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Bridging the Gap Between Energy and the Environment

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*Energy policy and environmental policy have always been intertwined, but the exact nature of those interrelationships are often difficult for the non-technical reader to understand. In an analysis that was originally included in an appendix of the R*eport of the Maine Commission on Comprehensive Energy Planning*, the former director of Maine's Office of Energy, John Flumerfelt, provides a clear and concise graphical summary of the relation between energy use and air pollution in Maine. His presentation frames the issues in ways that identify important energy and environmental questions for Maine.*

In 1991, the Maine State Planning Office (SPO) developed an analytical tool to help policymakers understand the relationship between energy use and its environmental impacts. The project involved the development of a set of "emission factors" that represent the emissions of air pollutants that typically can be expected when a certain fuel is used in a certain way. The emission factors were based primarily on data originally published by the U.S. Environmental Protection Agency (EPA), and they were developed in conjunction with the Bureau of Air Quality Control of the Maine Department of Environmental Protection. The factors are averages based on the way that energy is currently used, including Maine-specific data such as boiler types, emission control technologies, and relative vehicle age. The final results of the project were included as an appendix to the 1992 *Final Report of the Maine Commission on Comprehensive Energy Planning* ("Energy Commission").

Originally, the project was conceived as a modeling tool that could be used in conjunction with an energy demand forecast. Energy forecasts attempt to predict the future by estimating how much energy society will use over time. Forecasts include the type of fuel (e.g., electricity, gasoline, natural gas, propane) and how it is distributed by economic sector (e.g., residential, commercial, transportation). Emissions factors could help predict the environmental characteristics of a variety or possible or expected energy "futures," and thereby assist in the development of sound energy policy. Although budget restrictions prevented the implementation of this broader modeling effort, the factors by themselves are a useful tool that allows us to see where energy goals (and/or problems) and environmental goals (and/or problems) intersect. Even without a more sophisticated modeling effort, this information can help policymakers identify goal areas and specific strategies that begin to integrate environmental issues into the energy planning process.

The emission factors developed by the State Planning Office address seven types of air pollutants: sulfur oxides (SO_x), nitrogen oxides (NO_x), volatile organic compounds (VOCs), carbon monoxide (CO), carbon dioxide (CO_2), methane, and respirable particulates (particulate matter under 10 microns in size, abbreviated as PM10). Among these pollutants, SO_x and NO_x emissions are chemical precursors of acid rain. NO_x, VOC and CO emissions are responsible for the buildup of tropospheric ozone, the unhealthful ozone "smog" that occurs near ground level. PM10 emissions represent a human health hazard due to their potential toxicity and the ease with which they are inhaled. CO_2 and methane are so-called "greenhouse" gasses associated with global warming concerns.

Table 1 expresses the SPO emission factors in the form of pounds of emissions per million Btu's (British thermal units) of fuel consumed. On average, and based on the way fuel is currently used in Maine, every million Btu's of energy used will result in the release of the number of pounds of each type of air pollutant listed in Table 1. Measuring energy based on its Btu content establishes a common measure of "energy equivalency," which allows us to compare fuels that are commonly measured in different units, such as gallons, cords, or tons. Therefore, one can read down the Table 1 columns and develop a sense of which fuels are typically cleaner or dirtier, relative to emissions of a particular pollutant.

TABLE 1: Maine Energy-Related Air Emissions
Pounds of Emissions Produced per Million Btus of Energy Consumed

