
USER'S GUIDE FOR ESTIMATING CARBON DIOXIDE, NITROUS OXIDE, HFC, PFC, AND SF₆ EMISSIONS FROM INDUSTRIAL PROCESSES USING THE STATE INVENTORY TOOL

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This section of the User's Guide provides instruction on using the Industrial Processes (IP) module of the State Inventory Tool (SIT), and describes the methodology used for estimating carbon dioxide (CO₂), nitrous oxide (N₂O), HFC, PFC, and SF₆ emissions from industrial processes at the state level.

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1.1 GETTING STARTED

The Industrial Processes (IP) module of the State Inventory Tool (SIT) was developed using Microsoft® Excel 2000. While the module will operate with older versions of Excel, it functions best with Excel 2000 or later. If you are using Excel 2007, instructions for opening the module will vary as outlined in the instructions below. Some of the Excel basics are outlined in the sections below. Before you use the IP module, make sure your computer meets the system requirements. In order to install and run the IP module, you must have:

- IBM-PC compatible computer with the Windows 95 operating system or later;
- Microsoft® Excel 1997 or later, with calculation set to automatic and macros enabled;
- Hard drive with at least 20MB free; and
- Monitor display setting of 800 x 600 or greater.

Microsoft Excel Settings

Excel 2003 and Earlier: For the SIT modules to function properly, Excel must be set to automatic calculation. To check this setting, launch Microsoft Excel *before* opening the IP module. Go to the Tools menu and select “Options...” Click on the “Calculations” tab and make sure that the radio button next to “Automatic” is selected, and then click on “OK” to close the window. The security settings (discussed next) can also be adjusted at this time.

Excel 2007: For the SIT modules to function properly, Excel must be set to automatic calculation. Go to the Formulas ribbon and select “Calculation Options.” Make sure that the box next to the “Automatic” option is checked from the pop-up menu.

Microsoft Excel Security

Excel 2003 and Earlier: Since the SIT employs macros, you must have Excel security set to medium (recommended) or low (not recommended). To change this setting, launch Microsoft Excel *before* opening the IP module. Once in Excel, go to the Tools menu, click on the Macro sub-menu, and then select “Security” (see Figure 1). The Security pop-up box will appear. Click on the “Security Level” tab and select medium. When set to high, macros are automatically disabled; when set to medium, Excel will give you the choice to enable macros; when set to low, macros are always enabled.

When Excel security is set to medium, users are asked upon opening the module whether to enable macros. Macros must be enabled in order for the IP module to work. Once they are enabled, the module will open to the control worksheet. A message box will appear welcoming the user to the module. Clicking on the “x” in the upper-right-hand corner of the message box will close it.

Excel 2007: If Excel’s security settings are set at the default level a Security Warning appears above the formula box in Excel when the IP module is initially opened. The Security Warning lets the user know that some active content from the spreadsheet has been disabled, meaning that Excel has prevented the macros in the spreadsheet from functioning. Since SIT needs macros in order to function properly, the user must click the “Options” button in the security message and then select, “Enable this content” in the pop-up box. Enabling the macro content for the SIT in this way only enables macros temporarily in Excel but does not change the macro security settings. Once macros are enabled, a message box

will appear welcoming the user to module. Click on the “x” in the upper right-hand corner to close the message box.

If the Security Warning does not appear when the module is first opened, it may be necessary to change the security settings for macros. To change the setting, first exit out of the IP module and re-launch Microsoft Excel *before* opening the IP module. Next, click on the Microsoft Excel icon in the top left of the screen. Scroll to the bottom of the menu and select the “Excel Options” button to the right of the main menu. When the Excel Options box appears, select “Trust Center” in left hand menu of the box. Next, click the gray “Trust Center Settings” button. When the Trust Center options box appears, click “Macro Settings” in the left hand menu and select “Disable all macros with notification.” Once the security level has been adjusted, open the IP module and enable macros in the manner described in the preceding paragraph.

Viewing and Printing Data and Results

The IP module contains some features to allow users to adjust the screen view and the appearance of the worksheets when they are printed. Once a module has been opened, you can adjust the zoom by going to the Module Options Menu, and either typing in a zoom percentage or selecting one from the drop down menu. In addition, data may not all appear on a single screen within each worksheet; if not, you may need to scroll up or down to view additional information.

You may also adjust the print margins of the worksheets to ensure that desired portions of the IP module are printed. To do so, go to the File menu, and then select “Print Preview.” Click on “Page Break Preview” and drag the blue lines to the desired positions (see Figure 2). To print this view, go to the File menu, and click “Print.” To return to the normal view, go to the File menu, click “Print Preview,” and then click “Normal View.”

Figure 1. Changing Security Settings

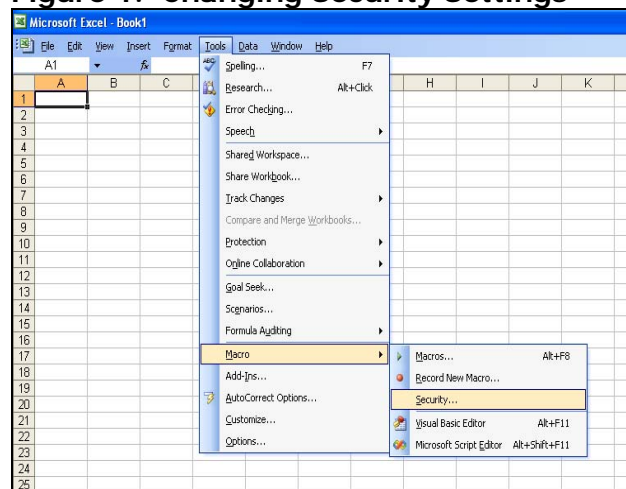
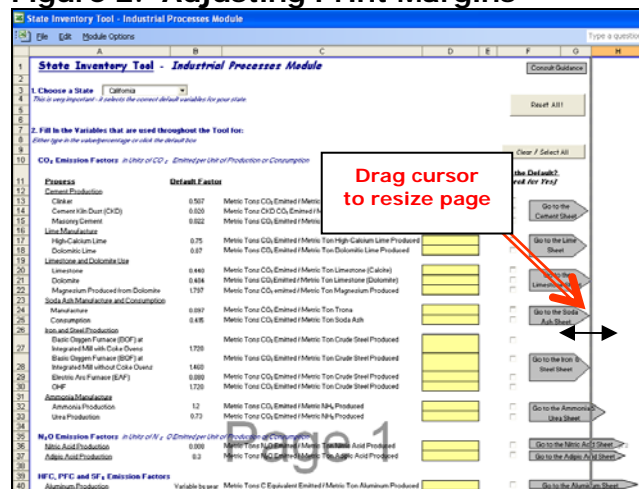


Figure 2. Adjusting Print Margins



1.2 MODULE OVERVIEW

This User's Guide accompanies and explains the Industrial Processes module of the SIT. The SIT was developed in conjunction with EPA's Emissions Inventory Improvement Program (EIIP). Prior to the development of the SIT, EPA developed the States Workbook for estimating greenhouse gas emissions. In 1998, EPA revisited the States Workbook and

expanded it to follow the format of EIIP guidance documents for criteria air pollutants. The result was a comprehensive, stepwise approach to estimating greenhouse gas emissions at the state level. This detailed methodology was appreciated by states with the capacity to devote considerable time and resources to the development of emission inventories. For other states, the EIIP guidance was overwhelming and impractical for them to follow from scratch. EPA recognized the resource constraints facing the states and developed the SIT. The ten modules of the SIT corresponded to the EIIP chapters and attempted to automate the steps states would need to take in developing their own emission estimates in a manner that was consistent with prevailing national and state guidelines.

Since most state inventories developed today rely heavily on the tools, User's Guides have been developed for each of the SIT modules. These User's Guides contain the most up-to-date methodologies that are, for the most part, consistent with the Inventory of U.S. Greenhouse Gas Emissions and Sinks. Volume VIII of the EIIP guidance is a historical document that was last updated in August 2004, and while these documents can be a valuable reference, they contain outdated emissions factors and in some cases outdated methodologies. States can refer to Volume VIII of the EIIP guidance documents if they are interested in obtaining additional information not found in the SIT or the companion User's Guide.

