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 or later, 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 and Later: 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: Because 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.

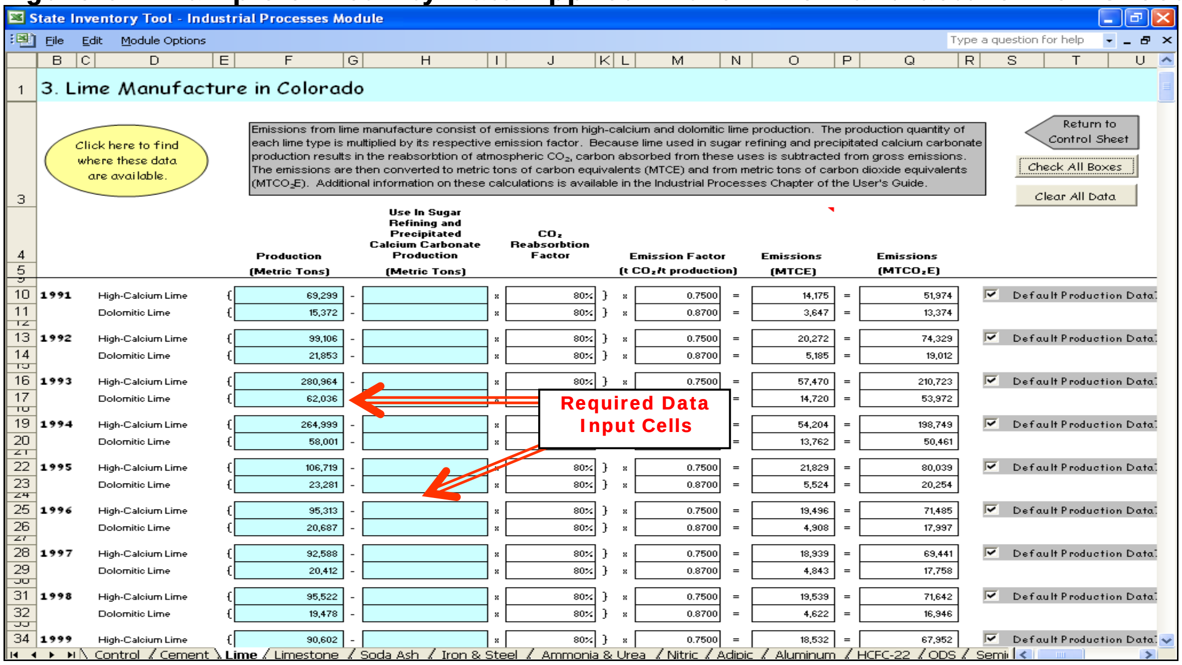
Excel 2007 and Later: If Excel’s security settings are set at the default level a Security Warning appears above the formula box in Excel when the IP module is initially opened. The Security Warning lets the user know that some active content from the spreadsheet has been disabled, meaning that Excel has prevented the macros in the spreadsheet from functioning. Because 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

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_2O Released after Pollution Control for nitric acid production	N_2O
Adipic Acid Production	Emission factor, production data, and Percent N_2O Released after Pollution Control for adipic acid production	
Aluminum Production	Emission factors for Prebake and Søderberg technologies and aluminum production data by technology	CO_2 and PFC
HCFC-22 Production	Emission factor and production data for HCFC-22 production	HFC, PFC, NF_3, and SF_6
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 inventory guidance, emissions of HFCs, PFCs, NF_3, and SF_6 from ODS substitutes and semiconductor manufacture 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.

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



Year	Lime type	Production (Metric Tons)	Use In Sugar Refining and Precipitated Calcium Carbonate Production (Metric Tons)	CO_2 Reabsorbtion Factor	Emission Factor (t CO_2/t production)	Emissions (MTCE)	Emissions ($MTCO_2E$)	
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				14,720	53,972	
1994	High-Calcium Lime	264,999				54,204	198,749	Default Production Data
	Dolomitic Lime	58,001				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

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 ($CaCO_3$) and dolomite ($CaMg(CO_3)_2$) 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

