

## **Appendix B. Residential, Commercial, and Industrial Fossil Fuel Combustion (excluding fuel used by fossil fuel production industry)**

### **Overview**

The RCI<sup>1</sup> sectors produce CO<sub>2</sub>, CH<sub>4</sub>, and N<sub>2</sub>O emissions when fuels are combusted for space heating, process heating, and other applications. Carbon dioxide accounts for over 98% of these emissions on an MMtCO<sub>2</sub>e basis in Vermont. In addition, since these sectors consume electricity, one can also attribute electricity use emissions to these sectors.<sup>2</sup> The RCI sector is the second highest source of gross GHG emissions in Vermont. Direct use of oil, natural gas, coal, and wood<sup>3</sup> in the RCI sector accounted for an estimated 27% of gross GHG emissions in 2005. Emissions associated with RCI electricity use are relatively low accounting for less than █% of total gross GHG emissions in 2005.

### **Emissions and Reference Case Projections**

Emissions for direct fuel use were estimated using the U.S. EPA's SGIT and the methods provided in the EIIP guidance document for RCI fossil fuel combustion.<sup>4</sup> The default data in the SGIT are from EIA's *State Energy Data (SED)*. The SED were revised using the most recent data available which includes (1) the 2002 edition of SED<sup>5</sup> for all fuel types; (2) 2003 data that EIA released during December 2005 and August 2006 for oil, natural gas, coal, and wood;<sup>6</sup> and (3) 2003 and 2004 electricity consumption and natural gas consumption estimates available from the EIA's *Electric Power Annual*<sup>7</sup> and *Natural Gas Navigator*, respectively.<sup>8</sup>

Reference case emissions for direct fuel combustion were estimated based on fuel consumption forecasts from EIA's *Annual Energy Outlook 2006*,<sup>9</sup> with adjustments for

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<sup>1</sup> The industrial sector includes agricultural energy use as well but this section excludes fuel used by the fossil fuel production industry. Emissions from energy used in the fossil fuel production industry are reported in Appendix E.

<sup>2</sup> One could similarly allocate GHG emissions due to natural gas transmission and distribution and other sources, but we have not done so here due to the relatively small level of emissions.

<sup>3</sup> Emissions from wood combustion include only N<sub>2</sub>O and CH<sub>4</sub>. Carbon dioxide emissions from biomass are assumed to be "net zero" consistent with U.S. EPA and IPCC methodologies, and any net loss of carbon stocks due to biomass fuel use should be picked up in the land use and forestry analysis.

<sup>4</sup> GHG emissions were calculated using SGIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter 1 "Methods for Estimating Carbon Dioxide Emissions from Combustion of Fossil Fuels", August 2004, and Chapter 2 "Methods for Estimating Methane and Nitrous Oxide Emissions from Stationary Combustion", August 2004.

<sup>5</sup> EIA *State Energy Data 2002*, Data through 2002, released June 30, 2006, [http://www.eia.doe.gov/emeu/states/state.html?q\\_state\\_a=vt&q\\_state=VERMONT](http://www.eia.doe.gov/emeu/states/state.html?q_state_a=vt&q_state=VERMONT)

<sup>6</sup> EIA *State Energy Data 2003*, [http://www.eia.doe.gov/emeu/states/\\_seds\\_updates.html](http://www.eia.doe.gov/emeu/states/_seds_updates.html).

<sup>7</sup> EIA *Electric Power Annual, 2004*, [http://www.eia.doe.gov/cneaf/electricity/epa/epa\\_sprdshts.html](http://www.eia.doe.gov/cneaf/electricity/epa/epa_sprdshts.html).

<sup>8</sup> EIA *Natural Gas Navigator*, [http://tonto.eia.doe.gov/dnav/ng/ng\\_cons\\_sum\\_dcu\\_SVT\\_a.htm](http://tonto.eia.doe.gov/dnav/ng/ng_cons_sum_dcu_SVT_a.htm).

<sup>9</sup> EIA *Annual Energy Outlook 2006 with Projections to 2030*, Energy Information Administration, Department of Energy, <http://www.eia.doe.gov/oiaf/aeo/index.html>.