The IP module calculates carbon dioxide (CO₂), nitrous oxide (N₂O), hydrofluorocarbon (HFC), perfluorocarbon (PFC), and sulfur hexafluoride (SF₆) emissions from the IP sectors shown in Table 1. While the module provides default data for each sector (depending on availability), if you have access to a more comprehensive data source, it should be used in place of the default data. If using outside data sources, or for a more thorough understanding of the tool, please refer to the following discussion for data requirements and methodology.

1.2.1 Data Requirements

To calculate CO₂, N₂O, and HFC, PFC, and SF₆ emissions from IP, general activity data on various IP sectors are required. A complete list of the activity data and emission factors necessary to run the IP module is provided in Table 1.

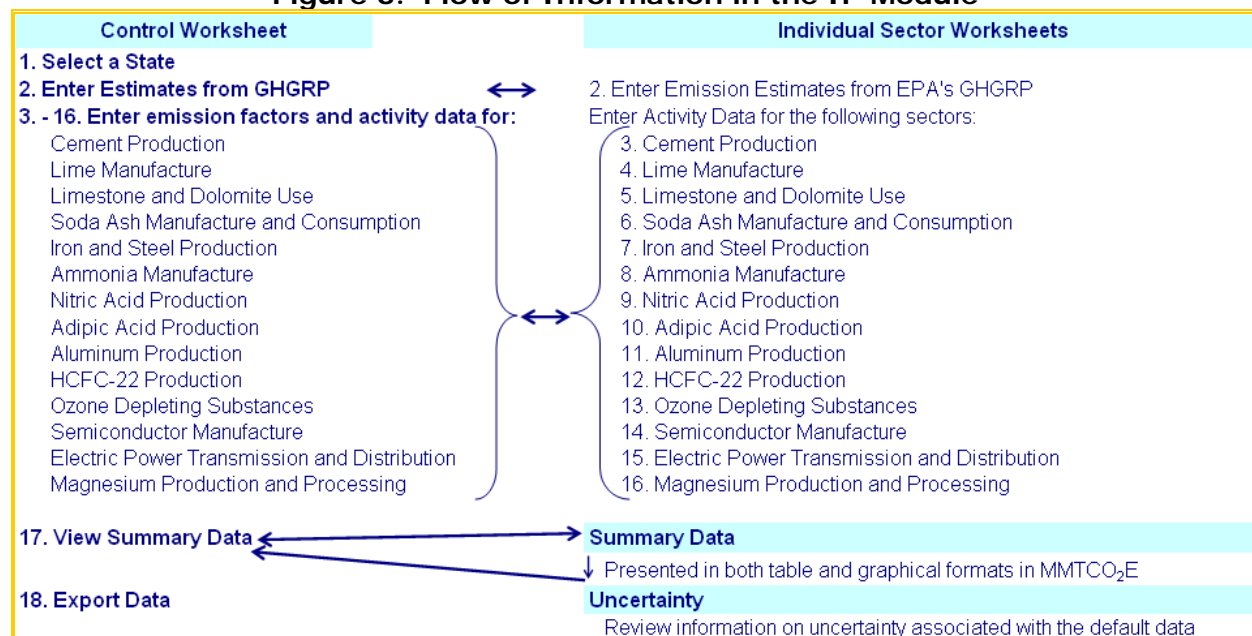
Table 1. IP Sectors, Data Requirements, and Gases Emitted

Module Worksheet	Data Required	Gas(es)
Cement Production	Emission factors and production data for clinker and cement kiln dust (CKD)	CO ₂
Lime Manufacture	Emission factors and production data for high-calcium lime, and dolomitic lime	
Limestone and Dolomite Use	Emission factors and consumption data for limestone, dolomite, and magnesium produced from dolomite	
Soda Ash Manufacture and Consumption	Emission factors and consumption data for manufacture and consumption of soda ash	
Iron and Steel Production	Emission factors and production data for Basic Oxygen Furnace (BOF) at Integrated Mill with Coke Ovens, Basic Oxygen Furnace (BOF) at Integrated Mill without Coke Ovens, Electric Arc Furnace (EAF), and Open Hearth Furnace (OHF)	
Ammonia Manufacture	Emission factors and production and consumption data for ammonia production, and urea consumption	
Nitric Acid Production	Emission factor, production data, and Percent N ₂ O Released after Pollution Control for nitric acid production	N ₂ O
Adipic Acid Production	Emission factor, production data, and Percent N ₂ O Released after Pollution Control for adipic acid production	
Aluminum Production	Emission factor and production data for aluminum production	HFC, PFC and SF ₆
HCFC-22 Production	Emission factor and production data for HCFC-22 production	
Consumption of Substitutes for Ozone-Depleting Substances (ODS)	No input data required*	
Semiconductor Manufacture	No input data required*	
Electric Power Transmission and Distribution	Emission factor and SF ₆ consumption data for electric power transmission and distribution	
Magnesium Production and Processing	Emission factor and consumption data for primary production, secondary production, and casting	

*According to the most recent inventory guidance, emissions of HFCs, PFCs, and SF₆ from ODS substitutes and semiconductor production can be estimated by apportioning national emissions to each state based on population. Because this tool apportions national emissions based on state population, the emission factors and activity data for these sources are not required.

1.2.2 Tool Layout

Since there are multiple steps to complete within the IP module, it is important to have an understanding of the module's overall design. The layout of the IP module is presented in Figure 3.

Figure 3. Flow of Information in the IP Module*

* According to the most recent inventory guidance, emissions of HFCs, PFCs, and SF₆ from ODS substitutes and semiconductor production can be estimated by apportioning national emissions to each state based on population. Because this tool apportions national emissions based on state population, no emission factors need to be entered for these sources.

1.3 METHODOLOGY

This section provides a guide to using the IP module of the SIT to estimate CO₂, N₂O, and HFC, PFC, and SF₆ emissions from IP. The sectors included in the IP module are cement production, lime manufacture, limestone and dolomite use, soda ash manufacture and consumption, iron and steel production, ammonia manufacture, nitric and adipic acid production, aluminum production, HCFC-22 production, consumption of substitutes for ozone depleting substances, semiconductor manufacture, electric power transmission and distribution, and magnesium production and processing. Since the methodology varies by sector, they are discussed separately and specific examples for each sector are provided.

The IP module follows the general methodology outlined in Chapter 6 of the Emissions Inventory Improvement Program (EIIP) guidance, however because of the automation of the calculations within the tool, the order of steps discussed in this guide do not always follow the order of steps discussed within the EIIP guidance document.

This User's Guide provides an overview of the estimation methodology used in the IP module by walking through the following steps: (1) select a state; (2) enter available data aggregated for EPA's Greenhouse Gas Reporting Rule; (3) enter emission factors and activity data for cement production; (4) enter emission factors and activity data for lime manufacture; (5) enter emission factors and activity data for limestone and dolomite use; (6) enter emission factors and activity data for soda ash manufacture and consumption; (7) enter emission factors and activity data for iron and steel production; (8) enter emission factors and activity data for ammonia manufacture; (9) enter emission factors and activity data for nitric acid production; (10) enter emission factors and activity data for adipic acid production; (11) enter emission factors and activity data for aluminum production; (12) enter emission factors and activity data for HCFC-22 production; (13) review sector

worksheet for consumption of substitutes for ozone depleting substances; (14) review sector worksheet for semiconductor manufacture; (15) enter emission factors and activity data for electric power transmission and distribution; (16) complete control and sector worksheets for magnesium production and processing; (17) review summary information; and (18) export data. The general equations used to calculate CO₂, N₂O, and HFC, PFC, and SF₆ emissions from IP are shown in the discussion of each specific sector.

Step (1) Select a State

To begin, select the state you are interested in evaluating. By selecting a state, the rest of the tool will automatically reset to reflect the appropriate state default data and assumptions for use in subsequent steps of the tool.

Step (2) Enter Emission Estimates for Facilities Reporting to EPA's Greenhouse Gas Reporting Rule

Beginning in 2010, many facilities were required to monitor, calculate and report their greenhouse gas emissions to EPA through its Greenhouse Gas Reporting Program (GHGRP). Under the program, EPA obtained data for 2010 emissions from facilities based on use of higher tier methods. For some of the source categories, all of the facilities that have that particular source category within their boundaries will be subject to the rule. For these facilities, EPA's analysis indicated that all or nearly all facilities within that source category emit more than 25,000 mtCO₂e per year, and that an "all in" would simplify their applicability determination. The sources included in the IP module that have been determined "all in" under the rule are listed on the Greenhouse Gas Reporting Rule worksheet. If available, the data entered in the yellow cells of this worksheet should represent the total state emissions for the source categories beginning in 2010 (e.g., the reported facility data should be summed).