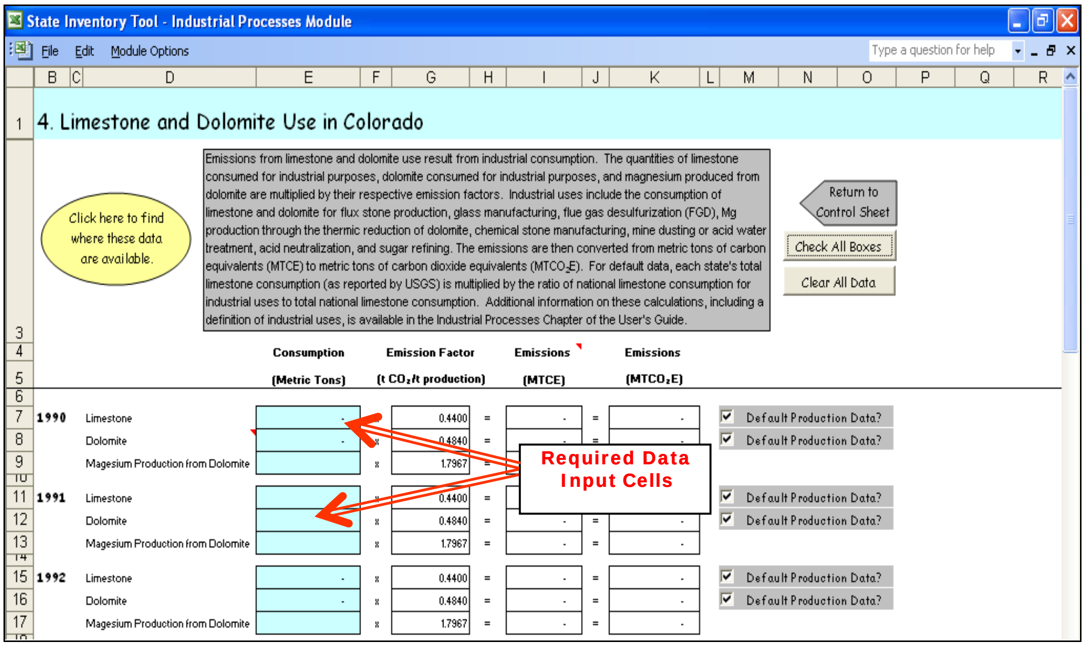
Production data for limestone and dolomite use, and magnesium production from dolomite are required as inputs in the blue cells of the limestone and dolomite worksheet as displayed in Figure 7. As an example, CO_2 is emitted as a by-product from the reaction of limestone or dolomite with impurities in the iron ore and fuels heated in a blast furnace. Activity data for limestone and dolomite use by state is available from USGS 2018.

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 ($MTCO_2E$). 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 CO_2 emissions from limestone and dolomite use.

Equation 4. Emission Equation for Limestone and Dolomite Use

$$\text{Emissions } (MTCO_2E) = \text{Consumption (metric tons)} \times \text{Emission Factor } (MT\ CO_2 / MT \text{ production})$$

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



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 CO_2 emissions from soda ash consumption.

Soda Ash Manufacture and Consumption Sector Worksheet

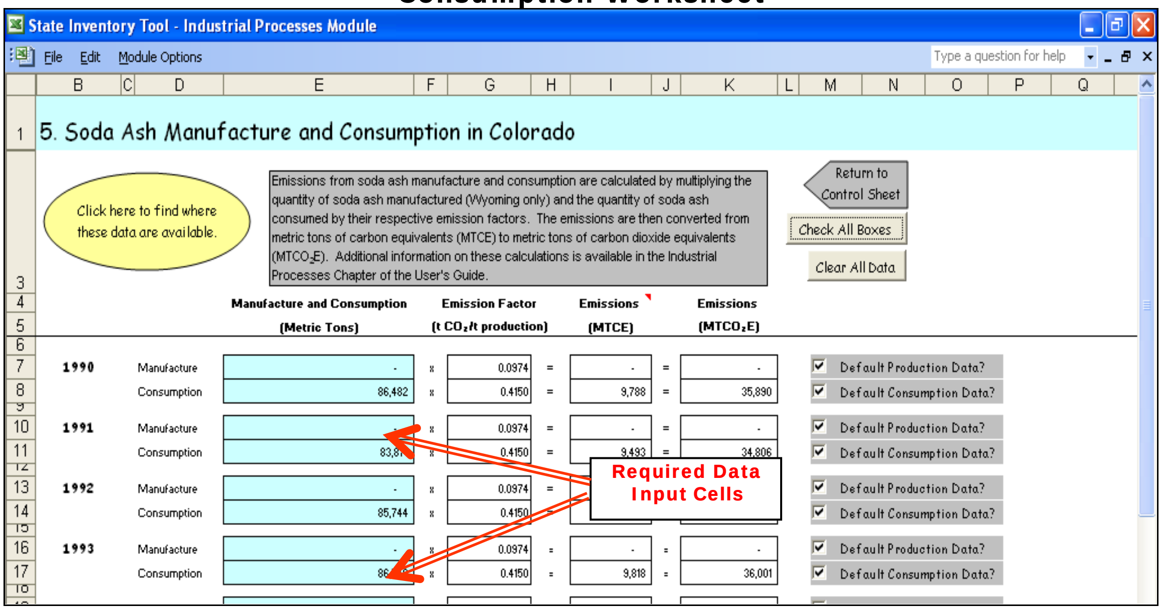
Production data for the manufacture and consumption of soda ash are required as inputs in the blue cells of the soda ash manufacture worksheet as shown in Figure 8. Under the soda ash production method used in some states, trona (an ore from which natural soda ash is made) is calcined in a rotary kiln and chemically transformed into a crude soda ash that requires further processing. CO_2 and water are generated as a by-product of the calcination process. CO_2 is also released when soda ash is consumed in products such as glass, soap, and detergents. Activity data for soda ash manufacture and consumption is available from USGS 2019b.