Vermont's projected population<sup>10</sup> and employment growth. Vermont employment data for the manufacturing (goods producing) and non-manufacturing (services providing) sectors were obtained from the Vermont Department of Labor.<sup>11</sup> New England regional employment data for the same sectors were obtained from the EIA.<sup>12</sup>

Table B1 shows historic and projected growth rates for electricity sales by sector. Table B2 shows historic and projected growth rates for energy use by sector and fuel type. For the residential sector, the rate of population growth is expected to decline slowly between 2004 and 2020 and this is reflected in the growth rates for fuel consumption. Natural gas consumption is expected to increase slightly while consumption of petroleum, wood, and coal is expected to decline slightly.

From 2004 and 2020, the commercial sector shows a higher rate of growth in fuel consumption relative to the residential and industrial sectors. This increase is in part associated with an increase in non-manufacturing employment (1.4% annually) over this period. From 2010 to 2020, natural gas consumption is expected to increase at a higher rate than for petroleum; however, the rate of consumption is expected to decline during this 10-year period for both of these fuels.

**Table B1. Electricity Sales Annual Growth Rates, Historical and Projected**

<b>Sector</b>	<b>1990-2004*</b>	<b>2004-2020**</b>
Residential	1.1%	1.4%
Commercial	2.1%	2.6%
Industrial	1.0%	0.3%
<b>Total ***</b>	<b>1.3%</b>	<b>1.5%</b>

\* 1990-2004 figures calculated from Vermont electricity sales by year from EIA state electricity profiles (Table 8),

[http://www.eia.doe.gov/cneaf/electricity/st\\_profiles/e\\_profiles\\_sum.html](http://www.eia.doe.gov/cneaf/electricity/st_profiles/e_profiles_sum.html).

\*\* 2004-2020 figures calculated from AEO2006 New England regional projections adjusted for Vermont's projected population for the residential sector, non-manufacturing employment for the commercial sector, and manufacturing employment for the industrial sector.

\*\*\* Total based on weighted average growth for the three sectors.

The industrial sector shows slight growth in the consumption of natural gas and wood, and a slight decline in the rate of consumption of petroleum from 2004 to 2020, while growth in manufacturing employment is expected to remain low (at about 0.1% annually) over this period. For both the commercial and industrial sectors, energy consumption and

<sup>10</sup> 1900-1999 population data from Vermont Department of Public Health, Agency of Human Services' website at <http://healthvermont.gov/research/intercensal/TABLE1.XLS>; 2000-2020 population data from U.S. Census Bureau's website at <http://www.census.gov/population/projections/SummaryTabA1.xls>.

<sup>11</sup> Vermont Department of Labor, U.I. Covered Employment & Wages (QCEW), Annual Averages, NAICS Based, 1988 – 2002 and 2002 2012, <http://www.vtlmi.info/ces.cfm>.

<sup>12</sup> EIA AEO2006 New England regional employment data obtained through special request from EIA (dated August 23, 2006).

resulting GHG emissions are projected to grow at a slower pace than GSP indicating an overall decrease in GHG intensity.<sup>13</sup>

**Table B2. Historic and Projected Average Annual Growth in Energy Use, by Sector and Fuel, 1990-2020**

	1990-2004*	2004-2010**	2010-2015**	2015-2020**
<b>Residential</b>				
natural gas	2.8%	0.3%	0.7%	0.6%
petroleum	1.8%	-0.4%	-0.3%	-0.7%
wood	-2.7%	0.2%	-0.7%	-0.2%
coal	-16.7%	0.1%	-0.5%	-0.5%
<b>Commercial</b>				
natural gas	2.2%	-0.8%	2.6%	2.0%
petroleum	2.7%	0.3%	1.2%	0.7%
wood	0.9%	0.1%	1.0%	0.6%
coal	-13.3%	1.0%	1.0%	0.6%
<b>Industrial***</b>				
natural gas	3.0%	0.8%	1.4%	1.0%
petroleum	4.0%	-0.5%	-0.1%	-0.4%
wood	-4.4%	1.6%	1.3%	1.2%

\* 1990-2004 figures calculated from historical consumption by sector and fuel type for Vermont.

\*\* Figures for the growth periods starting after 2004 calculated from AEO2006 New England regional projections adjusted for Vermont's projected population for the residential sector, non-manufacturing employment for the commercial sector, and manufacturing employment for the industrial sector.

