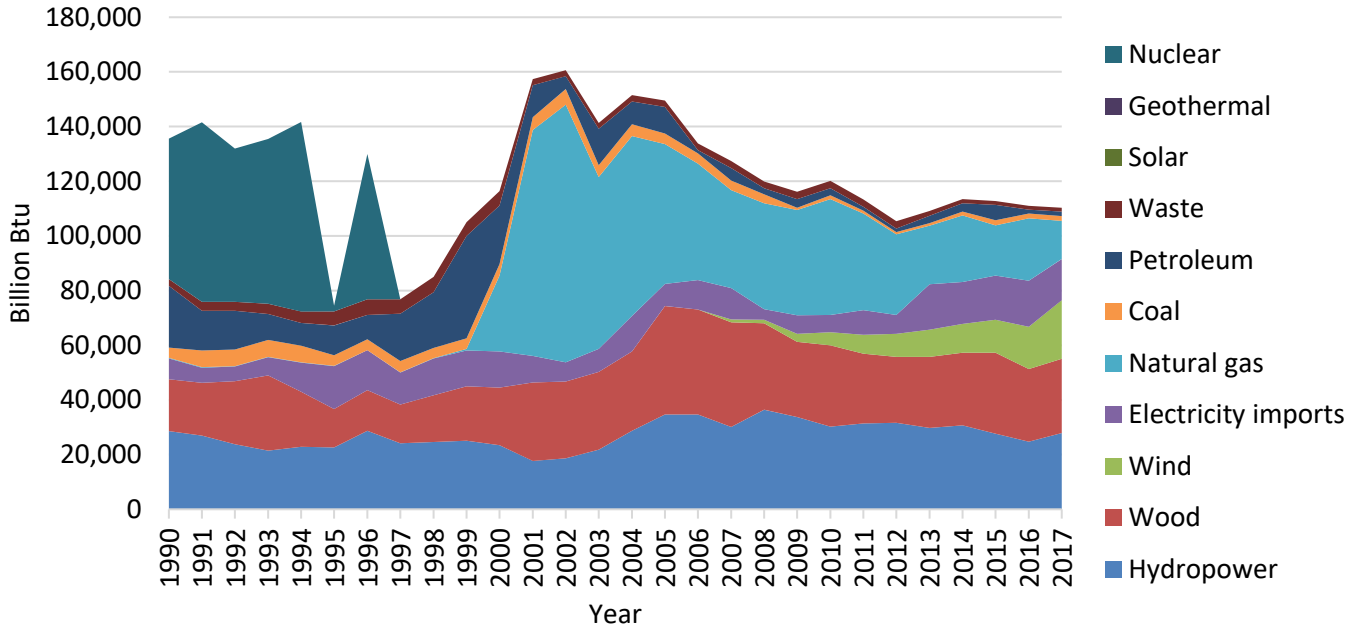

Figure E1. Energy consumption in the electric power generator sector

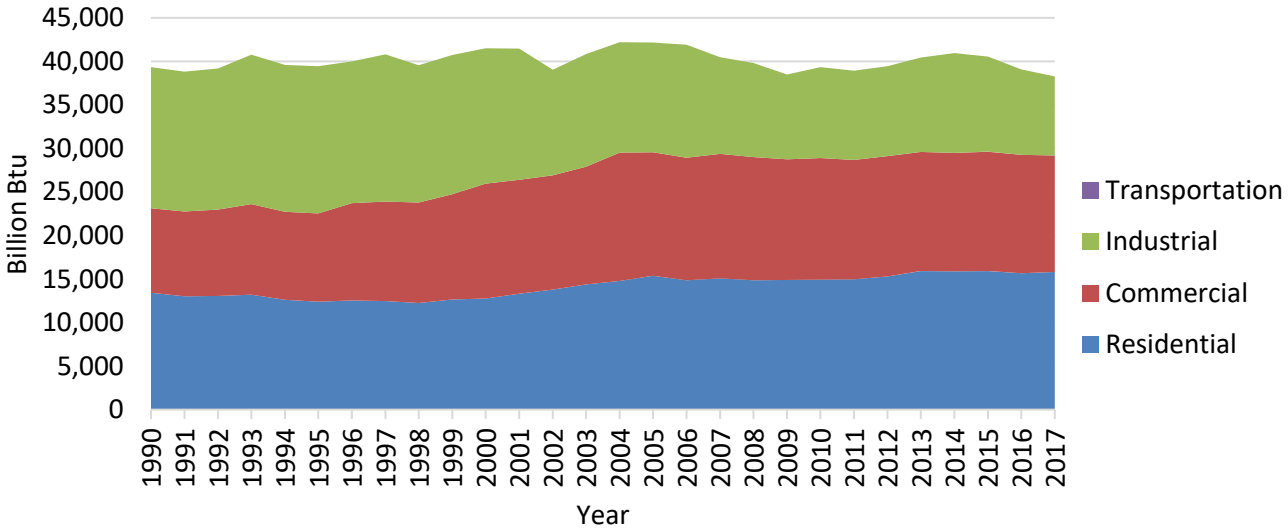

Figure E2. Electricity consumption by sector

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