To obtain GHGRP data for your state:

- 1) Go to <http://ghgdata.epa.gov/ghgp/main.do>
- 2) Select your state
- 3) At the bottom of the webpage (under the map), only check chemicals, metals, and minerals sectors.
- 4) Within each of these categories, hover over the gear to the right for each, and only check the industries that apply below.
- 5) Select "APPLY"
- 6) View applicable facilities and emissions for your state, and record the estimates in the yellow cells on the Greenhouse Gas Reporting Rule data input worksheet.

Step (3) Enter Emission Factors and Activity Data for Cement Production Control Worksheet

The second step for the control worksheet is to either select the default data provided or to enter user-specified data that will be used throughout the tool. To proceed with the default data, select the "Clear/Select All" button for each sector on the control worksheet or check the individual default box directly to the right of specific yellow input cells. See Figure 4 for locations of the "Clear/Select All" buttons, individual default check boxes, and yellow input cells. Note that this number can be overwritten if you later discover that the data for your

state differ from the default data provided by the tool. To enter user-specified inputs, enter data directly into the yellow input cells. If the user-specific inputs do not match the default data in the control worksheet (i.e., the default value is overwritten), the text will appear red. Information requirements on the control worksheet for each sector are discussed separately below.

Figure 4. Control Worksheet for the IP Module

Process	Default Factor	Metric Tons CO ₂ Released / Metric Ton of Product Produced	Factor Used	Use the Default? (Check for Yes)	Navigation
3. Cement Production					
Clinker	0.597	Metric Tons CO ₂ Released / Metric Ton of Clinker Produced		<input type="checkbox"/>	Go to the Cement Sheet
Cement Kiln Dust (CKD)	0.020	Metric Tons CKD CO ₂ Released / Metric Ton of Clinker CO ₂ Released		<input type="checkbox"/>	
4. Lime Manufacture					
High-Calcium Lime	0.75	Metric Tons CO ₂ Released / Metric Ton of High-Calcium Lime Produced		<input type="checkbox"/>	Go to the Lime Sheet
Dolomitic Lime	0.67	Metric Tons CO ₂ Released / Metric Ton of Dolomitic Lime Produced		<input type="checkbox"/>	
5. Limestone and Dolomite Use					
Limestone	0.440	Metric Tons CO ₂ Released / Metric Ton of Limestone Produced		<input type="checkbox"/>	Go to the Limestone Sheet
Dolomite	0.484	Metric Tons CO ₂ Released / Metric Ton of Dolomite Produced		<input type="checkbox"/>	
Magnesium Produced from Dolomite	1.797	Metric Tons CO ₂ Released / Metric Ton of Magnesium Produced		<input type="checkbox"/>	
6. Soda Ash Manufacture and Consumption					
Manufacture	0.087	Metric Tons CO ₂ Released / Metric Ton of Soda Ash Produced		<input type="checkbox"/>	Go to the Soda Ash Sheet
Consumption	0.415	Metric Tons CO ₂ Released / Metric Ton of Soda Ash Consumed		<input type="checkbox"/>	
7. Iron and Steel Production					
Basic Oxygen Furnace (BOF) at Integrated Mill with Coke Ovens	1.720	Metric Tons CO ₂ Released / Metric Ton of Crude Steel Produced		<input type="checkbox"/>	Go to the Iron & Steel Sheet
Basic Oxygen Furnace (BOF) at Integrated Mill without Coke Ovens	1.460	Metric Tons CO ₂ Released / Metric Ton of Crude Steel Produced		<input type="checkbox"/>	
Electric Arc Furnace (EAF)	0.080	Metric Tons CO ₂ Released / Metric Ton of Crude Steel Produced		<input type="checkbox"/>	
CIP	1.720	Metric Tons CO ₂ Released / Metric Ton of Crude Steel Produced		<input type="checkbox"/>	
8. Ammonia Manufacture					
Ammonia Production	1.2	Metric Tons CO ₂ Released / Metric Ton of Ammonia Produced		<input type="checkbox"/>	Go to the Ammonia & Urea Sheet
Urea Production	0.73	Metric Tons CO ₂ Released / Metric Ton of Urea Produced		<input type="checkbox"/>	
9. Nitric Acid Production					
Nitric Acid Production	0.000	Metric Tons H ₂ O Released / Metric Ton of Nitric Acid Produced		<input type="checkbox"/>	Go to the Nitric Acid Sheet
10. Adipic Acid Production					
Adipic Acid Production	0.3	Metric Tons H ₂ O Released / Metric Ton of Adipic Acid Produced		<input type="checkbox"/>	Go to the Adipic Acid Sheet
11. Aluminum Production					
Aluminum Production	Variable by year	Metric Tons C Equivalent Released / Metric Ton of Aluminum Produced		<input type="checkbox"/>	Go to the Aluminum Sheet
12. HFC-22 Production					
HFC-22 Production	0.02	Metric Tons HFC-22 Released / Metric Ton of HFC-22 Produced		<input type="checkbox"/>	Go to the HFC-22 Sheet
13. Consumption of Substitutes for Ozone-Depleting Substances (ODS)					
Consumption of Substitutes for ODS				<input type="checkbox"/>	Go to the ODS Sub Sheet

The first type of required data in the control worksheet is emission factors for clinker, and cement kiln dust used in cement production. CO₂ emissions from cement production consist of emissions produced during the cement clinker production processes, and are in units of metric tons of CO₂ released per metric ton of clinker or cement kiln dust produced. Emissions from the production of masonry cement are accounted for in Lime emissions estimates.

Cement Production Sector Worksheet

The activity data required to populate the blue cells in the cement production worksheet are metric tons of clinker produced annually, as shown in Figure 5. Select "Check All Boxes" if you would like to use default data provided in the IP module. Activity data for cement production by state is available from USGS 2013e. CO₂ is created when calcium carbonate (CaCO₃) is heated in a cement kiln to form lime (calcium oxide or CaO) and CO₂. This process is known as calcination or calcining.

Cement clinker emissions are calculated by multiplying the clinker production quantity by the emission factor entered on the control worksheet, and adding the product to the emissions from cement kiln dust (a by-product of cement clinker production). The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). Equation 1 shows this calculation for CO₂ emissions from cement production.

Equation 1. Emission Equation for Cement Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Production (metric tons)} \times \text{Emission Factor (t CO}_2\text{/t production)} + \text{Emissions from Cement Kiln Dust (Metric tons CO}_2\text{)}$$

Figure 5. Example of Activity Data Applied in the Cement Production Worksheet

State Inventory Tool - Industrial Processes Module

2. Cement Production in Colorado

Click here to find where these data are available.

Select All Defaults

Return to Control Sheet

Check All Boxes

Clear All Data

	Production (Metric Tons)	Emission Factor (t CO ₂ /t production)	Emissions (Metric Tons CO ₂)	Emissions from Cement Kiln Dust (Metric Tons CO ₂)	Emissions (MTCE)	Emissions (MTCO ₂ E)
1990	613,888	0.0000	-	-	-	-
1991	647,570	0.0000	-	-	-	-
1992	694,457	0.0000	-	-	-	-
1993	694,457	0.0000	-	-	-	-
1994	643,000	0.0000	-	-	-	-
1995	630,000	0.0000	-	-	-	-
1996	630,000	0.0000	-	-	-	-
1997	982,000	0.0000	-	-	-	-
1998	979,000	0.0000	-	-	-	-
1999	988,000	0.0000	-	-	-	-
2000	1,070,888	0.0000	-	-	-	-
2001	896,500	0.0000	-	-	-	-
2002	958,000	0.0000	-	-	-	-
2003	1,075,000	0.0000	-	-	-	-
2004	1,242,897	0.0000	-	-	-	-
2005	1,204,500	0.0000	-	-	-	-

Default Production Data?

Step (4) Enter Emission Factors and Activity Data for Lime Manufacture

Control Worksheet

The emission factors for high-calcium lime and dolomitic lime manufacture are the next required inputs on the control worksheet. Lime is manufactured by heating limestone (mostly CaCO₃) in a kiln, creating CaO and CO₂. The IP module estimates these CO₂ emissions from two types of lime: high-calcium lime and dolomitic lime production.