\*\*\* Coal has not been used by the industrial sector since 1997 and is not anticipated to be used by Vermont industries in the future.

## Results

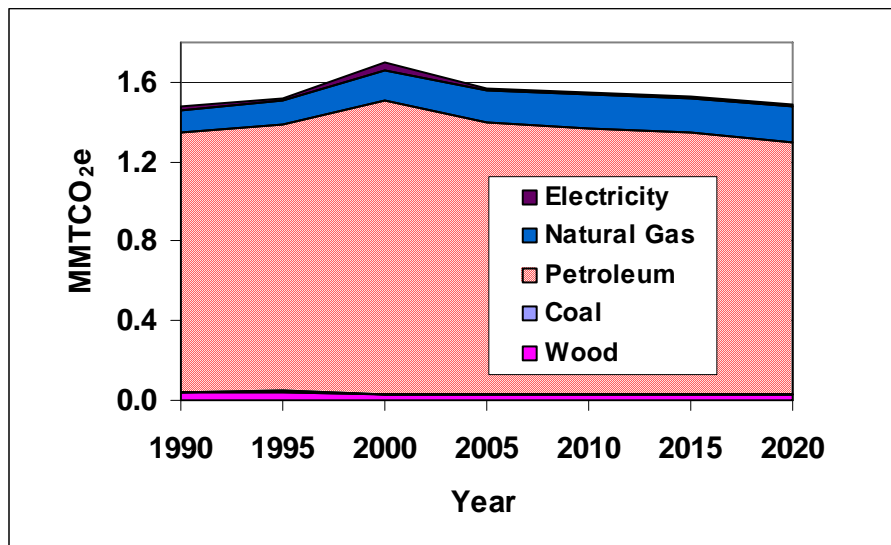
Figures B1, B2, and B3 show historic and projected emissions for the RCI sector from 1990 to 2020. The residential sector accounts for 55% to 60% of total RCI emissions, the commercial sector accounts for 21% to 28% of total RCI emissions, and the industrial sector accounts for 16% to 18% of total RCI emissions. Petroleum consumption accounts for the largest component of each sector's emissions. For the residential sector, petroleum consumption accounts for about 87% of total gross emissions, natural gas consumption accounts for 10% to 12% of total emissions, and wood consumption accounts for about 2% of total GHG emissions.

For the commercial sector, emissions associated with the use of petroleum and natural gas are expected to increase by about 1% annually from 2004 to 2020. Petroleum consumption accounts for about 77% of total gross emissions, natural gas consumption accounts for 20% of total emissions, and wood consumption accounts for less than 1% of total GHG emissions.

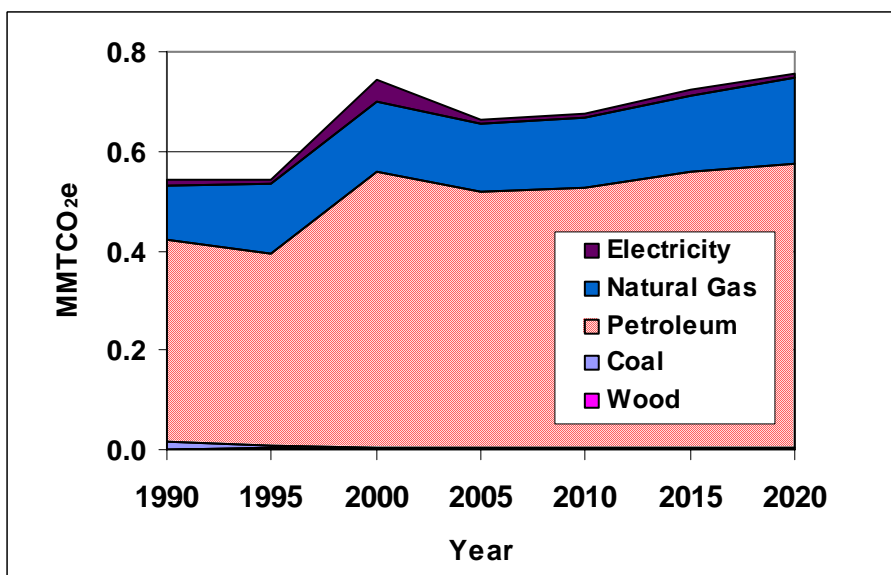
<sup>13</sup> These estimates of growth relative to population and employment reflect expected responses – as modeled by the EIA NEMS model -- to changing fuel and electricity prices and technologies, as well as structural changes within each sector (e.g., subsectoral shares, energy use patterns).

