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# USER'S GUIDE FOR ESTIMATING CARBON DIOXIDE AND METHANE EMISSIONS FROM NATURAL GAS AND OIL SYSTEMS USING THE STATE INVENTORY TOOL

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This section of the User's Guide provides instruction on using the Natural Gas and Oil Systems module of the State Inventory Tool (SIT), and describes the methodology used for estimating greenhouse gas emissions from natural gas and oil systems at the state level.

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## 1.1 GETTING STARTED

The Natural Gas and Oil Systems module 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 Excel basics below. Some of the Excel basics are outlined in the sections below. Before you use the Natural Gas and Oil Systems module, make sure your computer meets the system requirements. In order to install and run the Natural Gas and Oil Systems 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 Natural Gas and Oil Systems 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 Natural Gas and Oil Systems 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 Natural Gas and Oil Systems 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 Natural Gas and Oil Systems 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,

*State Greenhouse Gas Inventory Tool User’s Guide for the Natural Gas and Oil Module*

“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 Natural Gas and Oil Systems module and re-launch Microsoft Excel before opening the Natural Gas and Oil Systems 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 Stationary Combustion module and enable macros in the manner described in the preceding paragraph.

### Viewing and Printing Data and Results

The Natural Gas and Oil Systems 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 Natural Gas and Oil Systems 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

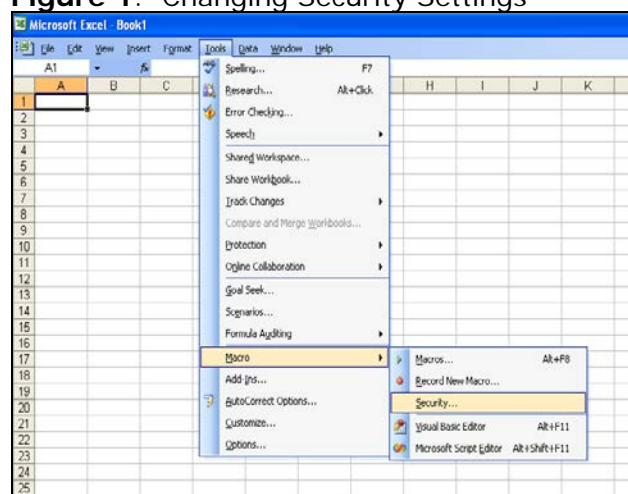
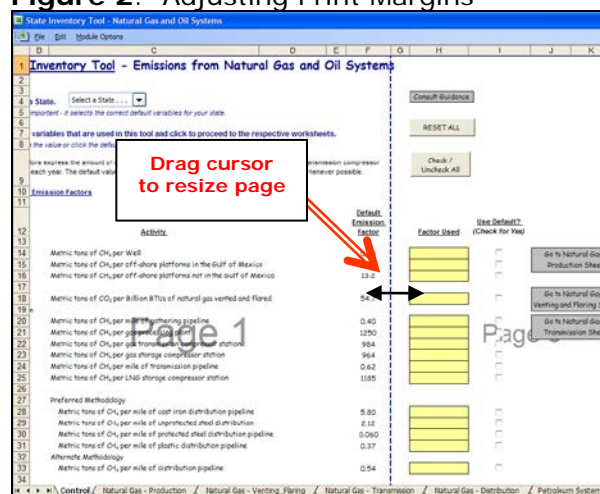


Figure 2. Adjusting Print Margins



## 1.2 MODULE OVERVIEW

This User's Guide accompanies and explains the Natural Gas and Oil Systems 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.

Because 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 Natural Gas and Oil Systems module calculates methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>) emissions from all phases of natural gas systems (including production, transmission, venting and flaring, and distribution) and petroleum systems (including production, refining, and transport). The module provides default data for all emission factors and provides some activity data; however, EPA encourages the use of more comprehensive data sources if they are available. Currently default data are not available in the SIT for the transmission, and distribution of natural gas or the refining, and transportation of oil. If using outside data sources, or for a more thorough understanding of the module, please refer to the following discussion for data requirements and methodology.

### 1.2.1 Data Requirements

To calculate CH<sub>4</sub> and CO<sub>2</sub> emissions from natural gas and oil systems, the following data are required:

- The number of wells and offshore platforms;
- Amount of natural gas vented and flared;
- The number of miles of gathering pipeline;
- The number of gas processing plants and compressor stations;
- The number of miles of transmission pipeline;
- The number of miles of distribution pipeline, if possible, by type (e.g., cast iron, steel, plastic)
- The total number of services (e.g., gas meters);

- Data on oil production, refining, and transportation; and
- Emission factors for each of the above activities.

A complete list of the activities for which activity data and emission factors are necessary to complete the Natural Gas and Oil Systems module is provided in Table 1.

