Appendix D. Industrial Processes

Overview
Emissions in this category span a wide range of activities, and reflect non-combustion sources of GHG emissions from the following industrial processes:

- CO_2 from:
  - Production of cement, lime, soda ash, ammonia, iron and steel, and ferroalloy
  - Consumption of limestone, dolomite, soda ash, and magnesium produced from dolomite;
- N_2O from nitric and adipic acid production;
- PFCs from aluminum production;
- HFCs from HCFC-22 production;
- HFCs, PFCs, and SF_6 from semiconductor manufacture;
- SF_6 from magnesium production and processing;
- SF_6 from transformers used in electric power transmission and distribution (T&D) systems; and
- HFCs and PFCs from consumption of substitutes for ozone-depleting substances (ODS) used in cooling and refrigeration equipment.

The industrial processes that exist in Vermont and that are included in the inventory and reference case projections include (1) the use of limestone, dolomite, and soda ash; (2) semiconductor manufacture; (3) operation of electric power T&D systems; and (4) use of ODS substitutes in cooling and refrigeration equipment.

Emissions and Reference Case Projections
GHG emissions for 1990 through 2005 were estimated using SGIT and the methods provided in the EIIP guidance document for this sector.[1] Table D1 identifies the information needed by SGIT to calculate emissions, the data sources, and the historical years for which emissions were calculated based on the availability of data. Table D2 lists the data sources, annual compounded growth rates, and years for which the reference case projections were calculated.

Results
Figures D1 and D2 show historic and projected emissions for the industrial sector from 1990 to 2020. Total gross GHG emissions were about 0.4 MMTCO2e in 2000 (4.7% of total emissions) and about 0.8 MMTCO2e in 2020 (8.8% of total emissions), indicating that the emission may double over this 20-year period.

Emissions from this category are expected to grow rapidly, as shown in Figures D1 and D2, almost entirely due to the increasing use of HFCs and PFCs in refrigeration and air conditioning equipment. HFCs and PFCs are used as substitutes for ODS, most notably

[1] GHG emissions were calculated using SGIT, with reference to Emission Inventory Improvement Program, Volume VIII: Chapter. 6. "Methods for Estimating Non-Energy Greenhouse Gas Emissions from Industrial Processes", August 2004.

CFCs (also potent warming gases) in compliance with the *Montreal Protocol* and the *Clean Air Act Amendments of 1990*.[2] Even low amounts of HFC and PFC emissions, from leaks and other releases under normal use of the products, can lead to high GHG emissions. Emissions from the ODS substitutes in Vermont have increased from 0.00075 $MMtCO_2e$ in 1990 to 0.162 $MMtCO_2e$ in 2000, and are expected to increase an average of 4% per year from 2000 to 2020.

Table D1. Approach to Estimating Historical Emissions

Source Category	Time Period	Required Data for SGIT	Data Source
Limestone and Dolomite Consumption	1994 - 2002	Consumption of limestone and dolomite by industrial sector for use as flux stone and in glass manufacturing.	Minerals Yearbook, 2004: Volume I, Metals and Minerals, (http://minerals.usgs.gov/minerals/pubs/state/vt.html).
Soda Ash	1990 - 2005	Consumption of soda ash used in consumer products such as glass, soap and detergents, paper, textiles, and food. Emissions based on State's population and estimates of emissions per capita from the U.S. EPA national GHG inventory.	Minerals Yearbook, 2004: Volume I, Metals and Minerals, (http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/). For population data, see references for ODS substitutes.
ODS Substitutes	1990 - 2002	Based on State's population and estimates of emissions per capita from the U.S. EPA national GHG inventory.	-- State 1990-1999 population from Vermont Department of Public Health, Agency of Human Services' (http://healthvermont.gov/research/intercensal/TABLE1.XLS). -- U.S. 1990-2000 population from U.S. Census Bureau (http://www.census.gov/popest/archives/EST90INTERCENSAL/US-EST90INT-01.html). -- State and U.S. 2000-2005 population from U.S. Census Bureau (http://www.census.gov/population/projections/SummaryTabA1.xls).
Semiconductor Manufacturing	1990 - 2002	State and national value of semiconductor shipments for NAICS code 334413 (Semiconductor and Related Device Manufacturing). Method uses ratio of State to national value of semiconductor shipments to estimate State proportion of national emissions.	Value of shipments from U.S Census Bureau's Economic Census (http://www.census.gov/econ/census02/). Data for State in 2002 Economic Census withheld; therefore, SGIT default values used for 1990-2002.
Electric Power T&D Systems	1990 - 2002	Emissions from 1990 to 2003 based on the national emissions per kWh and State's electricity use.	National emissions per kWh from U.S. EPA GHG inventory (U.S. EPA 2005 Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003).