Lime Manufacture Sector Worksheet

Production data for high-calcium dolomite and dolomitic lime, and the amount of these used in sugar refining and precipitated calcium carbonate are required inputs in the blue cells of the lime manufacture worksheet as shown in Figure 6. Activity data for lime manufacture by state is available from USGS 2015a.

Before entering the production of high-calcium and dolomitic lime, you must correct for the water content of hydrated lime. The water content can be assumed to be 24.3 percent for high-calcium hydrated lime and 27.3 percent for dolomitic lime. To correct for the water content of hydrated lime, multiply the production data for high-calcium hydrated lime and dolomitic hydrated lime by their respective percentages of *dry* lime to find the corrected

production numbers for both varieties of hydrated lime. An example of this correction for high-calcium lime is shown in Equation 2.

Equation 2. Example Calculation for Hydrated Lime Correction

$$\text{Corrected Lime Content of High-Calcium Hydrated Lime (metric tons)} = \text{High-Calcium Hydrated Lime Production (metric tons)} \times (1 - 0.24 \text{ metric tons water/metric ton high-calcium hydrated lime})$$

To calculate emissions from this source, the production quantity of each lime type is multiplied by its respective emission factor from the control worksheet. Because lime used in sugar refining and precipitated calcium carbonate production results in the reabsorption of atmospheric CO₂, carbon absorbed from these uses is subtracted from gross emissions. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). Equation 3 shows this calculation for CO₂ emissions from cement production.

Equation 3. Emission Equation for Lime Manufacture

$$\text{Emissions (MTCO}_2\text{E)} = [\text{Production (metric tons)} - \text{Sugar Refining and Precipitated Calcium Carbonate Production (metric tons)} \times \text{CO}_2 \text{ Reabsorption Factor (80\%)}] \times \text{Emission Factor (MT CO}_2\text{/MT production)}$$

Figure 6. Example of Activity Data Applied in the Lime Manufacture Worksheet

Click here to find where these data are available.

Emissions from lime manufacture consist of emissions from high-calcium and dolomitic lime production. The production quantity of each lime type is multiplied by its respective emission factor. Because lime used in sugar refining and precipitated calcium carbonate production results in the reabsorption of atmospheric CO₂, carbon absorbed from these uses is subtracted from gross emissions. The emissions are then converted to metric tons of carbon equivalents (MTCE) and from metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet
Check All Boxes
Clear All Data

		Production (Metric Tons)	Use in Sugar Refining and Precipitated Calcium Carbonate Production (Metric Tons)	CO ₂ Reabsorption Factor	Emission Factor (t CO ₂ /t production)	Emissions (MTCE)	Emissions (MTCO ₂ E)	
1991	High-Calcium Lime	69,299		80%	0.7500	14,175	51,974	Default Production Data
	Dolomitic Lime	15,372		80%	0.8700	3,647	13,374	
1992	High-Calcium Lime	99,106		80%	0.7500	20,272	74,329	Default Production Data
	Dolomitic Lime	21,853		80%	0.8700	5,185	19,012	
1993	High-Calcium Lime	280,964		80%	0.7500	57,470	210,723	Default Production Data
	Dolomitic Lime	62,036		80%	0.8700	14,720	53,972	
1994	High-Calcium Lime	264,999		80%	0.7500	54,204	198,749	Default Production Data
	Dolomitic Lime	58,001		80%	0.8700	13,762	50,461	
1995	High-Calcium Lime	106,719		80%	0.7500	21,829	80,039	Default Production Data
	Dolomitic Lime	23,281		80%	0.8700	5,524	20,254	
1996	High-Calcium Lime	95,313		80%	0.7500	19,496	71,485	Default Production Data
	Dolomitic Lime	20,687		80%	0.8700	4,908	17,997	
1997	High-Calcium Lime	92,588		80%	0.7500	18,939	69,441	Default Production Data
	Dolomitic Lime	20,412		80%	0.8700	4,843	17,758	
1998	High-Calcium Lime	95,522		80%	0.7500	19,539	71,642	Default Production Data
	Dolomitic Lime	19,478		80%	0.8700	4,622	16,946	
1999	High-Calcium Lime	90,602		80%	0.7500	18,532	67,952	Default Production Data

Required Data Input Cells

Step (5) Enter Emission Factors and Activity Data for Limestone and Dolomite Use Control Worksheet

The next inputs on the control worksheet are emission factors for limestone and dolomite use, and magnesium produced from dolomite. Limestone (CaCO₃) and dolomite (CaMg(CO₃)₂) 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 (Mg) production.

Limestone and Dolomite Use Sector Worksheet

Production data for limestone and dolomite use, and magnesium production from dolomite are required as inputs in the blue cells of the limestone and dolomite worksheet as displayed in Figure 7. As an example, CO₂ is emitted as a by-product from the reaction of limestone or dolomite with impurities in the iron ore and fuels heated in a blast furnace. Activity data for limestone and dolomite use by state is available from USGS 2015b.

The quantities of limestone consumed for industrial purposes, dolomite consumed for industrial purposes, and magnesium produced from dolomite are multiplied by their respective emission factors. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). For default data, each state's total limestone consumption (as reported by USGS) is multiplied by the ratio of national limestone consumption for industrial uses to total National limestone consumption. Equation 4 shows this calculation for CO₂ emissions from limestone and dolomite use.

Equation 4. Emission Equation for Limestone and Dolomite Use

$$\text{Emissions (MTCO}_2\text{E)} = \text{Consumption (metric tons)} \times \text{Emission Factor (MT CO}_2\text{/MT production)}$$

Figure 7. Example of Activity Data Applied in the Limestone and Dolomite Use Worksheet

Click here to find where these data are available.

Emissions from limestone and dolomite use result from industrial consumption. The quantities of limestone consumed for industrial purposes, dolomite consumed for industrial purposes, and magnesium produced from dolomite are multiplied by their respective emission factors. Industrial uses include the consumption of limestone and dolomite for flux stone production, glass manufacturing, flue gas desulfurization (FGD), Mg production through the thermic reduction of dolomite, chemical stone manufacturing, mine dusting or acid water treatment, acid neutralization, and sugar refining. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). For default data, each state's total limestone consumption (as reported by USGS) is multiplied by the ratio of national limestone consumption for industrial uses to total national limestone consumption. Additional information on these calculations, including a definition of industrial uses, is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet
Check All Boxes
Clear All Data

	Consumption (Metric Tons)	Emission Factor (t CO ₂ /t production)	Emissions (MTCE)	Emissions (MTCO ₂ E)	
1990 Limestone	-	0.4400	-	-	<input checked="" type="checkbox"/> Default Production Data?
1990 Dolomite	-	0.4840	-	-	<input checked="" type="checkbox"/> Default Production Data?
1990 Magnesium Production from Dolomite	-	1.7967	-	-	
1991 Limestone	-	0.4400	-	-	<input checked="" type="checkbox"/> Default Production Data?
1991 Dolomite	-	0.4840	-	-	<input checked="" type="checkbox"/> Default Production Data?
1991 Magnesium Production from Dolomite	-	1.7967	-	-	<input checked="" type="checkbox"/> Default Production Data?
1992 Limestone	-	0.4400	-	-	<input checked="" type="checkbox"/> Default Production Data?
1992 Dolomite	-	0.4840	-	-	<input checked="" type="checkbox"/> Default Production Data?
1992 Magnesium Production from Dolomite	-	1.7967	-	-	<input checked="" type="checkbox"/> Default Production Data?

Required Data Input Cells

Step (6) Enter Emission Factors and Activity Data for Soda Ash Manufacture and Consumption

Control Worksheet

Soda ash manufacture and consumption emission factors are required inputs on the control worksheet in order to calculate emissions from this source. Although only three states produced soda ash at the time of publication (Wyoming, California, and Colorado), all states consumed it. Thus, all states should estimate CO₂ emissions from soda ash consumption.

Soda Ash Manufacture and Consumption Sector Worksheet

Production data for the manufacture and consumption of soda ash are required as inputs in the blue cells of the soda ash manufacture worksheet as shown in Figure 8. Under the soda ash production method used in some states, trona (an ore from which natural soda ash is made) is calcined in a rotary kiln and chemically transformed into a crude soda ash that requires further processing. CO₂ and water are generated as a by-product of the calcination process. CO₂ is also released when soda ash is consumed in products such as glass, soap, and detergents. Activity data for soda ash manufacture and consumption by state is available from USGS 2015c.