**Table 1. Data Requirements for the Natural Gas and Oil Systems Module**

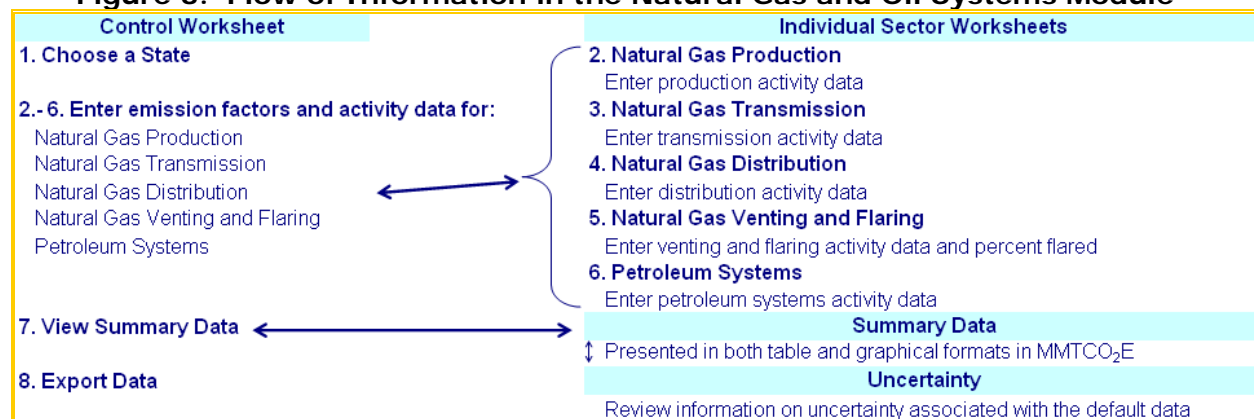
<b>Module Worksheet</b>	<b>Activity Data and Emission Factors Required</b>
Natural Gas - Production	Number of wells Number of shallow-water off-shore platforms Number of deep-water off-shore platforms Emission factors for all of the above (MT CH <sub>4</sub> /well or platform)
Natural Gas - Transmission	Miles of gathering pipeline Number of gas processing plants Number of gas transmission compressor stations <sup>1</sup> Number of gas storage compressor stations <sup>1</sup> Miles of transmission pipeline Number of LNG storage compressor stations Emission factors for all of the above (MT CH <sub>4</sub> /unit)
Natural Gas - Distribution	Miles of cast iron distribution pipeline <sup>2</sup> Miles of unprotected steel distribution pipeline <sup>2</sup> Miles of protected steel distribution pipeline <sup>2</sup> Miles of plastic distribution pipeline <sup>2</sup> Number of services Number of unprotected steel services Number of protected steel services Emission factors for all of the above (MT CH <sub>4</sub> /unit) Emission factor for alternate method* (MT CH <sub>4</sub> /per mile of distribution pipeline)
Natural Gas - Venting and Flaring	Billion BTUs of natural gas vented and flared Emission factor (MT CO <sub>2</sub> /Billion Btu natural gas vented and flared)
Petroleum Systems	Barrels of oil produced Barrels of oil refined Barrels of oil transported Emission factor (kg CH <sub>4</sub> /1000 barrels)

<sup>1</sup> An alternate method is available in which only total transmission pipeline miles are required, and the number of gas transmission and storage compressor stations is calculated based on this entry.

<sup>2</sup> An alternate method is available in which only total distribution pipeline miles are required, rather than by pipeline type.

### 1.2.2 Tool Layout

Because there are multiple sections to complete within the Natural Gas and Oil Systems module, it is important to understand the module's overall design. The layout of the Natural Gas and Oil Systems module and the purpose of its worksheets are presented in Figure 3.

**Figure 3. Flow of Information in the Natural Gas and Oil Systems Module\***

\* These worksheets are the primary worksheets used in the Natural Gas and Oil Systems module; subsequent worksheets are used to populate the default data and are provided for informational purposes only.

## 1.3 METHODOLOGY

This section provides instructions for using the Natural Gas and Oil Systems module of the SIT to estimate fugitive emissions from natural gas and oil systems. Emissions are calculated for several subcategories, including the production, flaring, transmission, and distribution of natural gas and the production, refining, and transportation of oil. Within the Natural Gas and Oil Systems module, it is important to account for emissions from natural gas and petroleum systems separately because the emission factors and methods are fuel specific. Because the methodology differs for each subcategory, they are discussed separately, and specific examples are provided.

### Box 1: State Energy Data Sources

Note that no default activity data are available for the transmission or distribution of natural gas. If state-specific data sources are not available, users can obtain much of the required data from the Energy Information Administration (EIA) (<http://eia.doe.gov>). The Mineral Management Services (MMS) also provides a comprehensive source of data for off-shore oil and gas production activities (<http://www.mms.gov>). In addition, the Office of Pipeline Safety (OPS) has detailed and exhaustive data on all kinds of pipeline (transmission, gathering, distribution, services) that is accessible to the public on its website (<http://ops.dot.gov/stats.htm>). The SIT has more detailed recommendations for data sources for each activity on the gas and oil data sources worksheets.

The Natural Gas and Oil Systems module automatically calculates emissions after you enter activity data for each worksheet (and select or enter the emission factors on the control worksheet). The tool provides default data for venting and flaring of natural gas and the number of natural gas wells, but data must be obtained for the remaining subcategories (see Box 1 for suggestions on where to find data).

The Natural Gas and Oil Systems module follows the general methodology outlined in the EIIP guidance, however because of the automation of the calculations within the tool, the order of steps discussed in this User's Guide do not 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 Natural Gas and Oil Systems module by walking through the following steps: (1) select a state; (2) enter emission factors and activity data for natural gas production; (3) enter emission factors and activity data for natural gas transmission; (4) enter emission factors and activity data for natural gas distribution; (5) enter emission factors and activity data for natural gas venting and flaring; (6) enter

emission factors and activity data for petroleum systems; (7) review summary information; and (8) export data.