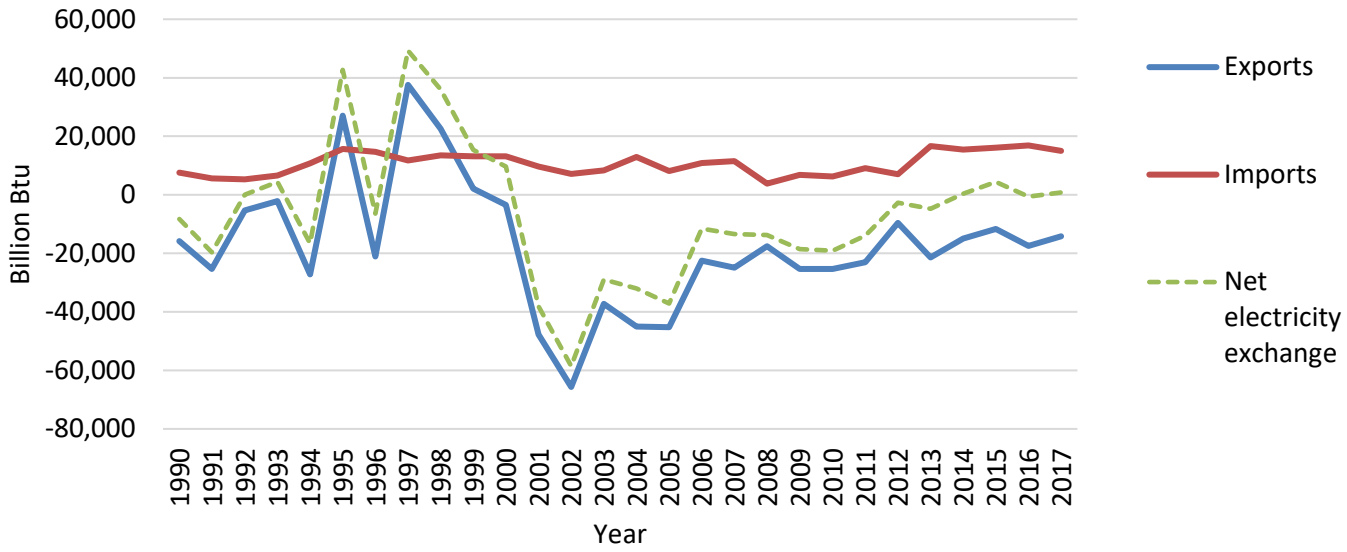

Figure E3. Electricity imports and exports from Maine

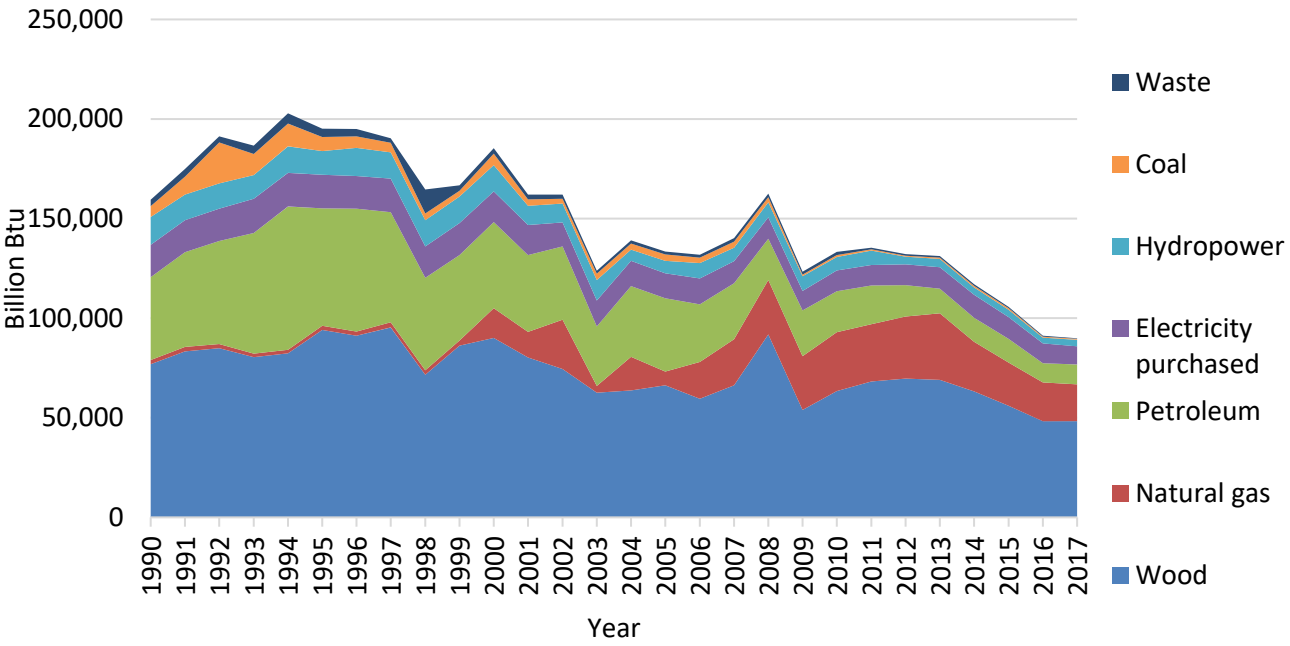

Figure E4. Energy consumption in the industrial sector

Appendix E (continued)