	SOx	NOx	VOC	CO	Methane	C02	PM10
MOBILE EMISSIONS							
Gasoline vehicles		0.6765	0.6796	6.0165	0.02787	154.8	
Diesel vehicles	0.3605	0.6286	0.0581	0.2427	0.00229	163.6	0.0099
RESIDUAL OIL (#5&6)							
Utility	0.9207	0.3971	0.0050	0.0327	0.00187	169.5	0.0066
Industrial	2.0724	0.3667	0.0019	0.0333	0.00667	169.5	0.1411
Commercial	1.9138	0.3667	0.0075	0.0333	0.00317	169.5	0.0941
HEATING OIL (#1&2)							
Utility	0.2692	0.1730	0.0014	0.0361	0.00037	163.6	0.0072
Industrial	0.3624	0.1442	0.0014	0.0361	0.00037	163.6	0.0072
Commercial	0.3624	0.1442	0.0025	0.0361	0.00156	163.6	0.0078
Residential	0.3634	0.1298	0.0051	0.0361	0.01283	163.6	0.0099
WOOD							
Fluidized bed	0.0081	0.1692	0.0012	0.0864	0.0288	369.5	0.0084
Non-fluidized bed	0.0081	0.2220	0.1000	0.2625	0.0288	369.5	0.0084
Typical Industrial	0.0081	0.2231	0.1231	0.3413	0.0288	369.5	0.3423
"Airtight" Woodstove	0.0284	0.1986	1.9858	19.149	4.5390	280.4	2.1277
EPA-Cert. Woodstove	0.0284	0.1418	1.2057	5.5319	1.8440	290.3	0.9220
COAL							
Industrial	1.4008	0.5755	0.0286	0.2449	0.0012	219.0	0.4045
Commercial	1.6250	0.5833	0.0292	0.2083	0.0013	231.8	0.5000
Residential	0.7800	0.5600	0.0280	0.2400	0.0012	206.7	0.4824
NATURAL GAS							
Industrial	0.00059	0.1367	0.0027	0.0342	0.0029	119.9	0.0029
Commercial	0.00059	0.0977	0.0052	0.0195	0.0026	119.9	0.0029
Residential	0.00059	0.0977	0.0052	0.0195	0.0026	119.9	0.0026
PROPANE							
Industrial	0	0.1355	0.0027	0.0339	0.0030	152.3	0.0028
Commercial/ Residential	0	0.0962	0.0051	0.0197	0.0026	152.3	0.0028
WASTE-TO- ENERGY	0.0065	0.5882	0.0041	0.2955	0.0006	216.1	0.0728

For example, Table 1 indicates that the coal and oil used in Maine produce higher SO_x levels per unit of energy than wood, natural gas and propane. Similarly, gasoline vehicles and residential "airtight" woodstoves are associated with pronounced emissions of carbon monoxide (CO). The factors in Table 1 also illustrate the significant reductions in most types of emissions associated with newer "EPA-certified" residential woodstoves relative to older "airtight" models. In the case of woodstoves, note also that the decrease in CO emissions achieved in new generation woodstoves is accompanied by an increase in CO_2 emissions. The increased combustion efficiency shifts the carbon that is present in the fuel from being released as CO to CO_2. In almost all cases, the factors represent emissions characteristics of average Maine energy use patterns and do not, therefore, reflect what might be achievable with newer technologies. Table 2 presents an estimate of current annual levels of energy-related air emissions in Maine by each fuel type and by energy use sector. These estimates, presented in tons of emissions, are based on the factors shown in Table 1 and the energy use estimates published in the 1992 Energy Commission report (which used 1989 energy data as its baseline). Annual tons of emissions were derived by multiplying the energy use estimates by the appropriate emission factors. The result, as shown in Table 2, suggests that modem energy use patterns in Maine are responsible for an annual total of approximately 33 million tons of emissions of these seven types of pollutants, although CO_2 accounts for approximately 32.8 million tons, or 98 percent of the total. The other six categories of pollutants are, therefore, responsible for a total of approximately 549,000 tons of emissions, led by ozone-causing carbon monoxide (CO).

Table 2: Maine Energy-Related Air Emissions
Estimated Total Annual Emissions by Fuel and Sector
(Tons)

By Fuel	**SOx**	**NOx**	**VOCs**	**CO**	**Methane**	**C02**	**PM10**	**Total**
Residual Oil (#5&6)	63,137	14,945	138	1,304	177	6,687,397	3,316	6,770,414
Heating Oil (#1&2)	9,371	3,477	107	931	235	4,229,782	236	4,244,139
LPG/Natural Gas	1	518	20	114	13	663,558	13	664,237
Wood	425	7,099	13,136	73,268	19,277	12,011,152	11,577	12,135,934
Coal/MSW	4,725	2,973	104	1,335	5	1,119,250	1,532	1,129,924
Gasoline		26,552	35,105	236,146	1,094	6,074,962		6,373,859
Diesel	4,574	7,977	737	3,079	29	2,076,438	125	2,092,959
By Sector								
Transportation	4,574	34,530	35,842	239,226	1,123	8,151,401	125	8,466,821
Industrial	49,009	11,698	1,005	4,026	353	7,569,683	6,644	7,642,418
Utility (inc. IPP & Cogen)	14,757	11,692	2,057	6,206	599	10,360,042	396	10,395,749
Commercial	7,154	1,899	43	327	19	1,436,764	390	1,446,596
Residential	6,739	3,723	10,400	66,394	18,737	5,344,649	9,244	5,459,886
Total	**82,236**	**63,544**	**49,349**	**316,181**	**20,832**	**32,862,542**	**16,801**	**33,411,485**