For all subcategories, the basic process is to multiply the activity data by the emission factor to obtain the emission estimate, which is then converted to million metric tons carbon dioxide equivalent (MMT $\text{CO}_2\text{E}$ ) by multiplying by the GWP of  $\text{CH}_4$  (25) and dividing by  $10^6$ . The general equation used to calculate emissions from natural gas systems is shown in Equation 1. The equation used for venting and flaring of natural gas is similar but includes the flaring percent and does not include the GWP because emissions are already in units of  $\text{CO}_2$ , as shown in Equation 2. The equation used for petroleum systems is shown in Equation 3.

#### Equation 1. General Emission Equation for Natural Gas Systems

$$\text{Emissions (MMT}\text{CO}_2\text{E)} = \text{Activity Data} \times \text{Emission Factor (MT CH}_4\text{/unit activity data)} \times 25 \text{ (GWP)}$$

#### Equation 2. Emission Equation for Venting and Flaring of Natural Gas

$$\text{Emissions (MMT}\text{CO}_2\text{E)} = \text{Activity Data (BBtu)} \times \text{Emission Factor (MT CO}_2\text{/BBtu)} \times \% \text{ flared} \div 10^6 \text{ (MT/MMT)}$$

#### Equation 3. General Emission Equation for Petroleum Systems

$$\text{Emissions (MMT}\text{CO}_2\text{E)} = \text{Activity Data ('000 barrels)} \times \text{Emission Factor (kg CH}_4\text{'000 barrels)} \div 1,000 \text{ (kg/MT)} \times 25 \text{ (GWP)} \div 10^6 \text{ (MT/MMT)}$$

### Step (1) Select a State

To begin, select the state for which you would like to perform the analysis. This step will automatically select the appropriate state default data for the remainder of the calculations throughout the tool.

### Step (2) Enter Emission Factors and Activity Data for Natural Gas Production

#### Control Worksheet

On the control worksheet, either select the default data provided or enter user-specified gas and activity-specific emission factors that will be used throughout the tool. To proceed with the default emission factors, select the "Check/Uncheck All" button or check the default box directly to the right of individual yellow input cells. Note that these numbers can be overwritten if you 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. See Figure 4 for locations of the "Check/Uncheck All" buttons, individual default check boxes, and yellow input cells. Information on emission factors is discussed below.



Figure 4. Control Worksheet for the Natural Gas and Oil Systems Module

The screenshot displays the 'State Inventory Tool - Natural Gas and Oil Systems' control worksheet. It features a table with the following columns: Activity, Default Emission Factor, Factor Used, and Use Default? (Check for Yes). The table is organized into sections: 2. Enter Emission Factors and Activity Data for Natural Gas Production, 3. Enter Emission Factors and Activity Data for Natural Gas Transmission, and 4. Enter Emission Factors and Activity Data for Natural Gas Distribution. Red arrows highlight the 'Check / Uncheck All' button and callouts for 'Select All Defaults', 'Required Data', and 'Individual Default Data Check Boxes'. The bottom of the screen shows a navigation bar with tabs for 'Natural Gas - Production', 'Natural Gas - Transmission', 'Natural Gas - Distribution', 'Natural Gas - Venting Flaring', 'Petroleum Systems', 'Summary', and 'Uncertainty / Gas D'.

Activity	Default Emission Factor	Factor Used	Use Default? (Check for Yes)
Metric tons of CH <sub>4</sub> per Well	Variable by year	Variable by year	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per shallow water off-shore platforms in the Gulf of Mexico and Pacific	134.8	134.82	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per deepwater off-shore platforms in the Gulf of Mexico and Pacific	558.5	558.54	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of gathering pipeline	0.40	0.40	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per gas processing plant	1250	1249.95	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per gas transmission compressor station	984	983.66	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per gas storage compressor station	964	964.15	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of transmission pipeline	0.62	0.62	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per LNG storage compressor station	1185	1184.99	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of cast iron distribution pipeline	5.80	5.80	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of unprotected steel distribution	2.12	2.12	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of protected steel distribution pipeline	0.060	0.060	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of plastic distribution pipeline	0.37	0.37	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per mile of distribution pipeline	0.54	0.54	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per service	0.015	0.0153	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per unprotected steel services	0.033	0.0328	<input checked="" type="checkbox"/>
Metric tons of CH <sub>4</sub> per protected steel services	0.003	0.0034	<input checked="" type="checkbox"/>
Metric tons of CO <sub>2</sub> per Billion BTUs of natural gas vented and flared	54.7	54.71	<input checked="" type="checkbox"/>

Default emission factors are provided in the Natural Gas and Oil Systems module for all natural gas and petroleum system activities, or they can be provided by the user. Examples of the emission factors being used are shown in each of the specific sector worksheet figures shown in subsequent steps.

The emission factors for natural gas systems, except production, are based on a study by the Gas Research Institute and the U.S. Environmental Protection Agency (GRI 1996). The study conducted a large survey of emissions from the natural gas industry and developed emission factors for three of the four natural gas activities in the SIT: processing, transmission (including storage), and distribution. Within each segment, industry facilities and operations were analyzed to identify fugitive emissions, leaks, and vented emissions. The study identified approximately 100 components of natural gas systems that are CH<sub>4</sub> emission sources. For each component, the study developed an emission factor.