Emissions from soda ash manufacture and consumption are calculated by multiplying the quantity of soda ash manufactured (Wyoming only) and the quantity of soda ash consumed by their respective emission factors. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E) as shown in Equation 5.

Equation 5. Emission Equation for Soda Ash Manufacture and Consumption

$$\text{Emissions (MTCO}_2\text{E)} = \text{Manufacture/Consumption (metric tons)} \times \text{Emission Factor (MT CO}_2\text{/MT production)}$$

Figure 8. Example of Activity Data Applied in the Soda Ash Manufacture and Consumption Worksheet

Click here to find where these data are available.

Emissions from soda ash manufacture and consumption are calculated by multiplying the quantity of soda ash manufactured (Wyoming only) and the quantity of soda ash consumed by their respective emission factors. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet
Check All Boxes
Clear All Data

		Manufacture and Consumption (Metric Tons)	Emission Factor (t CO ₂ /t production)	Emissions (MTCE)	Emissions (MTCO ₂ E)	
1990	Manufacture	-	0.0974	-	-	<input checked="" type="checkbox"/> Default Production Data?
	Consumption	86,482	0.4150	9,788	35,890	<input checked="" type="checkbox"/> Default Consumption Data?
1991	Manufacture	-	0.0974	-	-	<input checked="" type="checkbox"/> Default Production Data?
	Consumption	83,871	0.4150	9,492	34,666	<input checked="" type="checkbox"/> Default Consumption Data?
1992	Manufacture	-	0.0974	-	-	<input checked="" type="checkbox"/> Default Production Data?
	Consumption	85,744	0.4150	9,492	34,666	<input checked="" type="checkbox"/> Default Consumption Data?
1993	Manufacture	-	0.0974	-	-	<input checked="" type="checkbox"/> Default Production Data?
	Consumption	86,482	0.4150	9,788	36,001	<input checked="" type="checkbox"/> Default Consumption Data?

Required Data Input Cells

Step (7) Enter Emission Factors and Activity Data for Iron and Steel Production

Control Worksheet

Emission factors for the following iron and steel production processes are required as inputs on the control worksheet: Basic Oxygen Furnace (BOF) at Integrated Mill with Coke Ovens, Basic Oxygen Furnace (BOF) at Integrated Mill without Coke Ovens, Electric Arc Furnace (EAF), and open hearth furnace (OHF). In addition to being an energy intensive process, the production of iron and steel also generates process-related emissions of CO₂. It is strongly advised that users enter state-specific information, as default data are based on national averages and are not available for all years.

Iron and Steel Production Sector Worksheet

Activity data for the production of iron and steel are required as inputs in the blue cells of the iron and steel worksheet displayed in Figure 9. The basic activity data needed are the quantities of crude steel produced (defined as first cast product suitable for sale or further processing) by production method. It is strongly advised that users enter state-specific information, as default data are based on national averages, are not available for all years, and are likely to be inaccurate for states. The national data are provided by the American Iron and Steel (AISI) Annual Statistics Report 2009 (AISI 2011).

Emissions from iron and steel production are based on the state-level production data assigned to production method based on the national distribution of production by method. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E) as shown in Equation 6.

Equation 6. Emission Equation for Iron and Steel Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Manufacture/Consumption (metric tons)} \times \text{Emission Factor (MT CO}_2\text{/MT production)}$$

Figure 9. Example of Activity Data Applied in the Iron and Steel Production Worksheet

Click here to find where these data are available.

Iron and steel production generate process-related emissions. The basic activity data needed are the quantities of crude steel produced (defined as first cast product suitable for sale or further processing) by production method. Default values are based on the state-level production data assigned to production method based on the national distribution of production by method. **It is strongly advised that users enter state-specific information, as default data are based on national averages, are not available for all years, and are likely to be inaccurate for states.** Activity data are then multiplied by the appropriate emission factor. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). This methodology is based on the Draft 2006 IPCC Guidelines for National GHG Inventories.

Return to Control Sheet
Check All Boxes
Clear All Data

	Production Method	State Production (Metric Tons)	Emission Factor (t CO ₂ /t production)	Emissions (MTCE)	Emissions (MTCO ₂ E)	
1997	BOF with coke ovens	245,436	1.72	115,132	422,150	<input checked="" type="checkbox"/> Default Production Data?
	BOF without coke ovens	245,436	1.46	97,728	358,337	
	EAF	381,369	0.08	8,334	30,558	
	OHF	-	1.72	-	-	
	Total					
1998	BOF with coke ovens	225,576	1.72	105,816	387,391	<input checked="" type="checkbox"/> Default Production Data?
	BOF without coke ovens	225,576	1.46	89,820	329,342	
	EAF	37,506	0.08	8,092	29,671	
	OHF	-	1.72	-	-	
	Total			203,728	747,004	

Required Data Input Cells

Step (8) Enter Emission Factors and Activity Data for Ammonia Manufacture**Control Worksheet**

The emission factors for ammonia and urea production are the next required inputs on the control worksheet. Emissions of CO₂ occur during the production of synthetic ammonia, primarily through the use of natural gas as a feedstock.

Ammonia Manufacture Sector Worksheet

Data for the production of ammonia and consumption of urea are required inputs in the blue cells on the ammonia production worksheet, shown in Figure 10. Activity data for ammonia manufacture by state is available from USGS 2015f. Activity data for urea consumption by state is estimated based on state data from AAPFCO (2014) and TVA (1991 through 1994).

Emissions from ammonia production and urea consumption are calculated by multiplying the quantity of ammonia produced and urea applied by their respective emission factors.

Emissions from urea consumption are subtracted from emissions due to ammonia production. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E) as shown in Equation 7 and Equation 8.

Equation 7. Emission Equation for Ammonia Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Production of Ammonia (metric tons)} \times \text{Emission Factor (MT CO}_2\text{/MT activity)} - \text{Emissions from Urea (MTCO}_2\text{E)}$$

Equation 8. Emission Equation for Urea Consumption

$$\text{Emissions (MTCO}_2\text{E)} = \text{Consumption of Urea (metric tons)} \times \text{Emission Factor (MT CO}_2\text{/MT activity)}$$

Figure 10. Example of Activity Data Applied in the Ammonia Production and Urea Consumption Worksheet

State Inventory Tool - Industrial Processes Module

File Edit Module Options

7. Ammonia Production and Urea Consumption in Colorado

Click here to find where these data are available.

Emissions from ammonia production and urea application are calculated by multiplying the quantity of ammonia produced and urea applied by their respective emission factors. Emissions from urea application are subtracted from emissions due to ammonia production. The emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Check All Boxes

Clear All Data

		Production & Consumption (Metric Tons)	Emission Factor (mt CO ₂ /mt activity)	Subtract emissions from Urea	Emissions (MTCE)	Emissions (MTCO ₂ E)	
7	1990	Ammonia Production	-	12	3,071	-	Default Production Data?
8		Urea Consumption	4,206	0.73	-	837	
10	1991	Ammonia Production	-	12	2,683	-	Default Production Data?
11		Urea Consumption	3,676	0.73	-	732	
13	1992	Ammonia Production	-	12	3,163	-	Default Production Data?
14		Urea Consumption	3,525	0.73	-	702	
16	1993	Ammonia Production	-	12	3,163	-	Default Production Data?
17		Urea Consumption	4,371	0.73	-	863	
19	1994	Ammonia Production	-	12	2,871	-	Default Production Data?
20		Urea Consumption	3,933	0.73	-	783	

Required Data Input Cells

Step (9) Enter Emission Factors and Activity Data for Nitric Acid Production**Control Worksheet**

The emission factor for nitric acid production is the next required input for the control worksheet. The production of nitric acid (HNO₃) produces N₂O as a by-product, via the oxidation of ammonia. Nitric acid is a raw material used primarily to make synthetic commercial fertilizer and is also a major component in the production of adipic acid (a feedstock for nylon) and explosives.

Nitric Acid Production

Data for the amount of nitric acid produced, as well as the percent N₂O released after pollution control are inputs for the nitric acid worksheet as seen in Figure 11. Activity data for nitric acid production is available from SRI 2000. The production of nitric acid (HNO₃) produces N₂O as a by-product, via the oxidation of ammonia. During this reaction, N₂O is formed as a by-product and is released from reactor vents into the atmosphere. At present, the nitric industry controls for oxides of nitrogen through two technologies: non-selective catalytic reduction (NSCR) and selective catalytic reduction (SCR). Only one of these technologies, NSCR, is effective at destroying N₂O emissions in the process of destroying NO_x emissions.