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 (MTCO$_2$E) 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



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 CO_2. 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

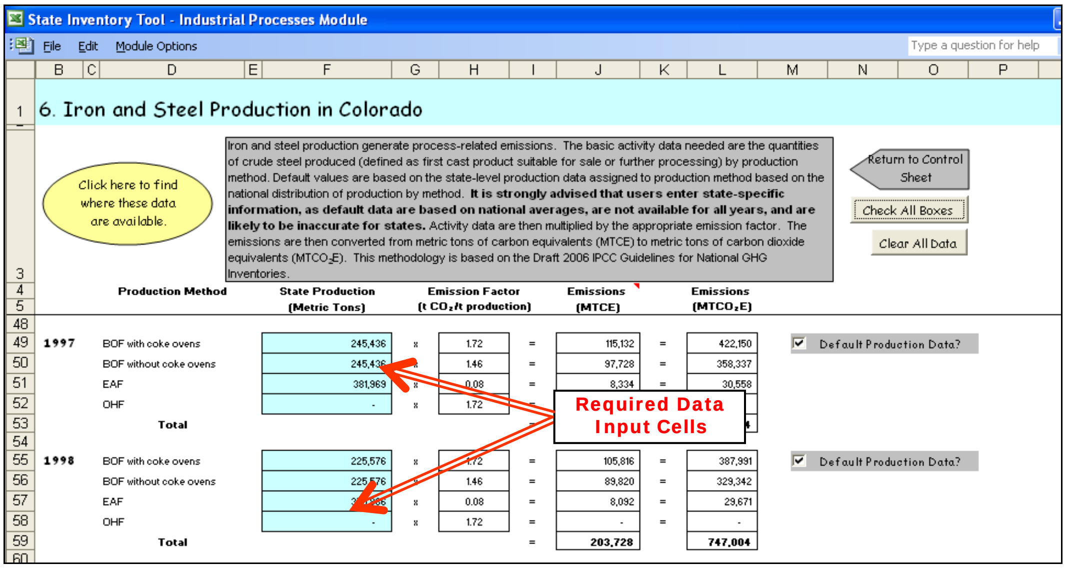
Activity data for the production of iron and steel are required as inputs in the blue cells of the iron and steel worksheet displayed in Figure 9. The basic activity data needed are the quantities of crude steel produced (defined as first cast product suitable for sale or further processing) by production 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 2010 (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 ($MTCO_2E$) as shown in Equation 6.

Equation 6. Emission Equation for Iron and Steel Production

$$\text{Emissions } (MTCO_2E) = \text{Manufacture/Consumption (metric tons)} \times \text{Emission Factor } (\text{MT } CO_2 / \text{MT production})$$

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



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 CO_2 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 2020d. Activity data for urea consumption by state is estimated based on state data from AAPFCO (2017) 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 ($MTCO_2E$) as shown in Equation 7 and Equation 8.

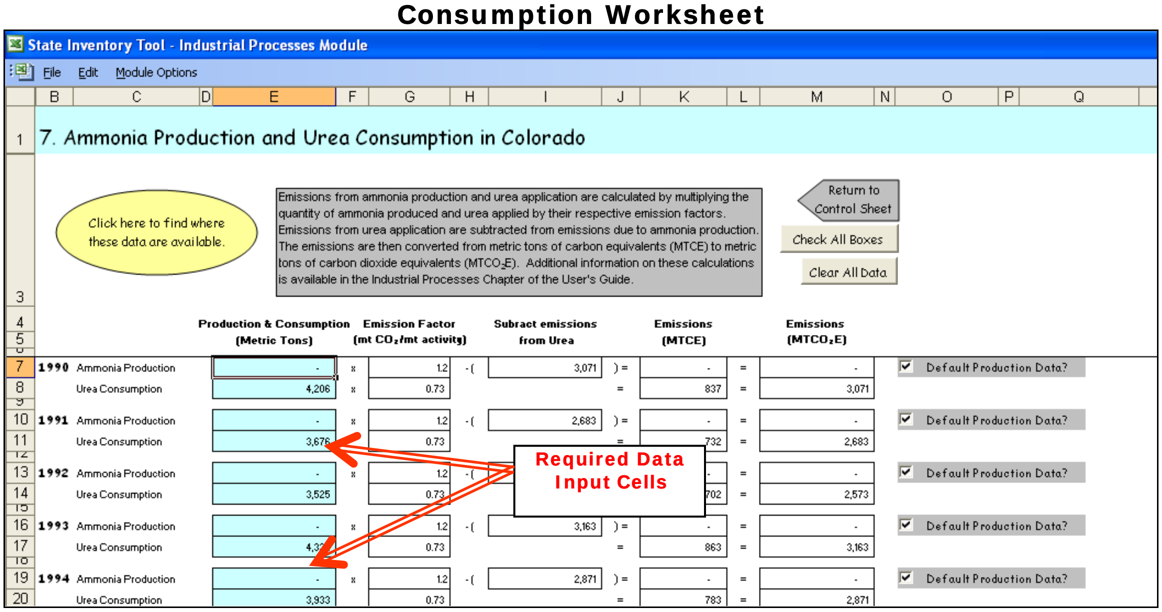
Equation 7. Emission Equation for Ammonia Production

$$\text{Emissions } (MTCO_2E) = \text{Production of Ammonia (metric tons)} \times \text{Emission Factor } (MT\ CO_2 / MT\ \text{activity}) - \text{Emissions from Urea } (MTCO_2E)$$