This finely grained GRI data on emission factors is the "Tier 3" approach developed by the Intergovernmental Panel on Climate Change (IPCC 1997) and is used to develop emission estimates for the annual Inventory of U.S. Greenhouse Gas Emissions and Sinks. However, to simplify the amount of data required in the SIT, each of the default emission factors provided accounts for emissions from several activities. For example, the default emission factor for natural gas production per well approximates emissions not just from wells but also from pneumatic devices, dehydrator vents, Kimray pumps, gas engines, and well clean-ups. Therefore, if users are supplying state-specific emission factors, all aspects of emissions must be considered.

For the natural gas production sector, enter emission factors on the control sheet in the yellow cells. The default emission factors for natural gas wells vary by year and region, while the default emission factors for offshore deep-water and shallow-water platforms do not vary by region or year. The emission factors for natural gas well production are based on the emission factors used in U.S. EPA (2020) and are ultimately based on GRI data source estimates.

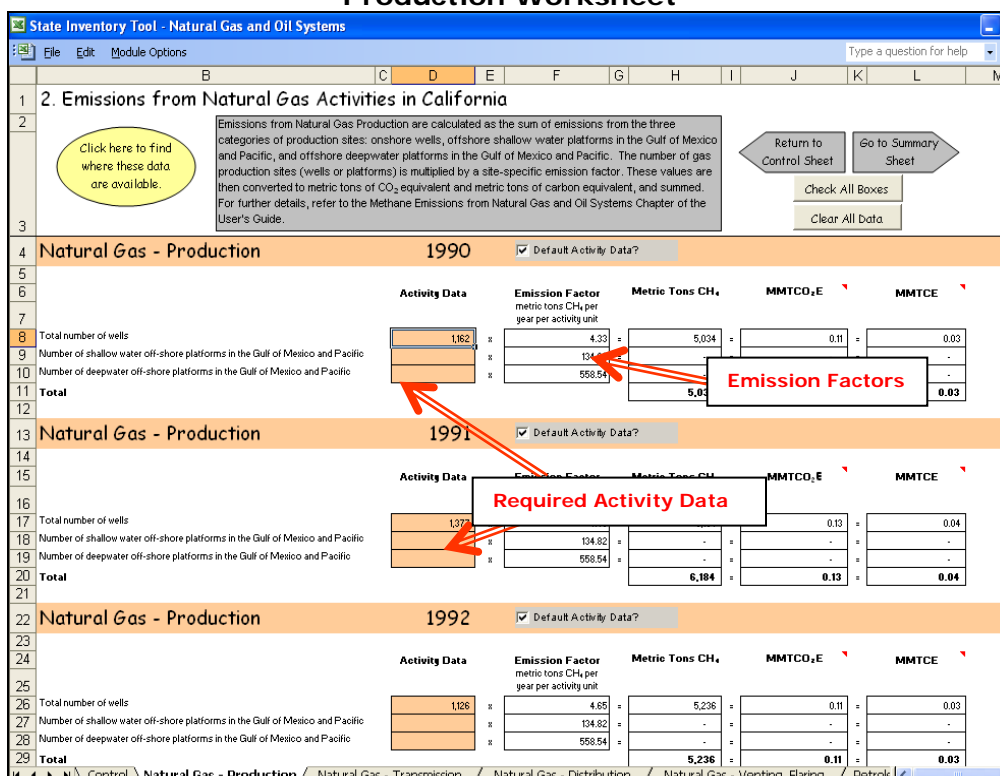
### **Natural Gas Production Worksheet**

Most gas production is from gas or oil wells. Gathering lines are used to bring raw gas to a collection point or points within a production field. Because CH<sub>4</sub> is the major component of natural gas, leaks or venting from the gathering systems result in CH<sub>4</sub> emissions.

Natural gas is usually processed in gas plants to remove and process the natural gas liquids and to prepare the natural gas for pipeline transportation. During processing, natural gas is dried, and a variety of processes may be used to remove most of the heavier hydrocarbons, or condensate, from the gas. Processed gas is then injected into the natural gas transmission system, and the heavier hydrocarbons are marketed separately. Major CH<sub>4</sub> emission sources in the gas processing are compressor fugitives, compressor exhaust, vents, pneumatic devices, and blowdown.

On the natural gas production worksheet, shown in Figure 5, the orange cells indicate where the required activity data are entered manually. Default data for natural gas well production from EIA (2020c) is available for most states. Emissions are calculated by multiplying activity data by the appropriate emission factor to obtain the total CH<sub>4</sub> emissions in metric tons. Then, the total emissions are converted into MMTCO<sub>2</sub>E, by multiplying by the GWP for CH<sub>4</sub> (25) and dividing by 10<sup>6</sup> (Equation 1).

**Figure 5. Example of Activity Data and Emission Factors Applied in the Natural Gas Production Worksheet**



**Step (3) Enter Emission Factors and Activity Data for Natural Gas Transmission**

Transmission pipelines are large diameter, high-pressure lines that transport gas from production fields, processing plants, storage facilities, and other sources of supply over long distances to local distribution companies or to large volume customers. A variety of facilities support the overall system, including metering stations, maintenance facilities, and compressor stations located along pipeline routes. Compressor stations, which maintain the pressure in the pipeline, generally include upstream scrubbers, where the incoming gas is cleaned of particles and liquids before entering the compressors. Reciprocating engines and turbines are used to drive the compressors. Major CH<sub>4</sub> emission sources are chronic leaks, compressor fugitives, compressor exhaust, vents, and pneumatic devices.