Emissions from nitric acid production are calculated by multiplying the quantity of nitric acid produced by an emission factor and by the percentage of N₂O released after pollution controls are taken into account. These emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E) as seen in Equation 9.

Equation 9. Emission Equation for Nitric Acid Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Production of Nitric Acid (metric tons)} \times \text{Emission Factor (MT N}_2\text{O/MT production)} \times \text{Percent N}_2\text{O Released after Pollution Control} \times \text{GWP N}_2\text{O}$$

Figure 11. Example of Activity Data Applied in the Nitric Acid Production Worksheet

	Production (Metric Tons)	Emission Factor (t N ₂ O/t production)	Percent N ₂ O Released after Pollution Control	Emissions (Metric Tons N ₂ O)	Emissions (MTCE)	Emissions (MTCO ₂ E)
1990		0.0080	100%	-	-	-
1991		0.0080	100%	-	-	-
1992		0.0080	100%	-	-	-
1993				-	-	-
1994				-	-	-
1995		0.0080	100%	-	-	-
1996		0.0080	100%	-	-	-

Step (10) Enter Emission Factors and Activity Data for Adipic Acid Production

Control Worksheet

The emission factor for adipic acid production is required next on the control worksheet. About 90 percent of all adipic acid produced in the United States is used in the production of nylon 6,6, as well as production of some low-temperature lubricants. It is also used to provide foods with a "tangy" flavor.

Adipic Acid Production Sector Worksheet

Data for the amount of adipic acid produced, as well as the percent N₂O released after pollution control are inputs for the adipic acid worksheet as seen in Figure 12. A dialogue box will appear if adipic acid is not produced in your state. Note that plants may consider this data confidential and could be reluctant to disclose it, in which case, states should use the adipic acid production capacity data in the Chemical Market Reporter.

Adipic acid is produced through a two-stage process. The first stage involves the oxidation of cyclohexane to form a cyclohexanone/cyclohexanol mixture. The second stage involves the oxidation of ketone-alcohol with nitric acid. N₂O is generated as a by-product of this reaction and enters the waste gas stream. In the United States, this waste gas is treated to remove NO_x and other regulated pollutants (and, in some cases, N₂O as well) and is then released into the atmosphere.

Emissions from adipic acid production are calculated by multiplying the quantity adipic acid produced by an emission factor and by the percentage of N₂O released after pollution controls are taken into account. These emissions are then converted from metric tons of N₂O to metric tons of carbon equivalents (MTCE) and then metric tons of carbon dioxide equivalents (MTCO₂E), shown in Equation 10.

Equation 10. Emission Equation for Adipic Acid Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Production of Adipic Acid (metric tons)} \times \text{Emission Factor (MT N}_2\text{O/MT production)} \times \text{Percent N}_2\text{O Released after Pollution Control} \times \text{GWP N}_2\text{O}$$

Figure 12. Example of Activity Data Applied in the Adipic Acid Production Worksheet

State Inventory Tool - Industrial Processes Module

File Edit Module Options Type

9. Adipic Acid Production in Colorado

Click here to find where these data are available.

Emissions from adipic acid production are calculated by multiplying the quantity adipic acid produced by an emission factor and by the percentage of N₂O released after pollution controls are taken into account. These emissions are then converted from metric tons of N₂O to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Clear All Data

Use Default Pollution Control Factor (100%, no pollution control)

	Production (Metric Tons)	Emission Factor (t N ₂ O/t production)	Percent N ₂ O Released after Pollution Control	Emissions (Metric Tons N ₂ O)	Emissions (MTCE)	Emissions (MTCO ₂ E)
1990		0.3000	100%	-	-	-
1991		0.3000	100%	-	-	-
1992		0.3000	100%	-	-	-
1993		100%	100%	-	-	-
1994		100%	100%	-	-	-
1995		0.3000	100%	-	-	-

Required Data Input Cells

Step (11) Enter Emission Factors and Activity Data for Aluminum Production

Control Worksheet

The emission factor for aluminum production is the next input on the control worksheet. The aluminum production industry is thought to be the largest source of two PFCs – tetrafluoromethane (CF₄) and hexafluoroethane (C₂F₆). Emissions of these two potent greenhouse gases (GHGs) occur during the reduction of alumina in the primary smelting process.¹

¹ Perfluorinated carbons are not emitted during the smelting of recycled aluminum.

Aluminum Production Sector Worksheet

Data for the production of aluminum are required in the blue cells of the aluminum worksheet, shown in Figure 13. Activity data for aluminum production is available from USGS 2015d.

The aluminum production industry is thought to be the largest source of two perfluorocarbons (PFCs) – tetrafluoromethane (CF₄) and hexafluoroethane (C₂F₆). Emissions of these two potent GHGs occur during the reduction of alumina in the primary smelting process.¹

Emissions from aluminum production are calculated by multiplying the quantity of aluminum produced during a year by the specific emission factor for that year. These emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents (MTCO₂E), shown in Equation 11.

Equation 11. Emission Equation for Aluminum Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Production of Aluminum (metric tons)} \times \text{Emission Factor (MT CE/MT production)}$$

Figure 13. Example of Activity Data Applied in the Aluminum Production Worksheet

Click here to find where these data are available.

Emissions from aluminum production are calculated by multiplying the quantity of aluminum produced during a year by the specific emission factor for that year. These emissions are then converted from metric tons of CO₂ equivalents to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Check All Boxes

Clear All Data

	Production (Metric Tons)	Emission Factor (t CE/t production)	Emissions (MTCE)	Emissions (MTCO ₂ E)	
1990	-	0.4255	-	-	<input checked="" type="checkbox"/> Default Production Data?
1991	-	0.4255	-	-	<input checked="" type="checkbox"/> Default Production Data?
1992	-	-	-	-	<input checked="" type="checkbox"/> Default Production Data?
1993	-	-	-	-	<input checked="" type="checkbox"/> Default Production Data?
1994	-	0.4255	-	-	<input checked="" type="checkbox"/> Default Production Data?
1995	-	0.4255	-	-	<input checked="" type="checkbox"/> Default Production Data?
1996	-	0.4255	-	-	<input checked="" type="checkbox"/> Default Production Data?

Required Data Input Cells

Step (12) Enter Emission Factors and Activity Data for HCFC-22 Production

Control Worksheet

The next emission factor required for the control worksheet is for HFC-23 emissions resulting from HCFC-22 production, in metric tons of HFC-23 emitted per metric ton of HCFC-22 produced.

HCFC-22 Production Sector Worksheet

HFC-23, one type of HFC, is known to be emitted in significant quantities as a by-product of HCFC-22 production. Data for the production of HCFC-22 are required inputs in the blue cells on the HCFC-22 production worksheet, shown in Figure 14. In order to obtain activity data, in-state manufacturers of HCFC-22 should be consulted first. Additionally the Chemical Manufacturers Association (Washington, D.C.), Alliance for Responsible CFC Policy (Arlington, VA), and Grant Thornton Consulting (Washington, D.C.) can be contacted for information on state-by-state production numbers.

Emissions from HCFC-22 production are calculated by multiplying the quantity of HCFC-22 produced by an emission factor. The emissions are then converted from metric tons of HFC-23 to metric tons of carbon equivalents (MTCE) and then metric tons of carbon dioxide equivalents (MTCO₂E) as in Equation 12.

Equation 12. Emission Equation for HCFC-22 Production

$$\text{Emissions (MTCO}_2\text{E)} = \text{Production of HCFC-22 (metric tons)} \times \text{Emission Factor (MT HFC-23/MT production)} \times \text{GWP of HFC-23}$$

Figure 14. Example of Activity Data Applied in the HCFC-22 Production Worksheet

State Inventory Tool - Industrial Processes Module

File Edit Module Options

11. HCFC-22 Production in Colorado

Click here to find where these data are available.

Emissions from HCFC-22 production are calculated by multiplying the quantity of HCFC-22 produced by an emission factor. The emissions are then converted from metric tons of HFC-23 to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Clear All Data

	Production (Metric Tons)	Emission Factor (t HFC-23/t production)	Emissions (Metric Tons HFC-23)	Emissions (MTCE)	Emissions (MTCO ₂ E)
1990		0.0200			
1991		0.0200			
1992		0.0200			
1993		0.0200			
1994		0.0200			
1995		0.0200			
1996		0.0200			
1997		0.0200			
1998		0.0200			

There is no default data associated with this sector. You will need to fill in all required production data in order to estimate emissions.