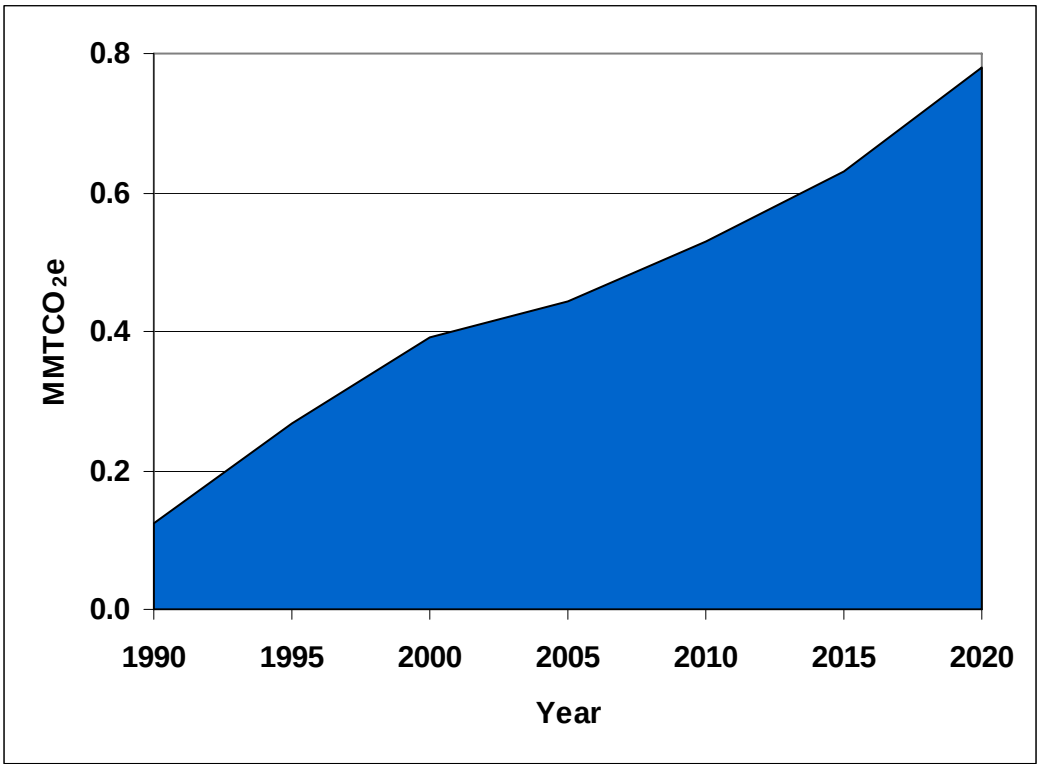
[2] As noted in EIIP Chapter 6, ODS substitutes are primarily associated with refrigeration and air conditioning but also many other uses such as fire extinguishers, solvent cleaning, aerosols, foam blowing, and sterilization. ODS substitutes depend on technology characteristics in a range of equipment. For the US national inventory, a detailed stock vintaging model was used, but this modeling approach has not been completed at the state level.