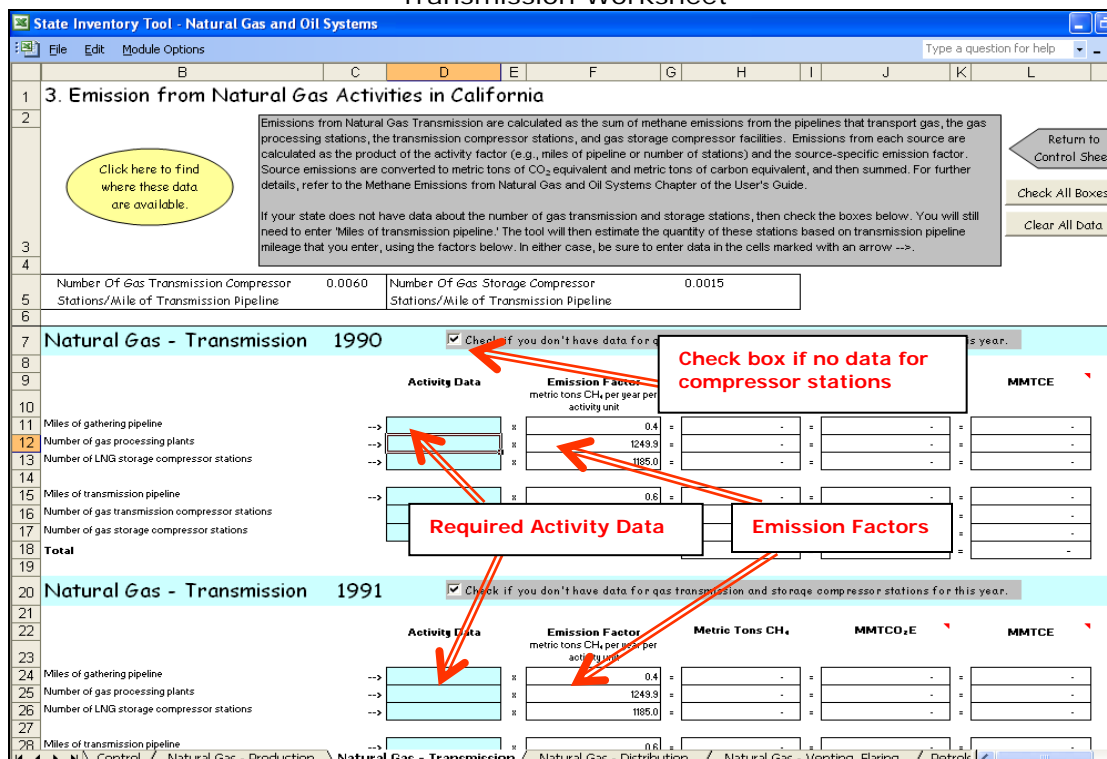
**Control Worksheet**

On the control sheet, enter emission factors (in metric tons of CH<sub>4</sub> per unit) for gathering pipeline, gas processing plants, gas transmission compressor stations, gas storage compressor stations, transmission pipeline, and LNG storage compressor stations.

### Natural Gas Transmission Worksheet

For the transmission worksheet, an alternate method is available if data on the number of gas transmission and storage stations is not accessible. To use the alternate method, check the box at the top of each year’s calculations, and make sure to enter 'miles of transmission pipeline' in the activity data. The tool will then estimate the quantity of these stations based on transmission pipeline mileage. An example of the transmission worksheet is shown in Figure 6 (input cells shown in blue).

**Figure 6. Example of Activity Data and Emission Factors Applied in the Natural Gas Transmission Worksheet**



### Step (4) Enter Emission Factors and Activity Data for Natural Gas Distribution

Distribution pipelines are extensive networks of generally small diameter, low-pressure pipelines. Gas enters distribution networks from transmission systems at city gate stations, where the pressure is reduced for distribution within cities or towns. Major CH<sub>4</sub> emission sources are chronic leaks, meters, regulators, and mishaps.