Required Data Input Cells

Step (13) Review Sector Worksheet for Consumption of Substitutes for Ozone-Depleting Substances (ODS)

Control Worksheet

There are no emission factor inputs required for the consumption of substitutes for ozone-depleting substances (ODS) as the calculations for this sector are performed on the sector-specific worksheet. Hydrofluorocarbons (HFCs) are used primarily as alternatives to several

classes of ODS that are being phased out under the terms of the Montreal Protocol and the Clean Air Act Amendments of 1990. ODSs, which include chlorofluorocarbons (CFCs), halons, carbon tetrachloride, methyl chloroform, and hydrochlorofluorocarbons (HCFCs), are used in a variety of industrial applications including refrigeration and air conditioning equipment, aerosols, solvent cleaning, fire extinguishing, foam blowing, and sterilization. Although their substitutes, HFCs, are not harmful to the stratospheric ozone layer, they are powerful GHGs.

Consumption of ODS Sector Worksheet

There are no inputs required for this worksheet. You should review this worksheet to learn your state's contribution to emissions resulting from the consumption of ODS substitutes. The major end uses that consume substitutes for ozone-depleting substances include motor vehicle air conditioning, commercial and industrial refrigeration and air conditioning, residential refrigeration and air conditioning, aerosols, solvent cleaning, fire extinguishing equipment, foam production, and sterilization.

Emissions of HFCs, PFCs, and SF₆ from ODS substitute production are estimated by apportioning national emissions to each state based on population. State population data was provided by U.S. Census Bureau (2016). The resulting state emissions are then converted to metric tons of carbon dioxide equivalents (MTCO₂E) as shown in Equation 13.

Equation 13. Emission Equation for Apportioning Emissions from the Consumption of Substitutes for ODS

$$\text{Emissions (MTCO}_2\text{E)} = \frac{[\text{National ODS Substitute Emissions (MTCO}_2\text{E)} \times \text{State Population}]}{\text{National Population}}$$

Step (14) Review Sector Worksheet for Semiconductor Manufacture

Control Worksheet

There are no emission factor inputs required for semiconductor manufacture on the control worksheet as the calculations for this sector are performed on the sector-specific worksheet. The semiconductor industry employs multiple long-lived fluorinated gases in the plasma etching and chemical vapor deposition processes. These include the PFCs CF₄, C₂F₆, and C₃F₈; HFC-23; and SF₆. With present industry growth and the increasing complexity of microchips, emissions from the semiconductor industry are expected to increase significantly.

Semiconductor Manufacture Sector Worksheet

There are no inputs required for this worksheet. You should review this worksheet to learn your state's contribution to emissions resulting from the manufacture of semiconductors. The semiconductor industry employs multiple long-lived fluorinated gases in the plasma etching and chemical vapor deposition processes and include PFCs CF₄, C₂F₆, and C₃F₈; HFC-23; and SF₆.

Emissions of HFCs, PFCs, and SF₆ from semiconductor production are estimated by apportioning national emissions to each state. National emissions are multiplied by a ratio of the value of a state's semiconductor shipments, as found in U.S. Census Bureau (2002),

to the value of national semiconductor shipments. The resulting state emissions are then converted into metric tons of CO₂ equivalents (MTCO₂E) as shown in Equation 14.

Equation 14. Emission Equation for Apportioning Emissions from Semiconductor Manufacture

$$\text{Emissions (MTCO}_2\text{E)} = \frac{[\text{National Semiconductor Manufacture Emissions (MTCO}_2\text{E)} \times \text{Value of State Semiconductor Shipments}]}{\text{Value of State Semiconductor Shipments}}$$

Step (15) Enter Emission Factors and Activity Data for Electric Power Transmission and Distribution

Control Worksheet

The emission factor for electric power transmission and distribution is required on the control worksheet. The largest use for SF₆, both domestically and internationally, is as an electrical insulator in electricity transmission and distribution equipment, such as gas-insulated high-voltage circuit breakers, substations, transformers, and transmission lines.

Electric Power Transmission and Distribution Sector Worksheet

This worksheet requires inputs for the amount of SF₆ consumed for electric power transmission and distribution as shown in Figure 15. Activity data for electric transmission and distribution are available from U.S. EPA (2016) and EIA (2016).

The largest use for SF₆, both domestically and internationally, is as an electrical insulator in electricity transmission and distribution equipment, such as gas-insulated high-voltage circuit breakers, substations, transformers, and transmission lines. The electric utility industry uses the gas because of its high dielectric strength and arc-quenching abilities. Not all of the electric utilities in the United States use SF₆; use of the gas is more common in urban areas where the space occupied by electrical distribution and transmission facilities is more valuable.

Emissions from electric power transmission and distribution are calculated by multiplying the quantity of SF₆ consumed by an emission factor. The resulting emissions are then converted from metric tons of SF₆ to metric tons of carbon dioxide equivalents (MTCO₂E) as shown in Equation 15. The default assumption is that the emission factor is 1, i.e. all SF₆ consumed is used to replace SF₆ that was emitted. Default activity data for this sector equals national SF₆ emissions apportioned by state electricity sales divided by national electricity sales.

Equation 15. Emission Equation for Electric Power Transmission and Distribution

$$\text{Emissions (MTCO}_2\text{E)} = \text{SF}_6 \text{ Consumption (metric tons SF}_6\text{)} \times \text{Emission Factor (MT SF}_6\text{/MT Consumption)} \times \text{GWP of SF}_6$$

Figure 15. Example of Activity Data Applied in the Electric Power Transmission and Distribution Worksheet

Click here to find where these data are available.

Emissions from electric power transmission and distribution are calculated by multiplying the quantity of SF₆ consumed by an emission factor. The resulting emissions are then converted from metric tons of SF₆ to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents (MTCO₂E). The default assumption is that the emission factor is 1, i.e. all SF₆ consumed is used to replace SF₆ that was emitted. Default activity data for this sector equals national SF₆ emissions apportioned by state electricity sales divided by national electricity sales. Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Check All Boxes

Clear All Data

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R														
1	14. Electric Power Transmission and Distribution in Colorado																														
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9	1992	12	10																												
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Step (16) Enter Emission Factors and Activity Data for Magnesium Production and Processing**Control Worksheet**

Primary and secondary production, as well as casting emission factors for magnesium production and processing are required in the control worksheet. The Mg metal production and casting industry uses SF₆ as a cover gas to prevent the violent oxidation of molten Mg in the presence of air.

Magnesium Production and Processing Sector Worksheet

In the blue input cells on the magnesium worksheet, enter the quantity of primary magnesium produced, secondary magnesium produced, and magnesium cast during a given year as shown in Figure 16. Activity data for the production and processing of magnesium by state are available at USGS (2015g).

The Mg metal production and casting industry uses SF₆ as a cover gas to prevent the violent oxidation of molten Mg in the presence of air. A gas mixture consisting of CO₂, air, and a small concentration of SF₆ is blown over the molten Mg metal to induce the formation of a protective crust. Most producers of primary Mg metal and most Mg part casters use this technique. SF₆ replaced the previously used sulfur dioxide due to the numerous health and safety risks associated with sulfur dioxide.

Emissions from magnesium production and processing are emitted during the production of primary magnesium, production of secondary magnesium, and casting of magnesium. The

emissions are calculated by multiplying the quantity of primary magnesium produced, secondary magnesium produced, and magnesium cast during a given year by their respective emission factors for the same year. The resulting emissions are then converted from metric tons of SF₆ to metric tons of carbon dioxide equivalents (MTCO₂E) as shown in Equation 16.

Equation 16. Emission Equation for Magnesium Production and Processing

$$\text{Emissions (MTCO}_2\text{E)} = \text{Quantity of Magnesium Produced (metric tons)} \times \text{Emission Factor (MT SF}_6\text{ /MT Magnesium)} \times \text{GWP of SF}_6$$

Figure 16. Example of Activity Data Applied in the Magnesium Production and Processing Worksheet

State Inventory Tool - Industrial Processes Module

File Edit Module Options Type

15. Magnesium Production and Processing in Colorado

Click here to find where these data are available.