Table D2. Approach to Estimating Projections

Source Category	Time Period	Projection Assumptions	Data Source	Annual Growth Rates (%)			
				2000 to 2005	2005 to 2010	2010 to 2015	2015 to 2020
Limestone and Dolomite Consumption	2003 - 2020	State manufacturing sector growth rate.	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.	0.1	0.1	0.1	0.1
Soda Ash	2006 - 2020	Growth between 2004 and 2009 is projected to be about 0.5% per year for U.S. production. Assumed growth is same for 2010 – 2020.	Minerals Yearbook, 2004: Volume I, Metals and Minerals, (http://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/).	0.5	0.5	0.5	0.5
ODS Substitutes	2003 - 2020	Based on national growth rate for ODS substitutes.	EPA, 2004 ODS substitutes cost study report.	15.8	7.9	5.8	5.3
Semiconductor Manufacturing	2003 - 2020	National growth rate (based on aggregate for all stewardship program categories provided in referenced data source)	U.S. Department of State, U.S. Climate Action Report, May 2002, Washington, D.C., May 2002 (Table 5-7). (http://yosemite.epa.gov/oar/globalwarming.nsf/UniqueKeyLookup/SHSU5BNQ76/$File/ch5.pdf).	3.3	-6.2	-9.0	-2.8
Electric Power T&D Systems	2003 - 2020	ditto	ditto	3.3	-6.2	-9.0	-2.8

Emissions of SF_6 from electrical equipment have experienced declines since the early-nineties (see Figure D2), mostly due to voluntary action by industry. SF_6 is used as an electrical insulator and interrupter in the electricity T&D system. Emissions for Vermont from 1990 to 2002 were estimated based on the estimates of emissions per kWh from the U.S. EPA GHG inventory (U.S. EPA 2005 *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*) and Vermont's electricity consumption. The U.S. Climate Action Report shows expected decreases in these emissions at the national level, and the same rate of decline is assumed for emissions in Vermont. The decline in emissions in the future reflects expectations of future actions by the electric industry to reduce these emissions.

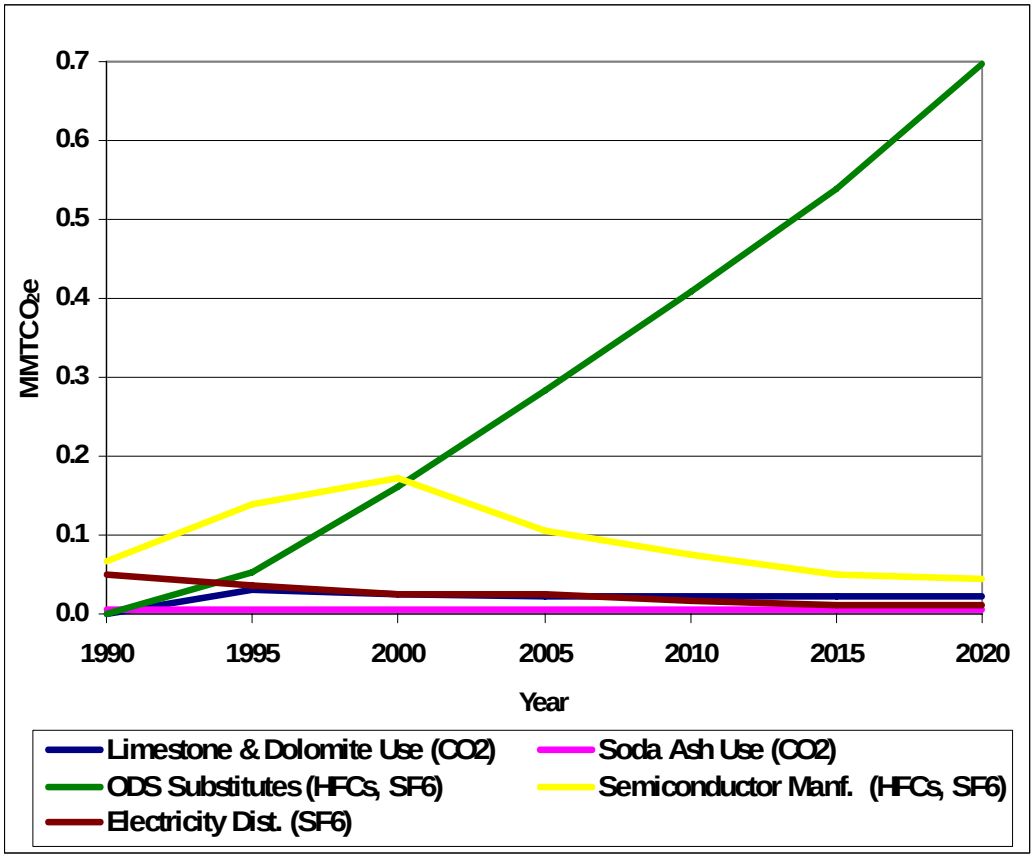
Figure D1. GHG Emissions from Industrial Processes, 1990-2020