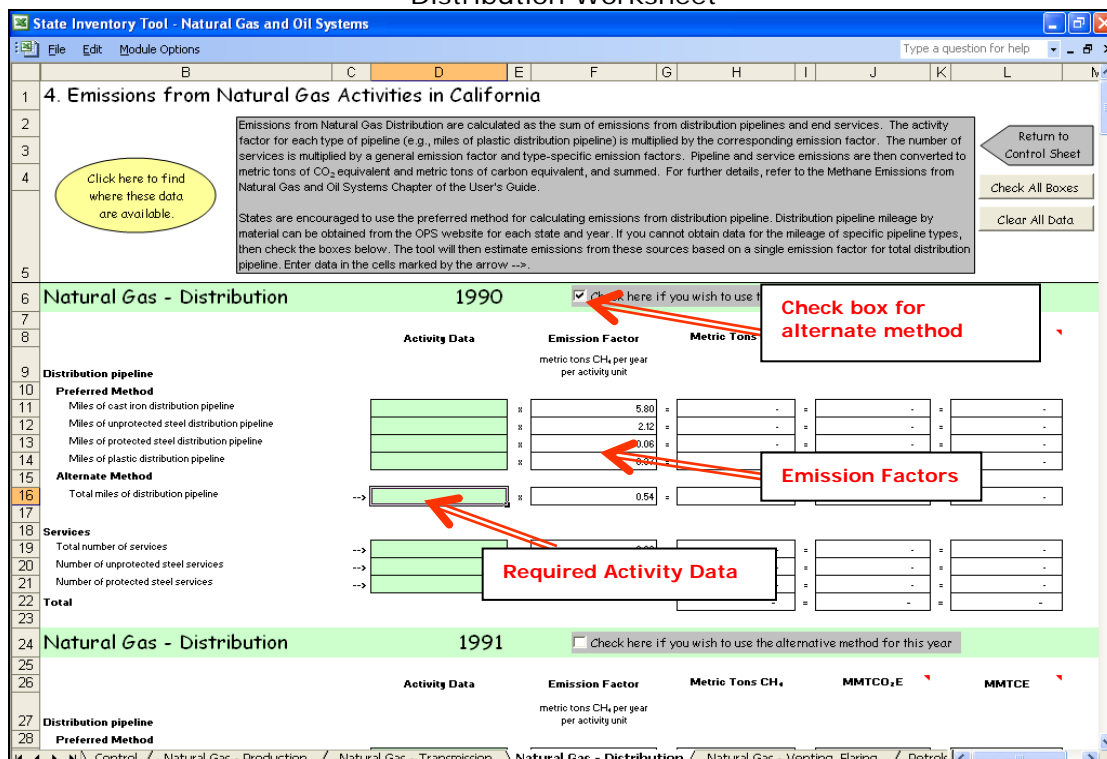
### Control Worksheet

If you are using the preferred method of calculating emissions from natural gas distribution, enter emission factors (in metric tons of CH<sub>4</sub> per mile of pipeline) for cast iron distribution pipeline, unprotected steel distribution pipeline, protected steel distribution pipeline, and plastic distribution pipeline. If you are using the alternate method, you need only enter an emission factor of metric tons of CH<sub>4</sub> per mile of distribution pipeline (all types of pipeline). Then for both methods, enter the emission factors for all natural gas services (i.e., end-users), for unprotected steel services, and for protected steel services.

### Natural Gas Distribution Worksheet

For distribution, states are encouraged to use the method provided for calculating emissions from specific types of distribution pipeline. However, an alternate method is offered based on a single emission factor for total distribution pipeline. If data are unavailable for the mileage of specific pipeline types, then check the box at the top of each year's calculations and enter the total pipeline mileage where indicated. The green input cells in Figure 7 show where activity data are required.

**Figure 7. Example of Activity Data and Emission Factors Applied in the Natural Gas Distribution Worksheet**



### Step (5) Enter Emission Factors and Activity Data for Natural Gas Venting and Flaring

#### Control Worksheet

Enter the emission factor for natural gas venting and flaring on the control worksheet. This emission factor must account for both vented and flared natural gas. The default emission factor is taken from U.S. EPA (2020).

#### Natural Gas Venting and Flaring Worksheet

The venting and flaring worksheet is unique because it calculates CO<sub>2</sub> emissions from flaring, and it requires both activity data for the amount of natural gas vented and flared, and the percent of gas flared. Default activity data are available in the SIT for most states

from the EIA Natural Gas Navigator.<sup>1</sup> An example of the use of the activity data, emission factor, and percent flared can be seen in Figure 8 (input cells are shown in pink). While the required activity data for this worksheet is the total amount that is vented and flared, the emissions calculations are for the amount of gas that's flared. The SIT assumes that 80 percent of this gas is flared and that the remaining 20 percent (i.e., the amount that's vented) must be accounted for in the petroleum systems production category. Because there is no default data for petroleum systems in the SIT, the user must make sure that the amount of gas flared is not double counted when calculating emissions from the petroleum systems category.

Venting and flaring refer to the disposal of gas that cannot be contained or otherwise handled. Venting and flaring activities are associated with combined oil and gas production and take place in production areas where gas pipeline infrastructure is incomplete, and the natural gas is not injected into reservoirs.

Figure 8. Example of Activity Data and Emission Factor Applied in the Natural Gas Venting and Flaring Worksheet

The screenshot shows the 'State Inventory Tool - Natural Gas and Oil Systems' interface. The main title is '5. Emissions from Natural Gas Activities in California'. A yellow callout bubble points to a section of the worksheet with the text: 'Click here to find where these data are available.' A grey text box explains: 'Emissions from Natural Gas Venting and Flaring are calculated as the percent of emissions flared. The amount of gas that is vented or flared is multiplied by a National emission factor. This total of potential emissions is then multiplied by the percentage of gas flared and converted to million metric tons of carbon equivalent.' Navigation buttons include 'Return to Control Sheet', 'Go to Summary Sheet', 'Check All Boxes', 'Clear All Data', and 'Use National Default Flaring Percent (80%)'. The worksheet is divided into sections for 1990 and 1991. Each section has a header row with 'Natural Gas - Vented and Flared' and the year. Below each header is a calculation row with columns for 'Activity Data', 'Emission Factor', 'Metric Tons CO<sub>2</sub>', 'Percent Flared', and 'MMTCE'. For 1990, the Activity Data is 1,275, Emission Factor is 54.71, Metric Tons CO<sub>2</sub> is 75,205, Percent Flared is 80%, and MMTCE is 0.02. For 1991, the Activity Data is 1,583, Emission Factor is 54.71, Metric Tons CO<sub>2</sub> is 86,824, Percent Flared is 80%, and MMTCE is 0.02. Red arrows point from callout boxes labeled 'Emission Factor', 'Activity Data', and 'Percent Flared' to their respective input fields in the calculation rows.