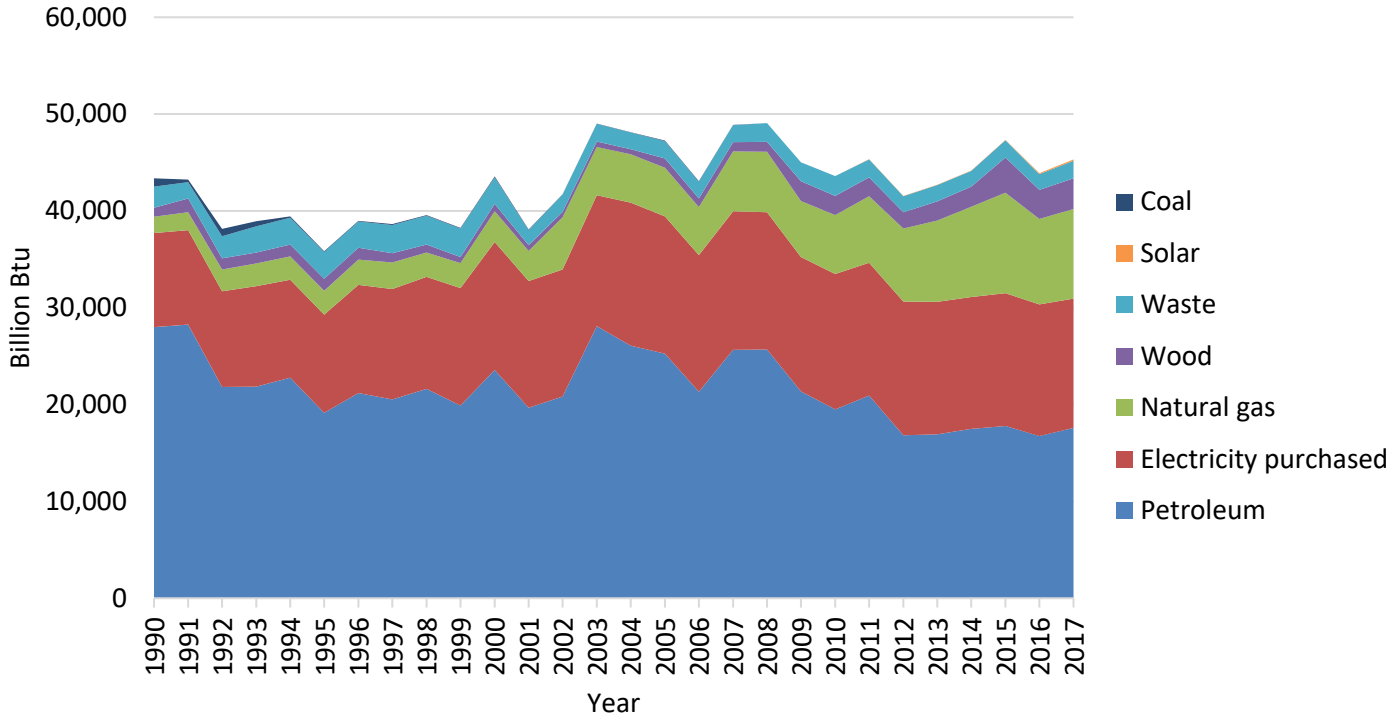

Figure E5. Energy consumption in the commercial sector