Emissions of SF_6 and HFCs from the manufacture of semiconductors have experienced declines since 2000 (see Figure D2). Emissions for Vermont from 1990 to 2002 were estimated based on the default estimates provided in SGIT that uses the ratio of the State to national value of semiconductor shipments to estimate the State's proportion of national emissions from the U.S. EPA GHG inventory (U.S. EPA 2005 *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2003*). For Vermont, the 2002 *Economic Census* withheld information on the value of semiconductor shipments to avoid disclosing confidential information for establishments in Vermont; consequently, the default data provided in SGIT were used. The U.S. Climate Action Report shows expected decreases in these emissions at the national level, and the same rate of decline is assumed for emissions in Vermont. The decline in emissions in the future reflects expectations of future actions by the semiconductor industry to reduce these emissions.

Commercial soda ash (sodium carbonate) is used in many consumer products such as glass, soap and detergents, paper, textiles, and food. CO_2 is also released when soda ash is consumed. SGIT estimates historical emissions based on the State's population and national per capita emissions from the U.S. EPA national GHG inventory. Population data for Vermont and the U.S. were updated in SGIT for 1990 through 2005. According to the USGS, this industry is expected to grow at an annual rate of 0.5% from 2004 through 2009 for the U.S. Information on growth trends for years later than 2009 was not available; therefore, the same growth rate was applied for estimating emissions to 2020.

Figure D2. GHG Emissions from Industrial Processes, 1990-2020, by Source



Limestone and dolomite are basic raw materials used by a wide variety of industries, including the construction, agriculture, chemical, glass manufacturing, environmental pollution control, and metallurgical industries such as magnesium production. For Vermont, activity in this category includes consumption of limestone and dolomite for use as flux stone and in glass manufacturing.[3] Recent historical data for Vermont were not available from the USGS; consequently, the default data provided in SGIT were used. The growth rate for Vermont's manufacturing sector (i.e., 0.1% annual) was used to project emissions to 2020.

Key Uncertainties

Since emissions from industrial processes are determined by the level of production and the production processes of a few key industries, there is relatively high uncertainty

[3] In accordance with EIIP Chapter 6 methods, emissions associated with the following uses of limestone and dolomite are not included in this category: (1) crushed limestone consumed for road construction or similar uses (because these uses do not result in CO_2 emissions), (2) limestone used for agricultural purposes (which is counted under the methods for the agricultural sector), and (3) limestone used in cement production (which is counted in the methods for cement production – note that cement production activity does not exist in Vermont).

regarding future emissions. Future emissions depend on the competitiveness of Vermont manufacturers, and the specific nature of their production processes.

The projected largest source of future industrial emissions, HFCs and PFCs used in cooling applications, is subject to several uncertainties as well. First, historical emissions are based on national estimates; Vermont-specific estimates are currently unavailable. For example, the SGIT method for allocating national emissions to states does not account for climatic variations in air conditioning use. Thus, emissions for northern climates may be overstated relative to southern climates. Second, emissions will be driven by future choices regarding air conditioning technologies and the use of coolants for which several options currently exist.