Year	Activity Data (Billion BTU)	Emission Factor (metric tons CO <sub>2</sub> per billion BTU)	Metric Tons CO <sub>2</sub>	Percent Flared	MMTCE
1990	1,275	54.71	75,205	80%	0.02
1991	1,583	54.71	86,824	80%	0.02

## Step (6) Enter Emission Factors and Activity Data for Petroleum Systems

### Control Worksheet

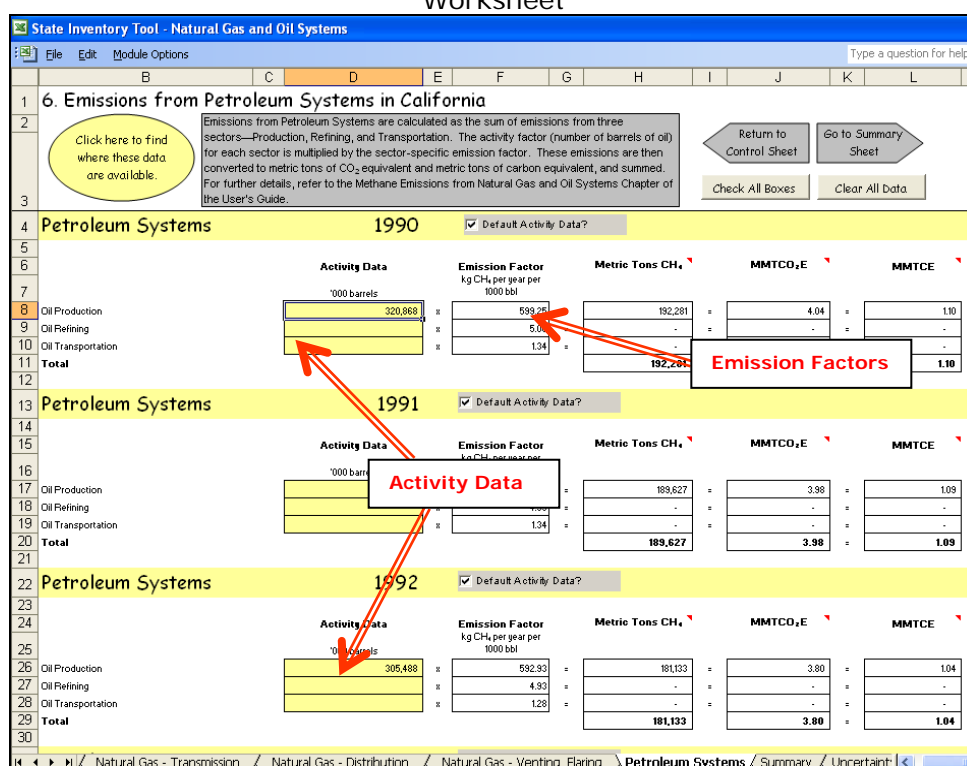
The petroleum system emission factors used in the SIT are implied emission factors derived from U.S. EPA (2020). Using the available published oil system emission estimates, the implied emission factors were developed by dividing the emission estimates from each of the major activity groups (production, refining, and transportation) by the appropriate activity data at the national level. These implied emission factors are calculated for each year in the SIT. States are encouraged to use state-specific emission factors if data are available, as actual emissions depend on site-specific characteristics including facility design, operation, and maintenance.

<sup>1</sup> Available online at: [https://www.eia.gov/dnav/ng/NG\\_PROD\\_WELLS\\_S1\\_A.htm](https://www.eia.gov/dnav/ng/NG_PROD_WELLS_S1_A.htm)

### Petroleum Systems Worksheet

Required data for the petroleum systems worksheet include the amount of oil produced (including venting), refined, and transported in the state. Figure 9 shows an example of the data used for this sector, the yellow cells are input cells. Default data are not provided in the SIT, so users must input data for emissions to be estimated. If state-specific data sources are not available, users can obtain oil production data from EIA’s Petroleum Supply Annual.<sup>2</sup> Refining data can be calculated using data from the Petroleum Supply Annual and the calculator provided in the SIT on the oil data sources worksheet. Currently, no uniform data source has been identified for oil transportation activities, so in the absence of other information it is recommended that users assume that the amount of oil transported is equivalent to the amount of oil refined in the state.

Figure 9. Example of Activity Data and Emission Factor Factors Applied in the Petroleum Systems Worksheet



CH<sub>4</sub> emissions from oil systems are estimated using the “Tier 1” approach developed by the IPCC (IPCC 1997). The approach is simpler than the method used for natural gas systems, but it is also less accurate. The SIT calculates emissions by multiplying the required state-level data on oil production, refining, and transportation by the appropriate emission factors and summing across activity types to calculate total emissions, as shown in Equation 3. The general sources of CH<sub>4</sub> emissions from oil systems that should be accounted for can be categorized into emissions from: (1) normal operations, (2) routine maintenance, and (3) system upsets and accidents.