For the industrial sector, Vermont’s manufacturing employment is expected to grow 0.1% annually. Consequently, emissions are expected to remain relatively constant from 2004 to 2020. Natural gas use is expected to increase slightly (about 3%) while petroleum use is expected to decline slightly (about 5%) over the 15-year time period. Petroleum consumption accounts for about 60% to 65% of total gross emissions in the residential sector. Natural gas consumption accounts for 33% to 37% of total emissions, and wood consumption accounts for 1% to 2% of total GHG emissions.

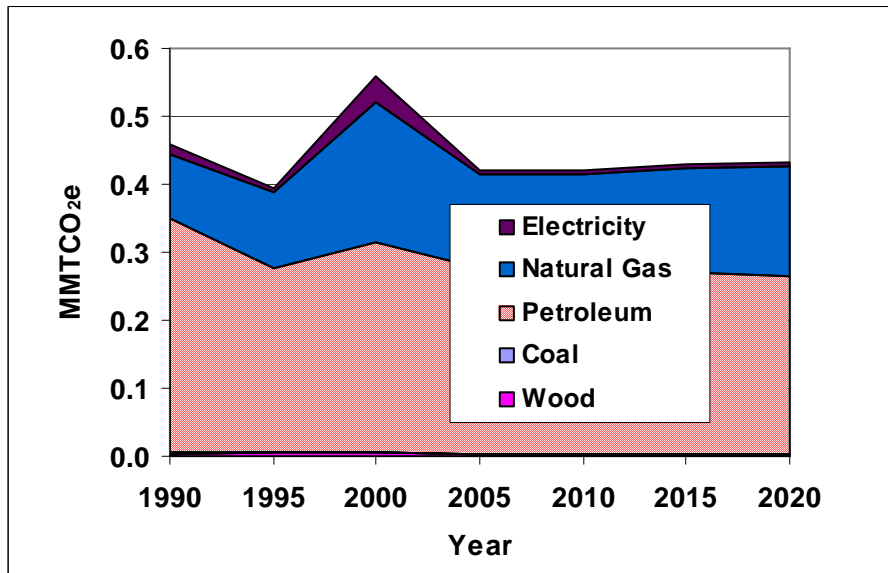
**Figure B1. Residential Sector GHG Emissions from Fuel Consumption**



**Figure B2. Commercial Sector GHG Emissions from Fuel Consumption**



**Figure B3. Industrial Sector GHG Emissions from Fuel Consumption**



### Key Uncertainties

Key sources of uncertainty underlying the estimates are as follows:

- Population and economic growth are the principal drivers for electricity and fuel use. The reference case projections are based on regional projections for EIA's New England modeling region scaled for Vermont population and economic growth projections. Consequently, there are significant uncertainties associated with the projections. Future work should attempt to base projections on data specific to Vermont to the extent that the data become available.
- The forecasts for wood and biomass consumption indicate little growth in the use of this fuel in Vermont. However, due to recent increases in fuel prices, there has been an increase in the use of wood furnaces to heat residential homes. In addition, new wood stove technology (i.e., pellet stoves) is expected to burn much more efficiently than previous designs thus reducing emissions; however, emissions test data are not yet available to determine how N<sub>2</sub>O and CH<sub>4</sub> emissions would change. Future work could focus on collecting data on woodstove sales for Vermont to support improvements to the projections for this category.
- The projections assume no large long-term changes in relative fuel and electricity prices, as compared with current levels and U.S. DOE projections. Price changes would influence consumption levels and encourage switching among fuels.
- It is unclear if demand-side management programs (such as those implemented through Efficiency Vermont) are adequately captured in the reference case projections since the projections are based on regional EIA forecasts. Although the growth rates for the RCI sector have been normalized to Vermont's population, manufacturing, and non-manufacturing employment, this methodology does not allow the effects of demand-side management programs to be distinctly quantified.

- Growth of major industries – the energy consumption projections assume no new large energy-consuming facilities. A few large new facilities – or the decline of major industries – could significantly impact energy consumption and subsequent emissions.