Equation 8. Emission Equation for Urea Consumption

$$\text{Emissions } (MTCO_2E) = \text{Consumption of Urea (metric tons)} \times \text{Emission Factor } (MT\ CO_2 / MT\ \text{activity})$$

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



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 (HNO_3) produces N_2O 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

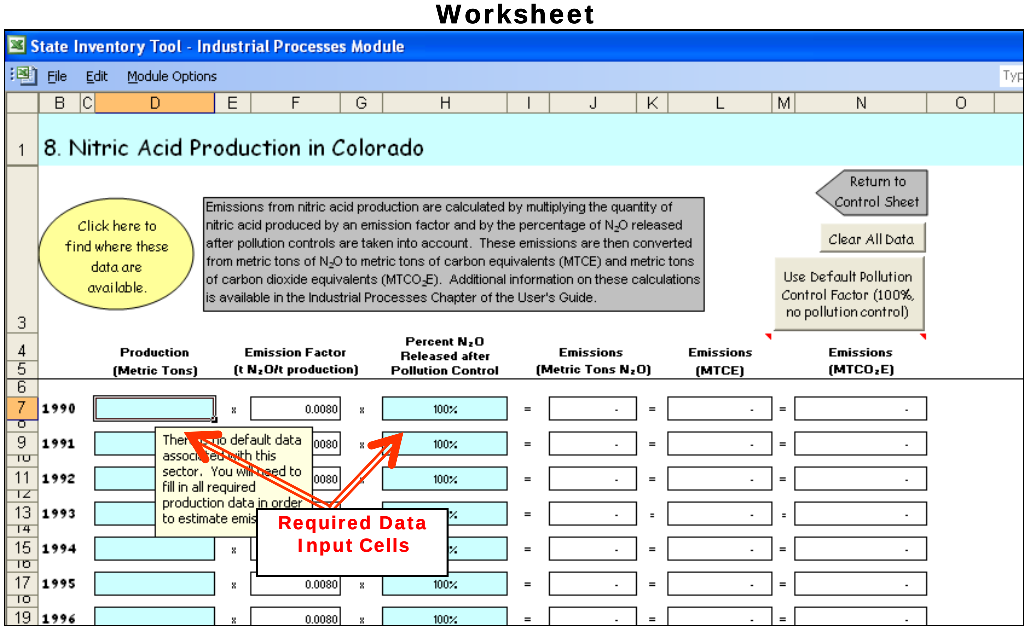
Data for the amount of nitric acid produced, as well as the percent N_2O released after pollution control are inputs for the nitric acid worksheet as seen in Figure 11. Activity data for nitric acid production is available from SRI 2000. The production of nitric acid (HNO_3) produces N_2O as a by-product, via the oxidation of ammonia. During this reaction, N_2O 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 N_2O 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 N_2O released after pollution controls are considered. These emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents ($MTCO_2E$) as seen in Equation 9.

Equation 9. Emission Equation for Nitric Acid Production

Emissions ($MTCO_2E$) =
Production of Nitric Acid (metric tons) × Emission Factor (MT N_2O / MT production) x Percent N_2O Released after Pollution Control x GWP N_2O

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



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 N_2O 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.

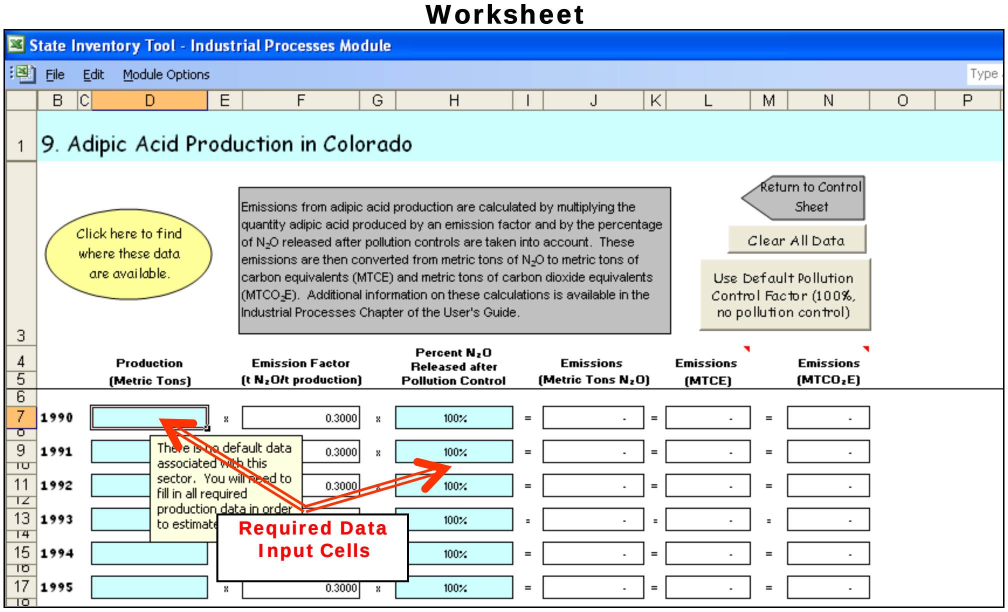
Adipic acid is produced through a two-stage process. The first stage involves the oxidation of cyclohexane to form a cyclohexanone/cyclohexanol mixture. The second stage involves the oxidation of ketone-alcohol with nitric acid. N_2O is generated as a by-product of this reaction and enters the waste gas stream. In the United States, this waste gas is treated to remove NO_x and other regulated pollutants (and, in some cases, N_2O 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 N_2O released after pollution controls are considered. These emissions are then converted from metric tons of N_2O to metric tons of carbon equivalents (MTCE) and then metric tons of carbon dioxide equivalents ($MTCO_2E$), shown in Equation 10.