While Table 2 presents current emissions estimates, the same method could be used to quantify the emissions characteristics of "what if scenarios, such as fuel switching or conservation programs. In this way, the factors can be used not only to analyze Maine's current energy picture, but also can aid in the development of future energy policies that result in desired environmental benefits. For example, one could quantify the tonnage reduction in SO_x emissions that would result from using natural gas to replace a specified percentage of the #6 fuel oil that is currently used in Maine paper mills. Or one could analyze the environmental benefits of replacing older "airtight" woodstoves with the new generation "EPA-certified" woodstoves.

To help interpret the information in Table 2, the same data is presented graphically in Figures 1 to 14 (below). For each category of pollutant, one graph depicts where the emissions come from by fuel type (e.g., heating oil) and a second depicts emissions sources by energy use sector (e.g., residential or commercial). The graphs illustrate that:

- The majority of Maine's SO_x emissions are caused by residual oil consumption in the industrial sector (60 percent) and the utility sector (18 percent);
- Maine's NO_x emissions are due primarily to gasoline consumption (42 percent) and transportation uses generally (54 percent);
- A majority of VOC and CO emissions are produced by gasoline, although a significant share comes from residential wood use;
- Most of Maine's (combustion-related) methane emissions are due to residential wood use;
- CO_2 emissions are spread fairly evenly across all fuels and sectors, although wood is the single largest contributor; and
- Wood use accounts for most of Maine's energy-related PM10 emissions, with residential use comprising 55 percent, and industrial use 39 percent.

Comparison of the two charts for each type of emission tells an important story about Maine's current energy picture and helps suggest appropriate directions for future energy policy initiatives. For example, reducing the state's dependence on oil continues to be an important policy goal, and most of the oil consumed in Maine is used in the form of gasoline or diesel fuel for transportation. Indeed, transportation use represents one of the largest components of the state's energy mix.[1] The fact that transportation energy use also accounts for a disproportionate share of Maine's energy-related air pollution reinforces the need to address energy use issues in the transportation sector. Transportation efficiency efforts, clean fuel and clean car programs, and switching to cleaner alternative transportation fuels all could result in a measurable reduction in air emissions. However, only the use of alternative fuels would address the dual goal of cleaner air and diversifying the energy mix in the transportation sector, which is now almost entirely dependent on oil.

Similarly, the emission factors suggests that SO_x emissions could be reduced significantly through fuel-switching efforts in the industrial sector to a low-sulfur fuel, such as natural gas. An expansion of Maine's natural gas pipeline capacity is currently in the advanced planning stages. At the same rime, this would help address Maine's higher-than-average dependence on imported oil.

The methodology developed by the State Planning Office also indicates that the electric power sector is responsible for a disproportionately low share of emissions of these types of pollution (especially for pollutants other than CO_2), despite the fact that over 40 percent of the state's primary energy supplies are used in this sector. In other words, on the basis of pounds of emissions per Btu of energy consumed, electricity in Maine is a notably clean resource. This is due to the state's relatively high dependence on nuclear and renewable resources for electric power generation, and relatively low dependence on fossil fuels. Also, the residual oil used in the utility sector (almost all of which occurs at the Wyman Station in Yarmouth) is a lower sulfur oil than is used in the industrial sector and is burned with more effective emission controls.

It is important to separate out CO_2 emissions in this type of analysis, because most of the CO_2 produced in Maine's electric power sector comes from biomass (wood-fired) energy plants. It remains unclear whether CO_2 emissions from renewable resources such as biomass contribute to global warming as significantly as emissions from non-renewable resources. Theoretically, the CO_2 may subsequently be recaptured through forest regrowth.

Of course, by themselves, the factors do not analyze the effects of, or establish the relative importance of, these types of air emissions. Quantifying the emissions does not necessarily indicate the existence of a pollution-related problem. Maine may or may not have a SO_x problem, or a PM10 problem or a CO_2 problem. Moreover, problems that do exist may be local or seasonal in nature. That analysis is not as much a matter of energy policy as it is a subject for environmental science. However, the methodology developed by the State Planning Office, as depicted in these tables and graphs, enhances our understanding of Maine's current energy picture with respect to its environmental attributes. It also serves to highlight areas that represent relative priorities for the use of limited resources and can help to identify unique opportunities where both environmental and energy advantages can be derived.