Emissions from magnesium production and processing are emitted during the production of primary magnesium, production of secondary magnesium, and casting of magnesium. The emissions are calculated by multiplying the quantity of primary magnesium produced, secondary magnesium produced, and magnesium cast during a given year by their respective emission factors for the same year. The resulting emissions are then converted from metric tons of SF₆ to metric tons of carbon equivalents (MTCE) and metric tons of carbon dioxide equivalents (MTCO₂E). Additional information on these calculations is available in the Industrial Processes Chapter of the User's Guide.

Return to Control Sheet

Clear All Data

		Magnesium Production and Processing (Metric Tons)	Emission Factor (t SF ₆ /t Magnesium)	Emissions (Metric Tons SF ₆)	Emissions (MTCE)	Emissions (MTCO ₂ E)
1990	Primary Production		0.0012	-	-	-
	Secondary Production		0.0010	-	-	-
	Casting		0.0041	-	-	-
1991	Primary Production		0.0	-	-	-
	Secondary Production		0.0	-	-	-
	Casting		0.0041	-	-	-
1992	Primary Production		0.0012	-	-	-
	Secondary Production		0.0010	-	-	-
	Casting		0.0041	-	-	-

Required Data Input Cells

Step (17) Review Summary Information

The steps above provide estimates of total CO₂, N₂O, and HFC, PFC, and SF₆ emissions from each IP sector. Total emissions are equal to sum of emissions from each of the fourteen IP sectors, for each year. The information is collected by sector on the summary worksheets. There is a summary worksheet in the IP module that displays results in MMTCO₂E. Additionally, the summary worksheet provides an overview of sources excluded from the current emission estimates. Users should review this list to see if they wish to go back and enter data for any of the omitted IP sectors. Figure 17 shows the summary worksheet that sums the emissions from all sectors in the IP module.

Figure 17. Example of the Emissions Summary Worksheet in the IP Module

Figure 17. Example of the Emissions Summary Worksheet in the H-Wood

	A	B	C	D	E	F	G	H	I	J	K	L	M
1	16. Colorado Emissions Summary (MTCO2E)												
2	<div><div>Return to Control Sheet</div><div>Review discussion of uncertainty associated with these results</div></div>												
3	Emissions were not calculated for the following sources: Ammonia & Urea, Nitric Acid Production, Adipic Acid Production, Magnesium Production, HCFC-22 Production, and Aluminum Production.												
4													
5		1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	
6	Carbon Dioxide Emissions	356,416	437,691	490,630	742,651	741,557	635,912	624,344	1,459,719	1,401,612	1,301,266	1,470,46	
7	Cement Manufacture	317,456	334,853	359,132	438,793	439,052	475,769	472,666	507,831	506,280	516,106	553,79	
8	Lime Manufacture	-	65,348	93,342	264,694	249,210	100,294	89,482	87,199	88,587	85,698	94,97	
9	Limestone and Dolomite Use	-	-	-	-	13,961	18,838	21,522	11,521	16,445	16,351	28,49	
10	Soda Ash	35,890	34,806	35,584	36,001	36,464	38,369	38,121	39,078	39,921	39,692	40,67	
11	Ammonia Production	-	-	-	-	-	-	-	-	-	-	-	
12	Urea Consumption	3,071	2,683	2,573	3,163	2,871	2,643	2,553	3,045	3,374	3,292	2,25	
13	Iron & Steel Production	-	-	-	-	-	-	-	811,044	747,004	640,128	750,30	
14	Nitrous Oxide Emissions	-	-	-	-	-	-	-	-	-	-	-	
15	Nitric Acid Production	-	-	-	-	-	-	-	-	-	-	-	
16	Adipic Acid Production	-	-	-	-	-	-	-	-	-	-	-	
17	HFC, PFC, and SF ₆ Emissions	359,636	352,122	369,299	435,573	539,491	777,976	944,426	1,107,975	1,215,151	1,352,579	1,473,54	
18	ODS Substitutes	4,384	8,548	23,519	85,582	193,906	437,580	611,006	785,752	899,999	1,027,680	1,166,99	
19	Semiconductor Manufacturing	52,518	52,518	52,518	65,647	72,212	89,243	99,121	104,724	129,904	133,586	117,12	
20	Magnesium Production	-	-	-	-	-	-	-	-	-	-	-	
21	Electric Power Transmission and Distribution Systems	302,734	291,056	293,262	284,344	273,373	251,153	234,299	217,499	185,249	191,313	189,42	
22	HCFC-22 Production	-	-	-	-	-	-	-	-	-	-	-	
23	Aluminum Production	-	-	-	-	-	-	-	-	-	-	-	
24	Total Emissions	716,052	789,813	859,929	1,178,224	1,281,048	1,413,887	1,568,770	2,567,694	2,616,763	2,653,845	2,944,07	
25													
26													

Step (18) Export Data

The final step is to export the summary data. Exporting data allows the estimates from each module to be combined later by the Synthesis Module to produce a comprehensive GHG inventory for the state.

To access the "Export Data" button, return to the control worksheet and scroll down to step 17. Click on the "Export Data" button and a message box will open that reminds the user to make sure all steps of the module have been completed. If you make any changes to the IP module later, you will then need to re-export the results.

Clicking "OK" prompts you to save the file. The file is already named, so you only need to choose a convenient place to save the file. After the file is saved, a message box will appear indicating that the data was successfully exported.

Note: the resulting export file should not be modified. The export file contains a summary worksheet that allows users to view the results, as well as a separate data worksheet with an unformatted version of the results. The second worksheet, the data worksheet, contains the information that is exported to the Synthesis Tool. Users may not modify that worksheet. Adding/removing rows, moving data, or making other modifications jeopardize the ability of the Synthesis Module to accurately analyze the data.

While completing the modules, you are encouraged to save each completed module; doing so will enable you to easily make changes without re-running it entirely.

Following data export, the module may be reset and run for an additional state. Alternatively, you may run the remaining modules of the SIT to obtain a comprehensive profile of emissions for your state.

1.4 UNCERTAINTY

In the upper right-hand corner of the Summary worksheet is a button: “Review discussion of uncertainty associated with these results.” By clicking on this button, you are taken to a worksheet that discusses the uncertainty surrounding the activity data and emission factors, and how the uncertainty estimates for this source category affect the uncertainty of the emission estimates for your state.

1.5 REFERENCES

AAPFCO 2014. Commercial Fertilizers 2013. Association of American Plant Food Control Officials and The Fertilizer Institute. University of Kentucky, Lexington, KY.

AISI 2011. *2010 Annual Statistical Report*. American Iron and Steel Institute, Washington, DC.

EIA 2016. *Electric Power Annual 2014*. U.S. Department of Energy, Energy Information Administration. Washington, DC. Internet address: <http://www.eia.gov/electricity/annual/>

SRI 2000. *2000 Directory of Chemical Producers, United States of America*. Stanford Research Institute. Menlo Park, CA.

TVA (1991 through 1994). Commercial Fertilizers. Tennessee Valley Authority, Muscle Shoals, AL.

U.S. Census Bureau (2016). *American Factfinder 2000-2014 Population*. U.S. Census Bureau, Washington, DC.

U.S. Census Bureau (2002). *U.S. Census Bureau Economic Census for Semiconductors*. Washington, DC.

U.S. EPA. 2016. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2014*. Office of Atmospheric Programs, U.S. Environmental Protection Agency. EPA 430-R-16-002. Internet address: <https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks-1990-2014>.

USGS 2015a. *Lime: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: <http://minerals.er.usgs.gov/minerals/pubs/commodity/lime/index.html>

USGS 2015b. *Crushed Stone: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: http://minerals.er.usgs.gov/minerals/pubs/commodity/stone_crushed/index.html

USGS 2015c. *Soda Ash: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: http://minerals.er.usgs.gov/minerals/pubs/commodity/soda_ash/index.html

USGS 2015d. *Aluminum: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: <http://minerals.er.usgs.gov/minerals/pubs/commodity/aluminum/index.html>

USGS 2015e. *Cement: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at:
<http://minerals.usgs.gov/minerals/pubs/commodity/cement/>

USGS 2015f. *Nitrogen: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at:
<http://minerals.er.usgs.gov/minerals/pubs/commodity/nitrogen/index.html>

USGS 2015g. *Magnesium: Minerals Yearbook 2014*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at:
<http://minerals.er.usgs.gov/minerals/pubs/commodity/magnesium/index.html>