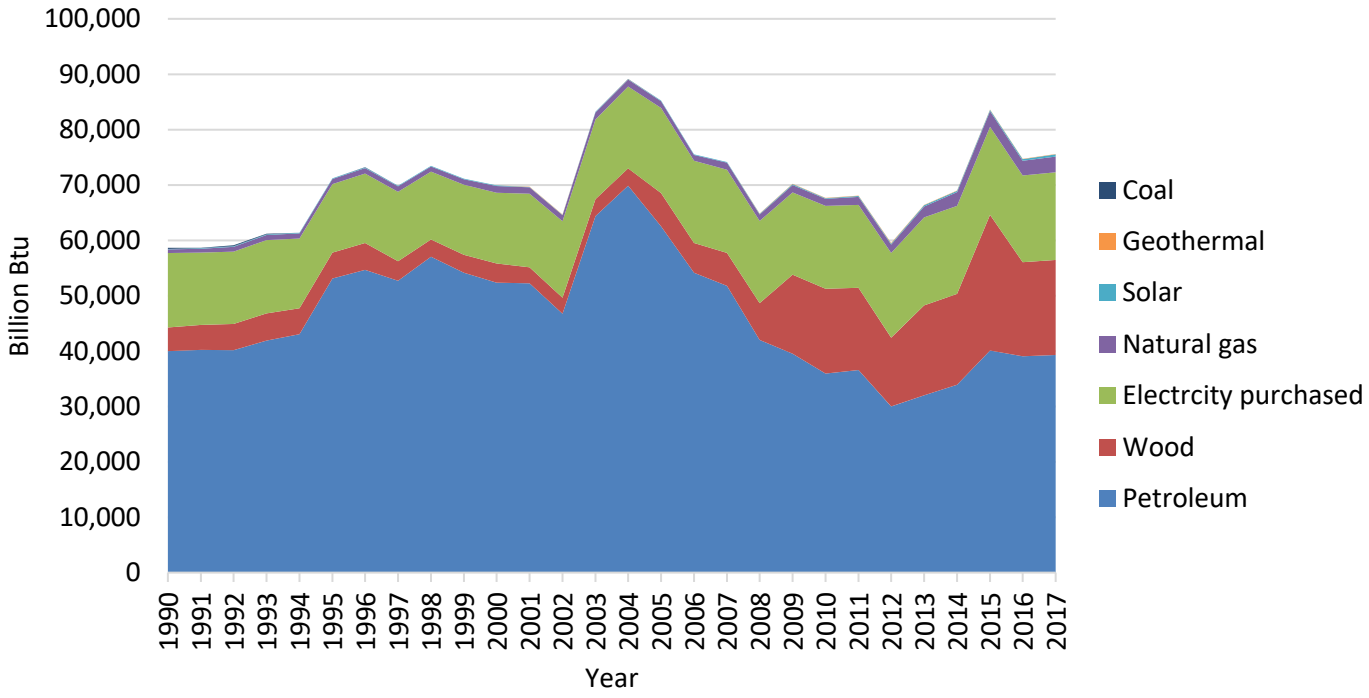

Figure E6. Energy consumption in the residential sector

Appendix E (continued)