Figure 1: SOx Emissions by Fuel

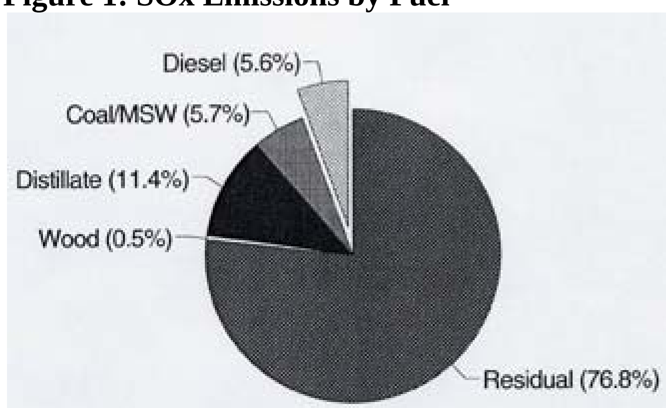


Figure 2: SOx Emissions by Sector

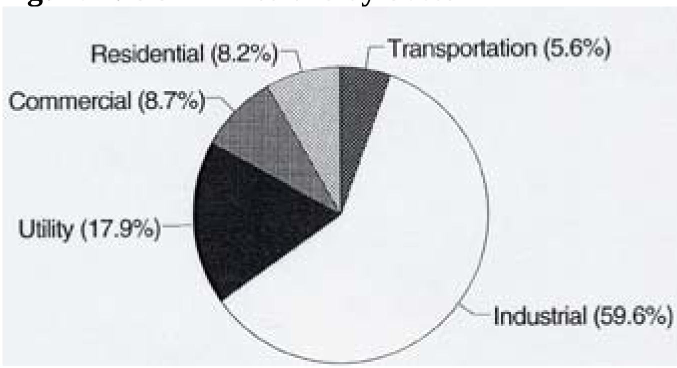


Figure 3: NOx Emissions by Fuel

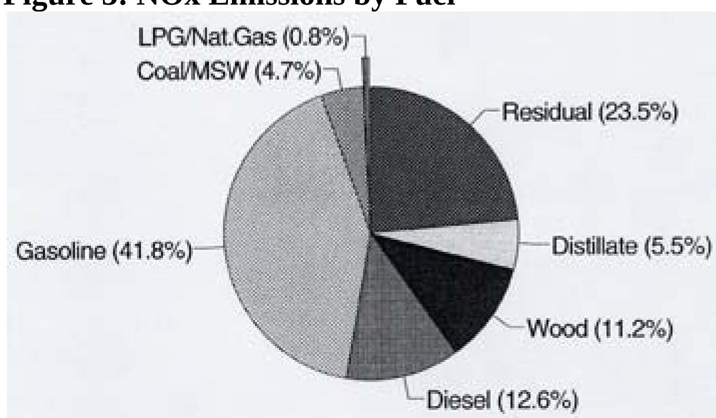


Figure 4: NOx Emissions by Sector

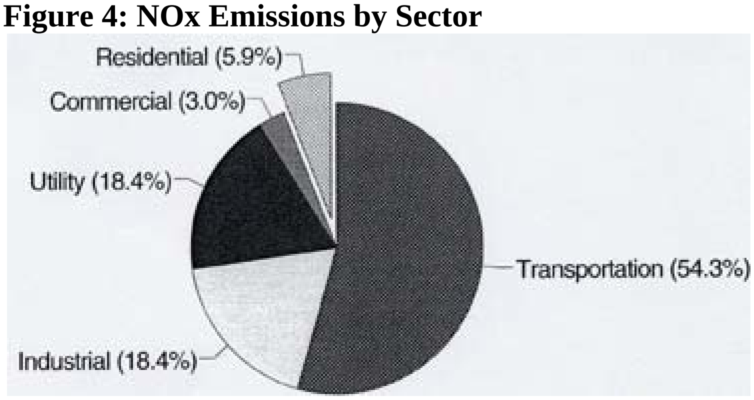


Figure 5: VOC Emissions by Fuel

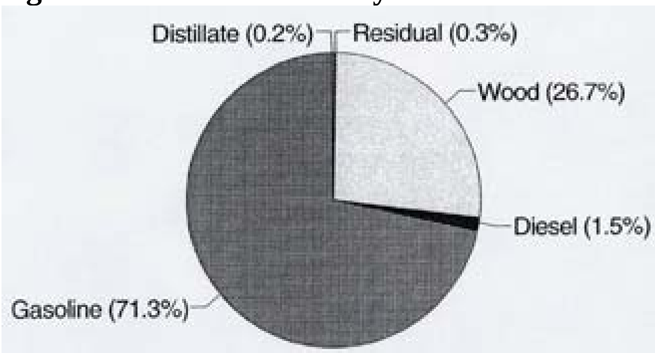


Figure 6: VOC Emissions by Sector

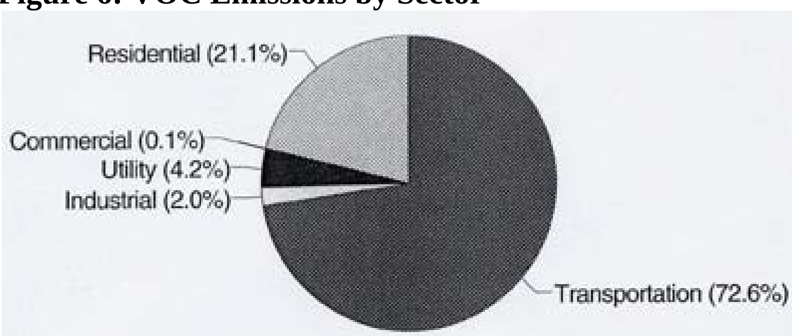