Equation 10. Emission Equation for Adipic Acid Production

Emissions ($MTCO_2E$) =
Production of Adipic Acid (metric tons) × Emission Factor (MT N_2O/MT production) x Percent N_2O Released after Pollution Control x GWP N_2O

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



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

The emission factors for aluminum production are the next required inputs on the control worksheet. The aluminum production industry is thought to be the largest source of two PFCs – tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6). Emissions of these two potent greenhouse gases (GHGs) and CO_2 occur during the reduction of alumina in the primary smelting process.[2] Emission factors are required as inputs on the control worksheet for PFC emissions, CO_2 emissions from Prebake technology, and CO_2 emissions from Søderberg technology.

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 2020b.

PFC emissions from aluminum production are calculated by multiplying the quantity of aluminum produced during a year by the specific emission factor for that year. CO_2 emissions from aluminum production are calculated by multiplying the quantity of aluminum produced during a year by a weighted CO_2 emission factor. The emission factor is weighted by the percent of aluminum production using either Prebake or Søderberg technology. If the percent of production by technology type is unknown, a default percentage is assumed based on national data from the U.S. Inventory (U.S. EPA 2020). It is strongly advised that users enter state-specific information, as default data are based on national averages.

These emissions are then converted from metric tons of carbon equivalents (MTCE) to metric tons of carbon dioxide equivalents ($MTCO_2E$), shown in Equation 11.

Equation 11. Emission Equation for Aluminum Production

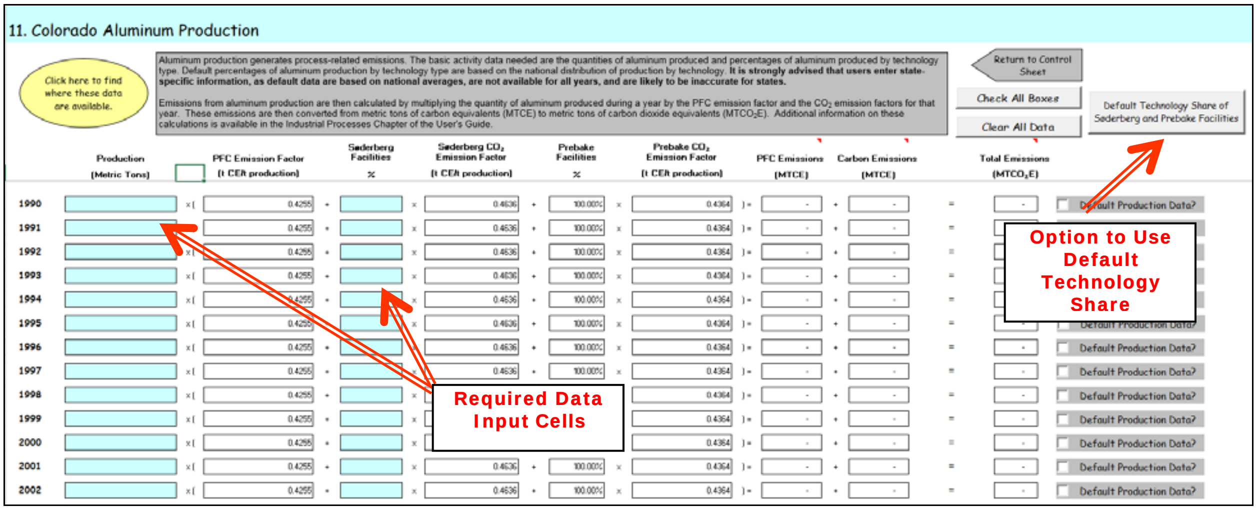
$$\text{Total Emissions } (MTCO_2E) = \text{PFC Emissions } (MTCO_2E) + CO_2 \text{ Emissions } (MTCO_2E)$$

$$\text{PFC Emissions } (MTCO_2E) = \text{Production of Aluminum (metric tons)} \times \text{Emission Factor (MT CE / MT production)}$$

$$CO_2 \text{ Emissions } (MTCO_2E) = \text{Production of Aluminum (metric tons)} \times [(\text{Percent of Production}_{Prebake} \times EF_{Prebake}) + (\text{Percent of Production}_{Søderberg} \times EF_{Søderberg})] \text{ (MT CE / MT production)}$$

[2] Perfluorinated carbons are not emitted during the smelting of recycled aluminum.