<sup>2</sup> Available online at: <http://www.eia.gov/petroleum/supply/annual/volume1/>.

Normal operations include emissions from the day-to-day operations of a facility. Oil production and transportation facilities can emit CH<sub>4</sub> due to a wide variety of operating practices and factors, including emissions from pneumatic devices, leaks from system components, emissions from process vents, emissions from starting and stopping reciprocating engines or turbines, and emissions during drilling activities.

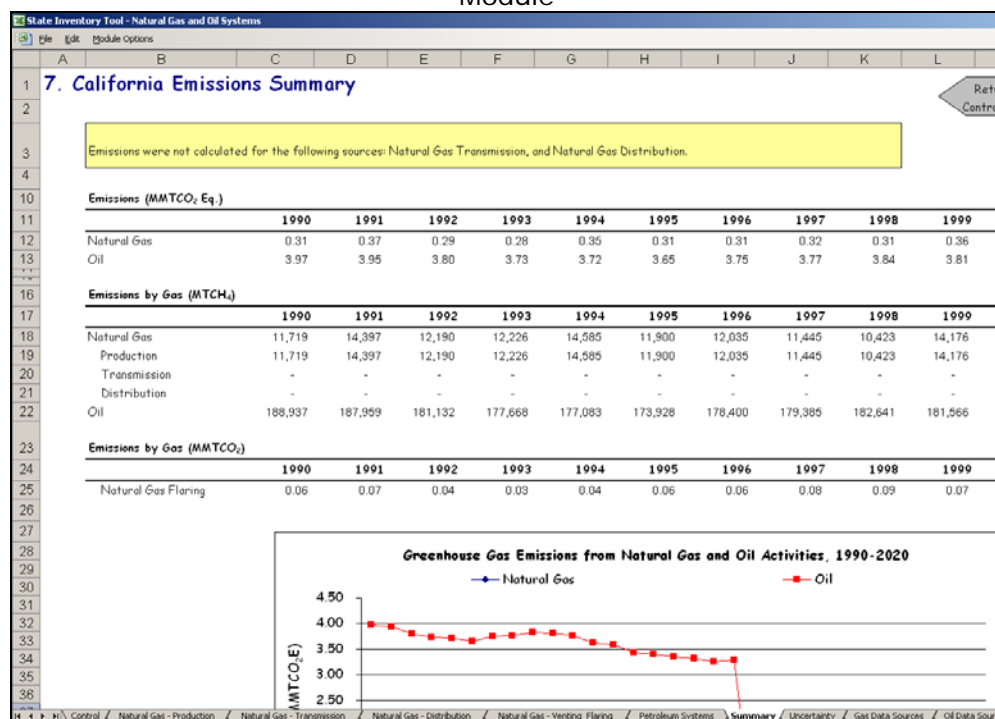
Routine maintenance includes regular and periodic activities performed in the operation of the facility. These activities may be conducted frequently, such as launching and receiving scrapers (pigs) in a pipeline, or infrequently, such as evacuation of pipes (“blowdown”) for periodic testing or repair. In each case, the required procedures release gas from the affected equipment. Releases also occur during maintenance of wells (“well workovers”) and during replacement or maintenance of fittings.

System upsets are unplanned events in the system. The most common upset is a sudden pressure surge resulting from the failure of a pressure regulator. The potential for unplanned pressure surges is considered during facility design, and facilities are provided with pressure relief systems to protect the equipment from damage due to the increased pressure. Relief systems vary in design. In some cases, gases released through relief valves may be collected and transported to a flare for combustion or re-compressed and reinjected into the system. In these cases, CH<sub>4</sub> emissions associated with pressure relief events will be small. In older facilities, relief systems may vent gases directly into the atmosphere or send gases to flare systems where complete combustion may not be achieved. The frequency of system upsets varies with the facility design and the operating practices. In particular, facilities operating well below capacity are less likely to experience system upsets and related emissions. Emissions associated with accidents are also included in the category of upsets.

### **Step (7)      Review Summary Information**

The steps above provide estimates of total emissions for each natural gas and oil activity. These are summed over all activities, for each year, and the information is collected on the summary worksheet. The summary worksheet displays results in MMTCO<sub>2</sub>E, as well as by individual gas. Additionally, the summary worksheet provides an overview of sources excluded from the current emission estimates. Users should check this list to see if they wish to go back and enter data for any of the omitted activities. Figure 10 shows the summary worksheet that sums the emissions from all sectors in the Natural Gas and Oil Systems module. In addition, the results are displayed in graphical format at the bottom of the summary worksheet.



Figure 10. Example of the Summary Worksheet in the **Natural Gas and Oil Systems** Module

### Step (8) 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 greenhouse gas inventory for the state.

To access the “Export Data” button, return to the control worksheet and scroll down to the bottom (8). 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 Natural Gas and Oil Systems 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 jeopardizes 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

- EIA, 2020a. EIA’s Monthly Energy Review. “June 2020 Monthly Energy Review.” Available at: <https://eia.gov/totalenergy/data/monthly/pdf/mer.pdf>
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