Figure 7: CO Emissions by Fuel

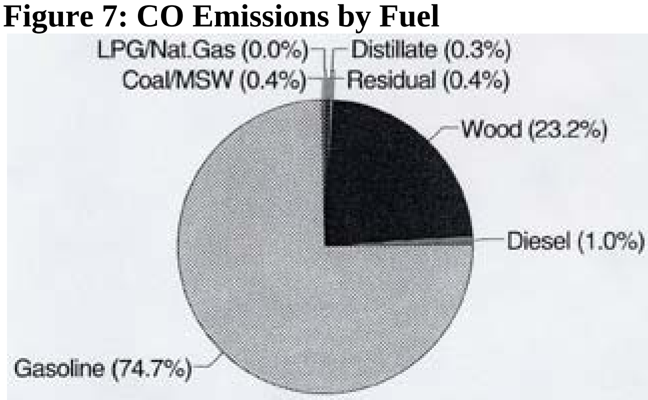


Figure 8: CO Emissions by Sector

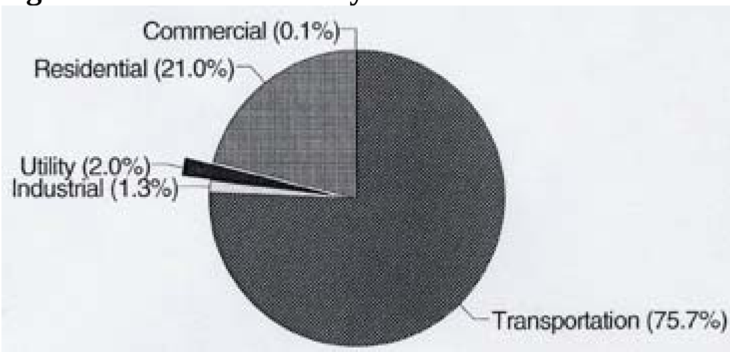


Figure 9: Methane Emissions by Fuel

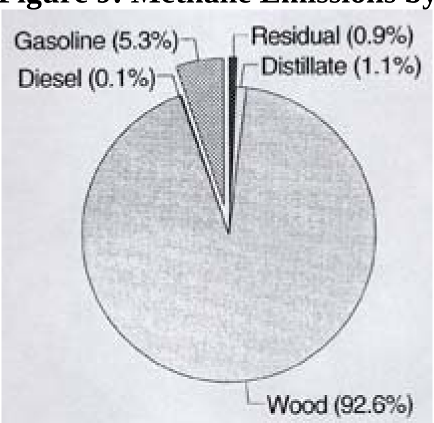


Figure 10: Methane Emissions by Sector

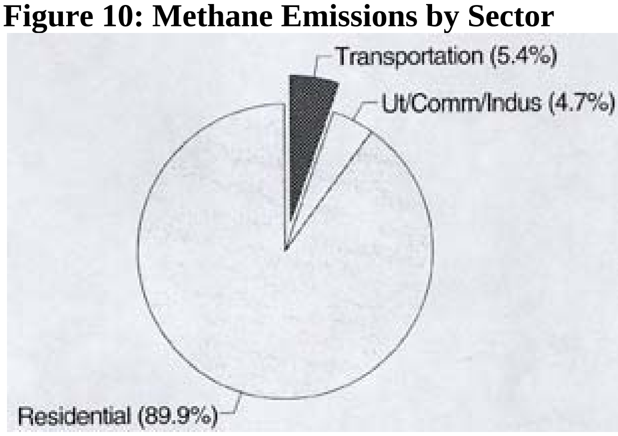


Figure 11: CO2 Emissions by Fuel

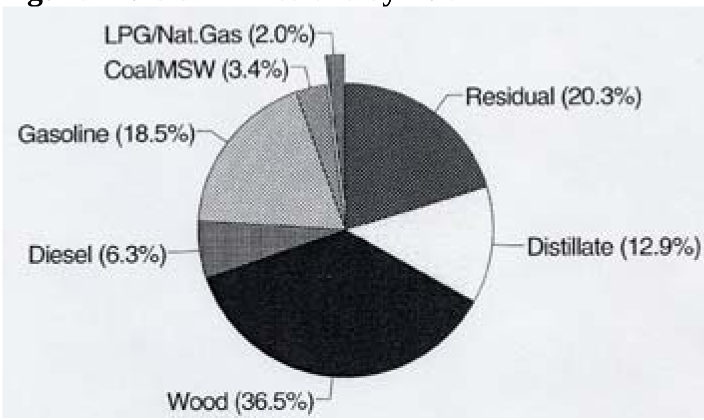


Figure 12: CO2 Emissions by Sector