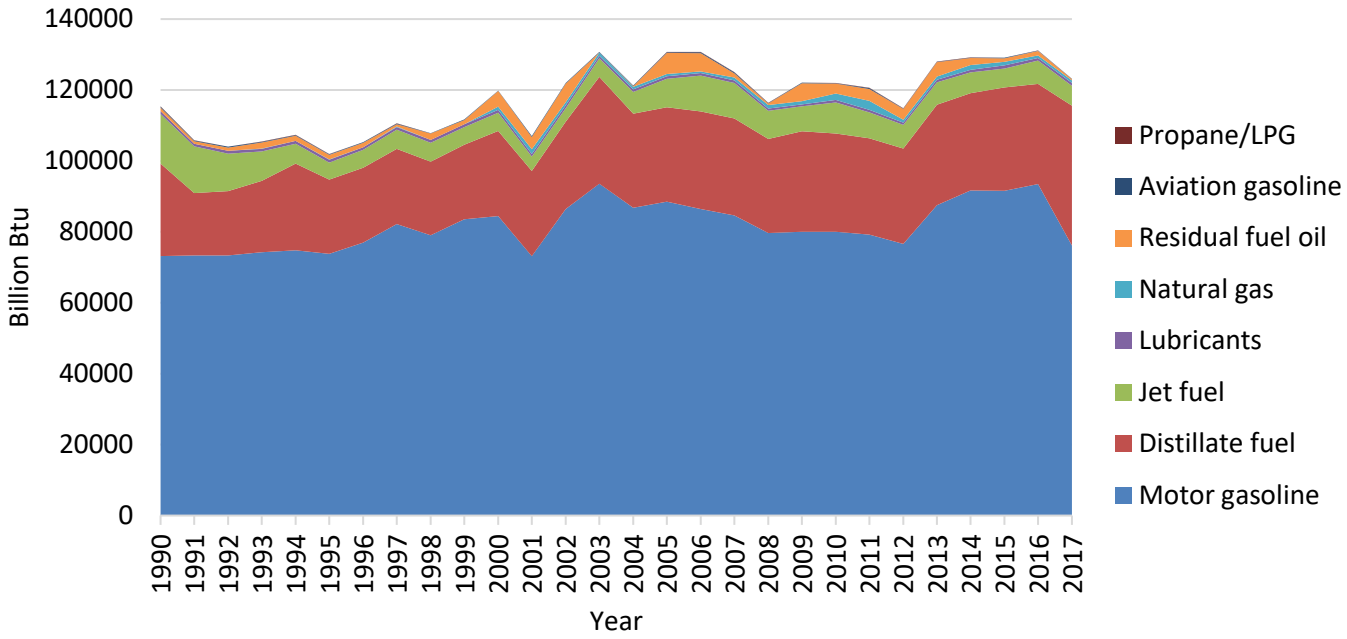

Figure E7. Energy consumption in the transportation sector

Appendix F: Petroleum consumption by fuel type in billion Btu

Table F1. Petroleum consumption by fuel type in billion Btu[17]

Fuel Type	1990	2000	2005	2010	2013	2014	2015	2016	2017
Distillate Fuel Oil	77,654	89,129	98,752	72,339	65,432	66,879	74,317	70,548	83,088
Motor Gasoline	74,206	84,921	89,924	81,786	89,118	93,159	94,348	96,166	78,938
Propane/LPG	5,201	5,035	8,832	10,873	13,014	13,578	13,840	13,466	14,115
Jet Fuel & Aviation Gasoline	14,327	5,276	8,284	8,832	6,391	5,919	5,528	6,652	5,715
Other*	5,501	4,301	3,574	6,183	5,439	5,714	6,453	4,689	4,882
Residual Fuel Oil	66,833	59,723	43,593	15,457	10,843	7,704	7,632	3,798	3,008
Kerosene	3,726	10,429	11,295	3,278	1,032	1,638	1,533	2,095	1,405
Total	247,448	258,814	264,254	198,748	191,269	194,591	203,651	197,414	191,151

*Asphalt, Road Oil, Lubricants, and Petroleum Coke

[17] 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) [18]	GHG Emissions ($MMTCO_2e$) [19]	Total energy per GDP (BBtu per million dollars) [20]	GHG emissions per GDP (tons CO_2e per million dollars)	GHG emissions per energy input (tons CO_2e per BBtu) [21]
1990	37,168	21.23	12.30	571	46.43
1991	36,082	20.75	12.75	575	45.11
1992	36,539	21.67	13.14	593	45.14
1993	36,755	21.38	13.19	582	44.11
1994	37,725	22.77	12.88	603	46.86
1995	38,681	21.56	12.05	557	46.25
1996	39,834	22.14	12.08	556	46.00
1997	43,035	22.58	11.22	525	46.76
1998	44,233	22.33	10.25	505	49.25
1999	46,393	23.31	9.79	503	51.33
2000	48,524	25.11	10.10	517	51.23
2001	49,419	25.25	9.00	511	56.75
2002	50,633	26.53	8.81	524	59.45
2003	51,729	26.20	8.70	506	58.21
2004	53,530	26.53	8.63	496	57.43
2005	53,613	25.61	8.56	478	55.84
2006	54,270	23.76	8.31	438	52.71
2007	54,001	23.40	8.34	433	51.96
2008	53,921	21.41	8.44	397	47.03
2009	53,064	20.39	7.78	384	49.36
2010	53,776	19.95	7.85	371	47.28
2011	53,088	19.43	7.93	366	46.17
2012	52,874	17.73	7.65	335	43.84
2013	52,505	18.49	7.92	352	44.50
2014	53,418	18.58	7.81	348	44.56
2015	53,781	18.74	7.92	348	43.96
2016	54,971	18.37	7.19	334	46.45
2017	56,189	17.51	6.98	312	44.68

[18] Bureau of Economic Activity, U.S. Department of Commerce (https://www.bea.gov/)
[19] Appendix A
[20] Appendix D, "Total Net Electricity"/ GDP
[21] Appendix D