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



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

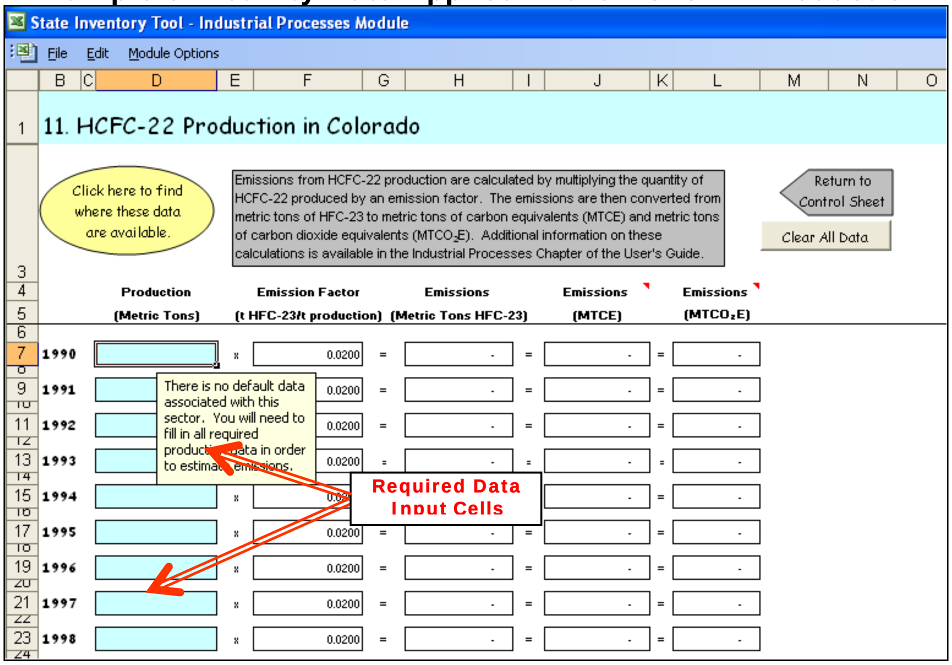
HFC-23, one type of HFC, is known to be emitted in significant quantities as a by-product of HCFC-22 production. Data for the production of HCFC-22 are required inputs in the blue cells on the HCFC-22 production worksheet, shown in Figure 14. In order to obtain activity data, in-state manufacturers of HCFC-22 should be consulted first. Additionally, the Chemical Manufacturers Association (Washington, D.C.), Alliance for Responsible CFC Policy (Arlington, VA), and Grant Thorton 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 ($MTCO_2E$) as in Equation 12.

Equation 12. Emission Equation for HCFC-22 Production

Emissions ($MTCO_2E$) =
Production of HCFC-22 (metric tons) × Emission Factor (MT HFC-23/MT production) x GWP of HFC-23

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



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 SF_6 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 (2020). The resulting state emissions are then converted to metric tons of carbon dioxide equivalents ($MTCO_2E$) as shown in Equation 13.

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

Emissions ($MTCO_2E$) =
[National ODS Substitute Emissions ($MTCO_2E$) × State Population] / 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 CF_4, C_2F_6, and C_3F_8; HFC-23; NF_3, and SF_6. 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 CF_4, C_2F_6, and C_3F_8; HFC-23; NF_3, and SF_6.

Emissions of HFCs, PFCs, NF_3, and SF_6 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 (2012), to the value of national semiconductor shipments. The resulting state emissions are then converted into metric tons of CO_2 equivalents ($MTCO_2E$) as shown in Equation 14.

Equation 14. Emission Equation for Apportioning Emissions from Semiconductor Manufacture

Emissions ($MTCO_2E$) =
[National Semiconductor Manufacture Emissions ($MTCO_2E$) × Value of State Semiconductor Shipments] / 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 SF_6, 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 SF_6 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 (2019) and EIA (2019).