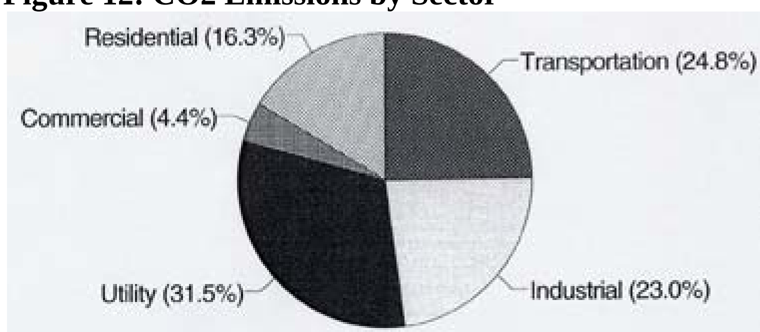


Figure 13: PM10 Emissions by Fuel

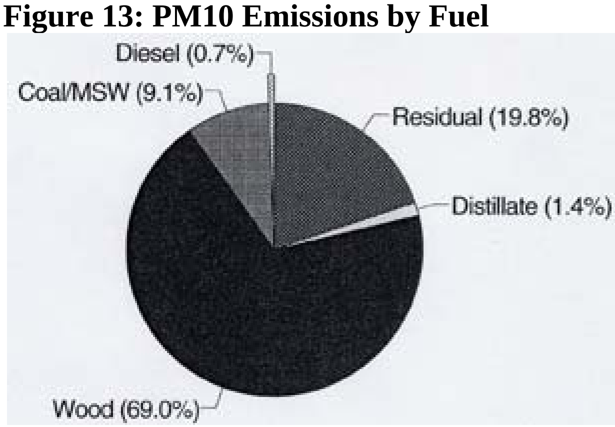
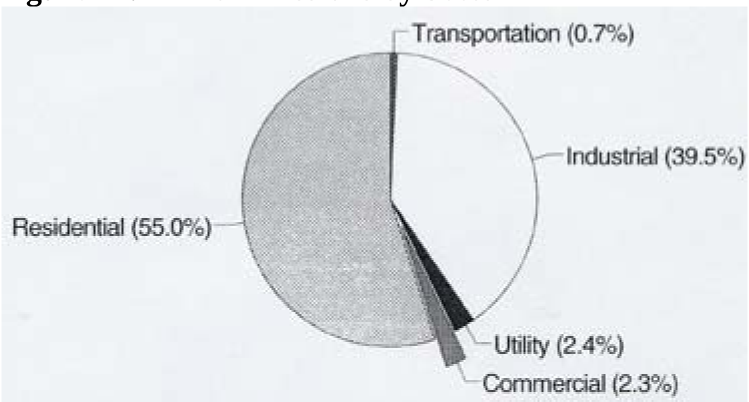


Figure 14: PM10 Emissions by Sector



Endnote:

1. Editor's note: For a detailed discussion of Maine's energy uses, see "Planning Maine's Energy Future," by Richard Silkman and John Flumerfelt, Maine Policy Review, Dec. 1991.

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