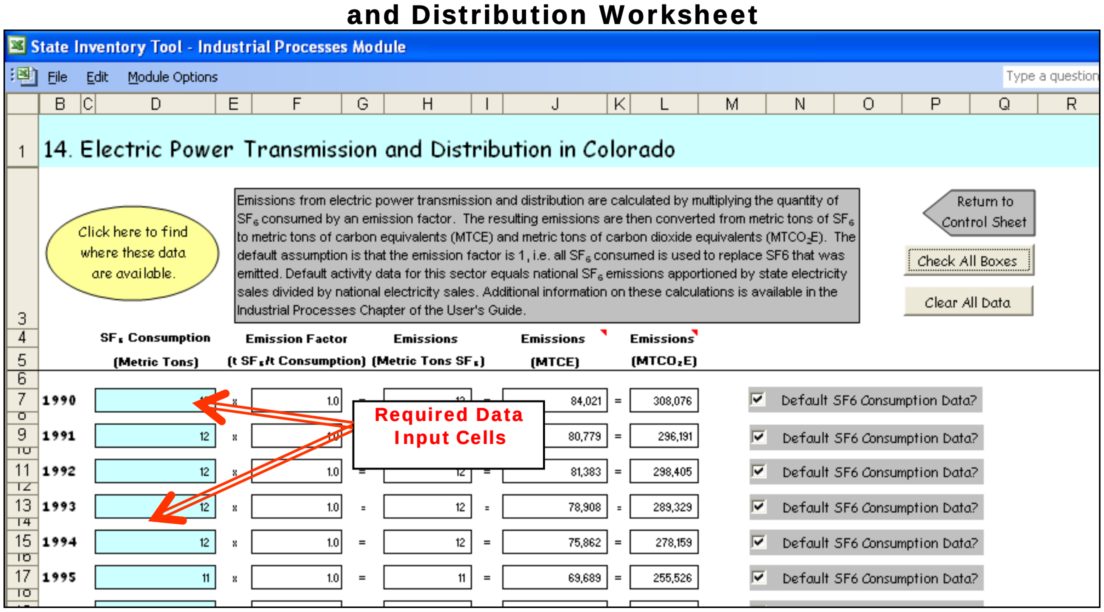
The largest use for SF_6, both domestically and internationally, is as an electrical insulator in electricity transmission and distribution equipment, such as gas-insulated high-voltage circuit breakers, substations, transformers, and transmission lines. The electric utility industry uses the gas because of its high dielectric strength and arc-quenching abilities. Not all of the electric utilities in the United States use SF_6; 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 SF_6 consumed by an emission factor. The resulting emissions are then converted from metric tons of SF_6 to metric tons of carbon dioxide equivalents ($MTCO_2E$) as shown in Equation 15. The default assumption is that the emission factor is 1, i.e. all SF_6 consumed is used to replace SF_6 that was emitted. Default activity data for this sector equals national SF_6 emissions apportioned by state electricity sales divided by national electricity sales.

Equation 15. Emission Equation for Electric Power Transmission and Distribution

$$\text{Emissions } (MTCO_2E) = \text{SF}_6 \text{ Consumption (metric tons SF}_6) \times \text{Emission Factor (MT SF}_6 / \text{MT Consumption)} \times \text{GWP of SF}_6$$

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



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 SF_6 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 are available at USGS (2020a).

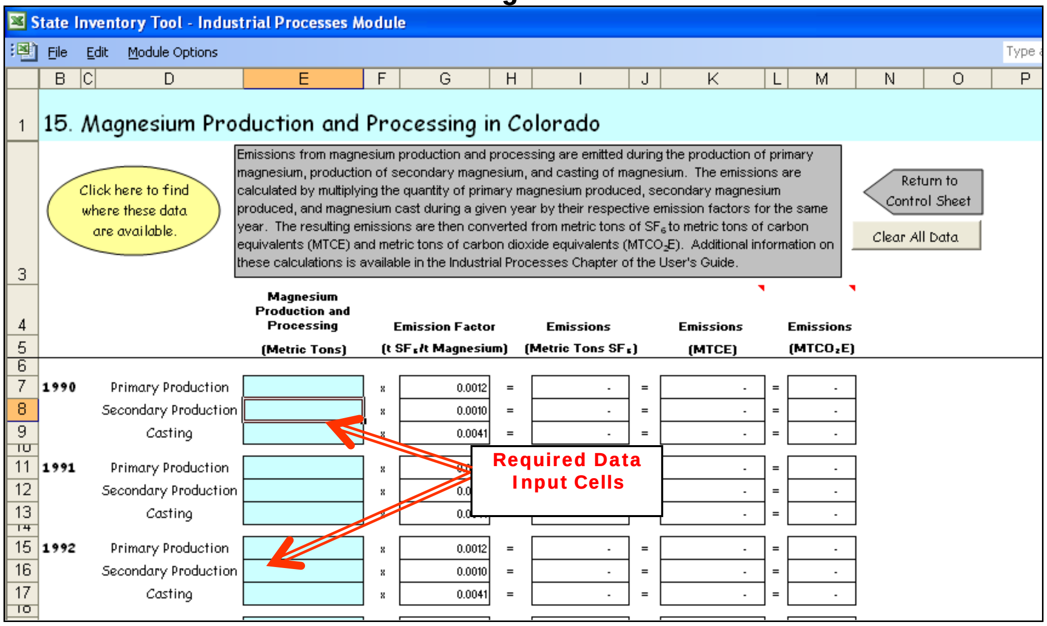
The Mg metal production and casting industry uses SF_6 as a cover gas to prevent the violent oxidation of molten Mg in the presence of air. A gas mixture consisting of CO_2, air, and a small concentration of SF_6 is blown over the molten Mg metal to induce the formation of a protective crust. Most producers of primary Mg metal and most Mg part casters use this technique. SF_6 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 SF_6 to metric tons of carbon dioxide equivalents ($MTCO_2E$) as shown in Equation 16.

Equation 16. Emission Equation for Magnesium Production and Processing

Emissions ($MTCO_2E$) =
Quantity of Magnesium Produced (metric tons) × Emission Factor (MT SF_6 / MT Magnesium) x GWP of SF_6

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



Step (17) Review Summary Information

The steps above provide estimates of total CO_2, N_2O, and HFC, NF_3, PFC, and SF_6 emissions from each IP sector. Total emissions are equal to sum of emissions from each of the fifteen 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 $MMTCO_2E$. 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

16. Colorado Emissions Summary (MTCO2E)

Return to Control Sheet | Review discussion of uncertainty associated with these results

Emissions were not calculated for the following sources: Aluminum Production, Carbon Dioxide, Ammonia Production, Nitric Acid Production, Adipic Acid Production, Magnesium Production, HCFC-22 Production, and Aluminum Production, PFCs.

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Carbon Dioxide Emissions	356,405	437,687	490,282	742,724	741,138	635,382	624,003	1,459,499	1,401,585	1,301,270
Cement Manufacture	317,456	334,853	359,132	438,793	439,052	475,769	472,666	507,831	506,280	516,106
Lime Manufacture	-	65,349	93,343	264,698	249,213	100,295	89,483	87,200	88,587	85,700
Limestone and Dolomite Use	-	-	-	-	13,544	18,336	21,147	11,270	16,388	16,363
Soda Ash	35,879	34,801	35,234	36,070	36,458	38,339	38,154	39,109	39,952	39,681
Aluminum Production, CO_2	-	-	-	-	-	-	-	-	-	-
Iron & Steel Production	-	-	-	-	-	-	-	811,044	747,004	640,128
Ammonia Production	-	-	-	-	-	-	-	-	-	-
Urea Consumption	3,071	2,683	2,573	3,163	2,871	2,643	2,553	3,045	3,374	3,292
Nitrous Oxide Emissions	-	-	-	-	-	-	-	-	-	-
Nitric Acid Production	-	-	-	-	-	-	-	-	-	-
Adipic Acid Production	-	-	-	-	-	-	-	-	-	-
HFC, PFC, and SF_6 Emissions	330,428	323,958	342,392	408,924	516,723	769,708	943,876	1,111,476	1,229,040	1,373,418
ODS Substitutes	3,790	7,433	23,805	81,995	191,236	440,111	616,624	791,842	905,695	1,039,978
Semiconductor Manufacturing	64,282	64,282	64,282	80,352	88,388	111,654	123,988	131,030	162,616	167,183
Magnesium Production	-	-	-	-	-	-	-	-	-	-
Electric Power Transmission and Distribution Systems	262,357	252,243	254,305	246,577	237,099	217,943	203,264	188,604	160,730	166,257
HCFC-22 Production	-	-	-	-	-	-	-	-	-	-
Aluminum Production, PFCs	-	-	-	-	-	-	-	-	-	-
Total Emissions	686,833	761,645	832,673	1,151,647	1,257,861	1,405,090	1,567,879	2,570,975	2,630,625	2,674,688

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.

> **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.

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.

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. 2017. Commercial Fertilizers 2014. 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. 2019. *Electric Power Annual 2018.* U.S. Department of Energy, Energy Information Administration. Washington, DC. Available at: http://www.eia.gov/electricity/annual/

IPCC. 2006. 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 4: Agriculture, Forestry, and Other Land Use. The National Greenhouse Gas Inventories Programme, The Intergovernmental Panel on Climate Change. [H.S. Eggleston, L. Buendia, K. Miwa, T. Ngara, and K. Tanabe (eds.)]. Hayama, Kanagawa, Japan.

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. 2020. *2000-2019 Population.* U.S. Census Bureau, Washington, DC. Available online at: http://www.census.gov.

U.S. Census Bureau. 2012. *U.S. Census Bureau Economic Census for Semiconductors*. Washington, DC.

U.S. EPA. 2020. *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2018*. Office of Atmospheric Programs, U.S. Environmental Protection Agency. EPA 430-R-20-002. Available online at: https://www.epa.gov/ghgemissions/inventory-us-greenhouse-gas-emissions-and-sinks

USGS. 2020a. *Magnesium: Minerals Yearbook 2017.* U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: https://minerals.usgs.gov/minerals/pubs/commodity/magnesium/index.html

USGS. 2020b. *Aluminum: Minerals Yearbook 2018.* U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: https://minerals.usgs.gov/minerals/pubs/commodity/aluminum/index.html

USGS. 2020c. *Lime: Minerals Yearbook 2017.* U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: https://minerals.usgs.gov/minerals/pubs/commodity/lime/index.html

USGS. 2020d. *Nitrogen: Minerals Yearbook 2017.* U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: https://minerals.usgs.gov/minerals/pubs/commodity/nitrogen/index.html

USGS. 2019a. *Cement: Mineral Industry Survey through December 2018*. U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: http://minerals.usgs.gov/minerals/pubs/commodity/cement/

USGS. 2019b. *Soda Ash: Mineral Industry Survey 2019.* U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: https://minerals.usgs.gov/minerals/pubs/commodity/soda_ash/index.html

USGS. 2018. *Crushed Stone: Minerals Yearbook 2016.* U.S. Geological Survey, Minerals Information Service. Reston, VA. Available online at: https://minerals.usgs.gov/minerals/pubs/commodity/stone_crushed/index.html